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THE AUSTRALIAN NAVAL ARCHITECT

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Cover Photo:

The 69 m vehicle-passenger catamaran ferry *Farasan,* recently delivered by Austal to Saudi Arabia (Photo courtesy Austal Ships)

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From the Division President

The long wait is now over. At the beginning of May the government finally delivered the White Paper *Defending Australia in the Asia Pacific Century: Force 2030*. The official launch was preceded by much speculation as key elements of the paper were leaked to the press, particularly in the last few days. The press continued with its review of the White Paper by announcing that the navy was the clear winner. More correctly, the clear winner is the Australian Defence Force. The White Paper clearly provides for a balanced defence force which will meet many roles in the future. Upon reading the paper, the four strategic drivers are defence of Australia against attack; security, stability and cohesion in our immediate neighbourhood; stability of the Asia-Pacific region; and preserving international order. These drivers lead to the foundations for Australian defence policy and help determine the future roles of the defence force. These include deterring and defeating armed attacks on Australia, contributing to the stability and security in the South Pacific and East Timor, and contributing to military contingencies in the Asia-Pacific region as well as the rest of the world. To address these roles, the White Paper suggests that the key focus areas should be undersea warfare and anti-submarine warfare as well as surface maritime warfare, air superiority, strategic strike, special forces, intelligence, surveillance and reconnaissance and, finally, cyber warfare. All of this leads to a balanced force for a multitude of activities.

Most readers of the White Paper will turn to the so-called "shopping lists" or future lists of assets that will be designed, built and delivered to the defence force during the life of the paper. The paper includes many items that collegiately come together to ensure that the aims and objectives are met. For the Royal Australian Navy this includes future submarines, surface combatants, frigates and offshore patrol craft — also included are a strategic sealift ship, a new supply ship and replacement heavy landing craft. There are numerous other assets which will be operated by both the army and air force to assist in these roles.

The key question for members of the Australian Division of the Royal Institution of Naval Architects is "what does this mean for us?" Any person can apply to become a member of RINA if they are associated with the design, building and management of ships and submarines — as well as other items, such as those found in the offshore sector. The White Paper certainly provides a multitude of opportunities for our membership, whether they belong to multi-national corporations through to individual consultancies. I certainly believe that anybody with a slight interest in the defence market will be able to find an activity arising from the White Paper. The universities and colleges also play an important part in responding to these opportunities. Our current and future students may be the ones who are putting the final touches to the designs of some of these future ships and submarines. If not current students, then I am sure some of the future students will be involved in the maintenance and through-life support for all of the new acquisitions. The Universities play an important part of providing a workforce which can sustain these projects.

In summary, I think that the new Defence White Paper *Defending Australia in the Asia Pacific Century: Force 2030* provides a significant number of opportunities and challenges for our organisation, industry and academia for many years to come. I look forward to reading future editions of *The Australian Naval Architect* about many of the successes that will have arisen as a consequence of this important policy document.

Stuart Cannon

Editorial

The press reaction to the Defence White Paper has highlighted the navy projects in the Paper with considerable attention to the high-profile projects like the future submarine. Whilst the submarine, in particular, will require considerable resources over the next fifteen years (and beyond), there are also notable challenges for naval architects in some of the smaller projects.

The White Paper outlines a proposal for around 20 new multi-role offshore combatants with a displacement of about 2000 t. The size is welcome — volume is cheap and increased size greatly improves seakeeping, endurance and performance. The real challenge lies in creating a true multi-purpose design which is 'all things to all people'.

A common ship hull and machinery with modular payloads for specific tasks is very attractive. Specialised modules, for minehunting for example, can be retained ashore fully maintained and operational in an ideal environment and only embarked when needed. The time the ship spends at sea in any year can be maximised. Modules which require maintenance or modification can readily be changed for others without tying the ship in port for long periods.

The concept is, of course, not new. The MEKO design of the Anzac-class frigates was, in part, sold on this basis but it is questionable if the potential benefits have actually been realised sufficiently to justify the extra structural weight and design complication needed to accommodate the modules. The US Navy's new LCS designs are also intended to deploy modularised payloads for different roles.

The challenge for the naval architects is to design a ship which can be equally effective as a patrol ship off the north-west coast and as a minehunter in the approaches to the southern ports. The roles are quite different, and satisfying both roles in one ship means that compromises are inevitable. A fully-fledged minehunter needs to have low magnetic signature and specialised sonars — patrol ships do not. Inevitably, there will have to be compromises. Similarly, it is possible that the ships employed in the hydrographic or oceanographic role may, for good practical reasons, spend most of their life in that role with modules rarely, if ever, changed.

Many years ago, Australia embarked on the design of a common combatant hull of about 1500 t displacement which could be built in several variants optimised for surface warfare, anti-submarine warfare or patrol duties. It was called a light destroyer (DDL) and, coincidentally, we were to have up to 20 of them. In the end, the ship became a general purpose destroyer of over 4000 t and the numbers had dropped to three by the time the project was cancelled.

There is, of course, a huge difference between the concept of the DDL and the proposed offshore combatant vessels. Today's project is much less ambitious and is much more practicable. Nevertheless the challenge to design a ship which can adapt to such varied roles remains considerable.

The extent of that challenge will emerge during the studies the Government has directed and it is possible that the concept may change as it is developed. Hopefully, whatever the outcome, a high degree of hull, machinery and electrical commonality can be achieved in the design of the new ships, for that will provide enormous benefits in logistic support and training.

John Jeremy

Letter to the Editor

Dear Sir,

I'd like to bring to your attention the excellent technical meetings which the ACT Section has been holding over the last few months. The topics and presenters have been of very high quality and interest has also been high. With topics ranging from the submarine *AE2*, to single maritime jurisdiction and landing-craft stability, there has been much to interest the audience.

I would further like to congratulate the Department of Defence for encouraging Peter Hayes to undertake a research master's degree in a very topical area. His recent presentation on his progress to date highlighted some remarkable aspects of the naval architectural capabilities within Australia in general, and the Department of Defence in particular. Many of your readers know Peter and his work in the area of surface-ship stability for the Royal Australian Navy. For many years he has been ensuring that our sailors have stable ships to take into harm's way for the huge variety of missions which they undertake. He has now turned his attention to issues specific to landing craft, and how both the army and navy utilise them.

The discussion following Peter's presentation highlighted to Defence that landing craft tend to have cargo as a much-higher proportion of full load than similar civil craft. Indeed, he told us that the mass of cargo can exceed the lightship of the craft. Defence landing craft also operate in contact with ships at sea, either through ramp-to-ramp marriage or (once the LHDs are delivered) docking. This introduces many extra complicating factors. Discussions further highlighted that Defence expects its craft to operate in significantly greater seas than equivalent civil craft.

It was pleasing to see that Navy, the Defence Science and Technology Organisation, and the Australian Maritime College are all involved in Peter's work, as this not only increases the resources and knowledge he has to call on to help his work, but will also enforce a level of rigour and peer review that otherwise might have been missing.

I look forward to the continuing program of interesting and stimulating technical meetings held by the ACT Section, and to seeing Peter present his final findings at a future conference or meeting. Peter himself acknowledged that he will not be able to address the full complexity of landing-craft operations, such as operating in surf and very shallow water, the effects of steep and breaking waves on vessel stability and, as was highlighted during the discussions following his presentation, the impact of damage on the stability and safety of landing craft in a hostile operational environment.

Dan Curtis

Ships of the RAN, and HMNZS *Canterbury* (fifth in the line in this phoito), entering Sydney Harbour shortly after dawn on 13 March for the RAN's 2009 Fleet Review
(RAN Photograph)

NEWS FROM THE SECTIONS

ACT

Annual General Meeting

The ACT section held its AGM on 31 March 2009 at Defence Campbell Park offices. The meeting had a high level of attendance from ACT section members, such that we almost ran out of chairs!

ACT Section Chair, Mr John Colquhoun, reported that the section had enjoyed some great events and presentations over the past year, and considered that this momentum is likely to continue in the next year.

ACT Section Treasurer, Mr Tim Lyon, provided a thorough report on the section's finances and recent audit, assisted by Dan Curtis.

Thanks to Dan, Tim, Dan, and auditor Garry Duck.

Committee

The election of office bearers at the Annual General Meeting was simple as the current committee was re-elected. The ACT Section Committee therefore remains:

Chair	John Colquhoun
Deputy Chair	Peter Hayes
Secretary	Glen Seeley
Treasurer	Tim Lyon
AD Council Nominee	Ian Laverock
Members	Joe Cole
	Dan Curtis
	Lindsay Emmett
	Rob Gehling
	Ian Laverock
	Kerry Johnson

Institutional Cooperation

A meeting of the secretaries of the professional institutions in the ACT was held shortly after the AGM on 17 March, with Jillian Carson-Jackson, Secretary of the Nautical Institute SE Australian Region, meeting with Glen Seeley, Secretary of RINA ACT Section and John Colquhoun, Chair of RINA ACT Section. Unfortunately Greg Hellesey, Secretary of IMarEST ACT Branch, was a late cancellation. Co-ordination of the three groups has allowed for greater participation and attendance at each other's meetings between the members of the three institutions.

Stability of Landing Craft

Section Deputy Chair, Peter Hayes, made a presentation on his research for his master's degree, *Dynamic Stability of Landing Craft,* on 17 March in the R1 Theatrette, Russell Offices. Peter's presentation was well attended with members from RINA, IMarEST and the Nautical Institute. The presentation highlighted current research on the stability of heavily-loaded landing barges, particularly in large beam seas. Peter's presentation showed the outcomes of his research, incorporating tests in the AMC towing tank using the wave generator.

Technical Meetings

The ACT Section has again been busy and is looking forward to completing a full program of technical meetings and functions for 2009–2010, with a number of technical presentations and functions planned. The annual dinner is set for August/September, to be organised by a sub committee. A number of more informal dinners are also envisaged, hopefully on a quarterly basis.

Glen Seeley

South Australia and Northern Territory

The SA and NT Section is approaching its first birthday at the end of May. We have made a good start in the first year of the Section. We have participated in all Joint Technical Meetings with the SA Branch of IMarEST, co-hosted the Annual Dinner, hosted a visit by the Chief Executive of RINA and continued to promote the naval architecture profession in the State and Territory. This is evidenced by the recent joining of ASC as a Corporate Member of RINA.

On 2 March, John Davis, Combat System Director, AWD Alliance, gave a very interesting presentation to the Joint Technical Meeting of the AWD Combat System, the basis of its design, its key capabilities, and the current status of combat-system equipment selection.

An AGM for the Section is currently scheduled for May. It is planned to combine the AGM with a social event for both members and non-members.

Ruben Spyker

New South Wales

Annual General Meeting

The NSW Section held its eleventh AGM on the evening of 4 March, following the March technical presentation and the Australian Division AGM in the Harricks Auditorium at Engineers Australia, Chatswood, attended by 12 with Graham Taylor in the chair.

Graham, in his second Chair's Report, touched on some of the highlights of 2008, which included ten joint technical meetings with the IMarEST (Sydney Branch), with attendances varying between twenty-three for Phil Helmore's presentation on *Hydrofoils Applied to Canting-keel Yachts*, and thirty-five for both Stuart Friezer's presentation on *Design and Construction of Incat's 112 m Wave-piercing Catamarans* and Adrian Broadbent's presentation on *Classification of the RAN's Amphibious Ship Project*. SMIX Bash 2008 was successful and was attended by 200, including a number of national and international 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 grand total of $70 in the Section account at 28 February 2009. 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 surplus sufficient to enable preliminary arrangements for SMIX Bash 2009.

There is a number of changes to the NSW Committee for 2009. Lina Diaz resigned from the Committee during 2008 due to the pressure of other things. Rozetta Payne and Matthew Stevens have accepted positions on the committee, and Rozetta has accepted the job of Assistant Secretary. As a result, the committee for 2009 is as follows:

Chair and AD Council Member	Graham Taylor
Deputy Chair	Craig Hughes
Treasurer	Adrian Broadbent
Secretary and AD Council Nominee	Craig Boulton
Assistant Secretary	Rozetta Payne
Auditor	Stuart Friezer
TM Program Coordinator	Phil Helmore
Member	Matthew Stevens

Committee Meetings

The NSW Section Committee met on 9 February and, other than routine matters, discussed:

- SMIX Bash: Accounts for 20008 not yet finalised, with sponsors to resolve and final payments to be made; Date for 2009 of Thursday 3 December reserved with Sydney Heritage Fleet.
- Technical Meeting Program 2009: Presentations have been firmed up, with one still to confirm.
- RINA representation on Reference Group for NSCV Part C, Section 1: RINA NSW Section has been approached to field a representative in Sydney for this Reference Group for the NSCV and will do so.

The NSW Section Committee also met on 18 March and, other than routine matters, discussed:

- SMIX Bash: Accounts for 2008 now finalised, and show a small surplus to be shared between IMarEST and RINA. Sydney Heritage Fleet has confirmed booking of *James Craig* for us for Thursday 3 December for SMIX Bash 2009
- National Approach to Maritime Safety Reform: The Australian Division Council has replied to a request for comment on the Regulatory Impact Statement, and there will be a second round of industry consultation in Sydney in April; one committee member has also commented.
- Issues paper on NSCV Accommodation: Two committee members have commented.

The NSW Section Committee also met on 29 April and, other than routine matters, discussed:

- SMIX Bash: Accounts for 2008 finalised, and deposit for 2009 booking of *James Craig* paid to Sydney Heritage Fleet.
- National Approach to Maritime Safety Reform: A stakeholder meeting had been held in Sydney on 17 April, outlining and discussing three main proposals, which three committee members had attended. Comments were invited on the second-draft Regulatory Impact Statement.
- Professional Indemnity Insurance: There is another player in the PI Insurance market in Australia, and a watching brief will be kept.
- EA's Engineering Week: Engineers Australia had approached RINA for suggested locations for site visits for their Engineering Week in April, and we had done so. As a result, we would also investigate a site visit to the new Sydney Slipways for RINA members.

The next meeting of the NSW Section Committee is scheduled for 10 June.

Innovation

Nigel Gee, marine consultant and past President of RINA, gave a presentation on *Experiences of the First Innovator-in-residence at Curtin University of Technology* to a joint meeting with the IMarEST attended by twenty-two on 24 February in the Harricks Auditorium at Engineers Australia, Chatswood. Nigel is well-known to many members, having attended several Pacific conferences in Sydney, and being a past President of RINA. He ran his own consultancy, Nigel Gee and Associates, for many years and designed a number of innovative vessels, including the fastest naval vessel for the US Navy, and was the father of the pentamaran concept. NGA was taken over by BMT to become BMT–NigelGee and he, himself, retired. He has been the Royal Designer to Industry in the UK, and spent last year as the Innovator-in-Residence at Curtin University of Technology in WA.

Introduction

Nigel began his presentation by apologising that the title of his presentation was not as advertised, *Innovation in Marine Technology—Fundamental or Fashion?* That had been the title of his recent presentation in Fremantle, to the inaugural conference on Innovation in High-Speed Marine Vehicles, while he was Innovator-in-Residence. However, he had competed his term of office and submitted the final report, and so this presentation was an update on the previous one.

He is, in fact, retired, but was pleased and honoured to be invited by Curtin University of Technology to look at innovation in ship design, and how industry and government could work with academia to augment this important area. The title, Innovator-in-Residence, however, came as a surprise to him. For the younger staff members at BMT–Nigel Gee it conjured up images of a super-hero coming to the aid of industry, and they had something of a field day, superimposing a picture of Nigel's head onto a picture of Superman! He showed the slide, but hastened to assure the audience that, when he arrived, he did not wear a uniform, or wear his underpants outside his trousers.

Definition of Innovation

Nigel investigated what actually constitutes innovation. One of his favourite sayings that he came across is that "Inventors turn money into ideas; innovators turn ideas into money". However, that isn't very helpful as a definition.

Having considered the issue, innovation is about problem solving. It uses known science. It uses existing technologies. It produces something of value. It either creates or addresses a need. Nigel's own definition then, is that "Innovation is creating or addressing needs by solving problems using known science and existing technology to create a product or a service of value."

Innovative Marine Vessels

Nigel then gave examples of a number of innovative marine vessels.

- Hovercraft were definitely an innovation, and NGA designed a successful version (which Nigel showed). They fulfilled a need (for people to go fast on water), used existing science, produced something of value, and many hundreds have been built.
- Hydrofoils also fulfilled the need for people to go fast on water. They reduced skin friction using available technology, and maybe 500 have been built.
- Surface-effect Ships (or side-wall hovercraft) were a hybrid of catamaran and hovercraft, due to Tattersall as the innovator.

These vessels all solved problems, but were complex. The hovercraft always had problems with skirt maintenance, hydrofoils with hitting things and, with SES, it was difficult to fit the engines into the slender hulls.

- The fast aluminium catamaran was an innovation by Westamaran who, in 1975, produced a simple aluminium catamaran, the Westamaran 140. To do so, they employed lightweight aluminium and high-speed diesels in combination, and produced a vessel which fulfilled a need. To date, more than 1000 fast aluminium passenger catamarans have been built.
- The wave-piercing catamaran was an innovation, the result of a collaboration between Phil Hercus and Robert Clifford.
- Building the wave-piercing catamarans bigger and to carry cars was a true innovation. The first six of the ground-breaking 74 m wave-piercers were immediately put into service crossing the English Channel.
- The Austal trimaran car ferry, *Benchchigua Express*, was a real leap in thinking. A trimaran is one hell of a catamaran! A catamaran is long and slender to obtain low wave making, but there is a penalty paid in skin friction. The trimaran, on the other hand, has a main hull and two smaller hulls, and does not pay the penalty in high skin friction.
- The trimaran has also been applied to miliary use for the US Navy in the shape of the littoral combat ship. Nigel showed a picture of the LCS balanced on the centre hull in a floating dock!

There are risks in innovation, and these can be high. Projects can fail to realise their full potential for a variety of reasons, not all of them being to do with technical excellence. Nigel then gave examples of a number of such vessels.

- The trans-Atlantic pentamaran, designed by NGA. Nigel defended this as a technical innovation, which got as far as the full design stage, with classification society approval, an operator, a shipper with cargo, ports ready, but could not obtain finance as the banks considered it too risky.
- FastShip Atlantic also had a problem with finance.
- WIG (wing-in-ground-effect) passenger vessels. There have been many prototypes, but there appear to be safety and legislative issues, coupled with low demand.
- Amphibious cars. The advertising dream just did not happen.
- The solar-powered torch. Sounds like a great idea, to charge the battery while the sun is up and then use it when the sun goes down. However, when the battery runs down while the sun is down, there is no way out, and demand is low.

Reducing the Risk

One of the ways of reducing the risk is by collaboration. A PhD study of innovation by Helen Cripps in WA has found that, in general, Australians *don't* collaborate. This is for a variety of perceived reasons, including:

- We would lose control of the intellectual property (IP). This is an enormous minefield.
- Funds would be diluted by administration costs.
- Too many people would become involved (and, a possible outcome) our competition would find out what we are doing.
- Who can we trust?

On the other hand, there are definite positives:

- You are no longer working alone.
- There can be checks on the basic science.
- The availability of technology.
- The availability of low-risk finance.

The checks on basic science and availability of technology can be provided by academia. For Nigel, the positives outweigh the negatives.

Industry and Academia

Let us now examine the differing drivers for industry and academia.

For industry, they are project-driven, like defined outcomes, fixed costs, fixed timescales, secrecy, and retaining the IP.

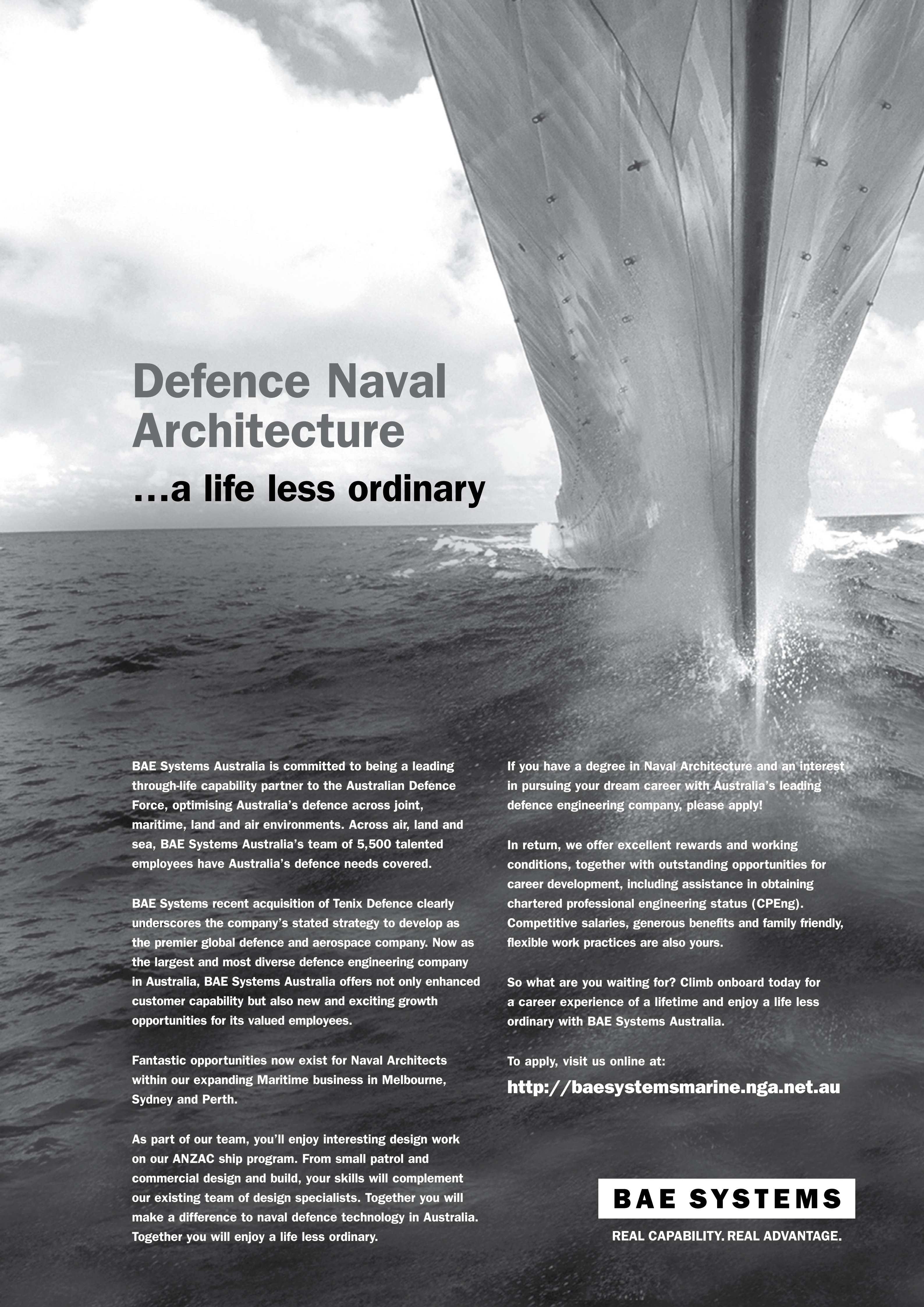
On the other hand, academia likes the freedom to pursue research wherever it leads, an open-ended timescale, peer-group recognition and publication, and retaining the IP.

There is an obvious mismatch here! While they don't match operationally, there is a nice match of complementary skills. We should therefore investigate how we can improve the match between their drivers. Possibilities include:

- The universities are the seller, so the impetus needs to come from their side.
- They need to undertake more marketing of their abilities.
- They need to clarify their IP position. In general, the universities want to commercialise ideas which come out of PhD projects, but industry view that as their competition.
- The universities need to define their unique selling point. This could be the highest level of science and knowledge, or review of ideas for getting the basic science correct.
- The role of undergraduate courses and experimental facilities should be promoted (e.g. the Australian Maritime College has the towing tank, cavitation tunnel, model basin, etc.) Not enough universities in Australia have undergraduate courses and such facilities.

Change

Steve jobs (the founder of Apple computers) said that innovation is the ability to see change as an opportunity rather than as a threat!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Change has to have the following characteristics: Firstly, it has to be affordable (the Westamaran catamaran was, in comparison to the hovercraft and hydrofoils with which it initially competed). It has to be transformational (the Austal trimaran was — it had lower fuel consumption and better seakeeping characteristics than the large catamarans comprising the competition). And, finally, it must be sustainable (the Solar Sailor is a good example, using the sails for propulsion by both the sun and wind).

The influences on change include:

- Population growth means that more sea transport will be required, since there are greater difficulties associated with an increase in transport taking place on land. Road congestion in Europe and the USA double about each decade, and rail faces the same problem, with only 5–6% currently going by rail. Much more can be quickly introduced on short sea ro-ro routes. The same problem will eventually come to Australia.
- Climate change — we will need more efficient ships, and this will provide work for naval architects and marine engineers.
- Fossil fuel shortages will mean that sustainable alternatives will be in demand, e.g. wind-assisted cargo vessels.

Global Financial Crisis

Hopefully, this is a temporary situation! However, some crystal-ball gazing shows the following likely scenarios:

- A slow-down in the small leisure-craft industry.
- A slow-down in orders for mega yachts (> 100 m). Initially, there may be no slow-down at all, as the big boys float along above it all and can still afford their toys. However, if it lasts, it may not be politically acceptable to be seen as building luxury items while others face such belt-tightening times.
- There will be a tightening of defence budgets.
- There will be a fall in the demand for fast ferries, but it will be good for fuel-efficient medium-speed ferries.
- There will be a demand for freight vessels, i.e. a modal shift from land to sea.

Research Needs

In order to effect these changes, research can be directed into the following areas:

- Skin-friction reduction. Catamarans, trimarans and pentamarans have reduced wave making, but there is much work to be done on reducing skin friction by way of compliant coatings, polymer injection and the like. The Office of Naval Research in the USA is investigating the Coanda Effect for possible applications.
- Ship motions and acceleration control. Ride control is big business for the fast ferries, but there is much work to be done on predictive ride control, rather than reactive.
- Resistance and propulsion analysis. It is not uncommon to obtain five differing results from tests of the same vessel by five different towing tanks, each of which uses their own fiddle factors gained from experience.
- Noise and vibration are being paid more attention now, especially in the structural area.
- Underwater noise has an effect on marine life in the offshore industry, and submarines are always concerned about radiated noise, and rely on it for detection of other vessels.
- Environmental factors, such as emissions, wake wash, noise, and fuel consumption.
- New materials (the composites field is advancing rapidly).
- Performing optimisations.

Skill Shortages

If we see a more-hopeful future for naval architects and marine engineers, then we need people to do the work.

In China, 33% of undergraduates study engineering, and similarly in India. However, in Australia, only 8% of undergraduates study engineering, while in the UK, the figure is only 3%. We can see from these figures that, in general, developing countries train engineers, while developed countries don't. This is a self-fulfilling prophecy!

Austal, when they received the order for high-speed catamarans for the US Navy, needed 50 naval architects and marine engineers to do the work. They have found them, but many came from overseas.

The Defence Science and Technology Organisation, if they receive the order for the Collins-class submarine replacements, will need 150 engineers!

Things which we can do include: improving the education of science and maths teachers, and improving their status and rewards; encouraging more students to take science and maths courses in Years 11 and 12; providing more science and engineering places in universities; encouraging basic and applied research; stimulating links between industry and academia; and providing financial assistance to innovators.

Curtin University of Technology has commenced an outreach program to schools. Thy constructed a ship towing tank from a length of 150 mm diameter PVC drain pipe, and the students loved the hands-on experience.

The Role of Government

State and Federal governments are committed to assisting innovators. Small-to-medium enterprises are the ones most in need of help. A "streamlined" grant system, providing finance against agreed milestones, is required.

A possible model for government stimulation of innovation would include the following steps:

- The innovator would provide a concise proposal of 10 pages, describing the innovation.
- This would be reviewed by a government-employed expert, to confirm that the time and costs were realistic.
- The proposal could be modified in the light of the expert's comments and updated, and approval given to proceed to Milestone 1.
- At each milestone, the project would be reviewed.
- The project could be halted at any time.
- Final payment would be made on successful completion.
- The IP passes to the innovator, but the innovator would be required to pay back (over time) the money received.

There is a number of advantages to this proposed system. There is a simple application process, and a short timescale to approval. It gets the universities involved. Public money is safeguarded by the milestone review process. The payback mechanism can be implemented through the taxation system. Administration is cut to the minimum. Most importantly, the innovator gets the funding which he/she needs to proceed.

Aesthetics in Fast Ferry Design

Nigel then showed slides of two vessels which had been designed by NGA. Both were catamaran ferries to carry 350 passengers at a speed of 35 kn, one was for Woods Hole, and one a tourist ferry for Bermuda. It was clear that the Bermudan tourist ferry needed to look nice, and so time was spent on getting the external appearance right, while for Woods Hole, the form followed the function, as too often happens.

Summary

In conclusion, we have defined what we mean by innovation. There are many examples of innovation, especially recently here in Australia. Risk is a major element in the equation, and there are ways in which risk can be minimised, but especially by collaboration. We need to look at how we can get industry and academia to collaborate more closely, and one area is ownership of the IP. There is a strong role which government can play, and this needs to be a simple, straightforward process.

Questions

Question time was lengthy and elicited some further interesting points.

Industry and academia are both interested in retention of the IP. The conditions of IP retention need to be carefully defined for both parties; the company needs to retain the IP if they develop something, while the IP may be retained by the university for original research to solve a problem.

The University of Tasmania has successfully courted Incat to get involved in the industry and the analysis of large high-speed ferries. And, if that can be sold to Incat, it can be sold to anyone!

The computer world, in general, shares information and, as a result, has expanded exponentially. They share and everyone gains. Nigel thinks that, in order for that to be achieved, there must be collaboration. Naval architects are famous for their secrecy. Patent law also needs an overhaul.

It was observed that, while innovations were made in Australia in the field of high-speed passenger catamarans, in looking back at them, we did not promote ourselves. The same thing happened with many of our previous innovations. The first purpose-built container vessel was Australian, as were the first coal-fired vessels, the first application of gas turbines to container vessels, and the first hatchcoverless container vessel.

The vote of thanks was proposed, and the "thank you" bottle of wine presented, by Craig Boulton. The vote was carried with acclamation.

Spencer Gulf Trans-shipment Facility

Jim Phillips of CSL Australia, gave a presentation on *Design and Construction of Project Magnet: the Spencer Gulf Trans-shipment Facility* to a joint meeting with the IMarEST attended by 29 on 4 March in the Harricks Auditorium at Engineers Australia, Chatswood.

Introduction

Jim began his presentation with a photograph of the iron ore loading jetty in Whyalla, and some of his earlier experiences in self-unloading bulk carriers, which started in Canada as Canadian Shipping Lines and then grew into an international operation, eventually expanding into Australia as CSL Australia. The Spencer Gulf operation has been a happy one for both CSL and OneSteel.

OneSteel is an Australian-based mining, ore-processing and steel-manufacturing company specialising in long products for the construction, mining, transport and agricultural industries. The company is a former subsidiary of BHP and was separated therefrom as part of a corporate restructure in October 2000; BHP then merged with Billiton to form BHP Billiton, the world's largest mining company.

The operation is a key link in the export of iron ore for OneSteel from the north and south Middleback Ranges (Iron Knob and Iron Baron are now closed), out through the port of Whyalla on the western side of Spencer Gulf, South Australia. The target markets are China, Japan, Korea and Taiwan. There is a draft restriction of 12.5 m in the port, and so capesize vessels (>150 000 dwt) which carry the bulk of the world's iron ore, cannot use the port. Several options were considered, including using handymax vessels (30–60 000 dwt; considered too expensive because of the number of vessels which would be required); dredging to at least 13.5 m so that Panamax vessels (65 000 dwt) could use the port (there would be significant environmental protection issues associated with dredging in Spencer Gulf); and trans-shipment into capsize vessels (the chosen solution).

Iron ore goes by rail from the ore deposits to Whyalla, where it is loaded onto self-unloading barges (SUB), which are then towed 7 n miles south into Spencer Gulf where the capesize vessels anchor in a designated area. A floating offshore trans-shipment barge (FOTB) is then towed and berthed alongside the anchored vessel, and the SUB berthed alongside the FOTB. The SUB self unloads onto the conveyor system on the FOTB, which loads the ore onto the capesize vessel.

Jim had brought along models of the FOTB and the SUB, and these provided a highlight for conversations during refreshments before the presentation.

Key Aspects of the Project

Key aspects of the project included:

- Design Optimization at CHEC
- Australian regulatory approvals
- Classification approvals
- Hull Construction at Ya Hua shipyard
- Outfit and SUL at Yangze Jiang
- Commissioning and cargo trials
- Delivery to Spencer Gulf
- Trans-shipment for OneSteel

CSL did a lot of modelling for the project, as they bear the operational risk of trans-shipment for ten years, while OneSteel bears the risk of maintenance of supply of ore. Modelling included meteorological studies and placement of wave-rider buoys so that they could determine weather working windows, environmental conditions, plant down-time, etc.

Construction was turned over as a detailed concept to the Chinese company CHEC (now CCCC) in a turn-key project, with liquidated damages for late delivery and bonuses for early delivery. Delivery slipped by about a month overall, but cost was kept to within 5% of the budget.

The Floating Offshore Trans-shipment Barge

Jim showed a general arrangement drawing of the FOTB, and then described the technical aspects. The capsize vessels anchor in a depth of 25 m of water about 7 n miles south of Whyalla in Spencer Gulf, ad the barge is then positioned alongside by a tug.

Two SUBs then shuttle backwards and forwards from Whyalla. The SUBs are large enough to load the cape-size vessel in about three days, and small enough to berth alongside the iron-ore jetty in Whyalla.

Svitzer Australasia are contracted to provide the towage services for the FOTB and the SUBs.

The SUBs unload into a hopper on the starboard aft quarter of the FOTB, and the conveyors on the FOTB then load the ore from there onto the vessel. In the design of the FOTB, they worked from the unloading point of the conveyor onto the vessel back down to the hopper to determine the angles of the conveyors and hence, ultimately, the length of the FOTB and height of cargo hold hopper on the SUBs.

Principal particulars of the FOTB are:

Length OA	96.0 m
Breadth (mld)	27.8 m
Depth (mld)	5.0 m
Draft loaded	2.8 m

Cycle-time Analysis

The cycle time analysis for the operation of a SUB is as follows:

Activity	Time (h)	Comments
Load SUB (at iron ore jetty)	3.33	3000 t/h
Unmooring	0.25	Two tugs
Transit to transfer point	1.56	One tug, 5.45 kn
Mooring (at FOTB)	0.50	Two tugs
Unloading SUB	2.86	3500 t/h
Shifting (during unloading)	0.50	With FOTB and two tugs
Unmooring	0.25	One tug
Transit to iron ore jettty	1.56	One tug, 5.45 kn
Mooring (at iron ore jetty)	0.25	Two tugs
Total	11.06	

The Self-unloading Barges

Jim showed a general arrangement drawing of the SUBs, and then described the technical aspects. The self-unloading barges displace 14 000 t when loaded, and carry up to 12 000 t of ore. This cubic capacity would not work for coal (which is much less dense), but works fine for iron ore. When a capsize vessel is light and the barge is loaded, it is a big ask to transport the ore up an 18° incline on the conveyor. However, the system has been designed around this, and the FOTB and the SUBs were purpose-built for the operation.

Principal particulars of the SUBs are:

Length OA	115.0 m
Breadth (mld)	27.8 m
Depth (mld)	7.5 m
Draft loaded	5.3 m

The SUBs have a 3CR12 lining 3 mm thick in the hopper. This is not as slippery as plastic, but stands up better in practice. The barges were end-launched at the Ya Hua shipyard on the Yangtze River and then went to a lay berth for fitout, which was subcontracted and worked well.

The SUBs are not ballasted, which provides a challenge for the tug masters when unloaded, but all of this has been accounted for in minimising the cycle time.

It takes between 14 and 16 SUB loads to load the capesize vessel, and this can be achieved in just over 3 days. Two tugs are required at each end, but one tug works both ends and tows the barges between, so the operation is done with three tugs. A fourth tug may be used to tow back the stern of the capesize vessel and create a lee for the transhipment vessels when conditions are difficult.

Self-unloading barge *Barngala* fitting out in China, showing the hopper and conveyor for unloading onto the FOTB (Photo courtesy CSL Australia)

FOTB *Sencer Gulf* and SUB *Middleback* alongside bulk carrier (Photo courtesy CSL Australia)

Conveyor system from FOTB onto the bulk carrier (Photo courtesy CSL Australia)

Testing

A big part of the job was figuring out the environmental conditions. This took a lot of work, because they needed confidence that they could keep working, and thus needed to know the weather and wave limits, and the mooring equipment which would be required. They set up a trials program with a model basin in China, and tested wave conditions extensively. Here he showed models under test in the basin in China. Spencer Gulf has short steep seas (due to the shallow water), and the model testing showed that they can continue working up to wave heights of 2 m and wind speeds of up to 25 kn. This has been exceeded in practice.

As the operation was designed, the capsize bulk carrier puts down her port anchor. The FOTB then goes alongside her starboard side. This worked OK in practice, until the tide changed and the current turned, leading to problems. However, these have been solved by using the tug to change the heading of the ship by up to 30^o, which allows them to keep working. The usual limit is with the FOTB in the exposed forwardmost position when loading the No. 1 hold.

The environmental controls on the project were huge, both from the marine side and from the air side. Iron-ore dust is a problem, and the conveyors are all covered in order to minimise the escape of dust. The topsides of the hopper on the SUBs are angled inboard to reduce dust, and there is also a water spray system to keep the dust down.

Key Players

The key players in the design-and-construct operation were:

- Contractor and overall design — CHEC
- Drawings and detail design — Bestway
- Self-unloading equipment — BMH Marine
- Mooring equipment — RR and Scotia
- Diesel generators — Caterpillar
- Building Yard — Ya Hua
- Outfitting Yard — Yangtze Jiang
- Classification — Lloyd's Register
- Flag — Australia (SA)

Schedule

There was a tight delivery schedule, with a planned 16 months from contract to delivery in China, with a further two months for delivery to Spencer Gulf and one month for commissioning at Whyalla.

Design and plan approval commenced on signing of the contract in June 2005, followed by commencement of construction and outfit in October 2005, then testing and trials, and delivery in China in November 2006.

Performance Risk

Performance risk was minimised by paying attention to the following: cargo-lift and unloading-rate guarantees were contracted with CHEC/BMH; the system was designed for OneSteel's cargo characteristics, and for realistic operating conditions which were confirmed by Australian consultants; materials-handling expertise was provided by BMH; there were extensive tests and trials in China; and they have backups in place for all automation technology by way of redundancy in the control systems and in the barges themselves.

Mooring System

For mooring the SUB to the FOTB, they wanted an automated system. There are two mooring posts positioned on the FOTB, and two sets of claws (having Teflon pads to minimise friction against the mooring post) on the SUB. The tugs push the SUB up to the FOTB, and operate the claws by remote control. Variations in draft of the SUB while unloading are catered for by the claws sliding up and down the mooring posts. The FOTB has a 2500 kW power pack, and there is a power umbilical to the SUB.

If the weather is difficult, then breasting lines from the SUB to the FOTB are added, but not otherwise. Loading the No.1 cargo hold is easy on a capesize vessel, difficult on a Panamax vessel, and hard on a handymax vessel.

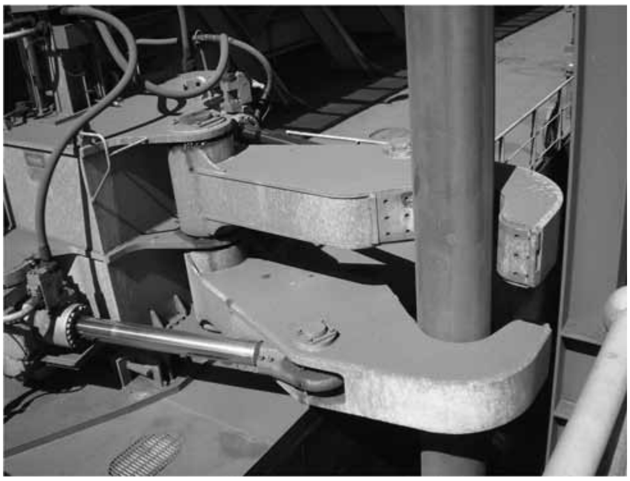
At present they are comfortably loading three capesize vessels per month. They could handle four, but this would require more personnel.

Loading operations onto *Iron Chieftain*
(Photo courtesy CSL Australia)

Automated mooring system showing
the claws on the SUB and the mooring post on the FOTB
(Photo courtesy CSL Australia)

Summary

CSL Australia have provided a system for the trans-shipment of iron ore from the port of Whyalla to the mooring area for capsize bulk carriers which handle the bulk of the shipments. The operation has proved to be successful for both CSL and for OneSteel.



Close-up of the claws on the SUB and the mooring post
on the FOTB
(Photo courtesy CSL Australia)

Questions

Question time was lengthy and elicited some further interesting points.

The ore is mainly (99%) shipped as lump ore and fines, the remainder (1%) in pellet form. They love pellets because they are so easy to handle.

Cleated conveyor belts were considered at the design stage to accommodate a larger conveyor angle but, in the end, they went for standard conveyor belts for reliability.

The FOTB has 40 t winches on board to move along the bulk carrier for sequential loading of holds, but this is done with assistance from one of the tugs when an SUB is alongside and must be shifted at the same time.

They investigated a single fixed mooring and buoy pattern extensively, but eventually settled on using the ship's own anchors for mooring, because no tug assistance would be required. There is no fixed pattern to the mooring; it is influenced by the time of day, the wind, and the state of the tide. The vessel simply weather-vanes around the anchor.

There is a designated mooring area in which the ships must anchor. There is a lot of traffic in Spencer Gulf, much of it heading to and from Port Pirie. The pilot puts the vessel on location.

The transhipments can be irregular and the transhipment vessels lay-up in Whyalla between transhipment operations. While some crew are permanent, others work between the transhipment operation and other CSL vessels as needed.

Bulk carriers converted with transhipment equipment are used in some operations, and provide the advantage of floating storage. In this operation specialised barges built to load at the Whyalla ore-loading facility were required. The unloading conveyor on the SUBs is a line belt with gravity discharge. The holds are hoppered, and the ore flows through gates onto the conveyor. This was designed with the unloading sequence in mind, with only one gate open at a time and the gate lies on the belt. At cleanup time, all gates are open.

For CSL this was a 50 million USD operation; for OneSteel it was a 500 million USD operation! Each is dependent on the other for the overall success.

Obtaining permits took longer in Australia than elsewhere. In China the time factor was the lead time in getting drawings out and, in particular, the time to obtain hardware. In fact, they had to commit to purchase of the slew bearing for the conveyor on the FOTB before committing to almost anything else.

They needed to do a lot of checking and plan approval of their own. For construction in China, a large effort was also needed there.

The vote of thanks was proposed, and the "thank you" bottle of wine presented, by Glenn Seeley of AMSA in Canberra, who had carried out some of the flag survey work. The vote was carried with acclamation.

Composite Yachts

Lachlan Torrance, Head of Composite Structures at Reichel Pugh Yacht Design (RPYD) in San Diego, USA, gave a presentation on *Engineering Design in Composite Yacht Structures* to a joint meeting with the IMarEST attended by 36 on 11 March in Room 101 in the School of Mechanical and Manufacturing Engineering at the University of New South Wales. Lachlan established a new attendance record for a presentation at UNSW, the previous highest having been for Tom Lamb's presentation on *Design for Production* on 26 August 2004.

Introduction

Lachlan began his presentation by saying that yacht construction is now having a lot of professionalism poured into it. The client wants a fast, lightweight boat, and wants it finished in a short timescale, which is very soon after he/she puts their money on the table. This presentation looks at how they take the design through to the building process. It is very fluid, and there are always lots of questions.

Engineering design in composite yacht structures is a progression of ideas tempered against the adaptation of existing methodology, construction techniques and client management, as the process balances time constraints against the design of fast, robust and light structures.

The simplistic management of the engineering process crosses from the client to the designer, to the builder and, ultimately, back to the client and crew. The composite engineering design is significantly more interesting than the endless phone calls and emails involved in the management process.

Where Does it Start and How Long Have We Got?

The client usually has a desire to spend a lot of money, and this is often combined with the crew's desire to spend a lot of the client's money! The client has probably been dreaming about this boat for years, and there are three common dream scenarios:

- a boat to win races;
- a boat to say "my boat is bigger than yours!"; or
- a boat in which to sail off into the sunset.

Now that the client has made the decision to go ahead with the dream boat, s/he wants to try it out tomorrow! However, the fact that it is a rush job for the designer and builder does not mean that either can cut corners. For example, *Wild Oats XI* took 11½ months for design, construction, launching and tuning until she was racing. On the other hand, they completed the naval-architecture design of a 60 m yacht and then handed it on, and it has been in the pipeline for 3½ years.

What Doesn't the Client Know?

It is sometimes difficult to pare away the rubbish which some clients want. They may have come from a production yacht to this, their first custom-designed racing yacht, and don't know what they need to know in order to specify what they really do want.

For serious race boats, the clients and crew are generally aware of the race or races in which they are interested, the prevailing conditions of the races, and have a fair understanding of how they would like the sailing control systems laid out. Clients at this point will usually meet with the design house for discussions of the overall concept, and the engineers are invited to be present, but sworn to silence to prevent client attrition!

The designers flesh out the ideas from there. i.e. how big, and the sailing conditions are used to define the rig size, the keel depth, etc. There is a number of iterations at the start, back and forth between the designer and the client as things are added, and the boat often grows 10–15% in length at this stage. RPYD has a total of six staff, and so they need to keep a lid on what happens, as the number of iterations must be limited.

The rules of classification societies often have a bearing, as do the regulations of the ISAF, e.g. for bunk positions and distances between.

What Doesn't the Designer Know?

It isn't so much that the designers don't know what the engineers need; they just don't want the structure there… or there… or over there! The designers do like to lay out their ideas for the structure, but it is important to involve the engineers early to avoid problems later.

In racing yachts, the premium is not only on the layout of the gear above deck and how the crew move around each other, but also the sail and gear management below. Most racing yachts have large-scale sails and gear, and so need to have an open alleyway through the vessel. The Volvo Ocean 70s are currently breaking booms, and so it is an advantage if they can feed the boom below for repairs.

And it all has to be lighter and stronger than the last one!

What Doesn't the Engineer Know?

Loads come from multiple sources and are frustratingly difficult to obtain and interpret. Quantifying the loads and their directions is like an impossible dream! You can instrument a boat and obtain loads and directions but, as soon as you change anything (e.g. the hull shape), everything else changes in response. They have documented cases of two essentially identical boats which the sailing masters set up differently, and the loads were entirely different.

Material processing in composites alters the strength and modulus of the final product and often this is altered well into the engineering cycle. Similarly, when composite panels from different production yards are tested, different test values are obtained. Combine this with scaled loads, and you get wide variations in performance.

As with all engineering, the starting point is the biggest step in the dark, after which many more assumptions can be added to diverge the mathematical model from reality. The requirement is to try and design out the foreseeable problems.

Who Told the Builder They Could Do That?

Early discussions with the builder are imperative, i.e. as soon as the designer has the preliminary hull shape it must be sent through to the builder so that they know the scale of the job. There is often three times the amount of material (both timber and composite) in the mould as in the hull itself. Complete hull and deck moulds are built for each job, and they must be more robust for production runs.

Discussions during construction are a weekly, if not daily, occurrence if the boat is to be built as per the design or adapted in a suitable manner. It is possible to get half-way through a design (and construction!) and then the owner changes his/her mind. They have had situations where bulkheads have had to be ripped out, and/or the last quarter of the hull thrown away to accommodate hull changes.

The biggest part is laying up, and the builder will tell the designer how he wants to carry out the operation. If the builder cannot build it efficiently, the way he wants, then he is unlikely to take a pride in it and produce the best possible result.

Builders do redesign significant sections of the vessel. RPYD design the hull, deck, beams and keel. The engineers do the laminates, fittings, padeye connections, mast base and collars, rudder quadrants, steering, etc., but some of this can be handed over to the builder. A lot of time can be spent nutting out details, while the builder has done these things many times and may end up doing his own way anyway! Discussions are therefore paramount.

RPYD does work with McConaghy Boats, and they have a lot of faith in this builder and leave the interior layout pretty much entirely in their hands. McConaghy often does a mock-up of the interior to help decide details for the client, and really makes the interior look special.

When all is said and done, the end product is a physical entity and not a computer screen full of numbers and lines.

Why Composites?

Composite materials have many advantages over conventional materials:

- they are stronger and stiffer than conventional materials with lower component weight, primarily due to the ability to tailor material strength to specific load paths;
- the comparative ease with which complex shapes can be manufactured; and
- reduced maintenance due to the material's resistance to environmental degradation.

Structural Layout

Structure is primarily used to facilitate the transfer of load to the hull and deck shells, and to prevent the hull and deck from distorting under such loads. The transverse structure transfers the rig loads to the hull and deck shells and supports the hull locally by reducing panel size. The longitudinal structure reduces the likelihood of panel buckling created by global bending and supports the local hull panels.

The mast on a 15 m yacht may place a 30 t (300 kN) load on the hull, and this can easily be 80–90 t (800–900 kN) on larger vessels. The boat therefore sees a huge deflection from the mast load. These boats are not like large container vessels which experience alternate hogging and sagging, they are always sagging due to the mast load. The designer tries to centralise the weight around the keel and keel structure so that the vessel pitches less. If the weight goes forward or aft, then the boat tends to dive into waves rather than riding over.

The hull and deck laminates are run through the ABS Rules for Ocean Racing Yachts (or the ISO standard which is now coming into play), to give the loads and to draw a line in the sand for panel strength. Results are not good for vessels which are flat in the bow sections, such as the TP52 (trans-Pacific 52 ft — 16 m) boats. The ABS rules define the minimum fibre reinforcing in the laminate , but then step back and leave it pretty much up to the designer; the ISO rule is much more prescriptive.

The TP52s were designed to race from Los Angeles to Hawaii, but there is now a big fleet in the Mediterranean as well. These boats have little in the way of structure or equipment forward of the mast bulkhead. They have a mainsheet and jibsheet bulkhead, but not much other structure. Much of the interiors are defined by the ISAF requirements; e.g. the bunk length is specified as 1950 mm, and so the bulkheads tend to be 2 m apart.

The designer and builder both want a thicker core to minimise the amount of structure inside the vessel, but this is not necessarily the best way to go. In vessels having wide, flat transoms, the centre of the bottom gets punched up and the panels take more load. The big boats regularly hit 40 kn, and a VO70 doing 25 kn recently went past a frigate doing 18 kn in heavy weather! They are now looking at speedboat structures and ply-over laminates like shingles.

When the panel analysis is done for defining the deck-beam structure, the global loads are applied to the hull and deck, and the fibre/laminate in the hull and deck checked, and the stiffness of the hull overall. The mast is stiff, so the more the forestay is tensioned to stiffen the rig, the more the hull has to be stiffened to take the load from the forestay. Consequently, there needs to be a lot of longitudinal structure in the deck to take the longitudinal compressive load from the forestay.

They generally use carbon or glass tapes (flat bundles of carbon or glass fibres) rather than Kevlar. Kevlar is not a good fibre for putting in a laminate stack because it is fluffy, with a lot of loft. It was used a lot for the VO60 and IMS boats, but is not used so much now.

Hull and Deck Layup

The outer skin requirements are determined by the rules and regulations, e.g. ABS, ISO, DNV, etc. Local panel strength takes account of hydrodynamic and hydrostatic loads, together with any other local loads, while global bending considerations determine panel buckling.

Epoxy resins have twice the elongation of vinylesters, and so some builders prefer to use epoxies. Microcracking of fibres puts in a stress concentration and, if the load is cyclic, it will fail! The elastic limit is therefore the microcracking limit.

The maximum steady-state load is what the designer works on, and this is less than the maximum dynamic load, which should only occur once or twice in the boat's lifetime. If it occurs more frequently, then it has to be designed for. Factors of safety are therefore needed to account for the occurrence of these low-frequency loads. For example, a margin of 80% on the backstay and 15% on the forestay are known through trial and error. Gurit has done good work on the instrumentation of loads but, as soon as the hull shape or tuning changes, so do the loads.

Factors of Safety

The validation of material properties and determination of accurate design values for a composite are vital to allow efficient and safe design of a component.

If the microcracking limit is not reached in a structure under load then, usually, there are no problems. The elastic limit of the structure is often taken as the metal-fitting failure load because, if the fitting fails, the supporting structure should remain intact. Similarly, the structure is often designed to the breaking load of the rig. If the mast falls over side, then the boat still floats OK. However, if the mast pulls out of the deck, then the hull is no longer intact.

Keel Structure

Several load cases need to be considered in the design of the keel structure, including the transverse sailing load case, grounding, pounding, slamming, inertia, and combined load cases.

The transverse sailing load case is the standard steady-state load case in calm water at a constant angle of heel. In a seaway, this gives rise to the pitching of the keel, but neither of these load cases is large in comparison to the slamming or grounding load cases. We want the keel structure to prevent the keel falling off and to help keep the vessel upright against the wind heeling moment.

Grounding shouldn't happen, but it does, and gives rise to a longitudinal moment. On a 10 m boat this can give an acceleration of 3*g*, and on a 20 m boat, 4.5*g*. This usually leads to fibre failure, rather than microcracking. The energy which is transmitted into the bulb in the case of grounding is immense. However, if the keel structure is too stiff, then all of the load is transferred into the hull. In this case, the keel tends to kick up at the back, and so internal structure is needed to take care of that. Keels are usually made of steel to make them sufficiently stiff. These vessels can reach 40 kn, but could never survive grounding at that speed. They can survive hitting whales and big fish, but there are usually problems for both at that sort of speed.

The pounding load case is what happens when the boat hits the bottom at low tide.

The slamming load case often occurs in a following sea and places a high load on the flat-of-bottom aft. It can also occur upwind, but in this case the boat is heeled as well, and the bottom is usually not so flat.

The inertia load case is to account for sailors running into things; i.e. the boat stops dead in the water, and the keel wants to keep going.

Canting keels provide a whole new dimension, and depend on discussions with the hydraulics guys and the manufacturers. These must also adhere to the load case requirements. There may also be fore and aft foils. Fortunately, RPYD have had no failures of canting keels, although they are aware of other failures, sometimes due to too little laminate in various areas. Loads can only be distributed via tension or compression, and this needs to be allowed for. The trunnions on the rams need to be built into a bulkhead, and this needs compressive carbon plates in the bulkhead sides to take the load.

There is a lot of fibre in the bottom of the boat to transfer the loads from the keel into the hull sides by way of bulkheads and frames. However, care needs to be taken with shear loads at the intersection of cores.

Finite-element Analysis

Finite-element analysis is of limited use in the fast-moving design industry. By the time the finite-element model has been set up and validated, construction may have already started. If finite-element analysis is going to be attempted, then it needs to be known about right at the start; it cannot be an afterthought.

They have done some of their own FEA, and have contracted some of it out. There is sometimes a problem with the modellers understanding what is actually going on in the structure, and they prefer to have someone in-house doing it so that they understand.

Software

Software in use includes AutoCAD for 2D drawing (which is most of the time), SolidWorks for 3D modelling, Rhino for surfacing, FastShip for hull modelling, and RANS for CFD.

Rudder Stocks

The design of rudder stocks works on very fine margins and is often at the limits of the materials. Where designers dream up foil shapes requiring material strengths in excess of those available, alternative solutions need to be found. This typically results in a geometry change, allowing additional material to be added, or the acceptance that composites are unsuitable and other materials may need to be used. The designer and the engineer need to consult closely here.

Typical rudders for yachts use NACA symmetrical sections, typically with a thickness-to-chord ratio of 10.8 at the base (tip), and 14 (or even 16–17) at the top.

Model Testing

Lachlan showed a slide of a model of one of their designs which had been tank tested at MARIN in The Netherlands. The model was 30 ft (9.14 m) long, and results were compared with CFD predictions for validation. Then other models are run through CFD, and a final model tank tested. It is usually a part of the contract that the models are destroyed when tests are completed!

Questions

Question time elicited some further interesting points.

The relationship between the designers and the engineers is good, and it needs to be. They could not do a good job otherwise.

They have not looked at fatigue life under microcracking in detail. Boats 2–3 years old are *old*, and no longer competitive in racing, due to the fast pace of developments. They *have* looked at the fatigue of steel in the keel structure.

The ABS 1994 rules for the structure of ocean racing yachts are under review, but with no fixed date for release in sight. The ISO rules will be applied to the TP52 boats by 2010. This will definitely add weight, as the rules are for recreational vessels, and are more prescriptive than the ABS rules.

RPYD was not involved in the development of the ISO rules, but Gurit was.

The vote of thanks was proposed, and the "thank you" bottle of wine presented, by Rozetta Payne of Gurit Australasia. The vote was carried with acclamation.

Classification of Naval Submarines

George Spiliotis, Senior Principal Surveyor and Area Manager Australia and New Zealand for Germanischer Lloyd, gave a presentation on *Classification of Naval Submarines* to a joint meeting with the IMarEST attended by 21 on 1 April in the Harricks Auditorium at Engineers Australia, Chatswood.

Introduction

George began by saying that this presentation was an update of one made originally by Lars Grünitz, who was currently in Singapore and unable to be present.

George began his career studying marine engineering and naval architecture at the Technical University of Hannover in Germany, ending up with his master's degree. He then signed on as third engineer on a crude oil tanker before coming ashore to take up a position with Howaldtswerke Deutsche Werft in Kiel, Germany, supervising the construction of submarines for the Hellenic navy. In 1980 he moved on and took up a position at the Hellenic shipyard in Skaramanga in the new construction department, and then, in 1983, moved on to take up a position as a surveyor with Germanischer Lloyd, and has remained with the company since.

Germanischer Lloyd

Germanischer Lloyd was formed on 16 March 1867 and is now an international classification society based in Hamburg, Germany. The company is a member of the International Association of Classification Societies, and was a founding member of the Naval Ship Classification Association (the military counterpart of IACS). GL is represented worldwide in 78 countries with 208 offices and 5500 employees. They have 35 years of experience in all types of combatant and non-combatant naval vessels, with 325 surface and sub-surface projects and 25 navies around the world.

Classification

Classification societies set the technical rules, confirm that the design and calculations meet the rules, survey ships and systems during construction, and periodically survey vessels to confirm that they continue to meet the rules. Rules published by GL include ship technology, materials, welding, naval ship technology, industrial services, etc.

The classification process involves three phases and sets of services:

- Design and pre-construction services: Engineering and advisory services, examination of construction documents, and hull and marine engineering in accordance with agreed rules (specification or class rules).
- Construction services: Assessment of production facilities to ISO9000ff, AQAO, welders, etc., testing of materials and equipment FAT, HAT and SAT, and supervision of construction to agreed rules.
- In-service services: Certificates and reports, periodical surveys, and maintenance of class.

The classification process begins with the Rules Coordination Department which proposes a set of rules. The rules are written by a specialist team, and then pass through a Technical Committee or a Technical Committee for Naval Ships, and are eventually modified by in-service experience feeding back through the Rules Coordination Department. In practice, engineering drawings for new construction are assessed for compliance with the rules, and surveys are carried out during construction and in service.

How Does This Apply to Submarines?

In general there are two main types of submarines, civilian and naval. The aim of civilian submarines is to make a profit, while the aim of naval submarines is to fight and win.

Typical notations for submarines would be ✠100 A 5 Sub for civilian (e.g. a tourist submarine), or ✠100 N 6 Sub for a naval submarine. The numeral indicates the period between main surveys, which is five years for commercial vessels (bound by IACS requirements), and six for naval vessels (not bound by IACS).

New GL rules for naval submarines were released in 2008, including major updates, with the following sections:

Part 0	Classification and Survey	
Part 1	Surface Ships	
Part 2	Sub-surface Ships	
	Chapter 1	Submarines
	Chapter 2	Remotely-operated Vehicles
	Chapter 3	Air-independent Power Systems for Underwater Use

The application to submarines includes the following:

- Approval of drawings.
- Surveys during construction (technical inspections, pressure tests, and acceptance tests including all functional tests).
- Admission to class register (e.g. ✠100 N 6 Sub for hull, or ✠MC U for unmanned machinery).
- Continuous X-rays in service.

Surveys

There are four different types of surveys conducted as part of the classification process: initial, annual, intermediate and class-renewal surveys.

At the initial survey, the vessel and systems are checked against the approved drawings.

At the annual survey, checks are made of all documentation, the important components, safety-related systems, and final tests.

The intermediate survey includes all annual-survey items, plus a tightness test on the pressure hull, testing of the ballast, trim and compression system, and a purity check on all breathing apparatus.

The class-renewal survey includes all intermediate-survey items, plus a complete external and internal survey, and dimensional check.

Checks at the surveys include structural strength, watertight integrity, stability, manoeuvring control, control of propulsion equipment, fire and flooding alarms, breathable atmosphere, and escape-and-rescue provisions.

Here George showed a diagram indicating the sequencing of surveys, together with allowable time windows for completion, which are usually ±3 months from the due date, except for the class-renewal survey, for which the window is only –3 months.

Special Surveys

There is a number of special types of survey which can be undertaken.

One such is the damage survey, which is conducted if a submarine or any part (e.g. an auxiliary system) suffers damage which affects class. The extent of the survey depends on the extent of the damage.

Surveys for naval submarines require experienced personnel with appropriate security clearances, medical certificates, and submarine rescue training. Core experts are based in GL's head office and travel as required.

Submarines for South Africa

Three submarines were built for the South African Navy and classed by GL. The vessels were constructed by the German Submarine Consortium, consisting of Howaldtswerke Deutsche Werft in Kiel, Nordseewerke in Emden, and MAN Ferrostaal in Essen. The vessels are of the conventional Type 209 Mod 1400 class submarines (SSK) and replaced South Africa's decommissioned French-built Daphné-class submarines.

The three submarines comprise the Heroine class, each of which is named after famous African heroines: SAS *Manthatisi* (S101) which arrived in Simonstown in April 2006, SAS *Charlotte Maxeke* (S102) which was commissioned in March 2007 and arrived in Simonstown in April 2007, and SAS *Queen Modjadji 1* (S103) which was commissioned in May 2008.

The South African Navy commissioned GL to class the new submarines, thereby becoming the first classification society in the world to class naval submarines. There were 500 main drawings approved for the hull, machinery, electrical, automations systems, piping and stability data. This was undertaken over a two-and-a-half month period, with a team of 35 engineers at GL checking all safety-related systems on the drawings. One task during the plan-approval stage was to develop the project specification.

The final checks for the initial survey of S101 was done over a period of four weeks, with GL actually on site for three weeks. The vessel was dry docked for the first two weeks, followed by one week alongside, and one week at sea.

The South African submarines have received a certificate of class only at this stage; statutory requirements are not included.

Why Class Submarines?

There is a number of reasons for the trend to class submarines in the current environment, including: the retirement of experts and specialists, shrinking defence budgets, training requirements, the advice needed for maintenance and repair, technology is becoming more complex and likewise, certification is becoming more complex; e.g. the Astute class, the UK's new nuclear submarines, require compliance with the MARPOL regulations. The design is approved against agreed rules, and safety standards are implemented. Third-party supervision and certification of the quality of construction is provided by an impartial body, who can also provide assistance during overhaul and maintenance as well as continuous training for navy and shipyard personnel.

Other services which can be provided for submarines include certification of components and systems with respect to safety, according to GL rules or to national or international standards and regulations.

Certification

Certification may involve any or all of the following:

- Checks on individual systems or components, including approval of drawings, manufacturer's shop approval, etc.
- Periodical survey of these systems or components to maintain certification, e.g. for air-independent propulsion with fuel cells of the HDW type, or deep-submergence rescue vehicles.
- Surveys of safety-critical components and equipment. GL will, on request, examine drawings, carry out all necessary surveys and tests, and issue relevant certificates.
- Special tests, such as for certification for fire fighting in enclosed spaces.
- Providing assurance of the quality of submarine repair and overhaul projects (for vessels not in class), e.g. repairs to the pressure hull, or overhaul of systems such as control and steering.
- Certification of workshops and the overhaul process.

Conclusion

Germanischer Lloyd is the first classification society in the world to provide rules for and to class naval submarines. Classification of naval submarines enables navies to build submarines, confident in the knowledge that they meet current best-practice standards and that the finished product is of high quality.

Questions

Question time was lengthy and elicited some further interesting points.

George referred previously to dimensional checks required at the class-renewal survey. Submarines face high pressures and, in order to provide information on incipient problems, dimensions are established at the initial surveys to establish a baseline. Periodic checks are subsequently made to see if there are differences from the baseline, including symmetry of the pressure hull, length, hog/sag, etc., which could indicate cracks.

There has been a number of submarine collisions recently, and the causes need to be carefully established. Survey covers the electrical and electronic systems, to ensure redundancy, as well as the masts to check for damage and correct operation. There are, in fact, three levels of assurance, including safety of personnel, and fitness for purpose (which is worked out with the particular navy). There are specific electrical requirements for submarines.

At the class-renewal survey, ultrasonic measurements of hull thickness are taken, as well as X-rays in specific areas. Approved companies may do ultrasonic thickness testing for GL, but GL also carry out their own random checks.

In addition to the GL Technical Committee and the Technical

Committee for Naval Submarines, GL have several specialist committees for hull, mechanical, electrical, etc. submarine systems, comprising more than 30 people.

Innovative design is possible, as designers can use any methodology they like. The classification society then comes along and applies their own standards to check that the design is safe for operation.

In general, the rules concentrate on conventionally-powered submarines, but GL can help with nuclear powered vessels. The UK's new nuclear-powered Astute class has used part of GL's rules, although the rules are not nuclear related.

Resistance of Fast Craft

Simon Robards of the NSW Maritime Authority gave a presentation on *Resistance Prediction for High-speed Transom-stern Craft* to a joint meeting with the IMarEST attended by 20 on 6 May in the Harricks Auditorium at Engineers Australia, Chatswood. Simon has recently graduated with a Master of Engineering degree for his research on the resistance of high-speed transom-stern craft.

Introduction

Simon began his presentation by saying that the aim of the research was to *improve* the resistance prediction of transom-stern craft, and not to argue the merits of transom sterns or to optimise them in any way. There are four main methods of predicting the resistance of such craft: experimental determination, estimation from regression analysis of results for similar vessels, computationally from fully non-linear fluid dynamics programs, and linear theory. There are drawbacks with each method.

The experimental method is costly, especially if there is any optimisation involved. Using results from similar vessels is limited to vessels of the same type. Fully non-linear computer codes have come a long way in both speed and accuracy but are still very time-intensive, and hull optimisation requiring continual refinement is not possible. The linear theory had its origins in the ground-breaking work of Michell (1898). However, the accuracy of prediction is affected by the fact that non-linear and viscous wave effects are not taken into account. The approach taken here was to try and improve the prediction from linear theory in a two-pronged approach.

Firstly, form factors were developed for an extensive database of existing experimental data for transom-stern vessels. Using the Hydros suite of programs developed by Lawry Doctors, form factors for the wave and frictional resistance were formulated by performing a regression analysis of the existing data. These form factors greatly improved the accuracy of prediction.

Secondly, research was directed at accurately predicting the dimensions of the hollow created in the water behind a transom stern as speed is changed. This hollow is part of the wave system created and so, the more accurately this shape can be predicted, the more accurate will be the prediction of wave resistance. An extensive experimental program was undertaken to experimentally determine the effect of speed and vessel dimensions on the length and depth of the transom hollow.

Form-factor Research

This part of the research was based on the approach taken by Doctors and Day (1997), who applied regression analysis to obtain the wave-resistance form factor f_W for the University of Southampton catamaran hull in the form $f_W = \Sigma a_{Wi} p_i$ where p_i are the hull parameters, such as L/B, B/T, C_P, etc. They showed that the resulting form factor f_W significantly improved the prediction.

This work was subsequently extended by Doctors (1998) who proposed that the frictional resistance form factor f_F could also be approximated in the same form, $f_F = \Sigma a_{Fi} p_i$. Doctors applied the method separately to three different model series, and the results were shown to be most favourable in increasing the accuracy of correlation between theory and experiment.

The limitation on the form factors calculated in these previous researches is that they only apply (with any deal of confidence), to the model series from which they were derived. The aim of the research here was to apply the method to a wide range of collected model data. The rationale was that the resulting form factors would have a much broader applicability in the accurate determination of a vessel's resistance when using the traditional Michell theory.

A large database of ship model data was collected, which entailed the digitising of published model plans and collation of the corresponding published resistance data. Data was collected for a range of vessels including both monohulls and catamarans. The final database from which the form factors were calculated included vessels from 13 different published model series, all of round-bilge hullform:

UNSW–AMC Lego series
University of Southampton catamaran series
National Physical Laboratory series
D-series
SKLAD series
Uniiversity of Southampton catamaran series with modified C_P
de Groot model series
Series 63 models
Series 64 models
SSPA model series
AMECRC model series
Nova model series
Compton model series

In all there were 218 hulls, representing 333 test cases (some models were tested at multiple drafts), and all test cases were tested at various speeds giving a total of 5634 data points. Here Simon showed the body plans of some of the models in the various series.

Originally, Doctors and Day used a select few geometric parameters in the formation of the form factors for the University of Southampton catamaran model series. However in the optimisation of the form factors for the entire database of models here, different combinations of parameters were used, with the final form factors based on the following 15 geometric parameters:

B/L, B/T, C_B^2Fn, $C_B(B/L)(L/s)$, C_{VP}, C_M, $S/\nabla^{2/3}$, $(S/\nabla^{2/3})^2$, $(B/L)^2$, C_P^2, $[C_B(B/L)(L/s]^2$, $(L/\nabla^{1/3})^2$, C_{VP}^2 and $C_M\,Fn$.

Coefficients were given for the a_{Wi} and a_{Fi} over all series, resulting in overall form factors of $f_W = 0.711$ and $f_F = 1.360$. Including these form factors in the total resistance formulation for the entire model database resulted in far greater correlation with the published experimental data, and represented a reduction in the overall root-mean-square error for specific resistance of 36%

The a_{Wi} and a_{Fi} coefficients were also determined separately for each series, resulting in separate equations and form factors f_W and f_F for each series. The form factors do vary widely, e.g. from 0.316 (SKLAD) to 2.945 (Compton) for f_W and from –0.129 (Series 63) to 1.832 (SKLAD) for f_F. So, if you know that your hullform is similar to one of the series, then use the form factors for that particular series or, even better, the equations for that series to find the f_W and f_F based on your hull parameters.

Transom-hollow Research

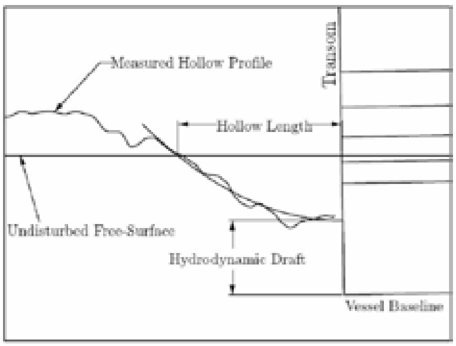
The second area of investigation in this research was improving the resistance prediction in the lower speed range. A graph published by Doctors and Day clearly showed that the accuracy of the theoretical prediction suffers in comparison to the experimental results below a Froude number of 0.5. The total resistance may be expressed as

$$R_T = f_W R_W + R_H + f_F R_F + R_A + R_{AA}$$

where R_W is the wavemaking ressitance, R_H is the hydrostatic resistance due to the fact that the transom is assumed to be running dry (with water cleanly separated), R_F is the frictional resistance, R_A is the correlation resistance, and R_{AA} is the air resistance.

It is a common approach in the discretisation of the hull to consider the hollow as a geometrically-smooth addition to the vessel. So, if we look at the total resistance formulation, the inaccuracy in prediction at low speeds becomes a two-fold problem.

R_W is calculated for the vessel and the hollow, so inaccurate prediction of the hollow length will produce inaccuracies in the wave-resistance prediction. Also, R_H results from the fact that the transom is considered to run dry at high speeds. However, at low speeds the hollow fills in and the transom becomes wet, so the hydrostatic term should also vary as the speed changes.



Transom hollow shape
(Diagram courtesy Simon Robards)

A program of both experimental and computational work was undertaken to measure the effect of transom dimensions, such as beam and draft, and the effect of vessel speed on the depth and length of the hollow.

Experiments

A series of five wall-sided flat-bottomed models with shaped bows was constructed. Each model was tested at the same five drafts, creating a range of B/T ratios. The ratio of dimensions between models was $2^{1/4}$, resulting in the fifth model being exactly double the dimensions of the first. For each of the 25 conditions, the models were tested at 25 speeds.

Model Dimensions

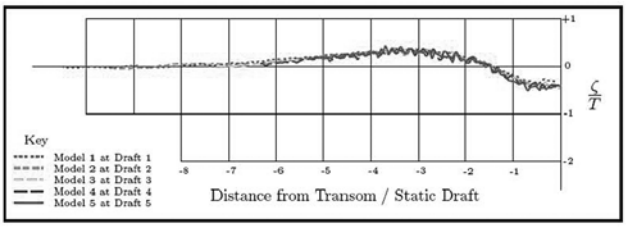
Model	L (mm)	B (mm)
1	800	100
2	951	119
3	113	141
4	1345	168
5	1600	200

Each model was tested at drafts of 50 mm, 59.5 mm, 70.7 mm, 84.1 mm and 100 mm. Because of the ratio of dimensions of $2^{1/4}$, the first model at the first draft was an exact geosim of the second model at the second draft, and so on.

All testing was done in the towing tank in the Ship Hydrodynamics Laboratory at the Australian Maritime College in Launceston. The models were set up with a wave probe on the centreline, commencing 600 mm behind the vessel. During a run, the wave probe was moved towards the hull using a pulley system and a position transducer to measure location, and the wave probe measured the elevation of the water surface, the combination of location and wave elevation giving the profile of the hollow formed.

Analysis

Plots of the wave elevation against the draft Froude number (based on static draft) showed a typical hollow and rooster-tail profile, with the biggest influences on the shape of the hollow being speed and *B/T* ratio. When the wave elevation/static draft ratio was plotted against position for each of the geosim models at one Froude number, the curves collapsed on top of each other, giving confidence in the overall method.



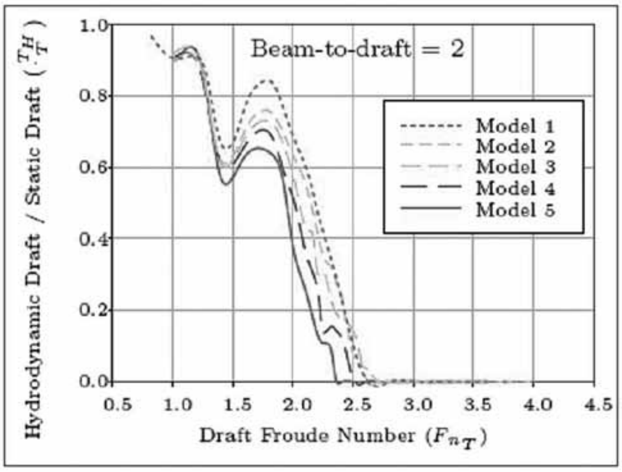
Wave elevation for all models at a Froude number of 1.4
(Diagram courtesy Simon Robards)

Plots of the hydrodynamic draft/static draft against draft Froude number for each model at each draft showed an interesting hump in the data, which follows a clear trend in that the hump occurs at a greater speed for the larger models (i.e. an increase in B/T ratio). When the hydrodynamic draft/static draft was plotted against draft Froude number for each model at the same *B/T* ratio, the hump occurred at the same draft Froude number for all models.

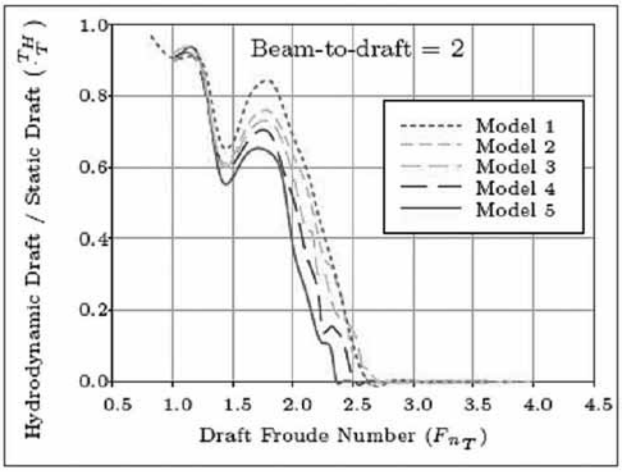
Regression analysis of the length of hollow and hydrodynamic draft yielded polynomial equations for these parameters in terms of the draft Froude number and the *B/T* ratio, each equation having 21 terms. When these equations were applied to the linear theory, a significant improvement in prediction resulted in the comparison with experimental results at the low speeds.

Wave Probe

However, there were some anomalies. At speeds above those required for full separation, when the measured profile was plotted against the trimmed vessel profile, the forward-most



Hydrodynamic draft/Static draft for all models at *B/T* = 2
(Diagram courtesy Simon Robards)



Hydrodynamic draft prediction by tanh and damped sine functions
(Diagram courtesy Simon Robards)

point of the measured profile was clearly lower than the lowest point of the transom!

After many hours checking calculations, on a hunch the wave probe was run down the tank without a model in front of it to check if it was recording a zero water elevation for the undisturbed water at all speeds. At the higher speeds it was found that the flow separated from the probe wires, resulting in a negative water elevation and explaining the anomaly.

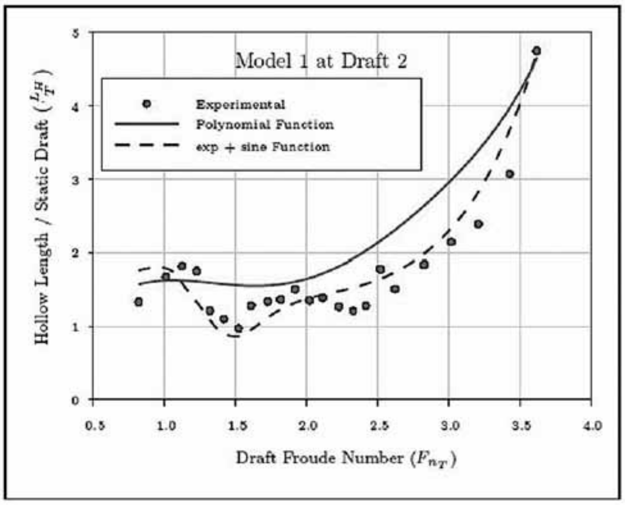
A further series of runs was made with the probe in isolation. It was found that the results exhibited a strange bi-furcation in the data above a probe Froude number of around 20. This could have been due to minor disturbance on the water surface or vibration in the probe wires causing deeper separation than on other runs. To check this, a piece of plastic was placed forward of the probe and just piecing the water surface sufficiently to disturb the water surface without making significant waves. This removed the bifurcation of the results and gave consistent deeper flow separation.

Results

The original data points were therefore corrected and the corrected wave profiles re-plotted. The values for hollow length and hydrodynamic draft also had to be determined again, so the opportunity was taken to revisit the algorithms developed for their prediction. The original polynomial for hydrodynamic draft had been developed using only the data up to the point of full separation and, for speeds greater than the point of full separation, the prediction rapidly diverged. A new form of the equations was therefore sought which would be more robust and dependable.

For the hydrodynamic draft, a hyperbolic tangent function was fitted as the main function, and the difference between this and the experimental points left the shape of the hump, which was then fitted with a damped sinusoid having polynomial coefficients based on the beam-to-draft ratio which was earlier shown to drive the speed at which this hump occurs. The result was a far greater correlation with the experimental results, especially in the prediction of the hump in the data, and that extrapolation to higher Froude numbers will tend towards zero as expected.

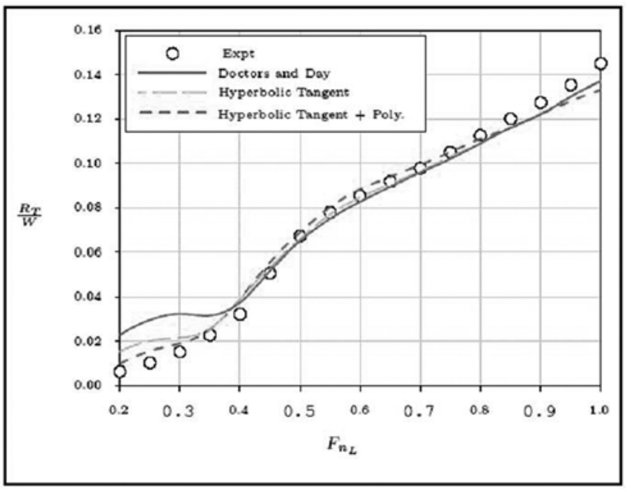
For the hollow length, an exponential function was fitted as the main function, and the difference fitted with a damped sinusoid, as for the hydrodynamic draft. The result was a far greater correlation with the experimental results, especially



Hollow length prediction by exponential and
damped sine functions
(Diagram courtesy Simon Robards)

in the prediction of the hump in the data.

The result of including these formulas in the Hydros suite of programs to predict the shape of the transom hollow greatly improved the resistance prediction in the lower Froude number range as expected, with the hyperbolic tangent function for the hydrodynamic depth providing the greatest improvement. The reduction in RMS error for the results was 42%.



Comparison of final functions with experimental results
(Diagram courtesy Simon Robards)

Conclusion

Regression analysis of existing published data was conducted to produce form factors for frictional and wave resistance. Use of these form-factors in the total resistance formulation produced a 36% reduction in RMS error between theory and experiment when applied to the entire model database.

An experimental programme was conducted on a systematic series of transom-stern models to measure the influence of speed, beam and draft on the shape of the transom hollow. Results were used to produce algorithms for the prediction of this hollow shape, and this has led to more accurate prediction of total resistance, especially at low Froude numbers.

For those interested, the thesis is available for download from UNSWorks at http://unsworks.unsw.edu.au/vital/access/manager/Repository/unsworks:3426.

Questions

Question time elicited some further interesting points.

While trim does affect the angle at the start of the hollow, trim did not appear to affect the results significantly. This was the reason that hydrodynamic draft was measured. However, static draft appeared to have a greater effect on hydrodynamic draft than trim.

The reason that a flat-bottomed, wall-sided vessel series was chosen for the experiments was to limit the investigation to the influences of beam, draft and speed.

It was noted that the form factors varied significantly between series. The best starting point is therefore to calculate the applicable form factors for your vessel using the overall form factor equations with the specific geometric parameters for your vessel. Should your design closely reflect the geometric parameters of one of the individual series, then the greatest benefit will be realised by utilisation of the calculated form factors for that series or indeed use of the form-factor equations for that series with the specific parameters for your vessel.

The vote of thanks was proposed, and the "thank you" bottle of wine presented, by Phil Helmore of the University of New South Wales.

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Doctors, L. J. and Day, A. H. (1997), Resistance Prediction for Transom-stern Vessels, *Proc. Fourth International Conference on Fast Sea Transportation*, UNSW, Sydney, July.

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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 remaining for 2009 (with exceptions noted) is as follows:

3 Jun	Rex O'Connor, Wärtsilä Australia *Boosting Energy Efficiency*
1 Jul	Forum/Panel Discussion *Harbour Ferries*
5 Aug	Leo de Yong (DSTO) and John Jeremy (RINA) *A Forensic Analysis of the wrecks of HMAS* Sydney *and HSK* Kormoran
2 Sep	TBA *The 2008–09 Volvo Ocean Race*
7 Oct	Rodney Humphrey, Det Norske Veritas *Investigaton of the Hull Girder Collapse of Containership MSC* Napoli
3 Dec	SMIX Bash 2009

Basic Dry Dock Course

Following on from the success of the course held in Melbourne in 2008, the Royal Institution of Naval Architects is pleased to announce that this course will again be held in Brisbane at Forgacs Cairnscross Dockyard on 7–10 September 2009.

This unique four-day course covers the fundamentals and calculations of dry docking. The course begins with the basics and safety concerns, and progresses through all phases of dry docking: preparation, docking, lay period, undocking, and ends with a discussion of accidents and incidents.

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 is designed to be relevant to dockmasters, docking officers, engineers, naval architects, port engineers and others involved in the dry docking of ships and vessels.

The course leader is Joe Stiglich, a retired naval officer and qualified NAVSEA Docking Officer who holds a masters degree from MIT in Naval Architecture and Marine Engineering. He has been responsible for over 250 safe docking and undocking operations, and currently runs a series of conference and training courses for personnel involved in all phase of the drydocking industry, and acts as a consultant for ship repair companies.

To register your interest in the course visit www.rina.org.uk/drydockaustralia2009.

The course program (including topics) and registration form may be downloaded from www.rina.org.uk/c2/uploads/basic dry dock _ australia 2009.pdf.


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CONGRESS

CLASSIFICATION SOCIETY NEWS

LR Asia Opens First Dedicated Training Facility for Marine Surveyors

Lloyd's Register Asia opened its first dedicated marine-surveyor training centre in Shanghai, PRC, on 25 March, ensuring that the LR Group's global marine team will continue to deliver the high technical standards demanded by the modern maritime industry.

The Maritime Surveyor Training Institute (MSTI) represents more than an US$8 million (£5.6 million) investment for the organisation in the first five years of operations, during which time 200 newly-trained surveyors are expected to graduate from the program.

"Quality staff training provides the most significant contribution to the continued development of our core product — the provision of independent technical assurance to the maritime industry," said Roy Ellams, Lloyd's Register Asia's Marine Training Manager for North Asia. "It ensures that we will always have the right skills to support the provision of maritime transport services which are safe for both mariners and the environment."

Ellams says the MSTI represents a new approach to the development of technical competency for the industry, offered at a time when commercial pressures are driving the need for innovation. With the recession shrinking access to new capital for companies in the maritime industry, he says new solutions are required for old problems.

"Innovation doesn't just happen, it has to be stimulated and encouraged," Ellams says. "The development of technical competencies is a key ingredient in that mix. It at once fulfils our responsibility to our staff, our clients and the greater public."

A key element in that new approach is the appointment of experienced "surveyor mentors" who will guide the trainees through the one-year program. Each program will feature 20 trainees, and two programs will be held each year.

The MSTI's integrated program consists of seven phases, including:

- a general introduction to Lloyd's Register's vision and values, the role of the surveyor, and occupational health and safety;
- materials and non-destructive testing, focussing on the application of materials rules;
- induction into survey: an overview of convention and rule requirements, the classification process from plan approval to ships in operation;
- introduction to classification: a closely mentored, on-the-job familiarisation with the application of the classification process;
- classroom training in new construction, periodical and statutory surveys (strong emphasis is placed on accessing information for the survey process);
- focussed field training led by dedicated mentors (this targets delegate specialisation); and
- classroom training: consolidating learning from focussed field training (emphasis on project-management and managing client relationships).

China was chosen as the location for the Group's first dedicated training centre due to that market's continual demand for knowledge development, says Ellams. "This program will put into the field skilled technicians who are able to deliver the most up-to-date and reliable classification services to reduce the industry's risks," he says. "It also will help to ensure that our staff continue to offer sound advice on the latest technical or regulatory issues that our clients may face."

Tom Boardley LR Marine Director

Tom Boardley, as Marine Director, recently assumed responsibility for Lloyd's Register's global marine activities, succeeding Alan Gavin in the position.

Tom has worked in the shipping industry since graduation from university in 1978 when he joined P&O. Working in liner management and agency operations, he represented P&O in the UK, Taiwan, Korea, Japan and Australia. In 2004 he became head of NYK Line's European container activities based in London. Most recently he was responsible for CMA CGM's UK-based operations, involving liner, agency and technical management responsibilities.

Commenting briefly on his new responsibilities, Tom said "I am very excited by the challenge of managing an organisation that sits at the heart of marine safety, marine technology and shipping operations. As a technical organisation, I believe that Lloyd's Register will continue to play a key role in working with ship operators, shipbuilders and regulators to support continued progress in the global shipping business. We have more than 2 800 marine surveyors, naval architects, engineers and supporting personnel in our network around the world — I am looking forward to helping all of them to realise our potential to support safety at sea."

Welding Workshop for Navy Ships Approved by GL

Thales Australia's welding workshop for navy ships achieved certification in accordance with GL Classification Rules and ISO standards on 19 March 2009. George Spiliotis, Germanischer Lloyd's Area Manager Australia and New Zealand, presented the certificate to Mr Robert Brownlie, Thales Quality Assurance Manager, Marine Services, in Sydney. Thales Australia is part of the Thales group and one of Australia's largest defence partners and shipbuilders in the Asia–Pacific region, operating a major shipyard in Sydney.

The certificate testifies that Thales Australia employs appropriately-qualified welders using welding procedures in accordance with GL Rules and ISO standards. This is a prerequisite for conducting work on hull structures and machinery components of the Anzac frigates and other GL-classed ships. The audit was conducted by technical experts from Germanischer Lloyd in Sydney during September 2008. The welding workshop certificate is valid until February 2012.

"Germanischer Lloyd provides the eight Anzac frigates of the Royal Australian Navy with the full range of classification services, including welders' qualification and welding procedures approvals. For that reason, highly-qualified and professional welders are indispensable", said Spiliotis.

There will be Twelve

The 2009 Defence White Paper has answered the question at last — how many submarines will replace the Collins class? The answer is twelve. In recognition of the importance of Australia's maritime approaches and trade routes to the security and prosperity of the nation, the Government has decided to make a substantial investment to double the Navy's current submarine fleet.

"This investment will provide Australia with a much greater ability to adequately defend our maritime region, protect and support other Australian Defence Force assets, and undertake strategic missions where the stealth and other operating characteristics of highly-capable advanced submarines is crucial," the Minister for Defence, Mr Joel Fitzgibbon said.

"We will carefully apply the lessons learned from the Collins class by appropriately engaging overseas Governments and both Australian and overseas industries in order to significantly reduce the risks," Mr Fitzgibbon said.

"This project will show the world what Australia can do if we set our minds to a task. The technological and industry spin offs from a project such as this will reach across the entire nation."

The distances involved in Australia's maritime geography mean that, to defend Australia and our interests, we must produce a conventional submarine with significantly higher levels of endurance and capability than exists anywhere else in the world. So, while we may use sub-systems from other successful submarine designs, the overall design will be unique.

"We also need to increase the number of submarines to sustain a force at sea large enough to defend our approaches in a crisis or conflict, to protect and support other ADF assets, and undertake certain strategic missions," Mr Fitzgibbon said.

Additionally, the Government has announced it will ensure that the capability offered by the Collins class remains high with further investment to the current fleet including replacement sonars and improved communications. Additional funding will also be invested in sustainment of the submarines in order to increase their operational availability.

Providing trained personnel to crew this increased submarine force requires a new approach. Navy has adopted a number of innovative initiatives under the New Generation Navy Strategy to ensure that the current shortfalls are addressed, and that a robust submarine workforce is built to meet this important challenge. These initiatives, combined with a range of recruitment and retention strategies also in train,

New Surface Ships for RAN

The 2009 Defence White Paper sets out a new capability direction with a significant focus on enhancing Australia's maritime capabilities for the 21st century.

In announcing the details of the Government's plans, the Hon. Joel Fitzgibbon MP, Minister for Defence, said:

"The Government will significantly enhance Australia's naval capability, with plans to acquire a more-capable fleet of eight larger and more versatile new warships to replace the current Anzac-class frigates.

"This enhanced naval capability will greatly boost Australia's ability to protect our maritime region and vital trade routes and, ultimately, provide the Navy with greater flexibility to deter potential maritime threats to our national sovereignty," Mr Fitzgibbon said

"The planned purchase of these new frigates is a key component of Australia's new force structure to meet the strategic requirements described in the new Defence White Paper," he said.

The sheer size of Australia's area of maritime interest, coupled with the complexity of likely maritime tasks and potential threats, creates particular challenges for Australia's surface combatant fleet.

"We need highly-capable ships that can network together and defeat the range of threats which they may encounter in order to deliver the strategic effect that can only be achieved by a surface-combatant task force. This project will deliver a class of ships able to respond to the range of challenges we are likely to face in our area of strategic maritime interest," Mr Fitzgibbon said.

While they will be able to defeat threats in the air and on the sea surface, as well as provide fire support to forces ashore, these frigates will have a specific capability focus on anti-submarine warfare. They will also allow for greater range and endurance, support naval helicopters, and have a sophisticated integrated sonar suite.

The Government has also directed Defence to commence studies into increasing the versatility and effectiveness of the Navy's patrol boat, mine counter-measures, hydrographic and oceanographic functions through the design of a new multi-role class of ship.

As part of these studies the Navy will look at rationalising the four different classes of ship which currently perform these three different roles through the acquisition of around 20 new multi-role offshore combatant vessels.

The common ship type will be able to use modular specialised systems which can be tailored for specific tasks. For example, there will be an uninhabited underwater systems module which can be fitted for mine counter-measures or hydrographic tasks when required.

The ships will be designed for multi-purpose tasking, with an anticipated displacement of up to 2000 t. The studies will look at various ship designs to deliver a multi-role ship class with a common hull, propulsion and support systems, a flight deck, and will be fitted with self-defence weapon systems as well as basic networking capabilities.

They will also have the ability to embark a helicopter or uninhabited aerial vehicle to allow a surge in surveillance and response capabilities without the need for additional ships to be deployed. It is anticipated that the project will generate a range of longer-term savings in operating and training costs by rationalising four classes of vessels into one.

The Government also announced plans to acquire a new strategic sealift ship based on a proven design displacing between 10 000 and 15 000 t to complete Australia's amphibious deployment and sustainment needs.

"The new strategic sealift ship will provide the Australian Defence Force with the capacity to insert remaining elements of a large protected land force after the initial tactical lodgement has been made from the Navy's two new Canberra-class Landing Helicopter Dock (LHD) amphibious ships," Mr Fitzgibbon said.

To undertake this complementary task, the new ship will be able to embark a number of helicopters as well as unload its vehicles and other cargo without requiring port infrastructure.

The Government will also acquire six new heavy landing craft with improved ocean-going capabilities to replace the Navy's ageing Balikpapan-class Landing Craft Heavy (LCH) vessels.

The new class of landing craft will provide intra-theatre lift to augment the larger Canberra-class LHDs and new strategic sealift ship. The new landing craft will have improved seakeeping characteristics and faster transit speeds than the LCHs which they will replace.

By the end of the next decade a new replenishment ship will be acquired to replace HMAS *Success*, which is the older of the Navy's two current underway replenishment ships.

This new replenishment ship will be capable of carrying fuel, stores, food and ammunition and have the ability to transfer this cargo to other major fleet units while underway. The ship will have the capacity to carry at least one helicopter, which will also ensure that it can extend its role to limited resupply of land forces operating ashore.

To sustain present capability until the new underway replenishment ship enters service, HMAS *Success* will undergo internal modifications in order to maintain ongoing compliance with new international requirements for tankers to be 'double hulled' to reduce the risk of environmental damage if an accident occurs.

Virtu Ferries Orders 107 m Austal Cat

Austal received its second large vehicle ferry order within a week after being selected by leading Maltese operator Virtu Ferries on 6 April to design and build a 107 metre vehicle-passenger catamaran. The Virtu Ferries' vessel will be built by Austal in Western Australian and is scheduled for delivery by mid 2010.

Intended for operation between Malta and Italy, the vessel will join Virtu Ferries' existing 68 m vehicle ferry *Maria Dolores* which was delivered by Austal in 2006.

Designed to carry 800 passengers and 230 cars at a speed of approximately 39 knots, the vessel will be Austal's 24th commercial delivery to operators in the Mediterranean region, which includes 14 large vehicle-passenger ferries.

Powering the vessel will be four MTU 20V 8000 M71L diesel engines at 9100 kW each driving Rolls-Royce Kamewa waterjets.

The vehicle deck will have the capacity to carry up to 230 cars or 45 cars and 342 truck lane metres, enabling Virtu Ferries to efficiently service the needs of private passengers with cars and campers, commercial tourist operators and trucking companies. Vehicle loading and unloading will utilise ramps installed on both the stern and port side.

Seating for the ferry's 800 passengers will be spread over two decks, each offering a passenger-friendly seating density of 2–3 seats per row, as well as a dedicated upper-deck lounge area overlooking the vessel's bow. A central staircase will lead to a first class seating area featuring natural overhead lighting, a separate kiosk and two VIP lounges. Outdoor seating will also be available for more than 110 passengers.

The vessel will be built in accordance with the requirements and under the survey of Det Norske Veritas, conforming to the International Maritime Organisation HSC Code and Malta Flag State and Italian Port State Regulations. Registration will be under the Malta Flag.

Principal Particulars:

Length OA	106.5 m
Length WL	92.4 m
Beam moulded	23.8 m
Hull depth	9.4 m
Hull draft (maximum)	4.90 m
Deadweight (maximum)	850 t
Passengers	800
Crew	24
Vehicles	230 cars or 342 truck lane m and 45 cars
Fuel (approx)	335 000 L
Propulsion	
Main engines	4 × MTU 20V 8000 M71L each 9100 kW
	4 × Kamewa 125SIII waterjets
Service speed	approx 39 knots (85% MCR and active ride control)
Classification	Det Norske Veritas

An impression of the 107 m catamaran to be built by Austal for Virtu Ferries
(Image courtesy Austal Ships)

Austal Tasmania Launches Police Vessel

In February, Austal's Tasmanian shipyard launched the first of three 22 m catamaran police boats being built for the Queensland Police Service.

Intended to patrol remote, tropical locations for extended periods, as far north as Thursday Island, each vessel has a cruising speed of 20 kn, a minimum range of 700 n miles and will be powered by two MTU Series 60 diesel engines. The ability to drive on/drive off a six metre rigid inflatable boat (RHIB) while underway is a significant feature of each vessel.

The launch is the latest milestone for the Tasmanian shipyard which, last September, delivered two 47.5 m high-speed catamaran ferries to Hong Kong operator New World First Ferry. Since being purchased by Austal in 2007 the facility has grown from 40 staff to more than 130.

Sea trials of the first Queensland Police vessel were carried out in March.

The first Austal police boat for Queensland on trials
(Photo courtesy Austal Ships)

New Head of Future Submarine Program

On 23 February the Minister for Defence, the Hon. Joel Fitzgibbon MP, announced the appointment of Rear Admiral Rowan Moffitt AO RAN to the new position of Head Future Submarine Program in the Defence Materiel Organisation (DMO).

The future submarine is planned to replace the Collins-class submarines commencing in 2025. This highly-complex project is a high priority for the Government.

RADM Moffitt will report to the Chief Executive Officer of DMO, Dr Stephen Gumley, and will lead a combined Navy, DMO and Capability Development Group Future Submarine Project Office. He began his duties on 23 February 2009.

AWD Work for Newcastle and Cairns

The Air Warfare Destroyer (AWD) Alliance has selected the FORGACS group and NQEA Australia as the preferred suppliers to build 70 per cent of the blocks which will make up Australia's three air-warfare destroyers.

The AWD Alliance CEO, John Gallacher says the work is worth in the region of $450 million and the selection of the two preferred suppliers is a major milestone for the $8 billion project which will provide the RAN with three of the world's most capable warships.

"This demonstrates that the Alliance is ready to begin constructing the ships. The AWD Alliance has moved into the 'production readiness' phase of the project and is on schedule to begin 'cutting steel' later this year.

"The work will create about 450 direct jobs and many more through sub-contractors and suppliers, which is good for the project and good for the nation," he said.

NQEA is a Cairns-based engineering and shipbuilding business specialising in provision of design, manufacture and project-management services to the maritime, industrial and aerospace markets. It has a shipbuilding record dating back to 1966, involving more than 220 vessels in the defence, tourism, commercial and luxury markets.

The FORGACS group, based in northern NSW, is one of Australia's leading ship construction, ship repair and engineering companies. The group's shipyard has a long history in the construction, conversion and repair of defence and commercial vessels including building hull blocks for the Anzac frigate program.

The AWDs will be built using a modular construction method involving fabricated and pre-outfitted hull blocks which are then joined together to form a completed ship. The contracts announced on 9 May will see 66 blocks (70 per cent) built at these two sites with the remaining 27 blocks (30 per cent) built at ASC's facility in Osborne, South Australia. The blocks to be built by NQEA will comprise more than 3000 t of steel and 1500 t of equipment and materials, and the contract will employ more than 300 people over a five year period. The FORGACS blocks will be made up of 1500 t of steel and 600 t of equipment and materials, requiring a workforce of more than 200 over the same period.

When completed, the blocks will be transported by ship or barge to the ASC facility where the block erection and integration will occur. On average, the blocks will measure 18 m × 12 m × 7 m and weigh up to 200 tonnes. Fabrication of the first ship is expected to begin later this year with final deliveries of blocks for the third ship expected in late 2014.

Austal Delivery to Saudi Arabia

Austal has successfully completed its largest individual ferry contract to date, following the delivery of two 69 m vehicle-passenger catamaran ferries *Jazan* and *Farasan* to the Kingdom of Saudi Arabia.

With the capacity to carry 650 passengers, 50 cars and 15 trucks, the two aluminium catamarans are part of a group of four Austal vehicle-passenger ferries ordered by the Saudi Arabian Ministry of Finance in 2007. The 88 m vessels *Riyadh* and *Cairo* were delivered to Saudi Arabia in December last year and later given to the Egyptian Government to improve ferry services across the Red Sea.

Farasan and *Jazan* will be operated by The Maritime Co. for Navigation from the port of Jazan in the south of Saudi Arabia along a 25 n mile route to Farasan Island. The Farasan Island archipelago has become an increasingly-popular holiday destination and diving location for locals, known for its spectacular coral reefs and abundance of underwater life.

As the island's main link to the mainland, the vessels' multi-purpose design features a vehicle-deck carrying capacity typical of much larger platforms, with space for fifteen 7 t trucks and maximum axle loads of up to 10 t. There is also space for 50 cars with trucks or 74 cars without trucks.

Austal has designed and installed both bow and stern vehicle ramps to ensure efficient vehicle transfer and reduced port turnaround times, meeting the client's need for "drive through" capability.

Suited to the short distance of the intended route, each vessel has a cost-effective service speed of 32 kn, with power from four MTU 16V 4000 M73L diesel engines producing 2880 kW each. Utilising advanced design technology, the vessel's hullform has been optimised to ensure maximum fuel efficiency which, along with the cost-effective service speed, delivers fuel consumption of only 2.21 t/h (including generators).

The high passenger density expected on the service meant that Austal's interior design team worked closely with the client to develop a highly practical seating arrangement for 650 passengers which maximises space and accessibility. All seating is situated on the upper deck, with seating density deliberately maintained at a passenger-friendly level of no more than three seats per row.

Facilities located on the passenger deck include a boutique gift store, food preparation and service area, and a dedicated VIP lounge overlooking the bow. In consideration of the cultural requirements of the route's predominantly Muslim clientele, the passenger deck features a dedicated seating area for families and children, as well as both men and women's prayer rooms and a children's play room.

Farasan Island's relatively small port means that vessel manoeuvrability was another important design consideration. Electric bow thrusters installed in each hull improve vessel manoeuvrability at slow speed in harbour, while passenger comfort is assured with the installation of Austal Ride Control, incorporating two interceptors and two forward T-foils.

A state-of-the-art bridge deck features the Austal-developed Marine Link ship control and monitoring system, allowing extensive monitoring of core onboard equipment as well as providing a comprehensive on-line system to manage all user manuals as well as ship drawings and documentation.

Both vessels recently made the 15-day delivery voyage from Western Australia to Jazan, via the Maldives and the Gulf of Aden, under their own power.

Principal Particulars

Length OA	68.6 m
Length WL	61.2 m
Beam (moulded)	17.65 m
Hull depth (moulded)	5.25 m
Hull draft (maximum)	3.2 m

Payload and Capacities

Passengers	650
Vehicles	50 cars and 15 trucks
Crew	18
Maximum deadweight	258 t
Fuel (maximum)	47 500 L

Propulsion

Main Engines	4 × MTU 16V 4000 M73L, each 2880 kW at 2050 rpm
Gearbox	4 × ZF 9050 NR2H
Waterjets	4 × Kamewa 80S3
Speed	32 kn @ 90% MCR

Classification

Germanischer Lloyd ✠ 100 A5 HSC-Passenger B OC3

Order for Largest Ever Austal Catamaran

Austal will build its largest catamaran to date following an order from Denmark's Nordic Ferry Services for the design and construction of a 113 m high-speed vehicle-passenger ferry. The vessel will be built at Austal's Western Australian shipyard and is scheduled for delivery in 2011.

An impression of Austal's catamaran for Nordic Ferry Services
(Image courtesy Austal Ships)

Designed to carry 1400 passengers and 357 cars, the vessel will be among the world's top 10 high-speed ferries in terms of capacity and will surpass the landmark 127 m trimaran ferry *Benchijigua Express* to boast the highest vehicle-passenger capacity of any Austal-built vessel.

The ferry is intended for operation between Rønne on the Danish island of Bornholm and Ystad in south-east Sweden, where it will join Danish operator BornholmsTrafikken's existing 86 m Austal catamaran *Villum Clausen*, which has been operating along the route since 2000.

With Danish environmental regulations for fast ferries among the most stringent in the world, Austal's design is required to comply with legislation covering environmental noise, wave-wash and exhaust emissions. The design also minimises the need for alterations to the route's existing port infrastructure, enabling both the 113 m catamaran and the 86 m *Villum Clausen* to operate in the summer season using the same vehicle and passenger ramps.

Three car decks accessible via both bow and stern ramps will ensure the efficient transfer of the catamaran's large vehicle capacity. Passenger seating is situated across two levels, with lounge-style facilities situated on the vessel's bridge deck and accessible via a large staircase. A fully-equipped catering area, separate bar facility, a dedicated shopping area and two child play rooms are also located on the upper deck.

The vessel will be powered by four diesel engines and will be built in accordance with the requirements and under the survey of Det Norske Veritas, conforming to the International Maritime Organisation's HSC Code.

Nordic Ferry Services is a joint venture between BornholmsTrafikken and Clipper Group.

Principal Particulars

Length OA	112.6 m
Length WL	101.3 m
Beam moulded	26.20 m
Depth	8.50 m
Capacity	
Passengers	1400
Crew	30–35
Vehicles	357 cars
Maximum Deadweight	1000 t
Fuel	160 000 L
Propulsion and Performance	
Engine	4 × diesel engines
Speed	Up to 40 knots

Second Austal LCS Ordered

In early May the US Navy announced the award of a fixed-price-incentive contract for the construction of a second Austal-designed and built Littoral Combat Ship (LCS).

Awarded to Prime contractor Bath Iron Works, a General Dynamics company, LCS 4, to be named *Coronado*, will be similar to the 127 m *Independence* (LCS 2), which is currently at an advanced stage of construction at Austal's US shipyard in Mobile, Alabama.

The award represents the second half of the two-vessel $US1.02 billion budget appropriation for the LCS program for US Fiscal Year 2009. Approximately 50 per cent of the total award amount is for work to be performed at Austal USA.

The announcement follows Austal's recent selection as Prime contractor for the US Navy's Joint High Speed Vessel (JHSV) program, potentially valued at more than $US1.6 billion.

Construction of Austal's second LCS will commence immediately at its shipyard in Mobile, where work is also well underway on the first phase of a new state-of-the-art Modular Manufacturing Facility (MMF).

The facility will allow quicker and more cost-effective construction of the ship components, or modules, which will then be transported to the existing assembly bays along the waterfront for erection and launch. Once completed, the 70 000 m^2 MMF will allow the delivery of multiple JHSV or LCS vessels per year.

Sea trials of Austal's first LCS, *Independence*, are scheduled for mid-2009, with delivery expected later in the year.

Austal Patrol Boats for Maltese Armed Forces

In February Austal secured its first European defence contract with an order for four 21.2 m inshore patrol craft — including training and spares support — for the Armed Forces of Malta (AFM).

The aluminium-hulled vessels will be built in Australia and are scheduled for delivery by the end of the year. Intended to assist the AFM with surveillance and border protection throughout Malta's coastal waters, the vessels will have a maximum speed of more than 26 kn and will be capable of mounting 7.62 mm and 12.7 mm guns.

An impression of the Austal patrol boats for Malta
(Image courtesy Austal Ships)

Thales Triple Frigate Docking

Thales Australia Platform Services recently performed the simultaneous docking of three major warships — the Anzac-class frigates HMAS *Anzac* and HMAS *Parramatta*, and the FFG-class frigate HMAS *Melbourne*. The last time three large navy ships were simultaneously docked at Garden Island was in 1974.

The combined docking of *Anzac* and *Melbourne* in the inner Captain Cook Dock was performed on Friday 3 April, with the docking of *Parramatta* in the outer Captain Cook Dock following on Monday 6 April.

In addition to a tripling of the usual complexities of docking a warship, simultaneously docking two ships of similar size alongside one another presents the significant challenge of aligning the ships in the dock. In a normal docking, lines are run between the dockside and the ship and these are tensioned in order to achieve the correct longitudinal and transverse alignment. However, in this case, two normal arrangements could not be used as the ships would have been in the way of each other's docking lines. Therefore the ships were partially secured to the docksides and partially to each other. This required some very careful coordination of lines in order to keep the ships in position while the water level was dropping. The trims and drafts of each ship were stipulated by the design office to ensure that one ship was completely settled into its docking cradle before the second ship began to contact its docking cradle. This allowed the Dockmaster to fully concentrate on the docking of each ship in turn.

The docking of *Parramatta* presented its own challenges — in this case fitting the ship into the outer dock. With the ship and outer caisson in place there is only one metre at each end between the extreme bow and the extreme stern and the ends of the dock.

Because all three ships required access to their sonar domes, each of the three set-ups had to be constructed with double-height docking blocks. Therefore the physical set-ups were the equivalent effort of simultaneously setting up six normal docking arrangements.

The docking evolutions were a success and resulted in a clean fit of all three vessels in their docking cradles on schedule. Well done to the dock group staff who worked tirelessly to complete the docking set-up in time and throughout the busy docking schedule, and the Thales design office and the Commonwealth Centre for Maritime Engineering (CME) staff, for the design and approval of the set-ups and the docking calculations.

Parramatta is planned to be in dock for about six weeks while the *Anzac* and *Melbourne* dockings will be of about eight weeks' duration.

New South Wales Industry News

Unlimited from Incat Crowther

A 24 m catamaran work boat, *Unlimited,* has been built for Offshore Unlimited, who provide comprehensive offshore services, including oil-rig supply, survey-ship re-supply and chase-boat services around Australia. This vessel marks the 20th Incat Crowther design built by Richardson Devine Marine in Hobart.

The platform is based on the highly-successful Incat Crowther catamaran hull form which has been heavily utilised in ferries, motor yachts and work boats around the world over the last decade. The platform features a highly-efficient hull shape which leads to lower power

Looking north over the Captain Cook Dock with HMAS *Anzac* and HMAS *Melbourne* in the Inner Dock and HMAS *Parramatta* in the Outer Dock
(Photo by George Hicks, courtesy of Thales Australia Platform Services)

Unlimited on trials
(Photo courtesy Incat Crowther)

requirements, lower fuel consumption and longer range capabilities. The hull has a wide beam, allowing easy engine-room access for maintenance and repair, spacious crew quarters, high load-carrying capability and possesses excellent seakeeping characteristics.

During the vessel-development stage, Incat Crowther worked closely with the customer and the shipyard to customise the standard platform to suit the client's specific requirements for the operation. These include a multi-purpose deck crane, incorporating a wireless-control system for launching the vessel's tender as well as general duties on the large open aft deck, which includes a 1.2 m^2 moonpool for underwater operations. In addition, the aft deck is fitted with securing points for a standard 20 ft container and a stern platform for water access. A unique feature for a lightweight aluminium high-speed catamaran is the addition of a towing hook, enabling the vessel to undertake lightweight tug duties with a bollard pull of 15 tonnes. The vessel has also been fitted with bow thrusters in both hulls for operating within close quarters of other vessels or structures.

The vessel maintains standard workboat characteristics, including the main cabin facilities forward. The main deck houses two crew cabins, a galley, mess area, bathroom facility and lounge. The fitout standard is very high, with the shipyard utilising its high-speed ferry standards for construction with a very smart, modern appearance. In the hulls are crew quarters for a further 10 crew and a large store room located in the port hull. A spacious wheelhouse is positioned on the upper deck and commands all-round visibility for the operational crew. Workspaces are also available for visiting engineers, with all the latest communication outlets available.

Powered by twin Caterpillar C32s, each producing 1044 kW brake power, the vessel will have a service speed of 26 kn. Sea trials were conducted in very rough conditions in Bass Strait. The trials proved that the vessel is a very robust and exceptionally sea-kindly vessel.

Unlimited has an extended range of 1875 n miles at 22 kn, thanks largely to two 12 500 L fuel tanks. This will allow the operator the range to reposition the vessel far more efficiently than with multiple refuelling.

Principal particulars of *Unlimited* are:

Length OA	24.00 m
Length WL	21.80 m
Beam OA	8.00 m
Draft (approx)	2.25 m
Passengers	38
Crew	12 overnight
Fuel	2×12,500 L
Fresh water	1×1500 L
Deadweight	55 t
Engines	2 × Caterpillar C32
	each 1044 kW @ 2300 rpm
Gearboxes	2 × Twin Disc MGX6599
Propulsion	2 × Fixed-pitch propellers
Service speed	26 kn
Max Speed	29 kn
Construction	Marine-grade aluminium
Survey	Marine and Safety Tasmania
	USL Code Class 2 Area A

Koh Prarb from Incat Crowther

Incat Crowther's latest design for Lomprayah High Speed Ferries Co. was launched following a traditional Buddhist naming ceremony held at the Sea Crest shipyard in Samut Prakarn Province, Bangkok, Thailand.

Like previous vessels for Lomprayah, the new vessel, named *Koh Prarb*, was built utilising one of Incat Crowther's pre-cut aluminium kits. These kits are developed in digital form complete with cut marks, water lines, centerlines, rolling marks and piece identification. All shell plates are provided in expanded form. The nested information is then used to cut the aluminium sheets for flat packing into standard containers. Specialist extrusions are used to simplify construction, which are all cut to length and loaded in the same containers.

Incat Crowther's Managing Director, Brett Crowther, says "Our kits are great for developing shipyards which have little experience in building this type of vessel. It takes a lot of the guesswork out of the initial estimation. In addition, we can provide these kits for developed shipyards who find themselves on tight schedules. By utilising our kit packs, they can free up their own resources to complete other tasks and projects."

Koh Prarb is a 29 m high-speed catamaran ferry, capable of carrying 350 passengers plus 10 crew at a service speed of 26 kn. The main cabin contains seating for 210 passengers in rows of aircraft-style seating. Television monitors are provided for safety and entertainment, while a canteen, located amidships, provides drinks, food, snacks and gifts. The upper-deck cabin has seating for 66 passengers seated in rows. An outdoor seating area for 65 passengers is fitted aft of the mid-deck cabin, plus an upper third-level sun deck.

The vessel is powered by two Cat C32s, each producing 1057 kW brake power and coupled to ZF gearboxes and 5-bladed Veem propellers.

Lomprayah Fast Ferries Co provides services to the east coast islands of Koh Tao, Koh Phanghan and Koh Samui from the mainland city of Chumphon in Thailand. They also provide luxury-coach transit from the major centres of Bangkok and Huahin to the vessel's main port. The business has experienced rapid growth since taking delivery of its first Incat Crowther vessel, *Pralarn*, in 2000.

Koh Prarb takes the total number of Incat Crowther vessels operating for Lomprayah to four, with an additional 29 m vessel still under construction.

Principal particulars of *Koh Prarb* are:

Length OA	29.00 m
Length WL	26.80 m
Beam OA	8.50 m
Draft (approx)	1.40 m
Passengers	
Main deck	210 internal
Mid deck	66 internal
Mid & Upper decks	74 external
Fuel	2×3000 L
Fresh water	1×2000 L
Deadweight	45.50 t
Main engines	2 × Caterpillar C32 each 1057 kW @ 2300rpm
Gearboxes	2 × ZF3050
Reduction ratio	2.48:1
Propulsion	2 × 5-bladed propellers
Service speed	26 kn
Gensets	2×Caterpillar C4.4
Survey	Thai Government Marine Department
Construction	Marine-grade aluminium

Ben Hercus

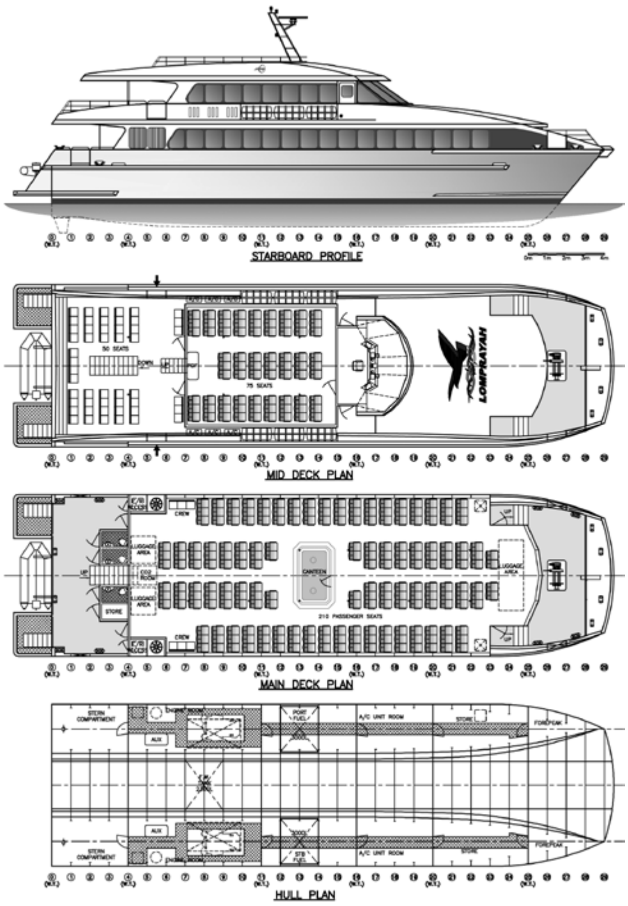
Gurit Australasia Busy

The past few months has seen the full abilities of the Gurit engineering team utilised in the design of marine composite structures. They have been working on several projects, all of which have different requirements on budget of engineering support, materials to be used and construction techniques. An example of this is the work they have been doing on the engineering of a 33 m catamaran passenger ferry for Cheoy Lee shipyard in China. The work involves the engineering of the entire structure for low cost, using polyester and glass reinforcements and designed to DNV's HSLC rules. This is work for a new client for the engineering team and is proving to be a good working relationship. The hull is single-skin hand-laminated polyester glass, with all flat panels laminated with vacuum-infused vinylester resin.

A similar project is for West Australian designer, Mark Ellis, who is designing a 24 m catamaran motor yacht. This is a project where Gurit have tailored the engineering support to suit the budget requirements of the design by providing the designer with typed specifications and sketches of any details from which the designer is producing drawings to send to the builder. The yacht is being built at Horizon Yachts in Taiwan, using glass fibre and vinylester resin, and this yard is using vacuum infusion to build the entire yacht to help save weight and reduce production time, so the laminates are designed to ensure good infusion properties.

Other motor yacht projects on which Gurit is working include a 15 m patrol boat for a middle-eastern client. This will be a production boat with twelve boats to be built using vacuum-infused epoxy resin and carbon-fibre reinforcements to provide light weight and reduce production time.

For another middle-eastern client they are designing a radar mast for a very large mega yacht which requires a complex study of the structure's natural frequencies to ensure that the vibrations generated by the yacht's machinery and motions do not generate unwanted vibrations and movement in the mast.



General Arrangement of *Koh Prarb*
(Photo courtesy Incat Crowther)

In the sailing yacht market, Gurit is working with two Australian yards to provide engineering support for two projects.

In Sydney they are working with McConaghy Boats to engineer the structure for an 80 ft (24.38 m) canting-keel cruising boat they are building. This project has used the full engineering abilities of the team, from hand calculations through to finite-element analysis used for engineering of the canting-keel structure. This project is currently in build with an expected delivery date of January 2010.

On the south coast of NSW, they are working with Azzura yachts on modifications to the Marten 67 they currently have in build. These are modifications to an existing engineering design which was completed last year. This is the second boat Gurit have engineered for them, as they previously engineered the smaller Marten 49.

Other work Gurit is completing is the engineering of some large fibreglass water-storage tanks for the mining industry. These tanks are being built in South Australia from vacuum-infused vinylester fibreglass to ensure excellent mechanical properties and light weight.

David Firth

New Catamaran from Incat

Incat Tasmania has delivered a 112 m high-speed catamaran to LD Lines which will be the largest-ever fast ferry to operate on the cross-channel routes between England and France. The vessel is also the world's largest diesel-powered catamaran and will be the first Incat 112 m ship to operate in Europe.

Entering service between Dover and Boulogne on 29 May 2009, the new fast ferry is also the first-ever freight-carrying high-speed vessel to operate across the Dover Straits. With *Norman Arrow,* LD Lines becomes the first-ever French ferry company to operate high-speed catamarans on the short sea routes from Dover.

The third vessel in the successful 112 m range from Incat, *Norman Arrow* is specifically designed with the European ferry market in mind.

Norman Arrow incorporates a range of enhancements derived from the operational experience of her two highly-successful Japanese predecessors. Most notable is the internal ramp system on the vessel's two vehicle decks. On the first two 112 m vessels, cars reached the full-length Tier 2 upper vehicle deck via an internal ramp from Tier 1. On the latest vessel, Tier 2 is accessed via a ramp system around the forward end of the ship leaving the main deck completely clear of obstruction for high-sided vehicles. Cars move in a clockwise direction starting at the port forward end of Tier 1, turning right to traverse across the bow area and end rising facing aft on the starboard side of Tier 2. This has served to increase vehicle deck capacity from 450 m of freight at 4.35 m clear height plus 193 cars at 4.5 m length, to 567 m of freight at 4.60 m clear height plus 195 cars at 4.5 m length. If the vessel was to be filled entirely with cars then up to 417 vehicles may be carried, compared with 355 cars on the earlier vessels.

The passenger spaces on board *Norman Arrow* are located on one deck, Tier 3. Boasting three distinctive lounges, the public spaces are accessed from the vehicle decks by stairways forward, midships and aft. Additionally, a ramp is fitted aft to provide barrier-free access between Tiers 2 and 3, ensuring that passengers requiring assistance enjoy all the craft has to offer.

The aft cabin is a spacious lounge containing a mix of comfortable Beurteaux Tourist High Back reclining seats. Blues, yellows, reds and greens are the predominant seating colours, all of which are finished in wool fabric upholstery. The lounge boasts two plasma-screen theatres and its own dedicated bar, with stylish glass-topped counters, providing facilities to serve a wide variety of food and beverages. A dedicated truck drivers' lounge and TV area is also provided. Large windows face onto the aft observation deck from where passengers have a spectacular view of the water jets in operation.

The vessel is powered by four MAN 20V 28/33D diesel engines, each rated at 9000 kW at 1000 rpm and delivering a low weight when compared to other engines in its class. The advantages of engine durability, efficiency, low noise and low maintenance costs make it the engine of choice for Incat vessels, not least being impressive fuel consumption, burning less fuel per cargo tonne per hour than any other high-speed catamaran.

The ferry is fitted with four of the largest transmissions from ZF Marine GmbH, the ZF 60000 NR2H, each with maximum rated power of 12 387 kW. Engine power is converted to propulsion thrust through four Wärtsilä LJX waterjets. A substantial weight saving has been achieved through the use of Centa carbon-fibre shafts. Some 70% of weight has been saved compared to the use of conventional steel shafts.

Norman Arrow has been specifically built for the European market by Incat for MGC Chartering, an Irish-based leasing company.

Principal Particulars

Length OA	112.60m
Length WL	105.60 m
Beam of hulls	5.80 m
Beam (moulded)	30.50m
Draft (approx.)	3.93m
Speed	40 kn
Deadweight	Up to 15 000 t
Gross tonnage	10 503
Classification	DNV ✠1A1 HSLC R1 Car Ferry "B" EO

Norman Arrow, Incat's latest 112 m catamaran ferry which was recently delivered for service in Europe (Photo courtesy Incat Tasmania)

Tony Armstrong Receives AGM Michell Award

Dr Tony Armstrong is this year's recipient of the 2009 AGM Michell Medal, the highest individual award of Engineers Australia's College of Mechanical Engineers. He is the Manager of Research and Development at Austal Ships, and displayed outstanding achievements in naval architecture, ship design and construction to win the award, developing new shipping technology and contributing to codes, standards and industry forums.

Tony was presented with a certificate and medal by the Chair of Engineers Australia's Mechanical College Board, Jenny Simpson, at a ceremony in Perth in late March.

The certificate states "For a worthy blend of notable and sustainable leadership pertaining to mechanical engineering within the Institution of Engineers Australia; long-standing eminence in mechanical engineering science or practice; and a highly significant contribution, through technical innovation, relating to the science or practice of mechanical engineering".

Tony Armstrong receives the AGM Michell Award from Jenny Simpson at the award ceremony (Photo courtesy Brian Marsden)

The full citation reads:

On leaving school in 1965, Tony joined Vickers Shipbuilders of Barrow-in-Furness, UK, as a student apprentice and, during a five year period, experienced the various activities of the shipyard, and obtained a degree in Naval Architecture from the University of Newcastle-upon-Tyne, UK. After graduation, he worked as an R&D engineer on various projects involving nuclear submarines and surface warships before moving on to the test and commissioning organisation and taking on responsibility for the hull integrity of the new class of destroyer, HMS *Sheffield*, which ironically was later sunk in the Falklands conflict.

He was offered a job as a design naval architect in Sydney, and emigrated to Australia with a wife and new child on Christmas Day 1974, just a few days before the shutters were put up on immigration from Britain, and arrived in Sydney as Cyclone Tracy was devastating Darwin. For almost three years Tony worked as a naval architect with the independent marine consultancy company, Eken and Doherty, designing several tugs, offshore supply vessels and the novel side-casting dredger, MV *April Hamer*, which is still operating at Lakes Entrance. Desiring some experience of regulations and legislation relating to ships, he moved to Hong Kong for two years and worked as a ship surveyor for the Hong Kong Government, mainly involved with new-building ships in Hong Kong and also overseas. He returned to Sydney in 1980 and re-joined the old firm, now called M.J. Doherty and Company, as a Director-Shareholder.

During the next six years, he was the principal designer for an innovative self-discharging bulk limestone carrier, MV *Accolade*, which is still operating out of Adelaide and believed to be the first large vessel designed for operation on compressed natural gas. This was followed by a bulk cement carrier, MV *Goliath*, which operated on the Australian coast for many years. To meet a very rapid design delivery schedule, the shape and structure for this vessel was conceptually designed on the fly in a hotel room in Norway during consultation with various European experts. There were also many tugs and offshore supply boats designed during this period, as M.J. Doherty and Company were one of the largest and busiest ship-design consultancies in the southern hemisphere. The supply boats were some of the largest and fastest in the world to be built at that time. Many of the designs were built at Carrington Slipways in Tomago, NSW, although some were also built overseas, including Japan, New Zealand and The Philippines. A branch office was opened in The Philippines, in support of a novel project financed by the Australian Government as part of Australia's overseas aid programme, to assist with the transportation and distribution of coal within that country. Two sizes of vessel were built of 5 000 t and 10 000 t capacity, and the company also took on the role of supervision and guidance for a new shipyard in The Philippines to build several of these craft. Tony was by this time the Managing Director of the Company, and negotiated the sale of the company to raise finance for expansion, remaining as General Manager during the transition period.

In 1986 Tony set up his own business, working from home in Sydney on various national and international design and shipbuilding projects. He also worked for Carrington Slipways as Manager of the Sydney Marketing Office throughout much of 1988, assisting with the preparation of a bid for the Anzac frigate project and, later on, a bid to build Australia's Antarctic research vessel. In early 1989 he was approached by Carrington Slipways to assist them with the design of this vessel, later named *Aurora Australis*, because the original European designers had gone into liquidation. As this was at an early stage of the project, there was very little design information available, consisting of less than half-a-dozen preliminary drawings and several pages of numbers defining the hull shape and a few pages of initial stability and strength calculations, and so the design task became essentially a new one. Because of the multiple functions of the vessel, the design had to incorporate all the international legislative requirements for a fishing vessel, a passenger ship, and a special purpose ship. Through 1989 there were also several other projects including the structural design of perhaps the largest commercial ship built in NSW, a 140 m ro-ro for Bass Strait.

In late 1989 Tony joined International Catamaran Designs (ICD) in Sydney, originally for a six-week secondment but which turned into six years working as Director of Design. These were turbulent and exciting times, designing many novel high-speed craft for which the designs were well outside the limits of international regulations. The world's first large high-speed catamarans were designed, and then built in Hobart, and a whole new Australian industry developed — the aluminium shipbuilding industry which is now one of the mainstays of shipbuilding in Australia, and one which other countries have not been able to replicate. In 1990 alone, ICD designed the 35 kn 35 m Sydney Harbour Jetcats, the 40 kn 74 m wave-piercing car ferries (five built), a 120 m wave-piercing catamaran car ferry for P&O and a 49 m wave-piercing passenger ferry built in the UK. All of these designs were "cutting edge" in that the dynamics of the aluminium structure were not fully understood, there were limited international safety regulations, and the classification society regulations governing structural design were only preliminary and applied only to ships up to 50 m in length! The first 74 m wave-piercer, *Hoverspeed Great Britain*, won the Hales Trophy in 1990 for the fastest crossing of the Atlantic by a passenger vessel, the first winner since SS *United States* in 1953.

Tony worked with the international regulators throughout the early 1990s to develop the regulations into the current safety standard called the 2000 High Speed Craft Code, published by the International Maritime Organisation, an agency of the United Nations.

Through involvement with the Australian Maritime Engineering Co-operative Research Centre, the opportunity arose to return to University in 1995 and, with financial support from International Catamarans, an aluminium shipbuilder in Hobart, Tony obtained a PhD at the University of New South Wales for his thesis titled *On the Viscous Resistance and Form Factor of High-Speed Catamaran-Ferry Hull Forms*.

Joining Austal Ships in Perth in 1998 as Manager R&D, the past ten years have been exhilarating and rewarding for Tony. Responsible for hull shapes and hydrodynamic features of over 39 ships, he has worked on maximising efficiency through minimisation of hull resistance and minimisation of motion. The first vessel which he worked on, the 86 m car ferry MY *Villum Clausen*, is the only vessel to have ever travelled more than 1000 nautical miles in 24 h, and the more-recent 56 kn MV *Shinas* is the fastest diesel-powered fast ferry ever constructed.

A highlight of 2003–04 was the development of the world's first high-speed passenger trimaran, which took the known advantages of a long and thin hull and developed it into a practical application. The 127 m MY *Benchichigua Express*, a 40 kn high-speed car ferry delivered in 2005, was subsequently chosen by BRW as one of the Seven Wonders of Australian Engineering in 2007.

The successful development of this craft came to the attention of the US Defence Company, General Dynamics, and the concept was developed into the LCS project for the US Navy. The 127 m long USS *Independence* is currently nearing completion at Austal's Alabama shipyard, and follow-on orders are currently under discussion. It is noteworthy that the next generation of US warships has been designed in Australia by Australian engineers.

The College of Mechanical Engineers awards the 2009 AGM Michell Medal to Dr Tony Armtrong for his balance of ingenuity, theoretical knowledge, and applications of them, along with devoting time to RINA and other industry organisations and nurturing young minds.

Phil Helmore

The Brothers Michell

The AGM Michell Medal is one of three awards given by Engineers Australia to high-achieving Australian engineers. It is awarded to perpetuate the memory of the Australian, Anthony George Maldon Michell (1870 to 1959). He was a consulting engineer in the field of hydraulics and pump design. At the beginning of the twentieth century, he invented the tilting-pad thrust bearing, which was a momentous technical innovation. This thrust bearing has been extensively used in ships. Michell was elected a fellow of the Royal Society in 1934 and was awarded the Kernot Medal in 1938 and the James Watt Medal in 1943.

The Michell Award was first presented in 1978. The field of naval architecture and shipbuilding has been well represented in terms of the number of the recipients. Thirty-two awards have been made since inauguration in 1978, and nine of these are naval architects or shipbuilders, or have connections with the industry. These have included Dr W. Hughes, Managing Director of Walker Bros shipyard in Maryborough and a propeller expert (1983), Professor Tom Fink of The University of New South Wales (1985), Mr Philip Hercus of International Catamaran Designs (1992), Prof. Bill Melbourne of Monash University, who did ship-related work in the wind tunnel (1993), Mr Donald Fry of NQEA Australia (1997), Mr Peter Farley, who designed and made the plasma cutters in use by nearly all shipyards (1998), Mr Christopher Norman of Austal Ships (2000), Em/Prof. Peter Joubert of the University of Melbourne (2001) and, now, Mr Tony Armstrong of Austal Ships (2009).

Just as illustrious an engineer was Anthony Michell's brother, the more-mathematically inclined John Henry Michell (1863 to 1940), who held an academic position at the University of Melbourne when he wrote his famous paper, "The Wave Resistance of a Ship" (1898). This publication is one of the three or four most-useful technical papers on ship hydrodynamics ever written.

There are many reasons why this paper was an astounding achievement. The most remarkable is that the resulting formula has not been improved upon to this day, in terms of its elegance and reliability. The formula is essentially a triple integral, with respect to the longitudinal and vertical coordinates over the ship centreplane, and the wave spectrum. Michell himself evaluated the formula for simple hull shapes in a purely manual manner. Today, one utilises a computer program for this purpose.

The basic Michell formulation has been extended to include the effects of finite depth and sidewalls (as in a towing tank) by Sretenski (1936), to multihulls by Doctors (1999), and to hovercraft by Barratt (1965). By combining aspects of these papers, the Michell formulation was modified in order to model a surface-effect ship by Doctors and McKesson (2006). With minor modifications, that original 1898 paper can be employed to calculate the wave system generated by any of these vessels. An excellent explanation of this approach was given by Tuck, Scullen, and Lazauskas (2000).

Material for this article was extracted from the website of Engineers Australia, as well as the abstract of Tuck (1988), which was written during the centenary year of publication of the paper by that outstanding Australian hydrodynamicist, John Michell.

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Lawrence Doctors

Referring to Ships as Female

For as long as anyone can remember, ships have been referred to as female, and I have been advising students of naval architecture to do the same. However, the political correctness of so doing in the modern era was called into question in class recently, and so some authoritative advice was sought.

Emeritus Professor Pam Peters, Professor of Linguistics at Macquarie University, author of *The Cambridge Australian English Style* Guide, and previous editor of the journal *Australian Style*, had this to say: 'Using the feminine pronoun to refer to a ship doesn't seem wildly sexist to me, though I guess the convention originated in a pretty masculine community. For me, it just connotes being part of that marine community, and doesn't demean women. Besides, the convention is so well known. I can't imagine women being offended by it, or grammatical purists making much of it (as the "wrong" pronoun). In both cases it's a well-known convention, with a solidarity function for those who use it.

Professor Peters, intrigued, shared the question with Adam Smith, who is *Australian Style*'s new online editor. They felt that it would encourage discussion, and indeed it did, with a reply by Linda Schultz with reference to the storm which erupted when *Lloyd's List*, in 1998, ventured to suggest that ships should no longer be called "she" (see http://news.bbc.co.uk/2/hi/business/138678.stm).

Messages of dissent—for the most part lighted-hearted—were dispatched from seafarers across the country following the suggestion. Captain Fred Boer emailed the paper from his vessel, saying 'As long as ships of every size and type require lots of paint to look good, they will be referred to as "she", at least by me.'

Editor of *Lloyd's List,* Leigh Smith, said 'We also heard from women who felt that calling ships "she" demonstrated how important and respected women are and always have been. 'As a result of the response we have had, we will not stop calling ships "she"'.

The Royal Navy is not amongst those that see the gender of their ships as an issue. A spokesman told *The Times* newspaper 'Ships are normally referred to by their name, or simply as "the ship". They are Her Majesty's ships, so I suppose they could be female.'

The origins of calling a ship "she" have been lost in the mists of time. Leigh Smith said "My own opinion on the subject is that, because seafarers were away at sea for such a long time, they developed a close relationship with their ships. They came to regard them with a great deal of affection and the practice of calling them "she" came about."

Chris Jones, Chairman of the Historical Maritime Society, said 'There has been a great deal of debate on this subject on the Internet, particularly through Compuserve's forums. I personally don't think there will ever be a definitive answer.'

There is also an article on the subject on Wikipedia, with arguments both ways (see http://en.wikipedia.org/wiki/Wikipedia_talk:Manual_of_Style/Archive_(ships_as_%22she%22).

Professor Peters' interpretation means that the choice is really up to the user, and the maritime community may happily continue to use "she" for ships.

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 150 dpi.
A resolution of 200–300 dpi is preferred.

What Future for Fast Ferries on Sydney Harbour?

Part 2

Martin Grimm and Garry Fry

Part 1 of this article in the February 2009 edition of *The ANA* focussed on the history of fast ferry services on Sydney Harbour and outlined the technical difficulties they had experienced. The final part examines alternatives for the longer-term provision of fast-ferry services on the harbour, as either fully self-funded operations or with some government subsidy.

What is required for the Manly to Circular Quay run?

The Freshwater-class ferries are clearly an economical option for the Manly to Circular Quay run, both for passengers and the NSW Government. Their combination of modest speed and significant passenger capacity naturally leads to a lower cost per passenger per trip, provided that they are reasonably patronised. The Walker report [1] indicates that, of all vessels in the Sydney Ferries fleet, this class is the cheapest to operate on a "dollars per seat per hour" basis as illustrated in Figure 1. While the basis of these figures is not clearly stated and it would be difficult to accurately isolate individual vessel class operating costs in an organisation with such a mixed fleet, it can be expected that the Freshwater class would have the lowest acquisition, crew, fuel and maintenance costs relative to passenger capacity.

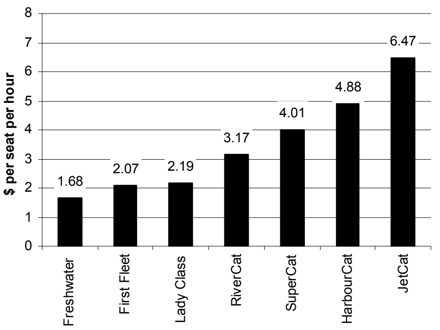

Figure 1: Operating Cost per Operating Hour per Seat, SFC fleet 2006–07 [1]

However, while the NSW Government has concluded that they are not obliged to provide a fast ferry service in addition to the Freshwater-class ferries, this does not mean that such a service is not in demand by the public or that it is unviable. Sensibly, the Walker report stated: "There ought to be a welcoming attitude by Government to proposals by any private provider for a high-speed service between Circular Quay and Manly… on a fully commercial basis, that is, on a cost-recovery basis with no government subsidy, except as may be involved in the liberal provision of access to wharves" [1]. This is the situation that currently prevails after Bass and Flinders Cruises won the contract to provide an interim 15-month fast-ferry service until March 2010. This service commenced in early February 2009.

The fact that the NSW Government received four bids in response to its request for proposals for this interim service indicates that the private sector sees this operation as being viable and profitable. On this basis, we have examined an alternative to the current service provided by Bass and Flinders Cruises. Unlike the proposal by Stuart Friezer [2], which would replace all vessels on the Manly to Circular Quay run with a single type, we see the place for a separate premium high-speed service operating in parallel with the slower, but cheaper, Freshwater-class ferries or their eventual replacements.

What Ticket Price for a Fast Ferry Service?

It might first be sensible to consider what passengers are willing to pay for the convenience of a fast ferry service on this route.

At the time of the closure of the JetCat service, a single ticket from Circular Quay to Manly was $6.40 for the Freshwater-class ferry and $8.20 for a JetCat with discounts available for multiple ticket purchases. Yet the Walker report [1] indicates that the operating cost per seat, per hour for the JetCat in 2006–07 was $6.47, compared with only $1.68 for the Freshwater class. This would imply that the JetCat ticket charge should have been about twice that of the Freshwater class (noting that the JetCat could complete about twice as many trips per hour) provided they both achieved similar load factors. Indeed, this premium on ticket price was typical in the early years of hydrofoil operations on Sydney Harbour and other international high-speed services where a traditional ferry operated in parallel. Over the years up to the termination of the JetCat service, this ticket price differential has been gradually eroded. A response to a question in the NSW Parliament regarding utilisation of Freshwater and JetCat ferries [3], reveals that the average load factor achieved during morning peak-period services to Circular Quay was around 56% for the JetCat services and only 43% for the Freshwater class. On this basis, the relative cost of JetCat tickets could justifiably have been set at around 46% more than those of the Freshwater class, or about $9.30.

Any private fast ferry operator needs to be able to offer a fare that is sufficiently low to ensure that a reasonable number of passengers elect to take the fast ferry rather than accepting the slower but cheaper Freshwater-class ferry. From conversations with numerous JetCat passengers, Garry Fry found most passengers felt that $10 was the most they would be willing to pay with a few indicating $15 would be the most. We believe that a fare of $15 would see around half the existing fast-ferry passengers reverting to using the Freshwater service or other alternatives. In any case, for such a premium ticket price, passengers would expect a quick, frequent, comfortable, high-quality and reliable service.

To date, Bass and Flinders Cruises have charged the same single-ticket price of $8.20 as was the case with the JetCats, or $6.72 per journey if a ten-journey Smart Card is used. A charge of $6.72 per trip therefore sets the benchmark for any alternative fast-ferry operations, assuming that this price is truly sustainable for Bass and Flinders Cruises. In our analysis presented below, we were unable to achieve such a low ticket price unless the number of passengers carried annually could be increased significantly above the figures achieved by the JetCats, or there was a degree of government subsidy on the ticket price.

Back to the Future — a Return to Hydrofoils

A key decision for any commercial operator is the selection of an appropriate combination of vessel capacity and frequency of departures. High-capacity fast ferries with 300 or more seats, as Bass and Flinders Cruises have adopted, would appear to be economically attractive considering their relatively lower operating costs per seat; however, the benefit is lost if it isn't possible to attract sufficient passengers to achieve a reasonable load factor. In that case, operating smaller ferries with lower direct operating costs may be more economical. A well-designed smaller fast ferry can achieve quicker boarding and disembarkation times, and can manoeuvre more easily within the confines of Sydney Harbour, allowing it to complete a trip in a competitive time and attracting customers accordingly.

This approach of adopting smaller ferries departing at frequent intervals is not new. As noted in Part 1, in the 1970s and 1980s the service to Manly was predominantly operated by a fleet of five hydrofoils with a capacity of 140 passengers each, with three in service during peak periods. The schedule provided departures from Circular Quay and Manly every 15 minutes or so during peak periods with a transit time of 13–15 minutes. As such, regardless of the time a passenger arrived at the terminal, the most time it would take them to complete a journey was around 30 minutes. Not a bad service!

We believe that smaller vessels requiring less power and having lower fuel consumption for a given speed, but providing higher frequency of departures, could again make the service overwhelmingly well patronised assuming, of course, that fares can remain reasonable.

Practical experience from the operation of various-size hydrofoils and, later, catamarans on the fast-ferry service to Manly indicates that even the 235 passenger capacity RHS 160F hydrofoils may have been too large for the run. These were more complex, and because of their size, somewhat more difficult to manoeuvre than the smaller PT 50 and RHS 140 hydrofoils. The JetCats and SuperCats, while having good slow-speed manoeuvrability by virtue of the wide separation of their propulsors, likewise were under-utilised at anything other than peak times during the day.

This brings us to our proposed fast-ferry type for this service. If we aim for a passenger capacity of around 150, then a ferry operating at up to 35 knots to achieve a 13 minute terminal-to-terminal time needs to operate at a relatively high Froude number. Hydrofoils have demonstrated that they are hydrodynamically efficient craft for such conditions.

Furthermore, the 140 passenger PT 50 and RHS 140 surface-piercing hydrofoils have demonstrated their ability to cope with the seas experienced within Sydney Harbour with very few weather cancellations over 26 years. Hydrofoils also suffer less speed loss in waves than other fast ferries. As such, provided that a mechanically-reliable design is selected, hydrofoils should be able to achieve a high level of schedule reliability.

While a fully-submerged hydrofoil would offer the most comfortable ride for a vessel of its size, the additional sophistication does not appear to be warranted for Sydney Harbour with its short and usually sheltered-sea conditions. A surface-piercing hydrofoil design incorporating flaps for motion control and to enhance manoeuvring is therefore proposed.

The PT 50 and RHS 140 hydrofoils are long since out of production, with Rodriquez now concentrating on the production of 220+ seat Foilmaster hydrofoils [3]. A hydrofoil along the lines of the *Kolkhida* (Figure 2) built by Ordzhonikidze Shipbuilding and Repair Yard in Georgia and the Volga Shipyard in Russia [4] is considered more appropriate.

Figure 2: Hydrofoil *Kolkhida*
(Photo www.foils.org)

A concept design of a modern 150 passenger hydrofoil with features similar to *Kolkhida* has been developed by Danish naval architect Søren Struntze and is illustrated in Figures 3 and 4 with key particulars in Table 1. This has a simplified layout compared to *Kolkhida* in that the hull depth has been increased slightly, allowing a pair of compact diesel engines to be installed in a machinery space below a continuous main deck. The MTU 12V 2000 M72, with a height of only 1385 mm, may be an appropriate choice of engine. There are several other candidate light and compact diesel engines on the market which may also be suitable. To overcome the inherent problems associated with propellers mounted on steeply-inclined shafts, as have traditionally been adopted on hydrofoils, a pair of mechanical transmission Z-drive propeller units similar to the Ulstein Speed-Z [4] are proposed. Replacement of inclined propeller shafts with podded propulsion units is not new. Rodriquez has previously experimented with this arrangement on a PT 20 and subsequently in its MEC-1 hydrofoil *MEC Ustica* [3]. However this hydrofoil adopted a hydraulic power-transmission system which would have resulted in greater transmission losses, and probably higher maintenance costs, than a mechanical Z drive. Unfortunately, presumably because of reliability problems with the equipment installed, this boat was unsuccessful in service. Ulstein claim that, due to the improved inflow into the propeller for the Speed-Z, model testing demonstrated that an improvement in propulsive efficiency of the order of 8% and a reduction in installed power of 13.8% is possible compared to inclined shafting for a comparable application [3]. Such a system is also less likely to result in cavitation erosion of the propellers and reduce noise and vibration levels.

The hydrofoil design has the practical attraction that the fenders for both the bow and stern foils also serve as boarding platforms, so that the rate of boarding and disembarkation can be maximised without the need for special berthing arrangements. The freeboard to the passenger deck when the hydrofoil is hull-borne is relatively modest at approximately 1.4 m. This should allow the hydrofoil to integrate relatively easily with existing wharf facilities in Sydney Harbour.

Minimisation of weight is crucial for an efficient hydrofoil.

While no detailed weight estimate has been prepared for the proposed design, it is anticipated that a slightly lower lightship weight could be achieved than *Kolkhida* due to reduced scantlings as a result of:

- Reduced overall length and greater structural continuity of the hull.
- Reduced bending moment due to shorter span of hull between foils and location of the engines close to the aft foil.
- Deeper hull increasing the hull girder section modulus.

We believe the production of such a hydrofoil is well within the capabilities of Australian shipyards.

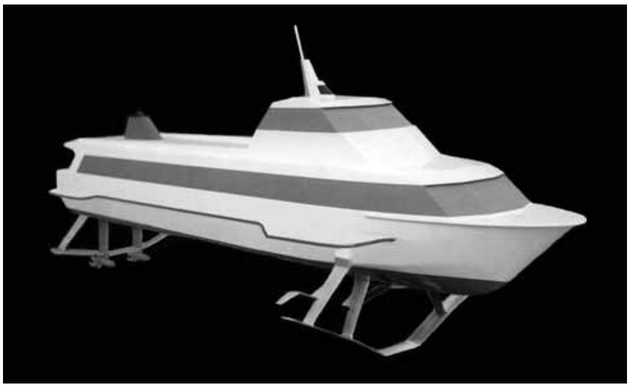

Figure 3: Artists impression of proposed 150 passenger surface piercing hydrofoil
(Image Søren Struntze)

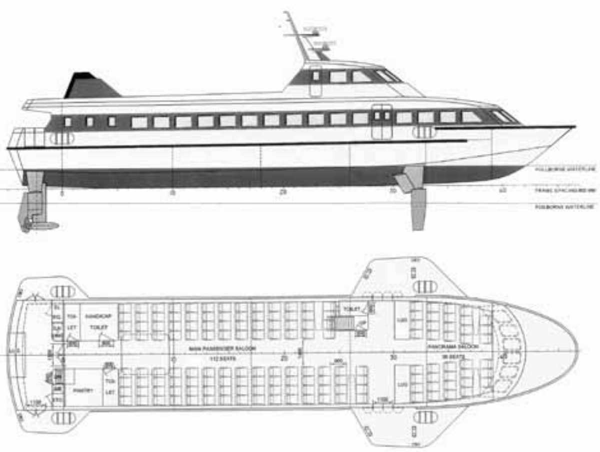

Figure 4: Arrangement drawing for conceptual 150 passenger hydrofoil

Principal particulars of proposed hydrofoil:

Length OA	31.2 m
Beam (over bow sponsons)	10.4 m
Full load displacement	70 t (approx)
Draft (hullborne)	3.5m
Passenger capacity	150
Service speed	35 knots
Propulsion engines	2 × MTU 12V 2000 M72
Propulsion power	2 × 1080 kW at 2250 RPM
Fuel Consumption (at 35 knots)	400 kg/hour

Assessment of Operating Costs

For the fast ferry service, we propose a weekday timetable as shown in Table 1. Utilising this timetable, and based on estimated production costs, the predicted propulsion performance of the hydrofoil, and extrapolation of data on the running costs of other fast ferry services, we have estimated the required ticket price for such a service.

Vessel	Depart Circular Quay	Arrival Manly	Depart Manly	Arrival Circular Quay
1	6:00	6:15	6:20	6:35
2	6:20	6:35	6:40	6:55
3	6:40	6:55	7:00	7:15
1	6:55	7:10	7:15	7:30
2	7:05	7:20	7:25	7:40
3	7:20	7:35	7:40	7:55
1	7:35	7:50	7:55	8:10
2	7:45	8:00	8:05	8:20
3	8:00	8:15	8:20	8:35
1	8:15	8:30	8:35	8:50
2	8:25	8:40	8:45	9:00
3	8:40	8:55	9:00	9:15
1	8:55	9:10	9:20	9:35
2	9:10	9:25	9:40	9:55
3	9:35	9:50	10:00	10:15
3	16:15	16:30	16:35	16:50
1	16:30	16:45	16:50	17:05
2	16:45	17:00	17:05	17:20
3	17:00	17:15	17:20	17:35
1	17:15	17:30	17:35	17:50
2	17:30	17:45	17:55	18:10
3	17:45	18:00	18:05	18:20
1	18:00	18:15	18:20	18:35
2	18:15	18:30	18:35	18:50
3	18:30	18:45	18:50	19:05
1	18:45	19:00	19:05	19:20
2	19:00	19:15	19:20	19:35
3	19:25	19:40	19:45	20:00
2	19:40	19:55	20:05	20:20
3	20:05	20:20	20:25	20:40
2	20:20	20:35	20:45	21:00

Table 1: Weekday timetable proposed for hydrofoil service

We would recommend the acquisition of five identical hydrofoils of which three would be in operation during peak periods with a fourth on standby and the fifth undergoing scheduled maintenance at any one time. This is the situation which had existed at the height of hydrofoil operations on Sydney Harbour and which allowed each boat to be taken into a complete overhaul every 12 months. However, given the high initial cost of such a strategy, it would also be feasible to achieve the timetable with only four boats. Even though this comes with the risk that any failure of an operational boat may occasionally lead to service cancellations, which may impact on patronage over time, our cost estimates are based on the latter approach.

As no hydrofoils (other than hydrofoil-assisted catamarans) have been built in Australia, and contract prices for shipbuilding projects are in any case not routinely reported, it is difficult to estimate a production cost. However based on re-scaling of reported costs for the Supercats and Red Jet 4 built by NWBS in 2002–03 [5], we estimate that a 150-passenger hydrofoil may be able to be built for about \$4.5 million in Australia today. In comparison, the 320 passenger *Ocean Dreaming 2,* recently delivered to Bass and Flinders Cruises, has reportedly been built for \$4 million. There would undoubtedly be some reduction in acquisition cost if a single order for four or five identical hydrofoils was made with a shipyard under a tightly-managed contract.

Engine maintenance is likely to be a reasonable contributor to operating costs and, certainly, to the reliability of the service. It might be sensible to enter into a long-term support contract with an engine manufacturer for maintenance of engines based on an agreed rate per hour of usage. This would place the onus on the manufacturer, as much as the designer, to ensure that the most-suitable engine type is selected for this service. In any case, to ensure that a reliable service can be maintained, spare engines should be purchased for the operation to allow a quick turn-around when major engine maintenance is required or if major engine faults develop.

To minimise operating costs, it is clearly important that the number of staff required to operate the service is minimised. For a similar hydrofoil service operating on a 12 n mile route between Velsen and Amsterdam in the Netherlands, with a fleet of four hydrofoils and a peak timetable operating two boats, Fast Flying Ferries had a total staff of only 14 [6]. However this number is based on each 79-passenger hydrofoil being crewed with only two captains who alternate roles. For another (formerly) popular and successful hydrofoil service on the 9.9 n mile route between Southampton and Cowes, eight crew were employed by Red Funnel to operate a service with a three-boat peak-period timetable similar to our proposal [7]. The crew in this case consisted of captain, engineer and deckhand, which is consistent with the former Sydney hydrofoils. At that time, Red Funnel employed only one shore-based engineer working exclusively on hydrofoils, with all major repairs and overhauls contracted out [7]. Our cost estimates are based on the assumption of a company with a total of 32 personnel, including administrative and shore-support staff and seven crews (consisting of captain, engineer and deckhand) required to maintain the three-boat peak-period timetable. This is dictated by the requirement for rosters to be limited to 12 hours or less from a safety perspective, thus necessitating two shifts per day. We assume that only seven administration and shore-support staff and four maintenance personnel are engaged. Some shore personnel may also be qualified masters or engineers to cover unexpected absences of rostered crew members. Staff salaries are based on those of the equivalent Sydney Ferries employees, with allowances for superannuation and workers compensation contributions. It should be noted that a 150-passenger capacity is the limit before two deckhands are required (for emergency mustering of passengers).

Maintenance costs take into consideration engine and drive-train maintenance, docking and coating maintenance, diving and hull cleaning and refurbishment costs, although these are difficult to estimate accurately. We have attempted to factor in the differences between boat types and sizes in the comparisons below.

Fuel cost is a major proportion of the total operating cost of a fast ferry. There is no doubt that a ferry operating at around 35 kn will have higher fuel consumption than one operating at a service speed of 24 kn as was the case for the Supercats when they operated on the Circular Quay to Manly run. These catamarans are reported by one source to have a fuel consumption of only 155 L per hour [8]; however, given their use of twin MTU 12V 2000 M60 engines, this was more likely to have been 310 L per hour. While we lack detailed powering analysis for the proposed 150-seat hydrofoil based on published fuel consumption figures for other hydrofoils, particularly *Kolkhida*, with a similar capacity and speed, we conservatively estimate that the design would have a fuel consumption of 475 L per hour at a fully-laden service speed of 35 kn. It is important to note that hydrofoils are able to maintain foil-borne cruising speeds at only 60–70% of engine power [9] [10] and, as such, fuel consumption can be considerably lower than derived from simple consideration of specific fuel consumption at MCR. With the use of a Z-drive in place of inclined shafts to reduce foil-borne resistance and increase propulsive efficiency, fuel consumption should be able to be further reduced over traditional hydrofoil designs of similar size.

In comparison to the 13–15 minute trip time offered by the hydrofoils, the requirements imposed by the NSW Government for the interim fast-ferry service sets a more leisurely maximum trip time of 20 minutes which provided considerable flexibility in the choice of boats that could be tendered for the service. This requirement was, no doubt, chosen to cater for readily-available boats on the east coast. This has allowed Bass and Flinders Cruises to offer a scheduled crossing time of 18 minutes giving them the ability to operate boats with cruising speeds from 22 knots (such as the initially chartered *Fantasea*) upwards. It also allows their newest vessel, *Ocean Dreaming 2*, to operate at a cruising speed significantly less than the 33 kn of which she is reported to be capable, while still achieving the scheduled timetable with associated savings in fuel consumption and operating cost.

For insurance cost, including public liability, we have allowed an annual cost of 3% of the capital cost of the boats. Fixed overhead costs include allowances for office rental and utilities, vehicles, wharf usage, advertising, annual surveys and associated classification society fees.

In an effort to contain ticket price, we have assumed a profit margin of only 10% on top of which taxes must be included. Considering the investment involved and the considerable variability in fuel and maintenance costs which may occur, we recognise this slim profit margin would probably not be considered sensible in most business sectors.

As a benchmark for comparison with the hydrofoil service, we initially present an operating-cost estimate for a service along the lines of the current operation by Bass and Flinders Cruises (with equivalent cost assumptions to the hydrofoil service as far as appropriate). We estimate that an average ticket price of $12.60 would be necessary for such a service utilising two new 320-passenger catamaran ferries with a third new catamaran in reserve. This is based on carriage of around 700 000 passengers per year during weekdays as achieved by the Jetcats. This corresponds to an average load factor of 28% for the catamarans. We have not accounted for the fact that such catamarans will be used for whale watching or charter while not operating the Circular Quay to Manly run. Naturally this greater utilisation of the boats and the associated additional revenue stream would allow a lower fare to be charged for the commuter service. This, and other proprietary cost information, would go some way to explaining why the company is able to offer a ticket price between $6.72 and $8.20. Table 2 provides a summary of our estimated cost components for a catamaran service assuming a cruising speed of 28 knots is adopted.

Unfortunately, it is difficult to quantify the influence that variations in departure frequency and crossing time would have on the patronage of a fast-ferry service. As a consequence, we have simply calculated the required load factor such that the hydrofoil service could operate at the same ticket cost as we have calculated for the catamaran service described above. For a $12.60 ticket price for the more-frequent operating schedule of the 35 kn hydrofoil service, a 37% average load factor would be required. This corresponds to approximately 908 000 passengers being carried per year. This target does not seem insurmountable given the attraction of the more-frequent departures and 13 minute crossing time. As a first approximation, the required ticket price as a result of increased or reduced passenger patronage will be inversely proportional to the average load factor achieved. As an example, if the hydrofoils achieved an average load factor of 50%, corresponding to around 1 200 000 passengers being carried a year, then the ticket price could be reduced to $9.45. Further details of the cost estimates made for this analysis are provided in Table 2.

Overall Operating Assumptions:	28 knot Catamarans	35 knot Hydrofoils	
Number of boats in fleet:	3	4	
Number of boats required for weekday schedule:	2	3	
Number of boat crews employed:	5 x 4 man	7 x 3 man	
Passenger capacity per boat:	320	150	
Revenue Earning Trips (one way) completed	150	310	pw
Average Achieved Load Factor (% of capacity)	28	37	%
Average Achieved Passenger Load per trip	89	56	
Number of passengers carried at	700 000	907 788	pa
Total number of staff in company	31	32	
Boat Technical Data:			
Cruising Speed	28	35	knots
Total Propulsion Fuel Consumption at cruise	384	461	L/hour
Total Fuel Consumption of genset(s)	14	14	L/hour
Total Installed Power for propulsion (MCR)	2088	2160	kW
Capital Costs:			
Invested cost per boat =	$4 000 000	$4 500 000	
Invested cost of fleet =	$12 000 000	$18 000 000	
Interest Rate (PA)	7.5	7.5	%
Service Life and repayment period	15	15	years
Fixed Capital re-repayments:	$1 334 898	$2 002 347	pa
Maintenance Cost (other than wages):			
Total maintenance cost per boat	$140.43	$122.60	/ hour
Maintenance cost for entire fleet:	$602 894	$788 435	pa
Insurance:	$360 000	$540 000	pa
Fixed Non-Salary Overheads:	$597 400	$704 100	pa
Administrative & Shore Personnel Costs:	$675 200	$675 200	pa
Maintenance Personnel Costs:	$516 240	$516 240	pa
Crew Costs:	$2 145 000	$2 345 000	pa
Fuel and Lub Oil Consumption and Costs:			
Fuel Use per trip	84.3	79.0	L
Lub Oil Use per trip	1.3	0.7	L
Unit Fuel Cost:	$1.20	$1.20	/L
Unit Lub Oil Cost:	$4.50	$4.50	/L
Fuel Cost	$101.18	$94.83	/trip
Lub Oil Cost	$6.00	$3.12	/trip
Total Fuel & Lub Oil Cost for fleet:	$1 061 844	$1 889 739	pa
Total Fleet Running Cost:	$7 293 475	$9 461 060	pa
Ticket Price calculations:			
Trip cost per passenger:	$10.42	$10.42	
Profit Margin	10	10	%
Goods & Services Tax (GST)	10	10	%
Average Required Ticket Price (one way)	**$12.60**	**$12.60**	

Table 2: Estimate of operating cost and ticket price for catamaran and hydrofoil fast-ferry services.

It should be noted that part of the reason that the load factor is relatively low and ticket price is reasonably high is because, for the Sydney-Manly run, in the morning the boats make the return trip to Manly nearly empty, and in the afternoon the opposite is the case. The average load factor is therefore unlikely to exceed 50% regardless of the quality of the service and the support of commuters. This problem remains regardless of the type of vessel selected for the service.

Conclusions

The calculation of the operating cost of fast ferries, particularly those not yet in service, is subject to considerable uncertainty. However we have demonstrated that it could be feasible to operate a passenger hydrofoil service on Sydney harbour that brings back a 10–15 minute departure frequency and a 13 minute crossing time with a 35 kn cruise speed from Manly to Circular Quay. This could be achieved at a ticket price comparable to that of a slower 300+ seat catamaran ferry, provided an average load factor of 37% could be achieved (~908 000 passengers per year) compared to 28% for the catamaran service (~700 000 passengers per year). We believe that the higher departure frequency and faster crossing time combined with good customer service and a reliable operation using stylish vessels, would attract more Manly commuters to this service, thereby achieving higher annual utilisation than that achieved for the JetCats. Higher utilisation in turn helps to reduce ticket price.

Even with such utilisation rates, we consider that it would be necessary to charge an average ticket price of at least $12.60 for a single ticket to make a modest return on investment for the operator. The difficulty for any private operator will be to increase ticket price to at least this amount from its current level without loosing patronage in the process. In practice, we feel that a degree of government subsidy is likely to be required if a true high-speed ferry service is to be maintained on Sydney Harbour in the long run.

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COMPUTATIONAL ANALYSIS OF SUBMARINE PROPELLER HYDRODYNAMICS AND VALIDATION AGAINST EXPERIMENTAL MEASUREMENT

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The hydrodynamic performance of a submarine propeller is critical to its operational capability. A well-designed propeller provides optimum speed and endurance with minimum vibration and acoustic emission. Within DSTO, there exists an ongoing research program which addresses the modelling of submarine hydrodynamic performance using both computational and experimental techniques. Together with the University of Tasmania (Australian Maritime College) and industry, DSTO has been undertaking detailed open-water studies of submarine propellers. This paper describes CFD calculations of a generic seven-bladed propeller which were performed over a range of advance numbers using the commercially-available CFD codes: CFX 11.0 and FLUENT 6.3.26. The results of these calculations were subsequently validated against propeller curves obtained from experimental measurements of the propeller made in the Tom Fink Cavitation Tunnel at the Australian Maritime College.

The calculated thrust and torque were found to be in good agreement with the experimental measurements over the range J=0.5–0.9, with thrust and torque predicted by both codes being within 4% and 5% of the measurements, respectively. The relative difference between the CFD calculations and experimental measurement increased for larger advance numbers. The CFX results for thrust and torque were found to be in closest overall agreement with the experimental measurements over the range of advance numbers calculated, whereas FLUENT provided the closest overall agreement for open-water efficiency. The propeller slipstream appeared to be well resolved close to the propeller where the mesh provided good resolution of the flow field. However the slipstream circumferentially mixed out whilst retaining a distinct radial variation. This may be attributed to a combination of mesh resolution and turbulence modelling. Future research will provide experimental measurements with which to validate the slipstream.

NOMENCLATURE

D	Propeller diameter (m)
J	Advance number
K_Q	Torque coefficient
K_T	Thrust coefficient
n	Rotational speed (rps)
Q	Propeller torque (Nm)
r	Radial location (m)
R	Propeller radius (m)
T	Propeller thrust (N)
V_A	Advance velocity (ms^{-1})
ρ	Density of water (kg/m^3)
η_o	Propeller open-water efficiency
μ	Dynamic viscosity ($kgm^{-1}s^{-1}$)

1. INTRODUCTION

The hydrodynamic performance of a submarine propeller is critical to its operational capability. A well-designed propeller provides optimum speed and endurance with minimum vibration and acoustic emission. Computational fluid dynamics (CFD) based on the solution of the Reynolds-averaged Navier Stokes (RANS) equations has been widely used to predict propeller hydrodynamics.

Throughout this paper we will restrict the application of the term "CFD" to refer to CFD methods based on the solution of the RANS equations, to distinguish it from CFD approaches based on the vortex lattice method (VLM) and boundary element method (BEM) such as the "panel method".

While there have been many experimental validation studies undertaken for surface-ship propellers, and although there has been published work on a submarine propeller in crashback or crashstop conditions [1, 2], based on a 5-bladed propeller with no skew or rake, there is still limited CFD data on submarine propellers. This is presumed to be due to the classified nature of the work. Some submarine propellers provide a unique geometry compared with other marine propellers. The main difference is the combination of relatively high skew, rake and aspect ratio, and the increased number of blades (sometimes up to 7), required for high power and minimum vibration and acoustic levels [3]. Therefore it is useful to undertake studies on non-military designs in an open forum which facilitates general discussion on the nature of the performance and the tools used for the analysis of such propellers.

Furthermore, with the capability to model the propeller and the submarine hull [4, 5] to a good level of accuracy, a natural extension is to model the complete propulsor/hull hydrodynamic system. This "whole systems" modelling approach can provide a powerful tool for improved hydrodynamics, avoidance of flow problems, and reduced acoustic signature associated with straight-ahead and manoeuvring conditions. An example of the application of a "whole systems" approach to the CFD modelling of a propeller and an underwater body (in this case an electric pod unit) is described in [6].

This paper provides results from a study on submarine propeller hydrodynamics which forms part of a larger research program, within DSTO, on submarine platform performance. In this paper, the performance curves of a generic seven-bladed propeller model (see Figure 1), based on geometry in Huang [7] with the blade sections in Brockett [8], are calculated using two commercially-available CFD codes: CFX 11.0 and FLUENT 6.3.26, which are validated against measurements obtained from experimental testing conducted at the Australian Maritime Hydrodynamics Research Centre (AMHRC) Cavitation Tunnel. The propeller performance was investigated by conducting an open-water test for two rates of revolution while varying the tunnel free-stream velocity to study the effect of Reynolds number variation.

This paper considers only the case of the lower Reynolds number range with a propeller rotational speed of 900 RPM. In Section 2 the experimental testing used to obtain the reference experimental validation data is discussed. The computational methodology underlying the CFD calculations is outlined in Section 3. In Section 4, the propeller curves obtained using CFD are compared with experimental measurements and conclusions drawn as to the accuracy of RANS CFD. The calculated flow field downstream of the propeller is examined in Section 5. It must be noted that the propeller slipstream has not been validated against experimental measurements. A discussion of the results is presented in Section 6. The conclusions of the study are presented in Section 7. An outline of the research program for on-going submarine propeller work is presented in Section 8.

2. EXPERIMENTAL TESTING

A range of advance numbers from 0.459 to 1.364 were tested, where the advance number is defined as

$$J = \frac{V_a}{nD} \tag{1}$$

and V_a is the speed of advance of the propeller, n the rotational speed of the propeller in revolutions per second and D is the propeller diameter.

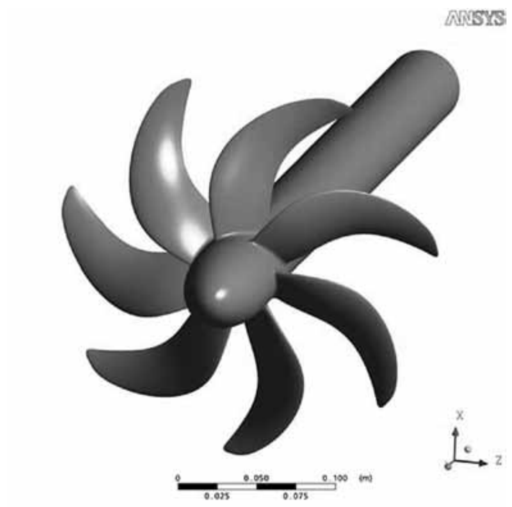

Figure 1: CAD image of propeller

Propeller diameter	250 mm
Hub diameter	52 mm
Number of blades	7
Expanded blade area ratio	0.61
Design pitch ratio at 0.7R	1.25
Projected skew angle	29°

Blade section: NACA 66 Modified Nose Tail [8]

Table 1: Propeller Description

Tests were performed in the AMHRC Tom Fink Cavitation Tunnel, a closed recirculating variable-pressure water tunnel. The test section has a 0.6 m × 0.6 m cross section and is 2.6 m long. The velocity may be varied from 2 to 12 m/s and the centreline static pressure from 4 to 400 kPa absolute. Studies may involve the investigation of steady and unsteady flows, two-phase flows including cavitation, turbulence and hydro-acoustics. Details of the tunnel setup and operation are given in Brandner et al. [9]. The propeller dynamometer characteristics are given in Table 2.

Max Diameter	300mm
Max mean thrust	500N
Max mean torque	50Nm
Max rate of revolutions	33Hz

Table 2: Propeller Dynamometer Details

Figure 2: Propeller Dynamometer Schematic

3. COMPUTATIONAL MODELLING

The computational modelling used as the basis of the experimental validation study is described below.

The geometry of the propeller and propeller hub was supplied as CAD geometry in STEP format. The computational flow domain extended radially out to a cylindrical wall surface located to give the same cross-sectional area as the cavitation tunnel test-section. This resulted in circumferential periodicity of the flow domain geometry, requiring the modeling of a 51.43° sector only, or in other words, one blade rather than seven. Since open-water flow is being considered and, with the assumption of circumferential periodicity of the flow domain, it was only necessary to model the flow around one blade.

A hybrid mesh of 1 259 103 cells was generated for calculating flow around a single blade using FLUENT's preprocessor Gambit. The meshing strategy adopted was focussed on producing a high-quality mesh around the blade in order to resolve flow features and boundary layers on the blade, as well as producing good resolution of blade wakes and vortices a certain distance downstream. Fig. 3 shows the surface mesh of the propeller. This figure was generated by copying and rotating the actual surface mesh used in the CFD model.

The commercially-available CFD codes CFX 11.0 and Fluent 6.3.26 were used for calculating the flow around the propeller. In order to properly compare the results obtained by the codes in a consistent manner, the Standard k-ε turbulence model was used to effect turbulence closure. The FLUENT calculations used the "Enhanced" wall function with the pressure-gradient effects option to effect turbulence closure in the near-wall region, whereas the CFX calculations used CFX's scalable wall function. FLUENT's Quick scheme was used for convective differencing for hexahedral cells, together with standard pressure interpolation. Whilst the limitations of the standard k-ε turbulence model are widely known, the model provides a good basis for a first benchmark experimental validation study. For the sake of brevity, the equations of the above-mentioned turbulence modeling will not be repeated here, rather the interested reader is referred to the CFX and FLUENT User Guides [10] and [11], respectively, and the references cited therein.

Calculations were run over the complete range of advance numbers tested. If the calculation of propeller curves is of primary interest, the calculation can be deemed to have converged when the thrust and torque acting on the propeller reach either a "constant" value or a periodically oscillating value. However, since the development of the downstream slipstream is of interest in this case, it is necessary to ensure that the downstream flow field converges. The convergence of the velocity at selected points in the downstream flow field was therefore monitored. Calculations were stopped when the thrust, torque and downstream velocity reached constant values or oscillated about a constant value.

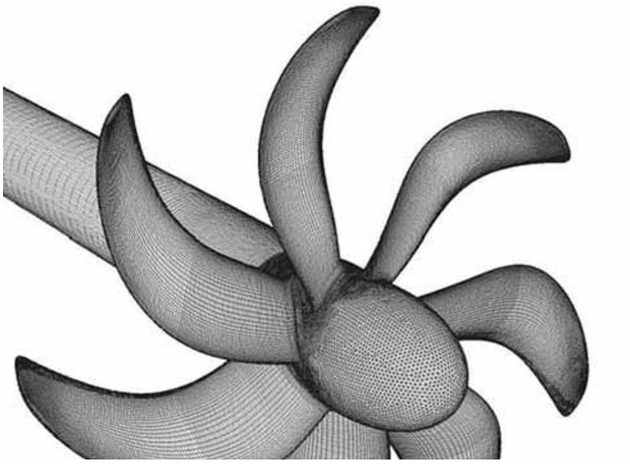

Figure 3: Surface mesh

4. EXPERIMENTAL VALIDATION

4.1 PROPELLER CURVES

The computational results are compared with the experimentally measured values of thrust coefficient (K_T), torque coefficient (K_Q) and propeller open-water efficiency (η_o) in Fig. 4 and Table 3. These coefficients are defined as

$$K_T = \frac{T}{\rho n^2 D^4} \tag{2}$$

$$K_Q = \frac{Q}{\rho n^2 D^5} \tag{3}$$

$$\eta_o = \frac{J}{2\pi} \frac{K_T}{K_Q} \tag{4}$$

where T is the thrust produced by the propeller, Q is the torque absorbed by the propeller, J is the advance number, ρ is the density of water, n the rotational speed of the propeller in revolutions per second, and D is the propeller diameter. Eight points on the characteristic curves, calculated using both codes, are tabulated in Table 3. The propeller design point is at J=1.0.

The experimental measurements shown in Fig. 4 correspond to a propeller rotational speed of 900 RPM. Error bars corresponding to a *relative* margin of 10% are shown about the experimental measurement points in order to allow visual assessment of the difference between the CFD results and the experimental measurements. The experimentally-measured values of thrust and torque in Table 3 have been linearly interpolated from the measurement points shown in Fig. 4, whereas open water efficiency has been calculated from these interpolated values.

The following is evident from the results:

1) Closest agreement with measured thrust and torque is obtained from the CFX results over the range of advance numbers calculated.
2) CFX produces a consistent under-prediction, whilst FLUENT produces a consistent over-prediction of torque over the range of advance numbers calculated.
3) The FLUENT results show a trend of increasing relative torque over-prediction with increasing advance number. The CFX results show increasing relative torque under-prediction for $J \geq 1.1$.
4) CFX produces a maximum relative difference in torque of –2.74% over the range of $0.5 \leq J \leq 1.10$. This value changes slightly to -3.49% over the range of $0.5 \leq J \leq 1.15$.
5) For advance numbers where positive thrust is produced CFX over-predicts the thrust, with a trend of increasing relative over-prediction.
6) For $J<0.9$, FLUENT under-predicts the thrust, but over-predicts thrust with increasing advance number, with a trend of increasing relative over-prediction.
7) CFX produces a maximum relative difference in thrust of 3.03% over the range of $0.5 \leq J \leq 0.9$. Over the range of $0.5 \leq J \leq 1.1$ the maximum relative error is within 10% of the experimental measurements.
8) Interestingly, for both codes for $J \geq 1.0$, there is little change in the absolute difference between the calculated and measured thrust. The increasing *relative* over-prediction is therefore a result of the increasingly small value of the thrust coefficient.
9) The CFX results show a trend of efficiency over-prediction, whilst the FLUENT results show a trend of efficiency under-prediction. FLUENT provides the closest overall agreement with the experimental measurements.
10) At J=1.0, which is close to the peak efficiency, FLUENT under-predicts this efficiency by 2.6%. CFX over-predicts this efficiency by 6.89%. The trend of efficiency over-prediction by CFX is due to an over-prediction of thrust and an under-prediction of torque over the range of advance numbers calculated.

4.2 BLADE LOADING

Whilst the pressure distribution on the propeller blades has not been validated, it is still of interest to understand how the calculated blade pressure loading changes with advance number, particularly as this affects the likelihood of cavitation. Fig. 5 shows the pressure distribution over both the pressure and suction sides of the blade at advance numbers of 0.5, 1.0 and 1.2. The pressure distribution over the blade has been plotted as a pressure coefficient defined by

$$C_p = \frac{(p - p_{ref})}{\frac{1}{2}\rho n^2 D^2} \tag{5}$$

where p_{ref} is a reference pressure. The results show:

1) At J=0.5, the blade is heavily loaded on both its pressure and suction sides. The pressure distribution suggests relatively high positive incidence on blade sections near the tip, resulting in low pressure on the suction side of these sections and the formation of a strong tip vortex. The lowest pressure occurs on the leading edge of the suction side of the blade towards the tip.

2) At J=1.0, there appears to be negative incidence on the blade at the lower blade sections, changing to positive incidence for blade sections near the tip. The lowest pressure region on the blade occurs on the suction side between approximately 25% and 75% of the chord length from the leading edge and runs from mid-span to the tip.

3) At J=1.2, there is clearly negative incidence on the blade sections. The lowest pressures on the blade therefore occur at the leading edge on the pressure side of the blade.

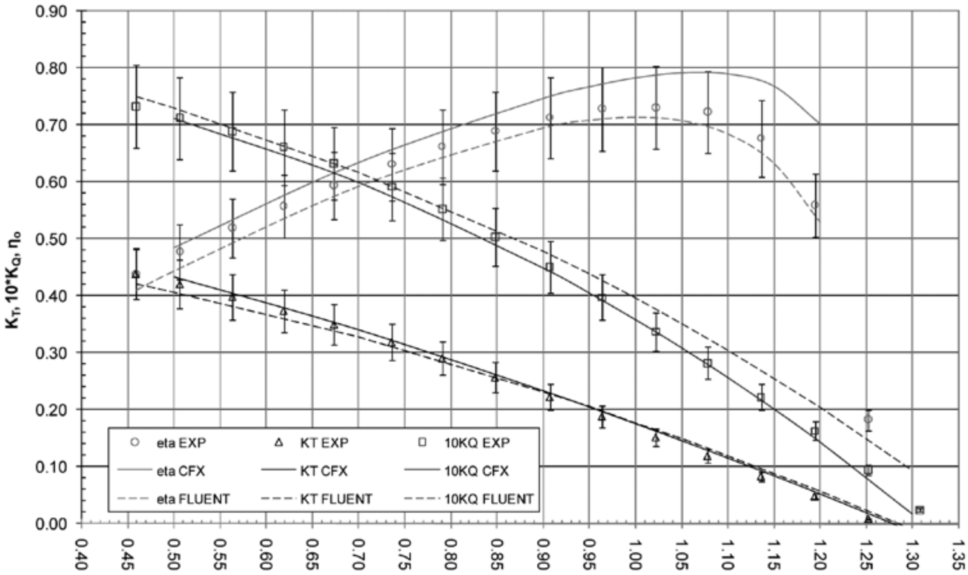

Figure 4: Comparison of calculated and measured propeller diagram

J	0.50	0.70	0.90	1.00	1.10	1.15	1.20	1.30
Calculated K_T – CFX	0.434	0.341	0.234	0.176	0.116	0.084	0.053	-0.014
Calculated K_T - FLUENT	0.407	0.328	0.233	0.178	0.119	0.088	0.057	-0.010
Measured K_T	0.424	0.337	0.227	0.166	0.105	0.075	0.044	-0.025
Abs. Error K_T – CFX	0.010	0.004	0.007	0.010	0.010	0.010	0.008	0.011
Abs. Error K_T – FLUENT	-0.017	-0.008	0.006	0.012	0.014	0.014	0.012	0.015
Rel. Error K_T – CFX	2.37%	1.11%	3.03%	6.19%	9.62%	12.70%	18.86%	-45.03%
Rel. Error K_T – FLUENT	-3.91%	-2.50%	2.56%	7.44%	13.17%	18.13%	28.06%	-60.06%
Calculated $10*K_Q$ – CFX	0.711	0.598	0.448	0.358	0.256	0.201	0.143	0.017
Calculated $10*K_Q$ – FLUENT	0.731	0.619	0.480	0.397	0.305	0.256	0.204	0.094
Measured $10*K_Q$	0.715	0.615	0.457	0.360	0.260	0.208	0.157	0.035
Abs. Error $10*K_Q$ – CFX	-0.004	-0.017	-0.009	-0.002	-0.003	-0.007	-0.014	-0.018
Abs. Error $10*K_Q$ - FLUENT	0.016	0.003	0.023	0.037	0.046	0.048	0.048	0.059
Rel. Error $10*K_Q$ – CFX	-0.54%	-2.74%	-1.95%	-0.65%	-1.30%	-3.49%	-8.73%	-51.68%
Rel. Error $10*K_Q$ - FLUENT	2.23%	0.53%	4.98%	10.31%	17.63%	22.82%	30.34%	169.73%
Calculated Eta – CFX	0.485	0.634	0.746	0.782	0.789	0.768	0.702	-1.680
Calculated Eta – FLUENT	0.443	0.592	0.694	0.713	0.684	0.632	0.530	-0.219
Measured Eta	0.472	0.609	0.710	0.732	0.711	0.658	0.539	-1.477
Abs. Error Eta – CFX	0.014	0.025	0.036	0.050	0.079	0.110	0.163	-0.203
Abs. Error Eta – FLUENT	-0.028	-0.018	-0.016	-0.019	-0.027	-0.025	-0.009	1.258
Rel. Error Eta – CFX	2.93%	4.06%	5.08%	6.89%	11.06%	16.78%	30.23%	13.75%
Rel. Error Eta - FLUENT	-6.00%	-2.92%	-2.31%	-2.60%	-3.79%	-3.82%	-1.75%	-85.19%

Table 3: Comparison of differences between CFD and measurement

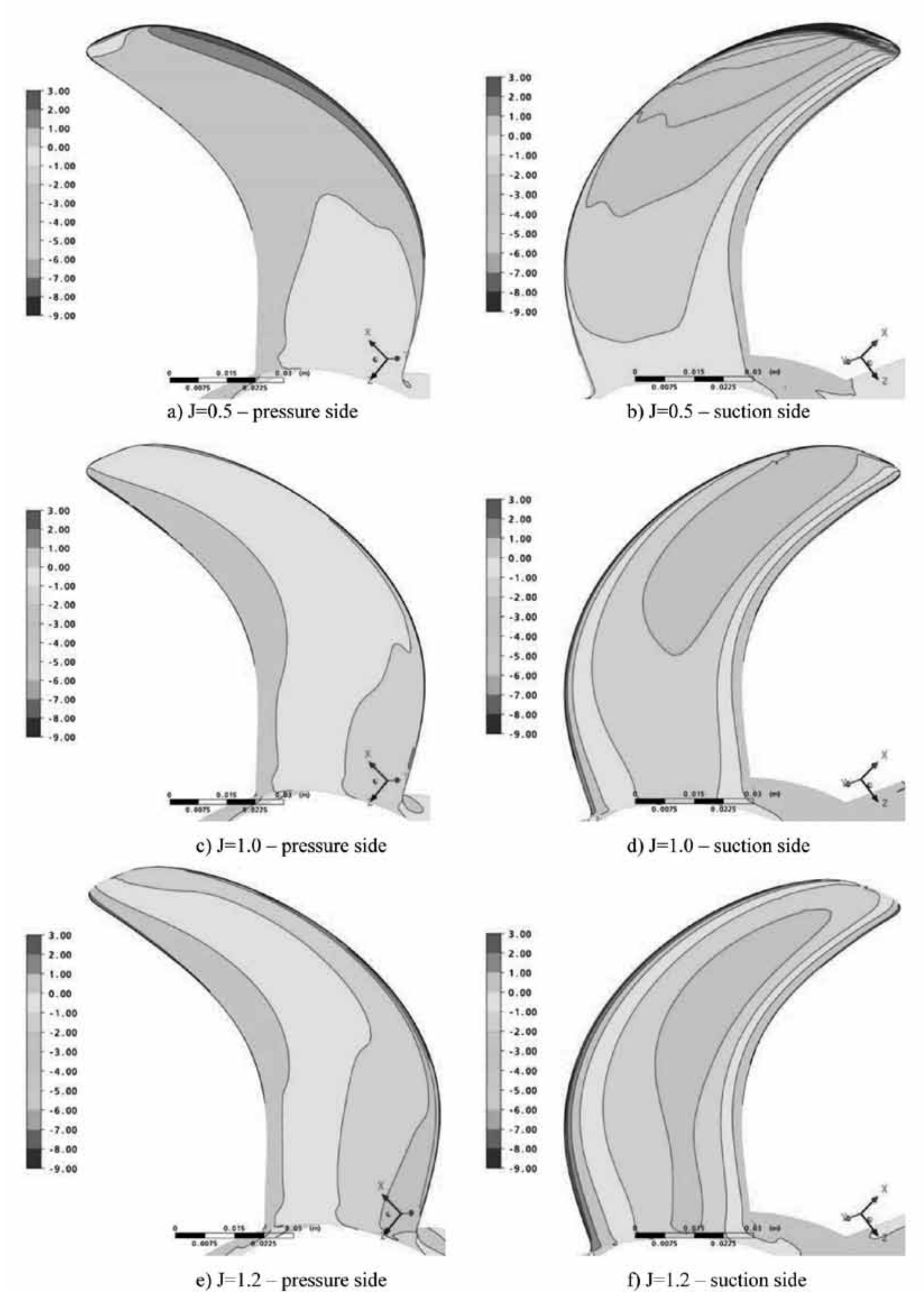

Figure 5: Variation of blade pressure loading with advance number

5. DOWNSTREAM SLIPSTREAM

Fig. 7 provides visualisation of the tip vortex obtained from the CFX results for advance numbers of 0.5, 1.0 and 1.2. A relatively-intense tip vortex is seen for J=0.5. At J=1.0, a less intense tip vortex is seen and at J=1.2, a tip vortex does not appear to be present. At J=0.5 and J=1.0 the tip vortex appears to lose its helicity a certain distance downstream from the tip. This is due to mesh resolution. Hub vortices have not been included in Fig. 7, as they do not appear to be predicted by CFX at these advance numbers.

The observed tip vortex behavior reflects the difference in pressure loading between the pressure and suction sides of the blade at the tip that is evident in Fig. 5. Recall that the blade tip is heavily loaded at J=0.5, while at J=1.2, the blade tip is lightly loaded.

The axial, radial and tangential velocities calculated using CFX for advance numbers of 0.5, 1.0 and 1.2 have been plotted in Figs. 8–10 for axial locations of 12% and 100% of the propeller diameter downstream of the reference plane at Y=0 m as shown in Fig. 6. In Figs. 8–10 the plotted velocity component has been non-dimensionalised by the axial velocity at inflow to the modeled flow domain. In these figures, the view is from upstream looking downstream and the propeller rotation is in an anti-clockwise direction. It must be noted that in Fig. 10, negative circumferential velocity indicates anti-clockwise rotation of the fluid. This is because the circumferential velocity was non-dimensionalised by the axial velocity which is negative in the coordinate system used.

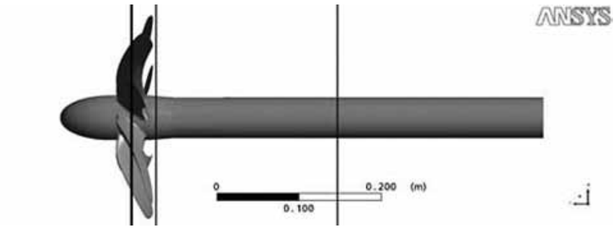

Figure 6. Axial reference planes

The CFX rather than the FLUENT results have been plotted as these provide the closest agreement with the experimental measurements for thrust and torque for each of these three advance numbers.

A careful examination of the figures reveals the following:

1) At a distance of 0.12D downstream of the propeller axis, a good resolution of the flow-field has been achieved for each of the three advance numbers. The wake from each blade boundary layer is clearly evident together with the tip vortex.
2) At a distance of 1.00D downstream of the propeller axis, the axial and tangential velocity components have become relatively circumferentially uniform. In this case the tip vortex and the wakes from the blade boundary layer have been "mixed out". This "mixing out" is less evident with the radial velocity component. There is however, a well resolved radial variation of velocity components.
3) Average slipstream velocity components at both downstream axial locations decrease with increasing advance number.
4) Slipstream contraction between the two axial locations is clearly evident from Fig. 8, for J=0.5, with both an increase in axial velocity and a reduction in the diameter of the slipstream.
5) Fig. 10 reveals that for J=0.5, the propeller induces rotational flow in the direction of propeller rotation well beyond its radius. The magnitude of non-dimensional circumferential velocity decreases with increasing advance number. Toward the radial boundary of the flow domain, rotation is induced in the opposite direction to the propeller rotation in order to conserve angular momentum.

6. DISCUSSION OF RESULTS

The results presented in this report represent initial experimental validation of computational analysis based on robust k-ε turbulence modelling. The computational mesh was generated to use wall functions, rather than resolving the boundary layer into the viscous sub-layer. This strategy was based on the good agreement between CFD and experimental measurements obtained on previous CFD propeller studies for high-skew propellers by Seil et. al. [12].

It must also be noted that in the experimental model testing, laminar regions are likely to extend from the leading edge of the blade downstream along the chord before a transition to turbulent flow occurs [13]. Defining Reynolds numbers based on chord length at r/R=0.70 as

$$Re_{0.7} = \frac{\rho c\sqrt{\left(V_a^2 + (0.7\pi nD)^2\right)}}{\mu} \tag{6}$$

where c is the section chord length and μ is the dynamic viscosity of water, the Reynolds number is approximately 405 000 at J=1.0. The CFD modelling, which used the standard k-ε turbulence model in our study, treats the flow as fully turbulent from the leading edge; this modeling assumption is incompatible with the flow over the physical model since it is expected to be laminar over a significant portion of the propeller blade chord in these experiments. This creates a clear modelling challenge and will lead to differences between the CFD results and the experimental measurements. At higher Reynolds numbers, representative of full-scale operation, the assumptions underlying the CFD modelling are more representative.

A question that naturally arises from the study is why CFX provides a superior prediction of propeller thrust and torque relative to FLUENT. If we make the assumption that both codes have implemented their standard k-ε turbulence models correctly, then the answer may lie in subtle differences in the turbulence model, differences in the near-wall modelling and the adequacy of cell placement close to the wall (for the RPM simulated).

The FLUENT results produced a forward thrust on the hub, which decreased slightly with advance number. At J=0.5 this force constituted 11.6% of the blade thrust and at J=1.20 this contribution increased to 178.7%. FLUENT RNG k-ε results, not presented in this paper, showed a very small positive contribution from the hub which became a small negative contribution with increasing advance number. The calculated hub force is influenced by blade-induced flow velocities, and hence is influenced by the turbulence model. It is therefore clear, that the hub force can have a significant effect on the agreement with the experimental measurements at high J values when the blade forces are relatively small.

Note that our CFD model did not account for the gap between the hub and the shaft in the experimental model and its effect on hub force.

In view of the above discussion, it is clear that achieving good agreement for thrust and torque at high J values will be difficult for the following reasons:

1) Propeller thrust and torque become small and so small absolute errors result in large relative errors.
2) Pressure loading will produce a smaller proportion of the propeller thrust and torque, and viscous shear affects will become more dominant. In view of the likely existence of laminar flow regions on the blade, this makes CFD prediction of the boundary layer development difficult due to the underlying assumptions of completely turbulent flow in the CFD modelling.
3) Hub forces can have a significant effect on the predicted thrust.

Note that in comparing the CFD results with the experimental measurements, the CFD results do not account for the effects of blockage due to tunnel wall boundary layer growth.

It is clear from the results that, whilst the mesh provides good resolution of the propeller slipstream close to the blade (for example at 0.12D downstream of the propeller axis as in Fig. 8-10), it does not provide a good circumferential variation of the slipstream and vortices further downstream; however, radial variations appear to be well maintained. The wake validations of Seil et al. [12] for a four-bladed high-skew propeller show that circumferentially-averaged flow angles tend to be well maintained nevertheless, and this is likely to be the case here too. With further effort into mesh resolution, it is expected that the circumferential variation of the slipstream could be maintained further downstream, despite the limitations of the turbulence modelling.

7. CONCLUSIONS

The results presented in this paper represent an initial experimental validation using the standard k-ε turbulence model with wall functions.

The CFX results were found to provide the best overall agreement with measured thrust and torque over the range of advance numbers calculated, whereas the FLUENT results produce the closest agreement with measured efficiency. There was a trend of increasing thrust over-prediction from both codes with increasing advance number. Closest agreement with experimental measurements for both codes occurred over the range J=0.5–0.9. In this case thrust and torque predictions for both codes were within 4% and 5% of the measurements, respectively.

The CFD calculations provided good detail of the propeller slipstream close to the propeller; however, the slipstream tended to circumferentially "mix-out" with increasing downstream distance.

Further investigation is required in order to:

1) Determine the grid dependency of the results,
2) Explain the differences in results produced by both codes, and
3) Improve the agreement with the experimental measurements, particularly over the range J=1.0–1.3.

8. FUTURE RESEARCH

Detailed measurements of the propeller slipstream will be made for further validation of the computational modelling, which will include steady and unsteady charactersitics of the flow field and surface flow visualisation. Experiments will include tripping the flow from the leading edge to ensure fully-turbulent flow over the propeller blades. Future work will investigate modelling of the complete submarine platform, including the appended hull with propeller, under straight ahead and manoeuvring conditions.

9. ACKNOWLEDGEMENTS

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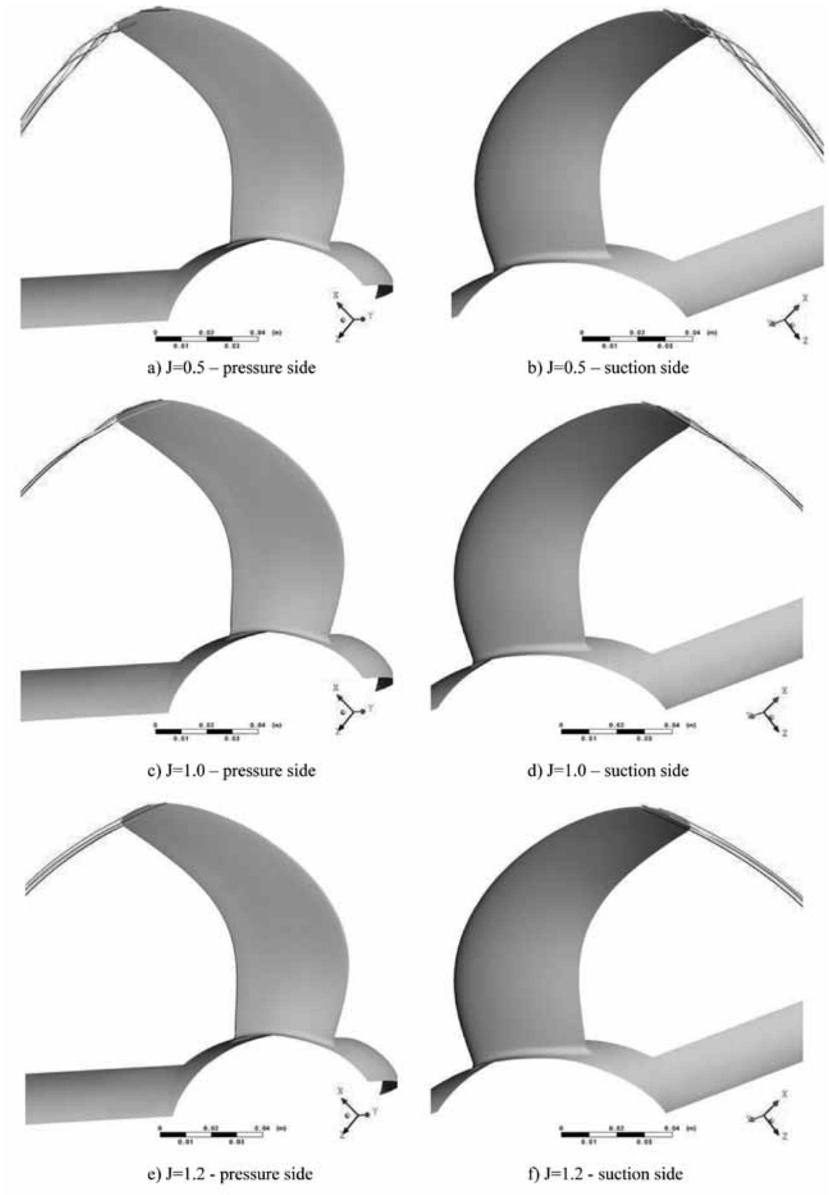


Figure 7: Effect of advance number on tip vortex formation

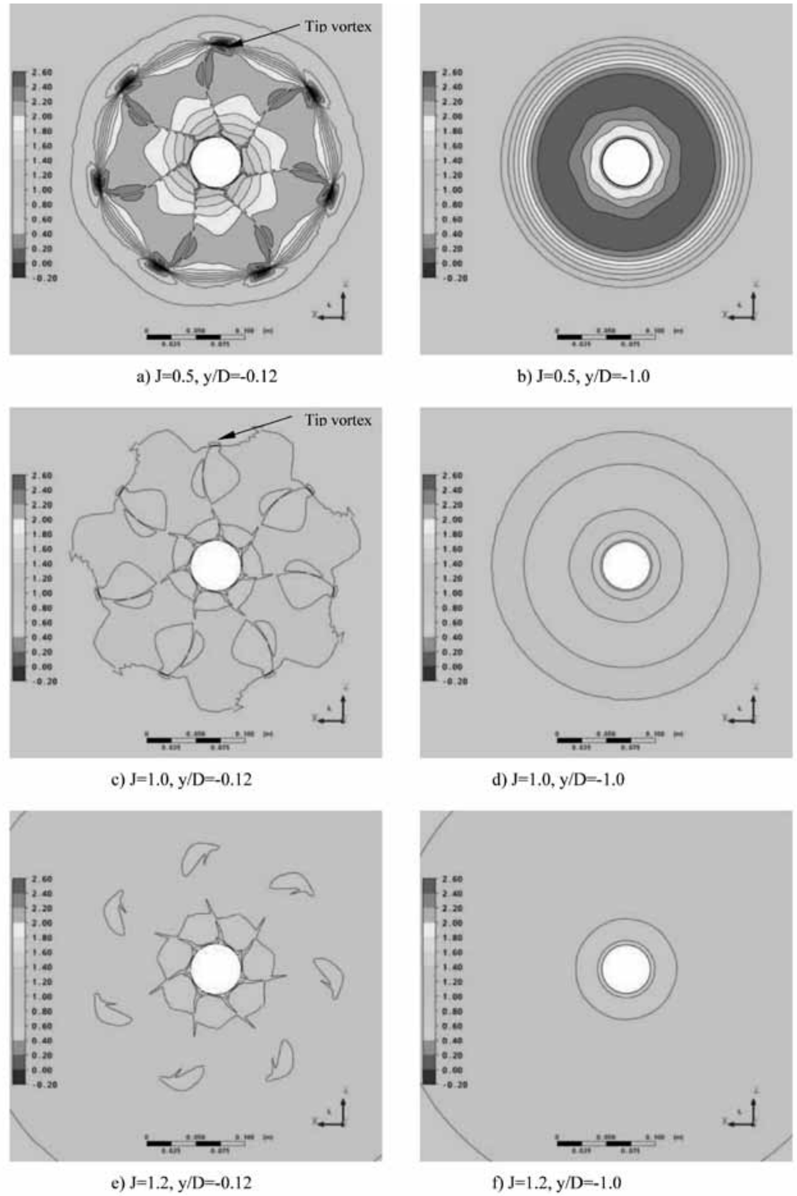


Figure 8: Comparison of non-dimensional axial velocity downstream of propeller axis

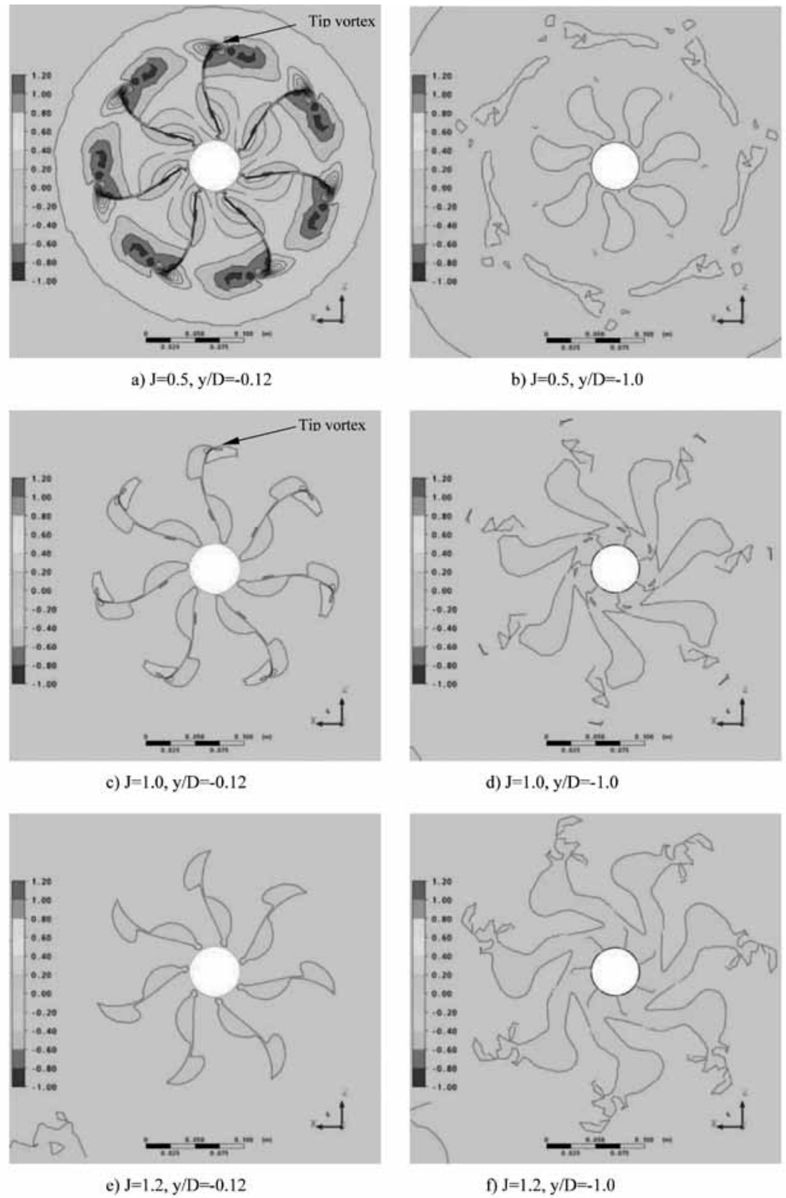


Figure 9: Comparison of non-dimensional radial velocity downstream of propeller axis

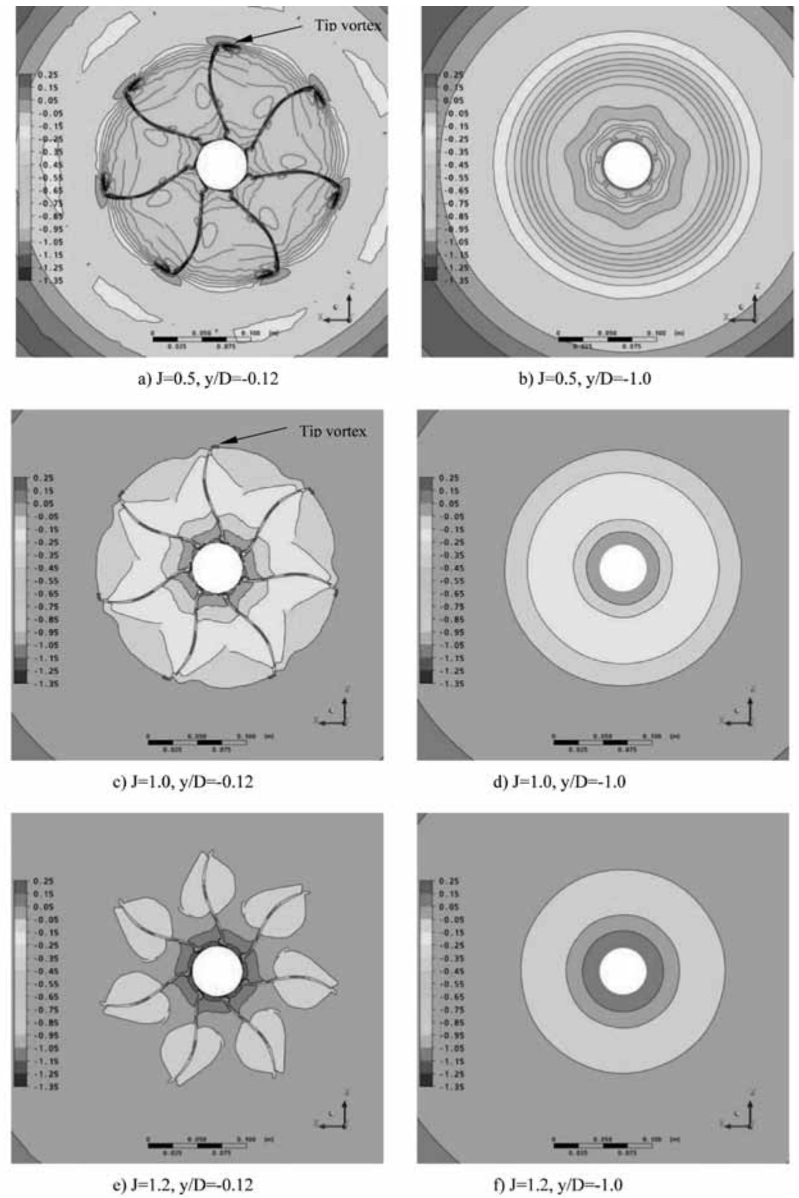


Figure 10: Comparison of non-dimensional circumferential velocity downstream of propeller axis

EDUCATION NEWS

University of New South Wales

Undergraduate News

Student–Staff Get-together

The naval architecture students and staff held a get-together on Thursday 26 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 course and matters of mutual interest. Pizza, chicken, beers and soft-drink were provided and, after a slow start, conversation was flowing pretty freely an hour later! This year we have seventeen students in the third year and about seventeen in fourth year (five expecting to complete in mid-year), most of whom attended. One of the post-graduate students came along as well as the three full-time staff. A broad mix, and some wide-ranging discussions ensued.

Graduation

At the graduation ceremony on 21 April, the following graduated with degrees in naval architecture:

Toby Austin Fraser	Honours Class 1 and the University Medal
Andrew Baglin	Honours Class 1
Rebecca Dunn	Honours Class 2 Division 1
Greg Laanemaaa	Honours Class 2 Division 1
Henry Morgan	Honours Class 2 Division 1

Toby Austin-Fraser's University Medal deserves special mention. The medal is awarded for an average mark for all subjects in all years of the degree course (weighted more heavily towards the later years) of 85% or more. To put this in perspective, of our 313 graduates in naval architecture, fifty-seven have been awarded Honours Class 1, and just nine have been awarded the University Medal: Joanna Mycroft (2007), Craig Singleton (2006), Tony Sammel (2004), Nigel Lynch (2002), Michael Andrewartha (2000), Steve Davies (1980), Brian Morley (1974) and Phil Helmore (1970).

Prize-giving Ceremony

At the prize-giving ceremony on the same day, the following prizes were awarded:

The Royal Institution of Naval Architects (Australian Division) Prize for the best ship design project by a student in the final year to Toby Austin-Fraser for his design of an 18 m composite cruising/racing yacht for a Townsville owner.

Graduates Toby Austin-Fraser, Rebecca Dunn and Andrew Baglin (R) with Naval Architecture Plan Coordinator Phil Helmore
(Photo courtesy Chris Dunn)

The David Carment Memorial Prize for the best overall performance by a naval architecture student in the final year to Toby Austin-Fraser.

The MSC Software Prize for the highest aggregate mark in NAVL4401 Ship Structures 2A and MECH9410 Finite Element Applications to Toby Austin-Fraser.

Congratulations to Toby on his fine performance!

Graduates Employed

Our April 2009 graduates are now employed as follows:

Toby Austin Fraser	Marine Vehicle Solutions, Christchurch, NZ
Andrew Baglin	PhD at the University of New South Wales, Sydney
Rebecca Dunn	PhD at the University of Tasmania, Hobart
Greg Laanemaaa	Crew on luxury yacht *Honey Bear*, Monaco
Henry Morgan	World tour, commencing South America

Thesis Projects

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

Toby Austin-Fraser (R) with the RINA (Australian Division) Prize and Medal
with Naval Architecture Plan Coordinator Phil Helmore
(Photo courtesy Diane Augee)

Simon Robards at the UNSW Graduation Ceremony on 16 December
(Photo courtesy Simon Robards)

High-performance Yacht Sails

There have been successful applications of solid-section foil-shaped sails, for example on the C-class catamarans. In an effort to improve the efficiency of yacht sails, Hamish Bush is investigating the feasibility of inflatable foil-shaped sails, which should produce higher lift than traditional single-skin sails. He has constructed an inflatable prototype for testing in the wind tunnel, and will compare the experimental results with those from a computational fluid dynamics analysis.

CFD Analysis of Ship Squat

There are numerical methods around for the basic prediction of ship squat, which is the loss of under-keel clearance when a ship is under way in shallow water or a channel. These methods rely on overall ship parameters, and generally take little or no account of the specific hull shape of a vessel. Nick Kitching is applying computational fluid dynamics to the prediction of ship squat, with the expectation that this will be able to take into account all the factors which affect the squat. Results from the CFD analysis will be compared with predictions from numerical methods and experimental results.

Upgrade of Computer Laboratories

Over the summer break, all computers in computer laboratories ME206 and ME306 were replaced with new fast quad-core processing machines with flat-screen monitors and all with full Internet access. This is expected to relieve some of the congestion which has previously been apparent at peak assignment times. In addition, the same software image is now distributed to all computers in both labs, also helping to relieve pressure between labs.

Design Laboratory

Plans are under way to convert Level 5 of the Mechanical Engineering tutorial building to a multi-functional Design Laboratory which can be used by the whole Faculty of Engineering. The concept is for a large space including desks, computers and whiteboards, which can be used in different ways, surrounded by offices and spaces for design-group meetings. While available for the whole Faculty, the School will have priority for its own classes.

Post-graduate and Other News

Graduation

At the graduation ceremony on 16 December 2008, Simon Robards was awarded his Master of Engineering (ME) degree by research for his dissertation on *Resistance of High-speed Transom-stern Craft.*

Engineering Alumni Dinner

The year of graduation is taken as the year in which your testamur was awarded. For most graduates, this is usually in the year following that in which their last coursework requirements were completed. For example, if you completed your coursework requirements at the final exams in November 2008, then you would expect to graduate in April 2009, and 2009 would be the year of your graduation.

The Engineering Alumni Anniversary Dinner for 2009 will be held on Friday 21 August 2009 at 1900 in Leighton Hall, Scientia Building, for the graduates of 1959, 1969, 1979, 1989 and 1999. So, if you graduated with David Gosling (1999), Murray Makin (1989), Mike Seward (1979), or Laurie Prandolini (1969), then you should be dusting off the tux or cocktail dress, polishing your shoes and asking your partner (if appropriate) to keep the evening of Friday 21 August free.

The latter class is distinguished by being UNSW's fourth graduating class of naval architects, the first having been Brian Robson in 1963.

Watch this space for updates, or check the Engineering website www.eng.unsw.edu.au/news/index.htm.

Head of School

A.Prof Philip Mathew remains acting as Head of School. The Dean of the Faculty of Engineering, Prof. Graham Davies, has called for applications for the position of Head of the School of Mechanical and Manufacturing Engineering.

Phil Helmore

Presentation at NSWC

Em/Prof. Lawrence Doctors of the Naval Architecture group at the University of New South Wales remains active in the area of research into the hydrodynamics of various types of high-speed ships.

He recently presented a survey lecture with the title *Hydrodynamics of the Air-Cushion Vehicle and the Surface-Effect Ship* at the Naval Surface Warfare Center in Bethesda, Maryland, USA, on 6 February 2009. Air-cushion vehicle (ACV) and surface-effect ship (SES) concepts offer interesting operational advantages in specialized marine applications. In particular, these concepts are being offered for the Sea-Base-Connector Transformable Craft (T-Craft) Prototype Demonstrator. They also present challenging problems for the researcher wishing to theoretically model them in an efficient manner. A survey of recent progress was presented, in which the hydrodynamic interactions of the seals and the sidehulls were accounted for in a physically-realistic manner. Comparisons with experimental data on towing-tank models were also made.

Lawrence Doctors

The Australian Maritime College

Steel-caps, Calculators and the Seaside

AMC first-year engineering students were thrown in at the deep end of the Tamar River in typical AMC fashion with activities at the Beauty Point campus. With the aim of illustrating principles and theories learnt in first semester and introducing students to concepts which follow in the semesters to come, Maritime Engineering and Hydrodynamics staff and Ports and Shipping staff worked hard to give students real-life engineering experiences. A few examples are given below:

Equilibrium and Inclination Experiments aboard FTV *Reviresco*

Students observed the effects of changing the height of the centre of gravity of a vessel with the use of models before undertaking an inclining experiment aboard the AMC fisheries training vessel, FTV *Reviresco*. While half the group conducted this experiment, the others investigated various marine and shore-based structures around the campus, drawing free-body diagrams and discussing engineering approaches to problems.

Speed Trials — FTV *Bluefin* and *Pinduro*

Students conducted a set of speed trials to determine the maximum speed that the AMC vessels *Bluefin* and *Pinduro* can attain over a measured distance. The key to success here was planning — students needed to consider what equipment was available on the bridge for recording position and speed, what ship details need to be noted and what environmental variables need to be measured.

Lecturer Robert Ojeda demonstrating the forces and moments which may apply to a floating object, in this case a scale model of the AMC fisheries training vesssel FTV *Bluefin*
(Photo courtesy Tristan Jennings)

Practical Ship Design aboard the Training Vessel *Stephen Brown*

Students were required to gather information onsite to perform design work as if they were field engineers. They gathered information and presented diagrams on the various components which make up the ship's structure in way of the hull cross section, and an overview of the powering and propulsion systems.

Marine Engine Systems on the AMC Training Vessel *Stephen Brown*

The pathway of the fuel-oil system was identified and flow diagrams developed to indicate fuel flows and devices encountered along the way to the combustion chamber. Students also measured shaft deflections of the engine crank.

How to Survive at Sea

Students completed Elements of Ship Board Safety Training in order to take part in the activities aboard AMC vessels, giving a unique insight into non-technical aspects of the engineering industry such as Occupational Health and Safety, fire awareness and survival training.

A big thanks to Tristan Jennings, 4th Year Naval Architecture student, who contributed to the writing of this article and also for taking the photos shown of the day.

Tristan Jennings
Irene Penesis

New Ocean Engineering Lecturer

Art Shrimpton has recently joined the National Centre for Maritime Engineering and Hydrodynamics as a full-time lecturer. Born in Worcestershire, in the UK, Art racked up all the appropriate sea time for his degree in Nautical Science in Plymouth before moving into the field of hydrographic surveying. In between working in the North Sea and Nigeria, he gained his master's degree in oceanography at UCNW, the field he worked in until doing his Diploma of Education at Fremantle in 2002.

Art has 20 years of maritime experience, having worked as a marine scientist on a large range of engineering projects at coastal and offshore locations across the globe. Most of that time he worked for Fugro Survey on projects as diverse as a year-long feasibility study for the Oman/India gas subsea pipeline in water depths of up to 3500 m, GIS platform risk analysis of oil-spill pollution on the coast adjacent to oilfields in the China Sea, and maintenance of a tropical-cyclone early-warning system on Australia's north-west shelf. After obtaining his diploma in education, he taught in several independent and state schools in both Australia and the UK, before turning to tertiary education at AMC.

Art lives in Launceston with his wife and two children. His wife Becky is a director of the Launceston City Council. His interests outside work are the environment, cycling (mountain and road) and dinghy sailing.

Art has started Semester 1 lecturing in offshore operations and project engineering and will be teaching geotechnology and foundations, and offshore engineering and design in Semester 2.

AMC Bachelor of Engineering Careers Day 2009

The third AMC Maritime Engineering Industry Day and Careers Fair, held on Friday 24 April, was a resounding success. Representatives from over 16 companies and organisations visited the AMC to present the opportunities which they can provide to engineering students. This was of great value not only for 4th year students looking for a job when they graduate but also students investigating work experience possibilities. All maritime engineering students had a free day to attend the busy day of activities.

Proceedings began on Thursday night with an informal gathering at a local hotel for students, staff and industry representatives. On Friday the industry representatives set up trade stands in an Expo Show and also gave short presentations to an audience of students. A free BBQ lunch was held for all involved and visitors to AMC were given guided tours of AMC's large array of facilities, unique in Australia.

The efforts of industry in attending the Industry Day and Careers Fair were greatly appreciated. Anyone who is interested in attending in the future, please contact Leslie Lundie (eng.careers.fair@amc.edu.au) to ensure that they are on the mailing list. Those companies who were in attendance this year included:

Commercial Marine Solutions
Lloyd's Register Asia
INTECSEA Worley Parsons
ASC
Clough
Neptune Marine Services
Austal Ships
BMT Defence Services (Australia)
DSTO
Technip Oceania
Defence Material Organisation
Royal Australian Navy
BAE Systems Australia
NT Department of Planning and Infrastructure
Formation Design Systems
AMOG Consulting

Giles Thomas

The AMC Careers Fair 2009
(Photo courtesy AMC)

Ocean Vehicle Design Projects 2009

Bachelor of Engineering naval architecture students undertake a design project in the unit ocean vehicle design (OVD) in their final year of study. They work in teams to a specification supplied by an industry 'client'. The designs and their industry 'clients' in 2009 are:

Patrol boat — Austal Ships
Search and rescue craft — BAE Systems
Pacific trader — BMT Defence Services (Australia)
24 m sailing yacht — Warwick Yacht Design (NZ)

The support of these industry clients is greatly appreciated, as is the input of a number of guest lecturers for the unit including Gordon MacDonald, Rob Gehling, Alan Muir and Ian Clayton.

Mid-year Final Year Research Project Presentations at AMC

This year two final-year students are finishing their projects mid-year. They will be making presentations on their work to students, staff and visitors on 5 June 2009. The presentations are as follows:

Added Resistance of Catamarans in Waves, by Nikki Daire

The primary aim of this project was to investigate the added resistance of catamarans when operating in head seas. The specific objectives were to:

- Investigate various post-processing techniques for determining the added resistance in head seas from the raw data obtained from physical scale model experiments; and

- Compare the added resistance of a range of catamaran hullforms operating in head seas using the results from a series of physical scale-model experiments.

Design and Development of a Multipurpose ROV, by William West

This project is focused on the design and construction of a remotely-operated underwater vehicle (ROV), powered by three 2.2 kgf thrusters, with an ability to operate at depths up to 30 m. The vehicle is 850 mm in length, of modular construction and is capable of carrying an array of instruments and sensors.

Modeled in CATIA and machined using CNC, the vehicle is being constructed using aluminium and composites. It will be fitted with the electronics designed and assembled at AMC/UTAS, with the intention of upgrading the vehicle to AUV capability at a later date. Full advantage of modern 'bus' systems will enhance the operation and control between pilot and vehicle.

Computational fluid dynamics (CFD) modeling is also being carried out to optimise the hull and thrusters configuration.

All visitors are very welcome, and should contact Prof. Martin Renilson at m.renilson@amc.edu.au, or on (03) 6335 4667 for further information and to book a place.

Guest Lectures by Rob Gehling of AMSA

Rob Gehling from AMSA recently visited the AMC and gave two presentations. Firstly Rob spoke to the bachelor of engineering first-year students on the topic *Regulations and Standards in the Maritime Industry*. This provided them with an excellent overview of the regulatory frameworks governing military, commercial and recreational vessels. In addition, Rob presented a lecture to the fourth year naval architecture students on *Stability in Ship Design*. Rob gave an overview of stability regulatory requirements for a range of vessels and provided individual details for the vessel types which the students are currently working on for their design projects.

Introduction to Management of Ports — Short Course

The Port Development Unit at AMC is running an intensive residential short course on the management of ports from 31 August to 4 September 2009. The objectives of this course are to broaden knowledge and understanding of the operational, governance and economic issues impacting the strategic policies of ports, and requiring effective management in order for ports to thrive and prosper in these challenging times.

The course is specifically aimed at:

- new recruits to port management;
- new recruits to port stakeholder organisations;
- regulators who have port issues in their portfolios, particularly those new to such a position; and
- staff in port middle management undergoing professional development in order to broaden and increase their managerial responsibilities.

For further details please contact Prof. Martin Renilson, Director of the Port Development Unit, at m.renilson@amc.edu.au, or on (03) 6335 4667.

New Editor for the International Journal of Small Craft Technology

Prof. Martin Renilson has now taken over as editor of the *International Journal of Small Craft Technology*. As most members will be aware, this forms Part B of the RINA Transactions. All papers are fully refereed and this is an important journal in the profession, particularly to those working in the smaller craft area.

Although there is a considerable backlog of papers going through the refereeing process, Martin would like to encourage people to offer papers to this journal. "I'm particularly keen to get a good representation of innovative papers from Australia, as I'm sure that there is a lot we can be saying about the interesting work that is being done in this country" he said. "Often people in the Northern hemisphere are unaware of what is going on here."

One of the roles of the editor is to select referees for papers, and then to judge if their responses mean that the paper should be accepted. He also has to ensure that the referees' comments are properly taken into account by the authors in the cases where they are required to make changes before being accepted.

Refereeing papers can be quite an arduous task; however, for the system to work properly, all those who want to publish in refereed journals need to be prepared to take on their fair share of refereeing. Martin would be particularly keen to hear from people prepared to act as referees. He can be contacted at m.renilson@amc.edu.au.

AMC Staff Member publishes a book on Marine Powering Prediction and Propulsors

The Head of the AMC National Centre for Maritime Engineering and Hydrodynamics, Prof. Neil Bose, has recently published his book on *Marine Powering Prediction and Propulsors*. While at the Memorial University of Newfoundland, Canada, Neil was the Director of the Ocean Engineering Research Centre from 1994 to 2000 and the Discipline Chair of Ocean and Naval Architectural Engineering from 1998 to 2003. In 2003 he was appointed to a Tier 1 Canada Research Chair in Offshore and Underwater Vehicles Design and he led the purchase and commissioning of an International Submarine Engineering Explorer-class AUV. His research interests include areas in marine propulsion, autonomous underwater vehicles, ocean environmental monitoring, ice/propeller interaction, renewable energy and aspects of offshore design. In a recent review, William B. Morgan, retired Head, Hydromechanics Directorate, Carderock Division, Naval Surface Warfare Centre, said:

'This book is an excellent interpretation of the hydrodynamics of the prediction of ship powering performance of various types of ship propulsors. It is based on extensive studies carried out by Dr Bose and his students and his long association with the Institute for Ocean Technology (IOT), National Research Council of Canada. As a result of his International Towing Tank Conference technical committee membership, he has captured the accepted international state of the art of ship powering prediction.

‘Dr Bose has extensively discussed most types of ship propulsors, including oscillating foils and wind-assisted propulsion devices. He has included a general discussion on ship resistance and the prediction of powering performance from model tests, primarily for conventional screw propellers. As a result of his experience with IOT, he has included the problems of screw propellers operating in ice, particularly with regard to strength. He has incorporated quite a complete list of references and has included examples to be worked by the reader. As such, the book should be particularly useful to students and those responsible for making powering predictions, especially to those getting started in the field.

‘This book is an excellent resource for non-conventional marine propulsors and should be particularly useful to naval architectural students and practicing naval architects.’

Gregor Macfarlane

INDUSTRY NEWS

Reducing the Noise Generated by Merchant Ships

There is increasing international concern about underwater noise pollution. For example, it is specifically mentioned in the recently-established EU Marine Strategy Framework Directive. Shipping is a major contributor to underwater noise pollution. In 2008, the IMO added ‘Noise from commercial shipping and its adverse impact on marine life’ to the work program of its Marine Environment Protection Committee (MEPC).

The International Fund for Animal Welfare (IFAW) has identified that significant reductions in ambient noise can be made by reducing the noise output from the noisiest vessels. Resulting from this, IFAW recently commissioned Renilson Marine Consulting Pty Ltd (RMC) to undertake a brief desk-top study into technologies which may be used to reduce the underwater noise output from the loudest commercial vessels.

The study found that there is considerable difference in the noise propagated by the noisiest and the quietest conventional merchant ships (excluding those designed specifically for low noise). It concluded that it is reasonable to develop a cautious note of optimism that the noisiest ships can be quietened using existing technology without reducing their propulsive efficiency.

The review made a number of recommendations which will be discussed at the forthcoming meeting of the MEPC in July 2009. There are still many data gaps in the understanding of noise output from large commercial vessels, and a considerable need for further research. It is hoped that governments and the industry will facilitate work to address these research needs. In addition, it is hoped that governments will encourage a review of their merchant fleets in order to identify vessels which would benefit most from efficiency improving technologies that are also likely to reduce underwater noise output.

The full report is available from (www.ifaw.org/oceannoise/reports) and further information from IFAW by contacting Russell Leaper at rleaper@ifaw.org.

Wärtsilä receives Propulsion System and first CWA Design Order for Taiwanese Chemical Tanker

Wärtsilä, the leading ship-power system integrator for the marine industry, has signed a design and propulsion system order with Taiwan’s Jong Shyn Shipbuilding for a product chemical tanker. The 6500 dwt vessel, due for delivery in 2011, is for CPC Corporation (CPC), a Taiwanese state-owned oil company. This is the first order through the Wärtsilä network for a design developed by Conan Wu Associates (CWA), a Wärtsilä Ship Design company, since it was acquired in September 2008.

In addition to the design, Wärtsilä will deliver the entire propulsion system, which is to be based around a 9-cylinder in-line Wärtsilä 32 main engine, gearbox, and a controllable-pitch propeller. Wärtsilä’s extensive scope of supply includes other equipment, such as a bow thruster, the propulsion control system, and all shaft seals and bearings. The contract also includes the supply of an integrated automation system for not only the machinery spaces, but the entire ship.

With an overall length of 110 m and beam of 18 m, the single-screw tanker will be equipped with a propulsion arrangement capable of delivering a ship speed of up to 13.4 kn, at design draught condition.

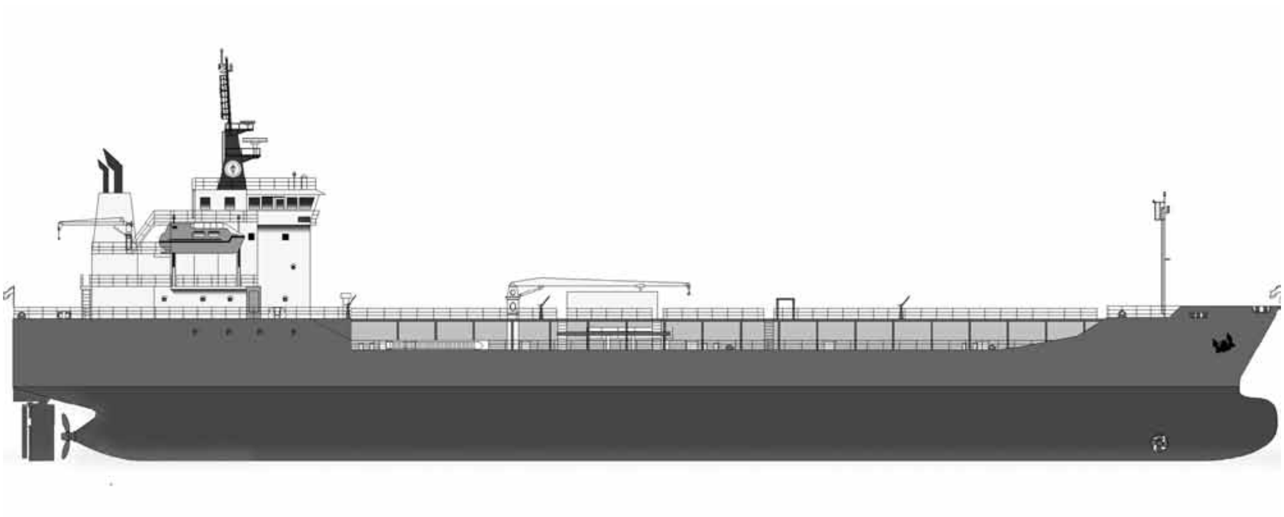
Willy Perng, Sales Manager, Wärtsilä in Taiwan, said that Wärtsilä has enjoyed a good and long-standing relationship with the customer. CPC has already 12 sets of Wärtsilä two-stroke engines installed in its fleet.

“The contract marks a significant milestone for Wärtsilä in that it is the first time we have dealt with the Jong Shyn shipyard. It is also the first time we have supplied CPC with new four-stroke main engines, and the first-ever ship design we have sold in Taiwan,” added Perng.

“The shipowner had specified a modern, fuel-efficient, and environmentally-sound ship, and Wärtsilä’s integrated ship power and design solution was the best choice. Our package was more cost effective than that of our competitors, as it included a life-time support and care package,” said Perng.

CWA, which now is a part of Wärtsilä Ship Design, was acquired by Wärtsilä to demonstrate Wärtsilä’s commitment to becoming the leading provider of ship-design services in specialised areas, including offshore and special vessels, as well as selected merchant vessels. The acquisition of CWA expanded the geographical scope of Wärtsilä’s ship-design services. It also complemented and broadened Wärtsilä’s ship-design competence to cover a larger range of vessel types, including smaller, less complicated, and more standardized vessels. CWA has its main operations in Singapore.

The Jong Shyn Shipbuilding Group was established in 1985 and is located in the technical area for shipbuilding in the Qi Jing District of Kaohsiung City, Taiwan.



Wärtsilä will deliver the design and propulsion system for the product tanker
to be built by Jong Shyn shipyard in Taiwan
(Image courtesy Wärtsilä)

CFD Provides the Edge in Design

In an increasingly-competitive global marine industry, naval architects are seeking an edge. Computational fluid dynamics (CFD) has the potential to significantly complement commercial design practices.

CFD, in particular Reynolds Average Navier-Stokes (RANS) codes are becoming more accurate in resistance prediction, according to Team New Zealand designer Nick Hutchins. "We saw free-surface RANS analysis becoming a reliable design tool in the last America's Cup cycle. We would not consider future campaigns without this capability within the design program."

It also offers a real alternative to tank testing. "CFD provides another option for design development; tank testing remains the benchmark, but you can explore different design characteristics a lot more efficiently with CFD"

Traditionally, the cost of CFD analysis has prohibited its widespread commercial use. At around $40 000 annually for the code and $10 000 upwards for the computers, few companies use it in-house. But contractors can offer small-to-medium businesses the expertise and software for occasional projects. "CFD can provide more-detailed information about specific flow in certain areas, for example, around propellers or water-jet intakes. With a specialist consultant who can ensure good results — and understand its limitations — CFD can offer enormous benefit." Visit Nick Hutchins Fluid Mechanics at www.nickhutchins.net for more information, or email nick@nickhutchins.net.

Wärtsilä receives Order for Equipment and Design of Field Support Vessel

Wärtsilä, has received a ship design order from the Norwegian shipping company Sartor Shipping AS. The order is for two Vik-Sandvik 465 FSV design vessels which will be built at the Wison Heavy Industry shipyard in China. Wärtsilä's scope of supply also includes two main engines, gear boxes and propellers. Sartor Shipping has options for further newbuildings at the yard. The vessels are due for delivery in 2010 and 2011.

The design incorporates a hybrid system which offers considerable fuel savings compared to a purely diesel mechanical solution. This is because the available power can be adjusted to meet the various demands of the different operations for which this type of vessel will be used. The savings will be particularly notable when operating at lower power loads.

Multi-functionality is an extremely important feature of this design, as the vessels are intended for use in a multitude of different tasks. These are likely to include offshore standby service, emergency towing, oil-spill recovery, remotely-operated vehicle operations, fire fighting, tanker assistance and surface surveillance.

The vessels will have the Dynamical Position system, DP II. The speed of the vessels will be approximately 15.5 kn and the vessels' length will be 65.9 m with a beam of 18 m. They will comply with the Bureau Veritas 'Clean Ship' notation for pollution prevention.

Wärtsilä acquired the global ship design group Vik-Sandvik in July 2008. This acquisition was a major step in Wärtsilä's strategy to strengthen its position as a total solutions provider and to be the most valued partner for its customers. By combining ship design capability with its existing offering in propulsion systems and automation, Wärtsilä is able to provide more added value to its customers, with further growth potential in new lifecycle services. Wärtsilä's goal is to become the leading provider of ship-design services in various segments.

The new-design Vik-Sandvik 465 Field Support Vessel).
(Image courtesy Wärtsilä)

VALE

Ernie Tuck

It is with sadness that *The ANA* records the passing of Ernest Oliver (Ernie) Tuck on 11 March 2009.

Ernie was born in Adelaide, South Australia. He and his younger brother were raised by their mother after his father, a World War II veteran, was killed in an automobile accident when Ernie was just 6 years old. This family tragedy had a happy consequence later, when Ernie met his future wife and often-acknowledged best friend, Helen, at a Legacy gathering for children of military veterans.

Ernie was an undergraduate student at the University of Adelaide from 1956 to 1959. He then completed a first-class honours degree in mathematics in 1960 under the supervision of Prof. Ren Potts. He undertook his postgraduate studies at the University of Cambridge where he was awarded a PhD for his thesis entitled *The Steady Motion of a Slender Ship* in 1963, under the supervision of Prof. Fritz Ursell.

From there he moved to a position at the David Taylor Model Basin to work with Francis Ogilvie and Nick Newman, and the California Institute of Technology before being recruited back to the University of Adelaide by Prof. Ren Potts as a reader in December 1967. He was quickly promoted to a personal chair in 1974 at the age of just 34. On the retirement of Prof. Ren Potts in 1990, Ernie became the Chair of Applied Mathematics and the Elder Professor of Applied Mathematics until his retirement in June 2002. He was then awarded the title of Professor Emeritus.

Em/Prof. Ernie Tuck
(Photo courtesy Yvonne Stokes)

Ernie's primary field of expertise was fluid mechanics. He worked on a wide variety of topics related to ship hydrodynamics, aerodynamics, acoustics, bio-fluid mechanics, and numerical analysis. His contributions to these fields were based primarily on analytic methods but, early on in his career, high-speed mainframe computers were becoming useful to scientists and engineers on a broad scale and Ernie was quick to embrace the developing field of numerical computation. This enabled him to produce practical and illustrative results based on his theoretical analyses. One of his most exciting computations was for the nonlinear waves generated by a submerged two-dimensional dipole in steady motion (*J. Fluid Mechanics*, v. 22 (1965) pp. 401–414).

Ernie had great expertise as a modeller, and published over 170 articles, with the vast majority being in the top journals in fluid mechanics; his papers are clear, concise, and stimulating. He also had a personal interest in games theory, and published articles on both blackjack and backgammon. After retirement Ernie became interested in Riemann's Hypothesis and wrote three papers in this area. This is usually regarded as a rather "pure" mathematical area but Ernie realized that the analytical skills honed in his hydrodynamic research could find application here.

Ernie's research is characterized by the recognition of new or unsolved problems, application of novel mathematical methods, and careful numerical analysis. He was particularly adept at solving complex problems with simple approximations, as in his applications of matched asymptotic expansions. When he first employed this method to analyse the wave resistance of slender ships it was relatively new, and unknown to most. Subsequently he found other problems to which the same method was applicable, including the squat of ships in shallow water, various types of flow or wave transmission through small gaps, end effects on blunt slender bodies, and bodies moving near a plane wall or in close proximity to other bodies. Several other topics which recur throughout the list of his publications include the strip theory of ship motions, Michell's thin-ship theory of wave resistance, planing, bodies with zero wave resistance, nonlinear free-boundary problems, numerical solution of integral equations, low-Reynolds number flows, wave resistance of multihull vessels, and lifting-surface theory.

His contribution to the paper Salvesen, N., Tuck, E.O., and Faltinsen, O. (1970), Ship Motions and Sea Loads, *Trans. Society of Naval Architects and Marine Engineers*, v.78, pp. 250–287, December, is no doubt the most lasting in terms of significance to naval architects. This publication is the basis of the vast majority of today's practical and accurate ship-motion prediction programs. An example of the high accuracy of this method was presented in *The ANA*, v.13 n.1, February 2009, p.4.

Ernie's work on squat (or sinkage) of ships in shallow water is an interesting example of his international stature in the field of ship hydrodynamics. He was asked to work on this problem soon after he arrived at the David Taylor Model Basin, motivated by the grounding of an aircraft carrier in the Gulf of Mexico. His brilliant analysis, which combined slender-body theory with the governing equations for shallow-water waves, revealed the nonlinear effect of a ship's speed on squat, particularly in the vicinity of the critical Froude number. He first reported his results in discussion of a paper by German researchers, where he showed how his elegantly simple theory could explain their experimental results. Subsequently he published this seminal work in *J. Fluid Mechanics*, v.26 (1966) pp.81–95. He also simplified the essential results in "Navigation" (*J. Australian Institute of Navigation,* v.3 (1970) pp.321–324), for the benefit of ship operators. The importance of his work was recognized after a widely-publicised accident: on 7 August 1992 the famous Cunard flagship, *Queen Elizabeth 2*, struck a shoal after leaving Martha's Vineyard en route to New York. The ship was behind schedule, operating at high speed, and passed over a shoal area because neither the pilot nor the ship's officers understood how the speed affected the squat. Ernie took a great interest in this accident, and subsequently he contributed a lucid overview of squat to the Workshop on Ship Squat in Restricted Waters held in Washington in October 1995.

Ernie was elected a Fellow of the Australian Academy of Science and a Fellow of the Australian Academy of Technological Sciences and Engineering. Being a Fellow of both Academies is a very rare distinction. In 1999, Ernie was awarded the Thomas Ranken Lyle Medal by the Australian Academy of Science, which recognises outstanding achievement by a scientist in Australia for research in mathematics or physics. In 1999 he was also awarded the Australia and New Zealand Industrial and Applied Mathematics (ANZIAM) medal by ANZIAM, a division of the Australian Mathematical Society, for his research achievements and his contributions to applied mathematics and ANZIAM.

An international award of which Ernie was proud was his selection as the Georg Weinblum Memorial Lecturer for 1990–1991. Named after the internationally-famous ship hydrodynamicist, the award required Ernie to deliver the Memorial Lecture firstly in Berlin in1990, and later in Washington in 1991.

In addition to frequent participation in ANZIAM conferences, Ernie made many longer trips to attend the ONR Symposia on Naval Hydrodynamics, IUTAM Congresses, the International Workshops on Water Waves and Floating Bodies (IWWWFB), and others. He was particularly active in small informal meetings, stimulated no doubt by his early exposure to seminars at Cambridge, and his early membership of the Analytical Ship-Wave Panel (H-5) of the US Society of Naval Architects and Marine Engineers.

Ernie successfully supervised 25 doctoral and 4 research masters students during his time at the University of Adelaide. At his retirement symposium in January 2003, 16 of these students were able to attend, including at least one who travelled from Europe for the occasion. This aptly demonstrates the very high esteem in which Ernie was held by his students.

Ernie was instrumental in the formation of the Department of Applied Mathematics in 1971, and was Head of that department on many occasions in the next 25 years. He also served as Dean of the Faculty of Mathematical and Computer Sciences from 1993 to 1996.

Prof. Nigel Bean
University of Adelaide

Sydney Harbour looked like a proper port again on Sunday 1 March when, with all suitable berths occupied by other ships, the liners *Aurora* and *Millennium* were moored at buoys in the harbour
(Photo John Jeremy)

MEMBERSHIP

The Australian Division Council

The first meeting of Council for 2009 was held on Wednesday, 4 March 2009 with the President, Dr Stuart Cannon in the chair. During the meeting, the following matters were discussed by Council and, where necessary, action was taken:

National Unified System for Vessel Safety

The sub-committee established to provide information on this important matter had reported to the President and it was agreed that a watching brief would be maintained with the knowledge that many individual members had attended briefing meetings on the proposal. Council was informed that a draft of a final document would be prepared sometime in late March or early April for consideration by COAG for their meeting in June 2009. Council will continue to maintain a watch on the progress of the proposal.

Additional Finance for the Division

During the visit of the Chief Executive to the Division earlier this year, the possibility of additional funding for the activities of the Division was raised. The Chief Executive explained the difficulties being felt due to the world economic situation and he believed it most unlikely that an increase would be provided.

Election of Vice-President of the Australian Division

The President advised the Council that Mr Peter Crosby had declined to accept nomination for the position for a further two year period as it was his wish to devote more time and effort into the activities of the SA and NT Section. The President thanked Mr Crosby for his assistance during the past two years and advised that Dr Renilson would be happy to accept nomination for the position. Council elected Dr Renilson to the position of Vice-President for a term of two years to commence at the conclusion of the Annual General Meeting.

Pacific 2010 International Maritime Conference

The Chair of the Organising Committee, Mr Jeremy, reported that the Committee was actively working toward the Conference although sponsorship might be affected due to the global financial crisis. Council appointed Mr Adrian Broadbent to the Organising Committee as a RINA representative, a suitable appointment as Mr Broadbent is the Chair of the Program Committee.

Inquiry Into the Loss of *HMAS Sydney II*

The President reported that a document prepared by the Australian Division of RINA and DSTO was lodged with the Commission of Inquiry in January 2009 and representatives from both parties appeared before the Commission on 12 and 13 January. A draft copy of the final document has been prepared by DSTO, and the Commissioner has indicated that the RINA/DSTO document may be included as an Annexure to the final Commission report. Dr Cannon noted the contribution of members of the Division, some also members of DSTO, to the Report and, in particular, the most valued input from Mr Lyon and Mr Jeremy.

Retiring Member of Council

Council expressed its sincere thanks to Mr Werner Bundschuh who was retiring from Council in accordance with the By-laws of the Division after his six years of service. During his term of service, Mr Bundschuh had contributed significantly to the business of Council by providing advice and insight into the maritime affairs of the country.

The next meeting of the Council of the Australian Division will be held on Thursday 25 June 2009.

Keith Adams
Secretary

Annual General Meeting of the Division

The Annual General Meeting of the Australian Division of the Royal Institution of Naval Architects was held on Wednesday 4 March 2009 following a combined Technical Meeting of the NSW Section of RINA and the Sydney Branch of IMarEST.

The President's Report, published in the February 2009 issue of *The Australian Naval Architect*, was received.

The Minutes of the last Annual General Meeting held in Canberra in March 2008 were confirmed as a true record of that meeting and the Financial Statement and Audited Accounts of the Division were received and adopted.

The Secretary announced, in accordance with the By-laws of the Division, the election for a term of two years commencing from the conclusion of the AGM of each of the following members:

Dr N. A. Armstrong
Mr J. M. Black
Mr P. R. Crosby
Mr J. C. Jeremy
Dr M. Renilson
Mr T. Lyon and
Mr G. R. Taylor.

Keith Adams
Secretary

FROM THE ARCHIVES

Due to the demands for space in this edition of *The Australian Naval Architect*, *From the Archives* has been set aside until the August 2009 edition.

NAVAL ARCHITECTS ON THE MOVE

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

Toby Austin-Fraser, a recent graduate of the University of New South Wales, has taken up a position as a naval architect with Marine Vehicle Solutions in Christchurch, New Zealand, who do a substantial amount of the naval architecture work for the Maritime New Zealand "Safe Ship Management" system.

Andrew Baglin, a recent graduate of the University of New South Wales, has taken up a scholarship at the University of New South Wales in Sydney to pursue his doctorate on the electromagnetic reduction of ship resistance, and continues very part-time as a naval architect at One2three Naval Architects.

Stuart Cannon has moved on within the Defence Science and Technology Organisation and has been promoted from Head of Surface Ship Structural Management to Research Leader of Surface Platform Systems within the Maritime Platforms Division in Melbourne.

Aaron Carle has moved on from Austal Ships, and has been contracting in composite construction in Taree, NSW.

Martin Christensen, many moons ago, took up the position of Engineering Manager for the Hydrographic System Program Office of the Defence Materiel Organisation in Cairns.

Glen Cobb has moved on from Lloyd's Register Asia in Melbourne, and has returned to Vancouver, Canada.

Rowan Curtis has moved on from the Centre for Maritime Engineering of the Defence Materiel Organisation and has taken up a position as a junior naval architect with the NSW Maritime Authority in Sydney.

Rebecca Dunn, a recent graduate of the University of New South Wales, has taken up a scholarship at the University of Tasmania in Hobart to pursue her doctorate on wave slamming loads on vessels in association with Revolution Design.

Owen Eckford moved on from Holman Webb many moons ago, and has taken up the dual positions of Chief Executive Officer of Westbus and Deputy CEO of Cabcharge Australia in Sydney.

David Firth has moved on within the Gurit organisation, returning from Newport on the Isle of Wight, UK, to take up a position as Design Engineer with Gurit Australia in Sydney.

Peter Gawan-Taylor has moved on from Avenger Yachts and has taken up a position as Design Office Manager with ST Marine in Singapore. ST Marine is a shipyard with around 3000 personnel and a design office of around 130, undertaking a mixture of commercial and naval shipbuilding and repair. Vessels currently under construction include a 160 m ro-pax ferry, a 107 m dive-support vessel, and seismic and anchor-handling vessels.

David Hooper has moved on within the BAE Systems organisation from Barrow, UK, where he worked on the Astute-class nuclear submarine project, and has taken up the position of Senior Naval Architect with BAE Systems — Maritime in Williamstown.

Andrew Joyce has moved on from Bain and Co. in Melbourne and has taken up a position as Manager of Strategy and External Communications with CSG Ltd, an IT services company, in Darwin.

Greg Laanemaa, a recent graduate of the University of New South Wales, has taken up a position as crew on *Honey Bear*, a 90 ft (27.4 m) Sunseeker luxury yacht, based in Monaco.

Steven McCoombe has moved on from Marine Safety Victoria and has taken up a position as a naval architect with the NSW Maritime Authority in Sydney.

Geoff Leggatt has moved on from Arup and has taken up a position as a naval architect/project manager with London Offshore Consultants (Australia) in Perth.

Mervyn Lepper has moved on from Bligh Water Shipping in Fiji and has taken up a position as a naval architect with Austal Ships in Fremantle.

Angus MacDonald is consulting as Business Eclipse in project management in the home-construction industry in Sydney.

Adrian Macmillan has moved on within the Woodside organisation and has returned after three years in California to take up the position of Senior Development Engineer on their Sunrise Project in Perth.

Brian Morley set up his own information technology consultancy many moons ago, and is consulting as Morley Consulting in Brisbane.

Joanna Mycroft has moved on from Rogers Yacht Design in Lymington, UK, and spent a month back in Australia, visiting family and friends in Albury, Melbourne and Sydney, before returning to the UK to seek new opportunities.

Giang Ngo has moved on from Transport SA and is now consulting as GN Marine Design in Adelaide.

Prasanta Sahoo has moved on from the Australian Maritime College, and has taken up the position of Associate Professor (Ocean Engineering) in the Department of Marine and Environmental Systems at the Florida Institute of Technology in Melbourne, Florida, USA.

Gayle Shapcott has moved on and has taken up the position of Manager of Canturi Jewels in Melbourne.

Chris Shead moved on from Garden Island Dockyard many many moons ago, to take up positions with the Department of Administrative Services, followed by Defence Support, and then outside engineering from where he retired in 2007. However, the work ethic remained strong, and he recently started doing project work in the real-estate industry.

LEUT Dominic Worthington has moved on from the position of AMEO on HMAS *Darwin* to commence training at the Submarine School at HMAS *Stirling* in Western Australia.

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 Keith Adams when your mailing address changes to reduce the number of copies of *The Australian Naval Architect* emulating boomerangs.

Phil Helmore