



Green Ship Technologies

IMarEST and Science & Innovation Network (SIN)

Institute of
Marine Engineering,
Science & Technology

IMAR^{EST}



UK Science
& Innovation
Network

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FOREWORD

Ships are by far the most efficient form of transport of mass goods, but growing concern about climate change, the environmental state of the world ocean and air quality close to major shipping routes and ports has led to the industry taking steps to tackle these issues, by introducing equipment, products and environmentally friendly operating procedures to protect the environment and comply with associated legislation. Whereas these often come at a cost to ship owners, operators and ultimately the end users of the goods carried by sea there are financial incentives introduced by Administrations, such as Singapore, to encourage an environmental response. These, for example, include the provision of incentives to ship owners who adopt energy efficient ship designs that reduce fuel consumption and carbon dioxide emissions such as the 50% reduction of Initial Registration Fees (IRF) and the 20% rebate on Annual Tonnage Tax (ATT). Greater incentives are also afforded to vessels under the Singapore flag which go beyond the IMO legislation

Additionally, with fuel being both the most expensive component of a ship's operating costs and the main source of air emissions, any reduction in consumption brings a financial as well as environmental benefit. Moving towards greener operations can also assist with building positive relationships with customers who wish to engage with shipping companies who are themselves demonstrating environmental concerns.

How can ships comply with the legislation and reap the benefits? What technologies, products and operating measures currently exist, what is on the horizon and are ship owners and operators truly engaged in the Green Agenda?

To address these questions, the Institute of Marine Engineering, Science and Technology (IMarEST) together with the Science and Innovation Network (SIN) held a high-level round table discussion in Singapore in March 2015.

Prior to this, an extensive questionnaire was sent out to companies and individuals requesting details of their experiences, expectations and concerns regarding environmental trends. Results of this survey were used as a guide to develop topics to be raised at the round table and as additional data for this report.

The round table itself, chaired by Richard Vie (112th President of IMarEST) gave a panel of experts from many sectors of the industry the opportunity to discuss green initiatives and debate the current problems and opportunities that exist, as well as whether it is possible to turn these opportunities into profitable investments.

ACKNOWLEDGEMENTS

In producing this report, we have been greatly assisted by the many individuals and businesses who contributed to both the survey and subsequent round table discussion. The 200 plus organisations who responded to the survey gave us a scalable and valuable insight into the thinking around green ship initiatives. The industry leaders who attended the round table added much to this and shared their own practical experiences and recommendations. We are most grateful to them all.





GREEN AGENDA PANEL

The roundtable was attended by representatives of the following organizations:

4 Green Ship Technologies

AkzoNobel

Centre for Maritime Studies (CMS), National University of Singapore

DNV GL

Green Agenda Panel

Institute of High Performance Computing, A*Star

Institute of Marine Engineering, Science & Technology (IMarEST)

Lloyd's Register

Maritime and Port Authority of Singapore

School of Mechanical & Aerospace Engineering, Nanyang Technological University

Sembcorp Marine

Shell

Singapore Maritime Institute

Swire Pacific Offshore

UK Trade and Investment

University of Newcastle

University of Southampton

MARINE ENVIRONMENTAL LEGISLATION

The harmful effects of emissions from industrial activities are well known and based on sound science. Particular advances in the knowledge of emissions took place in the 1970s with several studies confirming the hypothesis that air pollutants could travel several thousand kilometres before deposition and damage occurred. Particular focus was paid to airborne deposits of sulphur dioxides and nitrogen oxides causing acid rain which damaged crops and forests in particular. In addition, continued research highlighted that inhalation of sulphur was contributing to respiratory problems. Attention was then paid to the harmful effects on human health for those living in the vicinity of ports due to the high levels of sulphur produced by burning of marine fuels.

To address the issues of shipping emissions as air pollutants, a new annex was added to the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1997. The Regulations for the Prevention of Air Pollution from Ships (Annex VI) seek to minimise airborne emissions from ships - Sulphur Oxides (SOx), Nitrous Oxides (NOx), Ozone Depleting Substances (ODS), Volatile Organic Compounds (VOCs) - and their contribution to local and global air pollution. Annex VI entered into force on 19 May 2005 and a revised Annex VI, with significant tightening of emissions limits, was adopted in October 2008 and entered into force on 1 July 2010.

As well as addressing air pollutants from shipping, the industry has also faced a challenge to meet a target for the reduction of greenhouse gas (GHG) emissions, in particular carbon dioxide (CO₂), in line with other industrial activities and in light of a projected increase in global trade. The reduction in GHG emissions is required to achieve stabilisation in global temperatures and mitigate the harmful impacts of climate change.

“ In 2007, international shipping was estimated to have contributed about 2.7% to the global emissions of CO₂. ”

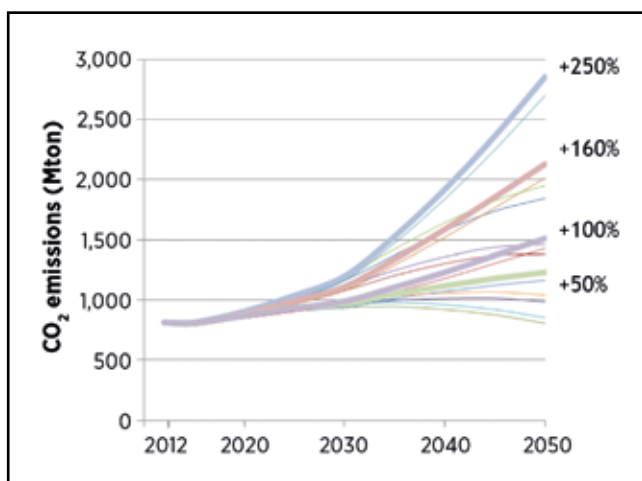
According to the International Maritime Organization (IMO) in its 3rd GHG report of June 2014, for the period 2007–2012, on average, shipping accounted for approximately 3.1% of annual global CO₂ and approximately 2.8% of annual GHGs on a CO₂e* basis. A multi-year average estimate for all shipping using bottom-up totals for 2007–2012 is 1,016 million tonnes CO₂ and 1,038 million tonnes CO₂e for GHGs combining CO₂, CH₄ and N₂O. International shipping accounts for approximately 2.6% and 2.4% of CO₂ and GHGs on a CO₂e basis, respectively. A multi-year average estimate for international shipping using bottom-up totals for 2007–2012 is 846 million tonnes CO₂ and 866 million tonnes CO₂e for GHGs combining CO₂, CH₄ and N₂O.

In 2007, international shipping was estimated to have contributed about 2.7% to the global emissions of CO₂.

In 2011, IMO adopted mandatory technical and operational energy efficiency measures which are expected to improve the carbon intensity of international shipping. However, with the industry expected to grow, absolute emissions are expected to continue to rise. The 3rd IMO GHG report shows only one or two future scenarios where CO₂ will start to fall in real terms.

The mandatory measures include an Energy Efficiency Design Index (EEDI) for new ships and a Ship Energy Efficiency Management Plan (SEEMP) for all ships. The regulations apply to all ships over 400 gross tonnes and came into force through the tacit acceptance procedure on 1 January 2013.

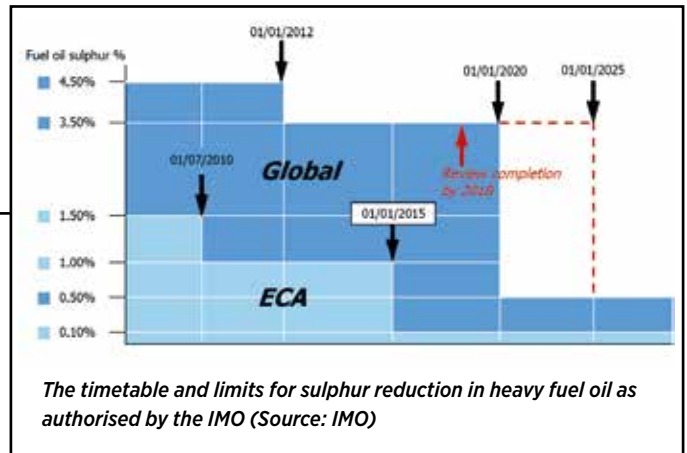
*Carbon dioxide equivalent, a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO₂e signifies the amount of CO₂ which would have the equivalent global warming impact.



CO₂ emission projections from the IMO 3rd GHG report (Source: IMO)

SULPHUR EMISSIONS LEGISLATION

Under the revised MARPOL Annex VI, the global sulphur cap was reduced to 3.50%, effective from 1 January 2012; then progressively to 0.50 %, effective from 1 January 2020, subject to a feasibility review to be completed no later than 2018. The limits applicable in Emission Control Areas (ECAs) for SO_x and particulate matter were reduced to 1.00%, beginning on 1 July 2010 and will be further reduced to 0.10%, effective from 1 January 2015.



NITROGEN EMISSIONS LEGISLATION

Progressive reductions in NO_x emissions from marine diesel engines installed on ships are also included, with a “Tier II” emission limit for engines installed on or after 1 January 2011; then with a more stringent “Tier III” emission limit for engines installed on or after 1 January 2016 operating in ECAs.

IMO regulations seek to minimize airborne emissions from ships (SO_x, NO_x, ODS, VOC shipboard incineration) and their contribution to local and global air pollution and environmental problems

GREENHOUSE GAS EMISSIONS LEGISLATION

The mandatory technical and operational energy efficiency measures which are expected to significantly reduce the amount of CO₂ emissions from international shipping are not considered by the IMO to be sufficient enough to satisfactorily reduce the amount of GHG emissions from international shipping in view of

the growth projections of human population and world trade. Therefore, market-based mechanisms have also been considered and would serve two main purposes: providing a fiscal incentive for the maritime industry to invest in more energy efficient means, and contributing to the potential off-setting of growing ship emissions.



OTHER ENVIRONMENTAL LEGISLATION

Other IMO environmental legislation which affects ship design and operations includes:

- **Marpol Annex I** which covers the prevention of pollution by oil from operational measures as well as from accidental discharges.
- **Marpol Annex II** which details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk.
- **Marpol Annex III** which covers prevention of pollution by harmful substances carried by sea in packaged form and contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications.
- **Marpol Annex IV** which details the requirements to control pollution of the sea by sewage.
- **Marpol Annex V** which deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of including the complete ban imposed on the disposal into the sea of all forms of plastics. A revision to Annex V prohibits the discharge of all garbage into the sea, except as provided otherwise, under specific circumstances.

In addition, there are measures in place to mitigate impacts to the environment and on human health caused by invasive species carried by ships either through fouling or in ballast water.

Biofouling, described as the undesirable accumulation of microorganisms, plants, algae and animals on submerged structures (especially ships' hulls), is considered one of the main factors for bio-invasions. The IMO has issued "Guidelines for the Control and Management of Ships' Biofouling" to assist in mitigation.

The problem of invasive species in ships' ballast water is largely due to the expanded trade and traffic volume over the last few decades and new areas are being invaded all the time. The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) was adopted by consensus at a Diplomatic Conference held at IMO Headquarters in London on 13 February 2004 and will require all ships to implement a Ballast Water and Sediments Management Plan, carry a Ballast Water Record Book, and carry out ballast water management procedures to a given standard. However, at the time of the round table the convention had yet to be ratified.



THE ROUNDTABLE – TOPICS

The roundtable panel was tasked with examining a number of questions relating to green shipping, pulling together experiences and understanding to address the following questions:

THE CURRENT SITUATION

- Does conforming to legislation impact on businesses? How? Which department takes the strain?
- Can and do shipping companies pursue other non-legislative initiatives to improve efficiency?
- Can investing in optional green initiatives help to win clients who themselves are expected by their customers to have strong 'green' policies in place?
- Does an investment in 'green' initiatives provide a good return on investment?

SHARING BEST PRACTICE

- What best practices can we recommend?
- Can we learn from other industries?
- What are the steps to take to conform to legislation?

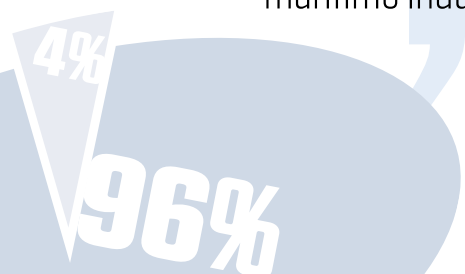
USE OF DIFFERENT MEASURES

- What are the best measures available and how should businesses access the value and impact? (E.g. carbon credits, LNG, antifouling, fuel efficiency etc.)

SUGGESTIONS

- What do we do next as a sector?

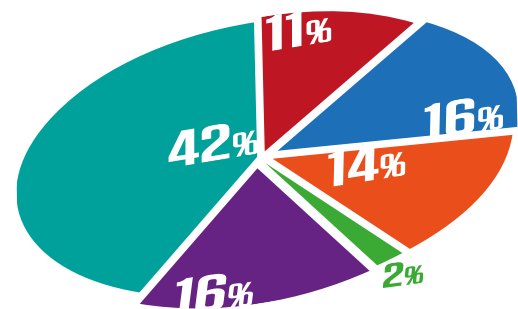
“ 96% of the industry agrees that a green agenda is important for the global maritime industry ”



RESULTS OF THE SURVEY

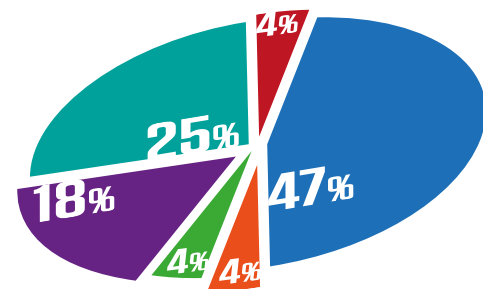
Two surveys were carried out by IMarEST. The first, supported by Colfax Fluid Handling, targeted UK companies and the second targeted companies in South East Asia although responses were also received from other geographical regions for both surveys. These surveys were a starting point for the discussions. The surveys highlighted that 96% of the industry in SE Asia agrees that the Green Agenda is good for the global maritime industry (compared to 88% in the UK), and 62% say it actually offers good value for money.

The survey produced around 150 responses in SE Asia, with a mix as follows:



- Ship Builder
- Ship Owner
- Equipment Manufacturer
- Ship Operator
- Charterer
- Other

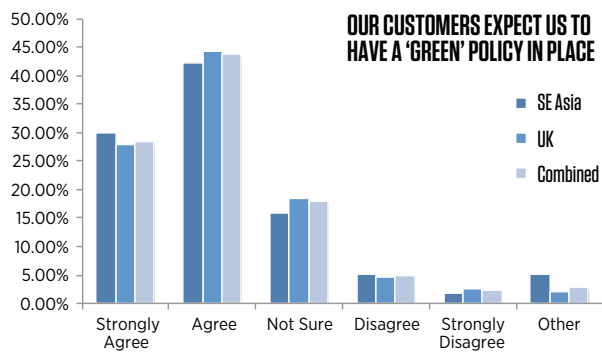
And who work in the following areas:



- Ports
- Leisure
- Offshore Oil & Gas
- Shipping
- Cruise
- Other

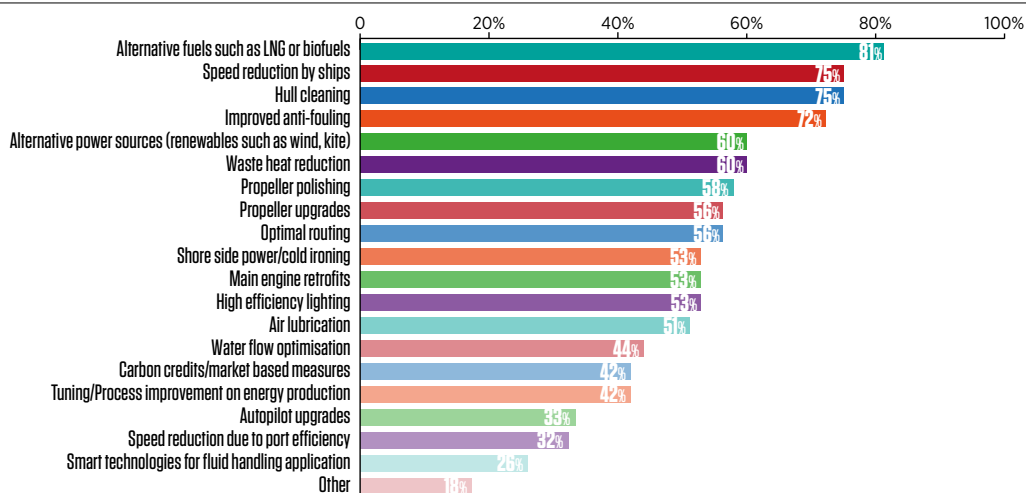
The survey showed that 90% of respondents in SE Asia think the Green Agenda can impact business and could act as a success factor, with 95% agreeing that more options need to be made available to encourage companies to invest in green initiatives.

It was widely believed by participants that their customers would expect owners to have a 'green policy' in place and from those responding from SE Asia 77% were actively investing in being green compared to 70% in the UK.

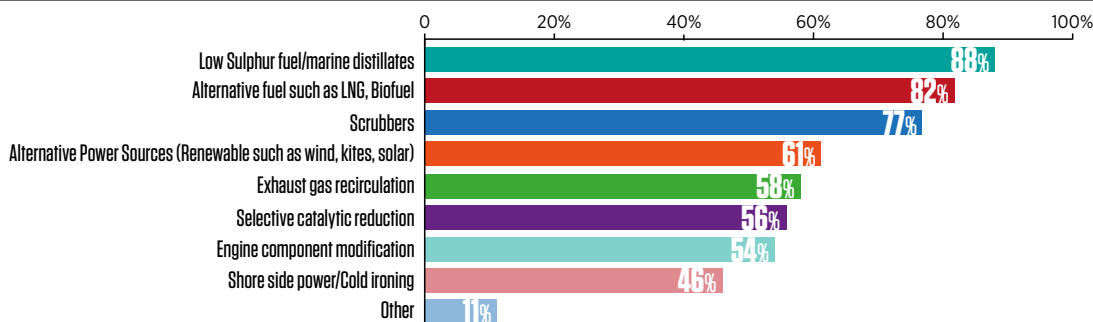


One of the most valuable results of the survey provided the following indications of awareness of various environmental processes within the community in SE Asia:

Awareness of green initiatives which impact greenhouse gas emissions:

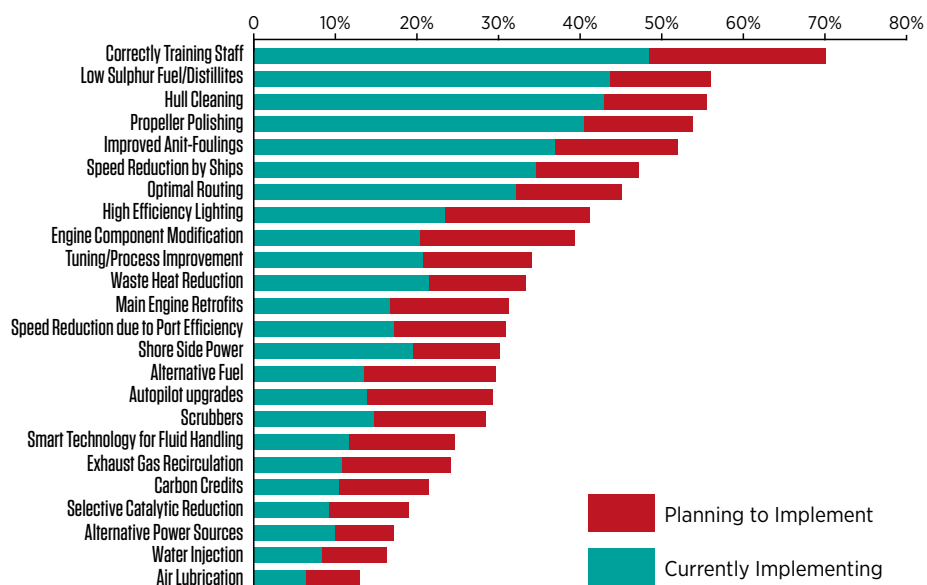


Awareness of green initiatives which impact NOx and SOx emissions:



TAKE UP OF GREEN INITIATIVES

Respondents to both surveys were asked to indicate the green measures they had taken up, or were considering adopting, and the combined results, which enable a broader picture, are shown:





ROUND TABLE DEBATE

The debate covered a wide range of topics and indicated a clear distinction between those practices that are mandatory and required by international legislation, and those that can make a significant contribution to improving the environment but which are at the behest of an owner and are voluntary.

THE INCENTIVE TO BECOME GREEN

Ships becoming more energy efficient will result in cost savings alongside the reduction in greenhouse gas emissions. However, implementing the technological and any operational changes required involves some complex cost-benefit analysis. Where those changes are related to ship design, there is perception that ship owners and ship operators are willing to incorporate measures to become greener when considering new builds. In order to undertake retrofits on existing ships, the technology has to be proven to be able to achieve large percentage improvements in performance.

There are other green technologies – largely those which reduce air pollutants (SOx and NOx) and those which mitigate against the introduction of alien species in ship's ballast water which don't bring any commercial benefit and where the incentive is to avoid non-compliance with legislation.

Singapore provides a number of incentive schemes under its Green Ship, and Green Port programmes both for those under the Singapore flag and others.

The Green Ship Programme encourages Singapore-flagged ships to reduce carbon dioxide (CO₂) and sulphur oxide (SOx) emissions with qualifying ships enjoying a reduction of Initial Registration Fees and a rebate on Annual Tonnage Tax. These incentives are maximised for ships going above and beyond the requirements of regulation.

- Ships that adopt energy efficient ship designs exceeding IMO's Energy Efficiency Design Index (EEDI) will enjoy 50% reduction of Initial Registration Fees and 20% rebate on Annual Tonnage Tax.
- Ships that adopt approved SOx scrubber technology exceeding IMO's emission requirements enjoy 25% reduction of Initial Registration Fees and 20% rebate on Annual Tonnage Tax.
- Ships that adopt both energy efficient ship designs and approved SOx scrubber technology exceeding IMO's requirements enjoy 75% reduction of Initial Registration Fees and 50% rebate on Annual Tonnage Tax.

The Green Port Programme encourages ocean-going ships calling at the Port of Singapore to reduce the emission of pollutants. Ocean-going ships that use approved abatement/scrubber technology or burn clean fuels (where clean fuels are defined as fuels with sulphur content of less than 1.00% m/m) during the entire port stay of 5 days or less within the Singapore Port Limits (from the point of entry into Singapore Port Limits till the point of exit) are granted 25% reduction in port dues; or if using clean fuels only while at berth will be granted 15% reduction in port dues.

Finally, the Green Technology Programme encourages local maritime companies to develop and adopt green technologies by providing a grant of up to 50% of total qualifying costs to co-fund the development and adoption of green technological solutions/systems. Grants are capped at S\$2 million per project, with an increased cap of S\$3 million per project for solutions/systems that can achieve more than 10% reduction in emission levels. The Green Technology Programme is open to Singapore-registered companies engaging in maritime-related businesses such as terminal operations, ship operations and harbour craft operations and a number of criteria apply.

However, despite incentives such as those described there is a general feeling that a ship owner has to have a positive green agenda and a desire to be portrayed as being green. Whilst most involved in the sector agree in principle with the concept of green shipping, they often take no action. It is essential that those involved in decision making take longer term views – the incentive needs to be a combination of a business driver plus a desire to make change. A step change could occur where social and environmental costs are perceived and ultimately treated differently, forcing a change in the whole model of shipping.

ACHIEVING A LEVEL PLAYING FIELD

A level playing field across international shipping and within ports would significantly improve the situation with examples of measurement, incentives and regulation discussed here.

Measurement

The geography of SE Asia, in particular in relation to the Port of Singapore, makes studies of air pollution difficult due to the impact of air pollution generated from neighbouring countries and vice versa. As such, measurements made from Singapore are probably not a very true indication of the air pollution produced by the port. Comparisons to other ports are, therefore very difficult.

“It is very difficult to quantify the savings that may be achieved through improved machinery efficiency and/or slow steaming when the bunker market is so volatile”

Los Angeles, for instance, is in a valley and the associated temperature inversions can lead to an exacerbation of the problem. Factors such as air pollution generated from neighbouring states, or a lack of comparison with other ports can result in a lack of willingness to make change. The key question is how can accurate measurements be made and compared?

Incentives & Taxation

A consistent financial programme incorporating incentives, taxation or both could help the shipping industry become greener. However, consistency in the incentives and taxation is key.

The Green Award certifies ships that are extra clean and extra safe. Ships with a Green Award certificate reap various financial and non-financial benefits. By rewarding high safety and environmental standards in shipping, the Green Award makes above standard ship operation economically more attractive. The Green Award certification scheme is open to oil tankers, chemical tankers and dry bulk carriers from 20,000 DWT and upwards, LNG and container carriers and inland navigation vessels. The Green Award procedure is carried out by the Bureau Green Award, the executive body of the independent non-profit Green Award Foundation. Rotterdam was the first port in the world to reward ocean-going LNG tankers which possess the Green Award certificate. Here, the Port Authority gives these ships a 6% discount on port dues when they arrive in Rotterdam. At ports in Belgium, Canada, Latvia, Lithuania, the Netherlands, Oman, New Zealand, Portugal and South Africa, the Green Award vessels also receive a considerable reduction on port dues.

Norway is another example where a financial programme is used with a NOx tax forcing a level playing field. In 2006, the Norwegian Parliament endorsed a tax policy on the emission of NOx from national shipping, among other sources, to be applicable from January 1st, 2007. The tax amounts to 2 Euros per kg NOx emitted from ships, fishing vessels and other industries. As an alternative to paying the tax, industry can voluntarily sign an environmental agreement. Companies that sign

ROUND TABLE DEBATE – CONTINUED

an agreement will be exempt from paying NOx tax in return for making a commitment to the obligations laid down by the business sector's NOx fund, whose primary task is to provide funding for NOx-reducing measures.

The UK car scrappage scheme can be considered as a case study where another sector has made an approach to improve its environmental footprint with government support. The scheme was introduced to encourage UK citizens to purchase a new car or van and scrap an old one that they had owned for more than 12 months. Would such a scheme work within shipping in order to incentivise the new build market and remove older ships from operations?

Regulation

The real way of ensuring a level playing field is to introduce global regulation, uniformly enforced with mandatory compliance. Hereby, legislation and consistent enforcement can be an enabler- where ship owners know the rules and can then work on operational efficiencies. Ideally, the IMO regulatory process needs to speed up in order to avoid a plethora of additional regional and national legislation. In some cases this is already occurring, such as within the EU and Japan, for example. Bureaucratically, different legislation makes compliance much harder and the IMO should be setting the overarching regulation.

Even with all the steps in place to ensure a level playing field, there will continue to be different types of ship owner those who will just comply with regulations with their main focus to remain competitive and those who may be considered "green" ship owners that will do more than is required, driven by a desire to protect the environment.

A HOLISTIC APPROACH

Shipping is a low margin industry and needs to be considered within a much broader transport system- road, rail and air. There are different challenges related to the greening of individual technologies, the greening of a ship, the greening of a fleet and the greening of a route. The challenge in protecting the environment is going to result in some wins and some loses and involves a careful balancing act. For example, scrubbers used to remove SOx can also produce chemicals that may cause harm and ballast water treatment systems (BWTS) are likely to result in an increase in energy consumption. By taking a holistic approach,

accepting there is unlikely to be an optimal solution can lead to the perfect application of imperfect solutions.

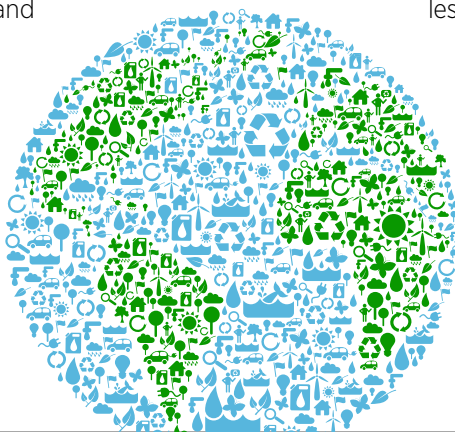
Investments in research and development can support the industries to develop green technologies. However, many nations do not have either the workforce or funds to develop this capability and a balance needs to be struck between those nations that can afford to invest with those who cannot. Developed countries should take practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to others.

Combining all the promises of all companies offering optimisation and other measures should potentially lead to maximised environmental performance. However, some of the measures are particularly challenging.

Hull form presents one challenge; the optimisation of hull form needs to be based on vessel specific operations and draft and should be related to every point in operation. For example, a ship with a bulbous bow will be optimised for a certain draft and if the ship is not operated at that draft the bow accounts for less efficiency. The design needs to be reconfigured for a range of different drafts, loading conditions, and operational routes. This is similar to propulsion- pitch and angle. One limiting factor may be that the majority of shipyards are either not able to technically achieve any further optimisation, or do not believe that any further optimisation can be achieved.

A second challenge is in operations. For a container ship, speed is always the main consideration along with logistics. Logistics become important where slow steaming causes inventory to be held at sea. This might not be the most cost effective solution with customers typically expecting the ship to be there when they are told it is going to be there. However, the primary influence is economics. When interest rates are low the differential between getting things on time or later becomes less relevant. In addition the fuel price influences motive and designs are changing accordingly with the need to save fuel.

Finally, a number of companies are promising big improvements in performance and big reductions in cost via the application of new technologies such as improved coatings. A number of schemes such as the "Save as you Sail" programme of the Sustainable Shipping



“It is easier to think up reasons not to do something than it is to create positive action”

Initiative will fund retrofitting of technologies with the proviso that the provider of those technologies guarantees the return on investment. However, working out the uncertainty in the measurements made on ship regarding efficiency then becomes a critical factor, particularly where the uncertainty may be bigger than the saving.

THE BALLAST WATER PROBLEM

The issue surrounding the delay in the ratification of the ballast water management convention could be received as a case of indifference amongst the shipping community to consider greener shipping. The delay in legislation is leading both to significant problems in the development of technical solutions, even resulting in the bankruptcy of companies and hereby a globally reduced technical capability. Additionally, although many of the treatment systems are ready, the ship owners are not proceeding with buying any due to the type approval process being inconsistent and the lack of security that the system will eventually compile.

INCREASING AWARENESS OF THE STATE OF THE GLOBAL OCEAN

To enable a shift change in attitudes towards green shipping there needs to be a better awareness of the state of the global ocean. It is very difficult to convince a politician of a problem that cannot be visibly seen versus one that has high coverage. To convince politicians to invest in mitigation of environmental issues is made harder by the fact that other social and health issues are more emotive. Additionally, history teaches us that big incidents often need to happen to drive change – such as lives lost at sea resulting in the requirement for fitting life boats. Similar incidents don't happen with climate change and any potentially chronic problems resulting from climate change cannot be seen.

However, the state of the global ocean is becoming increasingly relevant. An era has been reached where there is a much better understanding of the state of the ocean and the impact our human actions are having are beginning to be seen. As a consequence all these issues will be at the forefront of the minds of politicians who are likely to drive the legislation. This legislation is likely to enter into force/become necessary in the next decade and will be global and will mean governments have to implement national laws.

SHIPS AS OCEAN OBSERVATORIES

The aforementioned lack of understanding of the importance of the ocean means the shipping industry is less engaged than it should be. In order to increase knowledge on the state of the ocean and to encourage shipping companies and crew to improve their understanding, there could be benefits to shipping companies pledging to provide information about the environment they are travelling through (for example collecting data on temperature, seawater composition etc.). This can be done by fitting oceanographic sensors at early stages of shipbuilding. There are a number of schemes that facilitate this, but there needs to be a coherent approach where data is sent back to a common database. The problem is that there is a layer of organisation required to drive this forward that doesn't presently exist and for shipping companies that already collect data there is perceived to be little support from those working on the data side and little return of information. Thus, succession is lost. For example, when a new superintendent takes over there is little understanding of the purpose and benefit. This principle would be easier for the big companies to invest in but a huge expense for the smaller ones. The data requirements and benefits need to be well highlighted to encourage engagements.

Could there be a common policy on the provision of oceanographic data from ships using the mechanisms of the IMO? At present Automatic Identification System (AIS) data is the only data that falls within this category. From this, there will be increasing benchmarking of operators against each other using information such as speed profile, emissions and anchorage. This information is very accurate (errors of only 5%) and is a very powerful big data source. AIS data is opening up human behaviours at sea and is just the starting point.

DEVELOPING A CULTURAL SHIFT

The lack of agreement between scientists and within the science community (in particular related to the ballast water guidelines) does not promote confidence in the shipping community. This factor, combined with a lack of understanding of issues which are not visible and easy to understand (such as invasive species and climate change) can prevent cultural changes. Culture is one of the principal barriers to greening of shipping. Everyone needs to feel responsible for the environment that we live in and to work in a culture where as much as possible is being done to protect the environment, thereby enforcing its importance in the minds of legislators.



CONCLUSIONS

The following recommendations were made by participants attending the roundtable

- A holistic approach needs to be taken towards managing environmental issues. The weakness of one needs to be balanced against the strength of another.
- Radical thinking is required to bring about change supported by sound business cases.
- New innovations should be embraced such as those within the antifouling community. Incentives should be provided for ship owners and shipping operators to take on new technologies and for industries to make them financially accessible.
- Ship owners should be encouraged to have a more open approach to sharing data and experience.
- A combination of solutions is required. For example, when you consider cars as a means of transport, fuel quality is important but how you drive the car is also important.
- Strong leadership is required in the industry, in particular related to LNG as a fuel.
- Small gains can be made everywhere rather than aiming to achieve one large gain. These collectively add up to make a big difference.
- Crew education and training is vital, in particular adequate training in the use of autopilot and holistic ship energy efficiency approaches for deck and engine.
- There needs to be improvements on the side of ports where even the most efficient ports are seen to work on old procedures. Coordination between sea and shore needs to be improved with a better ability to predict estimated departure and arrival times (EDT and ETA).
- Shipyards are likely to need to become systems integrators. Persuading ship builders and ship yards to sign up to an integrated approach is a particular challenge which may be too hard to realise unless there is a change in attitude and contractual arrangements. There is a need to avoid the conflict between ship designers and ship operators. Those who design and build and those who operate need to look at the optimal way forward.
- Centralised data and integration of data into operations should allow for better decision making, optimisation of routes etc.
- Regulators need to come up with a structure that can be worked within and be encouraged to fund R&D which can look into solutions and innovations.
- Green indexes need to be made meaningful and ship owners better informed
- Smart sensing, data networks and autonomy will all be enhanced and different contracting models for different ships will need to be introduced.

WAY FORWARD

The IMarEST has a number of Special Interest Groups (SIGs) across the spectrum of environmental shipping such as alternative fuels, emissions, ballast water and biofouling management. These SIGs will take the

conclusions from the round table and take action to address them via the production of guidance, position papers and numerous other activities. Interested parties should contact technical@imarest.org

ABOUT THE INSTITUTE OF ENGINEERING, SCIENCE AND TECHNOLOGY (IMarEST)

The IMarEST is an international membership body and learned society for all marine professionals. It is the first Institute to bring together marine engineers, marine scientists and marine technologists into one international multi-disciplinary professional body. It is the largest marine organisation of its kind with a worldwide membership of over 16,000 based in 128 countries.



Working with the global marine community, the IMarEST promotes the scientific development of marine engineering, science and technology, providing opportunities for the exchange of ideas and practices and upholding the status, standards and expertise of marine professionals worldwide.

The IMarEST has a growing network of Corporate Marine Partners who benefit from a tailored programme to support each global organisation's specific requirements. Packages provide companies with a competitive edge by investing in staff and supporting Initial and Continuous Professional Development, supporting local, national, or international promotional programmes, providing specialised recruitment solutions, accrediting training courses, creating exclusive online networking and collaborative working, developing bespoke networking events and providing company employees with access to one of the largest online knowledge resources – the IMarEST's extensive Virtual Library.

The IMarEST is a respected authority in every maritime country. It is a Non-Governmental Organisation with consultative status at the International Maritime Organization (IMO), observer status at the Intergovernmental Oceanographic Commission, the International Hydrographic Organization (IHO) and meetings related to the London Convention/London Protocol, and it has special consultative status with the Economic and Social Council of the United Nations (ECOSOC), which facilitates its access to other international intergovernmental meetings where its specialized marine expertise is of particular use, e.g., the United Nations meetings on Areas Beyond National Jurisdiction, the Intergovernmental Panel on Climate Change (IPCC) and the work of the International Seabed Authority on marine mining. It is a nominated and licensed body of the Engineering Council (UK), a member of the Science Council and has significant links with many other maritime organisations worldwide.

IMarEST runs a series of industry leading and technically excellent events and conferences as well as publishing internationally recognised publications including: The Journal of Marine Engineering and Technology; The Journal of Operational Oceanography; and The Marine Professional.

www.imarest.org

ABOUT THE SCIENCE AND INNOVATION NETWORK

The South East Asia Regional Science and Innovation Office of the UK Foreign and Commonwealth Office is based in the British High Commission, Singapore. The Science and Innovation section in the British High Commission is part of the Foreign and Commonwealth Office's global Science and Innovation Network (SIN).



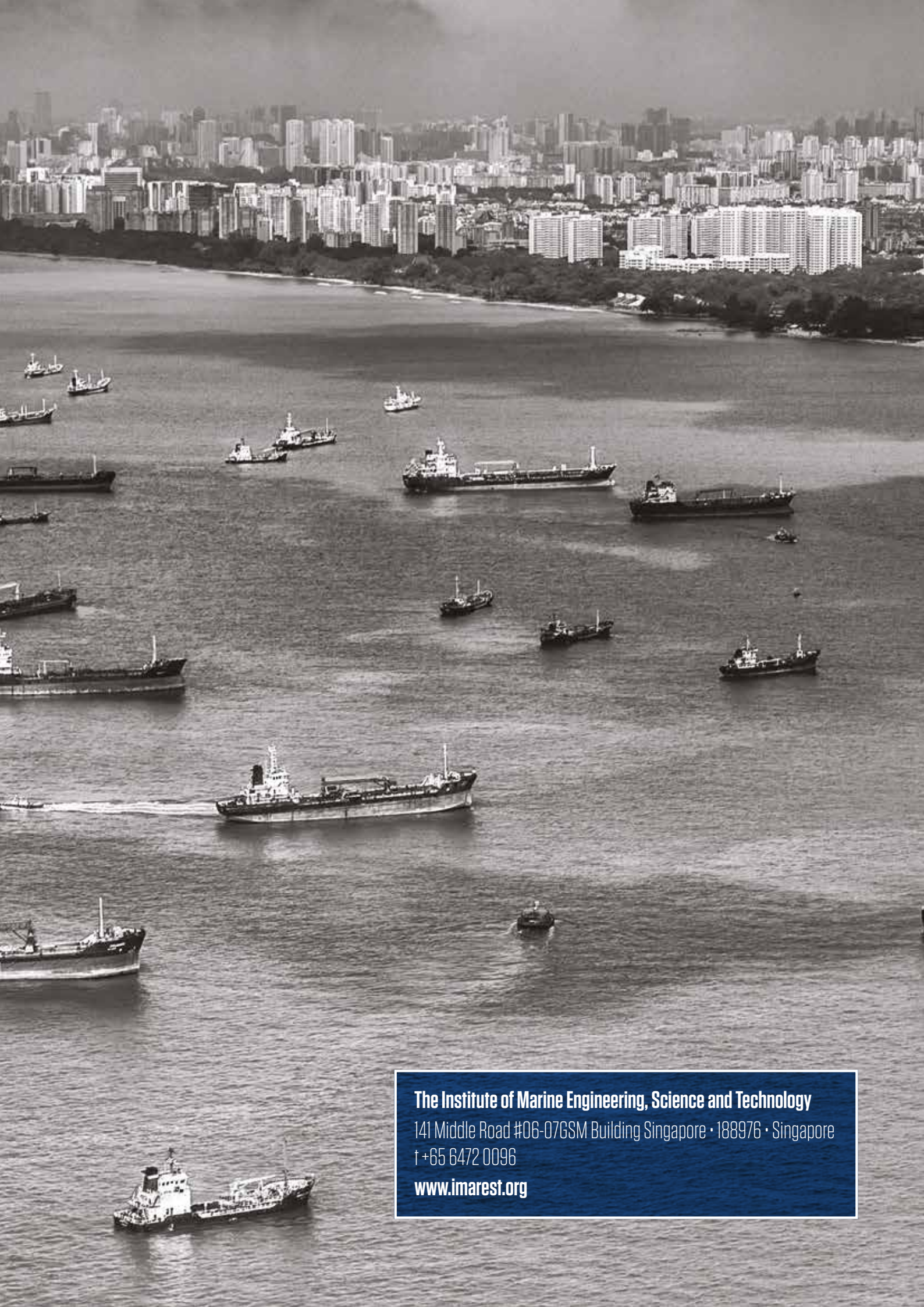
Our main areas of activity are:

- Fostering collaboration between scientists in the UK and Singapore;
- Analysis and reporting on research and technology developments in Singapore to inform UK government policy and to keep UK industries and academe abreast of developments in Singapore;
- Raising awareness of UK S&I strengths, promoting the

UK as modern, creative, successful and relevant;

- Working closely with our UK Trade and Investment colleagues to promote inward investment and trade; and
- Co-ordinating S&I activities regionally in partnership with UK missions across South East Asia

The office has arranged scientific workshops in many areas such as immunology, neuroscience, aquaculture and microelectronics to bring researchers together to explore potential collaborations. We also fund travel grants (Collaboration Development Awards) for researchers from South East Asia to visit the UK to develop collaborations further with the aim of proposals being drafted to submit to research funding bodies.



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