THE AUSTRALIAN NAVAL ARCHITECT

Volume 26 Number 2
May 2022

The Austal-built Tongan Navy Guardian-class patrol boat VOEA *Ngahau Siliva* leading Royal Australian Navy ships HMAS *Adelaide*, HMAS *Canberra* and HMAS *Supply* into Nuku‘alofa harbour during Operation Tonga Assist 2022
(RAN photograph)

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Cover Photo:

The 76 m high-speed catamaran ferry *Santa Monica 1* recently completed by Incat Tasmania for Seaworld Express Ferry of South Korea (Photo courtesy Incat Tasmania)

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From the Division President

To all Australian naval architects: welcome to the May edition of your favourite, most informative, and most relevant publication, *The Australian Naval Architect*. Some things change and some things just don't: here I am back at the helm after almost ten years and, I note from the start of my last address in 2013, that "….the election date has been announced and the Government is in caretaker mode. "That certainly hasn't changed, nor has the uncertainty which a Federal election brings to all of us far too regularly — here's hoping for some stability going forward!

Given the many strange and unpredicted events over the last couple of years, what can we expect looking ahead? One positive that I have seen is the wider realisation that shipping is, as it always has been, a critical lifeline for this island continent, be it the greater understanding of our dependence on vital imports, or the shipping of goods to Western Australia when both road and rail links are degraded or cut altogether (our supermarket shelves here in WA are still looking rather sparse!) And, of course, the heightened awareness of our country's security, given the deteriorating situations around the world. In my personal opinion it is imperative that we make prompt, informed decisions and get on with the current program of building up our national defences to an effective level and, on the marine side, that means naval architects being there to inform these decisions and then carry them out. I am well aware that whatever I write here is quite likely to have been overtaken by the politics of frigates and submarines before you read these lines!

Like many of you, I do find it difficult to be on top of everything that is developing around the world, but one matter on which I have not seen enough emphasis is the increased potential fire risk to car carriers and ferries as more and more alternative-fuel vehicles are carried, be it lithium batteries, hydrogen, or any other alternative fuels in their tanks. This can affect us all — if good, effective work is being done in this field then I would like to see it reported in this publication.

Now, looking ahead, what are my plans as your Division president for the next two years?

- First, I intend to spend the next couple of months talking to as many of you as possible; in this respect Zoom/Teams meetings have proved their worth — by the time you read this I will have "sat in" on two or three Section meetings and, hopefully, communicated directly with many more of you. I really do want to know just what you all need from RINA from here on in. Both London and Division are working to better support you, but there is no substitute for that personal "face-to-face" with you to best inform my thinking. Then some of my intentions are to:
- ensure that RINA's voice is effectively heard and that the essential roles of naval architects are understood at all levels of education in Australia, particularly at the NSC as well as at AMC and UNSW Canberra;
- continue to improve communication and cooperation with Engineers Australia for the benefit of all naval architects and other professional engineers working here in the marine industry; and

Jim Black

- ensure that there is effective succession planning in place, where and when appropriate, for key Division and Section personnel, and those volunteering in key positions to support our important activities around the country.

All thoughts, comments and assistance with any of these matters will be most welcome!

Unfortunately, I will not have been able to come across the country for this year's Indo Pacific IMC but I fully intend to be there in 2023. I hope that it will again be well attended by members. Our new forward-looking Chief Executive, Chris Boyd, will be at the conference and is then visiting Tasmania, South Australia and Western Australia — I trust he will be well supported and that you will showcase the best of Australian maritime know-how to him.

So, finally, my thanks to all who have taken us to where we are now: Gordon, Violetta, Rob, Craig, all on Council, and particularly to all who are going to take us onwards from here — I look forward to working with you and taking our great Royal Institution of Naval Architects forward into a secure, prosperous and sustainable future. Please feel free to chat to me any time on 0418 918 050 or jimblack.marine@iinet.net.au

Jim Black

Editorial

This edition of *The Australian Naval Architect* is being assembled in the week after the Indo Pacific 2022 International Maritime Exposition was held in Sydney. This major event, which included our International Maritime Conference (IMC2022) conducted with our colleagues from the Institute of Marine Engineering, Science and Technology and Engineers Australia, was to have been held in 2021, but the pandemic meant that it had to be rescheduled until this year.

The pandemic continues, of course, and provided many challenges for our organising and program committees and some presenters were forced to withdraw, sometimes at short notice, resulting in many changes to the program. In spite of our usual practice of selecting more papers than we had time for, the withdrawals meant that there were no presentations scheduled for the afternoon of the third day.

Despite these challenges, registrations for IMC2022 were a record at just under 370 — the highest since we became associated with the Exposition 20 years ago. IMC2022 was just one of many conferences and symposia held over the three days, including the RAN's flagship Sea Power Conference. The International Convention Centre was humming with activity.

Overall, the statistics for the event, the biggest in 20 years, are impressive. There were more than 25 000 visitor attendances, 736 participating companies from 23 countries, 115 official defence, industry, academic and government delegations and 40 nations represented with 39 Chiefs of Navy or their counterparts from all over the world. Whilst the event inevitably had a naval focus this year, there was something of interest for everyone.

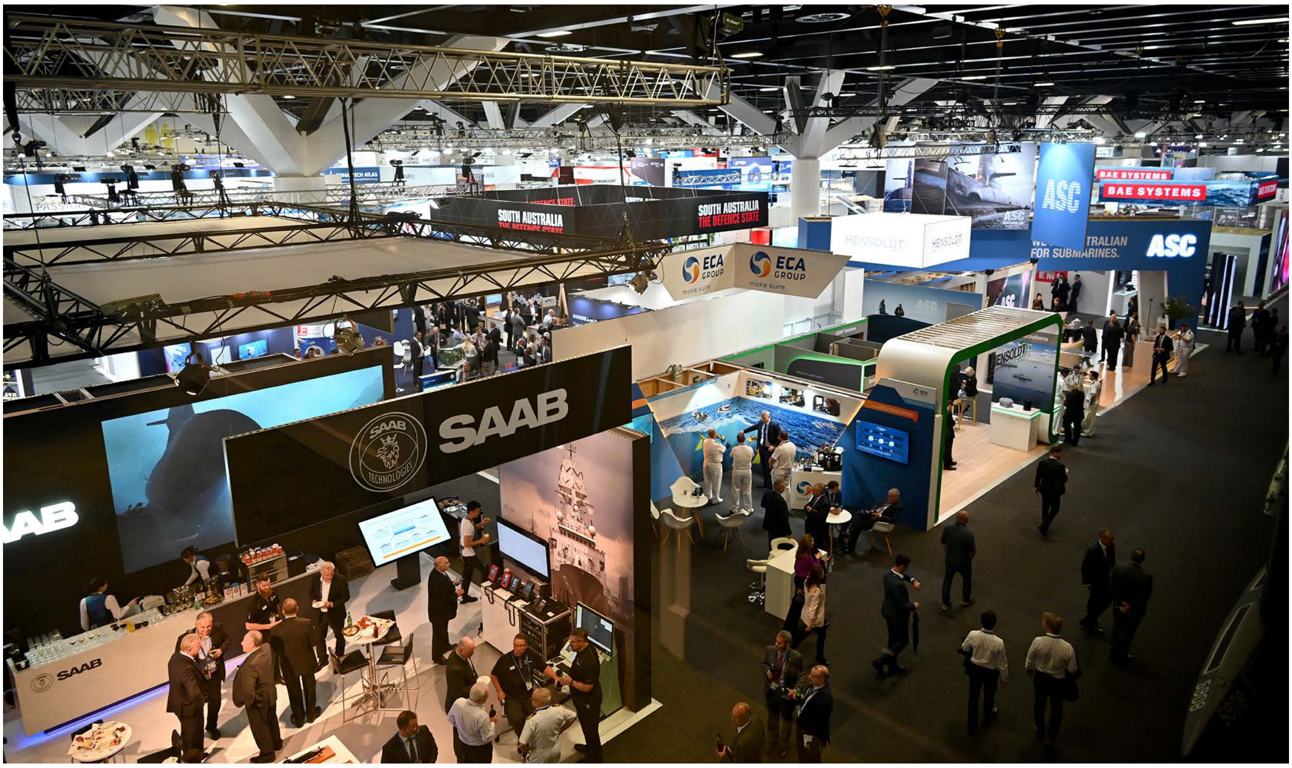
We were also pleased to welcome the new Chief Executive of the Royal Institution of Naval Architects, Chris Boyd, to Sydney. He was kept running from the moment he landed in Sydney!

IMC2022 did not just happen. It was the product of much work, not only by the presenters, but by the members of the Organising and Program Committees — all volunteers. As Chair of the Organising Committee, I extend my thanks to them all for their contribution and hard work. We will have a full report on the event in the August edition of *The ANA*.

On another subject, on Page 51 we report on the introduction by BAE Systems Australia and the employer association Ai Group of a degree apprenticeship program at the start of the 2023 academic year, which will be delivered by Victoria University. Apprentices will study for a degree, initially in systems engineering, in parallel with gaining on-the-job training with their employer. BAE Systems hopes that, if successful, the scheme might be extended to include a variety of engineering degrees.

The scheme, which has been successful for BAE Systems in the UK, is described as 'novel', but the older members amongst us will be very familiar with the approach. It is certainly familiar to me — I started work as an apprentice ship draughtsman and studied naval architecture part time at UNSW. It was hard work — two afternoons and three nights per week at the University for seven years — but it was a tremendous learning experience. Part time courses were phased out during the 1960s. Learning that way enhances understanding through practical experience and builds a relationship with an employer from the beginning.

John Jeremy



The Indo Pacific 2022 International Maritime Exposition held at the International Convention Centre in Sydney on 10–12 May was the largest in the 20 year history of the event
(Photo John Jeremy)

LETTER TO THE EDITOR

Dear Sir,

In the last edition of The ANA, the article *The New Naval Architecture Degree Program at UNSW Canberra* mentioned that UNSW (1958) had grown out of the Sydney Mechanics School of Arts (1833) later becoming the Sydney Technical College (STC 1878) and the NSW University of Technology (1949). The following are some comments about early Naval Architecture courses.

Prior to World War II, naval architects in Australia had been generally qualified in Britain as no such local course was available. However some establishments with an overseas qualified naval architect recognised senior draftsmen as naval architects if they had experience in calculations and related academic studies in other engineering disciplines. Indeed this could also be found in the Department of Navy (prior to combining to form the Department of Defence in 1973) up till the early 1960s, and naval architects were not paid as much as mechanical and electrical engineers.

Early in WWII the need for a naval architecture course in Australia was recognised. Accordingly, around 1941 this was added to the other approximately 18 Diploma courses at Sydney Technical College at Ultimo. These courses were completed part time over five years, with classes on week nights and Saturdays, leading to the award of "Associate Sydney Technical College" (ASTC). These awards were phased out by 1962.

In 1949 the NSW University of Technology was founded, co-located with STC, and in 1951 this new establishment took over the engineering, applied science and related Diploma courses. Starting in 1954 some diploma courses were upgraded to BSc(Tech) degrees which could be completed in six years part time, with some BE courses coming later. The physical move to the Kensington campus took place from 1955 to 1967, the last to move being Civil Engineering. In 1965 at Ultimo I remember a combined class in lofting, plate expansion and timber boat construction with the shipwright apprentices, and undertaking one of the common engineering subjects in class and laboratory.

Diploma courses in naval architecture were also offered at Whyalla until 1967, and at RMIT.

When I started in the Garden Island Dockyard drawing office in 1965 while studying part time, except for one person who had worked his way up through drafting, all Garden Island naval architects, (and many mechanical and electrical engineers,) held diplomas from the STC.

Hugh Hyland

COMING EVENTS

NSW Section Technical Presentations

Technical presentations are arranged jointly with the IMarEST (ACT & NSW Branch) and held on the first Wednesday of each month, starting at 6:00 pm for 6:30 pm and finishing by 8:00 pm (local times).

Presentations will continue for the foreseeable future as webinars, hosted by RINA. Registration is *not* required, and details for connection will be provided in the flyer for each meeting. When pandemic restrictions permit and it is safe to do so, consideration will be given to a return to face-to-face presentations.

The *Coming Events* page on the RINA NSW Section website is updated with details and changes as soon as they become available.

The program of meetings remaining for 2022 is as follows:

1 Jun Dave Giddings, Manager, Drive Marine Services and Boatcraft NSW
Modern Technology Resins, Coatings and Glues

6 Jul Matt Johnston, Manager Maritime Safety and Environmental Policy, Australian Maritime Safety Authority
Australia's Regulatory Framework for Autonomous Vessels and Decarbonisation

3 Aug IMarEST — Jotun
TBA

7 Sep RINA — Damen
Tug Electric-drive Technology—The Future is Now

5 Oct Lachlan Toohey, Senior Technical Officer, Australian Centre for Field Robotics, University of Sydney
Hover-capable Autonomous Underwater Vehicles: Design and Use Cases

1 Dec SMIX Bash 2022

ACT Section Technical Presentation

24 May Francois Flocard, Principal Engineer, UNSW Water Research Laboratory
The Australian Wave and Tidal Environment and the Inherent Marine Renewable Energies

This presentation will be held as a webinar using the Zoom software platform at 6:30 pm AEST. Registration is required. Further details will be circulated to Section Secretaries prior to the event, or you can register directly at https://forms.gle/3JsGn65MdzE6Lf8fA.

Victorian Section Technical Presentations

23 June Zoe Williamson, Association of Professional Engineers Australia
Victorian Engineering Registration

TBA Altair Engineering and SSI (ShipConstructor Software Incorporated)
CAD/CAE Workflow—Capturing, Validating and Optimizing Structure Design in Shipbuilding

The presentation on 23 June will be held as a webinar using the Zoom software platform at 7:30 pm AEST. Registration is required. Further details will be circulated to Section Secretaries prior to the event.

Maritime Robot X Challenge 2022

The Maritime Robot X Challenge 2022 will take place at the

Sydney International Regatta Centre on 11–17 November 2022 and is a collaboration between the US Office of Naval Research (ONR), the Australian Defence Science and Technology Group (DST), and RoboNation.

The RobotX Challenge is an international university-level competition designed to foster interest in autonomous robotic systems operating in the maritime domain, with an emphasis on the science and engineering of cooperative autonomy. Team members can be from a single university or from several universities. This competition facilitates the building of international relationships between students, academic institutions and industry partners, and provides opportunities for innovators to demonstrate their potential and to make substantial contributions to the robotics community. The RobotX Challenge 2022 will be the fourth such event, the first of which was held in Singapore in 2012.

See https://robotx.org/ for more information about the challenge, and get a glimpse of the competition in Australia at https://youtu.be/oXlsnz4ye64.

The base platform for Robot X Challenge 2022 is the Wave Adaptive Modular Vehicle (WAM-V), which teams must outfit with propulsion, control systems, sensors, and other systems necessary to accomplish the competition challenges. All teams competing in Robot X must use the same core platform as the basis for their multi-vehicle multi-domain autonomous maritime system of systems and, to this end, RoboNation awarded a limited number of the WAM-V platforms to teams which committed to participate in this and future Maritime RobotX Challenges and Forums.

AOG Energy 2023

AOG Energy is Australia's premier oil, gas and energy trade event held annually in Perth, and is organised by Diversified Communications Australia.

For over 40 years, AOG Energy has been recognised as *the* premier Australasian oil, gas and energy event, bringing together the entire supply chain from across Australia and the globe.

We regularly connect with our community so that AOG Energy can continue to meet the needs of the industry. Recently we surveyed our audience, spoke to key exhibitors and consulted with our industry committees on their objectives for AOG Energy 2022. The results demonstrated that, while there is an appetite for local connection, it is abundantly clear that there is a stronger desire for this to happen at the large global scale to which the industry is accustomed.

We are committed to delivering the event annually; however, we understand that 2022 will continue to present its challenges in connecting the market at scale. We want to do the best by you and reunite the industry at the right time, therefore have made the difficult decision to cancel AOG Energy for 2022.

We look forward to bringing the industry back for a true celebration of what the Australasian oil, gas and energy market has to offer and to continue to innovate towards a clean energy future. The next edition will next take place on 15–17 March 2023 at the Perth Convention & Exhibition Centre.

For further details, visit the AOG Energy website at https://aogexpo.com.au/

Submarine Institute of Australia 11th Biennial Conference

Nuclear-powered Australian Submarines — Challenges and Opportunities

The announcement of the AUKUS Agreement on 16 September 2021, agreeing to the acquisition by Australia of nuclear-powered submarines, resulted in a radical shift in strategic planning for the future Australian submarine force.

The Submarine Institute of Australia's (SIA) 11th Biennial Conference (7 – 9 November 2022, Hotel Realm, Canberra) will focus on the unique and unprecedented challenges arising from the decision to acquire nuclear-powered submarines and now facing the Australian defence community.

The SIA invites Australian and international government agencies, maritime academic research and industry organisations to participate in the conference and to contribute presentations aligned with the conference theme of: *Nuclear-powered Australian Submarines — Challenges and Opportunities*, including issues such as cost, schedule, training and technical risk factors associated with the introduction of nuclear-power technologies, in a time frame commensurate with the avoidance of any 'Capability Gap' in submarine availability, all of which present a huge challenge for government, industry and academia.

This conference focuses on the full spectrum of sovereign and international academic and industrial collaboration and support required to successfully transition from an Australian submarine capability focused on the maintenance and evolution of the Collins-class submarines to a capability focused on the ability to manufacture, maintain and evolve an Australian nuclear-powered submarine capability.

The SIA is currently seeking abstracts for in-person presentations which align well with the conference objective and theme. Accompanying PowerPoint presentations will be made available to conference delegates. Abstracts (250 words maximum) — outlining proposed presentations, for review and acceptance by the SIA — should be submitted no later than Tuesday 31 May 2022. The selection of presentations will be made and all applicants advised by Thursday 30 June 2022.

For more information please access the website at: www.submarineinstitute.com/sia-conferences/Speakers.html

NEWS FROM THE SECTIONS

ACT

Annual General Meeting

The ACT Section held its Annual General Meeting on Tuesday 26 April via RINA's Zoom software platform. There has been a number of changes to the Committee, with Peter Hayes, Alistair Smith, Ahmed Swidan and James Loram moving on, and Trevor Dove, Jordan Rayson, David Lyons and Jeremy Nolan joining. As a result, the newly-elected Committee comprises

Chair	Warren Smith
Deputy Chair	Trevor Dove
Secretary	Jordan Rayson
Assistant Secretary	Martin Grimm
Treasurer	Lauchlan Clarke
AD Council Nominee	Lily Webster
Members	Ray Duggan
	David Lyons
	Jeremy Nolan

The section thanks all outgoing committee members for their contributions, and all those who attended the AGM.

Warren Smith provided the following in his *Chair's Report* which captures the sentiment of the committee:

> A second year of COVID-19 restrictions continued to influence and limit our Section's activities in 2021–22. While organising fewer meetings than has been the Section's norm, we have had the opportunity to engage nationally from our own desks and home offices. This has been possible by attending meetings hosted by other sections virtually, broadening the exposure of the presenters and our own experience. It has developed for me, and I suspect for you too, a sense of wider connection within the Australian RINA community. Perhaps, even in post COVID-19 times, this points to a useful way to foster a vibrant technical program, using technologies to support hybrid meetings. Another benefit has been the more regular recording of technical presentations and the asynchronous viewing so afforded.
>
> For me, it remains an honour and privilege to serve as the Chair, and I look forward to another interesting year learning together and building relationships. To conclude, and as similarly stated last year, as the Section activities revolve around technical meetings, please do not hesitate to step forward and share your knowledge and experience, or even volunteer to lead a provocative discussion. The Section is what we make it.

The ACT Section continues to hold webinar presentations, rather than in face-to-face format. In recent months, some potential options for presentations have fallen through. The next technical presentation is scheduled for 24 May; see *Coming Events* in this issue.

ACT Section members have been able to participate in webinar presentations hosted by other sections. The ACT Section therefore thanks other Australian Sections for extending invitations to their technical meetings, which have been appreciated by ACT Section members.

Lily Webster
Martin Grimm

Queensland

LR Seasafe

Stefano Perisco, Business Development Manager for LR Seasafe, Lloyd's Register. gave a presentation on *LR Seasafe: Providing Certainty for Critical Marine Calculations* as a webinar hosted by RINA using the Zoom software platform on 28 April. This presentation attracted 20 participating on the evening.

LR Seasafe Professional is a stability software package which can be used by designers for hull model generation and stability checks, compliance verification and stability book preparation.

LR Seasafe Professional is a proven modern statutory compliance calculations and naval architecture solution, integrated in one software package for use by designers and consultants. The system focuses on rapid development of 3D vessel models which are suitable for running the necessary calculations, from initial new design stages to the creation of stability booklets, loading manuals, marine operations manuals, etc.

LR Seasafe Professional is used for modelling and calculations for all types of vessels from passenger ships, ro-pax ferries, heavy-lift vessels and FPSOs to offshore structures, semi-submersibles jack-up rigs and luxury yachts.

LR Seasafe Professional has general approval by Lloyd's Register as an IACS UR L5 — Type 2 and/or Type 3 loading instrument. LR Seasafe Professional provides a user-friendly interface for performing loading operations, stability and strength calculations and other compliance-related checks. It provides accurate, robust calculations presented in a form tailor-made for designers and consultants.

The layout, content and format of tables, diagrams and reports can be fully customised for any end-user requirements and saved within their user profile. The software uses a fully functional interactive 2D/3D model of the vessel to display ship attitudes, cargoes, reference points, damages, points of grounding, draft marks and other vital data. It performs all statutory intact and damage stability calculations.

LR Seasafe Professional is installed in the offices of ship operators/owners, consultants, emergency response groups and shipyards as well as approval bodies such as Lloyd's Register (LR) (including LR Ship Emergency Response), other classification societies and flag administrations, and leading offshore designers.

LR Seasafe Professional models can be converted to LR Seasafe Onboard loading computers, offering a potential reduction in the modelling fees and providing consistency between design and operational documents and, in particular, in the context of class approval.

This presentation gave an overview of the LR Seasafe package.

This presentation was not recorded.

Ashley Weir

South Australia and Northern Territory

Australian Naval Classification

Michael Zgosnik, Project Engineering Manager, Australian Naval Classification Project, Bureau Veritas, gave a presentation on *Australian Naval Classification* as a webinar hosted by RINA using the Zoom software platform on 16 March. This presentation attracted 11 participating on the evening (8 in person and 3 online).

Australia has laid the foundation for the largest recapitalisation of the Royal Australian Navy in modern history, underpinned by a continuous national naval shipbuilding plan (NNSP). However, Australia's national naval shipbuilding enterprise is challenged by reports of delays and cost overruns.

To remediate some of these challenges, defence will implement a contemporary and outcome-based Australian Naval Classification Framework (ANCF). The cornerstone of this framework is the implementation of a Goal-Based Rules system, derived from the NATO Standard ANEP-77. This rules system is known as the Australian Naval Classification Rules (ANC Rules) and will be the foundation for the design, construction, classification and operation of naval vessels in Australia.

The Presenter

Michael Zgosnik is an ex Royal Australian Navy Marine Engineer, having served for just over nine years in the permanent forces. He served on board Australia's largest naval vessel, LHD HMAS *Canberra*, and has been instrumental in the implementation of the Defence Seaworthiness Regulations within the Navy.

The presentation was recorded and is expected to be uploaded to the RINA YouTube channel when permission to do so is received.

The UniWave King Island Project

Scott Hunter, Chief Technology Officer, Wave Swell Energy, gave a presentation on *The UniWave King Island Project* as the first webinar hosted by RINA using the Australian Division's new Zoom account on 16 March. The presentation was watched by 11 attendees on a screen in the Lecture Theatre S112 in the Engineering South building at the University of Adelaide's North Campus on Wednesday 20 April, and attracted a further 6 online for a total of 17 participants.

Wave Swell Energy (WSE) is an innovative Australian renewable-energy technology company whose technology operates as an artificial blowhole, extracting the energy from ocean waves via an air turbine as the waves recede. The Wave Energy Converter (WEC) has no moving parts in the water, which greatly increases its durability, reduces the cost and risks associated with access for maintenance, and ensures that there is no risk to marine life.

A 200 kW demonstration WEC (UniWave200) has been designed, built, transported and, in January 2021, installed off the coast of Grassy on King Island, Tasmania. This project showcases Australian engineering and construction expertise, involving more than 120 personnel from various industries and disciplines. The experience gained in developing this project has allowed WSE to establish an accurate baseline from which to estimate the cost and performance of future WECs.

This presentation provided an insight into the UniWave200 project from concept development through to the operation.

The Presenter

Scott Hunter is the Chief Technology Officer of Wave Swell Energy. He has a Bachelor of Engineering degree in Naval Architecture from the University of New South Wales, and has been involved in the development of marine renewable technologies in Australia and the USA for more than 18 years. Since joining WSE, Scott has been heavily involved in developing and validating the core intellectual property of WSE. As a Director of WSE, Scott's board responsibilities include overseeing and evaluating the company's design and technology operations.

The presentation was not recorded.

Cameron Wilkinson

Victoria

Portable Active Heave Compensation

Ben Healy, Managing Director of Thrust Maritime, gave a presentation on *Portable Active Heave Compensation — A story of Australian Innovation* as a webinar hosted by RINA using the Zoom software platform on 10 March. This presentation attracted 22 participating on the evening.

Ben spoke about Thrust Maritime's internal development project to design and manufacture an active heave-compensating winch system that is highly portable and can be rapidly installed on a wide range of offshore support vessels, to provide a cost-effective and flexible lifting/launch/recovery capability. The project started with clear design goals, including that the system should be able to hold a load steady in higher sea states than those in which a typical ROV would be launched and operated. The system could be used by itself, but is primarily intended to be used with an A-frame, such as those manufactured, leased, and sold by Thrust Maritime.

Of particular interest was Ben's candid discussion about the final design of the system being significantly more complex than originally envisaged. This is a valuable lesson for any engineers considering a novel technology development project. The success of the resulting product is a testament to Thrust's expertise and persistence.

Ben explained various innovative features of the system, such as

- all-electric drive with low-inertia motor;
- the different heave-compensation modes in which the system can be operated;
- multiple layers of redundancy to ensure that operations can continue or be returned to a safe state in the event of a primary power-supply failure;
- interchangeable shells on the winch drum to allow different diameter wire ropes to be used;
- adjustable bolted brackets for deck attachment on different ships; and
- how the complete unit can be stowed in a 20 ft shipping container for transport and storage.

The presentation also covered the testing program for the system—including prototype testing, factory testing of individual sub-systems and the complete system, and sea trials — to demonstrate how necessary this aspect of the project was in order to obtain full confidence in the final product. Ben also shared video showing the factory testing system which Thrust developed to simulate full-scale ship motions, prior to sea trials, within their workshop to provide a realistic input signal to the Motion Reference Unit.

In conclusion, this was an engaging and highly-interesting presentation which gave real insights into the challenges involved in developing an innovative engineering system from initial concept right through to a market-ready product.

The Presenter

Ben Healy is an engineer/naval architect and the Managing Director of Thrust Maritime. His background includes significant experience in subsea operations from the practical, project-management and engineering aspects. He has led the development of a fleet of high-integrity launch-and-recovery systems. From 2019 through 2021, Ben was a key member of the team drafting the new IMO global diving regulations.

Ben studied engineering at the Australian Maritime College, business at Monash University and, in earlier days, graduated from the Royal Military College, Duntroon. He served in the Australian Army for over 20 years and is a specialist in long-range waterborne surveillance.

The presentation was recorded, and is expected to be uploaded to the RINA YouTube channel soon.

Upcoming Technical Presentations

The Section Committee had been hoping to host a technical presentation on the topic of *Vestas Sailrocket 2* by Paul Larsen, the current water speed sailing record holder but, unfortunately, the presentation had to be cancelled.

Upcoming events which the Section is planning are:

- A webinar by Zoe Williamson from the Association of Professional Engineers Australia on the topic of *Victorian Engineering Registration*; this webinar is currently pencilled in for 23 June; and
- A presentation by representatives from Altair Engineering and SSI (ShipConstructor Software Incorporated) on the topic *of CAD/CAE Workflow—Capturing, Validating and Optimising Structure Design in Shipbuilding*.

Victorian Section Committee

The Victorian Section is looking to expand its Committee and would welcome enquiries from any members who might be interested. Please contact me at vicsec@rina.org.uk if you would like to find out more.

Tom Dearling
Chair
RINA Victorian Section

Western Australia

Green Water on the Deck of an FPSO

Jinzhu Xia, Principal, Naval Architecture and Mooring, MISC Malaysia, gave a presentation on *A New Approach for Quantifying Green Water on the Deck of an FPSO* at the Meeting Place Community Centre, South Fremantle on 27 April, and streamed live via the Teams software platform.

The effect of green water impact on the deck of an FPSO is often a serious concern during engineering. Insufficient understanding can easily lead to over design.

Based on comprehensive model tests conducted at MARIN, a modified dam-break solution was proposed and has been successfully applied to calculate green water height and speed on the deck during FPSO design.

This presentation was based on a publication accepted by OMAE 2022, and gave an overview of the problem and its solution.

The Presenter

Jinzhu Xia is currently the Principal, Naval Architecture and Mooring with MISC Malaysia, for the execution of Petrobras's MERO 3 FPSO Project, which is to be commissioned in 2024.

Nathan Chappell

New South Wales

Annual General Meeting

The NSW Section held its 24th AGM on the evening of 2 March, following the March technical presentation, with Belinda Taylor in the chair.

Belinda, in her first Chair's Report, summarised the NSW Section's activities over the last twelve months. It had been another challenging year with the continued disruption of the pandemic in our lives. Despite the distraction that the pandemic presented, the NSW Section persevered with a full program of technical presentations and the return of SMIX Bash.

All technical presentations in 2021 were held jointly with the IMarEST (ACT & NSW Branch) as video-conference webinars, with four hosted by Engineers Australia and the remaining five by RINA. Attendances varied between 156 for Eric Desjardin's presentation on *Construction of Advanced Composite Racing Yachts*, and 12 for Pier Nissotti's presentation on *Application of Intershield 6GV to a Royal Australian Navy Flight Deck*, with an average of average 82, which far exceeds our long-term average of 28 for face-to-face meetings at the Engineers Australia Chatswood venue.

2021 saw the return of SMIX Bash, albeit with reduced numbers due to pandemic restrictions. The 21st SMIX (Sydney Marine Industry Christmas) Bash was held on Thursday 2 December 2021 aboard the beautifully-restored *James Craig* alongside the North Wharf, Darling Harbour, from 1730 to 2130 and, despite restricted numbers, was another outstanding success. Thanks must go to the Organising Committee and the sponsors who supported the event because, without them, the "Bash" could not happen. In what has been a difficult year for many industries, it was particularly promising to see so many new sponsors supporting the event this year. SMIX Bash this year came in with a small surplus, which we have shared with the IMarEST. Our share of surpluses obtained from our social activities over the years is used to enhance our Section activities, including a "thank you" bottle of wine for our technical presenters. In addition to the bottle of wine, a Certificate of Appreciation is also given to each presenter.

Looking ahead to 2022, we are considering a return to face-to-face meetings in a COVID-safe manner. We already have a diverse schedule of technical meetings planned for this year. We have the Indo Pacific 2022 International Maritime Conference and Exhibition in May which is a fantastic celebration of our industry's achievements, and RINA will have a stand at the Exhibition.

Adrian Broadbent presented the Treasurer's Report. As at 31 December 2021 (the close of our financial year), we had a balance of $5040 in the Section account. This is a small change from last year due to our meetings being conducted on-line to meet pandemic restrictions for all of 2021 and, hence, minimal meeting costs incurred.

SMIX Bash is funded separately through the Social account which currently has a healthy balance which allows us to plan for SMIX 2022 and to support the NSW members, mainly for additional catering at the technical meetings (when we can have them) and presentation gifts to our speakers. SMIX 2021 was held successfully, albeit with reduced numbers due to pandemic restrictions. Our sponsors continued to generously support the event and we achieved a small surplus, equally split between RINA NSW Section and IMarEST ACT & NSW Branch.

There is a number of changes to the NSW Committee for 2022. Jason Steward has resigned from the Committee and from RINA, due in part to the pressure of other things. All other committee members have agreed to serve for a further term in their current positions. Jason was our Secretary and an elected member of the Australian Division Council when he resigned; with Lauren Stotz taking up the position of Secretary, and John Butler has been elected to the Australian Division Council.

New nominations for the Committee were subsequently called for and, as a result, Ehsan Khaled and Lauren Stotz have been elected. As a result, we now have eleven members on the Committee.

The NSW Section is also represented on the Australian Division Council by Craig Boulton as Treasurer.

The NSW Section Committee for 2022 is as follows:

Chair and SMIX Bash Committee Chair	Belinda Tayler
Deputy Chair and TM Program Coordinator and Website	Phil Helmore
Treasurer and Nominee to AD Council	Adrian Broadbent
Secretary	Lauren Stotz
Auditor	David Wong
Members	Craig Boulton
	John Butler
	Valerio Corniani
	Ehsan Khaled
	Molly McManus
	Alan Taylor

Committee Meetings

The NSW Section Committee met on 15 March and, other than routine matters, discussed:

- SMIX Bash 2021: All sponsorships have been received and all expenses paid, resulting in a small surplus which will be shared with the IMarEST, and the proceeds of the raffle will be donated to the Sydney heritage Fleet.
- SMIX Bash 2022: *James Craig* has been booked for Thursday 1 December; the Organising Committee has been formed and the letter to sponsors is to be updated for this year.
- Technical Meeting Program: We now have a full program of presentations for this year with the IMarEST; consideration is being given to a return to face-to-face meetings.
- AD Council Report: AD Council expects that (a) sections will provide a member to engender sponsorship/advertising in *The ANA*; and (b) sections will work closely together with the local Engineers Australia division. RINA Australian Division now has charity status with the ATO and so has GST exemption.

The NSW Section Committee also met on 26 April and, other than routine matters, discussed:

- SMIX Bash: The IMarEST share of the 2021 surplus has been paid and raffle proceeds donated to the Sydney heritage Fleet; SHF to be asked whether closing time for 2022 can be extended; letter to sponsors for 2022 being updated.
- Technical Meeting Program: Presentation for June re-arranged; presentations to continue by webinar for the foreseeable future.
- Proposed Changes to Rules for Sections: Document circulated from Australian Division noted, and comments sought.
- Liaison with Engineers Australia: Document circulated from Australian Division noted, and comments sought.

The next meeting of the NSW Section Committee is scheduled for 28 June.

Design and Construction of the New Spirit of Tasmania Vessels

Bernard Dwyer, Managing Director/Chief Executive Officer of TT-Line, gave a presentation on *Design and Construction of the New Spirit of Tasmania Vessels* as a webinar hosted by RINA using the Zoom software platform with the Deputy Chair of the NSW Section, Phil Helmore, as MC on 2 March. This presentation attracted 24 participating on the evening.

Introduction

Bernard began his presentation with an introduction to TT-Line and their current operation. TT-Line is a State-owned entity which operates with an independent Board and, as a result, is required to be self sufficient and pay a dividend to the Tasmanian Government.

They currently operate two identical vessels, *Spirit of Tasmania I* and *II*, which ply between Station Pier in Melbourne and the Port of Devonport [Spirit of Tasmania III, *which plied the Sydney–Devonport route, was sold in 2006 and is now* Mega Express IV *of Corsica Ferries in Italy* — Ed.]

Spirit of Tasmania I
(Photo John Jeremy)

These vessels commenced operation in 2002 and brought a big change to the Tasmanian economy. The vessels can operate at 28.5 kn, leaving at 7:30 pm for a crossing of Bass Strait and arriving at the other end at 6:00 am. This is important for freight, as a 6:00 am arrival in Devonport enables trucks to reach Hobart, unload and reload, and be back in Devonport in time for the 7:30 pm departure for the return voyage across Bass Strait. However, the vessels typically operate at 24 kn to maintain that schedule. If they have access problems, and are delayed by up to two hours, then they can increase speed to the 28.5 kn to catch up and remain on schedule.

During busy periods, e.g. in peak tourist season over summer, they also have day sailings as well. However, with the time taken to tie up, discharge, clean, reload and depart at both ends, they cannot fit two sailings into 24 h. In addition, passengers on day sailings need to be entertained for the whole trip as they don't have berths, where passengers on evening departures usually head straight for their beds after sailing.

Four or five years ago, they were carrying 340 000 passengers per year with 48 day sailings, 60% of which was tourists and 40% freight. Freight is carried only on trailers, not in containers. They knew that there was a lot of demand which was not being satisfied.

So, three years ago TT-Line spent $31 million on the vessels to update the interiors, delete the defunct swimming pool area, etc. and, in the subsequent time, went from 48 to 180 day sailings per year, increased to 450 000 pax/year and carrying 115 000 TEU/year; a remarkable increase in business. This showed that the demand is there, but they knew that they could not increase capacity further with the existing vessels.

Aiming for New Vessels

They therefore set about designing new vessels to cater for the demand which they knew was there. They spoke to TasPorts, and to the Devonport Harbourmaster to determine the largest vessel which would be able to berth in Devonport. They aimed for an increase in capacity of 40% and, in 2018, signed a contract with the German company Flensburger Schiffbau-Gesellschaft (FSG) to build two new vessels, with the first expected to enter service in 2021. However, FSG ran into financial difficulty and could not build the vessels.

TT-Line then went back to another tenderer, the Finnish company Rauma Marine Constructions (RMC), and came up with a Memorandum of Understanding in the middle of the pandemic. However, the Tasmanian Government at that stage insisted that wave-piercing catamarans also be considered together with the large monohulls. The operations of both were reviewed, and the Government eventually agreed that the MoU with RMC was the best option, and the contract for construction by RMC was signed in April 2021.

Geelong Terminal

Over four years of planning, they had also been thinking laterally and, if they were going to change some things, then why not change other things as well to assist in the efficient operations of the two ports?

At the Station Pier terminal in Melbourne they have a 1 ha site, which significantly constrains their operations with passenger vehicles, caravans and freight vehicles. They investigated the site at Corio Bay in Geelong and found that, with a 12 ha site, they had much more space both for vehicle parking and for loading and discharge. Here Bernard showed a slide of the Geelong terminal.

Artist's impression of the TT-Line terminal at Geelong
(Image courtesy TT-Line)

An advantage of the increased space is that freight customers will be able to drop off their freight for loading 24 h before departure, compared to 3 h at Station Pier. The passenger and freight vehicles can also be kept separated. The building to the right of the vessel contains the facilities, including a coffee shop for tourists and freight drivers to relax. The vessels will load vehicles over the stern in Devonport and over the bow in Geelong, so the whole operation becomes drive-through, and they expect to reduce the total turn-around time, including cleaning, from 3.5 h to 1.5 h. The new vessels are 40% larger than the existing vessels and more efficient. As demand increases, they will be able to add in day sailings and still keep to a 24 h schedule, which they can't at the moment. This is expected to cater for projected demand over the 25-year life of the vessels.

Artist's impression of starboard bow of the new
Spirit of Tasmania vessels
(Image courtesy TT-Line)

Artist's impression of port quarter of the new
Spirit of Tasmania vessels
(Image courtesy TT-Line)

The New Vessels

The new vessels will be named, unsurprisingly, *Spirit of Tasmania IV* and *V* — the brand is now well-known and loved. The livery will be red-and-white, similar to that on the current vessels, and the Spirit of Tasmania logo has been refreshed to highlight the bow of the ship against the blue sea and sky framed within the shape of Tasmania.

Principal particulars of the new vessels, in comparison to the current vessels, are

Vessel	*Spirit IV* and *V*	*Spirit I* and *II*
Length OA	212 m	194 m
Beam	31 m	25 m
Deadweight	6400 t	5651 t
GT	48 000	29 338
Passengers	1800	1400
Cabins	301	222
Standard recliners	118	121
Business recliners	53	0
Vehicle lanes	3700 m	500 m
Main engines	4×Wartsila LNG and diesel each 10 305 kW @ 600 rpm	4×Sulzer V16 diesel each 10 560 kW @ 510 rpm
Propulsion	2×CPP	2×CPP
Speed	28.5 kn	28.5 kn
Route distance	Geelong–Devonport 242 n mile	Melbourne–Devonport 232 n mile
Crossing time	9–11 h	9–11 h
Classification Society	LR	ABS

The engines on the new vessels are dual fuel, and they expect to be operating mostly on LNG when they arrive. Carbon emissions are increasingly important, and the engines are also expected to be able to operate on the new biofuels. The Tasmanian Government is looking at the generation of hydrogen in Tasmania, and so TT-Line is also looking at that.

The vessels will be able to carry 1800 passengers on day sailings, and 1150 overnight, as all overnight passengers are berthed. There are 8 accessible cabins, all with interconnecting doors to cabins for support people.

The move to the new terminal in Geelong will happen this year. *Spirit of Tasmania IV* is expected to arrive in Australia in 2023, and *Spirit V* a year later so, for a while, there will be a combination of the old and new vessels operating.

General Arrangement

Here Bernard showed a general arrangement drawing of the new vessels, zooming in on features of interest. However, as some of the information is sensitive, the drawing has not been included here and descriptions may suffice.

The fast rescue boat is located at about mid-height of the superstructure where, in the current vessels, it is located on the top deck.

Safe return to port is critical, and there is a second safe-return-to-port bridge provided with duplicated controls. There are also rations kept onboard for both crew and passengers—it is at that sort of level.

The crew work four weeks on and four weeks off. Their cabins and private recreation area are on the top deck. The officers and crew cabins are mainly on the outside so that they obtain natural light. However, there are skylights to the passageway for the inside cabins so that they also receive some natural light.

There are both economy-class and business-class recliners, as well as multiple classes of cabins, lounges, and recreation bars.

The new vessels use all of the beam for cabins, where the current vessels have walkways outside of the cabins. There are outside areas at the stern of the vessels for people to take the fresh air.

There are two cinemas, a teenagers' lounge, a library, and a café in the centre of the vessel. There is also a tasting bar/lounge for tasting Tasmanian produce. The retail area is five times the size of that on the current vessels.

The *a la carte* restaurant has been brought back—it was removed on the current vessels when they were refurbished, much to the chagrin of some people. There is a big buffet restaurant which caters for the majority of the passengers.

There are two gaols (i.e. brigs).

There is a drivers' lounge for the freight drivers; it is not large, but is as provided for freight drivers in Europe.

Decks 3, 5 and 7 are for motor vehicles and freight. Ramps for loading of passenger and freight vehicles are necessarily close together. The current vessels have a height limit of 2.1 m for passenger vehicles, and they can raise or lower the hanging decks as required. The new vessels have a height limit of 2.2 m, and a 2.3 m width as well, both for safety and passenger comfort. Without the hanging decks, the height limit is 4.8 m, which caters for the new standards for caravans and motor homes as well as for freight vehicles. Deck 3 can cater for vehicles 4.8 m high and 3.2 m wide. As a matter of interest, vehicles on all decks can be unloaded via Deck 3 if necessary.

The pet kennels on the current vessels are on the vehicle decks, so the owners cannot visit their pets while the vessel is under way. On the new vessels, the pet kennels are in the casings, outside the vehicle decks, and have their own air conditioning, etc., so owners can visit and exercise their pets while under way.

On the current vessels there is no lift access to every level. Foot passengers come on board and up escalators to reach their deck. On the new vessels there will be no escalators, and foot passengers will either use stairs or the lifts to reach every level.

There is a trailer lift from Deck 5 to Deck 3, so that trailers carrying frozen stores for the vessel can be driven to Deck 3 and unloaded directly into the store.

The main engines are located about two-thirds of the length aft of the bow, with the LNG tanks in the space forward of the engine room. They expect to have to fill the tanks every second trip.

Passengers typically drive onto the vessels (90%) and the remainder (10%) are on foot. There is gangway ability onto

Deck 8 in Devonport, but at Geelong the foot passengers will come onto the vessel by bus!

Construction

RMC began constructing *Spirit of Tasmania IV*, the first of the two new vessels, at its yard in Finland on 28 February. The start of construction was marked with a traditional steel-cutting ceremony, which included a welcome address from Jyrki Heinimaa, CEO and President of RMC. The ceremony was completed with the signing of steel plates to commemorate the occasion.

Delegates from RMC and TT-Line at the steel-cutting ceremony
(Photo from Cruise&Ferry website)

Conclusion

TT-Line has embarked on a significant upgrade program for their trans-Bass Strait service. The new vessels are larger than the current ones, have 40% more capacity, more features, and are more environmentally friendly. In addition, the move of the Victorian terminal to Geelong is expected to streamline the operation, reduce the turn-around time to 1.5 h, and enable each vessel to have two return sailings in 24 h in peak periods. This is expected to meet the projected demands on the service for the next 25 years.

Questions

Question time was lengthy, and raised some further interesting points.

The current vessels have one stern thruster and two bow thrusters, but are unable to operate more than two at any one time. The new vessels will have the same arrangement, but will be able to operate all simultaneously.

The new vessels will be fitted with active-fin stabilisers which are larger than on the current vessels.

They are aware of methane slip, which results directly from the performance of the engine itself. Methane slip occurs either by leakage through piston rings, or as a result of insufficient combustion, when gas is emitted unburned from the engine. Because it is unplanned and, thus, largely unmeasured, it is generally seen as a greater environmental threat than planned emissions due to bunkering, fuel changes, pipework leaks, etc. Two-stroke cycle diesel engines (as fitted to the new vessels) generally produce minimal amounts of slip, but they will be monitoring it and adjusting engine load and propeller pitch for minimal slip.

They did consider azipod propulsion, but all the analyses showed that twin controllable-pitch propellers was the more-efficient option. The controllable-pitch propellers are inward turning, a decision taken after extensive tank tests.

The auxiliary machinery comprises Wärtsilä 9L20DF sets.

Bernard indicated that he would be happy to arrange a tour of *Spirit IV,* after arrival in Australia and before entering service, for RINA Tasmanian Section—watch for her arrival!

The presentation was not recorded due to the sensitive nature of some of the material presented.

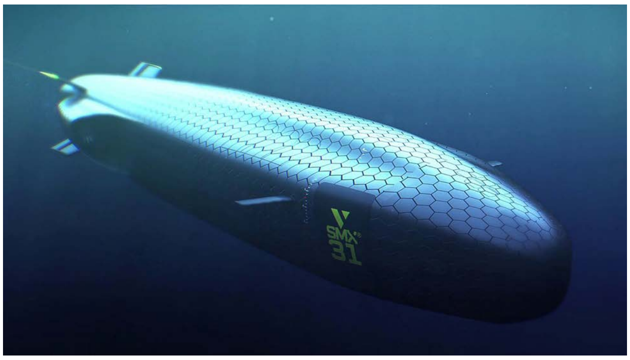
The certificate was subsequently posted to Bernard.

Seakeeping of a Surfaced Underwater Vehicle

Mathieu Courdier, PhD Candidate and Laurie Prandolini Scholarship holder, Australian Maritime College, gave a presentation on *Seakeeping of a Surfaced Underwater Vehicle* as a webinar hosted by RINA using the Zoom software platform with IMarEST Committee Member, Greg Hellessey, as MC on 6 April. This presentation attracted 23 participating on the evening.

Introduction

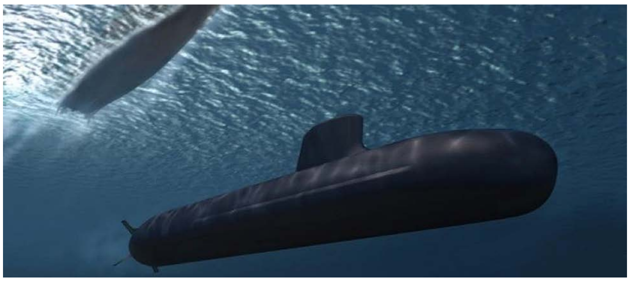
Mathieu began his presentation by presenting different types of underwater vehicles. They included Naval Group's 18 m military underwater vehicle, Triton Submarines' leisure, commercial, professional and ultra-deep submersibles, autonomous underwater vehicles (AUVs) for research and, of course, Naval Group's Barracuda-class, the USA's Virginia-class, and the UK's Astute-class submarines.



Naval Group's 18 m military underwater vehicle
(Photo courtesy Naval Group)

Triton Submarines' leisure craft
(Photo courtesy Triton Submarines)

NATO CMRE research submersibles
(Photo courtesy NATO CMRE)



Naval Group's Barracuda-class submarine
(Photo courtesy Naval Group)

Why should we consider underwater vehicles? The planet has about 1400×10^6 km^3 of water volume, or about three times as much sea volume as land. We know far less about the sea than we do about the land mass. Also. more and more of humanity depends on the oceans for energy, for food, or for transportation. Thus the only way to effectively manage this is with machines that go underwater.

Underwater Vehicles

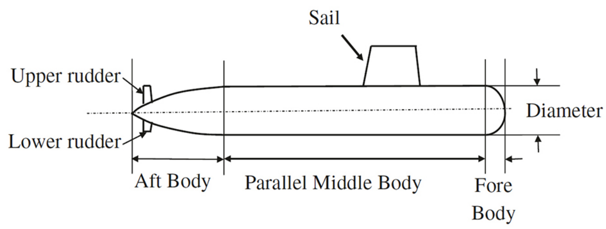
Underwater vehicles may be categorised in many ways. One way is to divide them into commercial, naval and special vehicles.

Commercial include research, industry and tourism underwater vehicles.

Naval includes nuclear-powered, conventionally-powered and midget submarines.

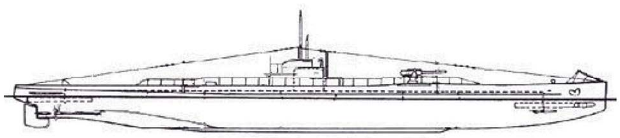
Special refers mainly to rescue craft which are typically carried by a surface ship and deployed for rescue operations.

A typical modern underwater vehicle has a parallel middle body, a hemispherical nose or fore body, a conical aft body, appendages including a sail and rudder, and a propulsion device. It is a 'torpedo-shaped' body which can benefit from the results of this research.



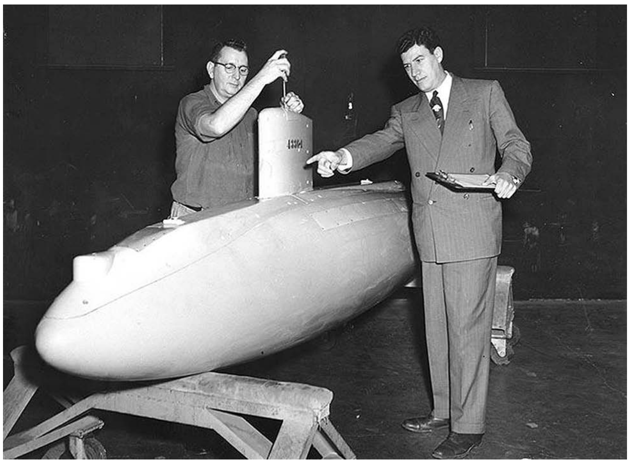
Typical modern underwater vehicle
(Drawing courtesy Martin Renilson)

The submersibles designed for World Wars I and II were based on surface ships, and their underbodies reflected that heritage rather than the modern shape. There was no magical transformation between the wars, and the shapes did not change much. The modern shape has developed from the substantial research which has been conducted since.



Typical WW I and WW II submarine
(Drawing courtesy Naval Historical Center)

In the early Cold War, the David Taylor Model Basin in the USA conducted a large amount of research on the best hydrodynamic shape for submarines, including tests on a model of USS *Albacore* in the towing tank in 1956.



Preparing model of USS *Albacore* for tests
at DTMB in March 1956
(Official US Navy photograph courtesy Naval Historical Center)

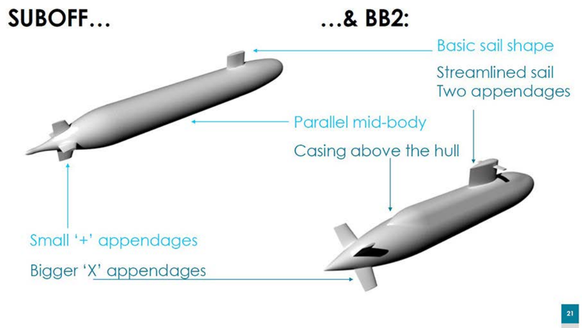
Here Mathieu showed a slide with twelve different types of underwater vehicles to show the extraordinary diversity now available, and a slide showing AMC's own autonomous underwater vehicle, *Nupiri Muka* [*meaning "Eye of the Sea" in palawa kani, the language of Tasmanian Aborigines; this AUV is capable of diving to 5000 m and aims to provide new insights into the role of Antarctica and the Southern Ocean in the global climate system* — Ed.]

AMC's autonomous underwater vehicle *Nupiri Muka*
(Photo courtesy AMC)

The largest submarines ever built were the six Soviets' Typhoon (Akula) class nuclear-powered ballistic missile (SSBN) submarines which were constructed at the Severodvinsk Shipyard, on the White Sea near Archangel. These vessels were 175 m long, had a surfaced displacement of 24 000 t and a submerged displacement of 48 000 t.

Typhoon-class submarine
(Photo from Naval Technology website)

There are two open-source submarine shapes on which much research has been, and is being, conducted. There are the Defense Advanced Research Projects Agency's Suboff model, developed at the David Taylor Research Center in the USA in 1989, and the Defence Science and Technology Organisation's BB2 model, developed by Peter Joubert in Australia from 2004.



Comparison of the Suboff and BB2 models
(Diagram courtesy Mathieu Courdier)

Why Surfaced Underwater Vehicles?

Simply, underwater vehicles (UVs) have to operate on the surface for some of the time—they all begin and end their operations there. Small UVs are launched on the surface, while large crewed UVs take on crew, fuel, water and stores on the surface before beginning their mission. Most need to be on the surface for communications. Conventionally-powered submarines must surface for air to run their diesel engines and to refresh the air for the people inside the hull.

A surfaced UV is subject to the waves on the water surface and, in addition, generates its own waves when running free, diving or surfacing. There is therefore much interest in the size and shape of the waves so generated.

Here Mathieu showed a video of the waves generated by a submarine running free on the surface.

Deployment of a research UV
(Photo courtesy NATO CMRE)

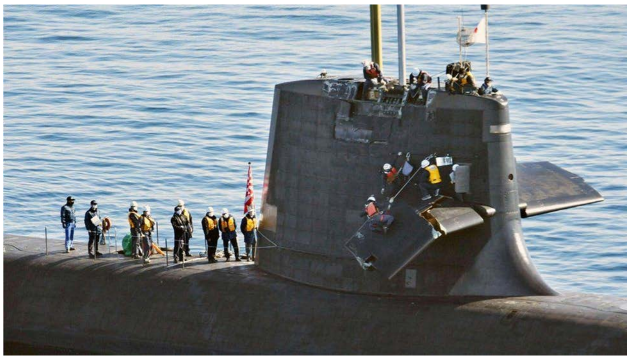
Deployment of *Nupiri Muka* in Antarctic waters
(Photo courtesy Mick Davidson)

Waves generated by a submarine travelling on the surface
(Photo courtesy Douglas Dammermuth)

Submarines are at their most vulnerable when surfacing, and there have been a number of collisions with surface vessels while doing so. Here Mathieu showed the results of three such collisions of US Navy submarines, one with a badly-damaged sail, and one with a bent sail which cost $120 million to repair, and one of a Japanese Navy submarine with a badly-damaged fin on the sail.

Damaged sail on USS *Nautilus* (SSN 571)
(Photo from NavSource website)

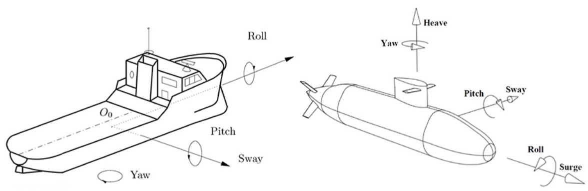
Bent conning tower on USS *Hartford* (SSN 768)
(Photo from Wikimedia Commons website)



Damaged fin on sail of Japanese submarine *Souryu*
(Photo from BBC website)

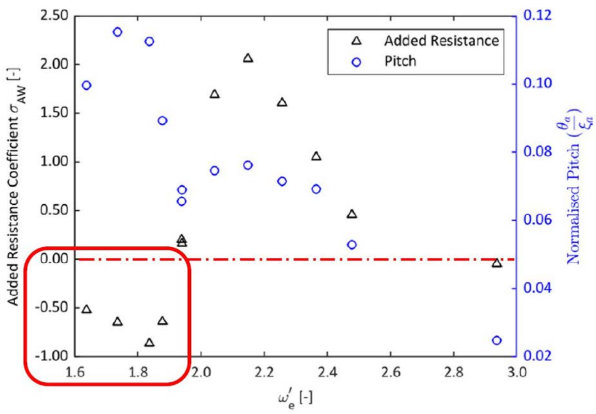
Problem Definition

What needs to be understood — is a submarine like a surface ship? A submarine, in general, travels in three dimensions, while a surface ship travels in two. So there is one additional level of complexity.



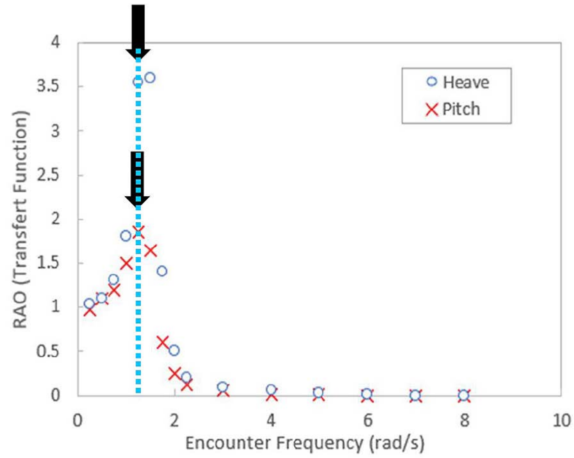
Comparison of degrees of freedom for a surface vessel and a submarine
(Diagram courtesy SNAME)

Also it has been shown at AMC since 2019 that underwater vehicles experience some hydrodynamic behaviours that are unheard of for surface ships. One difference is that the heave and pitch motion responses for a surfaced underwater vehicle are different to the ones of a surface ship. The known behaviour is a single peak in the amplitude of the heave and pitch motions for a given wave encounter frequency, whereas this becomes much more complex for a surfaced UV: the peaks of heave and pitch motion occur at different values of encounter frequency, and the peak heave motion occurs near a trough of pitch motion. As a result, submarines are more susceptible to adverse seakeeping behaviour than normal ships.

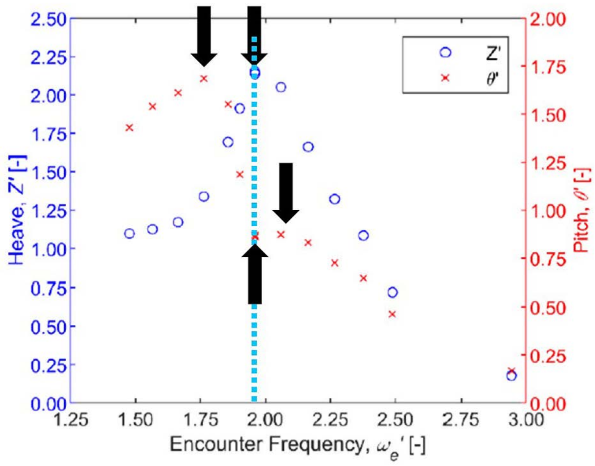


Added resistance coefficient vs encounter frequency
(Graph courtesy Mathieu Courdier)

Another difference is that the added resistance coefficient is negative for some low values of wave encounter frequency. This is a sign that the heave-pitch motion is coupled with some resistance parameters.



Classical pitch and heave motion for a surface vessel
(Graph courtesy Mathieu Courdier)



Non-dimensional pitch and heave motion response for a submarine operating at Fr of 0.196 in 2.0 m wave height
(Graph courtesy Mathieu Courdier)

Seakeeping of a Surfaced Underwater Vehicle

Here Mathieu showed some slides of submarines operating on the surface in various conditions.

Surfaced submarine in heavy seas
(Photo courtesy Naval Group)

Royal Marine commandos deploying from an Astute-class submarine in Lyngenfjord, Norway
(Photo courtesy Naval Group)

Research Impact

Who will benefit from this? The main question is *What is the seakeeping response of a surfaced underwater vessel in waves?* This can be subdivided into four separate questions.

What is the effect of *depth* on the seakeeping behaviour of a UV?

What is the effect of *wave parameters* on the seakeeping behaviour of a UV?

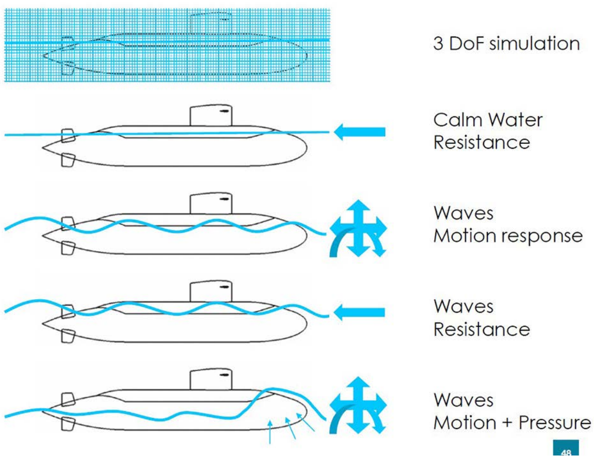
What is the effect of *hull shape* on the seakeeping behaviour of a UV?

What is the effect of *appendages* on the seakeeping behaviour of a UV?

The significance of the work is that it tackles the operational surface requirements for current and future UV projects.
It will directly benefit:

- Defence projects (i.e. navies around the world), and crewed submersibles.
- Research, science and exploration AUVs and ROVs.
- Industry needs for the energy and IT industries using robots and survey vehicles.
- Over time, from design to operation, by way of guidance for designers and operators.

The main novelty that this research brings to the field is a set of guidance for designers and operators, and some original fluid dynamics knowledge.



Guidance for designers and operators and fluid dynamics knowledge
(Diagram courtesy Mathieu Courdier)

Methodology

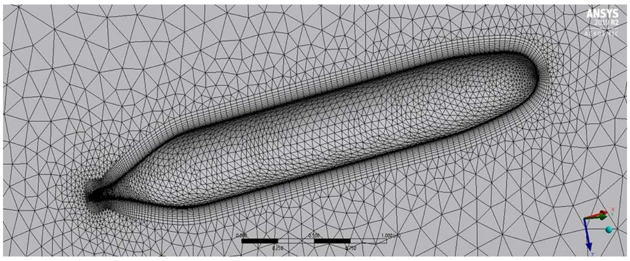
This is what I actually do! It involves both computational fluid dynamics (CFD) and experimental fluid dynamics (EFD)

EFD is the "real world" visualisation; it takes time, is expensive, and challenging.

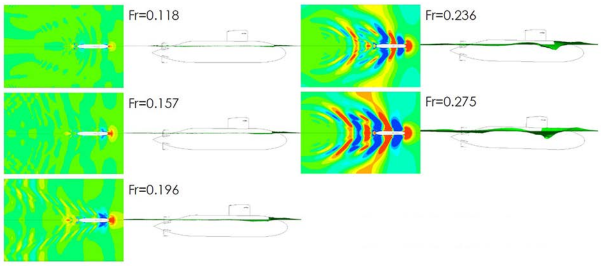
CFD is the mathematical model of the physics; it also takes time, is also expensive, and is still challenging!

We use experiments to feed in to the mathematical model and check that the model is working as it should. We then run case scenarios to find better solutions, and then can run better experiments to investigate some points in more depth.

The CFD mesh of the 1.69 m Suboff model which I am using has 10 million points in the mesh, and the computer uses 120 cores for calculations which take about 5–7 days per simulation.

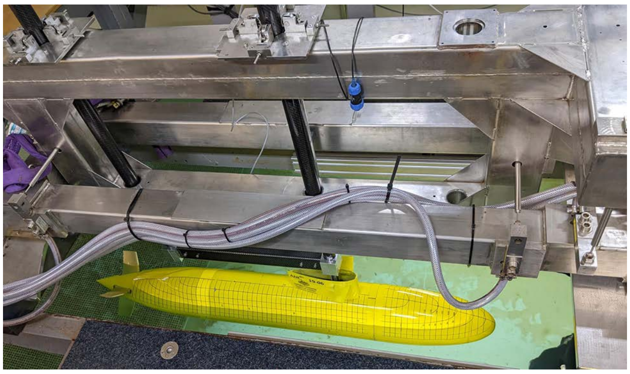


CFD mesh for Suboff model
(Drawing courtesy Mathieu Courdier)



CFD results for 1.692 m Suboff model operating at speeds of 0.48 m/s (Fr = 0.118) to 1.12 m/s (Fr = 0.275)
(Diagrams courtesy Mathieu Courdier)

The EFD involves testing a 1.692 m Suboff model in the towing tank at the same speeds as run in the CFD.

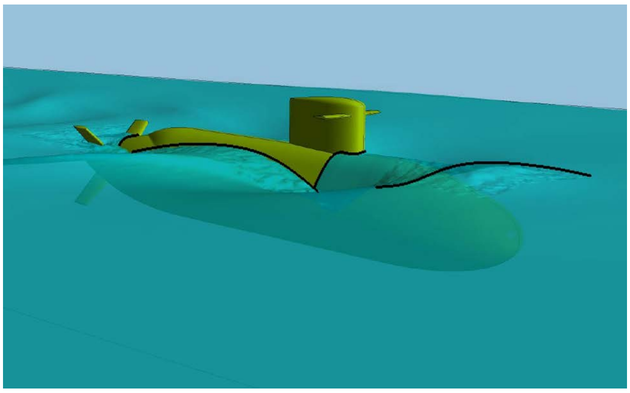


The submarine model in the towing tank
(Photo courtesy Mathieu Courdier)

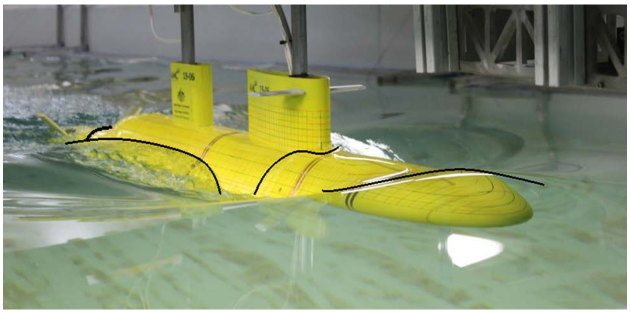
The submarine model being tested in the towing tank
(Photo courtesy AMC)

Verification and Validation

Results so far have shown good agreement between the CFD predictions of waves generated by the Suboff model and the waves generated by the model in the towing tank and the run-up of water onto the hull and the base of the sail.



CFD results for model wave generation at 1.12 m/s (Fr = 0.275)
(Image courtesy Mathieu Courdier)



EFD results for model wave generation at 1.12 m/s (Fr = 0.275)
(Photo courtesy Mathieu Courdier)

The experimental results so far have provided the verification and validation of the CFD results, and verified the calm-water resistance predictions. The design and manufacture of the new test rig now allows us to test some conditions that we were not able to do with the old one. This is instrumental in developing the next CFD simulations. I now have to test the effects of wave parameters, hull shape variations, and the influence of appendages.

Conclusion

Underwater vehicles are widely used in the industrial and scientific world, as they allow for easy, safe and cheap access to operations. Submarines also are important in navies as they provide unrivalled operational advantages. Despite being used at depths, UVs are required to travel on the sea surface for some period of time and for critical operations, where they are subject to waves. However, most of the hydrodynamic knowledge applicable to conventional surface ships is not relevant to UVs due to their particular hullforms. Also, hydrodynamics is of paramount importance, as it defines the ability of a UV to carry out its mission: hence seakeeping, resistance and manoeuvrability form the subjects of this research.

The research undertaken here uses computational fluid dynamics which allows modelling of the fluid flow around an UV hull. The variation of such parameters as the speed, the wave height and the hull shape helps to understand the flow dynamics. The CFD model has been validated using experimental fluid dynamics, and the calm water resistance measured. The project now leads on to testing the effects of wave parameters, hull shapes and appendages.

Acknowledgements

I would like to acknowledge

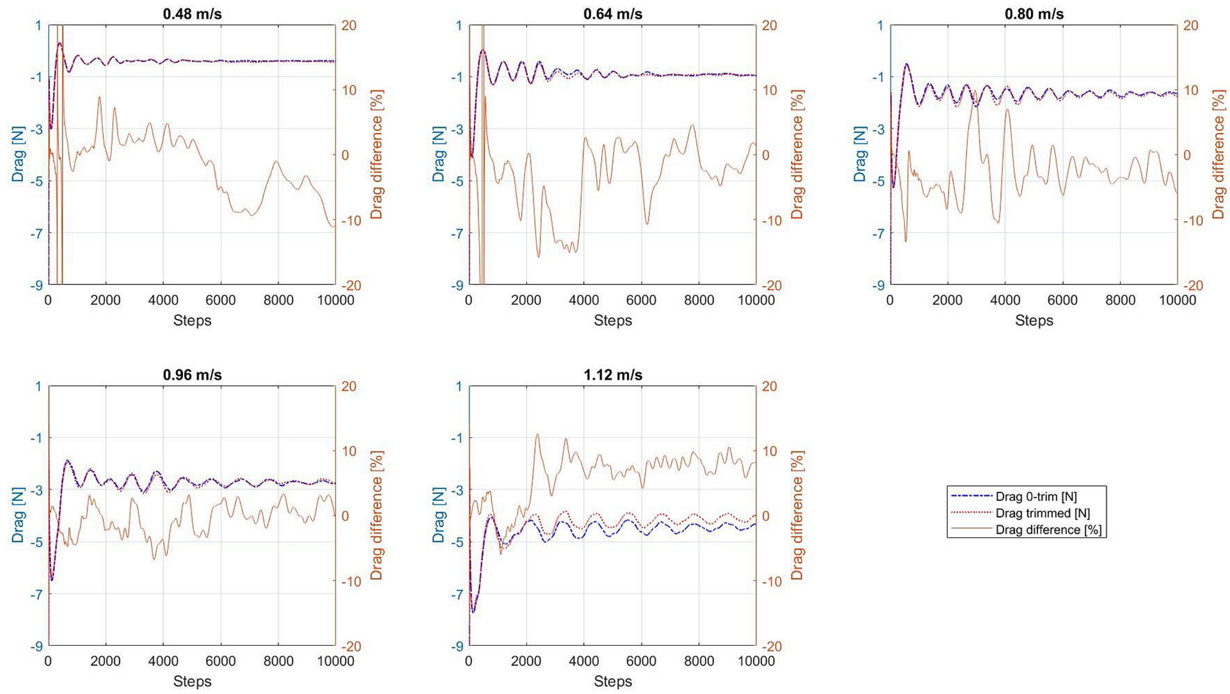
- IMarEST for the grant of the Laurie Prandolini Scholarship and the Stanley Grey Research Fellowship and their continued support for the project;
- DST Group for their support with experimental techniques; and
- RINA for organising this presentation.

Questions

Question time raised some further interesting points.

On the diagram showing non-dimensional pitch and heave for the submarine, there are two peaks for the pitch response—and it is not known why!

The scale factor here between the CFD and EFD is 1:1, i.e. using a 1.692 m model. The full scale BB2 model was 70 m



CFD calm water resistance results for model at various speeds vs time steps
(Graphs courtesy Mathieu Courdier)

long, and clearly too large to fit into the AMC towing tank. However, the model is perfectly scalable, and has been tested around the world at many different scales.

The model will be tested in head seas first and, if time permits, then at other orientations to the waves. However, this is for one PhD degree, not several!

The model has so far been tested only on the surface at a typical surfaced displacement but can, of course, be tested at varying depths of submergence.

To dampen pitching motions, we need to understand that different speeds, wave heights and encounter frequencies result in different pitching motions. We can use gyroscopes, water ballast, etc., depending on the case.

Free water in free-flooding spaces is really hard to simulate. In the BB2 model there is no flooding water, so the free-flooding tanks are not considered.

The presentation was recorded, and is now available on the RINA YouTube channel (see *The Internet* column).

The certificate was subsequently posted to Mathieu, and the "thank you" bottle of wine delivered via an eGift card.

Marine Biofouling

Clare Grandison, Discipline Leader Environmental Signatures, DST Group, gave a presentation on *Marine Biofouling: What is it, Why Does it Happen and Why Should we Try and Stop it?* as a webinar hosted by RINA using the Zoom software platform with NSW Section Deputy Chair, Phil Helmore, as MC on 4 May. This presentation attracted 18 participating on the evening.

Marine biofouling is the accumulation of unwanted biological organisms on surfaces submerged in the marine environment. Biofouling has significant impacts on shipping and marine infrastructure worldwide. Biofouling growth on vessel hulls leads to an increase in hydrodynamic drag as the vessel moves through the water, resulting in greater operating cost (through increased fuel consumption) and significant environmental impacts as a result of increased emissions. In addition, shipping can act as a vector for the transfer of marine pest species between global regions, resulting in further environmental and economic impacts through loss of biodiversity and impacts on aquatic industries such as aquaculture and tourism.

Defence Science and Technology (DST) undertakes a wide range of research into the prevention and control of biofouling on vessels and equipment, both to ensure the efficient and environmentally-sound operation of our fleet, and to protect the unique Australian marine environment from the introduction of unwanted marine species.

This presentation explained the phenomenon of biofouling, how and why it occurs, its impacts, and some ways it can be prevented, including using 3D printing technology.

Clare's presentation was based on a paper which is about to be published in the journal *Ocean Engineering*.

The presentation was not recorded.

The certificate was subsequently posted to Clare, and the "thank you" bottle of wine delivered via an eGift card.

Phil Helmore

CLASSIFICATION SOCIETY NEWS

ABS Publishes Practical Guidance on Hybrid Electric Power at Sea

ABS has added to its industry-leading series of maritime technical guidance with the publication of *Practical Considerations for Hybrid Electric Power Systems Onboard Vessels*. The publication explores the different forms of hybrid electric power systems (HEPS) and offers practical insight into their application on board. It explores renewable energy sources, energy storage systems, battery-management approaches, the potential for modelling and simulation, and the impact on port infrastructure as well as the regulatory landscape.

"Hybrid electric power systems are a viable option to support the industry in meeting IMO's GHG reduction targets. We see a wide variety of applications at sea and these diverse operational profiles have created multiple power and propulsion architectures. This insight from ABS is designed to support the industry in capitalising on the potential of HEPS technologies with a focus on safety and sustainability," said Patrick Ryan, ABS Senior Vice President, Engineering and Technology.

Practical Considerations for Hybrid Electric Power Systems Onboard Vessels can be downloaded from

https://absinfo.eagle.org/acton/attachment/16130/f-a131a1dc-42cb-4c46-a49c-57f5408f2f4c/1/-/-/-/-/hybrid-electric-whitepaper-22116.pdf

A copy of the ABS *Guide for Hybrid Electric Power Systems for Marine and Offshore Applications*, which sets out the class requirements for such systems, is available from

https://ww2.eagle.org/content/dam/eagle/rules-and-guides/current/conventional_ocean_service/319_gn_hybrid_electric_powers_systems_marine_offshore_2022/hybrid-electric-power-systems-guide-feb22.pdf

ABS News, 6 April 2022

DNV and Partners Launch SAFEMATE Project

At the Nor-Shipping trade fair in April, DNV, Kongsberg Maritime, Kongsberg Seatex, Bastø Fosen and NTNU announced the launch of the new SAFE Maritime Autonomous Technology (SAFEMATE) project. The Research Council of Norway-funded project will work on improving and assessing the safety and efficiency of autonomous navigation systems and deploy a pilot on an operational ferry, *Bastø VI*.

The promise of automating more functions in shipping shows great potential, and interest continues to grow throughout the industry as more projects are developed. For autonomous navigation, in particular, the technologies which support object detection and collision avoidance have the potential to enhance safety and efficiency across the whole industry.

For these technologies to be widely adopted, the systems not only need to be developed, but tools and processes which assess and assure their safe function must be in place. The SAFEMATE project is designed to cover both of these aspects and test automated systems to assist navigation, while keeping an operator in the loop.

"For DNV, our focus is on building trust in complex software-controlled systems through testing and verification," said Pierre Sames, Group Research and Development Director. "Modern vessels are already complex automated systems, but building in autonomous decision-support capability increases this complexity immensely. This is why it's vital to develop a framework comprising processes and tools which can assess the safety performance of these systems, both in the design stage and throughout operations. As these systems include machine-learning modules, they require a new approach to safety assessment and verification."

"We are delighted to see safety in maritime navigation at the core in the SAFEMATE project, with backing from leading industrial players and academia," said Børre Flaglien, Director of Bridge Systems at Kongsberg Maritime. "Kongsberg will through this project build on its strong position in autonomy-enabled technology and provide automated advisory to manned vessels. Our Bridge Control System will double as a digital crew member, warning of dangerous situations (including collisions) and advise on a preferred deviation manoeuvre."

"The SAFEMATE project is an important step forward for us in Torghatten and a continuance of the good work we have been doing on the topic of autonomy," said Jan-Egil Wagnild, CTO at Torghatten AS. "The technology and processes developed in the project are a few of many pieces in the puzzle when working on increased safety, energy efficiency and the enablement of integrated operations. Together with strong industry players in the project, we believe that the project will answer a lot of key questions and provide us with valuable learnings."

"The SAFEMATE project is key to further developing the Kongsberg Situational Awareness solution," said Henrik Foss, Product Manager, Kongsberg Seatex AS. "The project focuses on exploiting technology brought forward for autonomous vessels, and how we can adapt this to increase safety and efficiency in the current bridge solutions. The SAFEMATE project enables us to work closely with users on integrating navigational decision support into the bridge in the best manner possible and with class on assurance frameworks which are essential for delivering these kinds of systems."

The SAFEMATE project will focus on routing and collision avoidance, to create a system which is able to detect threats and obstacles in the marine environment, interpret this information, and communicate a solution to an on-board operator. The system will be tested though the use of simulators and with human operators in the loop and then will be deployed in full-scale trials on *Bastø VI*, the Bastø Fosen ferry which operates between Moss and Horten across the Oslofjord.

Bastø VI
(Photo from DNV website)

SAFEMATE has been partially funded by the Research Counsel of Norway through the MAROFF-2 Program.

DNV News, 5 April 2022

Fincantieri's 75th Vessel Built to LR Class

Lloyd's Register, a leading provider of classification, compliance and advisory services to the marine and offshore industries, and Fincantieri, one of the world's largest shipbuilding groups, marked a milestone in their long-standing relationship, with the delivery earlier this year of cruise ship *Discovery Princess*, the 75th vessel to be built to LR class by Fincantieri.

Discovery Princess
(Photo from CruiseMapper website)

LR Group CEO, Nick Brown, presented a plaque featuring an image of *Discovery Princess* to Giorgio Gomiero, Fincantieri Senior Vice President Operations, Merchant Ships Division, and Pierluigi Punter, Fincantieri Vice President Engineering & Design, Merchant Ships Division, at the shipbuilder's office in Trieste on 16 March.

The relationship between LR and Fincantieri dates back to 1990. The 75 vessels comprise a total of over 6 million GT. Together they have been built for various different owners and have carried more than 190 000 passengers. This year, Fincantieri will deliver a further four cruise ships to LR class.

2022 marks the 150-year anniversary of LR in Italy. Since the first LR surveyor in Genoa was appointed in 1872, LR has supported Italy to become a global leader in passenger ship building. Sharing rich maritime heritage, LR and Fincantieri have together achieved numerous notable industry firsts, such as *Carnival Destiny*, delivered in 1996, the first cruise ship over 100 000 GT and the world's largest cruise ship at that time. *Grand Princess* was also the largest cruise ship in the world when delivered in 1998. Additionally, LR classed the first dual-fuel/LNG ferry ever built in Italy, *F.A. Gauthier*, delivered by Fincantieri in 2015.

LR Group CEO, Nick Brown, said "LR is immensely proud of our long-standing relationship with Fincantieri, as we share a common vision for greater sustainability and the acceleration of digital technologies within complex new construction projects. We are delighted to celebrate this milestone of 75 passenger vessels delivered together in the year that LR marks its 150th anniversary in Italy."

LR News, 16 March 2022

FROM THE CROWS NEST

WWSR Spirit 2

On 8 October 1978, 44 years ago, Ken Warby blasted across Blowering Dam to set his second (and current) World Water Speed Record of 317.6 mph (511.1 km/h).

Dave Warby of Warby Motorsport is attempting to break his father Ken's World Water Speed Record in their latest vessel, *Spirit of Australia 2.*

The Warby Motorsport Team took *Spirit of Australia 2* to Talbingo Dam in the Snowy Mountains to conduct their next tests on the weekend of 2–3 April. However, the rain and wind came in during the first run, and stayed, ending the weekend of tests. They expect to try again soon, and when tests on Talbingo Dam are completed, to be back on Blowering Dam in the second half of this year

Spirit of Australia 2 on Talbingo Dam on 2 April
(Photo from Warby Motorsport Facebook page)

WWSR Longbow

Britain has re-entered the contest for the World Water Speed Record with a new vessel, *Longbow*, having commenced construction in April 2018.

With the painting of the underside of *Longbow*'s hull completed, in March she was carried out of the building shed by 36 pairs of willing hands, turned over, sat on her brand-new trailer, and the trailer wheeled into the shed for the completion of construction.

Longbow ready to be turned over in David Aldred's driveway
(Photo from Longbow website)

Much of the subsequent time has been spent on one of those jobs which not many relish: sanding the inside of the hull where epoxy had wept out during clamping and fixing of the outer plywood skins.

Longbow the right way up on her trailer in David Aldred's shed
(Photo from Longbow website)

SP80 Aims for World Sailing Speed Record

The world sailing speed record is currently held by Australian Paul Larsen in *Vestas Sailrocket 2* at an average speed of 65.45 kn (121.1 km/h) over the 500 m track.

SP80 is the vessel being designed and built by engineering students from the Swiss engineering school École Polytechnique Fédérale de Lausanne (EPFL) to attempt the world sailing speed record and take it back to Europe. They are aiming for a speed of 80 kn (148 km/h) using a boat with shaped hulls, propelled by the usual kite wing, while the overall stability is achieved via super-ventilating hydrofoils.

However, the boat will be longer than the initial concept, now 10 m long and 7 m wide. With a sleeker shape and stretched, aggressive lines, other elements have also been refined to increase the stability of the structure.

Construction is progressing; the main hull has been completed by the renowned shipyard Persico Marine in Italy, and was due to arrive in the EPFL workshop in Switzerland in April. While the shipyard continues the construction of the beam and floats, the EPFL team will take over the main hull and integrate all the mechanical systems.

The final assembly of the boat is scheduled for next (northern) autumn with an official launch before the end of 2022. After a few months of optimisation and testing, the first record attempts will take place in summer 2023 in the south of France.

Phil Helmore

SP80 at speed under the kite
(Image from SP80 website)

Austal Patrol Boats for RAN

On 23 March Austal Australia delivered the first of six Evolved Cape-class Patrol Boats (ECCPB's) to the Royal Australian Navy.

The vessel, ADV *Cape Otway*, was officially accepted and named by the Minister for Defence, The Hon. Peter Dutton MP, at a ceremony held at Austal's Henderson, Western Australia, shipyard. He was accompanied by the Chief of the Royal Australian Navy, Vice Admiral Michael Noonan AO, and Head of Maritime Systems, Capability Acquisition and Sustainment Group, Rear Admiral Wendy Malcolm CSM.

Speaking at the delivery ceremony, Austal Limited Chief Executive Officer, Paddy Gregg, said that the first Evolved Cape-class Patrol Boat to be delivered reflects the collective skills, teamwork and capability of the national naval shipbuilding enterprise.

"Sheds don't build ships, people do. And it's great to celebrate today with representatives from Austal, the Department of Defence, our proud supply-chain partners and many more businesses in the defence industry across Australia," Mr Gregg said.

"This first Evolved Cape-class Patrol Boat was a true team effort, drawing on the expertise, drive and commitment of hundreds of talented people who are fundamentally contributing to the national security of this country.

"Apprentices, university graduates, trainees, tradespeople and professionals; we're not just building patrol boats, we're designing and constructing (and indeed, sustaining) naval assets which are keeping Australia's border secure."

The 58 m aluminium monohull patrol boat is the first of six to be delivered to the Royal Australian Navy under a $324 million contract awarded to Austal Australia in May 2020. With greater capability than the benchmark Cape-class patrol boats, the Evolved Capes feature new, larger amenities to accommodate up to 32 people, improved quality-of-life systems and advanced sustainment intelligence systems which will further enhance the Royal Australian Navy's ability to fight and win at sea.

The vessel was constructed in approximately 18 months, employing approximately 400 people directly in Western Australia, and engaging more than 300 supply chain partners across Australia. In 2022, Austal Australia is scheduled to deliver an unprecedented nine new naval ships to the Commonwealth of Australia, including four Evolved Cape-class Patrol Boats for the Royal Australian Navy (SEA1445-1) and five Guardian-class Patrol Boats to the Department of Defence under the Pacific Patrol Boat Replacement Project (SEA3036-1).

To coincide with the acceptance of the first Evolved Cape-class patrol boat, the Chief of Navy, VADM Michael Noonan, revealed the names of the six new vessels.

"They will be named Australian Defence Vessels (ADV) *Cape Otway, Cape Peron, Cape Naturaliste, Cape Capricorn, Cape Woolamai* and *Cape Pillar*.

"Each name continues the lineage of the Cape-class patrol boats, all named after significant capes around Australia.

"The first boat, ADV *Cape Otway*, will be home-ported at HMAS *Cairns* by mid-2022. She will be joined by another

ADV *Cape Otway*
(Photo courtesy Austal)

Evolved Cape-class patrol boat and four Arafura-class offshore patrol vessels by the end of 2028," VADM Noonan said.

Earlier, on 5 March, Austal had welcomed the Assistant Minister for Defence, The Hon. Andrew Hastie MP, to officially launch the second of the Evolved Cape-class Patrol Boats to be delivered to the Royal Australian Navy. This vessel will be formally accepted by Defence in July this year. The remaining boats are under construction at the Henderson shipyard in Western Australia and the final boat is expected to be delivered by May 2023.

Austal Australia has launched Hull 812, the second of six Evolved Cape-class Patrol Boats for the Royal Australian Navy at the company's shipyard in Henderson, Western Australia (Photo courtesy Austal)

On 18 April, Austal welcomed the Prime Minister of Australia, The Hon. Scott Morrison MP, to the company's Henderson shipyard, where he announced that the Department of Defence will order an additional two Evolved Cape-class Patrol Boats for the Royal Australian Navy, for $124 million.

Prime Minister Morrison was joined for the announcement at Austal by the Minister for Defence Industry, The Hon. Melissa Price MP; the Assistant Minister for Defence, The Hon. Andrew Hastie MP,the Attorney General, Senator The Hon. Michaelia Cash, the President of the Senate, Senator The Hon. Slade Brockman and the Liberal candidate for the seat of Fremantle for the upcoming election, Bill Koul.

Another EPF Order for Austal

On 4 May Austal announced that the United States Navy has exercised a $US230,545,382 ($A324.6 M) fixed–priced incentive (firm target) contract option for the detailed design and construction of Expeditionary Fast Transport (EPF) 16 by Austal USA.

EPF 16 will be the third ship constructed in Flight II configuration, which has enhanced medical and aviation capabilities. Austal USA has successfully delivered twelve EPF ships to the Navy since 2012, on schedule and on budget and is currently constructing EPFs 13, 14 and 15 at the company's shipyard in Mobile, Alabama.

EPF 13 is being developed as a prototype for autonomous operations, while EPFs 14 and 15 were redesigned to deliver greater medical capability and capacity.

Austal's Chief Executive Officer, Paddy Gregg, said that the contract for another EPF with enhanced medical capabilities highlighted both the success of the high-speed vessel and its flexibility to deliver various mission profiles.

"Austal's Flight II EPFs will further enhance the US Navy's capability and enable a fast response with expanded medical support facilities available for any mission or theatre of operation," Mr. Gregg said.

"We are delighted to see the EPF platform being deployed globally and we're excited to begin production of another highly-capable ship for the United States Navy."

The United States Navy's fleet of Expeditionary Fast Transport ships conduct humanitarian assistance, disaster relief, maritime security, surveillance, command and control, and counter-narcotic missions around the globe. The versatility of the EPF design provides a significant operational capability which can be tailored to the needs of each fleet and combatant commander's geographic command.

Flight II ships enhance the original capabilities of the Spearhead-class EPFs through incorporation of reconfigurable spaces for operating and post-surgical recovery efforts. Combined with the ship's V-22 capable flight deck, Flight II ships provide unmatched versatility.

Construction of EPF 16 will commence later this year with delivery projected for 2025. In addition to EPFs 13, 14 and 15 currently in production, Austal USA is currently constructing the Independence-variant Littoral Combat Ships (LCS) 32, 34 and 36; and is under contract for LCS 38. Following the opening of the company's new steel shipbuilding production line, construction will soon commence on the first of two Navajo-class Towing, Salvage and Rescue Ships (T-ATS), T-ATS 11 and 12 for the United States Navy.

EPF 16 will be the third ship constructed by Austal USA in Flight II configuration, which has enhanced medical and aviation capabilities (Image courtesy Austal USA)

Austal USA Expands

On 13 April, Austal announced that Austal USA had officially opened the company's new state-of-the-art steel shipbuilding facility in Mobile, Alabama, enabling the simultaneous production of both aluminium and steel hulled ships.

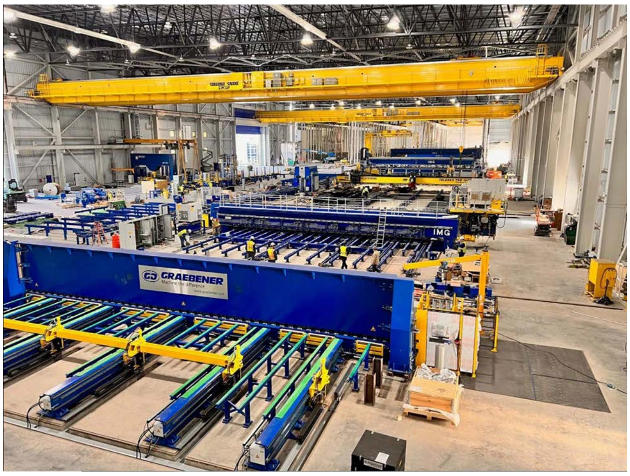
The first vessels to be built in the new steel facility will be two Navajo-class Towing, Salvage, and Rescue Ships (T-ATS) for the United States Navy, which were placed under a $US144 million contract in October 2021.

Austal's Chief Executive Officer, Paddy Gregg, said that the opening of the new steel facility marked a significant development in Austal USA's shipbuilding capabilities, allowing multiple steel vessel projects to be undertaken, in addition to aluminium vessels.

"Austal USA is now ready to start constructing steel ships for the US Navy, including the Navajo-class Towing, Salvage, and Rescue Ships, and can offer this expanded shipbuilding capability to new customers such as the United States Coast Guard," Mr Gregg said.

Financing for the new steel shipbuilding facility was provided in part by a Defense Production Act (DPA) Title III Agreement between the United States Department of Defense and Austal USA. The agreement, valued at $US50 million, was announced in June 2020. Austal USA matched these funds and invested an additional $US50 million into the completion of the steel facility.

The new steel manufacturing facility includes the latest in computerised and robotic steel processing equipment to handle all the current and future demands of the US Navy and the US Coast Guard. A 6 000 m^2 stock yard will be utilised for handling the raw steel and a 2 000 m^2 paint facility will provide the ability to paint and blast simultaneously in two separate cells, or both cells can be combined providing the ability to paint super-modules.



Austal USA has officially opened new a steel shipbuilding facility at the company's shipyard in Mobile, Alabama (Photo courtesy Austal USA)

An aerial view of Austal USA's new steel shipbuilding facility (Photo courtesy Austal USA)

East Coast Submarine Base

The Commonwealth Government announced on 7 March that a new submarine base will be built on the east coast of Australia to support the nation's new nuclear-powered submarines, providing deployment opportunities in both the Indian and Pacific oceans.

The new base will add capacity and capability to Fleet Base West in Western Australia, home of the Navy's Collins-class submarines, which will also receive significant funding to support Australia's nuclear-powered submarines and enable regular visits from the United States and United Kingdom's nuclear-powered submarines.

The Department of Defence estimates that more than $10 billion will be needed for facility and infrastructure requirements to transition from Collins to the future nuclear-powered submarines, including the new east coast submarine base.

The Prime Minister, the Hon. Scott Morrison MP, said that the decision to establish an east coast submarine base has been under consideration for many years and would enhance Australia's strategic deterrent capability in the Pacific Ocean.

"Australia faces a difficult and dangerous security environment and we must continue to invest in growing the capability of our ADF to ensure that we keep Australians safe," the Prime Minister said.

"Under our AUKUS partnership with the United States and the United Kingdom we will have access to the best technology in the world to support our efforts to deter threats against our national interest in the Indo Pacific.

"This new 20-year investment is vital for our strategic capabilities, but it will also provide long-term economic opportunities at both our submarine bases on the east and coasts.

"Our investments will also flow into our operations in Western Australia, with significant funding flowing to upgrade facilities there for our future submarines and to support our allies in the United States and United Kingdom.

"Fleet Base West will remain home to our current and future submarines, given its strategic importance on the Indian Ocean."

Following significant work by the Department of Defence, which reviewed 19 potential sites, three preferred locations on the east coast have been identified, being Brisbane, Newcastle, and Port Kembla.

The locations were selected on submarine basing criteria, which included access to exercise operating areas, proximity to industrial infrastructure, and significant population centres to support personnel and recruitment.

The Minister for Defence, the Hon. Peter Dutton MP, said that the Australian Defence Force had not constructed a major new base since Robertson Barracks in the 1990s, and an extensive process would now begin.

"We took the important decision in 2021 to pursue nuclear-powered submarines with the support of our American and British partners, in response to the changing strategic environment," Minister Dutton said.

"Nuclear-powered submarines have superior characteristics of stealth, speed, manoeuvrability, survivability and endurance when compared to conventional submarines.

"With the ability to operate from both coasts, this will make our nuclear-powered submarines more responsive and resilient to meet the strategic environment.

"Today's announcement will ensure that Australia has the infrastructure and facilities ready to support those submarines when they enter service.

"A new Navy base on the east coast will also have significant advantages for training, personnel and for Australia's defence industry."

Navy's current fleet of Collins-class submarines and other maritime capabilities will be able to be operated out of the new east-coast base, which will provide critical support to the ADF's undersea capability.

Defence will engage with state and local governments to determine the optimal site, which will be informed by the ongoing work of the Nuclear Powered Submarine Taskforce. This initial work is expected to be completed by the end of 2023.

Major Investment for Henderson, Western Australia

It was announced on 15 March that the Commonwealth Government will invest up to $4.3 billion to deliver Western Australia's first large-vessel dry berth, creating a world-class precinct at Henderson in Western Australia.

The Henderson dry-dock will enable the construction and sustainment of large naval vessels in Australia and support an even stronger commercial shipbuilding and sustainment market in Western Australia.

Government-owned Australian Naval Infrastructure will oversee the design and construction of this infrastructure, with work to start in 2023 and initial operations to commence in 2028.

The Commonwealth intends to work closely with the Western Australian Government and industry to develop a comprehensive master plan for the defence precinct at Henderson to ensure that this investment fully supports the national naval shipbuilding enterprise effectively.

This project is likely to create at least 500 direct construction jobs at its peak, and thousands more through local sub-contracts and the national supply chain. Once completed, this infrastructure will help support at least 2000 direct shipbuilding jobs at Henderson, particularly as continuous naval shipbuilding in Western Australia comes to fruition as part of the national naval shipbuilding enterprise.

Young Endeavour Replacement Contract

Birdon announced on 10 May that it had been awarded the contract to design and build the replacement for the brigantine Sail Training Ship (STS) *Young Endeavour*, which has been operated by the Royal Australian Navy for more than three decades, providing youth development and sail training for Australian youth under The Young Endeavour Youth Scheme.

Birdon will work with Dykstra Naval Architects of The Netherlands on the core vessel design, and will also be responsible for the design, engineering, and integration of all the vessel's systems, including mechanical, electrical, propulsion, communication and navigation systems.

An impression of the new ship to replace *Young Endeavour* (Image courtesy Birdon)

The replacement vessel design is testament to over 18 months of hard work from the Dykstra and Birdon engineering teams, and this new contract is recognition of the team's ingenuity and capacity.

"It's an honour to have been selected to design and build the *Young Endeavour* replacement tall ship. It is a unique vessel, providing leadership opportunities to young Australians that we are proud to be able to ensure continues. It is also an important step in Birdon's vision, as an Industry Partner, to deliver increasing sovereign capability in support of the Australian Naval Shipbuilding Plan" Birdon CEO, Jamie Bruce, said.

Incat Tasmania Delivers 76 m Catamaran for South Korea

High-speed craft specialist Incat Tasmania is breaking new ground with its latest high-speed catamaran, a 76 m fast ferry for Seaworld Express Ferry of South Korea which was completed in April.

Just as Incat led the way with the world's first car-carrying high-speed catamarans in the pioneering 74 and 78 m fast ferries of the early 1990s, this new 76 m vessel is expected to be the high-speed craft market's frontrunner in terms of economy, seakeeping and comfort for vessels of its size.

Capable of accommodating 621 passengers and crew and 86 cars at speeds of over 40 knots, *Santa Monica 1* features Incat's tried-and-proven evolved hullform with its new centre-bow arrangement, reflecting over thirty years of experience building market-leading high-speed vehicle-passenger ferries.

With a significant improvement in both waterline length and vessel trim compared with those early 74 and 78 m craft, together with a motion control system, the Incat 76 m catamaran benefits not only from vastly improved speed and fuel consumption but also provides a smoother ride and an enhanced onboard experience for both passengers and crew.

Designed by Revolution Design, *Santa Monica 1* is a truly fast vessel, achieving a maximum speed of 49.7 kn on sea trials. The contract speed of 42 kn with 100 t deadweight aboard was achieved with a margin in excess of 5 kn.

Build lighter and stronger has always been a mantra at Incat where Chairman and Founder, Robert Clifford, points out that aluminium is one third the density of steel. The ability to build strong aluminium structures at lowest mass means that

The 76 m high-speed catamaran ferry *Santa Monica 1* recently completed by Incat Tasmania for Seaworld Express Ferry of South Korea (Photo courtesy Incat Tasmania)

the vessel requires less power, consumes the lowest possible amount of fuel, and delivers the most efficient solution to meet operator requirements.

On board *Santa Monica 1* passengers can enjoy an abundance of natural light in spaces featuring high-quality carpet, durable timber-look walkways, stainless steel fittings and tasteful wall panelling.

All passenger facilities are situated on one deck which is fitted out for 606 passengers with 72 executive seats and 98 reclining seats in the forward business class lounge, 232 seats midships and 204 seats in the aft cabin, all supplied by Beurteaux.

A services block separates the forward and midship sections and houses male and female toilets, a crew mess and a centrally located servery, food preparation area and bar. Finished with stainless steel and glass cabinets to display hot and cold meals, drinks and desserts, the servery is bounded by wide corridors either side allowing customers easy viewing and access while preventing crowding and long lines.

Evacuation facilities for passengers and crew on board *Santa Monica 1* comprise four Liferaft Systems Australia Marine Evacuation Stations, two port and two starboard. Each can serve up to a total of 200 persons.

As with all large Incat vessels, the superstructure — Tier 2 and above — is an independent structure, connected to the hull via rubber isolation mounts, for optimum noise and vibration performance.

Vehicles are handled via a vessel-mounted ramp at the stern. Car space sizes are 4.50 m × 2.30 m, while commercial vehicle lanes on the main vehicle deck are 3.10 m wide and have a clear height of 3.5 m. Maximum loads are 5 t for single axle, dual wheel.

The use of extensive lighting and apertures at the foredeck and stern provide a high level of natural light and air movement through the vehicle deck, and this is enhanced by the light tones of rapid-access composite structural fire protection provided by Ayres. All vertical structural steel members are painted bright yellow so obstructions to vehicles or passenger movement are easily identified.

Situated atop the passenger deck, *Santa Monica 1*'s wheelhouse features the latest navigation, monitoring, and control equipment. A dedicated docking station, 360-degree views and CCTV deliver a high level of safety and control during voyages and docking.

The vessel offers views from raised helm seating, with all instruments fitted in dark grey and black consoles to aid night vision and minimise distraction. A separate ship's office and lounge is located aft of the bridge where crew can layout charts, plan voyages or relax from day-to-day activities.

High levels of operability are key and nowhere is this more evident than in *Santa Monica 1*'s spacious machinery rooms. The craft is equipped with four Caterpillar C280-16 engines which each deliver 5650 kW at 100% MCR. Each engine drives a steerable Kongsberg Kamewa S90-4 waterjet via a Reintjes VLJ 4431 gearbox. Four Caterpillar C7.1 generators rated at 200 ekW each and 380 V, 60 Hz, supply electrical power.

Principal Particulars

Length	75.5 m
Breadth	20.6 m
Draft	2.35 m
Deadweight	300 t
Persons	621 (passengers and crew)
Vehicles	86 cars or
	256 commercial vehicle lane metres
Main engines	4 × Caterpillar C280-16
Speed	47.3 kn at 100 t deadweight
Class	DNV ✠1A HSLC R1 Ferry B EO

ShadowLark from Incat Crowther

ShadowCat and Triton Submarines have collaborated to develop and introduce a new launch-and-recovery craft (LARC) dubbed ShadowLark.

Designed by Incat Crowther, ShadowLark is a package priced under USD$10 million for delivery in less than 14 months which includes a 24 m LARC designed to carry a Triton 3300/3 MKII submersible. The submersible is designed to comfortably seat three people (pilot and two guests) and dive to depths as great as 1000 m for up to 12 hours.

ShadowLark has been developed as a scalable solution to the logistical challenges associated with launching, recovering, and supporting a submersible weighing up to 12 000 kg which requires a stable, protective and spacious at-sea platform. The efficient platform is proven to fulfil the requirements and is ideally suited to:

- operate independently;
- support an existing private, research-focused or chartered yacht fleet;
- serve as a multi-function package for marine research institutes, documentary film-makers, underwater archaeology and surveying missions; or
- add new underwater options to luxury resort excursion packages around the world.

In addition to an increasing volume of private enquiries, Triton reports a significant and growing demand from the non-profit and commercial sectors for submersible charter. With very few submersible charter opportunities available globally, ShadowLark is anticipated to gain considerable attention as a charter investment.

With an 8.5 m beam and a draft of 1.5 m, ShadowLark includes a dive centre, lounge, galley, bar and storage over three decks. In addition to a four-person crew capacity, it also offers stowage for a tender, and a pair of jet skis.

"Because all ShadowCat vessels are fully bespoke, this highly-capable concept can be constructed as is or can serve as a starting point for a more customised option. For example, we can enlarge ShadowLark to house bigger submarines or to make room for additional leisure and entertainment areas," said ShadowCat founder, Robert Smith. "As evidenced by award-winning *Hodor* and recently-delivered *Wayfinder*, ShadowCats are designed to carry the best toys in the world. We are keen to collaborate with submersible industry leader Triton Submarines on the development of this innovative new offering to meet the growing needs of this emerging market."

"ShadowLark is a purpose-built craft specifically designed and engineered to safely, efficiently and effectively launch, recover and support a Triton submersible," said Patrick J. Lahey, President and co-founder of Triton Submarines. "Our goal is to make it possible for more people to own, operate and enjoy exploring the ocean from the comfort and safety of a Triton submersible. By collaborating with ShadowCat, a company with a demonstrated track record of success in developing commercially-rated support yachts, we are assured of ShadowCat's efficacy while staying true to the objective of creating an affordable, efficient, safe and entirely practical platform. Clients around the world can now enjoy the simplicity, elegance, excitement and safety of exploring the ocean in a Triton submersible supported by a craft which can be operated affordably, but with absolutely no compromises in terms of its capacity to do the job for which it was built. Triton looks forward to working together with ShadowCat on the creation this remarkable and much-needed craft."

The ShadowCat line of bespoke support yachts was developed and designed by renowned naval architect and catamaran design expert Incat Crowther and yacht industry authority YCTS, Ltd. Established in 2018, the working partnership has successfully completed two bespoke ShadowCat vessels, the award-winning 66 m *Hodor* and the 68 m *Wayfinder*. The vessels are products of respected Spanish shipyard Astilleros Armón, with a third in the ShadowCat vessel series due for launch by summer 2022

Triton Submarines of Sebastian, Florida, is the most experienced civil submarine producer in the world today — and the only contemporary manufacturer of acrylic and titanium pressure-hull-equipped personal submarines to deliver multiple classed and certified vessels with rated diving depths as shallow as 200 m to depths as great as 11 000 m. Triton Submarines' senior staff have over 400 years of combined experience with more than 100 different submersibles, and their operations team members have together logged over 35 000 dives. Triton clients also enjoy superlative after-sales service and technical support from a company dedicated to their total satisfaction. Triton Submarines, through its delivered 36000/2 model and contribution to the Five Deeps Expedition, engaged in record-breaking dives to the deepest point of the world's five oceans with the first submersible ever certified for Full Ocean Depth operation.

Principal particulars of ShadowLark are

Length OA	23.9 m
Length WL	23.3 m
Depth	3.40 m
Beam OA	8.50 m
Draft (maximum)	1.50 m
Passengers	6
Crew	4
Fuel oil	9000 L
Fresh water	1500 L
Sullage	1500 L
Main engines	2×Volvo Penta D16M R2 each 559 kW @ 2200 rpm
Propulsion	2×propellers
Generators	2×Cummins 17.5 MDKBR
Speed (service)	20 kn
(maximum)	25 kn
Construction	Marine-grade aluminium
Flag	USA
Class/Survey	TBA

Stern deployment from ShadowLark
(Image courtesy Incat Crowther)

35 m Catamaran from Incat Crowther

Incat Crowther has announced the commencement of construction of a 35 m catamaran for CTM Deher of Guadeloupe in the French West Indies. The Incat Crowther 35 is being built by PT Kim Seah Shipyard, Indonesia, a wholly-owned subsidiary of Singapore's publicly-listed Penguin International, using Incat Crowther's Digital Shipbuilding solution. This solution brings together the designer, the shipyard and the owner under one cohesive process from conception through delivery.

Incat Crowther was instrumental in the development of the project and, by working in close collaboration with the operator, facilitated shipyard selection and the contracting solution, and will be involved in quality assurance throughout the shipbuilding and delivery process.

A key feature of Incat Crowther's Digital Shipbuilding solution is a comprehensive 3D digital model of a ship, comprising all its structural parts, mechanical and systems components, and associated data. This complete model of the ship allows rigorous control of the construction and quality-management processes, as well as the mass of the vessel, to ensure that it will perform and function exactly as required.

Additionally, Incat Crowther will be providing its Quality Management System, a sustainable model overseeing the construction of operationally-optimised vessels at trusted shipyard partners. An on-site representative, working closely with the shipyard's engineering team, will report directly to the owner.

Stern view of 35 m catamaran for CTM Deher
(Image courtesy Incat Crowther)

Starboard bow of 35 m catamaran for CTM Deher
(Image courtesy Incat Crowther)

The newbuild ferry will carry 316 passengers over two decks in two distinct classes. A large midship staircase links the two decks and houses additional luggage racks. A kiosk is located at the aft end of the main deck, with bathrooms aft. A large luggage room is located aft of the main deck cabin, with separate access. Overhead gantries assist with the movement of large, heavy luggage trolleys.

The aft exterior portion of the mid deck features exterior seats for 48 passengers. The wheelhouse is elevated for good all-round visibility.

The vessel will be powered by twin MTU12V4000 main engines producing 1380 kW each and driving five-bladed propellers. The vessel will have a service speed of 25 kn at reduced MCR.

Incat Crowther's Digital Shipbuilding solution and Quality Management System combine to deliver the optimum solution in terms of quality, value and operability.

Principal particulars of the new vessel are

Length OA		36.0 m
Length WL		36.0 m
Beam OA		9.8 m
Depth		3.4 m
Draft	(hull)	1.3 m
	(propellers)	2.0 m
Passengers		316
Crew		5
Fuel oil		10 000 L (day tanks)
		10 000 L (delivery tanks)
Fresh water		2000 L
Sullage		1000 L
Main engines		2MTU 12V4000 M53
		each 1380 kW @ 1800 rpm
Propulsion		2×fixed-pitch propellers
Generators		2×Perkins 99 kW
Speed	(service)	25 kn
	(maximum)	28 kn
Construction		Marine-grade aluminium
Flag		French flag register
Class/Survey		Bureau Veritas, I✠Hull ✠Mach
		HSC-Cat A Sea Area 2

Crew Transfer Vessels from Incat Crowther

Incat Crowther has announced the award of a three-vessel order for WINDEA CTV LLC, a US operator of offshore crew transfer vessels (CTVs). Two of the CTVs will be built by St Johns Shipbuilding in Florida and one will be built by Gulf Craft in Louisiana.

The WINDEA CTV fleet is owned and operated by MidOcean Wind LLC and Hornblower Wind, LLC (a member of the Hornblower Group), with technical and operational support from WINDEA Offshore shareholder Ems Maritime Offshore GmbH, which operates a fleet of CTVs in the European market with more than 10 years of experience. MidOcean brings a 40+ year track record of US Jones Act shipowning in various vessel classes. Hornblower's global footprint includes operating more than 150 vessels on the north-east coast and providing full value-chain marine services, including design, build, delivery, maintenance, and operations services for clients across government, municipal, military, and private sectors. This partnership is well positioned to build and operate a large fleet of CTVs which will be needed to serve the ongoing, rapid expansion of offshore wind power in the north-east and across the United States.

All three vessels will initially be chartered by GE on the Vineyard Wind Offshore wind farm 15 n miles off the coast of Massachusetts. The vessels, which are 30m in length, are based on well-proven CTVs developed by Incat Crowther. They feature a large foredeck with a 23 t-m knuckle-boom crane and container securing lugs offering exceptional flexibility. The vessels incorporate Incat Crowther's patented Resilient Bow Technology minimising boat landing impact forces. As is common with all Incat Crowther CTVs, the vessels have a deadweight capability in excess of 50 tonnes.

A resiliently-mounted superstructure offers excellent comfort for both technicians and crew, with six crew berths provided in above-deck staterooms. Other notable features include a large wet room and stores warehouse, fully-featured bathrooms and a discreet mess area. Workshop and utility spaces in the hulls are immediately accessible from the cabin.

The vessels are to be propelled by quad Volvo IPS propulsion units driven by Volvo DI13 main engines. They are fully hybrid-ready, meaning that the integration of the hybrid system is completely accommodated in the design. This includes dedicated voids for batteries, reserved cabling space and battery-removal hatches.

The vessels will be designed and built under Bureau Veritas class and comply with US Coastguard CFR 46 Subchapter L regulations.

Starboard bow view of *Windea CTV*
(Image courtesy Incat Crowther)

Principal particulars of the new crew transfer vessels are

Length OA		30.0 m
Length WL		27.9 m
Beam OA		10.0 m
Depth		4.40 m
Draft	(hull)	1.40 m
	(maximum)	1.70 m
Technicians		24
Crew		6
Fuel oil		36 000 L
Fresh water		3500 L
Sullage		2500 L
Main engines		4×Volvo D13 each 515 kW @ 2250 rpm
Propulsion		4×Volvo IPS 30
Generators		2×40 kW
Speed	(service)	26 kn
	(maximum)	29 kn
Construction		Marine-grade aluminium
Flag		USA
Survey		USCG CFR 46 Subchapter L
Class		Bureau Veritas

Stewart Marler

John Oxley Launched and *Kanangra* Docked

The Sydney Heritage Fleet, Thales Australia and Ausbarge Marine Services, in a massive coordinated effort in the Captain Cook Dock at Garden Island, have launched *John Oxley* from the *Sea Heritage Dock* where she has been under restoration alongside the SHF yard in Rozelle Bay, and docked *Kanangra* for her restoration.

Beforehand, the volunteers and staff of Sydney Heritage Fleet spent a hectic 12 months getting *John Oxley* ready to be refloated, a task made even more challenging by COVID-19, lockdowns and record deluges of rain. Likewise, *Kanangra* had to be prepared to be in a fit state, with contingencies which included multiple pumps—it had been 32 years since she had last been docked.

John Oxley on board the *Sea Heritage Dock* was moved from Rozelle Bay down the harbour to Garden Island on 30 March, escorted by tugs *Arana, Morpeth, Bronzewing* and *Currawong*.

John Oxley and the *Sea Heritage Dock* were docked down in the Captain Cook Dock, and the flooding holes on the *Sea Heritage Dock* opened. When the CCD was then flooded, *John Oxley* floated for the first time in 25 years and was moved to a temporary berth at Glebe Island.

The CCD was pumped out and dock blocks and Acrow-like props, designed by John Butler Design, on the *Sea Heritage Dock* set up for *Kanangra*, and maintenance carried out on the *Sea Heritage Dock* itself, as the last time it was docked was when *James Craig* was launched and *John Oxley* docked. There was general relief when it was found that the *Sea Heritage Dock* was in surprisingly good condition and fit for many more years of service.

Kanangra was gently moved from Rozelle Bay down the harbour to Garden Island on the evening of 12 April, escorted by tugs *Arana, Morpeth* and *Currawong*.

Kanangra entered the CCD, the dock was pumped out, *Kanangra* docked down on the *Sea Heritage Dock*, and the flooding holes on the *Sea Heritage Dock* closed by their covers. When the CCD was flooded, *Kanangra* was lifted high and dry on the *Sea Heritage Dock* for her restoration.

Kanangra on the *Sea Heritage Dock* and *John Oxley* have returned to Rozelle Bay. It had been a momentous two weeks. Restoration work will continue on *John Oxley* in the water, while the docking of *Kanangra* will allow the Sydney Heritage Fleet to commence restoration of the hull to complement the work already underway on the superstructure and machinery.

Congratulations to all involved on a well-executed operation!

Phil Helmore
Mori Flapan

John Oxley moving down-harbour to Garden Island
(Photo courtesy Mori Flapan)

John Oxley and the *Sea Heritage Dock* docked down
in the Captain Cook Dock
(Photo courtesy Lachlan Jarvis)

Kanangra passing through the Glebe Island Bridge
on her way back to Rozelle Bay
(Photo courtesy Mori Flapan)

Analysis of Sailing Catamaran Hull Alignment

Christopher Murman, Manager, Floating Point Designz
and
Alex Heath, CFD Consultant

Abstract

In this paper there is an exploration of the benefits of utilising an asymmetrical demihull cross section on a sailing catamaran and, by varying the angle of the demihulls with respect to the vessel's centreline, to measure the overall resistance produced, utilising the Ansys CFX computational fluid dynamics package. An asymmetrical cross-section hullform was chosen, with a minimum midship wetted girth penalty.

Initial numerical simulations indicated a reduction in overall resistance, so further numerical simulations were conducted to refine the local minimum. Due to the limited availability of the CFD resources for this research, the exact value of the local minimum was not determined; however, the graphs presented indicate that the hull alignment angle for minimum resistance has been located closely.

Introduction

Modern catamaran design has trended towards simple symmetrical hull forms. This trend has been driven by factors such as ease of design and construction, simplified production methods and, in some cases, a desire not to be too different from the 'norm'. Paralleling this trend has been a common tendency to deviate from many sea-kindly design characteristics in favour of sales and marketing-driven forces with a view to forging sales statistics. This paper seeks to address some of these trends.

The idea for this paper came about after closely examining numerous sailing catamarans (both sail and power) while underway. The first author observed many similar wave characteristics and behaviours, despite the wide array of hull characteristics, sailing conditions and sea states.

There have been many papers examining catamaran hull spacing and the resulting hydrodynamic effects. Extensive research efforts have resulted in only one paper examining the effects of altering the longitudinal hull form configuration with a view to minimising the hydrodynamic resistance characteristics, namely, Chen et al. [1], and no papers were found on the effects of varying the demihull alignment relative to the centreline.

The authors recognise that this is early days and experimental testing is required to verify the numerical simulations, as well as more variables to be explored. However, the results of the numerical simulations are interesting and the authors are keen to air the concept and provide a springboard for further work.

Hypothesis

When comparing the sailing performance of catamarans to that of monohulls, it can easily be argued that catamarans suffer from a reduced ability to sail to windward due, in part, to their inherently increased beam characteristics. This research seeks to explore the benefits of reduced hydrodynamic drag by utilising an asymmetrical demihull cross-section while also varying the demihull alignment to increase the inherent windward performance of a sailing catamaran.

The leeward hull, being asymmetrical, will generate a lifting force to windward (in addition to the usual centreboards or stub keels), thus allowing the vessel to point higher into the wind. However, detailed exploration of this aspect of the research has been postponed to a later date.

Catamaran Hydrostatic Particulars

The characteristics shown in Table 1 were set for the test model.

Table 1 Principal Particulars

Parameter	**Value**	**Units**
Length WL	15.00	m
Beam WL at FP	8.030	m
BWL/LWL	0.535	
LCG	52.5	% LWL
Displacement	12.00	t
Hull speed	10.5	kn
Angle of heel	0	deg

Assumptions

1. The hull speed was calculated using the following formula to estimate the maximum hull speed of a typical displacement sailing catamaran:

$$V_{HS} = 2.72\sqrt{L_{WL}} \quad [1]$$

where

V_{HS} = Hull speed (kn)
L_{WL} = Length WL (m)

$$V_{HS} = 2.72\sqrt{L_{WL}} = 2.72\sqrt{15.0} = 10.5 \text{ kn}$$

2. The angle of heel was assumed to be zero for the purposes of simplifying the analysis utilising CFD.

Midship Section Shape

The asymmetrical cross-section utilised was chosen with the following objectives in mind:

(a) using the inherent hydrodynamic lift characteristics of the asymmetrical demihulls to provide improved windward sailing performance for the sailing catamaran vessel;

(b) maximising hull volume; and

(c) minimising wetted-surface characteristics.

The midship section shape comprises a quarter circle of radius *R* and a small additional volume on the outboard side of the demihull; the beam of this additional volume at the waterline is ⅓*R*, see Figure 1. The value of *R* was adjusted to accommodate the required displacement, see Table 1 above.

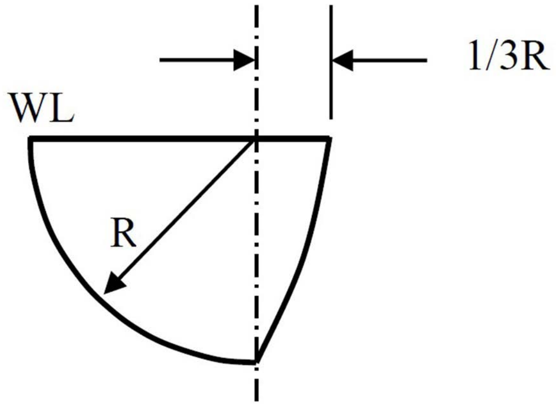


Figure 1 Midship section shape
(Diagram courtesy Christopher Murman)

In order to address the problem of excessive wetted surface area, as identified by Harris [2], the quarter-circular midship section was chosen.

The Appendix provides a comparison of a number of common cross-sectional shapes versus midship wetted girth. It is shown there that the wetted girth of the chosen midship section is 6.28% greater than that of a semi-circular cross section of the same area. It is therefore suggested by the first author that the additional 6.28% wetted girth penalty is less than that of many other cross-sectional shapes which are commonly utilised in modern sailing catamaran design.

Method

Using the asymmetrical sailing hullform shown in Figures 2, 3, 4 and 5, the longitudinal hull alignment was varied about the forward perpendicular (FP) of each hull, with the stern of each demihull angled out (see Figure 5). The total hydrodynamic resistance was calculated utilising the Ansys CFX computational fluid dynamics package.

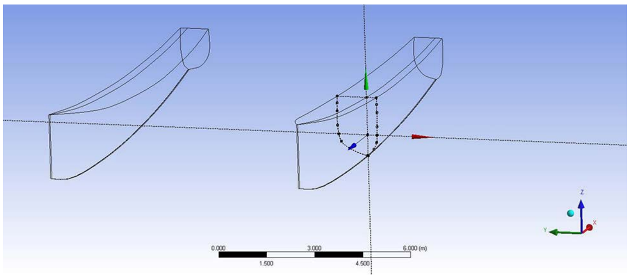


Figure 2 Line drawing of demihulls
(Diagram courtesy Alex Heath)

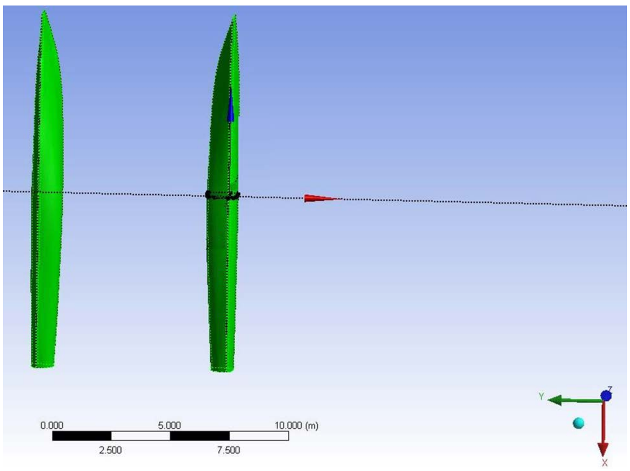


Figure 3 Plan view of demihulls
(Diagram courtesy Alex Heath)

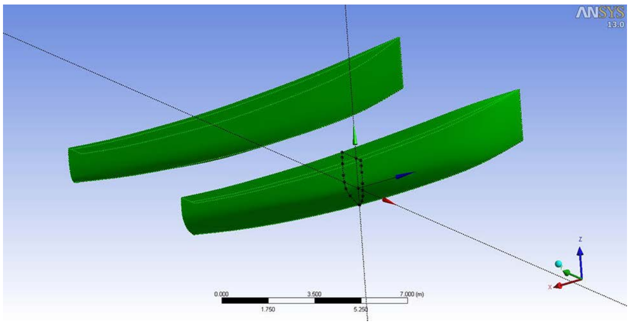


Figure 4 Perspective view of demihulls
(Diagram courtesy Alex Heath)

Variations in the hull alignment are measured as an angle from the centreline of the vessel, as illustrated in Figure 5.

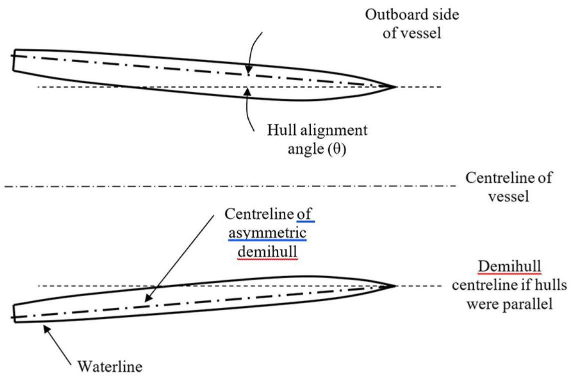


Figure 5 Demihull alignment
(Diagram courtesy Christopher Murman)

Results

Initial numerical simulations were conducted with demihull alignment angles of 0°, 2° and 4°. The zero-degree angle provides the base measurement for comparisons of resistance with the increased angles of demi-hull alignment.

The results are provided in Table 2 and Figure 6.

Table 2 Initial Resistance Results

Alignment angle (deg)	Resistance (N)
0	2910
2	2870
4	3060

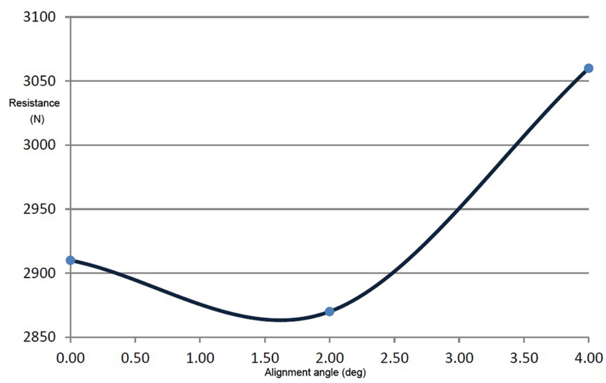


Figure 6 Graph of initial results
(Graph courtesy Christopher Murman)

Examination of the graph suggests that a local minimum of resistance lies between alignment angles of 1° and 2°. In order to verify the existence of a local minimum, a second study was conducted with the alignment angles set at 1.0° and then 1.5° respectively. The results of the second study are combined with the previous results in Table 3 and shown in Figure 7.

Table 3 Final Resistance Results

Alignment angle (deg)	Resistance (N)	Difference (%)
0	2910	0
1	2860	–1.72
1.5	2849	–2.10
2	2870	–1.37
4	3060	+5.15

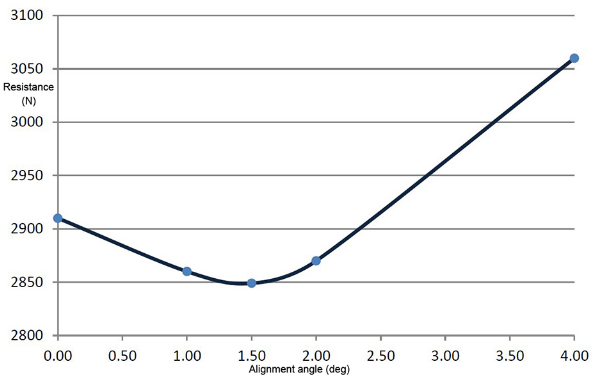


Figure 7 Graph of final results
(Graph courtesy Christopher Murman)

Table 3 and Figure 7 confirm the existence a local minimum of resistance between alignment angles of 1° and 1.5°. The first author acknowledges that this is currently only confirmed for the current model at the current hull speed. These results may vary for different cross-sections and at varying hull speeds.

Conclusion

The objective of the numerical simulations was to test for changes in the hydrodynamic resistance characteristics by systematically varying the demihull alignment (relative to the centreline of the vessel).

For the hullform and single hull speed chosen (namely the maximum displacement hull speed of a sailing catamaran, see Equation 1), associated with small variations in the hull alignment angle (see Figure 5) measurable differences in the total resistance were observed.

Initial numerical simulations suggested the existence of a local resistance minimum between demihull alignment angles of 1.0° and 2.0°. This was verified by conducting further numerical simulations at demihull alignment angles of 1.0° and 1.5° respectively.

It is therefore suggested that a local resistance minimum exists between the demihull alignment angles of 1.0° and 1.5°.

Further Work

This idea could be further developed by model testing to verify the numerical simulations, as well as further CFD studies. From the aforementioned close physical observations, the first author believes the following;

1. It is unlikely that the current hull alignment angle will be optimal for any other hull speed, except the one specified here as determined by Equation 1. The interference point of the inboard bow waves moves down the tunnel as speed increases until the hull speed is reached, whereupon the merged waves trail aft of the hull. However, this represents an opportunity for further testing and research.
2. The primary objective of the paper is to improve sailing performance (i.e. to windward). Hence the reduced wave-making resistance should be considered a bonus, rather than the primary objective. The ability to point higher into the wind while under sail represents an exciting opportunity for further development.
3. If the reduced resistance were to be used as a primary objective, then the resulting power catamaran would be best suited to an application with a limited service speed range.

References

[1] Chen, X.-N., Sharma, S.D., and Stuntz, N., Wave Reduction by S-Catamaran at Supercritical Speeds, Journal of Ship Research, Vol. 47 No. 2, June 2003, pp. 145–154

[2] Harris, R.B., An Introduction to the Design of Multihull Sailing Craft, Marine Technology, SNAME, Vol. 5 No. 4, October 1968, p. 347.

Appendix — Model Cross Sectional Girth Analysis

Since wetted surface area plays a part in the resistance budget, it is instructive to analyse the midship wetted girths of a number of common cross-sectional shapes for the same cross-sectional area.

1. Semi-circular Cross Section

Let A_2 represent the area and C_2 the circumference of a semi-circle.

$$A_2 = \frac{\pi R^2}{2} \qquad [A1]$$

$$C_2 = \pi R \qquad [A2]$$

For unit cross-sectional area, $A_2 = \frac{\pi R^2}{2} = 1$

$$R = \sqrt{\frac{2}{\pi}} \qquad [A3]$$

Substituting [A3] into [A2]

$$C_2 = \pi\sqrt{\frac{2}{\pi}} = 2.507$$

2. Model Cross Section

The model cross section is closely approximated by a quarter circle and a triangle, as shown in Figure A1, where *x* is a fraction of *R*.

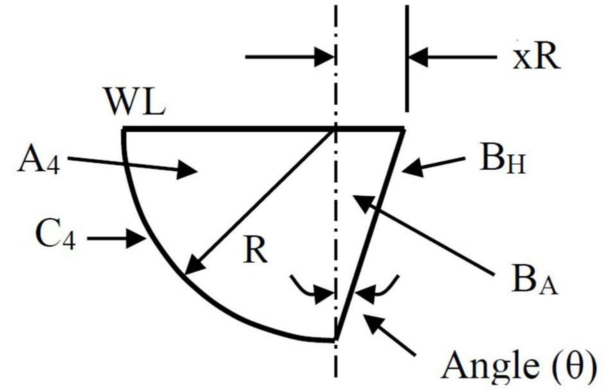


Figure A1 Model cross section
(Diagram courtesy Christopher Murman)

Let A_4 represent the area and C_4 represent the circumference of the quarter circle respectively, and let A_B represent the outboard triangular cross-sectional area and C_B represent the length of the hypotenuse of the triangular area B.

$$A_4 = \frac{\pi R^2}{4} \qquad [A4]$$

$$C_4 = \frac{\pi R}{2} \qquad [A5]$$

$$A_B = \frac{xR^2}{2} \qquad [A6]$$

$$C_4 = \frac{x}{\sin(\tan^{-1}(x))} \qquad [A7]$$

Total cross-sectional area A_T is

$$A_T = \frac{\pi R^2}{4} + \frac{xR^2}{2}$$

For unit cross-sectional area, $A_T = \frac{\pi R^2}{4} + \frac{xR^2}{2} = 1$

$$R = \sqrt{\frac{1}{\left(\frac{\pi}{4}+\frac{\pi}{2}\right)}} \qquad [A8]$$

Total midship section girth C_T is

$$C_T = \frac{\pi R}{2} + \frac{x}{\sin(\tan^{-1}(x))} \qquad [A9]$$

Substituting [A8] into [A9] and setting $x = ⅓$

$$C_T = \frac{\pi}{2}\sqrt{\frac{1}{\left(\frac{\pi}{4}+\frac{\pi}{2}\right)}} + \frac{x}{\sin(\tan^{-1}(x))} = 2.664$$

Comparing the midship wetted girth of the model with that of a semi-circle, the model has 6.28% more wetted girth. It is interesting to note that a local midship wetted girth minimum exists for $x = 0.428$. However, it is suggested by the first author that this may significantly diminish the lift characteristics of the asymmetrical hull form, due to the proportionally larger area on the 'small' side of the asymmetrical midships cross section.

3. Semi-elliptical Cross Section

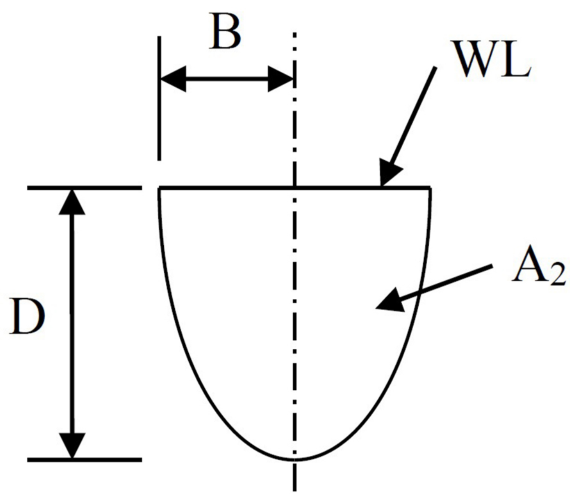


Figure A2 Semi-elliptical cross section
(Diagram courtesy Christopher Murman)

Let A_2 represent the area and C_2 represent the circumference of the semi-ellipse respectively, and let B represent the half-beam of the demihull and D the draft of the demihull. For the purposes of analysis, we assume that the waterline beam is two-thirds of the draft, a typical characteristic configuration of a modern sailing catamaran.

$$B = \frac{D}{3} \qquad [A10]$$

$$A_2 = \frac{\pi BD}{2} \qquad [A11]$$

Substituting [A10] into [A11]

$$A_2 = \frac{\pi D^2}{6} \qquad [A12]$$

For unit cross-sectional area, $A_2 = \frac{\pi D^2}{6} = 1$

$$D = \sqrt{\frac{6}{\pi}} \qquad [A13]$$

and

$$B = \frac{\sqrt{\frac{6}{\pi}}}{3} \qquad [A14]$$

Now, using Ramanujan's Second Approximation for the circumference of an ellipse

$$C_2 = \frac{\pi(D+B)}{2}\left\{1 + \left[\frac{3\left(\frac{(D-B)}{(D+B)}\right)^2}{10+\sqrt{4-3\left(\frac{(D-B)}{(D+B)}\right)^2}}\right]\right\} \qquad [A15]$$

Substituting [A13] and [A14] into [A15]

$$C_2 = 3.078$$

The midship wetted girths of the cross sections are compared in Table A1.

Table A1 Midship Wetted Girths of Cross Sections

Shape	Midship wetted girth	Difference (%)
Semi-circle	2.507	0
Model	2.664	+6.28
Semi-ellipse	3.078	+22.8

Comparing the midship wetted girth of the semi-ellipse with that of a semi-circle, the semi-ellipse has 22.8% more wetted girth. However, the wetted girth of the model is significantly less (16.5%) than that of the semi-ellipse, which is a common cross-sectional shape used in modern sailing catamaran design.

The Authors

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A sight not often seen on the water — Australian Army soldiers from 2nd Battalion, Royal Australian Regiment, deliver water tanks via Zodiac inflatable boat to Kotu Island, Tonga, as part of Operation Tonga Assist 2022
(RAN photograph)

The Effect of Hull Surface Roughness on the Performance of a Model Sailing Yacht

Kim Klaka

Summary

The formulae used to calculate the influence of hull surface roughness on frictional resistance for ships and yachts are not applicable to model sailing yachts because the Reynolds numbers at which they operate are different. Several published formulations for the effects of hull surface roughness on friction were examined. The results from the most promising formulation were used to predict the performance gained by smoothing the hull of a 1 m long model yacht with different grades of sandpaper. A trial was conducted to validate the results.

There is considerable benefit in maintaining a smooth surface in order to promote laminar flow if sailing in conditions of negligible environmental turbulence. However, the amount of environmental turbulence in open water suggests that the incoming flow is already mostly turbulent. This might not be the case for enclosed ponds.

If the flow over the hull is fully turbulent, sanding the hull using 600 grit paper instead of 80 grit paper improves performance over a typical model yacht race course by less than one boat length.

The theoretical predictions of roughness effect from White (2006) are probably the most appropriate for a model racing yacht.

1. Nomenclature

AR_E	Effective aspect ratio
AR_G	Geometric aspect ratio
C_F	Friction coefficient
ΔC_F	Increase in friction coefficient due to surface roughness
C_L	Lift coefficient
d	Grain size diameter (µm)
f	Friction factor
h_S	Sub-layer thickness
H	Boundary layer shape factor = displacement thickness/momentum thickness
k	Roughness height (m or µm)
L	Waterline length (m)
Re	Reynolds number
Tu	Turbulence factor
x	Distance from leading edge (m)
x_{TR}	Distance of transition point from leading edge (m)
V	Flow velocity, boat speed (m/s)
υ	Kinematic viscosity (m^2/s)

2. The Questions to be Answered

Those readers not familiar with the fluid mechanics of flow over a solid surface should read Appendix A before proceeding further.

2.1 Is Laminar Flow Present?

The hull of a typical 1 m long model sailing yacht operates at Reynolds numbers from about 4×10^5 to 2×10^6 which is close to, or within, the laminar flow range. There are at least two subsequent questions which need to be answered before any conclusions can be drawn:

- Is the flow already turbulent when it reaches the hull?
- Is the hull too rough to maintain laminar flow for any significant length?

It might be thought that these questions have already been answered through towing tank tests on scale model ships. There are two reasons why this is not the case:

- Most tank models are larger than model sailing yachts and the tests are conducted at Reynolds numbers three or four times higher than those of model sailing yachts.
- The towing-tank model problem is the inverse of the sailing model yacht problem. In the towing tank it is necessary to trip the flow from laminar to turbulent near the bow, thereby maximising the extent of turbulent flow and thus simulating the flow conditions on the full-size vessel. The aim for the model sailing yacht, on the other hand, is to minimise the extent of turbulent flow.

If laminar flow exists over most or all the model sailing yacht hull, then conventional hydrodynamic theory (backed by experiments) states that roughness does not increase drag in laminar flow, so roughness will not increase drag on the model yacht. If this is true, then it is unnecessary to sand down the hull.

2.2 How much does Roughness in a Turbulent Boundary Layer affect Speed?

As with the first question, it might be expected that this one is readily answered by applying pre-existing formulations used for ships and yachts. As shall become evident, this does not work.

In the following analysis, the hull is assumed to have no pressure gradient. Whilst this is not strictly correct, it does make the analysis manageable and is a reasonable approximation for a slender hull sailing in line with the flow, i.e. with no leeway.

The flow over the keel or rudder of a model yacht requires different assumptions to be made. It is not addressed in the main body of this article, but an introduction is given in Appendix B.

3. Roughness Height Discrepancies and Sandpaper Grade

Table 1 Roughness height for different surfaces

Type of surface finish	Roughness height k (µm)					
	van Oossanen (2018)	Larsson et al. (2014)	Massey (1979)	Hoerner (1965)	Schultz (2002) max	Schultz (2002) rms
Sanded with 600 grit then polished	0.2			0.5	2	0.27–0.3
Sanded with 600 grit	0.73				8–9	0.67–0.73
Sanded with 400 grit	0.77				8–9	0.70–0.77
Sanded with 60 grit	1.63				12–13	1.43–1.63
AC racing yacht	1					
Standard racing yacht, 400 grit cleaned daily	2					
Painted but not sanded	5	50–100		5–200	39–50	3.4–5.0
Primed new steel plate	40–60		45	50		
Flat plate sprayed with antifouling paint	40–75					
Cast iron	250		250	250		

Before the hydrodynamics of the problem are explored, there is an issue regarding the estimation of hull surface roughness height. The roughness height for different surface finishes is quoted in a variety of texts, but they do not always state what measure of height is being used, e.g. rms height, maximum height or some other measure of height. The values shown in Table 1 illustrate the problem.

The figures from van Oossanen are stated to be "average" values. The values from Schultz are given as ranges because they vary with the length over which the sample is measured. It should be borne in mind that the height and length scales of the roughness are not the only roughness parameters correlating with increased friction. The shape of each protrusion and the density distribution of the roughness also influence friction. This is the subject of considerable ongoing research (e.g. Harvald, 1983; Howell and Behrends, 2006) and lies beyond the scope of this paper.

The large disparities shown in Table 1 and the lack of clarity in the definitions of the roughness heights quoted make it difficult to apply these data reliably to friction formulations.

There is another anomaly, which is more easily clarified. When sanding with a particular grit size of sandpaper, the roughness height generated is an order of magnitude less than the diameter of the grit in the paper (see Table 2).

Table 2 Sandpaper roughness and surface roughness

ISO sandpaper grade	Surface roughness height *k* (µm)		Grain size (µm)	
	k rms (Schultz)	*k* max (Schultz)	Average particle diameter (Wikipedia)	Particle diameter (Grainger)
P600	0.67–0.73	8–9	26	26
P400	0.70–0.77	8–9	35	36
P220	0.74–0.86	9	68	
P120	0.9–1.02	9–10	125	
P80			200	190
P60	1.43–1.63	12–13	270	265
Unsanded painted	3.4–5.0	39–50		

From the above data, the relationship between paper grade and grain size can be approximated as:

$$\text{Paper grade} = \frac{15500}{d} \quad [1]$$

where d = grain size diameter (µm) and the relationship between paper grade and maximum roughness k_{max} can be approximated as:

$$k_{max} = \frac{22}{\text{Paper grade}^{0.15}} \quad [2]$$

4. Environmental Turbulence

The question arises as to whether the water in which a model yacht sails already contains turbulence caused by wind, waves, current, and anthropogenic factors (ship wakes, propeller vortices, etc.) Such turbulence will inhibit the presence of laminar flow, and may completely eliminate it. How likely is this?

Environmental turbulence can be characterised by the parameter Tu, which is the ratio of velocity perturbations to the mean velocity. For a yacht moving through water, the mean velocity in the denominator is dominated by the boat speed of the yacht. If this is the case, the slower the boat speed the higher the value of Tu in a given body of water. It follows that the turbulence factor Tu for a model yacht will be as much as one order of magnitude higher than it is for a (much faster) full-size yacht travelling in the same body of water.

Hoerner (1965, Ch. 10-2, Fig. 2) shows experimental results for the same foil tested in a wind tunnel and a towing tank. The friction coefficient measured in the tunnel is a lower value than that measured in the tank at the same Reynolds number, until the Reynolds number is high and both are in turbulent flow. This implies that water in a towing tank has natural turbulence that inhibits or prevents laminar flow being established.

Vijgen *et al.* (1992) report that, in the upper layers of the ocean, the natural Tu is between 0.1% and 1.2%. (This paper also provides an interesting insight on the effects of environmental turbulence on laminar flow over foil sections for yachts.) If the Tu for a model yacht in this environment is one order of magnitude higher, it will experience a Tu of between 1% and 12%. Van Oossanen (2018) states that the critical Reynolds number for transition is halved when Tu increases from 0.1% to 0.35%. White (1974) states that for a Tu of 0.6% the transition Reynolds number is 1×10^6, which is typical for model yacht sailing conditions. Also, when Tu increases from 0.08% to 3%, the transition Reynolds number decreases from 2.8×10^6 to 1×10^5.

These findings suggest that there is likely to be sufficient turbulence, in open expanses of water at least, to eliminate the presence of laminar flow. Yacht designer David Pedrick, who has dealt with this question of environmental turbulence during several America's Cup efforts, feels that environmental turbulence largely negates the development of laminar flow. "We've used electronic sensors and microphones to test for laminar flow," he says. "You can get some, but not much" (Pedrick, c.2018).

I have not yet found information on the amount of environmental turbulence in ponds of the size used by model yachts. This could be for the reason given in MacIntyre *et al.* (2018): "Studies of the mixing dynamics of ponds are rare." The value of natural Tu would have to be less than 0.6% for there to be any chance of laminar flow, which is midway in the range of values for open waters. The short fetch and correspondingly small non-breaking waves on model yacht ponds will result in much less mixing than in open waters, implying a correspondingly lower value of Tu. This increases the possibility of laminar flow existing, compared with the environment in which "big boats" sail. But it is still only a possibility.

5. Effect of Roughness within Laminar Flow

Most fluid mechanics text books show that roughness does not affect friction in laminar flow, therefore roughness does not matter until transition is reached. This widely-accepted conclusion is supported by several theories backed up by experimental results.

However, this assumption of laminar-flow friction being independent of surface roughness is becoming increasingly open to challenge. Gloss and Herwig (2010) looked at micro flows (but it is also applicable to macro flows), showing that roughness increases friction in laminar flow as well as in turbulent flow, but through very different mechanisms. They measured and modelled the frictional drag for varying roughness heights in both laminar and turbulent flow between two flat plates. The numerical values for Reynolds number and roughness are not easily adapted to the case of a single flat plate, but they show that roughness does increase frictional drag in laminar flow.

6. Effect of Roughness on Transition Point

If laminar flow is possible over at least some of the hull, then it would be very useful to know just how much laminar flow there is. Hoerner (1965, Ch. 2-9, Fig. 10) suggests that the critical roughness height k_{crit} which causes transition from laminar to turbulent flow is given in terms of the transition-point distance from leading edge x_{TR} by:

$$\frac{10^4 k_{crit}}{x_{TR}} \approx 2.5 \qquad [3]$$

The value of 2.5 actually varies from 2 to 4.

The disadvantage of this equation is that the location of the transition point must be known in order to find out what the critical roughness height is that causes the transition.

Estimates from model experiments for the transition point on a smooth surface vary quite a lot, probably because of slight pressure gradients, slight roughness, and the level of environmental turbulence.

Hoerner (1965) suggests that the transition Reynolds number lies somewhere within 0.5–0.6×10^6. He also states that, for constant-pressure surfaces, the transition Reynolds number is "of the order of 2.4×10^6" and that laminar flow is always stable at Reynolds numbers below 6×10^4. White (2006) reports that the transition Reynolds number is 2.8×10^6 for a smooth plate when the environmental turbulence is a low 0.02%. He also provides data showing that the transition Reynolds number decreases by one order of magnitude for the range of roughness heights of interest here.

Van Oossanen (2018) and White (2006) provide a method for estimating the transition point as a function of the boundary layer shape factor *H* (Equation 4), though White states "This method is not well verified versus experiment."

$$log_{10}(Re_{tr}) \approx -40.4557 + 64.8066H - 26.7538H^2 + 3.33819H^3 \qquad [4]$$

It is worth noting that transition does not occur at a single point, rather it has two boundaries. The first is where transition to turbulent flow starts to develop in isolated locations and the second is where the flow everywhere downstream is fully turbulent.

7. Effect of Roughness within Turbulent Flow

7.1 Critical Roughness Height

If the flow is turbulent, then there is considered to be a critical roughness height below which the roughness has no impact on friction. The critical roughness height can be determined by using the traditional assumption that the surface is hydraulically smooth if the roughness height does not protrude through the laminar sub-layer which exists within the turbulent boundary layer. The notion that a surface is either hydraulically smooth or "fully rough" is a good approximation for high Reynolds number flows, but it may be too simplistic for the lower Reynolds number flows of a model yacht. "Fully rough" is a concept which might be described as when the roughness height is sufficient to fully disrupt or destroy the laminar sub-layer. There is clearly an intermediate roughness height which increase friction slightly but does not completely destroy the laminar sub-layer. This intermediate roughness height is of little interest to full-size vessels, but it lies at the core of the model yacht hull smoothness question.

The formula for the sub-layer thickness from Larsson *et al.* (2014) is:

$$h_s = \frac{10^{-4}}{V} \qquad [5]$$

where h_s = Sub-layer thickness (m)

V = Boat speed (m/s)

The sub-layer thickness was estimated by Schlichting (in Olson, 1973, and Harvald, 1983) to be:

$$h_s = \frac{100\upsilon}{V} \qquad [6]$$

where h_s = Sub-layer thickness (m)

υ = Kinematic viscosity (m^2/s)

V = Flow speed (m/s)

Neither of the above equations include any length term, whereas qualitative descriptions of the sub-layer describe how the thickness increases along the surface. Hoerner (1965) provides a formula which includes a weak dependence on length:

$$\frac{h_s}{x} = \frac{105}{Re_x^{\frac{11}{12}}} \qquad [7]$$

where x = Distance from the leading edge of the plate (m)

Re_x = Reynolds number based on x

The sub-layer thickness can also be inferred from formulations for friction increase, as it corresponds to the roughness height at which the friction increase tends to zero (see Section 8 and Table 6).

7.2 Friction Coefficient

7.2.1 Nikuradse Pipe Experiments

The effect of roughness on friction drag was first quantified by Nikuradse (1933) in experiments on flow through pipes. His famous graph, often called a Moody chart, forms the basis of friction curves found in many text books, e.g. Figure 1.

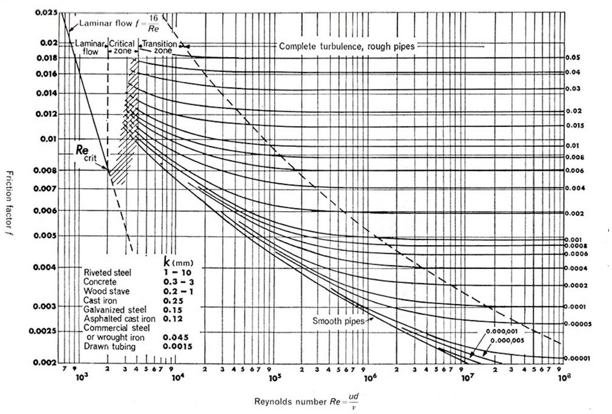

Figure 1 Typical friction curve (Diagram from Massey, 1979)

Note that the Darcy friction factor *f* on the vertical axis is 4×C_F (White, 1974), and the Reynolds number on the horizontal axis is based on pipe diameter, which is not the equivalent of boat length — there is more than one order of magnitude difference.

The graph shows that, as roughness height increases, so does the friction. It also shows that the increase in friction is independent of Reynolds number for the values at which most ships and yachts operate. When the flow is in this condition it is considered to be fully rough, and the independence from Reynolds number makes calculation of friction in these conditions quite straightforward.

Unfortunately, model yachts operate at much lower Reynolds numbers, never reaching the fully-rough condition unless large protuberances are added to the surface. Furthermore, the roughness curves in the Moody chart for the Reynolds number regime of relevance to model yachts are poorly delineated and, in some instances, absent. This is probably due to lack of data in this region.

7.2.2 1978 ITTC Method

There are several formulations for evaluating the effect of increasing roughness on friction for fully rough flow, but model yachts do not operate in fully rough flow. The 1978 ITTC method (Harvald, 1983) is presented here because the results (in Section 8) show how misleading they can be for model yachts.

$$\Delta C_F = \left[105\left(\frac{k}{L}\right)^{0.333} - 0.64\right] \times 10^{-3} \quad [8]$$

Harvald defines k as "the mean apparent amplitude of the surface roughness over a 50 mm wavelength". On inspecting the source from which this definition derives, (British Ship Research Association, in Harvald), it is the mean of the maximum amplitudes, not the mean amplitude.

7.2.3 Van Oossanen

Van Oossanen (2018) has developed an approximate formula for friction coefficient as a function of Reynolds number and roughness height, which has neither a terminal value at high Reynolds number nor a minimum critical roughness height, i.e. the smoother the surface, the lower the friction. This alternative formula is:

$$\Delta C_F = a[log10(Re)]^b \quad [9]$$

Where a and b are functions of a Reynolds number which uses the roughness height for its length dimension.

The range of Reynolds numbers for which this formula is applicable is not stated, but the presence of Reynolds number in the equation indicates that it might be applicable to flows which are less than fully rough. Results are given for Reynolds number as low as 10^6, which is representative of model yacht conditions.

If Equation 9 is valid for model yachts, then there is no limit as to how smooth the hull should be.

7.2.4 Schultz

Experimental work conducted by Schultz (2002) deserves close attention for two reasons. Firstly, the experiments were conducted very carefully and the roughness of the surface was rigorously categorised. Secondly, and of particular relevance to this paper, the surface roughness was not created by adding roughness particles; rather it was developed by sanding a painted surface with increasingly finer grades of paper. This is the same technique used by sailors to finish a hull surface. Unfortunately, the lowest Reynolds number in the Schultz experiments was approximately 2.8×10^6, which lies just beyond the operating regime of a model yacht.

7.2.5 White

White (2006) derived a formulation which is for all turbulent flow conditions from hydraulically smooth to fully rough.

$$Re = 1.73125(1 + 0.3k^+)e^{0.4\lambda} \times \left[Z^2 - 4Z + 6 - \frac{0.3k^+}{1+0.3k^+}(Z-1)\right] \quad [10]$$

where $Z = 0.4\lambda$

$$\lambda = \sqrt{\frac{2}{C_F}}$$

$$k^+ = \frac{Re\left(\frac{k}{L}\right)}{\lambda}$$

The roughness height k is defined by White as the average size of a grain attached to the surface. As with Equation 9 from van Oossanen, inspection of Equation 10 shows that there is no critical roughness height. If the roughness height is set to zero, the results follow the same trend as for standard smooth-turbulent formulations (Nikuradse, etc.) Equation 10 is considered the most likely to yield valid results for model yachts. (Note that this equation is from the 3rd edition of White; the one in the 2nd edition contains an error.)

8. Numerical Results

The formulae in the previous section have been applied to a model yacht with a hull waterline length of 1 m. Four speeds were investigated:

Table 3 Sailing speeds investigated

Sailing condition	Approx. boat speed (kn)	Boat speed (m/s)	Reynolds number
Light airs sailing	1	0.5	4.2×10^5
Windward sailing	2	1.0	8.4×10^5
Hull speed	2.5	1.3	1.1×10^6
Planing	4	2.0	1.7×10^6

8.1 Transition Point

The location of the transition point, assuming a smooth surface with no pressure gradient, was calculated from three different sources using the upper (fully smooth) and lower (fully rough) bounds for transition. The results are shown in Table 4.

Table 4 Transition point distance from bow

$L = 1$ m		**Light airs**	**Upwind**	**Hull speed**	**Planing**
	V (m/s)	0.5	1.0	1.3	2.0
		x_{TR} (m)			
Hoerner rough		0.14	0.07	0.05	0.04
Van Oossanen rough		1.62	0.81	0.62	0.41
White rough		0.67	0.33	0.26	0.17
average rough		*0.81*	*0.40*	*0.31*	*0.20*
Hoerner smooth		5.71	2.86	2.19	1.43
Van Oossanen smooth		11.48	5.74	4.40	2.87
White smooth		6.66	3.33	2.55	1.67
average smooth		*7.95*	*3.98*	*3.05*	*1.99*

The results show that:

- if there is negligible environmental turbulence and the hull is smooth, then the entire hull will be in laminar flow; and
- even if the surface is rough, between 20% and 80% of the hull will be in laminar flow provided that there is negligible environmental turbulence.

Therefore there is considerable benefit in maintaining a smooth surface to promote laminar flow, but only if sailing in conditions of negligible environmental turbulence.

8.2 Critical Roughness

Some critical roughness estimates for a hydraulically smooth surface are shown in Table 5.

Table 5 Critical roughness (sub-layer thickness)

$L = 1$ m		**Light airs**	**Upwind**	**Hull speed**	**Planing**
	V (m/s)	0.5	1.0	1.3	2.0
		k_{max} (μm)			
Equation 5 (Larsson)		200	100	77	50
Equation 6 (Olson)		238	119	92	60
Equation 7 (Hoerner)		735	389	306	206

All these values are considerably higher than the roughness of an unsanded painted surface (see Table 2), implying that there is no advantage in sanding down even the roughest of paint finishes.

However, Schultz (2002) found that there is a decrease in friction drag as increasingly-finer grades of sandpaper were used, terminating once 400 grit paper was used. Table 2 shows that sanding with 400 grit paper creates a roughness height of 8 microns.

8.3 Drag Increase above Critical Roughness

When using the data and equations discussed in Section 4, the question arises as to whether the roughness length dimension k is the rms value, the maximum value, or some other value. This was resolved by plotting the friction increase against roughness height for the Schulz experimental results and comparing them with the output of Equation 10. The results in Figure 2 show clearly that the roughness dimension used in Equation 10 cannot be the rms value, and that using the maximum roughness height yields realistic results.

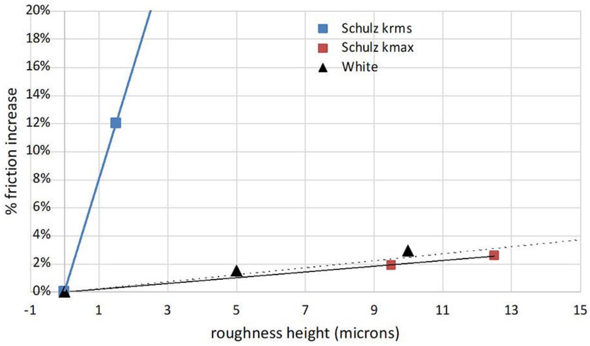

Figure 2 Effect of roughness parameter on friction results

Having made this determination, the increases in friction due to roughness from sources discussed in Section 4 were estimated at a boat speed of 1.3 m/s (hull speed); the results are shown in Table 6.

Table 6 % Change in friction drag at $Re \approx 10^6$

Roughness height (mm)	**van Oossanen (2018)**	**Schultz (2002) $k = k_{max}$**	**White (2006)**	***ITTC (fully rough)***	***Gloss & Herwig (2010) (laminar flow)***
2	0.05	<1.0	0.5	15	
10	0.9	1.9	2	36	9
50	5	5	9	71	7
100	8		16	90	
				120	

The percentage increases in friction for laminar flow from (Gloss and Herwig, 2010) are similar to some of those in turbulent flow. However, the absolute values of drag increase are low because the drag in laminar flow is much lower than in turbulent flow.

When discussing the results it is important to bear in mind the following:

- The van Oossanen results *might* be applicable to model yachts, although it is not clear.
- The Schultz results are for Reynolds numbers higher than those experienced by model yachts.
- Then White results are valid for Reynolds numbers and roughness regimes typical of model yachts.
- The ITTC values are for the fully rough condition, not normally found in model yachts.
- The Gloss and Herwig results are for laminar flow only.

Taking into account those constraints, it can be seen that:

- the ITTC "big ship" formulation considerably overestimates the friction increase due to roughness; and
- roughness heights below about 5 microns create negligible friction increase in a turbulent boundary layer.

It is considered that the White formulation of Equation 10 is appropriate for both model and large yachts. This view was partially tested by applying the equation to a full-size sailing yacht for which Larsson *et al.* (2014) provide graphical data. The results agreed to within 8%.

Equation 10 was then applied to a model yacht scenario, yielding the results shown in Figure 3.

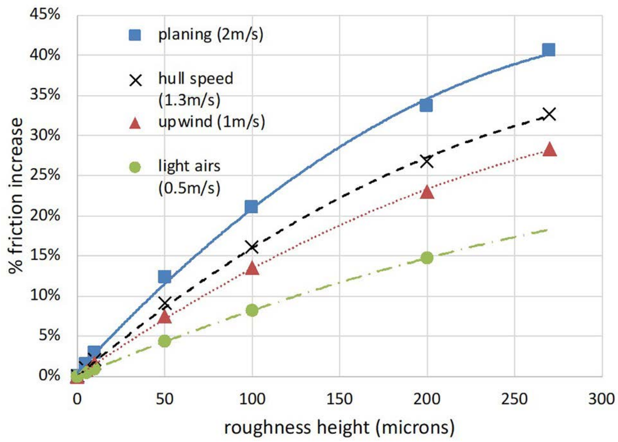

Figure 3 Effect of roughness height on friction (Equation 10)

9. Predicted Effect of Hull Roughness on Boat Speed

Calculating the friction increase due to roughness is not the end of the task; it is the speed loss on the race course which is of ultimate interest. The impact of a given increase in friction on boat speed depends on several factors, including:

- the proportion of total drag attributable to friction drag;
- the relationship between drag and boat speed; and
- the impact of a reduction of boat speed on other components of drag.

A velocity prediction program (VPP) was used to investigate the effect of friction increase on performance. The calculations were performed by Bantock (2021) using the WinDesign VPP (Oliver 2021). The yacht modeled was a DragonFlite 95, the same as was used in the full-scale trials described in the next section. The friction increase for different roughness heights was simulated by changing the wetted surface area. Sample results are shown in Figure 4.

By obtaining best-fit linear trendlines for the data in Figure 4 and combining them with Equations 2 and 10, the percentage speed change when sanding down with different grades of sandpaper can be calculated. The resulting speed differences have been applied to a typical model yacht racing course of 90 m leg length, two laps upwind and downwind. The results for a wind speed of 10 kn are shown in Figure 5, in terms of boat lengths lost on the course compared with a fully-smooth hull.

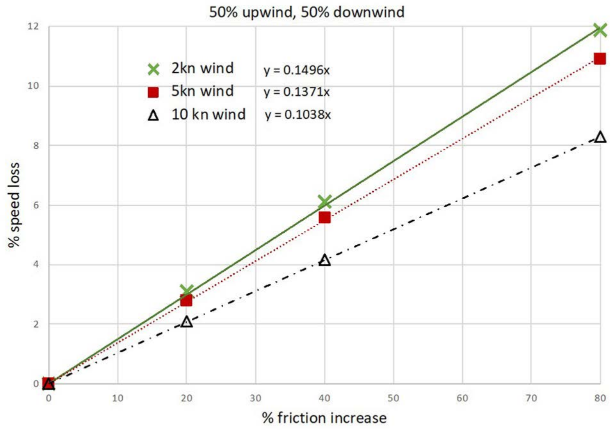

Figure 4 Effect of friction increase on speed loss

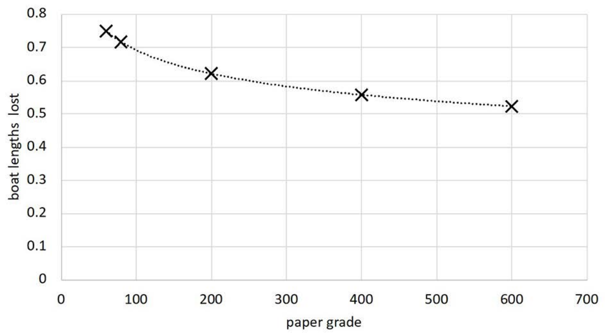

Figure 5 Effect of sandpapering on distance lost

The surprising observation is that sanding the hull using 600 grit instead of 80 grit paper improves performance over the course by less than half a boat length. It is important to note that this assumes:

- there is strong environmental turbulence (and therefore negligible laminar flow);
- there is no pressure gradient over the hull; and
- the influence of roughness on the foils is an entirely different matter, not considered here.

10. Full Scale Trials Validation

A qualitative trial was conducted using a DragonFlite 95 radio-controlled model sailing yacht (DragonFlite, 2022). The yacht is 0.95 m in length overall.

The yacht was firstly raced in two regattas with a very smooth bottom to establish benchmark performance. The smoothness was estimated as 2 μm, achieved by sanding progressively through sandpaper grades down to 1200, then finishing with cutting compound to obtain a "matt mirror" finish. A rough surface finish was then applied, comprising spherical particles of approximately 60–80 grit size, densely packed in varnish applied by brush. The 60–80 grit particles correspond to a roughness height of about 235 μm (Table 2).

The yacht was raced with this surface finish in a third regatta, then the varnish mix was removed and the hull sanded back to the original matt mirror finish and raced again in a fourth regatta. The regatta results are shown in Table 7.

The races conducted with the varnish-grit finish were held on the Swan River at the South of Perth Yacht Club, Western Australia, on Friday 15 October 2021 with nine boats competing. They were mostly the same boats raced against before and after that date, so they provided a reasonable benchmark. The course was windward–leeward (two laps), with the distance from top to bottom mark about 90 m. Winds were light with periods of calm (2–5 kn recorded at the nearby on-water weather station). There was partial wind shadowing from nearby jetties. The water surface was quite glassy except for the occasional wake from a passing power boat. The grit surface stayed intact for the duration of the racing.

Table 7 Regatta Results

Regatta No.	No. of boats	Overall placing	Best race
1 (smooth hull)	6	2nd	1st
2 (smooth hull)	6	1st	1st
3 (rough hull)	9	7th	3rd
4 (smooth hull)	8	3rd	1st

During the first, second and fourth regattas, with the smooth hull, boat speed upwind was usually amongst the best in the fleet, downwind it was about average. During the third regatta, with the varnish-grit finish applied, boat speed upwind and downwind was slower than every other boat. The boat had definitely lost its sparkle, similar to when the rig tune is completely wrong.

The average speed loss during the rough-hull trial was evaluated by estimating distance lost over the course, then converting that to boat speed loss. This resulted in an estimate of 5% boat speed loss. This observed speed loss of 5% is reasonably close to the 4% loss predicted by the VPP for light winds using the data from Figure 3 and Figure 4. This provides some validation for the theoretical predictions of roughness effect from White (2006).

11. Conclusions

- There is considerable benefit in maintaining a smooth surface in order to promote laminar flow if sailing in conditions of negligible environmental turbulence.
- The amount of environmental turbulence in open water suggests that the incoming flow is already mostly turbulent. This might not be the case for enclosed ponds.
- The predictions of roughness effect from White (2006) are probably the most appropriate for a model racing yacht.
- If the flow over the hull is fully turbulent, then sanding the hull using 600 grit instead of 80 grit paper improves performance over a typical model yacht race course by less than one boat length.

12. Acknowledgements

Thanks are extended to Graham Bantock of SAILSetc for running the VPP and offering technical advice, including how best to create the hull rough surface for the sailing trial. Thanks are also due to Dr Tim Gourlay of Perth Hydro for suggestions on how best to solve the transcendental Equation 10 of White, which confirmed my belief that mathematics is mystical.

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Appendix A The Basic Science

This appendix is for those readers who are not familiar with the fluid dynamics of flow over surfaces.

A1. Types of Resistance

Resistance is the force opposing the forward motion of the yacht. It is sometimes called drag (drag and resistance are almost the same thing). The two main components of resistance are wavemaking resistance and viscous resistance. Viscous resistance is further sub-divided into two components: skin friction resistance and viscous pressure resistance. Whilst it is very insightful and convenient to consider each component in isolation, it must be borne in mind that all the components interact with one another. For example, the wavemaking resistance alters the amount of surface area of the hull in contact with the water, thus affecting the friction resistance.

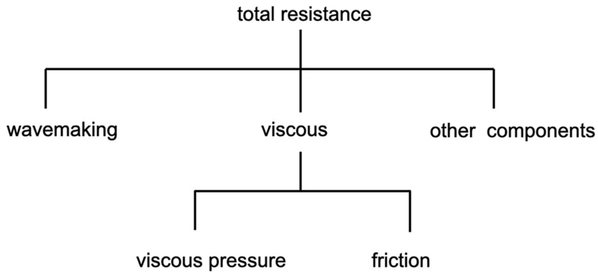


Figure A1 Components of resistance

A2. Components of resistance

A2.1 Friction Resistance

This is the component of resistance due to the friction between the water and the yacht hull. The amount of frictional resistance is directly proportional to the amount of underwater surface area of the hull, i.e. the "wetted surface area". It is this component of resistance which is affected by hull surface roughness.

A2.2 The Boundary Layer

When the hull moves through the water, the water particles right next to the hull surface end up being carried along with the yacht. The layer of particles just outside the first layer is also dragged along with the yacht, though not quite so fast. The next layer out is dragged along even less, and so on until, at some distance out from the hull, the water particles are not moved at all. The effect is analogous to taking a pack of playing cards and throwing them onto a table. The table is the equivalent of the hull and the cards are the layers of water moving past it. Each card sticks a bit to the next one.

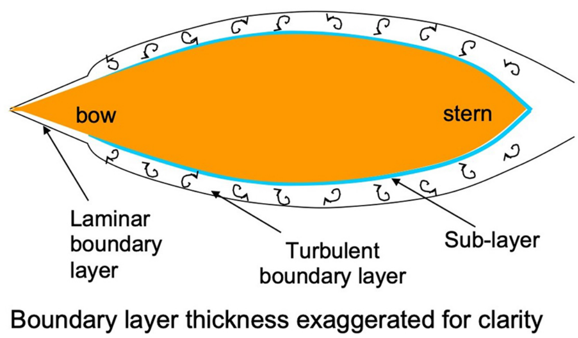


Figure A2 The boundary layer

The region of water next to the hull which is affected by the hull moving forwards is called the boundary layer. The boundary layer is quite thin, typically less than 20 mm on a keelboat, and considerably thinner on a model yacht. So it is not readily visible unless you are really looking for it. However, it is this boundary layer of water, and what goes on inside it, that is the key to understanding how the hull surface roughness affects the performance of a yacht. The creation of the boundary layer requires energy. That energy is drawn from the boat by reducing the speed of the boat, i.e. the boundary layer creates resistance.

There are, broadly speaking, two types of flow inside the boundary layer: laminar and turbulent. Laminar flow is when the water particles slip smoothly over one another, rather like the pack of cards do. Turbulent flow is when the water particles are moving around randomly, with layers mixing together and particles crossing each others' paths.

Laminar flow has much less drag than turbulent flow, but it only exists at slow boat speeds, over short distances from the bow. These conditions occur very rarely on a full-size boat, but they are quite likely for the hull of a model yacht. How likely? That is the question that led to the research described in this paper.

A2.3 The Sub-layer

Inside this thin boundary layer of turbulent flow there is an even thinner layer of water, called the sub-layer. The sub-layer is really thin, typically less than 0.1 mm, which is the thickness of a human hair. It is difficult to imagine that this wafer-thin layer of water is so influential on boat speed, but it is. If the roughness of the hull surface is high enough to protrude through the sub-layer, it will cause an increase in friction drag. The more it protrudes, the greater the friction drag.

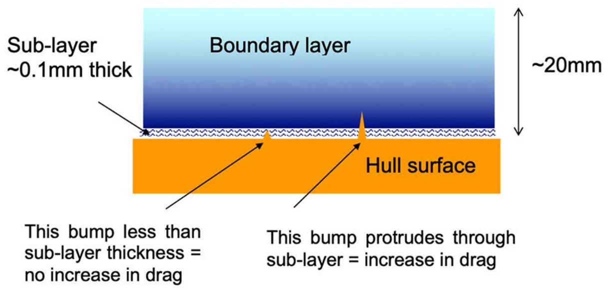


Figure A3 The sub-layer

If the roughness is less than the sub-layer thickness, then the hull surface is known as a hydraulically-smooth surface, and making the surface any smoother will not reduce the drag further, no matter how much sanding is done. So for minimum friction drag, if the boundary layer is turbulent then the hull surface roughness should be no higher than the sub-layer thickness. The sub-layer thickness depends on the speed of the yacht and, to a much lesser extent, how far back from the bow it is being measured. As you move aft along the yacht from the bow, so the sub-layer thickness increases. However, at any chosen point on the yacht the sub-layer thickness *decreases* as boat speed increases. So the hull must be smoothest near the bow, and it has to be smoother for high-speed yachts than for low-speed yachts.

All the above is for a boundary layer with turbulent flow. If the boundary layer is laminar, which can occur on a model yacht, conventional fluid dynamics states that roughness will not increase the friction drag. This turns out to be a slight over-simplification.

A2.4 Separated Flow

There is a third type of boundary flow, called separated flow. As the name implies, it occurs when the entire boundary layer separates away from the hull, leaving a void to be filled with eddies or swirls. Separated flow can occur with both laminar and turbulent flow boundary layers. It is usually visible at the stern of the boat in the form of the wake (the eddies and swirls created by the separated boundary layer). Separated flow is triggered by the curvature of the surface causing an adverse pressure gradient pushing against the boundary layer, "peeling" it off the hull. The extra drag (resistance) created by separated flow is a component of viscous pressure resistance, not friction resistance. Separated flow is influenced by surface roughness, but not in a generalised or readily-quantifiable way. It will not be considered further here.

A2.5 Reynolds Number

Readers might be familiar with the Mach number, which is used to describe whether an aircraft is flying faster or slower than the speed of sound. There is a similar type of number, called the Reynolds number, which describes the type of flow over the surface of the hull. Scientifically, it is the ratio of inertial forces to viscous forces. For a yacht hull the Reynolds number *Re* can be approximated mathematically as:

$$Re = Vx \times 1.7 \times 10^6 \quad \text{[A1]}$$

where V = Boat speed (kn)
x = Distance along the hull from the bow (m)

This means that, if the hull is very long, or if it is travelling very fast, then the Reynolds number is large and the viscous forces are less important than the other forces (e.g. wavemaking resistance). The Reynolds number also turns out to be an indicator of whether there is likely to be turbulent flow or laminar flow in the boundary layer. Indeed, for a smooth surface with no pressure gradient, there is a specific Reynolds number, called the critical Reynolds number, beyond which laminar flow cannot exist (about 1×10^6). The value of the Reynolds number also determines how thick the boundary layer is, how thick the sub-layer is, and lots of other boundary layer characteristics.

Appendix B Surface Roughness Effects on Foils

The fin and rudder of a typical model yacht of waterline length 1 m operate at Reynolds numbers from about 2×10^4 to 1×10^5.

Thin foils at zero inflow angle have low pressure gradients, so they are likely to be operating in laminar flow owing to their chord length being an order of magnitude smaller than the hull length. However, for thicker foils or for foils operating at some inflow angle, the pressure gradient probably determines the likelihood and extent of laminar flow.

B1. Zero Inflow Angle

For zero inflow angle, the foils can be treated as for the hull. The assumption of zero pressure gradient is clearly false over most of the foil surface. However, it is favourable for retaining laminar flow near the nose and, for laminar flow sections at least, it remains favourable for some way aft, perhaps 60% of the chord length. The nature and extent of laminar flow over the rear half of the foil is strongly dependent on the section used. So treating the foil in the same way as the hull (i.e. flat plate with no pressure gradient) gives estimates of the transition point which are valid only if transition occurs well aft; otherwise the results are of questionable validity.

B2. Angle to flow

At typical leeway angles when sailing to windward, can there be laminar flow over the foils? The foils operate at a lift coefficient C_L of between 0.2 and 0.4 when sailing to windward, as shown in Table B1.

Hoerner (1965, Ch. 2-12) states that, for a smooth 65-series

Table B1 Lift coefficients sailing to windward

DragonFlite 95	Keel	Rudder
Span (mm)	300	150
Chord (mm)	70	45
AR_G	4.29	3.33
AR_E	7.29	5.67
C_L @3°	0.233	0.215
C_L @5°	0.388	0.359

section (i.e. a "laminar flow" section), for a lift coefficient higher than about 0.1 to 0.2, "the flow around the leading edge disturbs the boundary layer so that it turns turbulent shortly aft of the leading edge". This is the standard explanation for the bucket shape in the lift vs drag curve and is in keeping with the results shown in Hoerner (1965, Ch. 2-12, Fig. 17). However, those results are at a Reynolds number of 6×10^6 ; they might be quite different at lower Reynolds numbers. The general view is that the lift coefficient for bucket sections on a model yacht foil should be kept below about 0.3 (Bantock, 2021).

The flow regime is further complicated by the possibility of a laminar separation bubble near the leading edge. Simons (1978, p.27) states that separation bubbles rarely occur on full-size aircraft, but they do occur on model aircraft wings. Full-size aircraft usually operate above Reynolds numbers of 1×10^6 whereas model aircraft operate at Reynolds numbers of around 1×10^5, putting them in the same flow regime as model yacht foils.

B3. Conclusions

- The foils are operating in laminar flow unless the leading edge or environmental turbulence trips it.
- There is a strong chance of a laminar separation bubble on the foils when sailing to windward. This detracts from performance. It may be worth trying to artificially induce turbulence in the flow over the foils.

INDUSTRY NEWS

A&P Group carries out two Bay-class Vessel Refits

A&P Group UK and A&P Australia have simultaneously carried out the refits of two Bay-class vessels; RFA *Cardigan Bay* in the UK and HMAS *Choules* in Australia.

RFA *Cardigan Bay* has recently completed her refit at A&P Falmouth and resumed the 'Fleet Time' schedule, while HMAS *Choules* continues her significant refit period in Sydney.

The Bay-class are amphibious landing ships built for the British Royal Fleet Auxiliary (RFA) during the 2000s. UK-based A&P Group supports RFA *Cardigan Bay*, RFA *Lyme Bay* and RFA *Mounts Bay* as part of its through-life support (TLS) contract with the Ministry of Defence.

HMAS *Choules*, formerly RFA *Largs Bay*, was purchased by the Royal Australian Navy in 2011. A&P Australia was incorporated in 2012 and has been supporting HMAS *Choules* since her arrival in Australia. In 2015, A&P Australia was awarded the In-Service Sustainment and Support Contract for HMAS *Choules* which was extended in 2019.

RFA *Cardigan Bay* has completed a significant mid-life refit at A&P Falmouth. The work included critical equipment and obsolescence upgrades and accommodation updates.

The vessel underwent a substantial docking period at the start of the refit carried out over 90 days including painting, hull access, stern/side ramp removal and significant work to the propulsion system. The remainder of the period was spent alongside A&P's Falmouth facility and ensured the continued performance and availability of this RFA Bay-class vessel.

RFA *Cardigan Bay's* refit was the second of three planned refits being delivered at A&P Falmouth for the Bay Class vessels, with RFA *Mounts Bay* completed previously and RFA *Lyme Bay* scheduled for 2022.

HMAS *Choules* alongside Garden Island in Sydney after the completion of the docking phase of her refit
(Photo John Jeremy)

Since 2019, A&P Australia has been tasked as the principal systems integrator for the HMAS *Choules* Capability Assurance Project (CAP). The project involves the design and installation of over 80 engineering changes across 44 capability enhancement areas to assure the capability and supportability of HMAS *Choules* until her planned withdrawal date early next decade.

"The CAP has been integrated with sustainment and has been delivered progressively through a number of maintenance periods; however, this current refit is the major upgrade window and is acting as a mid-life upgrade for the ship," the company stated.

Refit Period 21 is spanning over 300 days at an estimated production cost of $90 million. It includes a major system renewals program which includes the dry exhaust, HVAC, ballast-water treatment, numerous auxiliary and mission system upgrades and enhancements, as well as a major sustainment package for hull and tank preservation, structural and machinery repairs, and planned maintenance across all fitted equipment including main engines, power generation, propulsion and auxiliary systems.

Regional Maintenance Centre Plans

On 18 February the Prime Minister, the Hon. Scott Morrison MP, announced the release of a request for tender for an industry partner to head a new Navy regional maintenance centre in Darwin. The announcement was made during Mr Morrison's visit to HMAS *Coonawarra*.

The regional maintenance centre will support new capabilities, including the evolved Cape-class patrol boats and Arafura-class offshore patrol vessels expected to arrive in Darwin in the next few years.

The centre will inject about $160 million into the Northern Territory's economy.

"As our most northern port, Darwin is a critical strategic location for Defence," Mr Morrison said.

"A network of four regional maintenance centres is being established in strategic locations across the country in support of the Government's continuous naval shipbuilding program.

"This will ensure complex naval capability is available when and where required."

Regional Maintenance Centre North is scheduled to be operational in 2023 and is a key part of Defence's Plan Galileo.

Also, on 11 May, the Commonwealth issued a request for tender for a Regional Maintenance Provider to provide maintenance management services for Navy vessels at the Garden Island Defence Precinct in Sydney, NSW. The role of the industry partner will include establishing robust, reliable and resilient supply chains on the east coast, liaising with the Commonwealth and suppliers to program, coordinate and verify maintenance delivery to meet demand, to drive the implementation of standardisation and continuous improvement to enhance efficiency and effectiveness of sustainment delivery; and to work with local industry to support the continued development of sovereign sustainment capability over time. The Regional Maintenance Provider will be working with Commonwealth personnel as part of one of the four regional maintenance centres. Tenders close on 16 September.

XL-AUVs for the RAN

The defence technology company Anduril Industries and the Australian Defence Force are entering into commercial negotiations for a $100 million co-funded design, development and manufacturing program for extra-large autonomous undersea vehicles (XL-AUVs) for the Royal Australian Navy.

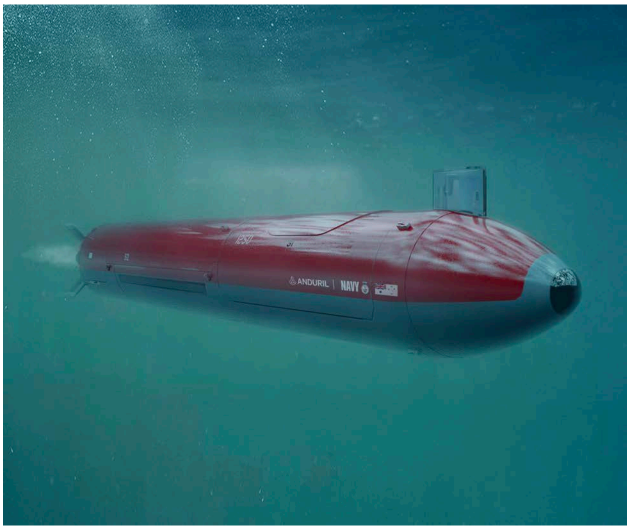
The XL-AUV program aims to develop an affordable, autonomous, long-endurance, multi-mission-capable AUV which can be optimised with a variety of payloads for a wide range of military and non-military missions.

These would include advanced intelligence, infrastructure inspection, surveillance, reconnaissance and targeting.

Under the three-year XL-AUV development program, three prototypes will be delivered to the Royal Australian Navy.

For its part of the deal, Anduril will design, develop and manufacture the XL-AUVs in Australia and will recruit, build and retain a highly-skilled workforce.

Recent signing of the agreement between Defence and Anduril (Photo courtesy Anduril)



Anduril will design, develop and manufacture XL-AUVs in Australia (Image courtesy Anduril)

In addition, the company intends to actively partner with other Australian SMEs and the research and technology communities to source nearly all elements of the supply chain for the program.

"The XL-AUV project is a significant investment in Australian industrial capabilities", said David Goodrich OAM, Executive Chairman and CEO of Anduril Australia. "Through this partnership, Anduril Australia will become a major player in the thriving defence industrial base in Australia and contribute to Australia becoming a leading exporter of the cutting-edge autonomous capability to the rest of the world."

BMT Design to be offered for Joint Support Ship Project

BMT, a leading international multi-disciplinary engineering and ship design consultancy, will offer an updated concept design from its ELLIDA™ multi-role logistics ship design family for the Royal Australian Navy's Joint Support Ship project, SEA2200. The ELLIDA™ family of concept designs, launched in 2019, builds on the experience of other BMT designed vessels in-service in the auxiliary market.

The modifications to the eventual RAN requirements will take advantage of the concepts having been designed with flexibility to allow them to adapt to differing customer mission requirements. This is combined with BMT's proven track record in developing specific solutions for naval customers. The design includes a ro-ro cargo capability, cargo stores and provision to allow replenishment at sea for fuel and dry stores, with a well dock to support amphibious operations.

ELLIDA™ has the ability to transport and deliver troops, vehicles, equipment and supplies to and from anywhere in the world in support of amphibious warfare and littoral operations, offering a versatile mix of ship-to-shore offloading and logistics capabilities to allow naval operations through landing craft, boat operations, multi-spot aviation and replenishment at sea. The centre of the ship has two extensive decks with flexible space for either vehicles, containers or equipment, ensuring that the vessel has the flexibility to adapt to differing mission requirements.

BMT's support vessel design will be offered to Australia (Image courtesy BMT)

Primarily a logistics ship with considerable capacity to carry solid stores and flexible options for loading, transferring or unloading, ELLIDA™ has been designed to provide strategic logistic transportation of rolling cargo, vehicles, troops and freight between operational areas to deliver support to amphibious operations using landing craft and helicopters. Also designed to operate as a humanitarian disaster-response vessel, the design is flexible to allow the addition of enhanced medical and/or replenishment-at-sea facilities.

Trevor Dove, Senior Business Development Manager, BMT, commented "Auxiliary amphibious vessels provide essential logistic support to sustain troops ashore. With many navies re-evaluating amphibious warfare operations in response to modern mission requirements, it is essential that support vessels are able to keep pace with evolving requirements to ensure that vital logistical and supply needs are met. Navies around the world need to be equipped with auxiliary platforms which have the flexibility to support global operations whilst maintaining the highest levels of safely and reliability, and we are confident that the ELLIDA™ family of vessels will deliver against these requirements."

The ELLIDA™ multi-role logistics ship is the third in the family of vessels designed by BMT for the auxiliary market, complementing the AEGIR family already in service with the Royal Fleet Auxiliary and the Royal Norwegian Navy and SALVAS concept. In developing the ELLIDA™ design, BMT applied the knowledge gleaned through the development of operational concepts against current and future doctrines of several navies. The concept is designed to be able to react to the dynamic functional requirements of military commanders in support of government policy for several different nations.

As the trusted partner for scientific and engineering-led advice, solutions, programmes and services, ELLIDA™ will be designed in Australia, drawing on BMT's global capabilities in ship design. Operating in six states in Australia since 2005, BMT has been supporting numerous major defence projects including the air-warfare destroyer design support, amphibious assault ship (LHD) operational safety case and auxiliary tanker double-hull design.

"BMT is proud of the long history we have in supporting Australia's naval capability, drawing on the extensive experience of our in-country experts to harness the knowledge we have gleaned through global ship design programs to ensure that we are delivering the best possible capabilities to the RAN, with platform designs which are fit-for-purpose and able to meet the needs of evolving mission requirements" Trevor Dove said.

Austal Teams with Raytheon and BMT

Austal Australia is teaming with local defence industry leaders BMT and Raytheon Australia to deliver the new Australian Independent Littoral Manoeuvre Vessel, or ILMV, for the Australian Army.

Based on a proven design and carefully tailored for the Australian environment, the proposed Australian ILMV is a world-class, future-ready capability and sovereign solution aligned with the Army's new and complex littoral manoeuvre requirements.

If selected to deliver the Army's LAND 8710-1A program, Raytheon Australia will lead the team to deliver the BMT-designed vessel, which will be built by Austal at the Henderson shipyard in Western Australia.

Austal's Chief Executive Officer, Paddy Gregg, said that the highly-experienced WA-based shipyard team has the capability and capacity to deliver this specific class of ships.

"As one of Australia's largest shipbuilders with an acknowledged world-class operation and decades of Australian Defence Force experience, we have an existing workforce which is trusted to deliver on multiple programs from our Henderson shipyard. Our unique ability to do production design in our shipyard will also minimise risk and cost to the LAND 8710-1A program," said Gregg.

"Our team has a successful track record in delivering ships every three months and this project will be key to providing a continuous shipbuilding program and preserving local jobs in this vital sovereign industry."

Michael Ward, Raytheon Australia's Managing Director, said his team, in collaboration with Austal and BMT, is ready to deliver a fielded and safe littoral manoeuvre capability to the Australian Army.

"Raytheon Australia knows how complex it is to bring a ship design to life — from training to operational testing and evaluation to sea trials and certifications. Our experience has taught us that this is a complex endeavour, requiring unique expertise which we have invested in developing over the past 22 years of delivering large-scale defence projects on time and to budget," Ward said.

"From our work to deliver the Hobart-class destroyers, and our current ever-greening activities on the LAND19 Phase 7B program, we have the relevant expertise, processes, tools and capacity to bring this new class of ships to life for the Australian Army. The Australian ILMV is a resilient and flexible vessel which meets Army's requirements. It is robust and capable, and future ready with clear growth and upgrade opportunities to ensure that our solution supports the Army in motion as they respond to accelerated warfare," he said.

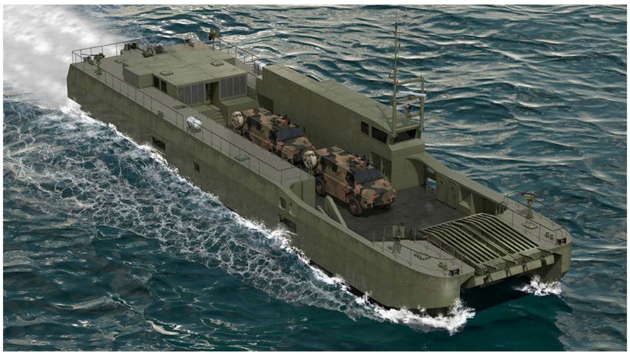
"Importantly, we are ready to start work now to meet Army's timeline and have the experience to work with them to realise the Australian ILMV's full operational capability" Ward said.

BMT Senior Business Development Manager, Trevor Dove, said that the vessel had been custom-made specifically for the Australian environment.

"We are thrilled to be able to offer our customised Australian Independent Littoral Manoeuvre Vessel design, optimising stability, speed, endurance, fuel, stores and accommodation for independent and in-company operations. Our Australian ILMV is based on BMT's existing landing-craft hullform, a mature design in the running for LAND8710-1A," Dove said.

"It is ready to be delivered, with growth margins for a future-ready Army." Dove said that the vessel had been custom-made specifically for the Australian environment.

"Our partnership with Raytheon Australia and Austal brings the experience and pedigree capable of delivering a low-risk solution designed specifically for current and future Australian Army Littoral Manoeuvre requirements."



If selected to deliver the Army's LAND 8710-1A program, Raytheon Australia will lead the team to deliver the BMT-designed vessel, which will be built by Austal at the Henderson shipyard in Western Australia
(Image courtesy BMT)

Serco and Civmec team for LAND8710 Phase 1A

Serco Australia and Civmec have announced a new partnership to deliver the next-generation in amphibious capabilities for the Australian Defence Force (ADF).

A new Joint Venture (JV) company, the Australian Maritime Alliance (AMA), will lead an Australia-wide team in pursuit of the LAND 8710 Phase 1A Program. Over the past year, the design of the new 'Oboe' Littoral Manoeuvre Vessel Medium (LMV-M) has been optimised and refined to meet the needs of the ADF, and now represents the next generation in amphibious capability.

Serco Defence Managing Director, Clint Thomas AM CSC, said that the alliance demonstrates the importance of delivering local industry resilience, facilitating workforce and workload predictability, and providing assured supply-chain access to build a trusted and sustained Australian shipbuilding sector.

"Serco and Civmec share a vision to provide the crucial leadership which the Australian shipbuilding sector requires, signalling an industry-led strategic approach to deliver and support essential sovereign military capabilities and sustainable workshare outcomes," Mr Thomas said.

"With Serco and Civmec's complementary capabilities and shared community values for realising the sustained growth of Australia's Shipbuilding Industry, our alliance is set to deliver proven benefits through uplifting Western Australian industry capabilities, matching Serco's global shipbuilding expertise and reach with Civmec's superlative workforce skills, proven technology and infrastructure capacity."

Serco Australia's program managers, naval architects and engineering specialists have supported naval and Commonwealth maritime operations around Australia, with a proven local supply-chain team and demonstrated ability to support the Army in a true partnership.

Serco has delivered 130 vessels into Commonwealth service and trained many thousands of bridge watchkeepers and seaboat crew for the Royal Australian Navy.

Civmec is a leading integrated, multi-disciplinary construction and engineering services provider to the marine and defence, oil and gas, metal and minerals, and infrastructure sectors, headquartered in Henderson, Western Australia.

Optronics System for Collins-class Submarines

The Royal Australian Navy's Collins-class submarines will be upgraded with a new "cutting-edge optronics system", according to the announcement made by the Defence Minister, the Hon. Peter Dutton MP.

The $381 million dollar investment into optronics will replace an aged technology on the submarines.

The optronics system is expected to help maintain the tactical advantage in intelligence gathering, surveillance, reconnaissance, and anti-surface warfare for the submarines.

The first submarine to undergo the upgrade will be HMAS *Rankin*, while the technology is expected to be operational by 2026. The refitting process is scheduled to start from 2024.

Wärtsilä to Deliver Power and Electrical Solutions for Australian RoRo

Wärtsilä will supply main and auxiliary engines, fuel storage tanks, gas handling equipment and electrical systems for a new ro-ro vessel being built for the Australian operator SeaRoad Shipping. The orders with Wärtsilä were placed in the first quarter of this year.

The 210 m vessel is under construction at the Flensburger Schiffbau-Gesellschaft (FSG) shipyard in Germany. The vessel will operate primarily on LNG fuel. Wärtsilä's depth

Wärtsilä will provide LNG fuel equipment and electrical systems for a new ro-ro vessel being built for Australian operator SeaRoad Shipping (Image courtesy Flensburger Schiffbau-Gesellschaft)

of experience and in-house know-how on LNG systems was a major consideration in the award of the contract.

The vessel will be powered by two Wärtsilä 46DF dual-fuel main engines and three Wärtsilä 20DF dual-fuel auxiliary engines. The fuel gas handling system and LNG tanks are designed with the gas valve units integrated into the tank connection space. This solution is unique to Wärtsilä and reduces the amount of piping needed, facilitating easier installation.

Wärtsilä will deliver almost every electrical system on board. This includes bridge consoles with integrated navigation, redundant dual-gyro compass systems, nautical sensors, external communication systems, power take-in and take-out (PTI/PTO) shaft alternators with multi-drive technology, monitoring and control systems, switchboards, internal communication, and safety systems as well as lighting.

Wärtsilä will design and integrate the entire electrical package, as well as delivering the cable network. The integration project continues a successful partnership between FSG and Wärtsilä in this area lasting more than 25 years.

"We recognise Wärtsilä's strong capabilities in LNG-related technologies, as well as their capabilities in electrical systems, and these solutions are an excellent fit for this vessel," said Philip Maracke, CEO, FSG. "We thank Wärtsilä for its excellent support and cooperation during the various phases of this project."

Matthias Becker, General Manager Sales, Wärtsilä Marine Power, said "We have enjoyed a very positive relationship with both the yard and the owners throughout this project. SeaRoad is committed to sustainable practices, and this very much aligns with our own commitment to the decarbonisation of shipping operations. The solutions selected for this vessel promote these ambitions."

Electrical installation will commence in this year, whilst the bulk of Wärtsilä equipment is scheduled for delivery to the yard during the first half of 2023; the ship is expected to be completed by the end of 2023. The vessel will have 3987 lane metres for various freight units and will sail on Bass Strait between Melbourne and Devonport, Tasmania.

HydroComp PropCad® 2022 Released

HydroComp PropCad 2022 continues to deploy new and expanded features for new and existing users. PropCad 2022 includes HydroComp's best tools for rapidly designing marine propellers, 2D drawings, and 3D CAD models — and a robust suite of supplemental tools to take propeller designs and construction documents to the next level.

Hub and TE Options

PropCad's recent features for trailing edge finishing have been expanded to support user-specified angles for the trailing edge. While primarily used in surface-piercing and cleaver propellers, this new feature also has aesthetic appeal on other round-ear designs.

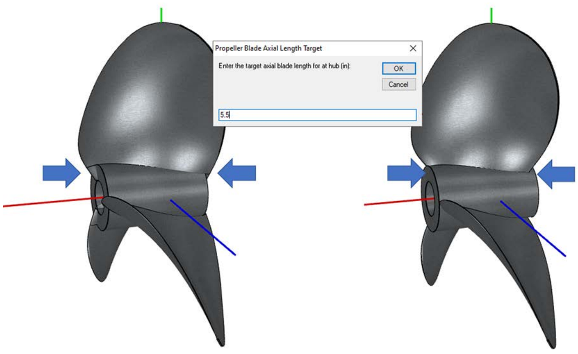
DNV 0039 Rules for Blade Thickness

Many users rely on PropCad's extensive library of propeller blade thickness rules from classification societies across the globe. PropCad's Class Thickness Reports make difficult calculations easy and streamline the approval process. PropCad 2022 now expands upon the existing collection of propeller rules with the addition of the DNV ruleset.

Blade Transform Utilities

Also a first in PropCad 2022 is a new utility to ensure that your blade design fits on to your boss. By allowing users to specify the final axial length of the blade at the intersection, designers, builders, and researchers can be sure their design fits on to the boss.

For additional information, visit www.hydrocompinc.com/solutions/propcad



Specification of blade axial length in PropCad 2022 (Image courtesy Hydrocomp)

Thales Australia and Ocius Advance Autonomous Threat Detection and Surveillance

Thales Australia and Ocius Technologies have entered a Teaming Agreement (announced on 10 May) to advance the development and deployment of a scalable Unmanned Surface Vehicle (USV) capability equipped for anti-submarine warfare (ASW) and surveillance missions — helping to protect Australia's borders.

The Australian-designed and manufactured Blue Sentry autonomous system, comprising a team of Ocius Bluebottle USVs integrated with Thales Australia's new thin-line fibre-optic towed array capability, are deployed from shore to autonomously patrol large areas of Australia's coastline, performing underwater ISR (Intelligence, Surveillance, Reconnaissance) missions for long periods of time at sea, and in extreme weather conditions.

Missions which would have previously required the deployment of crewed assets for many days to complete will be able to be conducted remotely using the Blue Sentry team of autonomous vessels at a significantly reduced cost of coverage.

Benefitting from more than 35 years of investment in sovereign towed array innovation in Australia by Thales, the Royal Australian Navy and DST Group, traditional towed array capability was first deployed on the Collins-class submarines to enable advanced threat detection and classification at sea.

In both form and function, Thales's sovereign thin-line fibre-optic towed array is a miniaturised version of a submarine fibre-optic towed array, enabling autonomous detection, classification and localisation of craft on the surface or below which generate acoustic noise or produce acoustic reflections. The Blue Sentry system's autonomous detection capabilities also enable covert communication to allies below the surface using long-range low-frequency underwater communications. The newly-developed thin-line towed array is designed, developed and manufactured at Thales Australia's Acoustics Centre of Excellence at Rydalmere in New South Wales.

Thales has been working collaboratively with Ocius since 2013 on the role of the USV in ASW — the Bluebottle is a standout USV platform for long-term maritime mission endurance.

Chris Jenkins, Chief Executive, Thales Australia and New Zealand, said "The detection and classification of modern undersea threats at tactically useful ranges requires a highly-optimised balance between the sensor and the platform to ensure success in the most challenging of acoustic environments. The specialist teams within Ocius and Thales Australia have worked to bring their respective capabilities together into the Australian designed and manufactured Blue Sentry product and we look forward to taking it into the future."

Robert Dane, Founder and Chief Executive of Ocius Technology, said "If you can imagine a map of Australia with Blue Sentry Bluebottles scattered about the Exclusive Economic Zone where illegal vessels know if they enter our waters, they will get stung. This is not only Australian sovereign capability it is the best; this is the quietest and most capable persistent USV platform combined with the best array."

Australian Businesses Contracted to support First Batch of three Hunter-class Frigates

Businesses around Australia will manufacture, assemble and supply thousands of valves for the first batch of three Hunter-class frigates, building Australian industry capability which will support continuous naval shipbuilding for future defence projects.

Working with the global independent valve company Score and the Commonwealth, BAE Systems has secured a firm commitment from Score that a significant amount of value ($26 million) and contracts will flow through the Australian supply chain.

Twelve companies from five States will be subcontracted by Score to part manufacture, supply and assemble more than 300 different types of whole-ship valves.

BAE Systems Australia CEO, Ben Hudson, said "We are committed to maximising opportunities for Australian businesses and thus creating Australian jobs, so we're delighted that a significant portion of valve assembly and testing will be done in Australia, by Australians.

"Securing such a significant portion of the valves scope for Australian companies is testament to our teams' collaboration with industry and the Commonwealth.

"As the Hunter program matures towards a second batch of Hunter-class frigates, there will be opportunities for other Australian businesses to join the valves supply chain.

"Growing Australian industry capability is essential to ensure that we support Australia's continuous naval shipbuilding strategy for future generations."

Score Australasia Director, Keith Simpson, said "We are committed to driving sovereign capability by increasing Australian manufacturing content and adding value to the local economy through the entire supply chain.

"This is a huge opportunity for Australian manufacturing, and we look forward to working with local manufacturers, both current and new, in achieving the best possible outcomes for the Hunter program and for Australian industry."

There are 305 types of valves in each Hunter-class frigate, and 5273 valves per ship. The largest valves are upwards of 400 mm bore size, while the smallest is 5 mm. Valves are spread throughout the warship in many different subsystems.

Australia's Hunter-class frigate
(Image courtesy BAE Systems)

HMAS *Toowoomba* was returned to the water at Henderson, Western Australia, on 12 April 2022 after an 18-month maintenance period.

Toowoomba is the fifth of the Navy's eight Anzac-class frigates to exit the dry production phase of the Anzac Midlife Capability Assurance Program (AMCAP).

This program involves significant out-of-water maintenance and upgrades to the overall capability of the Anzac class.

The ship is scheduled to return to an operational cycle at the end of this year (RAN photograph)

The Armidale-class patrol boat HMAS *Maitland* was decommissioned at the Larraykeyah Defence Precinct in Darwin on 28 April 2022. The second of the class to be decommissioned, *Maitland* is being demilitarised before being taken to Austal's facility at Henderson for conversion into an autonomous test vessel by Austal and L3Harris. Trials under the RAN's Patrol Boat Autonomy Trial will begin in late 2023 or early 2024 (Department of Defence photograph)

EDUCATION NEWS

UNSW Canberra

Courses

We have passed a historic day with the first classes of our inaugural courses in the new Naval Architecture program being taught: Building the Fleet and Naval Architecture Practice, Hydrostatics and Stability. Indeed, the first semester is nearing its conclusion and the first exams are now being set. While some activities and lectures began online due to COVID-19, we are now back fully face-to-face. We trust that being face-to-face continues as a reflection of our new "normal".

Field Trips

We have also conducted our first field trip, including the conduct of an inclining experiment on the Sydney Heritage Fleet's tug HTS 502 *Currawong*; a visit to Garden Island Naval Dockyard hosted by Thales, including trips to the dock floor and pump room; a visit to classification society Lloyd's Register, and a visit to naval architecture consultancy Incat Crowther. All those that assisted and hosted us are thanked — Phil Helmore and Tim Drinkwater (SHF), Murray Makin and James Johnston (Thales), Graeme Brown (LR), and Matt Lyon and Henry Morgan (IC).

The inclining experiment on *Currawong* was successful, with the R^2 value of the line fitting our movement data being 0.9999, and the final result showing a difference of 0.4% in the displacement of the lightship from the last previous inclining experiment (for survey) in 2017. A good, no, an excellent result! Phil is especially thanked, but it is noted that he has done it a few times before with David Lyons and previous student cohorts from UNSW Sydney. Perhaps this brings back memories for some of the readership as past graduates of the UNSW program during Phil and David's tenures.

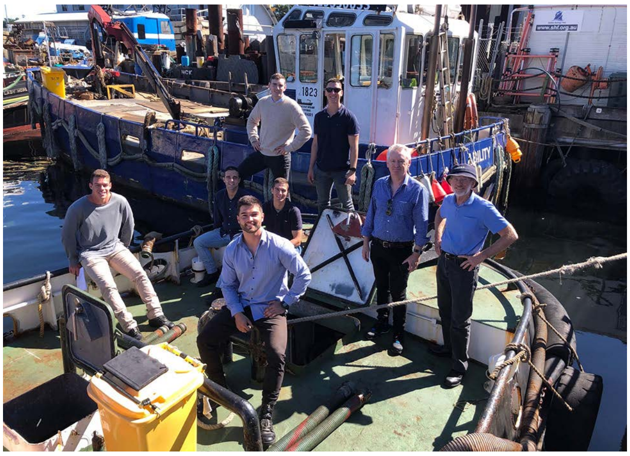
A further field trip will see us attending the Indo Pacific 2022 International Maritime Exposition and the International Maritime Conference in May.

Staff

The last piece of news is that Dr Prasanta Sahoo has joined our teaching team, arriving back in Australia in April. He comes to us by way of the Florida Institute of Technology which followed a significant prior period at the Australian Maritime College. We warmly welcome him and look forward to his contributions.

Please do not hesitate to contact me via email (w.smith@unsw.edu.au, or navarch@adfa.edu.au) or by other means if you have any questions or would like to contribute to our enterprise.

A/Prof. Warren Smith
Naval Architecture Program Coordinator
School of Engineering and IT
UNSW Canberra



The inclining crew on *Currawong*
Warren Smith (R) and David Lyons (2nd from R)
(Photo Phil Helmore)

Morning tea in the canteen at the SHF
(Photo courtesy Warren Smith)

Currawong (502) and *Bronzewing* (501) alongside at the Sydney Heritage Fleet on 19 April
(Photo Phil Helmore)

HTS *Currawong*

Bronzewing (HTS 501) and *Currawong* (HTS 502) were two of the four 50 ft (15.2 m) Bronzewing-class small harbour tugs (HTS) designed by John Boulton and built by Stannard Bros Slipway and Engineering at Berrys Bay for the Royal Australian Navy. They were handed over to the Sydney Heritage fleet in 2012 and put into survey for SHF operations with the help of stability books worked up by Mori Flapan on the basis of inclining experiments carried out on the vessels by the Year 3 students from UNSW Sydney in 2012 and 2017 respectively. They are now used by the SHF to assist manoeuvring their vessels in the harbour.

HTS 503 was also bult by Stannard Bros Slipway and Engineering and, after service in the RAN, was given to New Guinea in 1974.

Mollymauk (HTS 504) was built by Perrin Engineering in Brisbane and, after leaving service in the RAN, her whereabouts are unknown.

Phil Helmore

BAE Systems Australia and Ai Group's Novel Approach to Future Careers

It was announced on 13 April that BAE Systems Australia and the employer association Ai Group will launch the nation's first degree apprenticeship program at the start of the 2023 academic year. The program will be delivered by Victoria University in Melbourne.

The degree apprentice program aims to dramatically increase skilled participation in major defence projects and has already received the endorsement of major employers in the sector.

BAE Systems Australia employs more than 200 graduates, interns and apprentices annually across the company's national defence and security business. The company is also in the Australian Association of Graduate Employers top 100.

BAE Systems, Ai Group and Victoria University will pilot an integrated learning program which will include on-the-job training and academic studies focused on a degree in Systems Engineering. Course specifications were developed in consultation with Apprenticeships Victoria and Engineers Australia.

The model is similar to a program which BAE Systems currently operates in the United Kingdom with the endorsement of the UK Government, industry leading employers and academic partners.

This program has successfully operated degree apprenticeships since 2015 where UK students are paid to work as apprentice employees and study at the same time.

BAE Systems and Ai Group are engaged and collaborating with employers to define shared requirements and outcomes. These companies include Dassault Systems, Advanced Fibre Cluster, Air Radiators, Navantia Australia, Memko and Systra.

The wider industry group will work with Victoria University to finalise the course ahead of calling for applications for between 20–40 students for the 2023 academic year. Success would see the program broadened to include a variety of engineering degrees.

BAE Systems Australia's Chief People Officer, Danielle Mesa, said "BAE Systems Australia will need hundreds, possibly thousands of engineers in the next three decades as major defence projects ramp up across the nation.

"The education sector is changing, technology is changing, and industry needs to be more involved. So, it's important to look at new and novel ways to influence the national curriculum so that we can provide alternatives for students who might otherwise not consider tertiary studies."

Executive Director of Ai Group's Centre for Education and Training, Megan Lilly, said "Ai Group believes that this approach is one which could benefit many employers and many future employees. We think that the apprenticeship model is one that is suitable for a range of occupations, not just trades.

"This pilot provides a great opportunity to test the model for professional occupations."

THE INTERNET

RINA Webcasts

RINA has set up a YouTube channel and RINA webcasts can be viewed there. The RINA YouTube channel is at https://www.youtube.com/channel/UChb1sfHbWfQmG-iwpp_QGJg/videos

Bookmark this website and keep your eye on it!

Video recordings of presentations should be sent to Ms Rusne Ramonaite <rramonaite@rina.org.uk> at RINA HQ for uploading.

Branch and Section presentations are shown second from right in the top line. Click on *View full Playlist* to see the list, or click on the search function to the right of *About* in the menu bar, type the title of the presentation you are looking for (or at least the first few words thereof) and press Enter.

NSW Section Webcast

The NSW Section webcast recorded and uploaded within the last three months is:

- *Seakeeping of a Surfaced Underwater Vehicle,* presented by Mathieu Courdier, PhD Candidate, Australian Maritime College, as a webinar hosted by RINA on 6 April 2022.

Phil Helmore

THE PROFESSION

Changes to NSCV Part C1

On 21 February AMSA called for comment on proposed changes to NSCV Part C1, which contains standards for wheelhouse visibility, escape, accommodation and personal safety.

The proposed changes include:

- meeting disability accessibility standards;
- improved standards for escape routes, escape lighting and signage;
- clarified definitions of 'special working decks' and 'working decks';
- further risk management associated with a person falling overboard and the recovery of persons overboard, by improving technology requirements and inclusion of a 'no-climb' zone;
- a minor relaxation of when toilet and ship sanitation facilities must be fitted;
- improved ventilation requirements;
- improved safety requirements for pilot vessels;
- changes to gangway requirements; and
- alignment of some requirements with already adopted national and international legislation and standards.

It is proposed that the amended NSCV Part C1 will only apply to newly constructed vessels and vessels which undergo modifications to the arrangement, accommodation, and personal safety aspects of the vessel.

Following consultation (which closed on 24 April), it is proposed that the new standard will come into effect on 1 January 2023 with a transition period of two years.

AMSA News, 21 February 2022

AMSA's Survey Matters

Survey Matters is AMSA's e-Newsletter relating to domestic commercial vessel (DCV) survey and is published approximately six times per year. You can request placement on the mailing list by emailing DCV Survey <dcvsurvey@amsa.gov.au>. The e-Newsletters are now also available online at https://www.amsa.gov.au/news-community/newsletters#collapseArea612

Items included in the March 2022 e-Newsletter included:

- Correct and incorrect use of conditions
- Inclining experiment methods
- NSCV C7A safety equipment requirements
- LPG Installation case study
- B extended operations
- N & C flag requirements
- Testing and servicing of fire suppression equipment
- Have your say: NSCV C1 consultation
- National Law review
- Construction barge safety campaign
- Exemption 6 has been updated

The article on *Inclining Experiment Methods* is reproduced below.

Phil Helmore

Inclining Experiment Methods

The National Law permits the use of equivalent and alternate solutions for meeting the standards. This may permit use of alternate inclining experiment methods, on a case-by-case basis. AMSA has, for example, allowed some smaller vessels to apply the ASTM F3052-14 and SNAME Technical Bulletin 9-1 methods for air inclinings.

An article entitled *Scaling the Wall: Inclining Experiment Analysis on Vessels with Chines, Hull Discontinuities or Asymmetry* was recently published by Richard Dunworth, Naval Architect, Department of Defence, in the November 2021 issue of *The Australian Naval Architect*. This article introduced and discussed the merits of a KN-based inclining experiment method which may deliver more-accurate inclining results for asymmetrical hull forms and vessels where waterplane-area changes during inclining, such as RIBs.

Surveyors who wish to apply this method for vessels which are difficult to incline in a traditional manner, or any other non-conventional method such as air inclining, can apply for an equivalent means of compliance using AMSA Form 649.

If you are considering applying for an equivalent solution, then please ensure that you are familiar with the method which you intend to apply and can demonstrate that the method will be at least as effective as the solution it replaces. For example, with the KN method:

- KN values must be available and accurate for small intervals of heel; 5-degree intervals such as traditionally used in a stability assessment are not sufficient; and
- procedures must ensure that the vessel is free to heel and will not hang on lines, touch bottom or similar, noting that the method does not appear to have a mechanism to identify these types of issues, particularly because results may be non-linear as waterplane area changes.

Survey Matters, March 2022

THE WALTER ATKINSON AWARD

A PRIZE FOR THE BEST WRITTEN PAPER PRESENTED TO A RINA FORUM IN AUSTRALIA IN 2021-22

Have you presented a written paper at a RINA Section meeting this year? If it is a really good paper you may be eligible for the highly prestigious Walter Atkinson Award named after one of the founders of the Australian Division.

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

The Award comprises three components:

- an engraved trophy or medal.
- a certificate for each author.
- a ticket to the event at which the award is to be presented.

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

A nomination must be a written paper, not simply a presentation, first presented either at a RINA Section technical meeting or RINA-supported conference in Australia, or first published in a RINA-supported publication in Australia (e.g. *The ANA*). Papers presented to the Indo-Pacific 2022 IMC are eligible for the Award if nominated, while papers published in *The ANA* are automatically considered to have been nominated.

All authors are eligible — Australian or overseas, members or non-members. Papers by multiple authors are eligible.

Visual presentations are not eligible unless they reflect the content of the presenter's written paper. Nominations of papers published in the period 1 July 2021 to 30 June 2022 must be received by the Secretary no later than 22 July 2022.

For further information refer to the Division's Walter Atkinson Award page on the RINA web-site or contact the Secretary.

Mail PO Box 462, Jamison Centre, ACT 2614
Email rinaaustraliandivision@iinet.net.au or ausdiv@rina.org.uk
Phone 0403 221 631

MEMBERSHIP

Australian Division Council

The Council of the Australian Division of RINA met on the afternoon of Tuesday 17 March 2022 by Zoom conference under the chairmanship of our outgoing President, Gordon MacDonald, in Airlie Beach with links to Cairns, Sydney, Canberra, Melbourne, Launceston, Adelaide and Perth. As the meeting was the week before the Division's Annual General Meeting, it was the last before the changeover of Council membership and the President thanked retiring members for their service. Council noted that John Butler had been appointed to a vacancy since Council's previous meeting and that Jim Black, as incoming Division President, was in attendance.

Among the items discussed were:

Vacancies — Vice President and Council Member

Council agreed that these vacancies should be filled through a proposal to be developed prior to the next (June) Council meeting.

Independent Review of Domestic Commercial Vessels Legislative Framework

Council approved in-principle a draft of the Division's submission, which was subsequently lodged following consultation with members following the meeting.

Formation of Improvement Committee

Taking into account the imminence of changes to membership of Council, initiation of this Committee was held over for action by the new Council, having been recommended by a working group which looked into the Division's policy direction in relation to naval shipbuilding.

Visit to Division by Chief Executive

Council noted that Chris Boyd would be attending Indo Pacific 2022 IMC in Sydney on 10–12 May to deliver a keynote address. In the week after the conference he would visit Adelaide, Launceston and Perth for a series of meetings with industry and members coordinated by the relevant Sections.

Registration of Division with Australian Charities and Not-for Profits Commission

Council received a report that registration had now been completed and the related tax concessions had been granted.

Council Meeting — London 19 January 2022

A report was received from the Division's attendees at the meeting. The main developments reported were:

- the proposal for Prof. Cat Savage to be elected as the Institution's President at the Annual General Meeting on 12 May;
- progress in the implementation of the digital steering group's recommendations which should be apparent to members in the coming months;
- the Institution has become a knowledge partner with Mærsk McKinney Møller Center for Zero Carbon Shipping; and
- substantial increase in readership of the IJME following changes to the editorial structure and new publishing arrangements with University Buckingham Press.

Government Initiatives

The Secretary reported that the Senate Economic References Committee inquiry into *Sovereign Naval Shipbuilding Capability* had issued a second interim report in February. As no final report was expected before the Federal election was called, the inquiry may lapse upon the dissolution of the current parliament. [*The final report was published as we go to press* — Ed.]

Renewed Agreement with University of Tasmania — AMC

During Council's consideration of correspondence, the Secretary reported that AMC had agreed to reviving the expired RINA–AMC agreement relating, in particular, to the election of AMC maritime engineering students as RINA Student Members.

Next Meeting

Council provisionally agreed to hold its next meeting on Tuesday 14 June 2022 at 1400 h Eastern (1200 h Western) Standard Time.

The draft minutes of the meeting have been circulated to Council members and are available to other members by request.

Visit by Chief Executive

As we go to press, the Chief Executive is continuing his visit following Indo Pacific 2022 in Sydney.

I can report that his keynote speech to the IMC covered the key position of our profession in ship design, construction and operation, together with developments both within the Institution and initiatives taken by the Division in an Australian context. The speech was well received.

In association with Indo Pacific, Chris and I also held important meetings with senior executives of Department of Defence, Naval Shipbuilding College and ASC. These meetings were largely to reinforce the messages of his keynote address, in particular the role of RINA as an honest broker in relation to problems in maritime engineering and the recruitment of secondary students into STEM courses, particularly maritime engineering. These meetings received welcoming responses.

His visit will conclude with visits to Adelaide, Launceston and Perth/Fremantle in which he will visit industry and educational participants/facilities as well as meet as many members as possible.

Bob Campbell Prize at Indo Pacific 2022 IMC

The Bob Campbell Prize, which is for the best paper and presentation at the IMC, is awarded in accordance with a bequest by Bob Campbell, an early chair of the IMC Organising Committee.

It was awarded for the second time at this year's IMC. The winner announced at the closing ceremony of the IMC was Nigel Doyle for his paper *Nuclear Propulsion is a Game Changer. What are the New Rules?*. Due to the closeness of the final scores, the judges also awarded honourable mentions to Levi Catton for *Nav Archs (You Gotta) Fight for Your Right (To Margins)!* and Rachel Horne for *Autonomous*

Vessel Regulation in Australia: A Review of the Existing Maritime Regulatory Framework and the Impact of the new Australian Code of Practice.

Having been tasked with coordinating the shortlisting and judging process, I would like to express my appreciation to Dan Curtis, Gregor MacFarlane, Alan Muir, Karl Slater, Warren Smith, Mike Squires and Lily Webster for volunteering to assist in undertaking this time-consuming process.

Rob Gehling
Secretary
Email ausdiv@rina.org.uk
Phone 0403 221 631

Changed contact Details?

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

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

RINA London		hq@rina.org.uk
Australian Div.		rinaaustraliandivision@iinet.net.au
Section		
	ACT	rinaact@gmail.com
	NSW	rinansw@gmail.com
	Qld	rinaqlddiv@gmail.com
	SA/NT	rinasantdiv@gmail.com
	Tas	tassec@rina.org.uk
	Vic	vicsec@rina.org.uk
	WA	wa@rina.org.uk

Phil Helmore

VALE

Jared Lee Mouldey

Known by his close mates as Aussie, Jared was a respected member of our unique community, taken from us well before his time. He passed away peacefully at home at Rocky Creek on 21 April 2022, after a short battle with a very aggressive form of cancer. Born in 1983, he grew up on the Atherton Tableland, learning to sail with the Tinaroo Sailing Club at the age of 12, and gaining a passion for boats. After graduating from high school in Atherton, he studied naval architecture between 2001 and 2005 at the Australian Maritime College in Tasmania, where he built a very close group of friends. He was a Chartered Engineer, MRINA, and will be missed by his close mates, as well as all those he befriended and shared laughs with on his journey through the industry.

As well as his thirst for a beer, and his laugh, professionally Jared will be remembered for his detailed eye, and astute engineering skills. In his most recent role, which he was loving before illness struck, he was based in Hobart as Superintendent with Damen, during the warranty period of *Nuyina*.

Prior to that, he spent some time broadening his skills in Queensland, with time at Field Engineers, honing his mechanical engineering skills on heavy machinery; McElligotts, supporting the application and inspection of protective coating systems, and demonstrated his knowledge of materials as an estimator at OneSteel.

Jared was not only passionate about the industry, but also building the industry near his hometown. Growing up in Atherton, not far from Cairns, he was very excited to grow opportunities for naval architecture and naval architects in the area. He started his career here with Norship, supporting their key clients, and returned later in his career to launch his startup naval architecture consultancy, Boatlab. Perhaps before his time, or an initiator of the most recent movement toward Cairns by Austal, he would be very happy with the build-up in Cairns.

Jared 'Aussie' Mouldey

As a naval architect, Jared spent time as an engineering manager with Army Marine, HSPO (CASG), supporting the Hydrographic Survey Fleet, Special Air Drop RHIB, LARC, and LCH. He also worked for Serco, as both a senior engineer for the Pacific Patrol Boats, and technical project manager for the ACPBs and, specifically, the structural remediation program.

Jared also had a long stint with Austal, where he worked on the Cape-class patrol boat, 20 m high-speed wind-farm work boat, the US Navy joint high-speed vessel (JHSV), and with the Austal Service Department in its formative years.

He will be missed by us all.

Jesse Millar

NAVAL ARCHITECTS ON THE MOVE

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

Nathan Grace has moved on from TEK-Ocean Energy Services and has taken up the position of Senior Project Manager with Hydro Tasmania in Hobart.

John Hayes has moved on from DOF Subsea and has taken up the position of Turnaround Coordinator with Shell in Perth.

Chris Hughes has moved on from Lloyd's Register and has taken up the position of Decarbonisation Specialist with Cargill in Geneva, Switzerland.

Nick Hutchins continues to work part time for Team New Zealand for the America's Cup (although that will ramp up as time draws closer to the next challenge in 2024), and has also set up a new company, FlowDeck, in Auckland, to provide a new CFD software tool which would potentially make CFD more widely accessible, cheaper and easier to use in the industry.

Mark Korsten has founded a new company, AUKUSJobs.com, which provides a platform for jobseekers to mathematically encode their skills and experience to make them instantly findable for defence industry companies [*see www.aukusjobs.com* — Ed.]

Andy McNeill has retired after completing the last decade with Lloyd's Register as a Senior Marine Surveyor.

Rozetta Payne has moved on within the Department of Defence and has taken up the position of Maritime Mine Warfare Patrol and Geospatial Domain Director with Navy Engineering Branch in Sydney.

Prem Shankar moved to Australia in December 2020, and registered and started his own business TheNavalArch (a naval architecture consultancy and e-commerce platform) in Melbourne in April 2021.

Mitchell Stone has moved on within McDermott International and has taken up the position of Installation Manager on the Icthys Phase 2A project in Perth.

Harry Stronach continues as a part-owner of Able Ships, based in Akaroa, NZ, mainly involved in survey work. Friends can find out more at https://www.ableships.co.nz/.

Dash Swift has moved on within Subsea 7 and has taken up the position of Operations Manager in Perth.

Samantha Tait has moved on from Systematiq and has taken up the position of Systems and Safety Assurance Manager with Metro Trains, and continues consulting as Tusk Engineering, in Melbourne.

Longbin Tao has moved on from Newcastle University, UK, and has taken up the position of Professor of Offshore Engineering at the University of Strathclyde in Glasgow.

Elliot Thompson has moved on within DNV and has taken up the position of Senior Surveyor in Sydney.

Brendan Thornton has moved on from Naval Group and has taken up the position of Senior Naval Architect with Australian Maritime Technologies in Melbourne.

Michael Tiller has moved on from Technical Panels Co. and has taken up the position of General Manager of TPSV, an RMA Group company, in Brisbane.

Todd Tippet has moved on from the Royal Australian Navy and has taken up the position of Director Patrol Boat Systems Program Office, Capability Acquisition and Sustainment Group with the Department of Defence in Darwin.

Shaun Yong has formed his own company and has taken up the position of Marketing Director of ERA Realty Network in Singapore.

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

Phil Helmore

Cruising Returns to Sydney Harbour

The Australian Government lifted its Biosecurity Determination to allow cruising to resume in Australian waters from 17 April 2022.

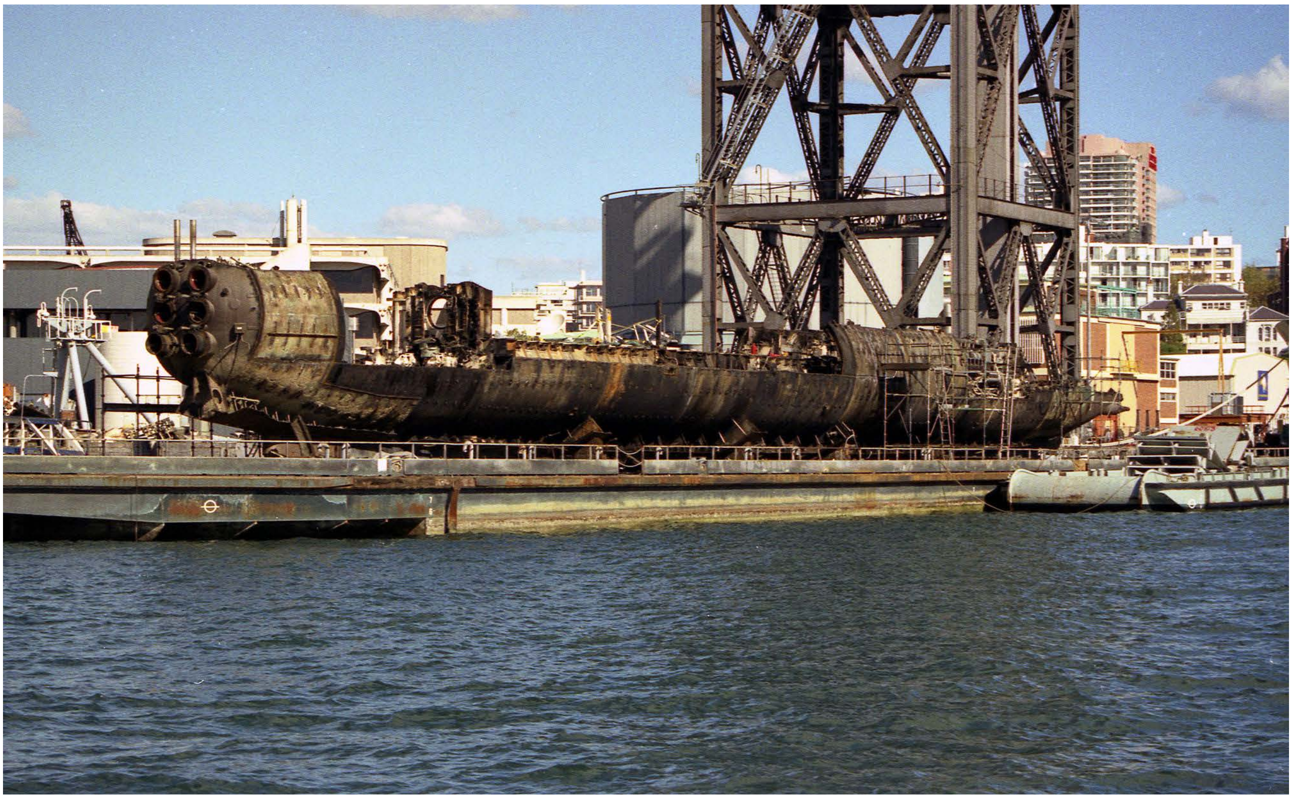
As part of preparations for the return of passenger cruise ships to Sydney Harbour, the Port Authority of NSW worked in close partnership with the Federal Government, NSW and other State Governments as well as cruise industry operators to plan for the safe resumption of cruising once the ban is lifted.

The priority for all parties involved with the resumption of cruising has been to ensure that strong safeguards are in place to mitigate the risk of COVID-19, and safety protocols to ensure that is the case have been developed. P&O Cruises Australia's *Pacific Explorer* returned to Sydney on Monday 18 April 2022. After an absence of two years, *Pacific Explorer* made the voyage back to Sydney from Europe. The ship will berth at several locations around the harbour during her six-week stay, including the Overseas Passenger Terminal in Circular Quay and White Bay facilities in Balmain. *Pacific Explorer*'s stay in Sydney Harbour will allow the cruise line to train crew, conduct operational manoeuvres, prepare for 'work up' or test voyages, the first passenger voyage, and inner-harbour activities.

Port Authority of NSW website

Pacific Explorer at anchor in Athol Bight on 7 May 2022
(Photo John Jeremy)

Holbrook, a town in southern New South Wales, is a favourite rest stop on the road between Melbourne and Sydney. To the surprise of many, there appears to be a complete submarine in an attractive park, complete with an excellent museum and café. It is actually the bow, stern, casing and fin of the Oberon-class submarine HMAS *Otway* (1968–94) set up on a concrete hull as part of the town's tribute to submariners — a story well worth exploring during a stop in the town
(Photo John Jeremy)



Holbrook obtained the parts of HMAS *Otway* when she was broken up by Sims Metal at Garden Island in Sydney in 1996. The *Otway* submarine memorial was dedicated on 7 June 1997
(Photo John Jeremy)

Ranger-class yachts *Vanity* (A2) and *Cherub* (A4) enjoying a fresh breeze during a sprint event conducted on Sydney Harbour recently by the Sydney Amateur Sailing Club. The club is celebrating its sesquicentenary this year
(Photo John Jeremy)