Submission No 16

EMISSION FREE MODES OF PUBLIC TRANSPORT

Organisation: Harwood Marine

Date Received: 9 July 2022

To: Committee on Transport and Infrastructure- Emission Free Modes of Public transport
From: Ross Roberts
Date: 9.7.2022

To the Committee on Transport and Infrastructure.

We have been working on our GILLS Technology for 11 years as part of our long-standing commitment to innovation in and supporting the shipping industry in Australia and globally to become more sustainable. **GILLS** stands for **G**as **I**njected **L**iquid **L**ubrication **S**ystem, and reduces the energy loss created by hull friction in the water, helping vessels to utilize less resources and emit less pollutants whether they are fossil fuel propelled or green technology propelled.

This technology is significant for fossil fueled vessels in their transition to lowering their carbon footprint, as mandated by the International Maritime Organization (**IMO**), which by association captures all Australian large vessels as they transit through this jurisdiction and must abide by these standards.

It has and will create new jobs in the NSW marine industry, in both regional and metropolitan areas, as well as manufacturing capability. Our shipyard has a manufacturing facility capable of making, with one input to be manufactured in overseas, and fitting the prototype technology, and to test this in the real marine environment. We believe that the increased demand for services, as a result of this innovation will also increase opportunities for other companies in the region, who have specialized equipment to reduce manufacturing costs.

Confirming the technology works in the marine environment and its quantifiable benefits in terms of reduction in CO2 biofouling and fuel savings will lead to increased demand and expand the marine industry in Australia to meet this demand here and globally.

The solution reduces fuel usage, global emissions and biofouling (marine growth) from ships and marine vessels by reducing friction of the hull when passing through the water.

The objective of our current shipbuilding and research collaboration, with AusIndustry, Sealink, AMC (Australian Maritime College) and UTAS (University of Tasmania), Macquarie University and Harwood Marine at our Shipyard near Yamba Northern NSW, is to confirm the previous R&D trials, and quantify the emission reduction component and the fuel reduction relationships as well as biofouling (which includes barnacles and weed build-up on a ship's hull surface)

We have invested in this solution over a number of years and without any significant Government support, but now, thanks to AusIndustry, have the ability to fit the prototype to a Sealink Catamaran Ferry vessel we are building in our shipyard, and to operate the research, and testing with a control vessel, to understand the full scope of the benefits to vessels in a real marine environment, which is challenging to replicate without full size trials.

Variables like wind, weather, tide and scales of influence are impossible to accurately replicate in a research laboratory.

We expect this testing period to be completed over 12 months, and on confirmation of the benefits, will allow us to engage in contracts with larger marine fleet providers in Australia, such as Sealink, to manufacture and fit their fleet size of 100 boats used throughout Australia for tourism and transport.

162-164 River Road
PO Box 96 HARWOOD NSW 2465
Email: [redacted]

Tel: + 61 (0) 2 6646 4222
Fax: + 61 (0) 2 6646 4472
Website: www.harwoodmarine.com.au

We believe this work could create $X millions of dollars in revenue for Harwood Marine and local economy, as well as many additional jobs at our shipyard.

Completion of a fleet and vessel size like Sealink would then allow us to further engage with Australian large vessel operators, like Rio Tinto, Fortescue Metals, BHP etc, as Australian bulk shipping is 5th largest shipping fleet by volume in the world.

We have already been in discussions with Rio Tinto, to scope fitting their fleets in the future subject to commercialization of the technology.

Global emissions from ships and marine vessels is a serious problem contributing to pollution around the world. One large ship is the equivalent to the pollution from 50,000 cars. The 10 largest ships in the world contribute more emission pollution than all the cars in the world. Also hull biofouling (barnacles and marine growth) which enters the marine environment by being dislodged from ship's hull with extremely toxic antifouling paints is also a significant environmental pollutant in the world's oceans. This practice to maintain boats and ships regularly all around the world emits toxins directly into our marine environments and the associated food chains.

The international Maritime Organization has mandated that every ship will need to reduce their impact on the global environment by 2023.

Burning ships bunker fuel, creates 90% of the worlds sulphur emissions, which is highly detrimental to our atmosphere and air quality and can cause respiratory illness, haze, acid rain and crop failures.

At the end of 2020 there was 62,100 commercial ships in the world with a combined DWT (cargo carry capacity) total of 2.033 Billion Tonnes.

Hull friction is the largest energy loss on a ship or boat, and has been the subject of much research over the years, and air lubrication, such as our GILLS innovation, is seen as one of the most promising developments to reduce this problem.

The media release "2020 big shipping shake up" link below, identified that burning ship's bunker fuel produces about 90% of global sulphur emissions.
https://www.visualcapitalist.com/imo-2020-the-big-shipping-shake-up

If we can reduce fuel used in ships and boats by 10% with our GILLS Technology, then we can reduce global fossil fuel usage and GHG emissions, including the world's sulfur emissions, by a significant 9%.
The solution that we have been working on for many years is to reduce the energy required to propel a ship or vessel through the water by a technology that reduces the friction of the hull.
The GILLS solution reduces the energy required for vessels to propel through the water, whether they be fossil fuel and green technology propelled. The conversion of the existing large vessels globally to alternative green power solutions may take many years, and our solution, which can be retrofitted to existing vessels, can play a significant role in reducing the fuel used and greenhouse gases expelled by the ship's engines, and help vessel operators to comply by the mandated codes and timelines of the IMO.
Our solution is both unique in its technology and is also unique in its ability to be retrofitted to vessel's hulls.
No other competitor globally has developed this technology and retrofitting capability, and our solution is protected by patents globally.

Our technology is innovative in that micro bubbles are created using Kelvin Helmholtz Instability (KHI), which is a naturally occurring technology, to create low energy micro bubbles that stay in suspension in the water coating the ship's hull.

Using air lubrication is a natural way of reducing hull frictional drag, and is also toxic to marine growth, so reduces the use of toxic antifouling paints and coatings. This discarded biofouling from paints enters the food chain of the marine environment around the world, and as yet is unquantified.

Regardless how the fuel, engines or propulsion systems or a ship or marine vessel are modified, the hull resistance through the water remains the largest energy loss and requires more power to overcome this loss. This increases the Global Greenhouse Gas emissions accordingly.

The system involves specifically the manufacturing of air mixing chambers, Gills vortex generators, as well as various hardware of piping and manifolds. Then this all gets installed at a shipyard/slipway or drydock. This involves mechanical construction in steel, aluminum or fiberglass, and has electronic monitoring in larger vessels.

Most countries in the world have their own shipping and marine transport and recreation operations so this is a global issue contributing to the degradation of the world's environment.
The opportunity is enormous as there are many ships, ferries, and boats, that will be non-compliant due to their environmental performance index, and the new rules based on the Paris climate accord. The IMO rules are endorsed to reduce the sulphur content of fuels, CO2 emissions and greenhouse gas reductions, the transmission of biological matter from different locations, as well as the various effects of Climate change from global warming.
We at Harwood Marine have been in business for 30 years and specialize in Shipbuilding, ship repair and developing green marine technology.
In 2010, we built the Oceanlinx wave generator for BHP at our Harwood Shipyard in record time and on budget.

We have published research data overseas, as the technology was developed in Japan, but want to begin commercialisation of the product on smaller vessels and believed conducting research and trials in Australia would accelerate this vision.
We are planning to test the prototype on Catamarans and ferries which is a very large commercial market in NSW, Australia and elsewhere, to confirm the results.

Research paper of the technology- This paper is peer reviewed by the prestigious Elsevier publication Science Direct and explains the research and trials of the WAIP Technology, which is the patented name of the GILLS Technology which is the commercial description- **G**as Injected **L**iquid **L**ubrication **S**ystem.

https://www.sciencedirect.com/science/article/pii/S0029801814004314

Our technology is protected under a number of Intellectual property rights – The technology was invented by Professor Yoshiaki Takahashi from Tokyo University former student of Takeo Inui inventor of the modern bulbous bow in 1963, now found on most large ships. The patents are held in Australia by GILLS WAIP Pty Ltd and exclusively? licenced to Harwood Marine for commercialization.

162-164 River Road
PO Box 96 HARWOOD NSW 2465
Email [redacted]

Tel: + 61 (0) 2 6646 4222
Fax: + 61 (0) 2 6646 4472
Website: www.harwoodmarine.com.au

Harwood Martine is one of the largest shipyards in Australia, both by area of land and lifting capacity of ships.

We are currently investing $3 Million in a new travelift and infrastructure that will allow us to lift many more vessels out of the water, and this will accelerate the installation possibilities.

We already have a number of domestic and international clientele for business growth.
The South pacific will also be a target market to lure vessels to our NSW Shipyard.

We have already gained International "Approval in Principle" from the French Society Bureau Veritas for the technology and we already work closely with these International Classification Societies (IACS International Association of Class Societies) and these organizations are the certifying bodies for Insurers and government authorities, so ships can trade internationally. Compliance in shipping is strictly regulated and we will work closely with the appropriate authorities as required.

There is always risk in any business but developing green technology to help save the global environment, is a very worthwhile pursuit.

Yours faithfully,

[redacted]

Harwood Marine

Ross Roberts - Chairman

p: +61 2 6646 4222 f : +61 2 6646 4472

m: [redacted] e: [redacted]

a: 163-164 River Rd, Harwood Is, NSW, 2465

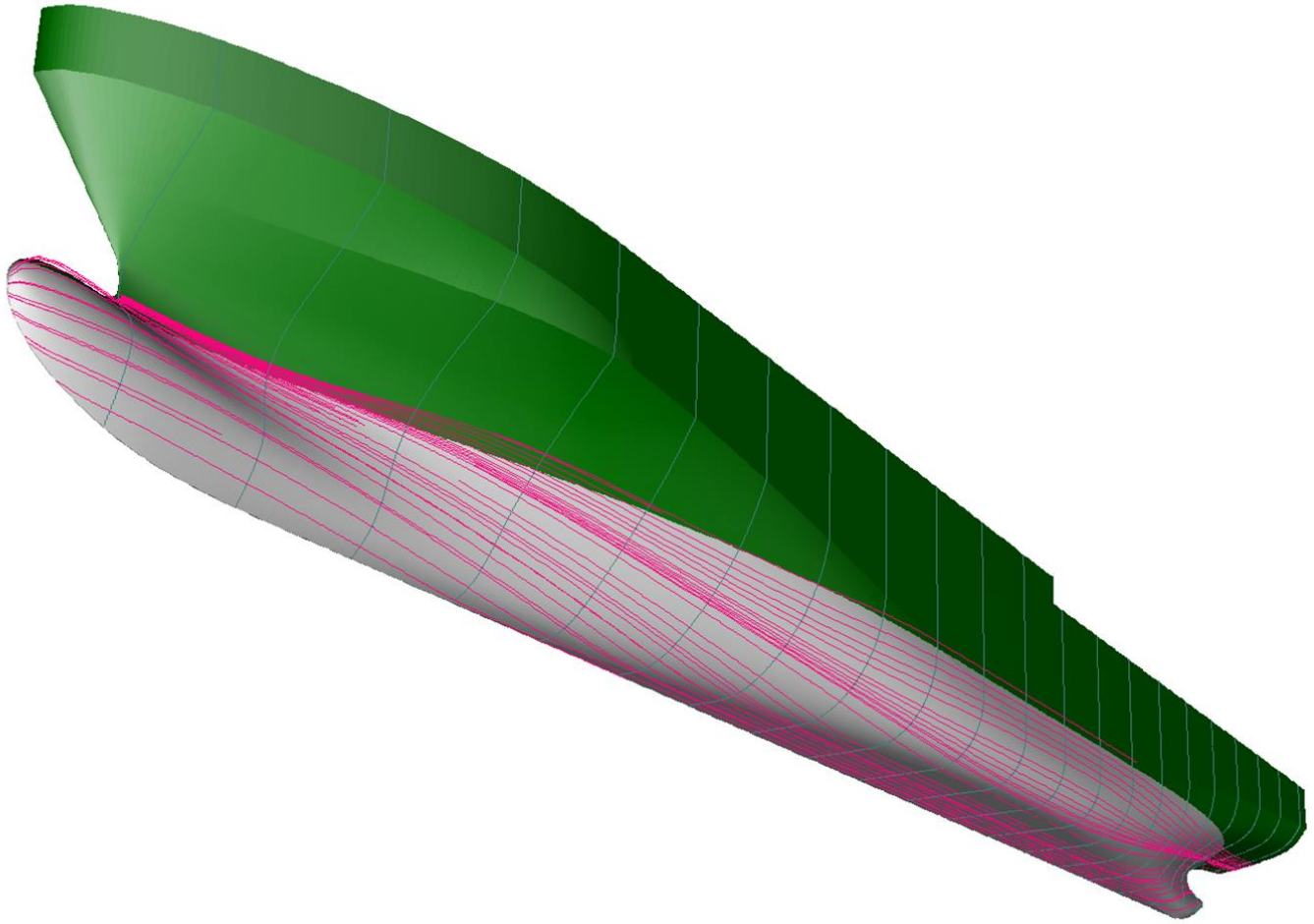
w: www.harwoodmarine.com.au

Shipbuilding. Design. Project Management

Attachments:

- AMC/Macquarie University /Harwood Marine Collaboration.
- AusIndustry Entrepeneurs Program Confirmation
- Bureau Veritas Approval In Principal
- Elsivier Science Direct Ocean Engineering Research Publication "Power-saving device for air bubble generation using a hydrofoil to reduce ship drag: Theory, experiments, and application to ships"
- IMO 2020 Big Shipping Shake-up media.

Air Lubrication System GILLS



GILLS (GAS INJECTED LIQUID LUBRICATION SYSTEM)

SHALLOW DRAFT VESSELS

Content

1. Introduction

The GILLS Technology has been designed to significantly reduce the drag i.e. frictional resistance of a ship . The technology will be individually adapted to each ship type to get the best possible result.

The engineering aspects will be introduced including the installation considerations.

For more details, an Installation Guide Line is available and can be customized to suit the requirements of the individual vessel.

The functionality of the GILLS Technology is based on two major features, namely:

- **Ultra Fine Microbubble generation by Kelvin-Helmholtz Instability**
- **Hull tightening effect of the microbubbles along the hull of the vessel**

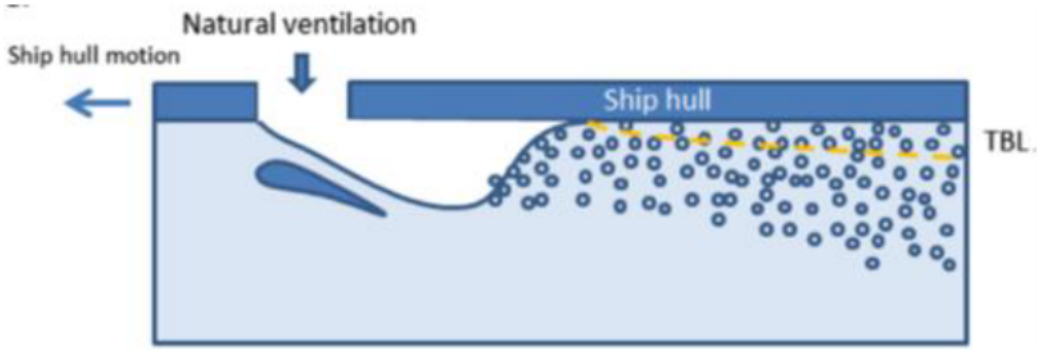
1. Introduction

The GILLS Units of the GILLS System is a device for Ultra Fine Microbubble generation. Different to conventional ways of microbubble generation, the GILL System reduces frictional resistance, thereby reducing power requirements by up to 15%.

GILLS achieves the reduction of drag by generating Ultra-Fine Microbubble (peak dia 1.0mm) by applying the physical phenomena Kelvin-Helmholtz Instability (KHI).

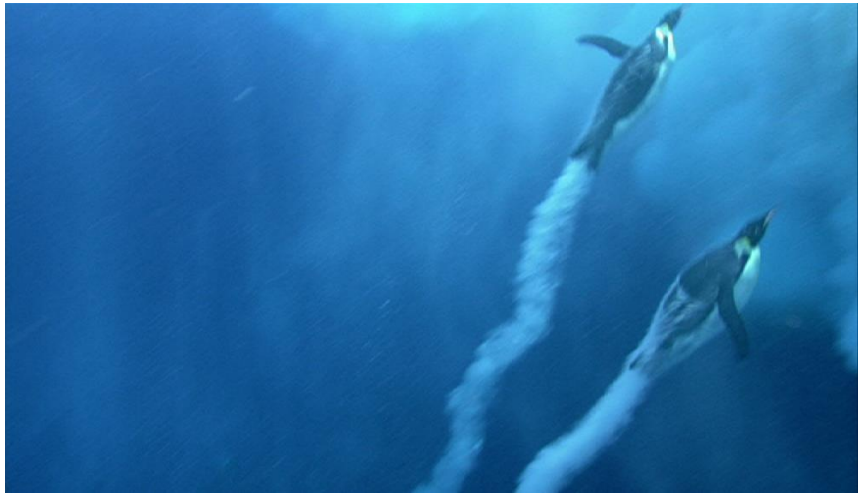
The Microbubbles are released as soon as generated. The Microbubbles stay in the water a long time and form a cloud with hull-tightening force on it.

Any ship that goes through the cloud, the hull drag is being reduced by hull-tightening Microbubbles



Harwood Marine

1. Introduction



Emperor penguins create bubble trail

The effect of Micro Bubbles reducing drag and thus resistance in the water can be observed by many examples in Nature

“The study authors surmise that the penguins lock their feathers down over the air compressed at depth. When they swim upward, the air expands. But they hold their feathers down against the force of expanding air that "will automatically issue as small bubbles. These tiny bubbles remove a huge portion of friction between the feathers and water—up to 100 percent. Experiments with bubbles against flat sheets, representing the sides of tankers, showed over 80 percent reduction in friction, according to Hughes and his co-authors. The penguin slides through the bubble jacket that it creates, leaving bubbles along its trailing wake. This must be how penguins rocket out of the water at 18 miles per hour”

Extract from Scientists Discover Secret to Fast Swimming Penguins
http://www.icr.org/article/7139/366/

Harwood Marine

1. Introduction

Marine Growth is a substantial environmental problem and also causes an increase of resistance of the ship hull in the water

Marine growth has to be removed, which is costly and time consuming

Oxygen is toxic for Marine organisms and thus the marine growth is greatly reduced by deploying GILLS

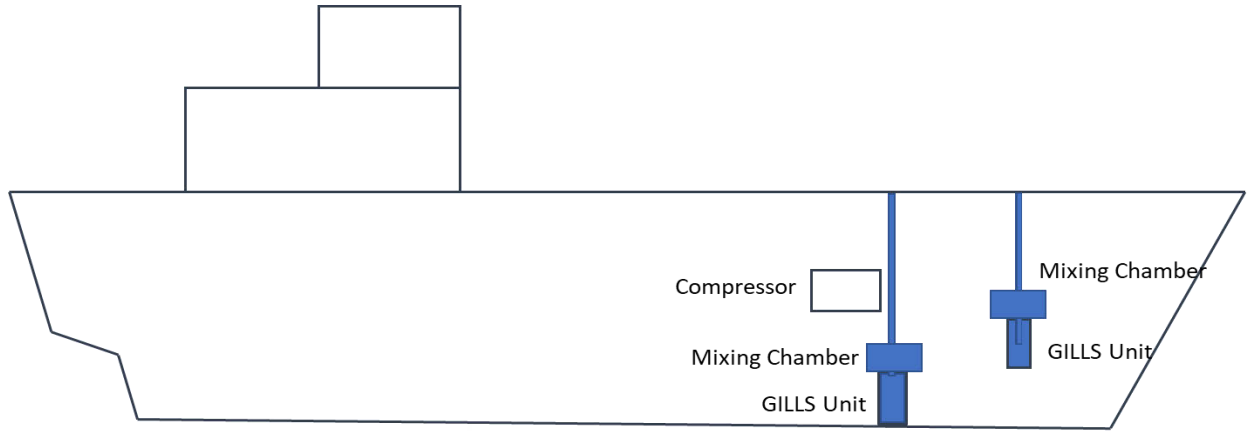
Typical pattern of Marine Growth or Biofouling

Pictures taken from New Ferry Misaki, Japan after longer period in operation and before cleaning of hull

Harwood Marine

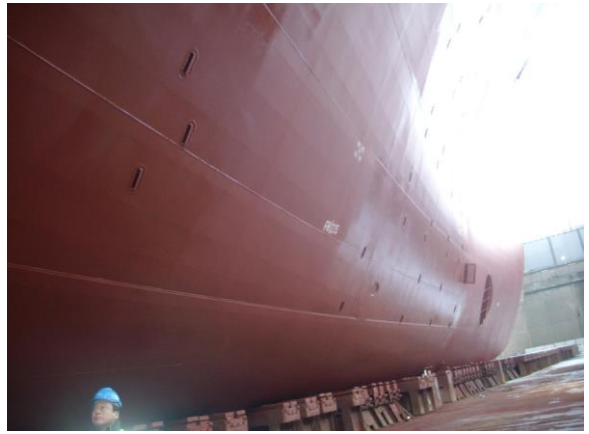
1. Introduction

The GILLS units will be mounted at the side of the ship's hull.



Power-saving device for air bubble generation using a hydrofoil to reduce ship drag: Theory, experiments, and application to ships – Science Direct Feb 2015

https://www.sciencedirect.com/science/article/pii/S0029801814004314



1. Introduction

GILLS On Filia Ariea – 10% Fuel Savings

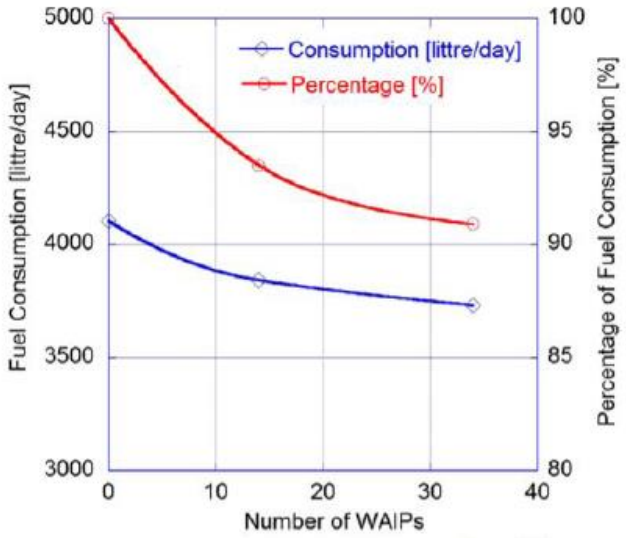


Fig. 12. Fuel consumption as a function of the number of WAIPs.

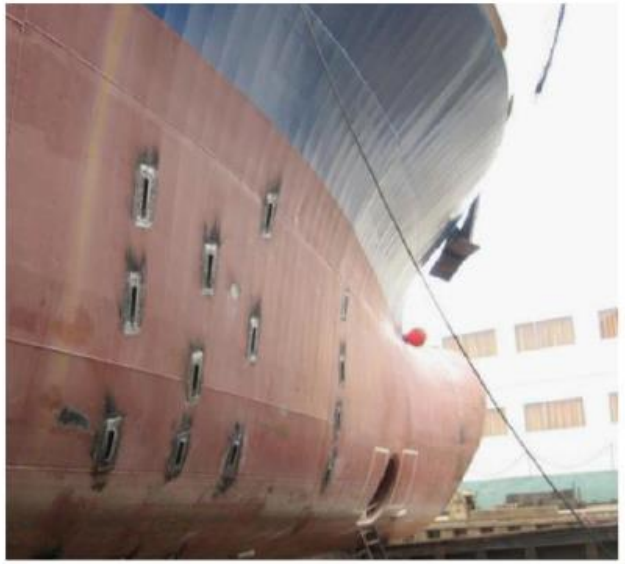


Fig. 13. Side view of the Filia Ariea (84.95 m (Lpp), 13.75 m (Bmd), 5.55 m (Dmd), 1440 kW (power)). WAIPs were installed on the ship as shown. (From Murai et al., 2010).

* Test results in Table 4 Sea Trials, I. Kumagaietal./OceanEngineering95(2015)183–194

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Harwood Marine

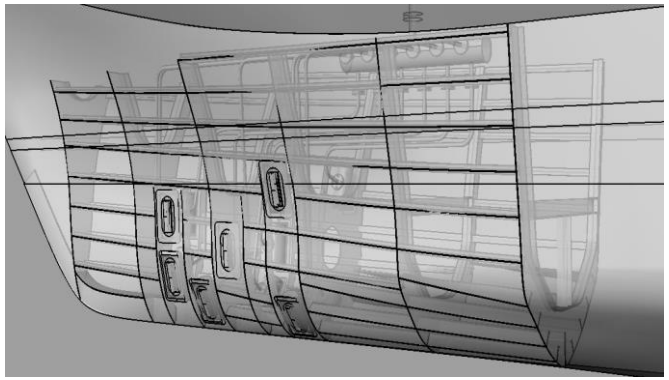
1. Introduction

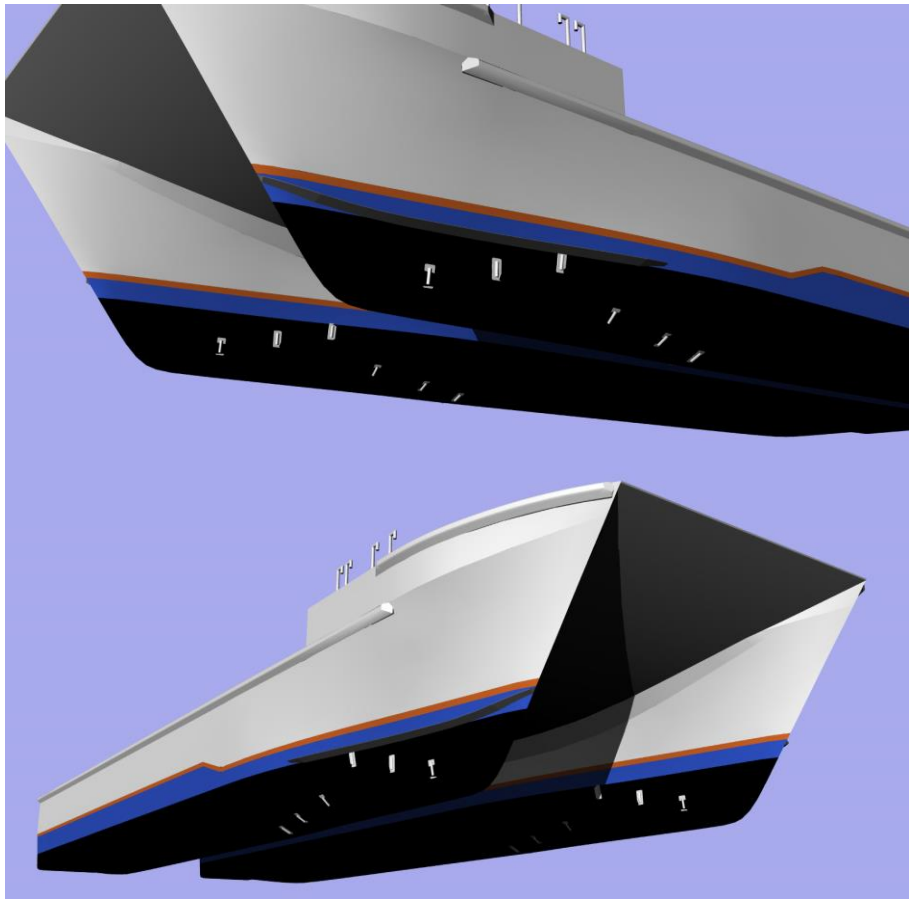
Catamaran Project at Harwood Marine NSW, Australia April 2022.

- Harwood Marine (HM), Australian Government, Australian Maritime College (AMC), University of Tasmania (UTAS), Macquarie University.
- A Project to be carried out at HM Shipyard Northern NSW.
- To install and monitor the system on a 50 mtr Catamaran with Sister ship as comparison.

Harwood Marine

1. Introduction – Catamaran Ferry





2. Key Performance Indicators (KPI) – I

- **Fuel Saving**

  The detailed research being backed-up by full scale installations, defines an average reduction of drag by about 7-10% if the GILLS technology is installed and the ship parameters of speed are correct. This relates directly into a fuel saving of about 7-10 % compared to the same vessel at the same conditions without GILLS. For every individual vessel, GILLS will provide a tailormade solution to ensure the best efficiency based on the hull and flow lines, the structural design of the hull and the accessibility to the system components.

- **Exhaust Gas Emission reduction**

  The exhaust gas emission of a vessel with GILLS will be lower by about 10% compared to the same vessel at the same operating condition without GILLS.

- **Bio Fouling**

  Air is toxic to marine organism. Thus the ship hull covered by the microbubbles will experience a much lower marine growth. This translates into a smoother hull surface, which consequently reduces the fuel consumption as well. At the same time the docking time and cost for hull cleaning will be reduced. This effect has been observed and recorded at the real ship installations.

- **Effective Hull Area**

  Unlike other ALS, GILLS is covering almost the entire wetted area with the micro bubbles. This increases the efficiency of the system since both bottom and hull sides are being covered by micro bubbles.

2. Key Performance Indicators (KPI) – II

- **Ship Speed**
  The GILLS system shows its best efficiency at ship speeds higher than 14 knots. There is no maximum limit for the ship speed for the use of GILLS.

- **Fast installation**
  The installation of the GILLS is straight forward and does not require special tools other than normal shipyard tools. The hull form and shape does not need to be modified. The vent foil units will be installed like a standard sea chest. The system is designed to be installed in new build vessels or as retro-fit during a docking period.

- **System Components**
  The system components are mainly standard components such as the pipe work, valves, manifolds. GILLS will deliver the patented vent foil units. GILLS will also provide fabrication drawings for the mixing chamber or alternatively deliver these components.

2. Key Performance Indicators (KPI) - III

- **Upgrading potential**

  GILLS and its partners are constantly developing the technology further. The GILLS system is designed to ensure that upgrades can be done with minimum effort and cost.

- **Return of Investment (RoI)**

  The return of investment depends on a number of factors such as usage of the vessel, fuel price, operating profile of the vessel and type of vessel. On average the ROI is between 1.5 and 3 years. This computation is only considering the saving in fuel consumption. It does not include potential saving in carbon tax, reduced hull cleaning and other advantages for the shipowner for applying green technologies such as financing.

3. System Design – for shallow draft vessels.

The GILLS System itself consists of the following components:

Vent foil unit

Mixing Chamber

Manifolds

Pipe work

Safety Shut off valves as required

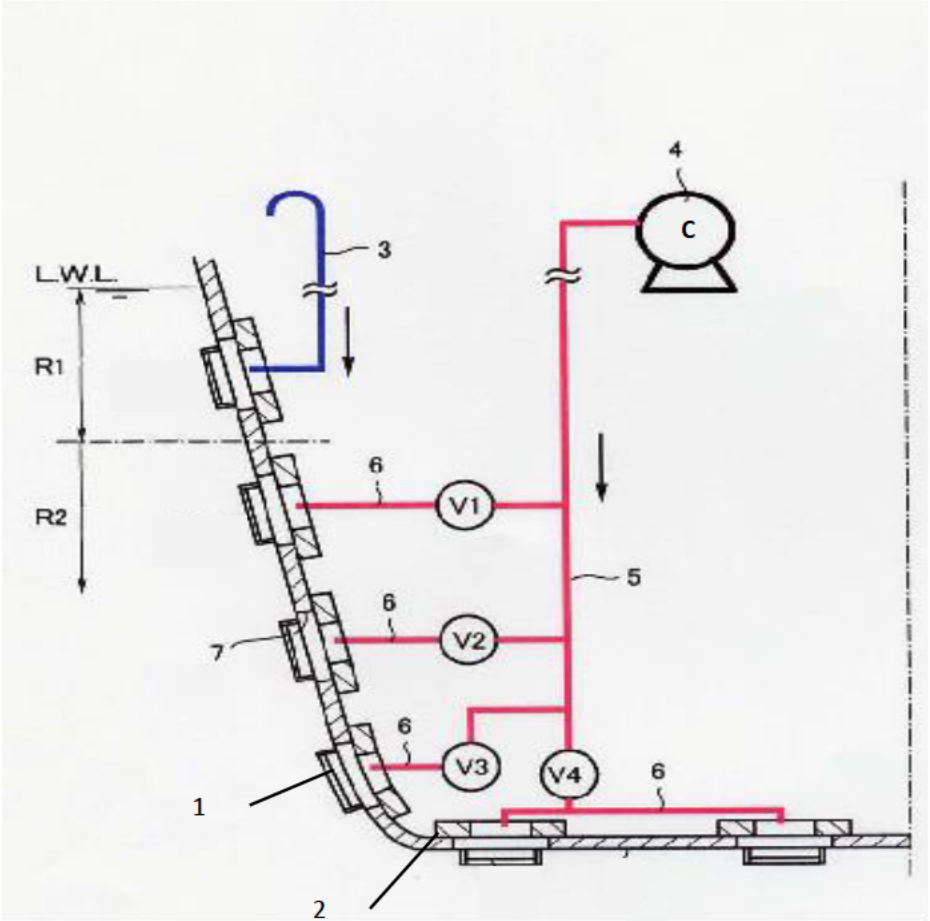
*** Compressor as required**

The GILLS Technology is suitable both for new build and for refit installations, since the system does not require any modification of the hull shape or form.

3. System Design

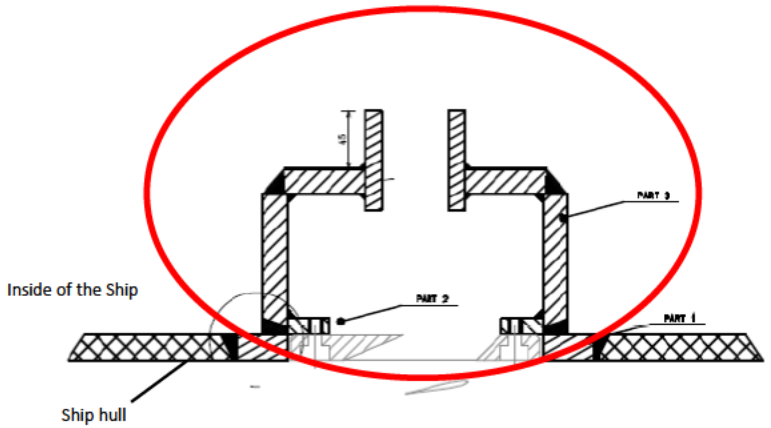
The GILLS System consists of the following Components:

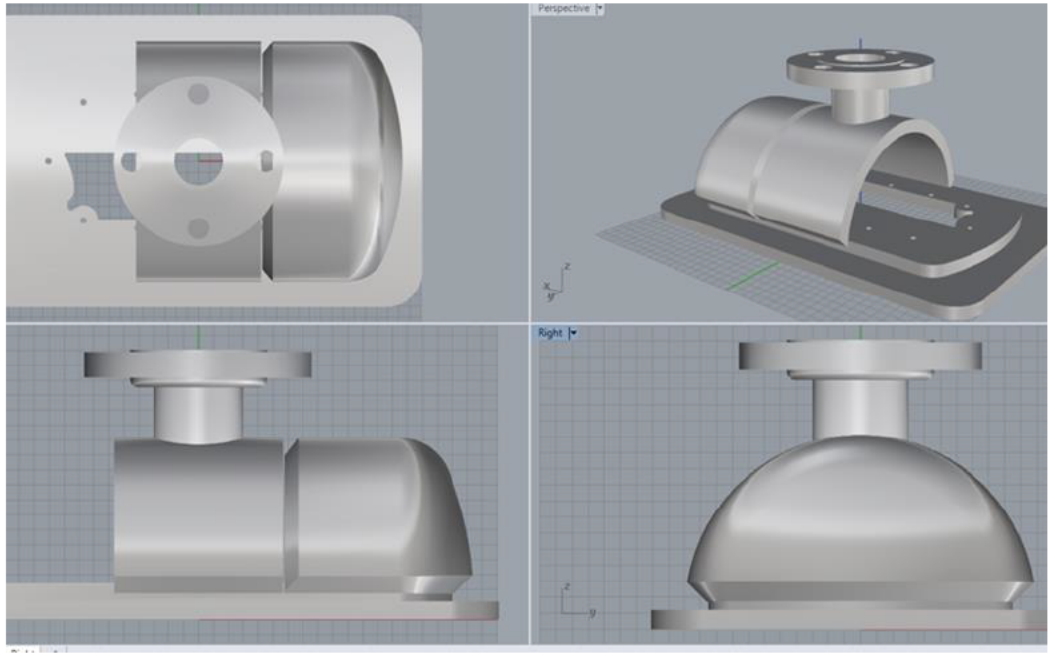
- Vent Foil Units (pos 1)
- Mixing Chamber (pos 2)
- Air pipe to atmosphere (pos 3)
- Screw type Marine Compressor (pos 4) (not required for less than 2 mtr draft.
- Air pipes and manifolds (pos 5,6)
- Hull (pos 7)
- Monitoring System can be included for extra cost.



4. System Components – Mixing Chamber

On the inside of the hull, the Mixing chamber with the flanges to the pipe work is connected. The mixing chamber is flange connected to the air pipe. Air and water will mix in the mixing chamber and air will be released to the open water in form od micro bubbles through the Vent Foil Unit





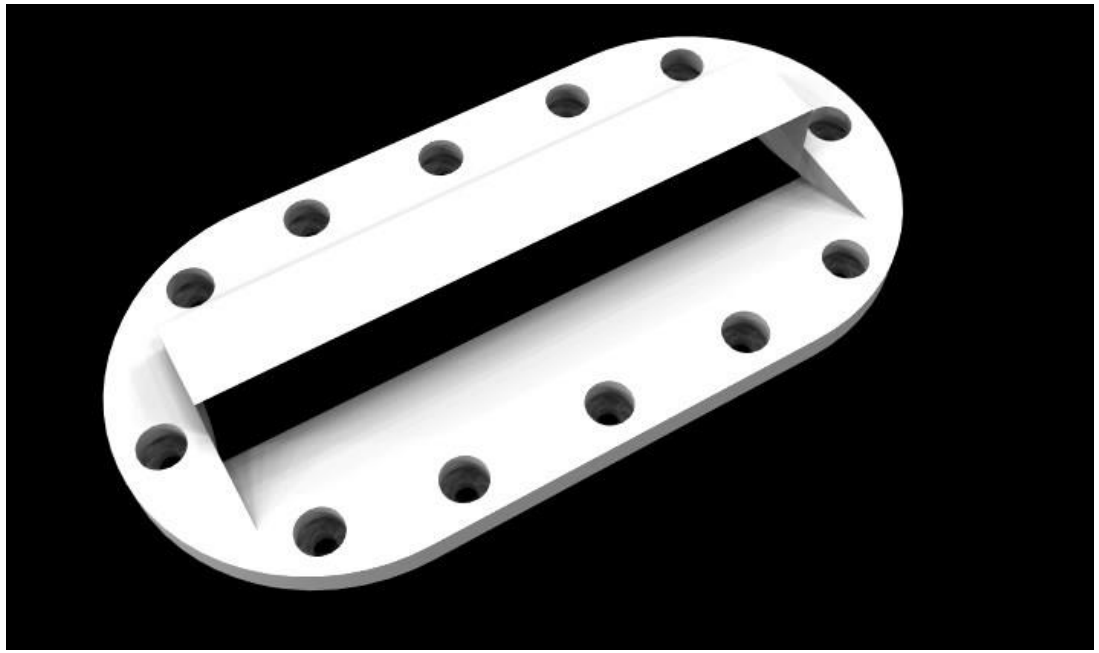
Mixing Chamber:

- Material: Marine Carbon Steel
- Certification: by Class (DNV-GL, BV, others)
- Number of units per vessel: 275
  (Example 210m container vessel)

4. System Components – Vent Foil Unit

The patented Vent Foil Unit is the core component of the system.

It is a robust machined part, material Marine Grade Stainless Steel. The Vent Foil Unit will be screwed to an adapter plate, which in turn will be welded to the steel hull. On the inside of the hull, the Mixing chamber with the flanges to the pipe work is connected. The Mixing Chamber is made of marine grade steel.



Vent Foil Unit:

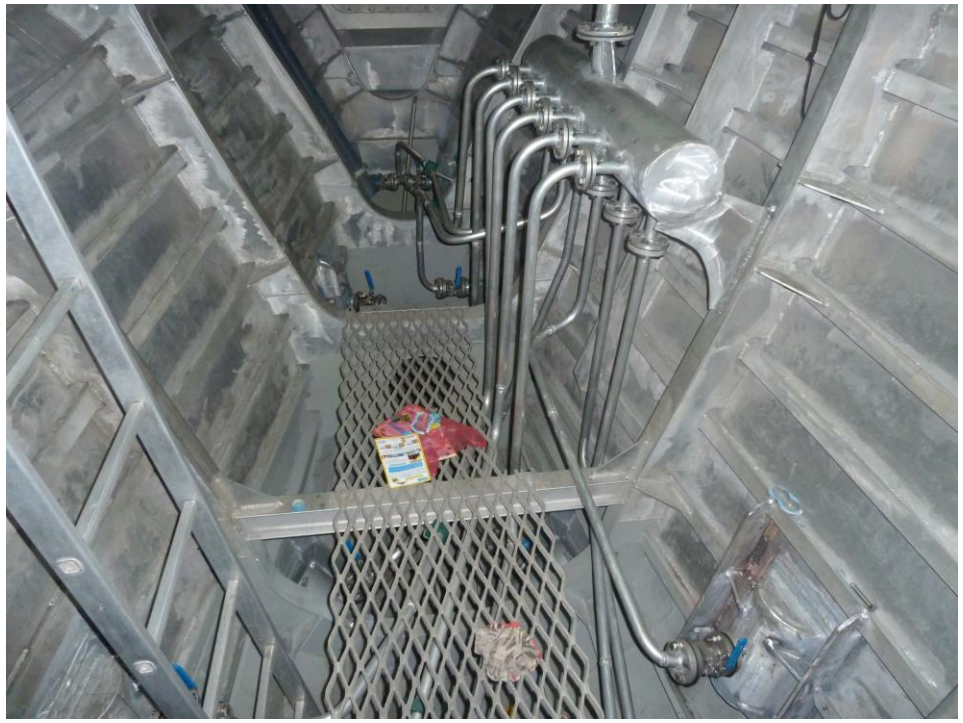
- Dimensions: 300 mm x 150 mm
- Weight: 3.6 kg / unit
- Material: Marine Grade Stainless Steel
- Certification: by Class (DNV-GL)
- Number of units per vessel: 275
  (Example 210m container vessel)

3. System Design – Shallow Draft - Catamaran Specific

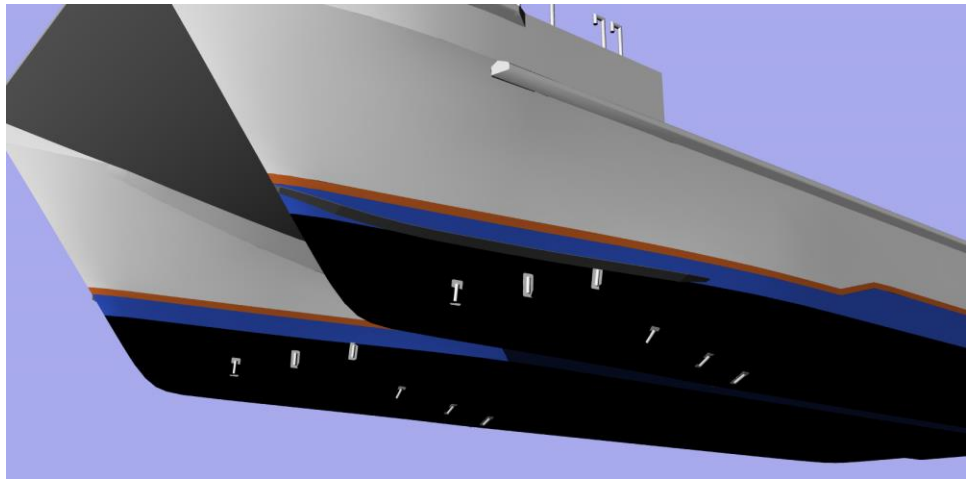
The GILLS System on Super Cat 25

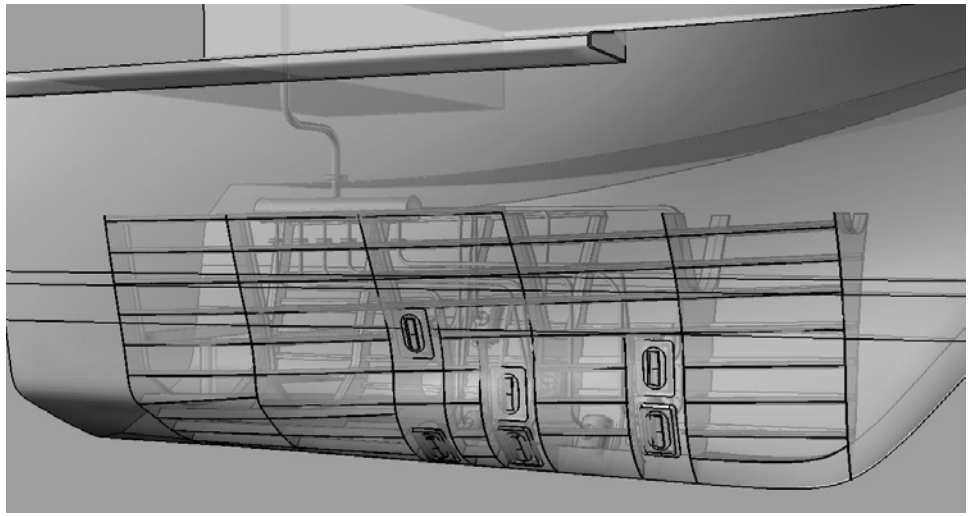
4. System Components – Manifold and Piping

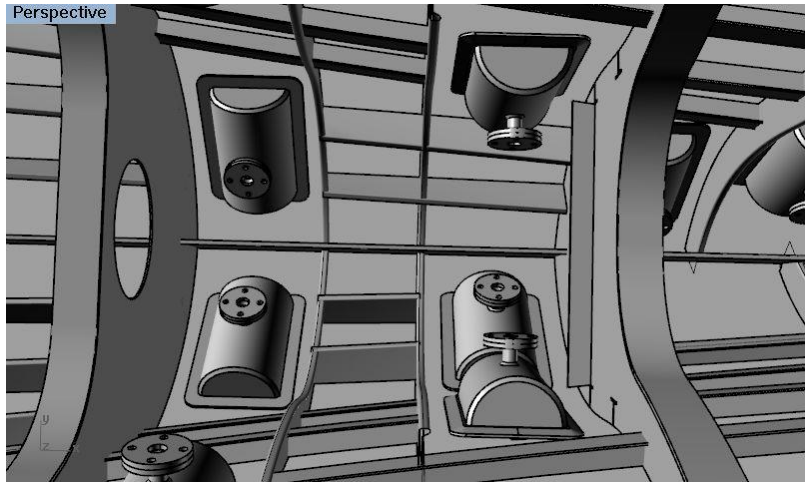
Manifold compents manufactured to suit Hull materials. Examples below were on an All Aluminium Incat Crowther designed former Sydney ferry catamaran, operating in Cebu Philippines.

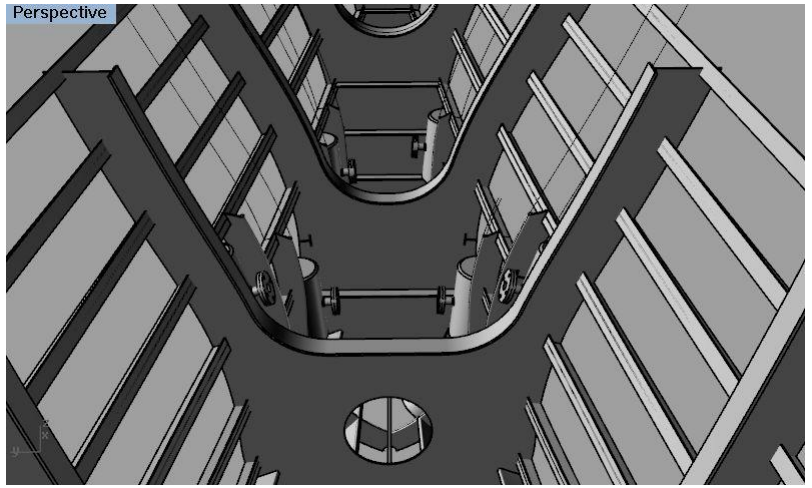


4. System Components – Manifold and Piping modelling



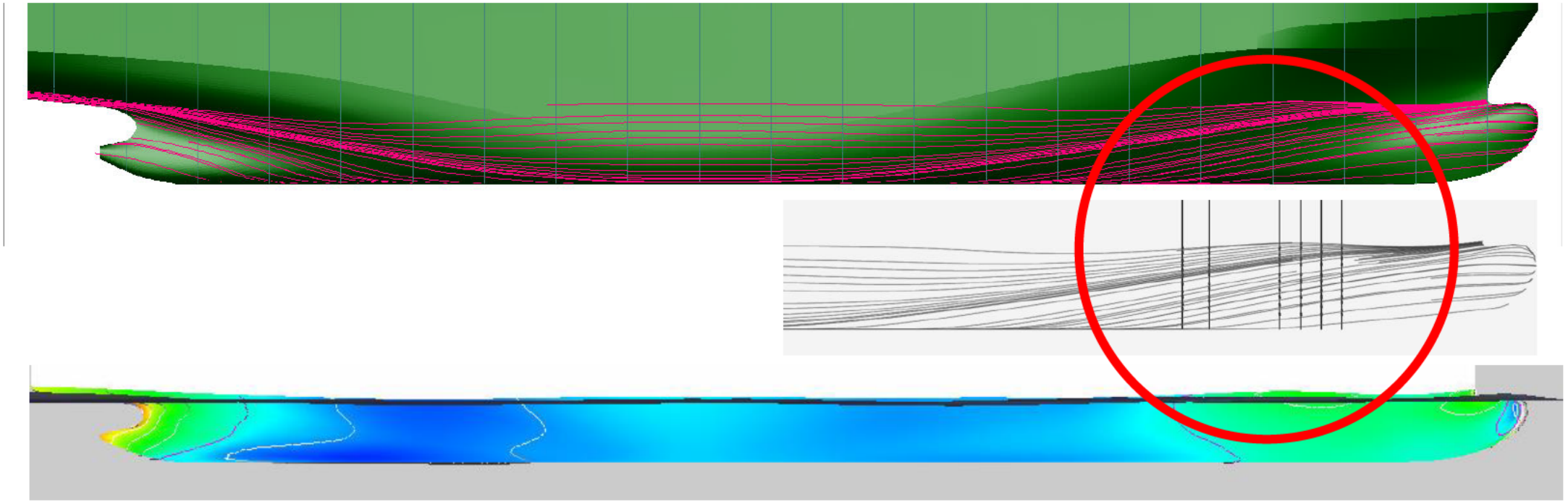






4. System Components – Positioning of the Vent Foil Units

Location of Vent Foil Units with reference to pressure and flow lines at the forward section of the hull



5. Energy Balance

Energy Balance at the example of the Filia Ariea based on the sea trail reports.

Measured power saving curve for the Filia Ariea with vent foil units. This includes:

Additional weight of the system < 1 % of additional loss

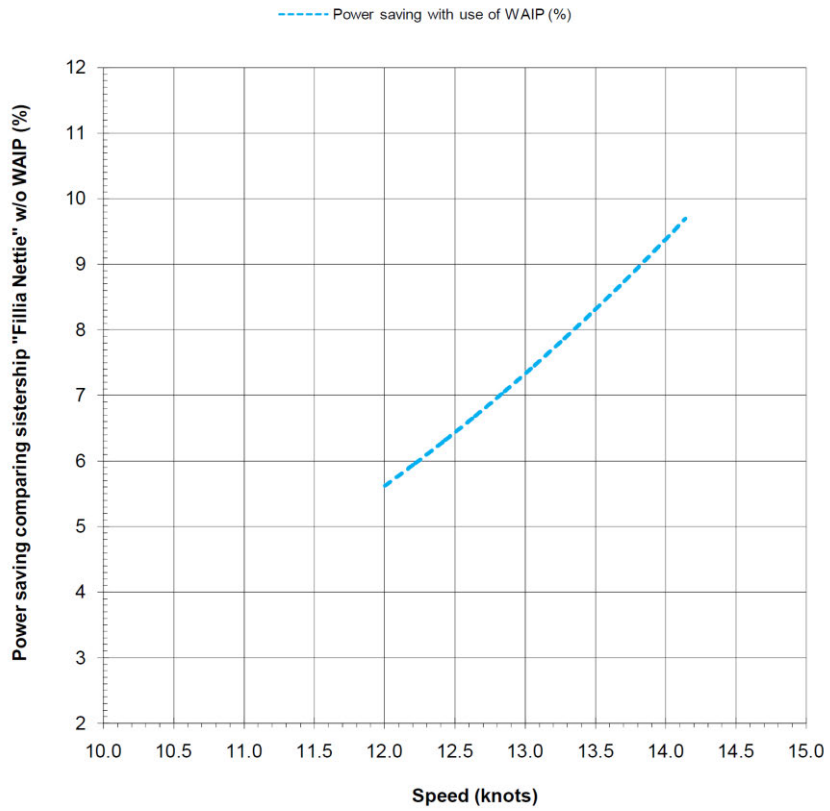
Additional Drag of vent foil about 1 %

The gross percentage in power saving at 14 knots would thus be: 9.5 + 1 + 1 = 11.5 %

The measured power saving at 14 knots is 9.5 %

Speed - power graphic

Ship's name	:	Filia Ariea	Draught fore	:	1.88 m
Report nr.	:	973-A / 08	aft	:	3.12 m
Date	:	June 12th, 2008	mean	:	2.50 m
Displacement	:	2150 t	Trial condition	:	Ballast
Corrected for shallow water and wind					



6. Approval in Principle

The Approval in Principle (**AIP**) has been provided by the Office of
the Classification Society Bureau Veritas

BUREAU VERITAS

CERTIFICATE of APPROVAL in PRINCIPLE

Certificate No.: SPO-2021-0001

At the request of:

GILLS PTE LTD

BUREAU VERITAS, acting within the scope of the general conditions of the Marine & Offshore Division (*), declares hereunder that the design of

Air Lubrication System – GILLS
(Gas Injected Liquid Lubrication System)

is approved in principle, with respect of the aim of the classification as defined in Part A, chapter I of the latest edition of our Rules and in the conditions stated in Annex 1.

The present design approval is referring to the general options chosen by the designer, as described in the documents listed in Annex 2.

For ship application:

- all relevant drawings, test or studies, reports and other documents necessary listed in Annex 3 are to be submitted for review.

The validity of this approval may have to be reconsidered, in case of any major modification likely to invalidate the principles shown on the documents listed in Annex 2.

This approval would become null and void should BUREAU VERITAS not be kept informed of such modifications.

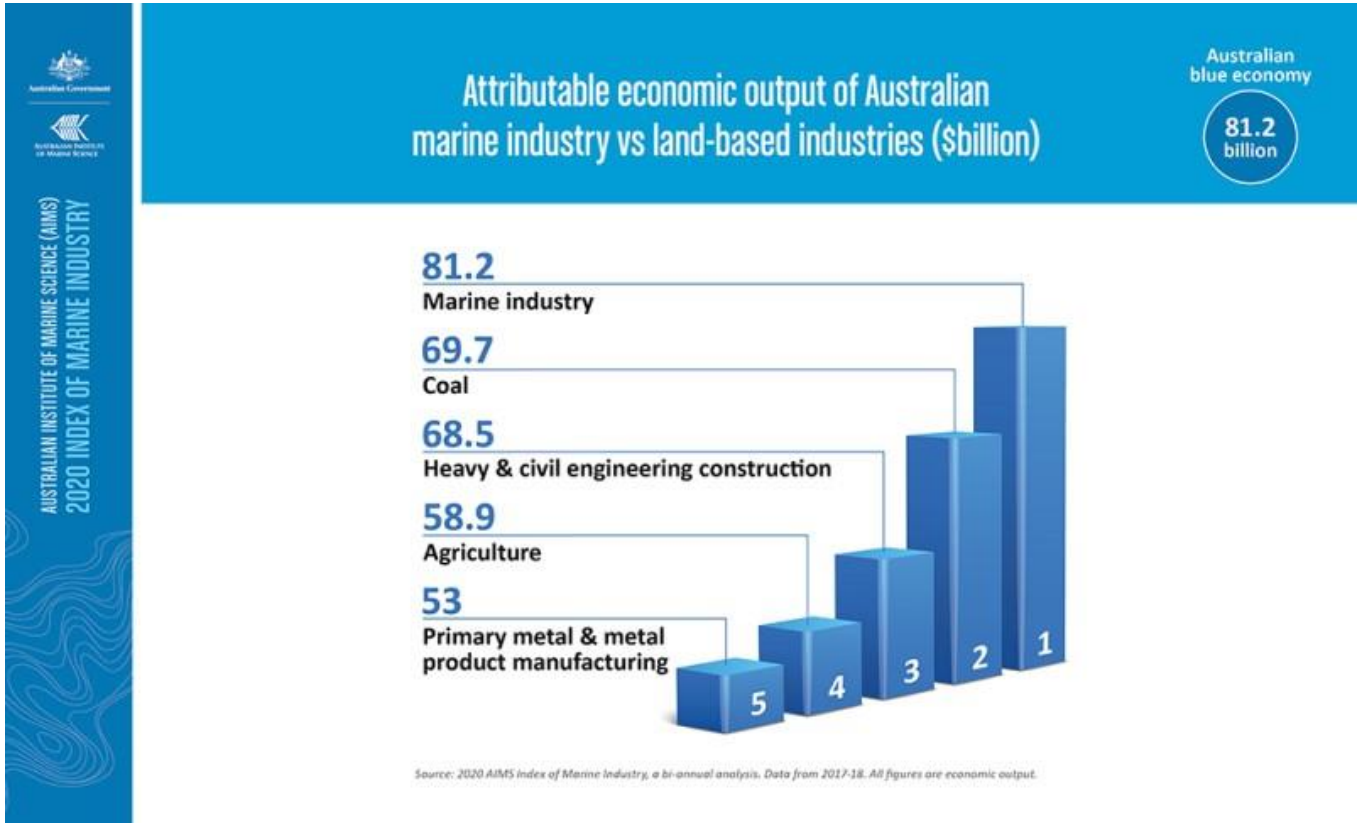
Issued at Singapore, on 26th March 2021

(*): see overleaf

Xin ZENG
Manager, Singapore Plan Approval Office

Harwood Marine

7. NSW /Australia Significance



Harwood Shipyard, will design, manufacture and install the system on new vessels, and retrofit on older vessels.

Larger vessels to 300 mtrs long could be done at Garden Island

Boosting employment and economic benefits to NSW.

Australia has the largest Bulk carrier fleet in the world, these ships could be docked and refitted with the new technology at Garden Island, Sydney NSW.

Harwood Marine

7. NSW /Australia Significance – Bulk Carriers largest Co2 emitters

7. NSW /Australia Significance

The mixing chamber, a main component will be produced at the Harwood Shipyard, but outsourced in NSW if demand is greater than supply.

This component is particularly significant since it is part of the ship hull's integrity and subject to quality scrutiny by the Classification Society.

It requires highest quality and accuracy of manufacturing and is a very important task.

Harwood Marine

7. NSW /Australia Significance

Harwood Marine is the trading name of the Australian Registered company Harwood Slipway Pty Ltd and is located and based in NSW.

Harwood Marine is a marine engineering, design, ship repair and shipbuilding company, employing and training workers in Regional NSW.

This opportunity gives NSW a leading edge, for Green marine environmental ship technology.

The patents for this technology are held in Australia but registered worldwide.

Harwood Marine

8. International Significance

NANYANG TECHNOLOGICAL UNIVERSITY

MAE Top Project Team awarded as one of the top 3 projects at SMI Forum!

Published on: 27-Oct-2015

At this year's Singapore Maritime Institute (SMI) Forum, our top project team led by MAE Associate Professor Li Hua was awarded as one of the top 3 projects by SMI! During the forum, Professor Li Hua gave a presentation about their research topic "Two issues on a novel air lubrication system for ship drag reduction", which aims to quantify the energy saving potential of WAIP for ship applications by investigating few fundamental and key issues.

The Singapore Maritime Institute (SMI) Forum 2015 that was held on 22 October is a major annual event for SMI to gather stakeholders to share and discuss important issues that impact the industry. Other than Professor Li Hua, the top project team includes Professor Daniel New (Co-PI), Dr. Lyu Xujian and Dr. Zhang Jun.

For years, the marine transportation industry has a strong demand for ship friction drag reduction aiming at increasing the ship range or speed, saving energy and cost, and reducing the greenhouse gas emissions. The outcome of this research will benefit the local maritime industry in Singapore definitely.

In 2015, Singapore Maritime Institute presented an Award to the Air Lubrication Technology, at that time still under the name of "WAIP" which was later changed to "GILLS"

Harwood Marine

8. International Significance

Springer

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JHD

Numerical investigation of frictional drag reduction with an air layer concept on the hull of a ship *

Jun Zhang[1], ShuoYang[1], Jing Liu[2]
1. *College of Aerospace Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China*
2. *Energy Research Institute @NTU, Nanyang Technological University, Singapore*

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Abstract: A novel air bubble lubrication method using the winged air induction pipe (WAIP) device is used to reduce the frictional drag of the hull of the ship and hence increase the efficiency of the propulsion system. This bubble lubrication technique utilizes the negative pressure region above the upper surface of the hydrofoil as the ship moves forward to drive air to the skin of the hull. In the present study, the reduction rate of the drag by applying the WAIP device is numerically investigated with the open source toolbox OpenFOAM. The generated air layer and the bubbles are observed. The numerical results indicate that the reduction rate of the drag closely depends on the depth of the submergence of the hydrofoil, the angle of attack of the hydrofoil, and the pressure in the air inlet. It is also proportional to the air flow rate. The underlying physics of the fluid dynamics is explored.

Key words: Winged air induction pipe (WAIP), drag reduction, frictional resistance reduction, hull of ship, OpenFOAM

In 2019 NTU published a paper of further development concerning the GILLS / WAIP system, focusing on the numerical investigations of the boundary Layer effects. This demonstrates further the interest and commitment of the Singapore Academia on this topic

9. Benefits

The benefits for the ship-owner or of both quantitative and qualitative character. For the example of the 200m Container vessel, the Return of Investment would be in the range of 1.5 to 2.5 years depending on a number of external factors. The total cost of installing GILLS is about half of the cost of installing a scrubber at the same type of vessel.

Benefits	Comment
Fuel Saving	About 10 %
Exhaust Emission Saving	About 10 %
Less Biofouling	Substantial reduction of docking time and docking cost
Ship Financing	Satisfying Banking Requirements for environmentally friendly design
External Funding	Support qualification for „Green Ship“ Programs

9. Bio Fouling – Global reduction of GHG 20-25%

Removing biofouling from the hull's surface could reduce greenhouse gas emissions by up to 25 per cent, according to a study published on November 4th by COP 26.

the preliminary study on the impact of bio siltation on ship green house gas emissions suggests that if 50 per cent of the hull surface were covered with a layer of 0.5 mm thick bio siltation, greenhouse gas emissions would increase by 20 to 25 per cent depending on the ship's characteristics, speed and other major operating conditions.

9. Benefits

The benefits for the operator of the vessel are in the lower carbon foot print of the vessel, combined with the real operational advantages of an increased pay load, extended range at in some limitations higher speed.

Benefits	Comment
Fuel Saving	About 7-10 %
Exhaust Emission Saving	About 7-10 %
Less Biofouling	Substantial reduction of docking time and docking cost
Enhanced payload	With lesser fuel consumption, either the payload of the vessel or the range can be extended.

End of Document – Thank You