



SIGTTO

AT 40 YEARS

1979-2019



Society of International Gas Tanker and Terminal Operators Ltd

A COMMEMORATIVE SIGTTO ANNIVERSARY PUBLICATION 2019

An aerial photograph of a large red and white LNG carrier ship docked at a terminal. The ship's deck is green and features various pieces of machinery, including cranes and piping. The terminal infrastructure, including pipes and walkways, is visible on the right side of the frame. The water is a deep blue, and other industrial structures are visible in the background. A large, semi-transparent white rectangular box is overlaid on the ship's deck, serving as a background for the text.

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A SIGTTO 40th anniversary commemorative publication

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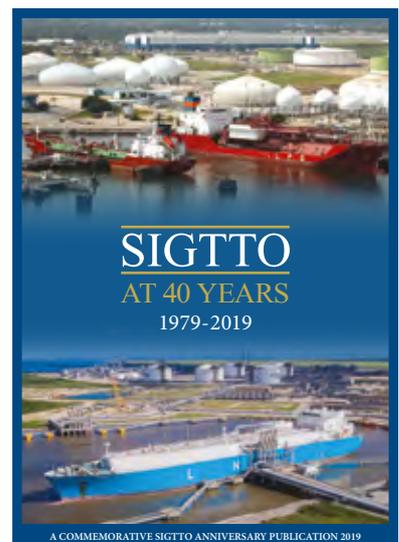
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*Top photo: Unigas ships at a Houston
LPG/chemical gas terminal, courtesy
Unigas; and bottom photo: LNG Unity
at Sabine Pass, courtesy TOTAL*

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Time to celebrate!

SIGTTO brought to book

Welcome to SIGTTO's 40th anniversary publication. This special issue is a celebration of the sterling service provided by the Society on behalf of the liquefied gas shipping and terminal industry over the past four decades. If the exemplary safety record achieved by those involved with handling liquefied cargoes is any reflection of the positive impact made by the Society over the years, and there is every reason that it should be, then SIGTTO does indeed have something to celebrate.

The backbone of this issue is comprised of 31 contributed articles by people who have played key roles in SIGTTO activities over the years. The compilation includes six submissions by SIGTTO General Managers, six by former Technical Advisers, five by past and present Presidents and Vice Presidents and eight by former and current members of the Society's General Purposes Committee (GPC). There are also six 'miscellaneous' contributions, including input from the Company Secretary, SIGTTO's publisher, the organiser of the Gastech series of meetings and a representative of the US Coast Guard.

Many of the contributors are SIGTTO multi-taskers, having served the Society in a diverse array of roles other than the one they are most renowned for. All have had long and varied careers in industry and in many of the commentaries you

will read in the following pages it is interesting to note how their day jobs and work for SIGTTO intertwined to the great and strategic benefit of both.

Taken in aggregate, the personal commentaries provide a unique insight into how the LNG and LPG sectors of the liquefied gas industry evolved and how SIGTTO helped the industry meet all the safety challenges encountered along the way. Details about early careers and work on key SIGTTO projects, such as the revision of the *International Gas Carrier (IGC) Code* and IMO Type C tank filling limits, are complemented by humorous anecdotes about people, places and situations encountered enroute and views on future challenges and optimum solutions.

Not all the contributions have a personal history/SIGTTO experience focus. Some of our authors have turned their attention to specific issues, such as liquefied gas project risks and certain technologies that, while holding great initial promise, have yet to realise that potential. We also include a feature on the pioneering industry leaders and teachers who did so much to set the liquefied gas industry off on the right course 40 years ago.

From a personal point of view, my own journey intersected with SIGTTO on several occasions in the early days, as I commenced my maritime journalism career at the time the Society was established. I was able to

help out with an edit of the first edition of *Liquefied Gas Handling Principles* back in 1986 and some subsequent editing work on other early SIGTTO publications. And throughout those first two decades I took pleasure in informing the readers of my own publications about the role and sterling work of the Society.

Since 2002 my path has been firmly aligned with that of the Society, as that is the year in which I started editing the biannual *SIGTTO News* newsletter, with Issue No 7. We replaced what had been launched in 1998 as a publication with a few pages of typed text and inset photos with a 12-page, full-colour, typeset periodical. More recently, we have done a similar upgrading job on the SIGTTO Annual Reports.

Shortly after the appearance of the revamped newsletter, SIGTTO issued two special Supplement publications, i.e. *Reminiscences of the Pioneering Days of LNG Transport* by William duBarry Thomas and Alex Pastuhov in 2003 and *Bulk Liquefied Gas by Sea: The Early Years* by former Society General Manager Robin Gray in 2004.

I had the good fortune to work with the authors in getting these two documents together and it is hard to imagine writers better qualified for the task. Alex Pastuhov helped develop the LNG containment system fitted on board *Methane Pioneer* while Barry Thomas worked on the designs of *Methane Pioneer*, *Methane Princess* and *Methane Progress* and actually sailed on the *Methane Pioneer* voyage that carried the first-ever LNG cargo. For his part Robin Gray worked at the shipyard in the North East of England that built several of the pioneering LPG carriers.

Another special publication I edited was *LNG Shipping at 50*, a 124-page commemorative issue compiled in 2014 on behalf of SIGTTO and GIIGNL in celebration of a notable golden jubilee. The publication received great praise for its comprehensive coverage of the past, present and future of LNG shipping.

This commemorative publication, too, has been a joy to work on. For a start, I've had a chance to liaise with the authors, many of whom I worked with in the past, and to discover more about their contributions to an eminently successful Society. Secondly, I've also gained greater insight into how SIGTTO established those early foundation stones that have stood it and the liquefied gas industry in such good stead over the last four decades. I know our readers will find much to enjoy in the following pages.

Mike Corkhill - Editor

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More than anything, the story of MISC is one of remarkable numbers. From its humble beginnings in 1968 with only two cargo ships, MISC today moves energy across the seas, with its fleet of close to 120 LNG, Petroleum and Product vessels, 15 Floating Production Systems (FPS) and two LNG Floating Storage Units (FSU). Yet our most significant number is 50, which signifies half a century of excellence with a proven track record of safety, reliability and on-time deliveries. Today, we are one of the world's leading providers of energy related maritime solutions and services. Imagine what we would achieve in the next 50 years.





All on board for a journey of discovery



I would like to extend to you all a very warm welcome to this, SIGTTO's 40th anniversary commemorative publication. This special issue is a celebration of the Society's first four decades in serving the liquefied gas shipping and terminal industry.

It has been quite a journey from the very early days of the Society to today. Forty years ago gas shipping was a fledgling industry, minute in comparison to the burgeoning oil tanker trades. There were only around 50 LNG and 150 LPG carriers in service. The LNG fleet primarily served a handful of dedicated projects while LPG carrier operations were piecemeal in nature.

Today, there are approximately 1,450 LPG and chemical gas carriers in service while the LNG fleet, which has now completed over 100,000 safe voyages without the breach of a containment system, is nearing 600 vessels. The majority of these LNG and LPG ships have been added to the fleet in the last 15 years. Stemming from these fleet expansions,

annual movements of LNG topped the 300 million tonnes (mt) mark in 2018 while the trade in LPG is set to exceed the 100 mt level for the first time this year.

The journey from 1979 to 2019, for both SIGTTO and the gas ship and terminal industry in general, has been a memorable one. It has also been a voyage of discovery for all the participants concerned, as we faced up to new challenges and corralled an industry's worth of expertise to meet them.

The first-hand accounts of a number of industry stalwarts who have served SIGTTO over the years have been brought together for this commemorative issue to give you some unique insights into the Society's journey and the foundations of its success.

The Society was formed in October 1979 which, coincidentally, was also the month I joined the UK Merchant Navy! I spent most of my 19 years at sea, from cadet to master, on gas ships!

I first became aware of SIGTTO in the early 1980s through its publications, including the first edition of *Liquefied Gas Handling Principles*. Little did I know that I would be the Society's General Manager when the fourth edition was published! I also recall the early days of the SIGTTO electric ship/shore link on board LPG vessels which followed the pendant and pneumatic links.

I met Chris Clucas, a key contributor to the work of the Society over many years, for the first time when I was chief officer, and prior to becoming master, with Dorchester Maritime. Chris was the company's gas consultant at the time and was already an active player in SIGTTO.

While working at Golar LNG in 2004, I was sent on secondment to the Society, working alongside James MacHardy and Roger Roue, then General Manager and Technical Adviser, respectively. I took over as the Society's second Technical Adviser from Chris Snape, with whom I had been

a cadet at Fleetwood Nautical College some years previously. Small world! Upon finishing my tenure as Technical Adviser, I joined BP but maintained my contact with SIGTTO as chair of the Society's Panel Meetings from 2008 to 2012.

It was a great honour and privilege to be appointed SIGTTO's eighth General Manager in 2012. Over the past few years the Society has developed, in tandem with the growth of the industry, into a modern, efficient organisation with more resources at our disposal and more activities underway than ever before. The latest jewel in the crown was our move to a new office last year after 25 years at our previous City of London address. The spacious and bright new premises will meet all the Society's anticipated needs for the foreseeable future.

When I look at the list of contributors for this publication, it is like a gas shipping and terminals hall of fame! There are some legendary names on our guest author list and I have greatly enjoyed their commentaries. I have always thought of myself as being fairly well up to speed with the annals of the Society but I found much new about SIGTTO to inform and amuse in the publication's pages. As you will see from the contributed articles, it has been a journey of discovery for all of us over the past four decades.

SIGTTO relies on its members to identify the need for and develop the industry best practice guidelines for which the Society is renowned. SIGTTO's Board of Directors plays a key role in directing this effort, assessing priorities and identifying the most appropriate way to bring the necessary resources to bear to achieve the desired goal with each project we tackle.

We look forward to continuing to apply this winning formula in the years ahead. In the meantime, until we celebrate our 50th anniversary in 2029, please enjoy *SIGTTO at 40!*



Golden Pass was one of the LNG export projects given the green light to proceed early in 2019; in this case for the construction of liquefaction trains at an existing import terminal

Wind set fair for liquefied gas trades



The various liquefied gas trades served by the Society's ship and terminal members are all on the rise, driven by strong demand, plentiful gas supplies, environmental concerns and supply chain technology advances. **Mike Corkhill** investigates

The two most important drivers for change in the liquefied gas trades in recent years have been the development of the vast shale gas resources of the US and global concerns about the environment and the need to reduce greenhouse gas emissions.

In the early years of the new millennium the energy-hungry US was anticipating huge volumes of LNG imports to compensate for depleting domestic gas reserves. It is interesting to note that one of the speakers at SIGTTO's Autumn 2003 Panel Meeting in Hamburg predicted that the US would grow from being a relatively minor LNG market, with just over 4 million tonnes (mt) received in 2002, to one importing 40 million tonnes per annum (mta) by 2010.

Shale gas gold rush

At about the time of that presentation, as a range of new LNG import terminals were under construction along the US Gulf Coast, George Mitchell, after many years of experimentation, discovered a hydraulic fracturing method which made the production of shale gas

commercially feasible. His successful work on the Barnett Shale fields in north central Texas was soon followed by similar plays in other shale formations, and the shale gas gold rush was on.

Overnight, the US, and the global, energy picture was transformed. As the decade progressed, the flow of US shale gas was so strong that the operators of the now completed but idle LNG import terminals decided to construct liquefaction plants on their premises to give their facilities a bi-directional capability and enable LNG exports.

It is not just LNG that has been impacted. Today, liquefied gas exports from the US are a particularly notable feature of the strong growth being experienced in a number of gas trades. The country's shale gas phenomenon has already propelled the US to the top spot amongst LPG-exporting countries worldwide and holds the potential to do the same thing in the LNG sector.

Thanks to shale gas, exports of ethane from US East and Gulf Coast terminals have also been inaugurated in recent years, including in very large ethane carriers

(VLECs) of 87,000 m³. Agreed purchase contracts with US sellers are set to make ethane the fourth largest gas carrier cargo, after LNG, LPG and ammonia, by 2020.

Finally, the volumes being produced of ethylene, a key petrochemical building block, are beyond even the needs of the burgeoning US chemical sector. To take advantage of the excess ethylene that has become available in the US, the world's first worldwide ethylene export terminal is scheduled to begin commissioning in Texas later this year. The facility will have a 60,000 m³ storage tank and the capacity to export 1 mta of ethylene, with relatively high loading rates. Infrastructure projects such as these help overcome the bottlenecks hindering growth in seaborne movements.

Offsetting global warming

Climate change is now a hot political topic worldwide. Although the push for a net 'zero emissions' environment at some point post-2050 has gained significant momentum, achieving that goal globally will present major challenges. There will have to be some bridging fuel amongst those currently available to fill the gaps that renewables may not be able, for the time being, to cover.

Of the fossil fuels, natural gas burns the cleanest and more and more governments are launching green policies which call on industry to substitute the use of gas in plants that traditionally consumed oil or coal. China's recent effort to switch from coal to gas as part of a programme to clean up its polluted cities is a case in point.

The good news for gas buyers and consumers is that there are plenty of reserves worldwide. In addition to the US shale gas resources, Australia, Qatar, Russia and Canada are rich in gas and sizeable new deposits continue

to be discovered, as evidenced by the recent finds off Mozambique and in the Eastern Mediterranean.

The cause of the gas user has also been buoyed by the services offered by the ship and terminal members of SIGTTO. The provision of larger, more fuel-efficient and well-manned ships; the introduction of improved containment and propulsion systems; and the growing use of floating regasification vessels have enhanced the safe, reliable and efficient deliverability of gas cargoes.

Steady LNG export growth

The seaborne trade in LNG increased by 8.3 per cent year-on-year in 2018, to reach 314 million tonnes (mt), following expansions of 9.9 per cent in 2017 and 7.5 per cent in 2016. Our colleagues at the International Group of LNG Importers (GIIGNL) in Paris, who maintain comprehensive statistics on global LNG movements, point out that last year's annual trade growth was the LNG industry's third largest on record, after 2010 and 2017.

Argentina began shipping cargoes in recent months, boosting to 21 the number of LNG export nations worldwide. On the import side of the equation, there are now 42 countries around the world receiving LNG carrier deliveries of the product, following the commencement of shipments to Bangladesh and Panama in 2018.

In terms of additional LNG export capacity in 2018, the prime movers were Australia, the US and Russia. The three countries were responsible for all eight of the new liquefaction trains commissioned last year, with Australia and the US each bringing three onstream and Russia the other two.

The new Australian units helped boost the country's LNG production by 11.1 mt in 2018, to 66.7 mt. Australia has started operations at seven new LNG export projects in recent years and, as these new facilities complete their build-up to full production, the country is poised to overtake Qatar to become the world's No 1 LNG exporter in the coming months. Qatar shipped 76.8 mt of LNG to global markets in 2018.

The new US LNG trains helped increase that country's exports by 8.4 mt in 2018, to 20.7 mt for the year. The two Russian trains to come onstream are both located at Yamal LNG's Sabetta terminal in the Russian Arctic. The facility only commenced operations in December 2017 and over the course of last year Yamal LNG exported 7.3 mt of LNG. The surges in output from the two countries mean that the US and Russia are now, respectively, the fourth and fifth largest LNG exporters worldwide, after Qatar, Australia and Malaysia.

The US and Russian growth curves are far from complete. Thanks to the shale gas revolution, the US is set to be rivalling Qatar and Australia for the top spot amongst LNG exporters by the early years of the next decade. Recently commissioned liquefaction trains continue to build towards full output, further new trains are under construction and a number of additional US LNG export schemes have been proposed by project developers.

As regards Russia, the developers behind the Arctic 2 LNG project, located near the Yamal LNG terminal at Sabetta, expect to give the 19.8 mta scheme the green light sometime in 2019.

GIIGNL points out that approximately 25 million tonnes per annum (mta) of new LNG liquefaction capacity is expected to come onstream worldwide in 2019, of which 21 mta is in the US.

During 2018 final investment decisions (FIDs) were taken on three new LNG export projects which will add an aggregate 21 mta to worldwide liquefaction capacity. At the end of the year around 66 mta of new LNG production capacity was under construction around the world, of which 53 mta is in North America.

More export project FIDs are due in 2019. Golden Pass LNG in the US and Mozambique LNG in East Africa were given OKs to proceed in the first half while, amongst those expected in the second half, is an approval by Qatar for a major LNG expansion scheme.

LNG import absorbers

China, South Korea, India, Pakistan, the Netherlands, Belgium and Turkey absorbed most of the additional LNG volumes that became available to the market in 2018. Last year China's LNG import volumes rose by 14.9 mt, while shipments to Korea jumped by 6.1 mt, to India by 3.2 mt,

Pakistan 2.2 mt, the Netherlands 1.2 mt, Belgium 1.0 mt and Turkey 1.0 mt.

China's rise up the LNG importers' league table has been meteoric, driven by the government drive to cut pollution through switching from coal to gas use in a large number of facilities. The country purchased 54.0 mt of LNG in 2018, up from 27.4 mt in 2016, 19.0 mt in 2014 and 14.7 mt in 2012. China overtook South Korea to become the world's No 2 LNG importer in 2017; only Japan, with 82.5 mt of purchases in 2018, ranks above China.

China commissioned four new LNG import terminals in 2018 while work began on the expansion of three existing facilities. In addition the construction of two further new terminals is underway.

India is another country with a growing requirement for LNG imports. Inbound shipments in 2018 reached 22.4 mt, the world's fourth highest import total and a 16.6 per cent year-on-year jump. Three new receiving terminals are set for commissioning in 2019, to add the country's four existing facilities.

In its report on the LNG industry in 2018, GIIGNL states that 10 new LNG import terminals aggregating 22.3 mta in receiving capacity came onstream last year, while expansion projects at another three terminals were completed. At year-end, the 42 LNG import nations offered a total of 868 mta of regasification capacity.

As the calendar flipped over to 1 January 2019, eight new floating regasification terminals and 14 new shoreside receiving facilities were under construction. These 22 new import terminals are set to provide an additional 95 mta of LNG receiving capacity.

LNG carrier fleet

According to GIIGNL, the global fleet of LNGCs stood at 563 vessels at the end of 2018, of which 512 were of >



Liquefied Gas Trades

> 125,000 m³ or above in size and 33 had a capacity of under 25,000 m³. By age 462 ships were 15 years old or less, and 208 were five years of age or less.

The LNGC orderbook at the end of 2018 stood at 138 units, equivalent to 25% of the existing fleet in capacity terms. A total of 57 vessels were delivered in 2018 while 77 newbuildings were contracted during the year, both records. Some 46 LNGCs are scheduled for completion in 2019.

At the end of 2018 there were 10 floating storage and regasification units (FSRUs) on order while the in-service FSRU fleet stood at 33 units, five of which entered service during the year. Three vessels in the FSRU orderbook are due for 2019 completions.

Volume LPG

Drewry reports that global seaborne trade in LPG is expected to grow by 6.4 per cent this year, rising from 96.4 mt in 2018 and passing the 100 mt threshold for the first time to reach 102.6 mt. Over 80 per cent of this volume is carried by fully refrigerated very large gas carriers (VLGCs) of 75,000 m³ and above on deepsea routes.

US LPG exports, which rose by 12.3 per cent in 2018 to 31 mt, are expected to maintain their strong growth profile over the next two years. BW LPG predicts that the country's net overseas shipments will climb by 13.6 per cent to reach 35 mt in 2019 and then surge a further 17.4 per cent in 2020 to top 41 mt for the year.

The Middle East as a whole exports a slightly higher volume of LPG than that of the US but the region's output is relatively stable and shipments from the US will begin to match the Middle East total as the country's rich shale gas resources continue to be exploited. Saudi Arabia, Qatar and Abu Dhabi are the Middle East's principal LPG exporters, with each of the three producing around 10 mt for overseas sales.

China imported 17.2 mt of LPG in 2018, a 5 per cent year-on-year rise, while Japan's imports, at 10.6 mt, were 3 per cent down. Indian LPG imports showed the strongest growth in 2018, jumping 12 per cent to 8.3 mt. Other key LPG import regions and countries in 2018 were South East Asia, with 8.1 mt, and South Korea, with 6.8 mt.

The LPG/chemical gas fleet

BW LPG, the operator of a large VLGC fleet, reports that there were 269 VLGCs on the water worldwide as of 30 April 2019. On that date there were 38 vessels on order, equivalent to 14 per cent of the existing fleet on a cargo-carrying capacity basis.

Most VLGC owners are currently specifying newbuildings in the 82-84,000 m³ size range, and the average age of



The Enterprise terminal in Houston is the world's busiest LPG export facility

the vessels in the fleet is nine years.

While 25 VLGCs were delivered in 2017, only 10 were completed last year. Five older VLGCs were scrapped in 2018.

VesselsValue has compiled LPG/chemical gas carrier fleet statistics for SIGTTO which are shown in the accompanying table.

LPG/chemical gas carrier fleet

(As of April 2019; vessel numbers include both ships in service and on order)

Gas carrier type	Number of vessels
VLGCs	307
VLECs	14
Large gas carriers (LGCs)	22
Mid-size gas carriers (MGCs)	122
Semi-ref ethylene	173
Semi-ref LPG	167
Fully pressurised ships	722
Total	1,527

Of the total fleet, 1,443 ships are in service and 84 on order

Source: *VesselsValue*

The semi-pressurised/fully refrigerated (semi-ref) ethylene carrier fleet ranges in size from small ships of 1,500 m³ working in the Japanese coastal trades to the 37,500 m³ ethane/ethylene-capable ships operated by Navigator Gas on deepsea routes.

The latter, flexible ships are capable of carrying not only natural gas liquids (NGL) feedstocks such as ethane, propane and butane but also the added-value monomers of ethylene, propylene and butadiene.

The emphasis in recent years when

specifying newbuildings has been on larger ships to enable all those along the supply chain to derive economy of scale benefits. There are now 55 ethane/ethylene-capable ships of 15,000 m³ and above either in service or on order. A number of the newer vessels burn ethane in their engines, a much cleaner source of power than traditional oil fuels.

Approximately 6 mt of ethylene is moved internationally by sea each year, and overall volumes and individual cargo parcel sizes are on the increase. Navigator states that the average ethylene cargo size had increased to 6,500 tonnes in 2016, in contrast to the 5,700-tonne cargoes that had been commonplace over the previous 10 years.

Annual movements by sea of ammonia, which is used primarily in fertiliser manufacture, stand at around the 18 mt mark. The majority of cargoes are moved in fully refrigerated large gas carriers (LGCs) of 60,000 m³ and mid-size gas carriers (MGCs) of 22,500-35,000 m³, although semi-ref ships are utilised for some shipments. The ammonia trade and fleet are relatively stable.

Fully pressurised ships are utilised as the final link in many seaborne LPG supply chains, to reach remote communities and those with limited supply requirements. The global fleet of 722 pressurised ships, which again is a relatively stable fleet, is fairly evenly split between vessels of less than 3,000 m³ and those between 3,000 and 11,000 m³ in size. Ship-to-ship cargo transfers from larger fully refrigerated LPG carriers equipped with reheaters are an important feature of the working life of many fully pressurised ships.

CONGRATULATIONS ON SIGTTO's 40TH ANNIVERSARY!



Nakilat is proud to be a member of SIGTTO for over a decade and will continue to extend our full support for the Society's endeavors in promoting further growth and development in the industry.



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TOWAGE

Nice place to start – LNG carrier owners got together at the Princess Hotel in Bermuda for their first exploratory talks on the possibility of an industry association



A trip down memory lane



Andrew Clifton*, SIGTTO's current General Manager, looks

back over the 40-year history of the Society

Although the first commercial cargo of LNG was delivered in October 1964, growth in this new maritime sector over the first decade was slow and patchy. Not surprisingly, there was no industry body dedicated specifically to liquefied gas transport, storage and handling during these formative years. By the mid-1970s, however, it was becoming apparent that the seaborne trade in LNG was about to take root and expand in Asia, Europe and the US.

Exploratory talks

Beginning in 1977 and 1978 a number of operators of the industry's pioneering LNG vessels entered into a mutual correspondence. They soon decided that the establishment of some form of industry association, in which LNG carrier operators worldwide could come together to discuss safety and reliability issues of mutual concern, warranted serious consideration. The carriage and handling of large quantities of cryogenic liquid,

which became flammable when vaporised, posed hazards that would benefit from a harmonised, industry-wide approach in the drive for risk minimisation.

Stemming from their correspondence, the operators convened a series of meetings, held between December 1978 and March 1979, to discuss the need for such an association in more detail and what the remit of this body might be. The first of the meetings took place at the Princess Hotel in Hamilton, Bermuda on 11-12 December 1978. While El Paso LNG Company was the prime organiser of the inaugural meeting, El Paso had taken note of the support given to the idea of a new industry association by a range of ship operators, including Compagnie Nationale Algerienne de Navigation (CNAN) of Algeria.

The participants at the inaugural meeting reconfirmed that the establishment of an industry body was an eminently sensible idea. The initial intention was to call the new association SIMTO, short for the Society for International Methane Tanker Operators. This reflected the fact that the early prime movers behind the initiative were LNG carrier operators.

However, attendance at the 1978/79 meetings included representation from across the broad field of liquefied gas transportation, including operators of LPG and chemical gas carriers. It was quickly recognised that any new industry body would be that much more valuable and

carry greater authority if it encompassed not only the full range of liquefied gas carrier cargoes but also the operation of terminals loading and receiving these cargoes.

Recognition of the need for a full spectrum of liquefied gas industry participants within the membership appreciated the fact that the safety and reliability issues confronting the gas ship community were broadly similar, irrespective of the cargo carried. It also acknowledged that cargo-handling operations at the ship/terminal interface represented the highest-risk activity in the overall supply chain, and that there would be great value in providing a channel of direct liaison between ship and terminal operators in matters of mutual safety and reliability.

After agreeing that the new industry body should embrace all liquefied gas cargoes carried by sea and terminal as well as ship operations, the Society of International Gas Tanker and Terminal Operators (SIGTTO) was chosen as the most appropriate name for the new association.

In these formative discussions for SIGTTO, the participants had the very ready help of senior executives from the International Chamber of Shipping (ICS) and the Oil Companies International Marine Forum (OCIMF). These two established maritime industry associations already covered seaborne liquefied gas cargo issues amongst their wide-ranging activities, and both enjoyed

consultative status at IMCO (now IMO).

A key question raised at the time was whether the perceived aims and activities of the proposed SIGTTO organisation could not be more appropriately achieved by ICS and OCIMF, either singly or in combination. It was ultimately concluded by all the parties involved that an association exclusively focused on the marine transport of liquefied gases offered the best solution. The optimum way of achieving the desired objectives would be through the creation of a single umbrella organisation as a comprehensive forum for discussions amongst liquefied gas ship and terminal operators.

SIGTTO takes wing

The end result of these formative liquefied gas meetings and inter-association deliberations was the establishment of the Society of International Gas Tanker and Terminal Operators Ltd as a Bermuda exempted, limited liability company. Membership and a shareholding in SIGTTO Ltd was open to those companies owning or operating a liquefied gas carrier or a liquefied gas marine terminal.

The first SIGTTO Board meeting was held in Bermuda on 5 October 1979 and the Society's founder members were:

- El Paso LNG Company
- Energy Transportation Corporation
- Malaysian International Shipping Corp
- BP Tanker Company Ltd
- Moore, McCormack Bulk Transport Ltd
- P&O Bulk Shipping Ltd
- Gotaas-Larsen Inc
- Marine Transport Lines
- Shell Tankers Ltd
- Exxon

A further Board meeting, with more members present, was held in Houston on 12 November 1979. At that gathering Maurice Holdsworth was appointed as the first General Manager of the Society and Barry Hunsaker of El Paso Natural Gas the founding President. At this time there were 52 LNG vessels in service worldwide.

SIGTTO's first Technical Adviser was Dick Oldham. He joined in July 1980 and he recalls his appointment well: *"Maurice Holdsworth and the 10 founder members had set up a Secretariat office near Marble Arch in London's West End. Having been a newbuilding superintendent - I built some of Shell's 75,000 m³ G-class LNG carriers for Brunei and the two 59,000 m³ I-class LPG carriers - and being used to being pretty autonomous, the attraction of an unknown and embryonic SIGTTO was pretty small. However, Maurice persuaded*

me and I became SIGTTO's first Technical Adviser in July 1980. The subsequent office in Staple Hall was much better appointed than the Marble Arch premises and my job was made much easier by the excellent members."

The first technical issues the Society dealt with were as follows:

- Contingency planning
- Ship/shore linked emergency shutdown
- Safe havens
- Cargo strainers
- Training

It is interesting to note that today SIGTTO's General Purposes Committee (GPC) is still discussing most of the above generic issues to one degree or another! Technology and the nature and spread of the industry evolve continuously and earlier editions of best practice guidelines need to be revised and updated, as required.

Within one year of the establishment of SIGTTO the membership had grown to 30 companies, including several terminal operators. One of the immediate priorities for the Society was achieving consultative status at IMO. This goal was achieved in 1982 when the membership had grown to 50 different organisations. By this time the Society had an active GPC and a well-established programme of Panel Meetings for the membership and invited guests.

Over the following years the membership expanded steadily and SIGTTO came to be acknowledged as the authoritative voice of the liquefied gas shipping and terminal industry. Its respected standing in the maritime community rested on the reputation that the Society quickly achieved for impartiality and integrity in addressing operational and safety issues. A number of industry best practice publications were produced and released for use by the

membership and the liquefied gas sector in general as a result of the consideration of topical issues by SIGTTO's GPC and the working groups it established.

General Manager roll call

Robin Gray became SIGTTO's second General Manager in May 1985, by which time the Society had over 60 members. Robin was followed in the role by Bruce Keer in June 1991 and in April 1993 SIGTTO moved from Staple Hall to a new office location in St Helen's Place, also in the City of London.

The day after SIGTTO held its St Helen's Place welcome reception IRA terrorists detonated a large bomb in the adjoining street of Bishopsgate. Fortunately, the blast occurred on a Saturday morning and no one from the Secretariat was in the office at the time. Nevertheless, the damage caused to the immediate area, including our premises, was substantial and access to the SIGTTO office was not permitted for several weeks afterwards.

In 1994 SIGTTO membership passed the 100 mark and in July 1995 Bruce Keer was succeeded as General Manager by Alain Vaudolon. Alain, in turn, was followed by John Gyles in July 1998. During the year the number of LNG ships in service reached 100.

By the time James MacHardy was appointed General Manager in February 2003, the liquefied gas industry was entering a phase of rapid expansion. Many new liquefied gas carrier operators were entering the market and, at the same time, new projects, terminals and ships were being commissioned.

Appointed as the seventh General Manager in May 2007, Bill Wayne led the Society at a time of continued great change in the seaborne transport of liquefied gases. Floating liquefaction vessels and regasification units were >



Gotaas-Larsen, a SIGTTO founder member, ordered some of the first spherical tank LNG carriers to be built



This 2004 photo shows a quartet of past SIGTTO General Managers: from left to right, James MacHardy, Bruce Keer, Robin Gray and John Gyles

SIGTTO GENERAL MANAGERS

(By tenure and their companies prior to joining SIGTTO)

Oct 1979 - May 1985	Maurice P Holdsworth (Shell)
May 1985 - Jun 1991	Robin C Gray (British Shipbuilders)
Jun 1991 - Jul 1995	Bruce E Keer (BP)
Jul 1995 - Jul 1998	Alain P Vaudolon (Petronas Tankers)
Jul 1998 - Feb 2003	John L Gyles (Shell)
Feb 2003 - May 2007	James MacHardy (BP)
May 2007 - Nov 2012	William S Wayne (Shell)
Nov 2012 - present	Andrew M Clifton (BP)

SIGTTO TECHNICAL ADVISERS

(By date of joining and company from which seconded)

Jul 1980	Dick Oldham
1983	Robin Buncombe (Shell)
Sep 1986	Roy D Izatt (Shell)
Sep 1988	Doug A Brown (BP)
Sep 1991	Richard H Chadburn (Shell)
Jul 1993	Ken Sprowles (Shell)
Jun 1994	John Cummings (Shell)
Jan 1997	Roger Roue (directly employed by SIGTTO)
Dec 1997	Marc Hopkins (BP)
Dec 2000	Gary Dockerty (Shell)
Apr 2002	Chris Snape (Shell)
Apr 2003	Andrew Clifton (Golar)
Dec 2005	Paul Steele (BP)
Dec 2007	Andy Murray (Chevron)
Sep 2008	Teo Popa (Golar)
Dec 2010	Craig Jackson (Teekay)
Jan 2011	Cherian Oommen (Maersk)
Nov 2012	Rick Boudiette (Chevron)
Jul 2014	Thierry Descamps (ConocoPhillips)
Oct 2015	Robert Steele (ExxonMobil)
Jan 2018	Rob Farmer (directly employed by SIGTTO)
May 2019	Uluc Kaypok (Shell)

> being introduced; ship and fleet size were increasing dramatically, as were the output capacities of shoreside liquefaction units; and innovative technologies, including new propulsion system types, were transitioning from the drawing board to ships under construction in the building dock.

It was during Bill Wayne's tenure that SIGTTO facilitated the revision of the *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)* on behalf of IMO. In 2008

SIGTTO formed nine working groups to carry out this revision work and the overall effort was coordinated by a steering group.

Nearly 140 experts, representing over 40 entities and 20 countries, worked on the IGC Code revision project over the course of the next two years, and SIGTTO ensured that a draft of the revised Code was delivered to IMO for consideration by that organisation (see page 78 for more details of this project).

The revised IGC Code was approved at the 92nd Session of IMO's Maritime

Safety Committee (MSC 92) in June 2013 and at MSC 93 in May 2014 it was adopted. The revised IGC Code entered into force in January 2016 and became fully mandatory in July 2016.

My own tenure

I became SIGTTO's eighth General Manager in November 2012, taking over the reins from Bill Wayne. In doing so, I became the first General Manager who had previously been a Technical Adviser for the Society.

At this point the range of people handling LNG in a marine environment was being extended due to the growing popularity of the use of LNG as a marine fuel for ships other than gas carriers. In 2013 SIGTTO formed the Society for Gas as a Marine Fuel (SGMF) to oversee the expanding LNG bunkering sector. SGMF has since become independent and a non-governmental >

Andrew Clifton

*Andrew Clifton is the General Manager and Chief Operating Officer of the Society of International Gas Tanker & Terminal Operators Ltd (SIGTTO) and has over 30 years' experience in the liquefied gas shipping industry. His gas career encompasses 19 years at sea, three of which as master, mainly on liquefied gas carriers; a first class honours degree in shipping operations; and 12 years of shore managerial experience prior to his appointment as SIGTTO General Manager.

Andrew's time ashore comprises three years at the UK's Marine Accident Investigation Branch (MAIB); time as a marine superintendent with Golar LNG; almost two years in the SIGTTO Secretariat as a Technical Adviser; and over five years in Indonesia with BP as LNG shipping manager for the Tangguh LNG project. Andrew was also the SIGTTO Panel Meeting Chairman from October 2008 until becoming General Manager in November 2012.

Andrew Clifton is the eighth SIGTTO General Manager, and the youngest at the time of his appointment. He is also the first General Manager who was formerly a Technical Adviser at the Society. On top of his SIGTTO commitments, Andrew is technical co-chair of the Gastech conference.



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> organisation (NGO) in its own right.

In 2016 SIGTTO published its first ever Strategic Plan in response to ongoing industry developments and the need to be ahead of the curve on behalf of the membership. The aim of the Strategic Plan, which was further updated in 2018, is to ensure that the Society remains relevant and fit for purpose to meet the needs and expectations of the membership in the 21st century. The Plan outlines a future vision of where activities should be directed through 2025 and explains the role of SIGTTO as society moves towards a net emissions-free world over the decades ahead.

The first-ever meeting of SIGTTO's new Human Element Committee (HEC) was held in 2016. The GPC, HEC and the Secretariat provide the vehicle through which the knowledge and information gathering within the organisation can best be promulgated to the full membership and the regulatory bodies that influence the industry. SIGTTO has now published over 50 books, recommendations and guidelines. This works out at an average of two new or updated publications per year over the life of SIGTTO.

SIGTTO is as strong now as it has ever been; the membership includes around 97 per cent of the world's LNG vessels and terminals and approximately 50 per cent of the LPG market. SIGTTO now has more members than ever before and remains the industry leader for best practice and technical support for liquefied gas shipping and terminals.

In 55 years of commercial operations, LNG carriers have delivered over 100,000 cargoes. During this period there have been no loss of cargo tank containment and no onboard fatalities directly attributable to the cargo. This is a very impressive, in fact, unprecedented, safety record for the carriage of liquid hydrocarbons at sea in bulk. SIGTTO has played a key part in achieving this safety record.

As a final point, the philosophy of the Society is best described in the words of its founding President, Barry Hunsaker of El Paso Natural Gas some 40 years ago:

"We will best achieve our goals by sharing with each other our non-proprietary technical and safety information and operating experiences through open and frank discussion. Only in this way will each of us benefit from the experience and knowledge gained by all of us and thus maximise the safety of our operations. Remember, the industry will be judged by the record of its least safe operator. Let's help ourselves by helping that operator".

Four SIGTTO decades in a nutshell

1970

OCIMF, an oil company tanker association with some limited involvement in the liquefied gas shipping sector, held its first meeting

1971

GIIGNL, an LNG importers association, was established

1977

A group of pioneering LNG carrier operators began to explore, through correspondence, the need for a dedicated LNG shipping association

1978

The LNG carrier operators met in Bermuda for the first of a series of meetings to further discuss the proposed trade organisation; it was decided to proceed with its creation

1979

The first SIGTTO board meeting was held in Bermuda, with 10 founder members and membership open to operators of all types of liquefied gas ships and terminals; Maurice Holdsworth was appointed the Society's first General Manager

1980

Membership of the Society had jumped to 30 companies by the end of the first year and had reached 50 by 1982

1982

The General Purposes Committee (GPC) was established as SIGTTO's principal technical body, and the first of what was to become a long-running series of SIGTTO Panel Meetings was held

1983

SIGTTO was granted consultative status at IMO

1984

SIGTTO published *Hydrates in LPG Cargoes – A Technological Review*

1985

Robin Gray succeeded Maurice Holdsworth as General Manager

1986

SIGTTO published the 160-page 1st Edition of *Liquefied Gas Handling Principles*

1987

SIGTTO published *Recommendations and Guidelines for Linked Ship/Shore Emergency Shut-Down of Liquefied Gas Cargo Transfer*

1991

Bruce Keer became the third SIGTTO General Manager

1993

SIGTTO moved to new offices in the City of London, at 17 St Helen's Place; no sooner than the move was completed when the nearby explosion of a terrorist bomb caused considerable damage and necessitated temporary accommodation for almost a year

1994

SIGTTO membership passed the 100 mark

1995

Alain Vaudolon succeeded Bruce Keer as General Manager

1997

The global fleet of LNG carriers in service reached 100 vessels

SIGTTO and IACS jointly issued *Application of Amendments to Gas Carrier Codes Concerning Type C Tank Loading Limits*

1998

John Gyles was appointed SIGTTO's fifth General Manager

SIGTTO issued its first newsletter; the publication, featuring typed sheets and inset photos, was upgraded to a 12-page, full-colour, biannual, typeset periodical with Issue No 7 in 2002

2000

SIGTTO's LNG LOG No 26, a statistical record of all LNG carrier voyages through December 2000, was the last in the series; the matrix of ship voyages and loading and discharge terminals had become too unwieldy to maintain

2001

Annual movements of LNG totaled 104 million tonnes (mt), exceeding the 100 mt mark for the first time

2002

SIGTTO organised its first Regional Forum, an event for its Scandinavian members in Oslo

2003

James MacHardy succeeded John Gyles as General Manager

SIGTTO issued *Reminiscences of the Pioneering Days of LNG Transport* as a special Supplement publication

SIGTTO published two core documents: *A Guide to the Safety of LNG Operations in Port Areas and Crew Safety and Training Standards for Large Gas Carriers*

2004

Following on from its 2003 publishing activity, SIGTTO issued a third core document, i.e. *Liquefied Gas Fire Hazard Management*

SIGTTO celebrated its Silver Jubilee with an evening reception at the IMO headquarters building in London

SIGTTO extended its Associate Member terms to enable class societies and port authorities playing host to liquefied gas terminals to join the Society

SIGTTO issued *Bulk Liquefied Gas by Sea: The Early Years* as a special Supplement publication

2005

The Society welcomed its first Russian and Chinese members

2006

IMO adopted SIGTTO's recently published *Competency Standards for Officers on LNG Vessels*

The SIGTTO/GIIGNL online database of combined ship and terminal information was put into service and made available to the membership

SIGTTO held its first Panel and GPC meetings in India, in Mumbai in April

The 200th in-service LNG carrier was commissioned

2007

Bill Wayne was appointed SIGTTO's seventh General Manager

2008

A global industry-led initiative to carry out a major revision of IMO's *International Gas Carrier (IGC) Code* was launched, with SIGTTO coordinating the effort

The Society's *LPG Shipping Suggested Competency Standards* was published

SIGTTO's publishing capabilities were strengthened when Witherbys merged with Seamanship International

The global fleet of LNG carriers in service reached 300 vessels

2011

The *SIGTTO LNG/LPG Officer Experience Matrix and LNG Ship to Ship Transfer Guidelines* publications were issued

The SIGTTO Board agreed that providers of specialist escort and harbour tug services at LNG terminals are entitled to associate membership

2012

Andrew Clifton became the first SIGTTO General Manager to have previously served as a Technical Adviser at the Society

2013

SIGTTO was instrumental in establishing the Society for Gas as a Marine Fuel (SGMF) as a new non-governmental organisation (NGO) to oversee the use of LNG to power all types of ship

The layout and design of the biannual SIGTTO newsletter was revamped, with the 'SIGTTO blue' replacing the old red headings and banners

2014

SIGTTO published *Guidance for LNG carriers transiting the Panama Canal*

The SIGTTO membership passed the 200 mark

The global fleet of LNG carriers in service reached 400 vessels

2015

SIGTTO published *Support Craft at Liquefied Gas Facilities – Principles of Emergency Response and Protection*

The associate membership criteria was amended to permit providers of liquefied gas training as well as operators of compressed natural gas (CNG) carriers and container

ships carrying LNG in cryogenic ISO tank containers to join SIGTTO

A Liquefied Gas Senior Executive Forum, the first in a new series of annual US conferences involving SIGTTO, SGMF and the US Coast Guard, was held in Houston

2016

The revised IGC Code entered into force on 1 January and became mandatory for all new ships with their keel laid on or after 1 July

Following a major update, the 530-page 4th Edition of *Liquefied Gas Handling Principles* was published

SIGTTO's new Human Element Committee held its first meeting

The Board approved the Strategic Plan 2016, which outlines a 2020 vision of where the Society aims to be at the end of the decade

2017

The *International Code for Ships using Gas or other Low Flash-Point Fuels (IGF Code)* entered into force on 1 January

The global fleet of in-service LNG carriers reached 500 vessels

The Floating LNG Installations Sub-committee was established as a subsidiary body of the Society's GPC, initially with three of its own working groups

2018

SIGTTO moved offices a short distance across the City of London, to 42 New Broad St, after 25 years at 17 St Helen's Place

The SIGTTO Panel Meeting held in London in April was the 64th in the series

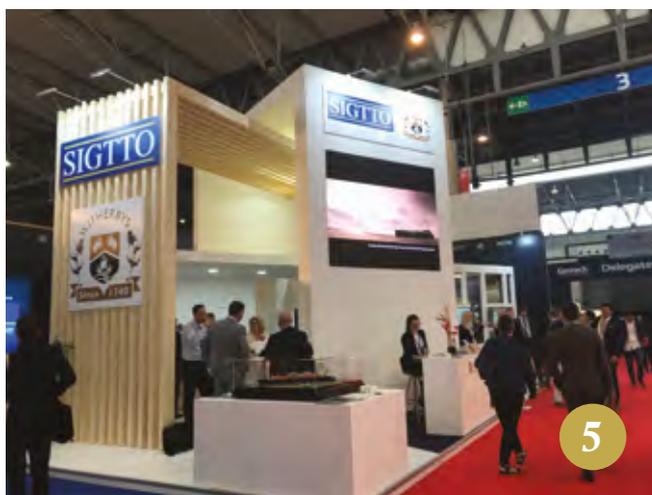
General Manager Andrew Clifton was appointed co-chair of the Gastech Technical Committee

2019

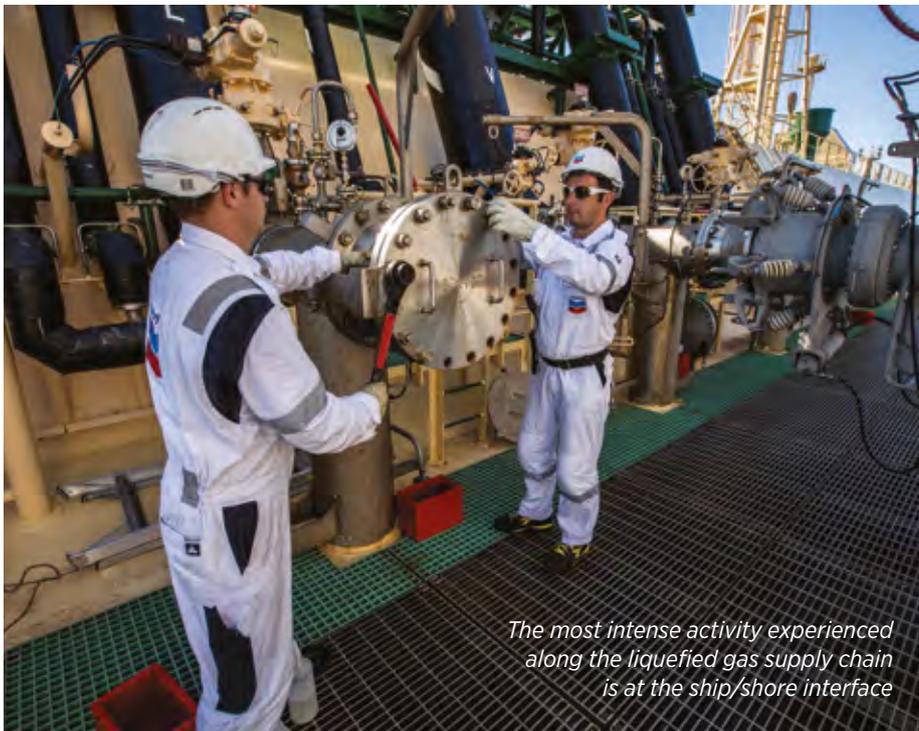
SIGTTO celebrated its 40th anniversary, not least with this special publication and a celebratory reception to be held in London, scheduled for 10 September

The Board approved *Recommendations for Management of Cargo Alarm Systems*, a new Human Element Committee document

A selection of photos from the Society's past



1. Roger Ffooks (left) and Mike Corkhill (the editor of this publication) on the occasion of SIGTTO's 25th anniversary
2. From left to right, Andrew Clifton (in his younger Technical Adviser days), Roger Roue and James MacHardy on the steps of the St Helen's Place office **3.** A 'technical visit' to Napa Valley's wine tanks is an essential part of SIGTTO gatherings in the San Francisco area **4.** The SIGTTO/Witherbys stand at Gastech is an important meeting place **5.** There's a storm in every port!



The most intense activity experienced along the liquefied gas supply chain is at the ship/shore interface

A living, breathing industry best practice library

Continually refreshed, SIGTTO's portfolio of publications provides an unparalleled source of sound advice on safe gas ship and terminal operations

For SIGTTO the proactive development of industry best practices and guidelines is one of the five central pillars in its drive to promote safe, environmentally responsible and reliable gas shipping and terminal operations. Work on this portfolio of guidance began with the establishment of the Society 40 years ago and the library has constantly been updated and augmented, as required, ever since.

Liquefied Gas Handling Principles

One of the first publication projects to be embarked upon by SIGTTO was also one of its most ambitious. The first edition of *Liquefied Gas Handling Principles*, the Society's flagship publication, was published in 1986 and quickly became not only an indispensable companion for all those training for operational qualifications but also a readily accessible reference work for those already engaged in liquefied gas operations.

Liquefied Gas Handling Principles, or

LGHP as it is affectionately known, was revised twice in the ensuing 14 years, the third edition, LGHP3, appearing in 2000. Over that period the book had become an acknowledged text for courses leading to the award of Dangerous Cargo Endorsements (DCEs) for seagoing certificates of competency. The publication's contents are also recommended by IMO in its Standards of Training, Certification and Watchkeeping (STCW) Convention.

By 2010 SIGTTO realised that LGHP would need to be updated once again, to a considerable degree, to take into account the many technological advances that had been made in the liquefied gas sector since the start of the new millennium. The wheels of a major revision were set in motion and the end result, LGHP4, was issued in July 2016.

The new 530-page edition incorporates extensive updates and a wide range of new material. Topics impacted by the changes include vessel design, propulsion systems, size of fleet, floating regasification and reliquefaction, Arctic LNG, containment systems, improved vessel

energy and environmental efficiencies, vessel capacities, equipment technology, industry best practices and legislation.

The primary target audience of LGHP4 is comprised of serving ships' officers and terminal staff who are responsible for cargo handling operations. Particular emphasis is placed on the importance of understanding the physical properties of liquefied gas cargoes in relation to the operation of gas-handling equipment and systems on the ship and at loading and discharge jetties.

Revised IGC Code

Another major revision of a key liquefied gas document made its appearance on the world stage in 2016 and, once again, SIGTTO played a key role in its update. Roger Roue provides a full account of the project to revise IMO's *International Gas Carrier (IGC) Code* on page 78. The updated Code is mandatory for new gas carriers whose keels were laid on or after 1 July 2016.

Although the Code had been the subject of several amendments since its initial adoption by IMO in 1983, they were piecemeal in nature and by 2007 SIGTTO realised that a major overhaul of the document was called for, in much the same way that there had been a need for the LGHP4 update. That year the UK government made a submission to IMO seeking support for a project to revise the IGC Code and proposing that SIGTTO lead the redrafting work, with assistance and input from shipping and terminal industry experts. The proposal was agreed to by IMO's Maritime Safety Committee (MSC) at its 83rd Session in October 2007.

Roger Roue details the extensive work involved in his article but, suffice to say, it was a notable undertaking, not least for him, then a SIGTTO Technical Adviser. In fact, coordinating all the work entailed in the IGC Code revision project became a fulltime job for Roger for over two years and SIGTTO needed to take on another Technical Adviser to handle all the other day-to-day work of the Society.

Training to the fore

SIGTTO's portfolio of industry best practice guidelines are clustered around themes central to safe operations, including training, the ship/shore interface, operations in ports, floating LNG vessels and, more generically, hazard management.

Training is a topic that has been the focus of a great deal of attention in the maritime industry, reflecting the extent to which the human element is a factor in so many accidents, mishaps and near-misses. The relatively complex nature >



Working in the escort mode, tugs are able to exert steering and braking forces on the ship in the event of an emergency

> of gas ship operations and the hazards posed by escaping cargo ensure that the focus on training in the liquefied gas sector is particularly acute.

While the DCE qualification laid down in the STCW Convention specifies the minimum requirement for gas ship crews, SIGTTO's membership realised that the training regime for its operators needed to extend further.

A first step was taken with the publication of *Crew Safety Standards and Training for Large LNG Carriers: Essential Best Practices for the Industry* in 2003. Drawing on the safety management systems of experienced LNGC operators, the SIGTTO document was prepared to provide guidance for use by not only shipowners but also flag and port state authorities and class societies in auditing for compliance with the International Safety Management (ISM) Code.

The next training document from SIGTTO was *LNG Shipping Suggested Competency Standards*, produced in 2005, followed by a second edition in 2008. Acknowledging the competence-based methodology laid down in the STCW Convention, the SIGTTO competency standards for the various officer ranks on board LNG carriers were adopted by IMO for inclusion in the STCW instrument.

While it is up to individual training establishments as regards how they fashion their courses around the SIGTTO standards, industry acceptance of their offering will benefit from accredited recognition of the course content. The Society prepared *The Verification of the SIGTTO Training Standards* as a document to assist with this compliance.

SIGTTO augmented its LNG publication with *LPG Shipping Suggested Competency Standards* in 2008. The LPG standards recognise the need to cover fully pressurised,

semi-pressurised and fully refrigerated LPG ships and ethylene carriers as well as operations such as cargo grade changing.

Because the interest in new LNG carrier propulsion systems did not begin in earnest until the early years of the new millennium, a large number of the long-serving ships in the LNGC fleet are still powered by steam turbines. To fill the gap in the new competency standards regime, SIGTTO issued *LNG Steamship Suggested Competency Standards for Engineers* in 2010.

The Society's competency standard publications are complemented by *SIGTTO LNG and LPG Experience Matrix Guidelines for Use*, issued as an information paper in 2016. The original *SIGTTO LNG/LPG Officer Experience Matrix* was published in 2011 in the hope it might be adopted as the industry standard from which to assess the adequacy of experience and training for officers serving on board LNG and LPG carriers. In the event some terminals and charterers began applying the Matrix prescriptively, believing that any shortfalls below the specified levels of experience, however small, to be unacceptable.

The 2016 Matrix document provides further guidance as to the recommended application of the Matrix in the assessment and management of risk. It points out that consideration should be given to other mitigating factors used in officer recruitment and development, including bespoke training; the manning scale in place; duration of employment with the LNG/ LPG shipowner/ operator; and the ship operator's wider competence management systems.

Safe port operations

Published in 2003, *LNG Operations in Port Areas* was produced as one of SIGTTO's

core documents to raise awareness amongst all the parties responsible for safe port operations of the special risks posed by the world's rapidly growing LNGC fleet. There are many port hazards, such as ship collisions, which cannot be managed by the gas sector alone, and the core document highlights the measures available to third parties to manage the risks associated with LNG vessels.

One safeguard employed by operators of LNG and other liquefied gas terminals is the use of berthing tugs with vessel escort, firefighting and rescue capabilities. Operating in the escort mode, such tugs are able to rapidly exert braking and steering forces on gas carriers in port approaches in the event of an emergency. However, active escorts of tankers proceeding at a reasonable speed in port waters are complex operations. For them to be carried out safely and effectively, tug and tanker crews and pilots need to work as a team, each aware of the constraints faced by the two other parties.

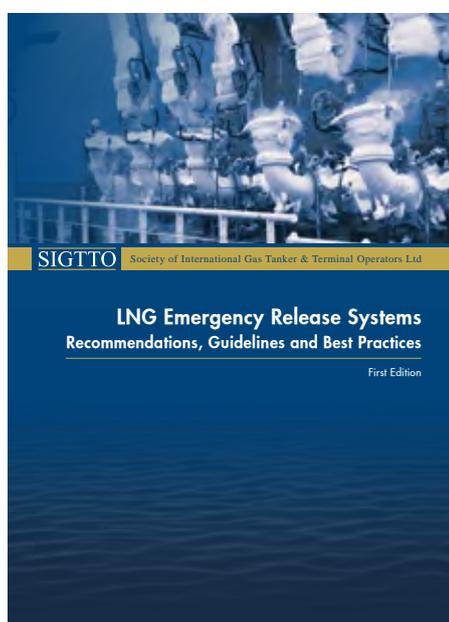
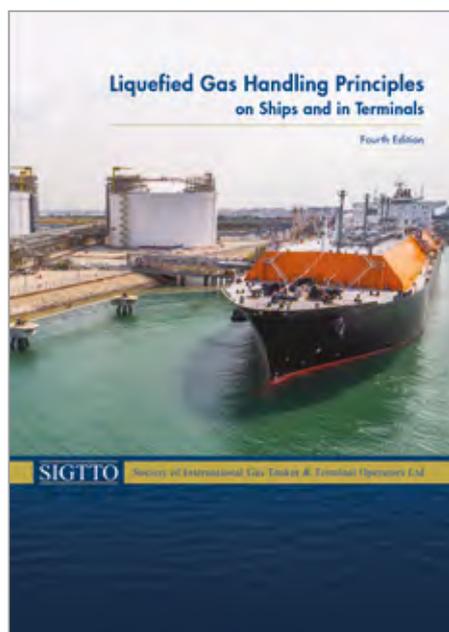
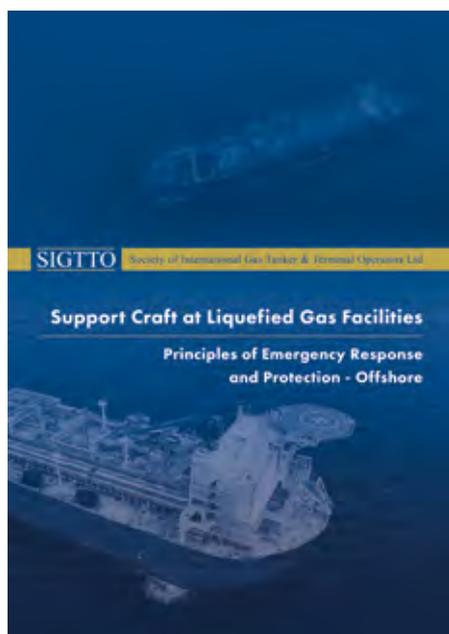
More recently, in 2015 and 2016, respectively, SIGTTO published *Support Craft at Liquefied Gas Facilities: Principles of Emergency Response and Protection - Onshore* and *Support Craft at Liquefied Gas Facilities: Principles of Emergency Response and Protection - Offshore*. The former covers vessel traffic at shore-based terminals while the latter deals with operations at gas terminals, including floating facilities, positioned at nearshore and offshore locations.

Each gas terminal, as part of its emergency response plan, has traditionally specified the performance standards that the specialist assist vessels it utilises must comply with. The two Support Craft documents have been prepared because the variable nature of these requirements has increased over the years as the global network of gas terminals has spread. The publications lay down industry-wide best practice guidelines for actions to be taken by gas terminal support vessels to prevent and mitigate accidents.

Ship/shore interface

Activity along the liquefied gas supply chain is at its most intense when the ship is moored at the terminal jetty either loading or discharging cargo. Recent interface-related SIGTTO publications include *LNG Emergency Release Systems - Recommendations, Guidelines and Best Practices*, published in 2017, and two that appeared in 2018, i.e. *Ship/Shore Interface for LPG/Chemical Gas Carriers and Terminals* and *Guidelines for the Alleviation of Excessive Surge Pressures on ESD for Liquefied Gas Transfer Systems*.

SIGTTO paid publications



SIGTTO Information Papers, Consolidated Ed 2019 (2019; £175.00)

Recommendations for Liquefied Gas Carrier Manifolds (2018; £175.00)

Ship/Shore Interface for LPG/ Chemical Gas Carriers and Terminals (2018; £175.00)

Guidelines for the Alleviation of Excessive Surge Pressures on ESD for Liquefied Gas Transfer Systems (2018; £175.00)

LNG Emergency Release Systems - Recommendations, Guidelines and Best Practices (2017; £125.00)

Liquefied Gas Handling Principles on Ships and in Terminals, 4th Ed (LGHP4) (2016; £275.00)

Support Craft at Liquefied Gas Facilities: Principles of Emergency Response and Protection - Offshore (2016; £125.00)

Support Craft at Liquefied Gas Facilities: Principles of Emergency Response and Protection - Onshore (2015; £125.00)

Guidance for LNG Carriers Transiting the Panama Canal (2014; £125.00)

Ship-to-Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases (2013; £275.00)

Liquefied Gas Carriers: Your Personal Safety Guide (2012; £25.00)

Application of Amendments to Gas Carrier Codes Concerning Type C Tank Loading Limits (2012; £25.00)

Liquefied Petroleum Gas Sampling Procedures (2010; £25.00)

LNG Steamship Suggested Competency Standards for Engineers (2010; £125.00)

LPG Shipping Suggested Competency Standards (2008; £125.00)

LNG Shipping Suggested Competency Standards, 2nd Ed (2008; £125.00)

Jetty Maintenance and Inspection Guide (2008; £175.00)

Hydrates in LPG Cargoes (2008; £75.00)

Liquefied Gas Fire Hazard Management (2004; £175.00)

Crew Safety Standards and Training for Large LNG Carriers: Essential Best Practices for the Industry (2003; £75.00)

LNG Operations in Port Areas (2003; £75.00)

Guide to Contingency Planning for Marine Terminals Handling Liquefied Gases in Bulk, 2nd Ed (2001; £40.00)

Guidelines on the Ship-Board Odourisation of LPG (2000; £40.00)

An Introduction to the Design and Maintenance of Cargo System Pressure Relief Valves Onboard Gas Carriers, 2nd Ed (1998; £40.00)

Site Selection & Design for LNG Ports & Jetties (Information Paper No 14) (1997; £40.00)

Details of more than 60 free SIGTTO publications, newsletters, annual reports and articles are given on the Society's website: www.sigtto.org

SUPPLYING ENERGY GLOBALLY

LAKE CHARLES LNG

The Lake Charles LNG project brings together two leading energy companies to develop a world-class LNG export facility in Lake Charles, LA, for export to global customers. The project is a 50/50 venture between Energy Transfer, one of the largest pipeline operators in the U.S. and Shell, a worldwide leader in gas and LNG.

The project, if sanctioned through an affirmative FID, would convert Energy Transfer's existing Lake Charles LNG import and regasification terminal to an LNG export facility with a liquefaction capacity of 16.45 million tonnes per annum. The project is fully permitted, uses existing infrastructure and benefits from abundant natural gas supply and proximity to major pipeline infrastructure, including Energy Transfer's vast pipeline network. The proposed project will use a best available techniques concept to be a class leader in terms of environmental emissions, performance and efficiency.

lakecharleslng.com





A great part of the proceedings at the 60th Panel Meeting in Livorno celebrated the 50th anniversary of commercial LNG shipping

visits involve trips to gas import or export terminals but there has been a good degree of variation over the years. The roster of technical visit hosts includes shipyards, repair yards, gas-handling equipment and system engineers, training establishments and a California winery, where features of the sophisticated bulk liquid containment system were subject to close scrutiny!

Lining up Panel Meeting speakers and presentation topics has traditionally been the responsibility of incumbent Technical Advisers. Many of the Technical Adviser commentaries in this issue are filled with amusing observations on challenges, logistics and otherwise, posed by the organisation of certain Panels they were associated with.

Panel notables

A number of the Panels proved to be particularly notable for one reason or another, and have gone down in the Society's folklore. For example, the keynote speakers at the 42nd Panel, which was held in Savannah, Georgia in April 2002, were William duBarry Thomas and Alex Pastuhov, who regaled delegates with their first-hand experiences of the initial trial shipments of LNG 43 years earlier. SIGTTO collected their presentation and additional relevant material and published it as a special Supplement publication, *Reminiscences of the Pioneering Days of LNG Transport*, in 2003.

The 97 delegates present for the Savannah meeting was a record for a Panel at the time but it did not stand for long. Eighteen months later, at the 45th Panel in Hamburg in September 2003, the attendance reached 141, while 200 were present for the 51st Panel in Paris in September 2007.

At around this time SIGTTO introduced some half-day open forum sessions at its Panel Meetings at which new topical issues of growing concern to the liquefied gas industry in general could be debated through wide-ranging question and answer dialogues. Ship vetting and the role of ship inspectors were discussed at the 46th Panel Meeting in San Francisco in April 2004 while the nascent evolution in LNG carrier propulsion systems came under scrutiny at the 47th Panel Meeting in Kertih, Malaysia in April 2005.

One of the most interesting presentations at the 50th Panel Meeting in Vancouver in September 2006 was that by Warwick Pointon, North Asia manager for NWSSS Company Pty Ltd, the company responsible for the transport of cargoes from Australia's North West Shelf project. Rather presciently, in view of the 2011 Fukushima earthquake and tsunami, he looked at the topic of >

Flagships of the open door policy

Although both SIGTTO Panel Meetings and Regional Forums enhance two-way communications with the membership, each has a specific role to play

SIGTTO's busy schedule of Panel Meetings and Regional Forums enables the Society to maintain a regular and ongoing dialogue with its full membership. On the one hand, the events provide opportunities for the Secretariat and members participating in current project working groups to highlight the key issues concerning the industry to the wider membership. And, on the other, the get-togethers enable each Society member to contribute to the discussions and raise new matters to consider.

Panel Meetings are the main SIGTTO events, attracting global audiences of member companies and guest speakers for a busy two days of presentations and discussions. Usually of a single day's duration, Regional Forums extend the outreach, being aimed at the Society's members within particular geographical areas.

Until recently, SIGTTO organised two Panel Meetings per annum, one in the spring and one in the autumn, while the Regional Forum programme has gradually been built up to the extent that there now around 10 or more such events around the world each year.

Panel main events

Whereas Regional Forums were only introduced in 2002, Panel Meetings were instituted virtually from the birth of the Society. There have been 64 SIGTTO Panel Meetings to date, the latest one being held in London in April 2018. They are usually hosted by a member company local to the event's venue. Smit Lamnalco, a SIGTTO Associate Member with an international presence, played host to those attending the 64th Panel in London.

As mentioned, two Panel Meetings per annum were the norm in the early days of SIGTTO. However, in recent years the Society has become increasingly involved in organising and chairing the shipping sessions of regular global events such as the Gastech and LNG series of meetings. Rather than deflect from the potential attendances at these shipping sessions, SIGTTO has eased back on the busy schedule of Panel Meetings and put more emphasis on Regional Forums in recent years.

Panel Meetings are usually augmented by technical visits, tacked on as a third day to provide interested parties with the opportunity to visit a nearby industrial site of notable importance. Usually, the

Panel Meetings & Regional Forums



SIGTTO General Manager Andrew Clifton addresses the Shanghai Regional Forum in December 2017 on the latest work of the Society's committees and working groups

> tsunami contingency planning in Japan, explaining the problems associated with developing effective tsunami contingency plans, not least the often conflicting needs of terminals and ships and the reliability of tsunami warnings.

With an LNGC fleet serving 15 different discharge terminals in Japan, NWSSS was faced with the challenge of assisting the individual terminals in devising contingency plans most appropriate to their prevailing conditions. It is reassuring to note that the 2011 tsunami, as devastating as it was, put only one of Japan's 25-plus LNG receiving terminals out of action, and that for only a short time.

The first ever Panel in India was held in Mumbai in April 2006 while China did not stage its inaugural Panel until April 2015 when SIGTTO members gathered in Shenzhen.

Quorum for a forum

Although they are a relatively new feature of SIGTTO's outreach programme compared to Panel Meetings, Regional Forums have rapidly gained favour and are now a key part of the Society's annual agenda. Each year SIGTTO organises, on average, 10 Regional Forums in various key liquefied gas geographical zones worldwide and in many locations these Forums are effectively taking on one of the roles traditionally filled by Panel Meetings. While Panels were evolving at the turn of the millennium into full industry seminars dealing with global issues, the new Regional Forums enabled SIGTTO to increase levels of contact with individual members as the membership ranks were growing.

The first meeting of SIGTTO's Scandinavian members, held in Oslo in May 2002, is acknowledged to be the first formal SIGTTO Regional Forum. This, despite the fact that SIGTTO's Japanese

members had traditionally met regularly at home, attended by SIGTTO Secretariat staff whenever possible, for many years. These Japanese member meetings, held virtually since SIGTTO was established, reflected (a) Japan's status as the world's leading importer of LNG since the inception of the industry and (b) the fact that 20-plus companies amongst the SIGTTO members are leading Japanese gas terminal and ship operators.

Every Scandinavian company that was a SIGTTO member had at least one representative present at the Oslo meeting in 2002, and that strong sense of community spirit has characterised Regional Forums ever since. All the participants agreed that the idea of an ongoing Scandinavian Regional Forum was a good one, and that a follow-up meeting should be held within the year. A number of issues were raised in Oslo, including ship vetting and mooring ropes, which went on to become agenda items for SIGTTO's General Purposes Committee and the subject of Society best practice guidelines.

Within the next couple of years annual Middle East, Pan American and Asia Pacific Regional Forums had been established. In the early days each Forum took on a distinctive characteristic, reflecting to some degree the majority interests then prevailing in a particular region. Thus, while the focus at the Scandinavian Forums was more on LNG and LPG shipping issues, the view of the liquefied gas industry from a corporate independent oil company (IOC) perspective was the central theme of early Pan American Regional Forum meetings in Houston. At the first Middle East Forums much of the discussion was led by major LNG production and export interests.

The first Mediterranean Regional Forum was held in Athens in 2004, and the event turned out to be a precursor

of a full Panel Meeting in the Greek capital the following year. This was the time when Greek shipowners were making their first foray into what turned out to be a major commitment to LNG carrier ownership and operation.

The high degree of flexibility inherent in the Regional Forum approach provides scope for special one-off events to be organised to meet specific needs. Thus, in 2012 special Forums were held in Brisbane and Panama. Delegates to the Brisbane gathering were provided with an update on the three coal seam gas-based LNG export terminal projects being developed around the Gladstone port area, while those to the Panama meeting, which was hosted by the Panama Canal Authority (PCA), learned about the likely impact of the then-imminent expanded capacity of the Panama Canal on global LNG trade routes.

Worldwide reach

Meanwhile, SIGTTO's Regional Forum programme has gone from strength to strength. The first South American Regional Forum was held in 2014, in Montevideo, and in 2016 the Asian Regional Forum was held in Tokyo, the arrangement effectively replacing the former regular meetings of the Society's Japanese members. The first Indian Regional Forum was also staged in 2016.

A total of 99 delegates were present for a European Regional Forum in Edinburgh in 2015 but that attendance record fell the following year when 110 turned up for the Society's second South American Regional Forum, in Buenos Aires.

SIGTTO staged 10 Regional Forums in 2018, in Oslo, Singapore, Athens, Buenos Aires, Tokyo, Perth, Shanghai, Dubai and two in Houston.

There is another new series of meetings that is now a regular feature of the SIGTTO calendar and that is the Liquefied Gas Senior Executive Forum. This event is held every December in Houston in conjunction with the US Coast Guard and the Society for Gas as a Marine Fuel (SGMF), and the first in the series took place in 2015. The 200-plus attendances of these Senior Executive Forums reflect the current high level of interest in gas carrier and terminal activities in the US, due not least to record LPG exports, the start of worldwide LNG and ethane export volumes and the introduction of LNG-powered ships and LNG bunkering.

The next SIGTTO meeting is an extraordinary one. On 10 September 2019 the Society will hold a Liquefied Gas Shipping Forum followed by a reception in London to celebrate its 40th anniversary. The event will take place as part of the London International Shipping Week 2019.

Learn new moves from the masters of gas

THE EXPERTISE OF OUR
GASBASSADORS SUPPORTS
YOUR TRANSITION TO GAS

OUR OFFERING
COVERS THE ENTIRE
GAS VALUE CHAIN

WÄRTSILÄ IS THE
MARKET LEADER
IN GAS SINCE 1996



WÄRTSILÄ CONNECTS THE DOTS TO THE GAS AGE

Wärtsilä has the expertise, experience and offering to enable your transition to the gas age. Our track record is in a class of its own, and we have solutions for all phases of the LNG value chain.

CONGRATULATIONS TO SIGTTO on this important milestone and we look forward to continuing our close co-operation in the furthering of the use of gas as an important fuel for the marine industry.



wartsila.com/lngandgas



The global FSRU fleet totaled 33 units at the end of 2018, while another 10 were on order

SIGTTO committees configured for the future

In revamping its committee structure, the Society has created more bodies to better channel the expertise required for an increasingly diversified workload

The General Purposes Committee (GPC), SIGTTO's technical body, has traditionally originated and coordinated all the internal projects generated at SIGTTO. Completion of the project work itself is carried out by working groups comprising relevant experts from amongst the membership. The technical publications which are the end-result of these projects are effectively the best practice procedures, recommendations and standards that guide the industry's day-to-day operations.

To deal with a growing and increasingly diverse industry, the Society's committee structure has been upgraded in accordance with the current Strategic Plan 2016. Amongst the measures that have been implemented is the establishment of a Human Element Committee (HEC) which, like GPC, is composed of representatives from SIGTTO member companies.

In addition, the Strategic Plan encourages the creation of a range of subcommittees, as needed, to support and augment GPC

and HEC. Following a GPC survey of members conducted in summer 2017 on topics worthy of further consideration by the Society, the first of these, the Floating LNG installations Subcommittee, was formed as a GPC sub-group.

GPC and HEC both meet twice a year, in the spring and the autumn, and report to the SIGTTO Board. Smooth interfacing arrangements between the various committees and subcommittees are an integral part of the restructuring exercise. For example, the HEC chair is also a GPC member and vice versa with the GPC chair.

GPC latest

SIGTTO's most recent GPC meeting, its 79th, was held in Shanghai in April 2019. The venue and timing were chosen to align with the LNG 19 conference and exhibition. The next GPC meeting, GPC 80, will similarly tie in with an international congress, in this case the Gastech 2019 event, when it is held in Houston in September 2019.

The coordination of GPC meetings with

these international gatherings reflects the strong ties that the Society has with the event organisers. SIGTTO General Manager Andrew Clifton chaired the shipping session at LNG 19 and will take on a similar role at Gastech 2019. In addition, he was recently appointed co-chair of the Gastech technical committee and is assisting with vetting the large number of presentations proposed for each event in the Gastech series.

Besides indicating the need for the new Floating LNG Installations Subcommittee, the summer 2017 GPC survey also revealed other topical issues worthy of consideration by new GPC working groups. Working groups on propulsion systems, reliquefaction systems, gangways, pressure relief valves and emergency shutdown (ESD) systems were duly constituted, and their work is progressing.

The Propulsion and Reliquefaction Working Groups have met face-to-face and are working in a collaborative fashion on their respective documents. The publications will include technical descriptions, with sections on risk, operations and safety, and will provide recommendations, guidelines and best practices for all the propulsion and reliquefaction systems under consideration.

The Gangways Working Group has prepared draft guidance for designers, terminals, vessel owners and operators on safe landing areas and gangway operations, and is aiming for document approval at GPC 80. Similarly, a pressure

relief valve (PRV) guidance document has been completed which updates gas carrier cargo system PRV design and maintenance guidelines previously issued by SIGTTO in 1998. The ESD Working Group is pressing ahead with a revision of SIGTTO's 2009 publication *ESD Arrangements and Linked Ship/Shore Systems for Liquefied Gas Carriers*. It is also working to align all ESD references across the SIGTTO publications portfolio.

Floating subcommittee

The remit of SIGTTO's new Floating LNG Installations Subcommittee (SC) is to provide guidance on the design and operation of the growing fleet of floating process vessels now being utilised by the LNG industry. The installations falling under the new group's purview include floating LNG production (FLNG) vessels, floating storage and regasification units (FSRUs), floating regasification units (FRUs) and floating storage units (FSUs).

At the two inaugural SC meetings, held in early 2018, it was recognised that there were three specific areas where participants in the floating LNG sector would derive benefit from the speedy availability of industry best practice guidelines. As a result three working groups were established to deal with topics relating to the site assessment, design criteria and operational guidance, respectively, as they relate to nearshore/offshore floating LNG assets.

Work by SC and its initial three working groups has progressed smoothly, to the extent that it is hoped to present a final guidance document for review at the 81st GPC meeting in spring 2020.

Human element in the spotlight

A key landmark in the process that resulted in the establishment of the Society's Human Element Committee (HEC) was the decision taken at the 64th GPC meeting in 2011 to establish a Human Factors Working Group. The new body was charged with creating a quality training regime for shore-based staff and trainers, based on the existing SIGTTO crew competency standards.

Completing its task as far as was practicable at the time, the Human Factors Working Group recommended that further work on competency assurance, including additional training of shore staff, human factors and process safety should be carried out as per GPC direction. A key achievement of the Group's deliberations was the *Suggested Quality Standards for LNG Training Providers* document which SIGTTO made available in November 2014.

SIGTTO's subsequent decision to form HEC as a full committee, as part of its

Strategic Plan 2016 initiative, recognised the critical importance of the human factor and training in gas carrier and terminal operations in the drive to sustain the liquefied gas sector's unparalleled safety performance. The HEC's remit includes, but is not limited to, competency and training, design and ergonomics and the human element side of incident investigation.

HEC met for the first time in September 2016, and its biannual meetings, which are held in Northern Europe, are timed for a date approximately six weeks before GPC meetings whenever possible. Such scheduling helps streamline the inter-committee liaison process.

HEC has 13 members and two observers, and the two initial meetings were focused on establishing the general scope and activities of the new Committee. The definition of the human element, the management of incidents and a review of the design and ergonomics of cargo control rooms were amongst those topics identified as worthy of consideration.

SIGTTO's HEC has recently published its first set of guidance. The document, *Recommendations for Management of Cargo Alarm Systems*, has been compiled by HEC's Cargo Control Room (CCR) Ergonomics Working Group and was approved by the Society's Board in May 2019.

The CCR Working Group has already embarked on its next project relating to cargo control room layout and ergonomics. Aspects such as control station layout, physical environment, operator interface, controls, displays and the human/machine interface (HMI) are being considered. The aim is to develop guidance for operators on how to improve

the safety of cargo operations through detailed consideration of operational practice within the specification and design of CCR workstations and HMI.

Two further HEC working groups currently have work underway. The Gap Analysis Competency Working Group is continuing to establish methodology for the major revision of SIGTTO's four competency publications. The introduction of new technologies in the LNG industry has resulted in a need to revise relevant parts of the Society's LNG carrier crew competency guidelines.

Finally, the Working Group for Shore Staff Competencies is involved with scoping the applicability of topics within its agreed terms of reference. Topics covered include shore staff competencies for owners/operators of gas carriers and their interfaces with vessels and terminals.

Going forward, HEC has established a 'Strategy Structure' chart to demonstrate how its work programme accords with an overall vision and the specific targeted goals of its human element programme. Upkeep of the 'live document' will itemise agenda items in progress and worthy of consideration grouped under the Committee's four strategic objectives, or pillars, i.e. human element/safety critical analysis, measurement tool/incident review, design and ergonomics, and competence.

SIGTTO continues to focus on accident prevention, not least through the use of major accident/process safety risk management tools like 'bow tie' and the prioritisation of training on major incident risks and avoidance. HEC will adapt its activities to accommodate ongoing developments in this field.



The Human Element Committee's first guidance document has been produced by the Cargo Control Room (CCR) Ergonomics Working Group

A selection of photos from the Society's past



1. Adele Ball (centre), SIGTTO's first Office Manager, helped the Secretariat maintain a steady course for many years **2.** James MacHardy visits the Ilawa lakeside training centre in Poland and the 11.5-metre Dorchester Lady, a manned scale model that enables officers to test their LNGC navigating skills **3.** Atlantic LNG hosted the 2000 Panel Meeting in Trinidad **4.** Technical Adviser Rick Boudiette, a US national, is introduced to the finer points of a game far removed from baseball at the Oval Cricket Ground in London **5.** General Manager Bill Wayne visited the Mizushima power station, then recently converted from coal to gas-burning, in 2008; the adjacent receiving facility had opened in 2006 as Japan's 26th LNG import terminal

Professor Kletz advised against the introduction of unnecessary complexities, whether in process plant or liquefied gas handling systems



In praise of the industry's pioneering teachers and leaders



Robin Gray, the Society's second General Manager, from 1985 to 1991, pays tribute to a number of early industry leading lights who brought significant benefits to SIGTTO's membership, not least by demystifying the technology of handling liquefied gas cargoes

The years pre-SIGTTO, coinciding with the nascent stage of gas shipping worldwide, posed unique challenges. The merits of liquefied gases as an energy source were attracting more and more attention, prompting far-sighted owners to embark on the construction of prototype LNG tankers.

I'd like to take the opportunity offered by the Society's 40th anniversary publication to acknowledge some of the tanker and terminal engineers and operators who played an invaluable role in establishing the solid foundations for the exemplary record that our industry has

continued to build upon over the years.

At the same time the technologies behind containment and propulsion systems and cargo-handling equipment were evolving, SIGTTO was embarking on developing its portfolio of industry best-practice guidelines, in many cases from scratch.

Teachers and the human element

SIGTTO's London base provided us with proximity and access to some key process industry experts in the UK chemical sector, including **Professor Trevor Kletz**, safety advisor at Imperial

Chemical Industries (ICI), **Gordon Sellars**, an ICI hazard analyst, and **Dr John Bond**, safety advisor at BP Chemicals.

Loved by its employees and with subsidiaries worldwide, ICI was central to UK chemical manufacture for over 80 years. On the gases front the company's Teesport works in North East England was active in the manufacture of ethylene and ammonia, the salt cavern storage of LPG, hydrate prevention and the road tanker delivery of liquefied gases to tanker jetties for gas carrier cooling-down trials.

Amongst his many projects, Prof Kletz masterminded the 1987 production of a video training package entitled *Safer, Cheaper Plants*, focused on the safety inherent in processes designed to avoid the introduction of unnecessary complexities. He also compiled *An Engineer's View of Human Error*, a valuable 1991 publication. In 1992 his ICI colleague Gordon Sellars prepared SIGTTO's *Guidelines on Hazard Analysis for Operators* (of which, more later).

Another teacher for our industry was Dr John Bond, especially his 1988 paper *The Management of Safety*. In it John outlined the Three Laws of Loss Prevention. The First Law states that he who ignores the past is condemned to repeating it, while the Second Law confirms that the key to success in preventing loss is to anticipate the future. The Third Law points out that what gets measured gets done. >



Japan was one of the first countries to be visited by SIGTTO, literally months after the Society was established

> The Three Laws of Loss Prevention stress that the most critical factor when it comes to ensuring safe operations is the human element. This observation was reinforced and put into words for SIGTTO, in different ways, by an impressive triumvirate. DuPont, the international chemical company, concluded that, after studying the lessons learned from almost 200 years of industrial experience, about 96 per cent of all incidents can be directly attributed to the actions of people, not to faulty equipment or inadequate standards.

For its part the Royal Air Force's Institute of Aviation Medicine found that after the error sources that could jeopardise safety are identified, it is prudent to adopt the pessimistic but practical philosophy that if an error can happen, it will. It is sensible to prevent the occurrence of any potentially dangerous event by making the action leading to such an outcome detectable ... by ensuring that it becomes known wherever it should be known. "This approach may seem rather obvious," said the Institute, "but it has not always been done in the past."

A Japanese LNG terminal operator that was a SIGTTO member weighed in on the human element argument by stating that "We reward staff who report near-miss incidents as if discovering buried treasure." The above three human element observations effectively signal implementation of the Second and Third Laws of Loss Prevention.

Type C tank safer loading limits

SIGTTO went to Canada and the US for laboratory modelling and large pressure tank expertise for a joint study, *Safer Loading Limits for Type C tanks*, completed jointly with the International Association of Classification Societies (IACS) for submission to IMO's Bulk Chemicals (BCH) Sub-committee. The study considered the behaviour of the liquefied gas contents

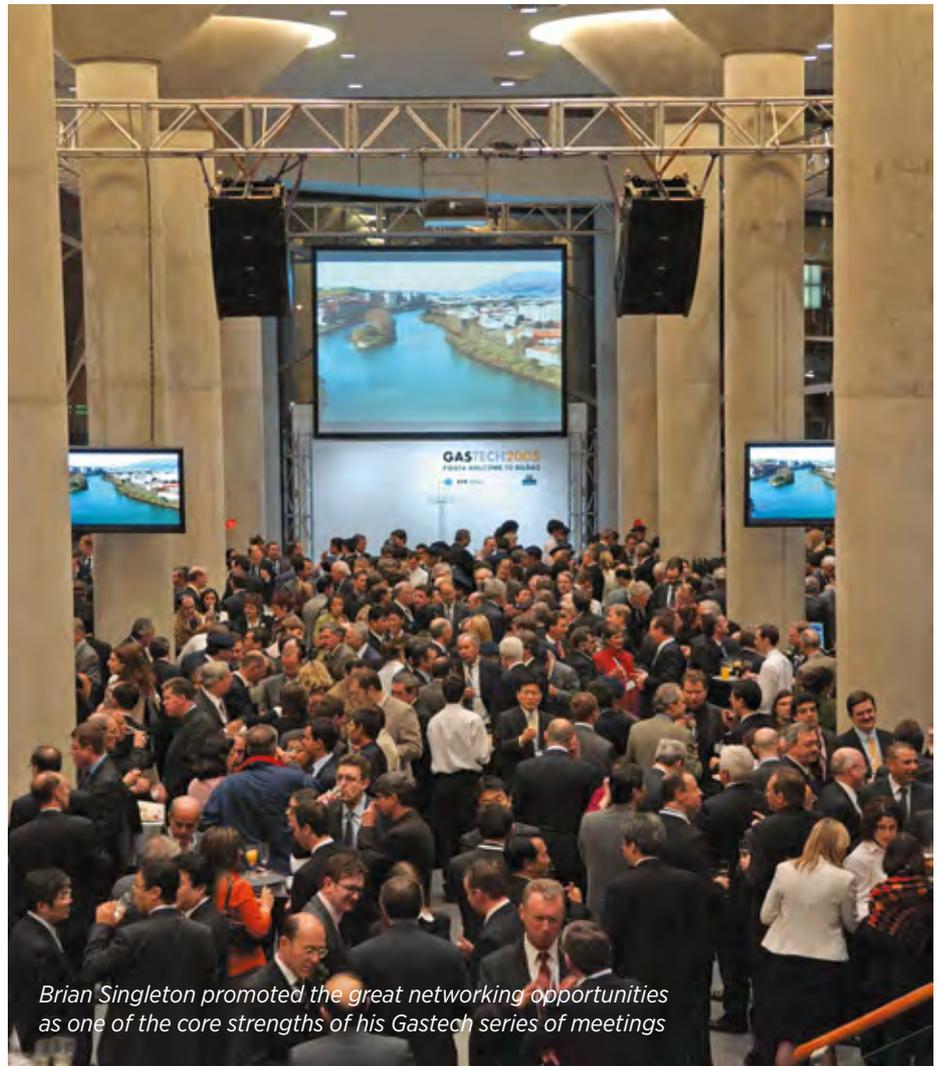
of Type C tanks in a fire situation.

The study's findings that (a) a 98 per cent liquid fill level offers the best protection against tank rupture on fire exposure and (b) the cargo tank pressure relief valve setting should be set at the maximum allowable relief valve setting (MARVS) of the tank, were agreed at IMO. The safety benefits stemming from such an arrangement include a minimisation of

inadvertent tank venting during normal operations and the delay in the venting for as long as is safe. Also, any tank venting that did occur would be limited to the minimum required to prevent tank over-pressure.

Professor Jim Venart of the Fire Science Center at the University of New Brunswick in Canada had developed a fully instrumented laboratory pressure tank with acrylic flat end plates and a high-speed photography capability. Degrees of fire engulfment of the unit could be simulated using electrically heated pads around the tank, and in this way it was possible to measure multiple liquid temperatures, vapour pressure, relief valve operations and vent pipe-to-atmosphere back pressure.

In 1986 the Fire Science Center was contracted to model the consequences of a collision between a laden LPG carrier and an oil tanker carrying naphtha. The scenario envisioned a large pool fire taking hold while the two vessels remained locked together. According to the Center's apparatus, the practical heat input was predicted to be some 2.9 times the heat input assumed in the Gas Carrier Code for relief valve sizing.



Brian Singleton promoted the great networking opportunities as one of the core strengths of his Gastech series of meetings

Prof Venart ran his model with the LPG carrier loaded to 98 per cent of its cargo tank volume and the pressure relief valve set at the MARVS for the tank.

The president of Fauske and Associates Inc, **Dr Hans Fauske** was contracted in 1988 to present simple calculational methods to verify safe pressure relief of liquid-filled ship tanks under practical fire exposure, and to describe the liquid fraction vented and its dispersion behaviour. SIGTTO was fortunate to have access, through Dr Fauske, to the methodology of the American Institute of Chemical Engineers' Design Institute for Emergency Relief Systems and to a detailed report on the fire engulfment of two 64-tonne LPG rail tank cars involved in a JP 4 jet fuel pool fire in 1973. The results of both confirmed Dr Fauske's predictions to be conservative by a factor of four.

Brian Singleton and his three co-directors established the Gastech series of LNG and LPG conferences and exhibitions in the early 1970s and were past masters at bringing the global industry together in amenable surroundings and arranging networking opportunities on an epic scale, including during relaxing and memorable evening receptions. Pre-event papers were complemented by post-event Gastech proceedings that logged all the discussions and provided an invaluable information source. SIGTTO took the opportunity to organise various of its internal meetings to coincide with the Gastech events and take advantage of the cross-fertilisation of ideas.

Pioneering leaders

We need to acknowledge the liquefied gas sector's pioneering naval architects, engineers, managers and entrepreneurs. One such was **Barry Hunsacker**, president of El Paso LNG Company in the US and also SIGTTO's founding President. It was Barry who gave the Society its unique terms of reference for the safe transport of liquefied gases when he stated "We will best achieve our goals by sharing with each other our non-proprietary technical and safety information and operating experiences through open and frank discussion. Only in this way will each of us benefit from the experience and knowledge gained by all of us and thus maximise the safety of our operations. Remember, the industry will be judged by the record of its least-safe operator. Let's help ourselves by helping that operator."

Martin Böckenhauer was a trusted supporter of SIGTTO. As chairman of both the Bulk Chemicals (BCH) and Bulk Liquids and Gases (BLG) Sub-committees at IMO, he brought an immense depth of



Phil Arthur, Dick Eddy and Barry Thomas were amongst the engineering support team on board Methane Pioneer in February 1959 when it carried the historic first-ever cargo of LNG

technical knowledge to the UN agency from his long career at Germanischer Lloyd and his participation in the work of IACS. His IMO chairmanships were renowned for the firm and fair way he steered the groups through sensitive and complex issues.

Bob Lakey, originally with the US Coast Guard (USCG), was another industry guiding light with whom the Society had a close affinity. He was chairman of the ad hoc working group set up in 1971 by IMCO, as IMO was then known, to develop a Gas Carrier Code with provisions governing the carriage of liquefied gases in bulk. The group carried out its work through to 1975 and Bob and his US colleagues insisted that the IACS members would need to be in full agreement on the central provisions governing cargo containment, cargo handling and materials of construction. The Code was adopted by IMCO in November 1975 and Bob Lakey went on to develop a successful gas shipping consultancy and strong ties with SIGTTO. He also found time, later in his career, to chair the Gastech series of conferences after Brian Singleton had departed the business.

Another USCG officer who made a



Bob Lakey chaired the Gastech series of conferences later in his career, while his wife Claudia provided sterling support on event-organising duties

notable contribution to international maritime safety was **CDR John William (Bill) Kime**. Bill logged 41 years of service with the Coast Guard, rising to the rank of admiral and becoming commandant of the agency, from 1990 to 1994. We knew him when he was chief of the Coast Guard's marine safety, security and environmental protection office and the leader of the US delegation at meetings of the IMO's Maritime Safety and Marine Environment Protection Committees.

Methane Pioneer contribution

The seagoing technical staff onboard the 5,500 m³ *Methane Pioneer* in February 1959, when the converted gas ship successfully transported the first seaborne cargo of LNG, from the US to the UK, included **Phil Arthur, Dick Eddy** and **William duBarry Thomas**. Phil was superintendent engineer with Stephenson Clarke, the operator of the historic prototype vessel. I would get to know Phil when his company later contracted the Tyneside yard of Hawthorn Leslie where I worked to convert a small coaster into a semi-refrigerated LPG/chemical gas carrier with two Type C tanks.

Dick Eddy and Barry Thomas were both naval architects with the consultancy firm JJ Henry, the company that masterminded the conversion of *Methane Pioneer* into the world's first LNG carrier. Dick went on to become a director of the Malaysian International Shipping Company (MISC). The five 130,000 m³ Gaz Transport membrane ships constructed for MISC in France in the early 1980s enabled Malaysia to become the world's sixth LNG export nation. By 1991, when I left SIGTTO, this fleet had logged an aggregate 822 voyages.

Barry Thomas was also closely involved with the specification drawn up for the 27,400 m³ *Methane Princess* and *Methane Progress*, the first two purpose-built commercial LNG carriers, completed in the mid-1960s. He is best known to SIGTTO >

Descartes was just one of many examples of the pioneering contributions made by France to the field of LNG carrier technology



> members as the compiler of the famous *LNG Log* series of publications on behalf of the Society. He had an unerring ability to not only record the achievements of the global portfolio of LNG ships and terminals in succinct style but also to put a humorous or insightful historical spin on these achievements, viz his *A Victorian Space Age Parable* on the inside back cover of *LNG Log 17*, published in 1991.

French contingent

France made a major contribution to liquefied gas transport from the outset and, amongst that country's early pioneers, **Renè Boudet**, **Jean Alleaume** and **Audy Gilles** stand out.

A larger-than-life character, Renè Boudet had established Gazocéan as an LPG carrier operator and trading company in 1957. In 1962 his naval architect, Jean Alleaume, convinced him of the merits of an LNG membrane tank containment system developed by Det Norske Veritas (DNV) and Gazocéan acquired the Norwegian patents to the design and further developed the concept in a project that was to yield the Technigaz Mark I containment system.

In 1963 Gazocéan formed Technigaz as its technical subsidiary, with Alleaume its director. The following year the company commissioned the 630m³ *Pythagore*, a prototype ship with a Technigaz membrane tank and secondary barrier. Boudet then established Conch Ocean, a joint venture with Conch, and in 1968 placed a speculative order for a 50,000m³ LNG carrier at the Chantiers de l'Atlantique yard in St Nazaire. That ship, *Descartes*, was the first commercial gas carrier with Technigaz Mark I membrane cargo tanks. The waffled stainless steel tanks were

insulated by the balsa wood insulation system developed by Conch. *Descartes* had logged 448 voyages by 1991.

Audy Gilles was the head of a Worms Group team that began work, with support from Gaz de France, on its own designs for a French LNG carrier in 1959. The experimental ship *Beauvais*, completed in 1962 and fitted with three different types of small tank, and France's first commercial LNG carrier, *Jules Verne*, delivered in 1965, were the tangible results from that group's early work. Unconvinced of the future commercial viability of the free-standing LNG tank systems of these first two ships, Worms established Gaz Transport to develop its own distinctive membrane tank system, with its 36 per cent nickel-sheet steel primary and secondary barriers of invar and perlite-filled plywood box insulation system.

The Gaz Transport membrane was chosen for two 71,500 m³ LNG carriers ordered at the Kockums yard in Sweden in 1967 by Phillips Petroleum and Marathon Oil for their planned Alaska/Japan project. **Bob Wheeler**, the marine superintendent at Marathon Oil, played a key role in establishing the systems that underpinned the successful operation of the two vessels. Named *Polar Alaska* and *Arctic Tokyo* on delivery in 1969, the pair remained in service for 45 years, while the Gaz Transport membrane, like the Technigaz system, has gone on to enjoy great success as an LNG carrier containment system. Established in 1994, Gaztransport & Technigaz (GTT) now manages both membrane technologies.

Another distinct early LNG containment system was the double-walled aluminium tank system developed by Esso for its

quartet of 40,000 m³ vessels required to transport cargoes from Libya to Italy and Spain. **Al Delli Paoli** was the Esso superintendent responsible for the fleet which comprised three ships built at the Italcantieri yard in Genoa and one at the Astano yard in El Ferrol in northwestern Spain. Esso was renamed Exxon in 1973, shortly after the ships entered into service, and in 1991 Delli Paoli was appointed Exxon's representative on SIGTTO's General Purposes Committee (GPC).

Spheres all round

The Kvaerner Group naval architect **Rolf Kvamsdal** in Norway became the public face of what turned out to be the most popular cargo containment system for the early generation of LNG carriers – the Kvaerner Moss spherical tank design. The Type B spherical tank was a simple, independent tank designed to the 'leak before failure' principle that obviated the need for much of a secondary barrier beyond a small drip tray, and several spherical tank designs were put forward in the late 1960s and early 1970s. The approaches differed only in the method in which the tanks were supported by the ship's hull structure and the Kvaerner Moss technology, encompassing a cylindrical skirt connected to the tank at an equatorial ring piece, proved the most efficacious.

The first Kvaerner Moss spherical tank ship, the 88,000 m³ *Norman Lady*, with its five tanks of 9 per cent nickel steel, was built by the Moss Rosenberg yard in Norway in 1973. In the following years Germany, the US, Japan and Korea joined Norway in building Kvaerner Moss spherical tank ships, and the 5083-0 alloy of aluminium came to be the favoured

material of tank construction. The most notable of the early spherical tank fleets was that made up of eight 125,000 m³ ships built by the General Dynamics Quincy yard in the US in the late 1970s for Energy Transportation Corp (ETC) and operation on the Indonesia/Japan project, then the world's largest. ETC's **Ed Tornay** was an early chairman of SIGTTO's GPC.

Japan at the centre

Japan has been receiving LNG since 1969 and has been the world's largest LNG importer since the start of the Brunei project in late 1972/early 1973. Upon its establishment, SIGTTO was quick to recognise the key roles played by Japanese gas buyers such as Tokyo Electric Power Co (TEPCO), Tokyo Gas and Osaka Gas and the leading Japanese shipowners, notably NYK Line, Mitsui OSK Lines (MOL) and K Line, in the development of their commitment to safe LNG transport. Shortly after its launch, in February 1980, the Society travelled to the country to visit existing and potential members.

Key Japanese liquefied gas industry leaders who provided strong support to SIGTTO during the Society's first decade were **Shigeetsu Miyahara** of TEPCO, **Akira Yazaki** of Tokyo Gas, **Ishigawa-San** of NYK Line and **Yasuo Hosoya** of TEPCO's Thermal Power Division. TEPCO and Tokyo Gas launched Japan's commitment to natural gas, imported from overseas liquefaction plants as LNG, with the joint purchase of Alaskan volumes from Phillips Petroleum and Marathon Oil, starting in 1969. LNG, which was discharged at the two utilities' shared Negishi receiving terminal in Tokyo Bay, accorded with the Japanese government's desire to cut down on atmospheric pollution and diversify the country's energy sources. Miyahara-San of TEPCO was an early SIGTTO Vice President.

TEPCO and Tokyo Gas commissioned their second joint LNG import terminal, at Sodegaura across Tokyo Bay from Negishi, in 1973 and shipments from Lumut in Brunei were the first to arrive. On SIGTTO's inaugural visit to Japan Azira Yazaki of Tokyo Gas arranged visits to not only the Sodegaura terminal but also the Higashi-Ohigishima receiving facility. The LNG Centre at the latter terminal is open to the public and plays host to an ongoing round of school visits. The user-friendly exhibits seek to explain the technology behind liquefied gas shipping and terminals in a simple, straightforward way and, by doing so, to allay any fears arising from the presence of this industrial activity.

Ishigawa-San of NYK Line made a keynote presentation at one of SIGTTO's

early meetings in Japan in which he described the first LNG project fleet of Japanese-owned vessels. The fleet comprised seven 125,000 m³ spherical tank ships, all of which were built in Japan and ownership was shared between NYK, MOL, K Line, Showa Line, YS Line and Japan LNG. The newbuildings, which commenced delivering in 1983, went into service carrying Indonesian LNG to Japan. The fleet augmented the eight ETC ships on the same route and consolidated Indonesia/Japan as the world's busiest LNG trade lane. By 1991 the septet had carried 1,012 cargoes to Japan.

Organisation of SIGTTO's follow-up Japanese visit fell to Yasuo Hosoya. The technical sessions, which were held at the TEPCO offices, were attended by 30 existing and potential members. A trio of receiving terminals were visited, namely Sodegaura, the Senboku facility of Osaka Gas and the Himeji terminal operated by Kansai Electric Power Co. Our host balanced the business of each day with a number of fine introductions to Japanese culture and cuisine.

Risk minimisation

Following a meeting on the same subject a year earlier, a number of European members of SIGTTO met in September 1988 to discuss the potential impact of the Seveso Directive on their operations. Directive 82/501/EC was a European law entitled *Directive on the control of major-accident hazards involving dangerous substances*, passed in 1982 as result of the Seveso chemical plant disaster which occurred in Italy in

1976. It was clear that, as a result of the rulemaking, risk assessment methods were to be applied to the liquefied gas shipping and terminal industry.

As some uniformity of approach was to be desired in the application of these methods, SIGTTO contracted Arthur D Little Ltd of Cambridge in the UK to draft appropriate guidelines, with appropriate input from a working group comprised of the Society's members. The result was the SIGTTO publication *Guidelines for Hazard Analysis as an Aid to Management of Safe Operations*. Published in 1992, the 160-page document came complete with worksheets and graphs for consequence analysis, hazard and operability (HAZOP) studies and failure mode and effect analysis, along with a three-page glossary of terms.

Your General Manager was a member of the UK Health and Safety Commission's Marine Risk Analysis Working Party from 1988. The final publication, published in 1991, 379 pages in length and entitled *Major Hazard Aspects of the Transport of Dangerous Substances*, found that the hazards associated with liquefied gas operations in port areas were "as low as reasonably practicable"!

What a privilege it was to meet all the liquefied gas teachers and leaders listed above over the period 1960-1991. LNG is the least-polluting hydrocarbon fuel and the finest industrial chemical feedstock. But beware. Operators, suppliers and domestic users constitute the human factor, the weakest link in a very strong chain. So, enjoy your privileges, keep learning and thank you for an unequalled record in safe gas ship and terminal operations.



Completed in 1973 as the first Kvaerner Moss spherical tank ship, Norman Lady remained in service for 40 years

Congratulations on SIGTTO's 40th anniversary

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To date only one compressed natural gas (CNG) carrier has been built

Blind alleyways in natural gas shipping?



Bill Wayne*, SIGTTO's seventh General Manager, looks at three early natural gas shipping technologies that, despite three decades of development, have not (yet) met initial high hopes

During the 1980s various internal studies were conducted at my company, Shell, into aspects of shipping natural gas. The three most significant ones were (a) the marine transport of compressed natural gas (CNG); (b) LNG boil-off reliquefaction on ships (DRL); and (c) floating LNG production (FLNG). This article briefly describes the studies and looks at the conclusions with the benefit of hindsight.

Compressed natural gas (CNG)

The drive to investigate the concept of the marine transport of CNG came from a perception that the costs of LNG production plants were too high. Wouldn't it be simpler and cheaper to keep the gas in the vapour phases throughout the supply chain?

The main challenge of CNG transport quickly emerged – that of the energy density of the product. We had to go to very high pressures, 300 bar plus, by which time the gas containment system had become very heavy and expensive. Even at these levels, the energy density was barely half that of LNG.

So, efforts were directed at finding lighter containers. The first step was to look at high-strength steels, then composites. Unfortunately, the latter were porous at the elevated pressures, so needed a metallic liner and the costs were rising. One CNG technology promoter came up with the idea of using relatively small diameter steel tube wrapped on a spool or 'coselle', but this approach still suffered the same problems – too heavy and low energy density.

It was becoming clear that CNG was not going to answer the problem of expensive LNG plants. However, maybe there was a niche where it would work ... In one strand of the study we looked at cooling the gas, which improved the economics, so we cooled it a bit more and the economics were better still – until we found that if we cooled it to -160°C we could eliminate the costly and heavy pressure vessels, whereupon the economics worked!

One final part of the study was to prepare an outline design of a CNG ship based on having a laden displacement the same as a standard LNG carrier of that

time, i.e. a 125,000 m³ vessel. The design resulted in a CNG ship which cost at least three times as much as the LNG carrier but carried only about one-sixth of its cargo.

One advantage was that, because the cargo containment system was so heavy, we didn't need any ballast water tanks, just a couple of trimming tanks. The disadvantage was that the draught, even when empty, was such that we could not find a drydock in the world with sufficient water depth over the sill to dock the ship.

And we haven't touched on the issues around how you actually load and unload one of these CNG ships.

LNG reliquefaction (DRL)

There were two drivers for investigating LNG reliquefaction on board LNG carriers. The first was that the large-scale LPG trade was all conducted with reliquefaction as the normal outfit for the carriers. Additionally, all LNG carriers employed steam turbines, which were recognised as having relatively poor thermal efficiency compared with diesel engines.

Whilst the then current LNG ships' fuel consumption closely matched the natural boil-off, one could foresee improvements resulting in reduced cargo boil-off gas rates, potentially making diesel propulsion and reliquefaction attractive. At that time investigations were already >

Projects based on the use of FLNG vessels positioned in far-offshore locations pose economic challenges



> under way on the consumption of boil-off gas in diesel engines, but we could not be sure of a successful outcome.

Our preliminary studies showed that the Brayton cycle offered the most practical technical solution. The result of the studies was that reliquefaction was technically feasible, but the economics didn't work.

At a qualitative level, remembering that all a reliquefaction plant does is produce LNG, the shore plant has the advantage of large-scale output; it employs in-to-plant gas priced at production costs plus royalties to drive it and, typically, it has a feed gas pressure about 60-70 bar. This, from a physics perspective, results in reduced power requirements resulting from the end-flash process.

In contrast, with a shipboard reliquefaction unit we have lost the benefits of scale and have very low feed gas pressure. Taken together, these considerations mean that the specific power requirement of a shipboard reliquefaction system is three to four times that of the large-scale LNG production plant. And we use expensive, bought-in conventional liquid fuel to drive it. In other words, if you want LNG, produce it in a large-scale plant on shore, not in small packets on ships.

Floating LNG (FLNG)

In the 1980s offshore oil production was starting to take off, initially with the introduction of the first floating storage units (FSU) and then floating production, storage and offtake (FPSO) vessels. The question was then asked: if it works for oil, why not LNG?

A particular drawback for shore-based LNG liquefaction plants processing offshore gas is the high cost associated with providing subsea lines to bring the gas to shore for processing. With the gas at some unspecified distance offshore, it would become cheaper to do everything – LNG production, storage and offloading

– offshore, by making use of a floating vessel. The broad conclusion of the FLNG study was that it was technically feasible.

The issue of cargo transfer was noted. It was assumed that early projects would be in benign conditions with side-by-side berthing. For more exposed offshore locations, the experience from the oil industry pointed to the advantages offered by tandem mooring schemes with dynamically positioned (DP) offtake vessels.

A couple of other points came out of the study. Because the product was competing against conventional LNG, from a major international oil company (IOC) perspective, we needed to go as large as possible for the economies of scale, i.e. the hull needed to be as big as could be competitively tendered to existing shipyards. We also recognised that major known onshore or nearshore reserves would need to be developed first, as they posed fewer technical and cost challenges. We specifically identified the Qatar North Field as one of these.

What these conclusions were effectively saying was that FLNG was only more economic against shore plants in the far offshore. However, a far-offshore FLNG project would still be very costly and could not compete against other nearshore or onshore reserves. In other words, you would only go the FLNG route when you had no other alternatives!

Another issue was that of expandability. The strategy for onshore LNG plants was that the initial project, maybe involving one or two trains, was designed with expansion in mind. The project would start up with the original trains but, after revenues were established, another train would be built, effectively at a marginal cost because it could utilise the existing storage tanks and export facilities, and then another train. At some stage more storage and a second jetty might be needed, but the costs are spread over a larger scheme. With FLNG, the only expansion option is another FLNG unit.

In conclusion

How do these studies from the 1980s look with the benefit of hindsight in SIGTTO's 40th year?

For CNG, the first CNG ship was delivered in 2018 to Indonesia. But only one such ship has ever been built. This would seem to validate the conclusions of the original studies: that CNG is a niche product and does not offer viable competition for conventional LNG in most cases.

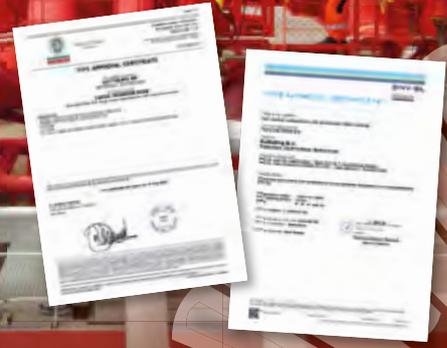
Regarding onboard reliquefaction, history relates that a major project selected this option – conventional diesel engines in tandem with reliquefaction plants - for a fleet of newbuilds in the 2000s. However, the promoters of that scheme are the only ones to have opted for that arrangement; no other project has followed that lead. Whilst the decision for this project was made when gas burning in diesel engines was largely unproven and steam turbines were not a practical solution for the size of vessels contemplated, the original conclusions of the study are still valid.

It is noted that many new LNG carrier newbuildings have been specified in recent years with two-stroke, gas-burning diesel engines in combination with partial reliquefaction systems. However, the argument for this arrangement is somewhat different and such a propulsion system was not considered in the original studies.

As regards the conclusions of the FLNG study, at the time of writing there are five FLNG vessels in service, one a conversion and four purpose-built. The first of the quintet entered service for Petronas in 2017. Of the complement, the largest is Shell's Prelude vessel which has the ability to process up to 3.6 million tonnes per annum of LNG. That capacity is three times greater than that of the next largest FLNG vessel. The conclusions of the 1980s studies would seem largely to have been correct, but the jury is out on the real part that the FLNG option will play in future LNG business.

** Bill Wayne worked for Shell International Marine in the 1980s, and from 1982 onwards his involvement was solely with the LNG/LPG shipping business. In 1984 he was appointed to be Shell's representative on SIGTTO's General Purposes Committee (GPC). He kept this position until 1996 when Shell posted him to Japan. After his return to London, he re-joined the GPC in 2001 and stayed on the Committee until he retired from Shell in 2007. He was then appointed General Manager of SIGTTO, a position he held until November 2012. This is the first of two Bill Wayne articles in this issue; the second is on page 98.*

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One outcome of the Type C tank filling limits debate was the production of SIGTTO guidelines on the design of masthead venting system design



SIGTTO in the Nineties



Dick Chadburn remembers the 1990s as eventful years for the Society, not least two Provisional IRA bombings and a long debate on IMO Type C cargo tank filling limits

I joined SIGTTO as a Technical Adviser in mid-1991 at the time when Bruce Keer became General Manager.

The outgoing General Manager, Robin Gray, had been deeply involved with modifying IMO's International Gas Carrier (IGC) Code to allow the cargo tank filling limits for Type C gas carriers to be extended. SIGTTO's position supported well-filled cargo tanks. In the event of fire impinging on a full tank, the venting process would keep the tank cool for considerably longer than the then IGC Code allowed. This was good for both safety and cargo-carrying capacity.

There was considerable opposition to the SIGTTO position from the US delegation. The Americans called on SIGTTO to demonstrate that the tank pressure relief valves (PRVs) could maintain an internal pressure of no more than 20 per cent above the maximum allowable relief valve setting (MARVS). By filling to SIGTTO's proposed levels, PRVs would be subjected to a liquid, two-phase flashing

flow about which little was known. Robin Gray thought that working in this particular area, along with the many other Technical Adviser tasks then pertaining, would appeal to me. So, I joined SIGTTO.

The outgoing SIGTTO Technical Adviser was Doug Brown. He accompanied me on my first encounter with the combined technical day and Board meeting that the Society held every six months at a venue chosen by a member company. In this case it was Taiwan. We were accommodated in a very traditional building which had originally been the headquarters of General Chiang Kai-shek.

After that inaugural trip Bruce Keer and I, as the new boys, settled into SIGTTO's routine. We were very ably assisted and guided by Mrs Adele Ball who had been secretary to SIGTTO's first General Manager, Maurice Holdsworth. I knew Maurice from our Shell days; he was an excellent manager and is rightfully acknowledged as a key mover and shaker behind the SIGTTO concept.

One of the most significant personal changes for me with my new job was the commuting. Having been spoiled for two decades by the location of Shell Centre adjacent to Waterloo station, I now found myself also having to face the "Drain", the underground line linking Waterloo with the City of London, and a walk from Bank station up Bishopsgate to Stonehouse Court off Houndsditch.

It was there that Bruce and I began to put into practice SIGTTO's objectives of safe working and standardisation at the ship/shore interface for gas ships and gas terminals. We also enjoyed getting to know the membership and continuing the aforementioned cycle of overseas visits and technical conferences. Another focus for us was assisting members when they approached the Secretariat with queries and problems.

Take it to the limit

As part of picking up the reins with the Type C tank filling limits work, I became involved with IMO's Bulk Chemicals (BCH) Subcommittee which was then chaired by Martin Böckenhauer. A naval architect with Germanischer Lloyd (GL) and the representative for the International Association of Classification Societies (IACS) at IMO, Martin was a splendid chap and a close friend of Robin Gray.

At some stage IACS and SIGTTO had sought an alliance to change the IGC

Code's Type C tank filling limit provisions. It had been accepted that the fuller the tank the longer it could remain cool under fire conditions. What remained to be determined, at the request of the US delegation, supported by other IMO member nations, was to prove that the PRVs could handle flashing liquid without exceeding a setting that was 20 per cent above MARVS.

Immediately prior to my joining SIGTTO, Robin had contacted Dr Hans Fauske, who was president of Fauske and Associates Inc and had connections with the University of New Brunswick in Canada. The University's Fire Service Center was researching the thermodynamics and fluid mechanics of two-phase flashing flow, a phenomenon about which we badly needed information. Martin recruited Gerd Würsig, also of Germanischer Lloyd, who was able, in tandem with Robin Gray, to check Fauske's conclusions.

The filling limits work turned out to be my main preoccupation during my six years with SIGTTO. Once we had determined that the PRVs were adequate for the role, the issue of whether we could have flashing liquid at the mast head vents was raised. As a result of these investigations, we compiled guidelines for the design of venting systems to prevent such happenings.

SIGTTO also produced a booklet entitled *Application of Amendments to Gas Carrier Codes concerning Type C Tank Loading Limits*. At Gastech 94 in Kuala Lumpur Martin Böckenhauer, Gerd Würsig, Bernt Olav Bauer-Nilsen from Det Norske Veritas and myself presented a paper outlining our findings, making the case that we could safely proceed with the proposed filling limits. That was the third

Gastech paper on the subject, the others being given in 1984 and 1990. Towards the end of my SIGTTO tenure, Roger Roue joined me as the Society's second Technical Adviser and, after my departure, he continued to tackle the final loose ends raised by the filling limits debate.

Caught up in politics

Unfortunately, political turmoil was to impinge on SIGTTO's technical activities during the 1990s. Just as Bruce Keer and I felt we were settled in at the Society, we received a rude awakening. At 9.20 PM on 10 April 1992 the Provisional Irish Republican Army (Provisional IRA) detonated a bomb in London's Baltic Exchange. SIGTTO's office in Stonehouse Court suffered damage in the blast; the ceiling over my desk was down and some windows were blown out.

The bombing took place at a time when SIGTTO's office rental agreement had a break clause. Bruce Keer decided we should seek pastures new at location with a lower rental fee. After a detailed search, we settled on 17 St Helen's Place, off Bishopsgate, which had been part of the old Indo-Suez Bank. We were most pleased with not only our new headquarters but also the rental charges, these being about half of what we were paying previously.

We moved in early March 1993 and were quickly up and running. We decided to have an office opening party and scheduled the event for 23 April 1993, a Friday. We had an excellent party, with many invited guests, and as we departed at a rather late hour we agreed with the caterers that they could come in over the weekend to clear up. Such plans went up in smoke at 10:27 AM the next morning, Saturday 24 April, when the Provisional IRA

detonated another, much larger bomb very close to our new home.

The explosives were packed in a truck parked in front of St Ethelburga's Church in Bishopsgate. Our office overlooked a small courtyard immediately behind the church. The detonation destroyed St Ethelburga's and wrecked much else, including our new offices. Fortunately, the caterers had not yet turned up when the blast occurred. Bruce Keer and I were permitted into the area on Monday morning to see the extent of the damage to No 17. It was eerie walking up Bishopsgate, with only the sound of glass crunching beneath our feet to break the silence.

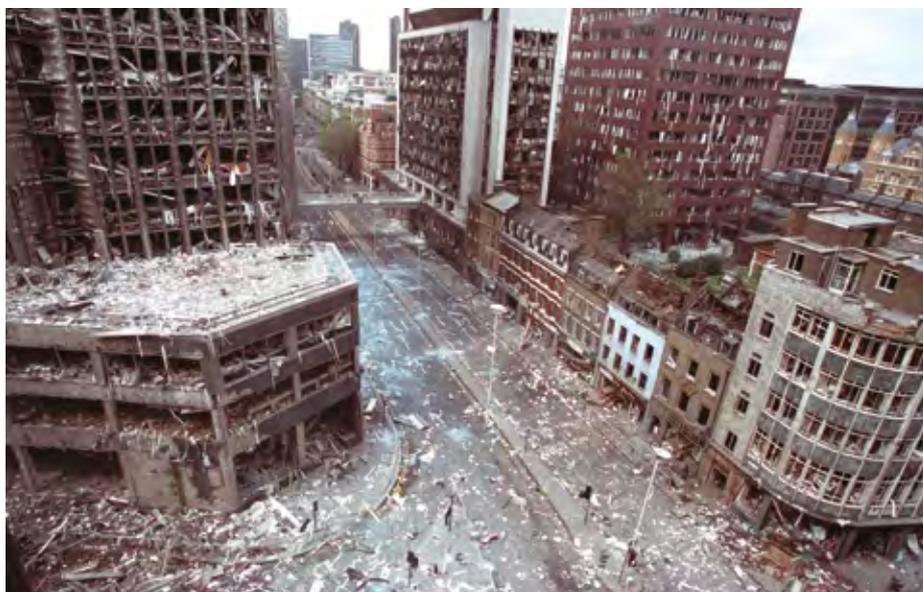
The SIGTTO office was a mess. All the false ceilings were down, and there was a hole in our boundary wall large enough for a man to pass into St Ethelburga's courtyard. Because our library had collapsed in on itself, we hardly lost any books or papers. The following week the Bishop of London and other officials approached us to see if they could assess the damage to St Ethelburga's. They borrowed my camera and passed through our wall to record the damage. The negatives, which they returned to me, bear testimony to the extent of the chaos.

SIGTTO removed to basement premises in Worship Street as temporary accommodation and everyone, wives included, helped in the office transfer operation. We remained in Worship Street for almost a year, until it was possible to return to a refurbished No 17 St Helen's Place. Mercifully, the City of London was free of further terrorist attacks during the rest of my time with SIGTTO.

When Bruce Keer retired, he was replaced as SIGTTO General Manager by Alain Vaudelon, with whom I had the same pleasant relationship. I was with SIGTTO for a further three years during which the SIGTTO membership continued to grow. In the closing stages of my SIGTTO career I took over the editorship of *LNG Log* from William duBarry Thomas. I produced the last hard copy, Number 21, before the *Log* went digital.

SIGTTO's reputation was also thriving during this spell. I kept a record of the queries with which I dealt in the April-to-June 1997 period. Of the 18 noted, only four were from members. SIGTTO was becoming an authority on liquefied gas shipping and storage even beyond its growing membership, and I'm pleased to note that this continues to be the case.

I look back on my time with SIGTTO with considerable nostalgia. It was a happy time for both my wife and myself. I met and worked with a number of excellent people, folk I remain in touch with today.



The Bishopsgate bombing forced SIGTTO into temporary accommodation for almost a year



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Pyeong Taek, Korea's first LNG terminal, had only been operational for four years when SIGTTO visited in September 1990



On organising SIGTTO Panel Meetings in the pre-internet age



Doug Brown, a SIGTTO Technical Adviser of 30 years ago, recalls the challenges of setting up SIGTTO Panel Meetings in the days before the facilitating wonders of IT communications

We take slick PowerPoint presentations at SIGTTO Panel Meetings for granted these days but it was not always the case. Thinking back to my days as Technical Adviser in SIGTTO from early 1989 to end 1991, organising events with the tools then at hand presented challenges, and there was always a story behind each Panel Meeting that was held.

My first Panel Meeting was in Perth, Western Australia in February 1989. Fortunately, almost all the arrangements had been made over the months before I joined the Secretariat, a time when communications consisted mainly of telex, fax and traditional 'snail' mail (although even that seemed fairly fast in those days).

Dark age technology

When I arrived at the SIGTTO offices in Staple Hall off Houndsditch in London,

the Secretariat (at that time comprising a General Manager, one Technical Adviser and two assistants) was working with two massive IBM Displaywriter word processor machines driven by 8-inch floppy disks connected to a golfball printer. Anything that was to be printed had to be written long hand, typed up by Adele Ball or Jackie White, printed, amended, reprinted (if necessary) and finally approved. This was a laborious process and all meeting documents were printed and posted out to our destination or hand-carried in the case of any last minute changes.

Secretariat presentations, which were usually delivered at that time by Robin Gray, the then General Manager, comprised a set of marker pens, clear acetate sheeting and an overhead projector, as we did not have the means to print to acetate sheets. Our guest speakers were usually a bit more organised, with their

presentation material pre-printed onto acetate sheets but still dependent on the ubiquitous overhead projector.

I managed to get the Secretariat, kicking and screaming against the intrusion, set up with personal computers (PCs). These machines didn't need both a boot disk and a file save disk and offered a little more functionality and flexibility. Possessing one of the PCs in my role as Technical Adviser meant that I was able to start doing a lot more than constantly trying to decipher my own handwriting for others to type up!

The Perth Panel Meeting went well, from what I recall, and the technical visit involved about 30 SIGTTO members flying from Perth to Karratha for a technical visit to the North West Shelf Project which, at that time, was still about six months away from start-up. The technical visit included >



An IBM Displaywriter in all its glory



The Sir Christopher Wren-designed Windsor Guildhall

> a tour of the LNG facilities and a trip out from the King Bay supply base on a tug to see the LNG berth from the water. The highlight (?) of the trip was a night in the Karratha International Hotel – still going strong today, just 30 years older!

My next Panel Meeting, scheduled for Edinburgh, is not one that I am proud of. I had strongly suggested that someone from the Secretariat should visit the appointed hotel to go through all the arrangements and make sure everything was OK - but I was told it was not necessary. Sadly, things were not OK on several fronts, and matters were made worse by the fire alarm going off several times on one of the nights we were there.

Jet-lagged SIGTTO members, especially the Japanese contingent, really did not appreciate standing outside in the street at 2:00 AM on a chilly night, half-dressed, awaiting clearance to return to their rooms. Fortunately, the technical visit to Braefoot Bay went off without a hitch, and I even managed to arrange a round of golf at Gleneagles for the Japanese members which was some sort of compensation.

Down Mexico way

Next up, we were off to Veracruz in Mexico. All members were to meet at a hotel at Mexico City airport and we would then fly down to Veracruz, visit the PEMEX facilities at Coatzacoalcos and then return to Veracruz for the Panel Meeting. Our commercial flight to Coatzacoalcos was at 6:40 AM and I had to shepherd the members across to the terminal (with luggage) and get them onto the flight.

At 6:30 all were checked in and heading to the gate but at that moment I realised that

I didn't have a ticket. Either my ticket had gone to someone else or we were one short in the overall headcount. Nevertheless, in those days of rather laxer airport security, I managed to get on the flight (with a ticket) along with everyone else.

Things were going OK (or so it seemed) until we got on a bus in Coatzacoalcos and our suitcases were put on the back of a truck that headed off in a completely different direction. Amazingly, when we arrived at the hotel later that day, via a PEMEX private flight from Coatzacoalcos to Veracruz, all our bags were waiting for us in our assigned rooms.

That first night PEMEX had arranged a reception in the centre of Veracruz. There, in the town square, was a stage, some entertainment and then we were all welcomed by the mayor who presented everyone with a scroll pronouncing them "distinguished visitors to Veracruz".

The following night, after the Panel Meeting, the late Dr Martin Böckenbauer of Germanischer Lloyd presented our host with a small box containing a piece of the Berlin Wall. When a piece of paper blew out of the presentation box as the gift was being handed over, I made a lunge for it but unfortunately ended up fully dressed, full length in the hotel pool, soaking not only myself but several members standing nearby. The rest got wet from tears of laughter as an extremely bedraggled Technical Adviser hauled himself from the pool!

SIGTTO's Seoul Panel Meeting in September 1990 was hosted by Korea Gas Corp (Kogas) and the technical visit was to the Pyeong Taek LNG receiving terminal. On the morning of the visit the reception

area of the Lotte Hotel was crawling with security guards as the then President of Kenya, Daniel Arap Moi, was also staying in the hotel and about to leave.

Outside, there were two coaches for us to visit the terminal in – and police all over the place. I checked that all our members were on board the coaches before setting off and, to my surprise, so did the police! We had a police motorcycle escort through the streets of Seoul until we hit the expressway, at which point a couple of police cars took over to escort us to our destination. Needless to say, we scythed our way through the traffic. I assume that some of the constabulary may have stayed behind to help the Kenyan President!

My final two Panels

In February 1991 we were in the final stages of preparation for a SIGTTO Panel Meeting in Damman at the kind invitation of Saudi Aramco. However, an escalation of tensions between Iran and Iraq caused a last-minute change of plans and we held the Panel Meeting close to London's Heathrow Airport at a hotel on the banks of the River Thames.

What I do remember about that get-together was commuting about four miles between my home and the hotel by boat and taking some members out on the river to get a view of Runnymede, famous as the place where King John signed the Magna Carta in the year 1215. The Panel dinner was held in Windsor Guildhall, an interesting cantilevered structure completed by Sir Christopher Wren in around 1690. The interior has full-sized and, in some cases, full-length portraits of every English king and queen, from Queen Elizabeth I to our current Queen – a most imposing venue.

My last Panel Meeting was in Kaoshiung in Taiwan in September 1991. All that I really remember about that occasion was a visit to the Yung An LNG terminal, being toasted on my departure from SIGTTO at the evening dinner by every member present (not to mention a recollection of the sore head afterwards!) and being dropped at the wrong terminal at Kaoshiung airport. As result of the latter error I had to sprint about half a mile carrying a heavy suitcase in order to catch my flight home, which was then boarding.

SIGTTO Panel Meetings have grown in size, quality and stature since that time and are far more professionally run. However, during those early days we always tried to give the impression of a swan serenely floating on the water, despite the fact that we were paddling like fury behind the scenes to ensure all went well ... and it usually did ... in the end.

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Beauvais, LNC carrier, 1962



Georgiy Brusilov, Arc7 Yamal LNG carrier, 2018

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Opened in 1985, the Futtsu facility is one of TEPCO's Tokyo Bay LNG receiving terminals

Japan, LNG and SIGTTO have deep, intertwined roots

Ryoichi Shirato* of TEPCO describes how LNG was introduced to Japan 50 years ago as well as his company's close links with SIGTTO since the Society's inception

First of all, congratulations to SIGTTO on its 40th anniversary and all that the Society has achieved so far. TEPCO and its new JERA joint venture partnership, as companies placing top priority on safety, welcomed the formation of SIGTTO as a global initiative focused on this same cause and have been proactively engaged in the management of the Society ever since.

The energy industry has changed significantly over the past 40 years, a period which can be considered as the "dawn of LNG". As a TEPCO executive, I have witnessed the conversion of thermal power plant fuel from coal and oil to LNG. In reminiscing about this energy transition, I would like to thank SIGTTO for its support in the development of a safety-first LNG industry.

Environmental concerns

Japan underwent excessively rapid industrialisation in the latter half of 1960s, a time when coal was the primary source of fuel. The burning of

large quantities of coal caused major atmospheric pollution problems and jeopardised the health of many living in the country's population centres.

Tokyo Electric Power Company (TEPCO) launched a number of initiatives with the aim of tackling this problem. In addition to work on the development of DeNOx and DeSOx technologies, the company had been seeking to procure fuels with a reduced sulphur content and to test the combustion of methanol in its thermal power plants.

At the time, however, DeNOx and DeSOx technologies were in the preliminary stages of development and early results were not particularly promising. Electrostatic precipitators, for example, barely improved a plant's environmental performance. When it came to obtaining fuel with a reduced sulphur content, the procurement of 1.2 million kilolitres per annum of Minas crude oil, enough to fuel the 1.05 GW Oi thermal power station, was the best that TEPCO could do in the short term.

The rapid rise in the number of vehicles on the country's roads contributed to

Japan's worsening air pollution during the 1960s. In certain weather conditions the combination of vehicle emissions and other atmospheric pollution resulted in smog that reduced visibility. Also, there was a tendency for pollutants to accumulate, especially at intersections in low-lying areas.

While pressure on Japanese industries to introduce measures to reduce air pollution was growing, it was apparent that a fundamental solution was not going to be easily found while the country was wholly reliant on coal and oil as energy sources.

It was at this point that Tokyo Gas Co Ltd, Japan's biggest gas supplier, was considering implementing a plan to liquefy natural gas produced at Kenai in Alaska, and to transport the LNG in dedicated tankers to Japan. Tokyo Gas realised that the project would need to process substantially large volumes to make it economically viable, considering the costs inherent in liquefying the gas, transporting the LNG to Japan in specialised gas carriers, and regasifying the cargoes on arrival. Because Tokyo's city gas demand was still relatively limited at that time, Tokyo Gas discussed with TEPCO the option of using some of the imported LNG as a thermal power plant fuel.

Although utilising large volumes of LNG for the purpose of power generation was internationally criticised 50 years ago as lacking in commonsense, the managements of Tokyo Gas and TEPCO jointly decided to press ahead with the Alaskan LNG project. The total contracted LNG import quantity for the two companies was 960,000 tonnes per annum.

The project enabled Tokyo Gas to increase the calorific value of the gas

delivered to its customers, due to the inherently different properties of town and natural gas, while the use of LNG by TEPCO enabled the company to utilise a much cleaner fuel in its power plants. A structure to receive and introduce LNG was in place as TEPCO's Minami Yokohama thermal power plant, situated adjacent to the Tokyo Gas Negishi LNG import terminal, had successfully tested methanol combustion in the recent past. Thus, on 4 November 1969 Japan received its first-ever LNG cargo, delivered from Alaska by the 71,500 m³ *Polar Alaska*.

More gas-fired power plants

Following the introduction of LNG as fuel, the Minami Yokohama thermal power plant began to build an excellent track record in reducing air pollution levels. Thereafter, TEPCO proactively promoted an increased utilisation of LNG through the construction of a new 1 GW-class, gas-fired plant; the conversion of existing oil-burning units into LNG-based thermal units; and the adoption of gas turbine combined-cycle units in the drive for enhanced thermal efficiency.

Today, 50 years after the introduction of LNG to our country, more than 70 per cent of the thermal power plants operated by TEPCO in Japan utilise LNG as fuel. TEPCO has also developed technologies that enable the 'cold' energy inherent in liquefied natural gas to be utilised as a power source in its own right.

TEPCO, like all firms handling large volumes of LNG, is sensitive to the public perception of such cargoes arriving in Japan as 'frozen fire' and is unstinting in its commitment to safe operations. Amongst the measures implemented



Polar Alaska, which delivered Japan's first LNG cargo 50 years ago, finished her working life in 2014 as SCF Polar

by TEPCO to ensure the safety of its LNG-related equipment, systems and operations are its "behaviour experiments" relating to the sea surface diffusion of LNG and the installation of water screen equipment in LNG storage tanks.

TEPCO and SIGTTO

Due to its safety-first policy TEPCO has been recognised as a company that "performs activities vital for safety measures in the LNG industry". Since 1981 the company's five vice presidents have consecutively served as vice presidents of SIGTTO.

During the tenures of these TEPCO vice presidents, SIGTTO has considered and examined numerous notable safety advances in liquefied gas equipment and operations, leading to the development of relevant industry best practice guidelines.

Amongst the many topics that have come under review over the period are the safety of LNG ship-to-ship (STS) transfers and, more recently, regular, in-depth discussions with the US Coast Guard (USCG) as that country's exports of LNG and LPG have begun to climb dramatically.

It is worth mentioning that over the past 40 years of expansion in liquefied gas shipping and terminal activities, there have been no notable releases of cargo from an LNG carrier and no known cargo releases resulting in a fatality. This exemplary safety record bears testimony to the work of SIGTTO over the past four decades in the wide-ranging dissemination of industry best practice guidelines.

Although I was also involved with coal as power plant fuel for a long time while with TEPCO, the use of coal is now facing strengthening social headwinds for environmental reasons. I now feel strongly that LNG has enhanced its leading position amongst the fossil fuels for not only environmental reasons but also because of the high safety levels inherent in the LNG supply chain. SIGTTO has contributed greatly to this achievement.

While LNG import volumes in several developed countries have reached a fairly mature stage, many developing countries

are waking up to the benefits offered by natural gas. The expanding use of LNG in developing countries will help further globalise LNG transport and consumption.

The increasing complexity of handling growing volumes of LNG via diversifying supply chains will demand the utilisation of new technologies such as artificial intelligence (AI) and the internet of things (IoT). SIGTTO needs to foresee the impact of such developments, not least in the areas of design, construction, equipment and operational safety.

Increasing concerns about climate change and global warming today are also driving the demand for renewable energy, and Japan is following in the footsteps of Europe and the US in promoting the use of renewables.

JERA and SIGTTO in unison

In this rapidly changing world TEPCO established JERA in tandem with Chubu Electric Power Co Ltd in April 2019. JERA will not only undertake the consumption of LNG in its power plants but also engage in the wider natural gas value chain, including LNG transport and trading.

The importance of LNG is set to rise in the years ahead as the product has a key, complementary role to play alongside the increasing use of renewables in future energy policies worldwide. As a result SIGTTO's role will remain undiminished for at least another 40 years, and JERA is looking forward to accompanying SIGTTO on that journey and advancing together.

Ryoichi Shirato

* Ryoichi Shirato spent 44 years with TEPCO, from 1962 to 2005. He was managing director of the company from 1998 to 2000 and executive vice president from 2000 until 2005. Ryoichi Shirato was SIGTTO Senior Vice President from 2001 to 2005 and president of Japan's Central Research Institute for the Electric Power Industry from 2005 to 2009.



The Alaska/Japan contract - Asia's first-ever LNG sales and purchase agreement



This underground LPG storage cavern in the US is similar to the facility utilised by Calor Gas at Immingham

Heavy-lifting – getting the Society’s foundations in place



Robin Buncombe, only SIGTTO’s second-ever Technical Adviser, looks back to those early days when it was important to get the correct foundation stones in place for a long-serving industry association

I joined what was then Shell Tankers UK (STUK) in 1965 as a marine engineer apprentice. I went to sea to see the world - and what did I do, I saw the sea from tankers. I rose through the ranks during my 13 years with the UK Merchant Navy, reaching the position of chief engineer. Then, in 1979, I was requested by Shell International Marine to develop, initiate and implement a brand new appraisal system for liquefied petroleum gas (LPG), liquefied natural gas (LNG) and chemical tankers.

A great deal of international travel ensued, enabling me to inspect and audit more than 600 owned or third-party gas and chemical carriers. I also collated other worldwide ship inspection data gathered by the safety officers of other hazardous cargo organisations and assisted in undertaking marine terminal audits. Following this work, in 1982, I acted as a build and commissioning cargo engineer on LPG carriers.

SIGTTO initiation

Between 1983 and 1986 I was seconded from Shell to SIGTTO to replace Dick Oldham as the Society’s sole Technical Adviser and to assist the then first General Manager, Maurice Holdsworth. In the role I was also responsible for developing technical publications, project engineering and training videos with associated documentation; organising SIGTTO Panel Meetings, gatherings of the General Purposes Committee (GPC) and seminars; and attending events in the Gastech series of conferences on behalf of the Society’s worldwide membership.

Importantly, we represented member interests as a non-governmental organisation (NGO) at the UN International Maritime Organization (IMO), and in relations with other industry associations such as the Oil Companies International Marine Forum (OCIMF) and the International Chamber of Shipping (ICS).

Maurice Holdsworth’s personal

assistant was Adele Ball, while Ellen Timpson (née Booty) and Wendy Parker (née Brighton) in support roles were also part of the strong and wonderful, albeit small, Secretariat team. During my time, Maurice – a true gentleman, scholar and strong advocate of gas ship and terminal safety – was replaced as General Manager by Robin Gray. Robin possessed the same characteristics as Maurice and was the instigator of a number of in-depth SIGTTO studies, including those on Type C tank filling limits and an understanding of hydrate formation. My immediate successors as Technical Advisers were Doug Brown of BP and Roy Izatt of Shell.

During my SIGTTO tenure, the Society moved its headquarters from Staple Hall, off New Street near Liverpool Street station in the City of London to nearby St Helen’s Place. My bedsit accommodation at the time was only a short walk away, at the lower end of the newly erected concrete jungle known as the Barbican.

Although it was conveniently located, the apartment block possessed no sense of community. Most of the residents remained strangers. For months I genuinely thought my next door neighbour – who I rarely saw – may have been a ‘belle-de-nuit’, as she was young, very attractive and worked strange hours that changed frequently. Talk about jumping to conclusions. I met her quite by chance in the local pub and hinted at my suspicions – at which point she burst into laughter, saying “How presumptuous! I work next door at the Covent Garden vegetable market in Spitalfields!”

Advancing risk minimisation

Following my SIGTTO tenure and after I left Shell, I became a safety consultant to the hazardous cargo transport and terminal industries until being headhunted by Calor Gas in 1991. I served with that company for 10 years as chief engineer marine terminals at Felixstowe, Immingham and Canvey Island.

The three UK facilities stored LPG and the Immingham terminal had a particularly notable feature. Calor Gas Ltd jointly owned two vast, underground caverns at the site, one for storing propane and the other for butane. The caverns, mined in chalk 180 metres underground, can each store up to 60,000 tonnes of LPG, and are designed to ensure that peak winter demand for LPG can be met. The gas is contained as a liquid in the caverns by the hydrostatic pressure of water in the surrounding chalk.

In the early 1980s SIGTTO organised a Panel Meeting on Humberside for its members during which attendees

were invited to view the Immingham terminal's underground tunnels via a metre-wide 'lift', a daunting jaunt to say the least; see the innermost workings of the comparatively new Humber Bridge; and participate in very interesting and extremely relevant discussions regarding the import, storage and export of LPG.

After my work for Calor Gas, but before retirement at the end of 2014, I became a part of a resilience multi-agency emergency planning officer (EPO) for county local authorities, working closely with emergency services, public utility companies and governmental bodies under the banner of the Suffolk Resilience Forum.

Throughout my working, and into my 'civilian', life, a primary focus for me has been the area of risk mitigation, safety management and emergency planning. A feature of this discipline is an understanding of the possible behaviour of others in various scenarios and the likely resultant outcomes.

The three C's – cooperation, coordination and communication – are essential across life and necessary for a complete understanding of risk. Adherence to these three goals has stood me in good stead over the years. It was, and remains, my guiding philosophy, and my time with SIGTTO proved invaluable in embedding these principles.

SIGTTO origins

Back in 1978 there was a growing perception amongst the general public that operations onboard gas carriers and at liquefied gas terminals were high-risk activities. A number of major explosion and pollution accidents involving large oil tankers had made the newspaper front pages and there was a growing belief that the seaborne trade in liquefied gases, still at a relatively early stage of development, posed even greater risks than crude oil.

This was the time when 13 major companies involved in the transport and handling of liquefied gases launched an international, cooperative effort to identify existing industry safety and technical standards. They also set themselves the target of determining whether or not there were any potential shortcomings in the existing safety regime and, if deemed necessary, how improvements should be initiated for the benefit of the industry, and society, worldwide.

It was decided that there was indeed a need to form an industry association to coordinate the preparation and dissemination of industry best practice guidelines amongst all participants. Although the majority of the original

13 companies were engaged in the LNG sector, it was decided early on that any revised and improved safety regime should also cover the seaborne transport, storage and handling of LPG. Thus, SIGTTO was established in 1979.

In the early to mid-1980s, during my secondment to SIGTTO, the Society's members and staff, along with personnel from related industry bodies with similar concerns, made significant progress in (a) investigating the issues that underpinned the safe handling of liquefied gases and (b) developing practicable operational measures and equipment standards that helped minimise associated risks. Although the work was challenging, it was also enjoyable, informative and, occasionally, amusing.

As the editor of the original *Liquefied Gas Handling Principles on Ships and in Terminals* publication, I still have a signed version of the limited numbered edition! During my time at sea I had acquired some basic computing skills on a device called a Sinclair ZX80 and so for the editing job I 'borrowed' one of the original Apple Mac machines and tried to convince Maurice and Adele of the merits of a personal computer system. "No need," they both said, "We already have a fax, telex and IBM golf-ball typewriters!"

In November 1984 I had the pleasure of attending the Gastech conference and exhibition, held at the RAI Convention Centre in Amsterdam. At the event Maurice Holdsworth presented a paper entitled

An Update on the Activities of the Society of International Gas Tanker and Terminals Operators Ltd. Dr Martin Böckenhauer, a strong supporter of SIGTTO, delivered another keynote paper entitled *The Filling Limitations of Cargo Tanks: A Review of the IMO Gas Carrier Code Requirements.*

Also amongst the number of great friends of the Society present at that particular Gastech event was Roger Ffooks, who chaired Session 4 of the conference on *Transportation, Technology and Operations*. It is pleasing to note that the Gastech series of meetings is now in its 47th year and going stronger than ever.

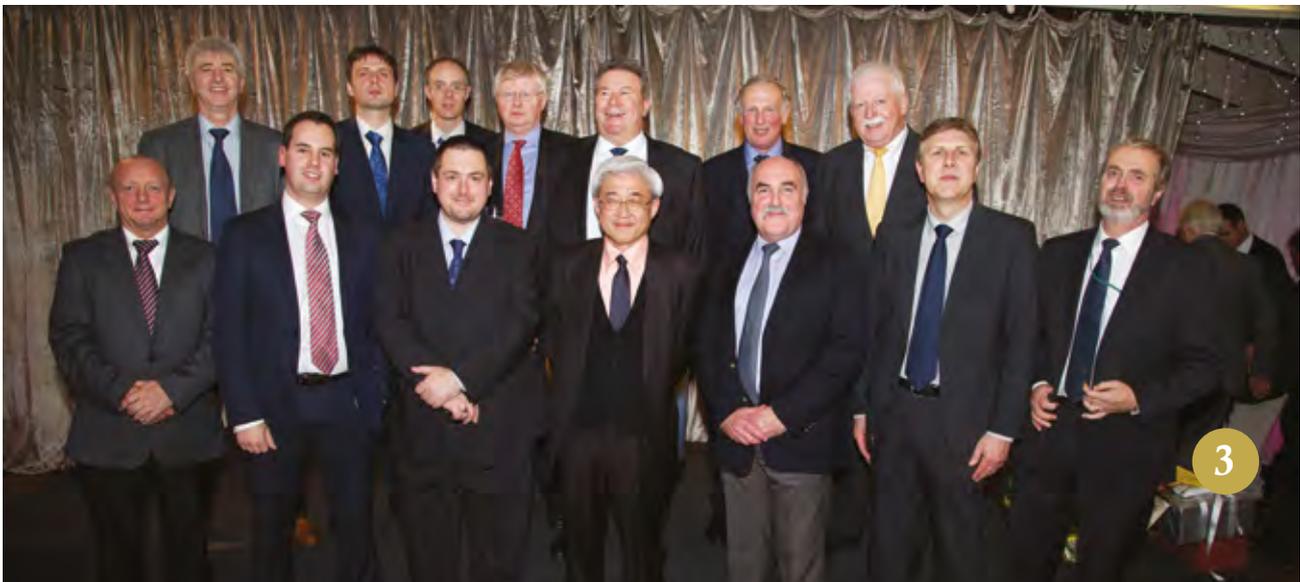
SIGTTO has made an immeasurable contribution to the development of a safe and healthy environment for gas ship and terminal operations over the past 40 years. Since its creation, the Society has increased its membership and enhanced its breadth in tandem with the strong growth of the industry.

Although much has changed in terms of technological advances in the 25 years since my secondment, not least in desktop computers, the principles remain the same. SIGTTO's *modus operandi*, namely the provision of relevant and up-to-date industry best practice guidelines and the organisation of a busy schedule of meetings worldwide to enable the cross-fertilisation of ideas amongst members, regulatory bodies and like-minded associations, merits emulation by all those responsible for upholding the highest standards in industrial safety.



The 1984 meeting was the second of four Gastech events that have been held at the RAI Congress Centre in Amsterdam

A selection of photos from the Society's past



- 1.** A SIGTTO technical visit to the Enterprise Hydrocarbons Terminal in Houston, the world's busiest LPG export facility
- 2.** SIGTTO General Manager Andrew Clifton attended the formal opening of the enlarged Panama Canal locks on 26 June 2016
- 3.** Technical Adviser Roger Roue helped coordinate the efforts of the various working groups charged with revising the IGC Code; pictured back row, centre, Roger is joined by a number of colleagues engaged on the project
- 4.** The South American Regional Forum of September 2016, held in Buenos Aires, holds the record for the highest attendance at a SIGTTO Regional Forum, with 110 participating; some of those delegates are shown here at the event's technical visit
- 5.** Alan Witherby (left) and Iain Macneil seal the deal as Witherbys and Seamanship join publishing house forces in 2008



A quartet of SIGTTO General Managers, pictured at the 25th anniversary reception in 2004 – Bruce Keer is second left; the others are, from left to right, James MacHardy, Alain Vaudolon and Robin Gray

Transitioning to a flexible gas ship fleet

Bruce Keer, SIGTTO's third General Manager, looks back a generation, to a time when the Society was making preparations for more flexible, multi-terminal LNG trading

As the third General Manager in SIGTTO, I had a hard act to follow. Robin Gray, the second General Manager, had an enormous technical understanding of the gas shipping industry through his experience with gas ship design and construction. I, on the other hand, had spent 40 years in the oil tanker business with BP.

In my latter years with the energy major I did get more and more involved with gas shipping, most notably through the Abu Dhabi's Das Island and Western Australia's North West Shelf (NWS) LNG export projects. I also managed BP Shipping's gas unit. With the NWS project I spent three years seconded to BP Australia during which time the arrangements for operating the shipping arm of the scheme were agreed between the six companies involved – BP, Shell, Woodside, Chevron, Mitsui and Mitsubishi.

I retired from BP in 1991 and took up the SIGTTO position on the retirement of Robin Gray. I was lucky to have the services of two excellent Technical Advisers - Dick Chadburn and Doug Brown - and an equally excellent secretary, Mrs Adele Ball.

Logging LNG ships and terminals

My first major job at the Society was to document all the details of the LNG

ships and the terminals in operation around the world. As a key aim of the exercise was to facilitate the ability of ship operators to load and discharge their vessels at more than one port, the data-gathering exercise encompassed logging ship mooring and berthing arrangements for all LNG carriers and terminals.

At that time most LNG carriers tended to be dedicated to certain routes, shuttling between appointed loading and discharge terminals. However, as the industry expanded, it seemed obvious to me that LNG carriers would need to be more flexible and have the availability to operate on a variety of different routes. As part of that early SIGTTO project Peter Denly did many of the calculations that were required to determine mooring line stresses.

Japan has been the leading importer of LNG throughout the history of SIGTTO. Japanese ship and terminal operators were quick to establish rules and practices governing the safe operation of LNG carriers, in particular their safe passage to and from receiving facilities in Tokyo Bay and other parts of the country. SIGTTO was involved in promulgating these industry best-practice guidelines throughout its membership of gas ship and terminal operators.

The Society had established sub-committees with the intention of

bringing together members to discuss operational safety matters. Terminal operators around the world offered to host these meetings to which all members, whether vessel or terminal operators, could bring their concerns, problems and experiences to the attention of their fellow industry participants. In this way we were all kept informed of the challenges facing the industry and given practical help and suggestions as to how best to meet these challenges.

Papers were written by the SIGTTO Technical Advisers and these were circulated to all the membership. Many were, and continue to be, offered freely to the industry. I believe this *modus operandi* helped to increase awareness and safety throughout the industry. Our industry's very low level of incidents provides not only an exemplary safety record but also proof of the efficacy of the approach.

In the five years that I was General Manager, the Secretariat itself had to cope with some challenging situations, as Dick Chadburn's descriptions of Provisional IRA bomb attacks in London in a separate article testify (see page 42). Although our offices suffered damages in two bombing incidents during our tenures, we kept operating nevertheless, albeit in three different office locations.

Booming gas carrier trades

The size of the gas shipping industry has increased enormously over the years. In 1997, as my tenure as General Manager ended, there were 103 LNG carriers in service, transporting about 82 million tonnes of LNG between 43 export and import terminals worldwide. Another 24 LNG ships were on order. The LPG carrier fleet numbered 906 vessels, with an additional 54 on order, engaged in the carriage of butane, propane, ammonia and petrochemical gases. The SIGTTO membership stood at nearly 100 companies and organisations. In comparison, during the same year an oil tanker fleet of some 3,200 vessels transported nearly 2,000 million tonnes of crude oil and refined products.

While the trade in crude oil and oil products has increased by only 50 per cent over the last 20 years, LNG movements have increased by 400 per cent. The more rapid growth of the gas shipping fleet will continue in the years ahead, with LNG's good fortunes being supported by strong growth in the LPG and ethane carrier sectors. The pioneering work we did 25 years ago, to gear up for more flexible gas carrier operations worldwide, is paying dividends.

The logo consists of a dark blue circle with two horizontal lime green bars, one above and one below the text.

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OCIMF's Mooring System Management Plans stand both its and SIGTTO's members in good stead

Industry watchdog and coach par excellence



Steffen Jacobsen, a former SIGTTO President about to become President once again, extols the virtues of the Society's communal spirit, inherent knowledge banks and symbiotic relationship with OCIMF

The gas transportation industry has undergone a huge expansion over the last 40 years, from being a small niche industry to what it is today - the key pipeline for ensuring the flow of clean energy across the world. Establishing the credentials of the global gas shipping sector, with its exemplary safety record, has been achieved by developing, swiftly and prudently, the best-practice measures deemed necessary under the guidance of a strong industry body.

Over the past four decades SIGTTO has been quick to identify emerging new gas shipping and terminal safety challenges and risks and then to provide industry with the appropriate best-practice guidance to meet the challenges and mitigate the risks. This capability is best illustrated by the Society's leading role in the development of the recently revised International Gas Carrier (IGC) Code and the new

International Code of Safety for Ships using Gases or other Low-Flashpoint Fuels (IGF Code), two cornerstone IMO documents.

Quickening pace of change

I have been involved with SIGTTO since 2007 and in the 12 intervening years alone the industry has changed in leaps and bounds. Recent developments include the following:

- The rapid growth of LNG transport volumes, both globally and in lot sizes
- The spread of the floating storage and regasification unit (FSRU) concept
- The establishment of safe LNG transport in extreme environments, as exemplified by the Yamal LNG project in the Russian High Arctic
- The evolution of gas-fired LNG carrier propulsion systems, highlighted by the rapid transition from steam turbines

- to four-stroke diesel-electric systems to two-stroke low-speed engines
- The use of LNG as fuel to power not only LNG carriers but all manner of other ship types
- The long-distance transportation of ethane as a petrochemical feedstock, and also the use of ethane as a propulsion system fuel
- The rapid expansion of the very large gas carrier (VLGC) fleet to carry the surging volumes of US LPG becoming available for export as a result of the shale gas revolution
- The major advances being made with LNG carrier containment systems, not least through their improved insulation capabilities
- The increasing technical complexity of operating modern cargo-handling equipment and systems

The gas shipping industry has managed the risks associated with the rapid technological advances of the past 12 years as effectively as it did in earlier times of less frenetic change. This has been achieved without any major incident involving a loss of cargo, thus ensuring a continuation of our sector's notable safety record. The fact that gas ship cargoes can be flammable and/or toxic and give rise to structural damage and personal injury due to their cryogenic carriage temperatures adds weight to the need for an unstinting, professional approach by all design, operational and managerial staff involved in the gas carrier and terminal sectors.

Of course, it would be inappropriate

to lavish all the praise for this exemplary performance on SIGTTO alone. Nevertheless, it is fair to say that the Society has contributed greatly to the safety record, not least by creating an environment where industry experts can gather to discuss in depth any relevant safety issues and best-practice guidance. The organisation has a proven capability in identifying issues where industry-wide guidelines, rules and best practices need to be developed and adopted without delay.

My involvement with the gas transportation industry began in 1983, at which time the nascent Society had already begun to develop and make available its portfolio of industry best-practice guidelines. I joined the SIGTTO Board of Directors in 2007 as a Maersk representative, and became President of the Society in 2012. I had to resign from this position in 2013 due to changes in my employment, but I rejoined the SIGTTO Board in 2016 after becoming CEO of Evergas. I am pleased to report that I have recently been appointed the Society's President once again and will commence service in that role as of November 2019.

My company, Evergas, is an active member of SIGTTO, with representation in both its General Purposes and Human Element Committees. We operate a fleet of new ethane carriers which is mostly involved in shipping ethane transatlantic, from the US to Northern Europe. Evergas was the industry's first operator to run the four-stroke engines on its ships on boil-off ethane gas for propulsion purposes.

During my earlier tenure as SIGTTO President, in 2012-2013, interest in using LNG as marine fuel had begun to take hold across a number of different sectors of commercial shipping. We felt that the workload associated with all the different queries and requests coming in to the SIGTTO Secretariat was becoming disproportionate to our primary focus on gas ship and terminal operations.

Following wide-ranging discussion at Board level, it was agreed that a separate non-governmental organisation (NGO) should be formed to take on responsibility for matters relating to gas-powered ships that are not gas carriers. That was how the Society for Gas as a Marine Fuel (SGMF) came to be established.

Today SGMF is a successful NGO with a significant membership. I am confident that with the introduction of the IMO 2020 global sulphur cap, mandating the use of ship fuel with a maximum sulphur content of 0.5 per cent, or equivalent, on 1 January 2020, we will begin to see an even larger switch to LNG as marine fuel over time.

And, while LNG may be the most popular of the gas fuels, the use of other gases such as ethane, propane, hydrogen and anhydrous ammonia to propel ships will also increase.

Oil tanker commonalities

I have also had the pleasure to be an active participant over many years in the activities of another major NGO involved in bulk energy shipping – the Oil Companies International Marine Forum (OCIMF). While OCIMF member fleets may be predominantly comprised of oil tankers, gas ships still figure prominently amongst the membership. With a foot in both camps, I must say that OCIMF and SIGTTO complement each other well.

While the complexities of gas transport eclipse those of oil transport in several respects, there is an undoubted commonality amongst the membership of the two NGOs in areas such as ship inspections, management systems, navigation and mooring. Both gas and oil tanker operators have benefited from the adoption of several common tools developed by OCIMF, including the Ship Inspection Report (SIRE) programme, the Tanker Management and Self-Assessment (TMSA) scheme and the Mooring System Management Plans (MSMPs).

So, this inter-NGO cooperation enables SIGTTO to generate guidelines, controls and tools specific to the gas shipping and terminal sectors as well as to rely on OCIMF publications that cover operational matters of concern to both gas and oil tankers. The combined coverage of these two NGOs is staggering; it is no surprise that safety improvements achieved by the oil tanker sector since the grounding of *Exxon Valdez* in 1989 have been every bit as notable as

gas shipping's ongoing safety record.

Although gas carrier operations represent by far the safest part of commercial shipping today, we cannot rest on our laurels. Gas shipping is currently undergoing a period of expansion that is greater than ever before, and new participants are joining the gas shipping club every day. Rapid fleet expansion combined with the increasing complexity of gas ships and their equipment are placing unprecedented emphasis on the need for competent and skilled seafarers.

The gas shipping industry as a whole has an obligation to ensure that a proper 'talent pipeline' is built and maintained. This will enable the industry, as it copes with this high-growth scenario, to have access to the human resources needed for the continued evolution of a safe, accident-free fleet. Technological advances have and will continue to support requirements for ship and shore employees conversant in everything from thermodynamics to control automation and information technology.

In taking a snapshot of the activities of SIGTTO's Human Element and the General Purposes Committees, it is difficult to take onboard the full range of important issues that are currently being dealt with. Without the voluntary work done by the members of these Committees, and the various Working Groups they engender, SIGTTO would not be able to perform the way it does.

SIGTTO's communal approach, as exemplified by the dedication of these membership teams and the open sharing of knowledge, experience and best practices, can only be saluted. At the end of the day, this voluntary work reinforces the greater good of the industry and continues to be a prime illustration of the spirit of SIGTTO.



Operated by Evergas, the 27,500 m³ ethane carrier *Ineos Intrepid* is also able to utilise ethane as a propulsion system fuel



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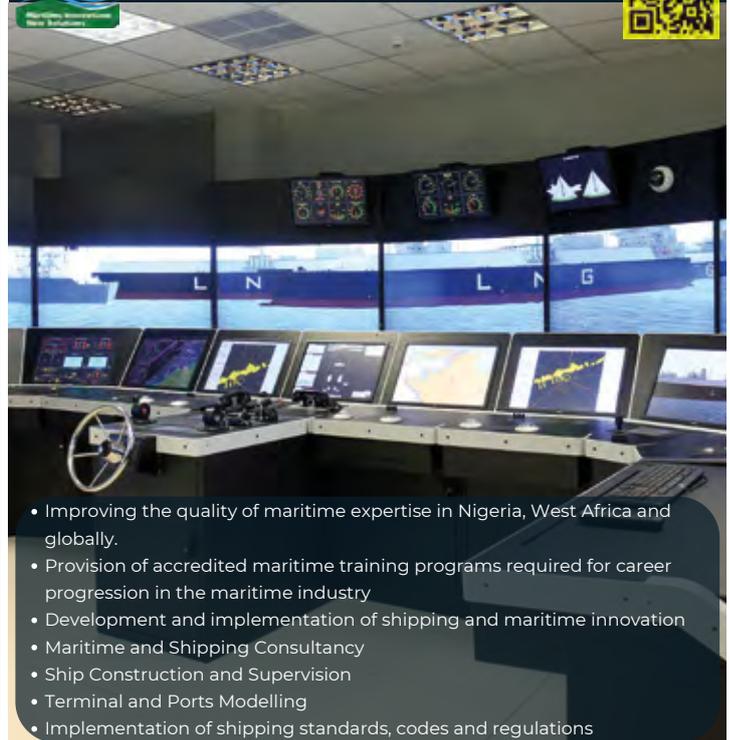
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OLT Offshore LNG Toscana is the company which manages the floating storage and regasification unit "FSRU Toscana". The Terminal is technologically innovative and well-advanced. It guarantees the maximum standards in terms of environmental sustainability and safety. "FSRU Toscana" is permanently moored off the Italian coast - between Livorno and Pisa - in the heart of the Mediterranean Sea. The Terminal has a regasification capacity of 3.75 billion Standard cubic meters per year and an LNG storage capacity of 137,100 cubic meters. The operational flexibility and the design of the Terminal allow SSLNG reloading opportunities available in future.



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SIGTTO ‘window to the world’ also has gas shipping roots



Iain Macneil, chief executive of Witherbys, SIGTTO’s publisher, traces a gas shipping career that has evolved in tandem with the industry’s NGO

I first encountered SIGTTO in the 1980s as a cadet onboard LPG carriers operated by Bibby Line of Liverpool. At the time I participated in LPG cargo grade changes and the Society’s *Liquefied Gas Handling Principles (LGHP)* was used in the planning of the cargo grade change operations on all our vessels and referred to throughout.

That early introduction to the SIGTTO brand was further emphasised by the advice of shipmates who counselled me when it came time to do my gas endorsement. They said I should do it in Edinburgh at The Centre for Advanced Maritime Studies, as the people at that training establishment worked closely with SIGTTO in the compilation of the very first edition of LGHP, published in 1986. When it comes to recommendations, and your shipmates point to a course that supports the industry standard publication for gas shipping, you can’t get a more honest testimonial than that. When the time came for me to do my gas endorsement, I followed their advice and achieved the desired end-result.

The spelling is S-I-G-T-T-O

After coming ashore and starting Seamanship International as a publishing venture, we increasingly found ourselves working with SIGTTO and Witherbys, another maritime publisher, during the mid-2000s. The first words to me of the then SIGTTO General Manager, James MacHardy, were “When we go to events and exhibitions, make sure the organisers spell SIGTTO’s name correctly”. Sure enough, at the next event, which was Gastech 2005 in Bilbao, and we participated in our first joint venture exhibition display with Witherbys and SIGTTO, we arrived at the exhibition hall to set up a stand that proudly displayed the name ‘SIGGITO’!!! I’ve since learned that the male brain apparently does not cope well

Witherbys has published all four editions of Liquefied Gas Handling Principles



with six letter abbreviations and over the years I’ve seen SIGITO and SIGGITO so many times that I’ve lost count!

My work with SIGTTO increased in 2006 when I co-chaired the SIGTTO LPG Competency Standards working group alongside two long-time SIGTTO stalwarts and good friends: Chris Clucas of Bernhard Schulte Shipmanagement (BSM) and George Perantsakis of Naftomar.

The following year was dominated by our final preparations for taking over Witherbys and moving all operations to Edinburgh. My lasting memory of that time was our staff, and I am sparing the blushes of Kat Heathcote – my better half - here by that generic reference to staff, getting the names SIGTTO and ISGOTT terribly mixed up. Maybe it was not that surprising, considering how often they encountered both of these two important and similar tanker shipping industry acronyms in the course of their day-to-day work. ISGOTT, by the way, stands for the International Safety

Guide for Oil Tankers and Terminals.

To have your publications actively used and referred to during shipboard operations is, for me, the best outcome that an industry body that produces technical and operational recommendations and guidelines can achieve. As SIGTTO’s publisher, my key focus is to help safeguard that position and continue to ensure they are practically used onboard the world’s LPG and LNG carrier fleets.

Book title advice

I’ve worked with three SIGTTO General Managers over the last 15 years and, if I was to consider the advice to give a new incoming General Manager, it would be to try and avoid SIGTTO book titles that begin with the word ‘Recommendations’ or ‘Guidelines’. In 2008 there were seven SIGTTO titles that began with ‘Recommendations’ or ‘Guidelines’, but we are down to a more manageable four today. There are alternative ways of getting the message across!

Gas carriers have gone through more change and innovation than any other sector of the tanker industry over the last 40 years. With the pace of advances in floating technologies, regasification, gas cargo containment arrangements, new propulsion systems, small-scale shipments, the use of LNG as marine fuel and the increasing interest in hydrogen as an energy source, there is every indication that the next 40 years are going to be fairly busy for SIGTTO!

SIGTTO provides excellent networking opportunities among shipping’s LNG and LPG industry professionals and, with two Society General Purpose and Human Element Committee meetings and ten Regional Forums per annum, it ensures every opportunity for engagement amongst a growing membership worldwide. Importantly, under the current leadership of Andrew Clifton as General Manager, it fosters an atmosphere of inclusion and welcome at all events, enabling all members to fully relax and participate.

With SIGTTO’s spacious new London office, an agreed future strategy for the Society and active participation at IMO, combined with the Society’s established links to the many industry bodies and non-governmental organisations (NGOs), SIGTTO is best positioned to represent the needs of the liquefied gas shipping and terminal industry going forward.

With 40 years of publishing for SIGTTO and supporting them at events behind us, Witherbys looks forward to this next phase for the Society and their Golden Jubilee in 2029.



Delivered by Samsung in 2009, the 266,000 m³ Mekaines was the second Q-max LNG carrier to come under the technical management of Nakilat

Insights from one of SIGTTO's longest serving Board members



Eng Abdullah Fadhlah Al-Sulaiti, Nakilat's CEO, has long personal experience of the merits of the Society's approach to ensuring safe liquefied gas operations

In my capacity as Chief Executive Officer (CEO) of Nakilat, I manage the diverse shipping and maritime business portfolio of what is the world's largest LNG shipping company. Besides vessel ownership and management, our diverse operations include ship repair and offshore fabrication, shipbuilding, towage, shipping agency and logistics services. I also serve as the Chairman for two Nakilat joint ventures, i.e. Nakilat-Keppel Offshore & Marine (N-KOM) and Nakilat Damen Shipyards Qatar (NDSQ).

I earned my degree in marine engineering from Southampton Maritime College in the UK and my shipping and maritime industry career spans more than 20 years, during which time I have gained experience in all aspects of the commercial, operational and technical management of LNG carriers. I started out with Qatargas Operating Company in 1997, and the highlight of my career to date was when I was tasked to oversee the construction of the 45 Q-flex and Q-max LNG carriers ordered by the State of Qatar.

During my tenure with Qatargas, I

held various senior positions, including technical superintendent, manager of the ship acquisition team and shipping manager. In addition, I have been a board member of Gulf Drilling International Ltd QSC since April 2018.

The maritime gas transport industry, particularly LNG, has been top of the league in terms of safe, efficient and environment-friendly operations for 55 years, since the first commercial LNG cargo was delivered in 1964. This has been achieved through strict attention to detail, dedication to safety, high standards of vessel design and rigorous, targeted training programmes for relevant ship and shore staff. The rapid development of liquefied gas carrier and cargo-handling technologies over the past 15 years has accelerated the acquisition of the necessary skill sets and added to the steepness of the learning curve for all participants in the sector.

Shipowner obligations

One aspect of LNG shipping that sets it apart from other maritime sectors is public perception. There is an underlying belief

amongst the general public that LNG operations are inherently unsafe due to the flammability of natural gas and the 'explosiveness' of the cargo. The general public tends to see LNG carriers as 'floating threats' due to a lack of understanding about both the physics of the cargo and the nature of actual cargo-handling operations. It is incumbent on our industry to maintain our exemplary safety record to ensure that there are no grounds for this misguided public perception.

Although the global LNG trade is opening up to spot and commodity trading, there is still a significant part of it carried out under dedicated long-term arrangements. These long-running contracts promote familiarity and help to enhance safety and efficiency.

Terminals, too, have a key role to play in promoting the image of a safe industry to a wider audience, including their local communities. Terminal owners also need to be able to demonstrate to regulatory agencies that their facilities are operating in a manner consistent with the rules and practices developed by the industry.

This robust regulatory/best practice regime has been established by IMO and industry associations such as SIGTTO and the Oil Companies International Marine Forum (OCIMF). These agencies can be justifiably proud of their accomplishments and should not be hesitant in coming forward to promote the merits of their work. For example, I think a higher profile for SIGTTO in the energy community would be helpful.

Environmental performance is another current focal point for the maritime sector. Owners and operators of gas carriers should be encouraged to demonstrate what they have accomplished and what they are continuing to do to improve the environment in terms of reductions in fuel consumption, carbon footprint and noise levels. The gathering of big data and its application in an effective way in shipping operations have a role to play.

LNG carrier technology has advanced rapidly over the past 15 years, as highlighted by the evolution from 2004's 145,000 m³ steam turbine-powered vessels to today's popular choice of 174,000 m³ ships propelled by slow-speed dual-fuel (SSD) engines. The latest vessels provide customers with a very competitive unit freight cost for their LNG transport. The technical advances have effectively created a three-tier LNG carrier market, i.e. vessels powered by steam, tri-fuel diesel-electric (TFDE) and SSD propulsion systems.

My Nakilat team and I closely follow all LNGC technological developments

and, although we don't expect the pace of technological advance of the past 15 years to be maintained, we have identified reliquefaction and other support machinery as areas for future focus.

In addition, as LNG gets more commoditised, we expect the small-scale LNG sector to grow due to the increasing use of gas as fuel for ships and power plants. At the same time employment of floating storage and regasification units (FSRUs) as a flexible import terminal option has opened new markets for LNG producers. Nakilat has also targeted FSRUs and small-scale LNG as sectors for strategic development.

Challenges ahead

Due to an increase in the global demand for natural gas, the LNG carrier fleet is expanding rapidly, in tandem with the growth in vessel size and the advances in ship technology. I find that gas shipping is currently not investing in new recruits and the attendant training and career development programmes to the extent needed to match the fast-developing industry's needs. The danger is that manpower shortfalls could result in the dilution of skills and competencies across the industry.

The career pathway from cadet to senior officer requires well over 10 years to complete, a relatively long time that a fast-growing industry simply does not have. Seafarers are also faced with increasingly sophisticated shipboard equipment and systems and an overdependence on digital tools. A great deal of data is now being sent from the ship to owner and equipment manufacturer offices ashore in near real-time. There is a risk with such arrangements that crews may feel one step removed from involvement in vessel operations. This, in turn, may negatively impact shipboard management of response measures when something goes wrong.

In overall terms independent shipowners have done a very good job in showing they are able to live up to the high standards demanded by the industry. In the past this good performance was underpinned by the fact that there were relatively few owners specialising in gas shipping and the commitment of such owners to safe operations and close links with charterers was total. New players are now entering the liquefied gas sector, however, and face steep learning curves to get up to speed. There is much to be learned from the experiences and systems of established gas industry players.

Owners need to be increasingly responsive to the needs of charterers. Relationships built between owners and

charterers need to go beyond what is written in the charter party in the drive to establish ties that become stronger and more cooperative with time.

Human error will always be the leading culprit for accidents but the scope for problems can only increase if the complexity of the systems makes it difficult for seafarers to respond effectively. Training programmes need to be continuously refined and upgraded, including to be able to take advantage of modern training tools, and SIGTTO has a key role to play in this respect. SIGTTO is well positioned to study these challenging issues through its working groups and by making use of consultants where necessary to develop guidelines that benefit the membership and the industry as a whole.

Personal congratulations

I would like to conclude by extending Nakilat's congratulations to SIGTTO on the occasion of its 40th anniversary. Nakilat is proud to have been an active Society member for over a decade and I personally am honoured to be one of the longest-serving member of the Society's Board, having held the position since my appointment at the 2007 Board and Annual General Meeting (AGM) in Houston.

Over the past 12 years I have had the privilege of hosting two Society events in Qatar. Both SIGTTO's Middle East Regional Forum in April 2014 and, more recently, the 2018 Autumn SIGTTO Board and AGM were held in Doha.

My close involvement with the Society at Board level over this time has provided

me with an insight into what a great and valuable resource the association and its membership are for meeting the specialist needs of our particular maritime sector. Other Nakilat participation in the Society's proceedings, including at meetings of the General Purposes Committee and various working groups, has reinforced our belief in the effectiveness of SIGTTO as the key conduit for safe and efficient gas shipping.

The Society produces the essential operating guidelines that have played a significant part in achievement of the industry's excellent safety record over the years. It also provides a platform for the gas shipping and terminal sector stakeholders to gain and exchange ideas on industry best practices. The contacts that Nakilat has made with all the key players in the industry through the Society's busy schedule of meetings each year have proved invaluable.

In addition to the participation in significant forums on topics of mutual interest, Nakilat, like all other members, also gains substantial benefits from its SIGTTO affiliation through the provision of technical advice and exclusive access to the latest policies and information impacting the industry.

These membership benefits are of major importance to Nakilat's business, given that we are the world's leading transporter of LNG. We salute SIGTTO for its achievements on the occasion of its 40th anniversary and look forward to further close liaison with the Society going forward in the ongoing commitment to safe operations by a growing gas shipping industry.



The global LNG training regime that has been developed, with the assistance of SIGTTO, is impressive but industry must continue to build upon it



My Energy Bridge regas vessel presentation at the SIGTTO Panel Meeting in Monaco in 2003 was made two years before Excelsior discharged her landmark Gulf Gateway cargo

SIGTTO guides LNG voyage of discovery



Although **Tony Galt** did not become involved with gas shipping until relatively late in his career, in the last two decades he has been SIGTTO representative for four leading companies

Following a corporate divestment of the Houston Ship Channel oil refinery at which I was the traffic superintendent, responsible for operations at the ship and barge docks, the new ownership reduced the refinery staff across all departments. I was one of the casualties, looking for a new job at the age of 50.

Enron entry point

In networking for a new position, a manager from a former employer connected me with one of his trading counter-parties. This connection developed into an interview with the project manager of Enron's Dabhol project in India. Through earlier industry articles concerning Dabhol, I knew that the power station's fuel was to transition from naphtha to LNG. Thus, in researching LNG before the interview, I came across SIGTTO and hustled out to purchase *Liquefied Gas Handling Principles on Ships and in Terminals (Second Edition)*.

At the interview I advised the project manager, Rick Bergsieker, that I had sailed on tankers but never an LNG

carrier. He was seeking someone for port operations and indicated that the specifics of the cargo would be handled by those experienced in LNG. Soon afterwards I was offered a position at Enron.

Within a few days I was called into meetings with shipping companies bidding to transport LNG to Dabhol. There I met Bob Lakey, a consultant to Enron, who advised me that the company should join SIGTTO. Enron joined and soon the Society's new member package of publications was received in my office. I was amazed at the library. And I am still amazed at the list of SIGTTO publications and their depths of detail. With Bob as a consultant and myself an employee, I was made the company's representative at SIGTTO.

After numerous shipping company bidders' meetings, a charter was signed for a new LNG carrier, a 135,000 m³ Moss Rosenberg spherical tank vessel to be built in Japan. The newbuilding order was followed by quarterly planning meetings and construction inspections by Lakey, with me in tow asking questions and taking notes.

At that time the Enron co-owned power station in Puerto Rico, Eco-Electrica, received its commissioning LNG cargo onboard the 87,600 m³ *Hoegh Galleon*, another spherical tank ship. While attending the discharge operation with the Enron team, I met Joe McKechnie who represented the cargo suppliers.

I then embarked on a steep and rewarding LNG learning curve through quarterly shipyard trips to Japan; attendances at SIGTTO Panel Meetings; visits to the Eco-Electrica and Dabhol terminals; meetings with former seafarers with extensive LNG experience; sitting in on charter party meetings for a second vessel; and interacting with shipowners' technical teams.

Onto the 'Energy Bridge'

Before and during the demise of Enron, Wayne Perry had been running their Dabhol marine group. However, before Enron's final collapse he had moved to El Paso and their 'Energy Bridge' regasification vessel project. Bob Lakey was already onboard as a project consultant and Alan Nierenberg was the primary naval architect.

Wayne advised that El Paso was seeking additional staff, experienced in tank vessel operations, because the Energy Bridge team's primary focus up until that time had been on the project's commercial viability. I joined El Paso and was appointed their representative at SIGTTO.

Sadly, Bob Lakey retired shortly thereafter but working with Al Nierenburg and the technical teams from the shipowner Exmar, the selected shipyard and APL, the supplier of the Energy Bridge's submerged turret buoy, was another unique experience. Thrown in at the deep end, I made a presentation on the Energy Bridge regasification vessel concept at the SIGTTO Panel Meeting in Monaco in 2003.

Although the project was short-lived under El Paso ownership, it was an idea whose time had come. Sold to the Kaiser Corporation and renamed Excelerate, the El Paso concept has since become popular within the industry as a means of facilitating LNG imports. Now referred to as floating storage and regasification units (FSRUs) and operated by a number of owners, regasification vessels comprise a significant and growing fleet.

Caribbean connections

Within a couple of weeks of the establishment of Excelerate, I received a call from Joe McKechnie at Tractebel, the former name of what was to become GDF Suez and, eventually, ENGIE. Tractebel needed a marine operations

person in their Houston office and I accepted the job. Once again, I became a company's representative at SIGTTO.

The company had a stake in the Atlantic LNG terminal in Trinidad and supplied the Eco-Electrica terminal in Puerto Rico from that location. As a consequence I made numerous trips to both islands for marine audits and inspections. Additionally, the company's project development teams were working on possible LNG receiving terminals on the west coast of Mexico and at Freeport in the Bahamas. I was appointed the marine operations person for the teams and SIGTTO's *Site Selection & Design (IP No 14) for LNG Ports & Jetties* became my bible for this work.

At one point I was required to attend the 138,000 m³ *Berge Boston* in Trinidad. On a ballast passage returning to Trinidad, the ship's gas alarm system indicated gas in the inter-barrier space of the No 1 cargo tank in which the 'heel' was being carried. After transfer of the heel to another tank, No 1 was gas-freed and then completely blanked off and disconnected from all cargo and gas systems to permit entry into the tank.

An inspection revealed about two dozen small holes in the primary membrane barrier caused by a broken bracket which had fallen from the pipe tower to the bottom of the tank. As the charterer's representative, I stayed on the ship together with repair teams from the shipowner and Gaztransport & Technigaz, the designer of the ship's NO 96 membrane tank containment system.

My involvement with the Bahamas Freeport receiving terminal project arose because GDF Suez had acquired from Enron the remnants of the work done on the proposed facility. The new plan was to truncate the Freeport/Florida gas

pipeline proposed earlier and to establish a floating LNG receiving terminal off Florida's east coast to deliver gas to the southern part of the state. Despite all the work carried out to prove the viability of the project, Florida's governor denied the Federal Deepwater Port permit that was required to establish the FSRU.

GDF Suez also commenced work on the Neptune project at about the same time. The scheme called for the establishment of an FSRU-based deepwater port off the coast of Massachusetts near Boston to enable the delivery of natural gas to the New England market in the volumes necessary to supplement the cargoes already arriving at the company's long-established shoreside Boston LNG terminal.

Another Freeport project

Acclimatised as I was to the temperatures pertaining in the southern US states, the prospect of winters in Boston working on the Neptune project was not appealing. Fortunately for me, at that time, in 2009, Freeport LNG (FLNG), operator of an LNG receiving terminal in Freeport Texas, was seeking a marine operations manager. By taking up the post I was able to keep close to my adopted home.

In my new position I once again became the company's representative at SIGTTO. Like so many other US LNG receiving terminals, the construction of the FLNG facility was approved when the country was believed to be "running out of natural gas" and in imminent need of burgeoning LNG imports. As it turned out, the newly built terminals were being commissioned just as the means of realising the potential of country's vast shale gas resources were being implemented. Overnight, the terminals became redundant in their

intended role as LNG receiving facilities.

Although Freeport LNG received a shipment near the end of its first year in operation, this commissioning cargo was required solely for the warranty performance of the regasification and gas export systems. Shortly thereafter, thanks to the availability of storage tank space, one customer concluded an agreement with FLNG to import, store and, when market conditions improved, reload the cargo for sale. The ability of an import terminal to reload cargoes had required a complete liquid flow process review and modifications/additions to the required systems, together with necessary documentation, to facilitate bi-directional cargo flow.

By 2014 the expiration of FLNG's permit to widen the existing federal channel into Port Freeport was on the horizon. A wider channel was deemed necessary to accommodate the passage of Q-max size LNG carriers to the terminal. The FLNG marine operations manager thus also became, at a stroke, the channel-widening project manager.

A somewhat hidden aspect of the project was the need to relocate the channel leading marks to the new centreline of the widened channel. The existing channel and the port's breakwater/jetty arrangements were such that widening could be performed only on one side of the channel. Relocating the US Coast Guard's nav aids properly, erected on another terminal's land, was an interesting process.

By the time that the channel-widening was underway, FLNG had initiated the planning and permitting procedures required for the construction of liquefaction trains and a new role for the facility as an LNG export terminal. The planned LNG production from three trains necessitated an expansion of the facility's dock basin to fit a second dock. After a number of iterations of the basin and dock layout were discussed with the US Coast Guard and the port's pilots, construction work began.

From becoming an LNG rookie rather late in my career, at the age of 50, through to retirement 20 years later, SIGTTO has been a constant companion and an irreplaceable resource to me. This late phase of my working life has never been less than exciting and I consider it a rare privilege to have had the chance to work with some of the most well-respected figures in the LNG marine world. Prominent amongst these are the Society's current General Manager and his two predecessors, its Technical Advisers and the individuals who have chaired the Society's General Purposes Committee (GPC) over the past two decades.



A channel widening project has been required to ready the Freeport LNG facility in Texas for its role as a major LNG export terminal



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Chevron congratulates SIGTTO on 40 years of promoting safety and operational reliability for gas carriers and terminals.

First Chevron Wheatstone LNG Cargo Departs for Japan

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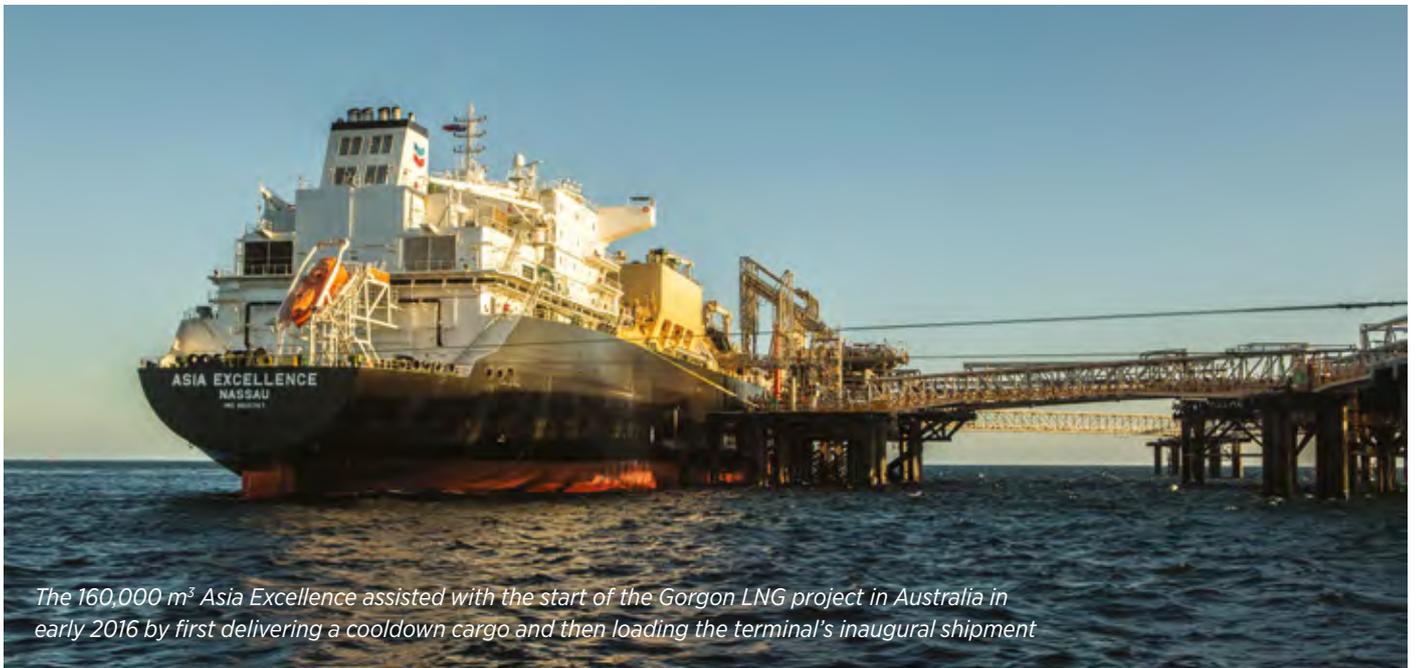


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The 160,000 m³ Asia Excellence assisted with the start of the Gorgon LNG project in Australia in early 2016 by first delivering a cooldown cargo and then loading the terminal's inaugural shipment

Chevron builds on SIGTTO industry platform



Mark Ross, president of Chevron Shipping Co and a former SIGTTO President, explains how the Society's portfolio of industry best practice guidelines facilitated the build-up of an LNGC fleet by his company

It gives me great pleasure in congratulating the Society of Gas Tanker and Terminal Operators (SIGTTO) on celebrating 40 years as the global authority for gas shipping and gas terminal operations. Throughout its existence SIGTTO has built a well-respected industry platform to establish and promote high standards and foster mutually beneficial relationships between industry and regulatory agencies.

My involvement with SIGTTO began in 2003 when I was appointed to its Board of Directors. I had the honour of serving as the Society's President, beginning in 2005, and during my tenure I was privileged to work with two extremely qualified and knowledgeable General Managers, James MacHardy and Bill Wayne. They were supported by a dedicated Secretariat, which included the current SIGTTO General Manager, Andrew Clifton, who was then working as a SIGTTO Technical Adviser.

When I took over as SIGTTO President,

the worldwide LNG fleet was approaching 200 ships and 15 countries were importing LNG. These seemed like big numbers at the time, but they pale in comparison with an LNG fleet that will soon number 600 ships delivering cargoes to 40 different countries. SIGTTO played a significant role in achieving this tremendous growth by helping to maintain our enviable reputation as a safe and responsible industry.

Building a gas business

My company, Chevron, has been a proud member of SIGTTO since the early days of the Society. Chevron's LNG journey began in the late 1980s, as a founding participant in the North West Shelf Venture, Australia's first and largest LNG project. In 2004 Chevron drew from its significant oil and LPG tanker experience to operate its first LNG carrier, the 138,000 m³ *Northwest Swan*.

As Chevron's global gas portfolio grew so did our company's need for LNG shipping.

Applying lessons learned from *Northwest Swan* as well as industry guidance from SIGTTO, Chevron managed the improved design, construction and operation of two LNG fleets supporting multiple projects throughout Australia and Angola.

To meet additional organisational capabilities required for our growing LNG fleets, Chevron trained existing crews from our crude and product tanker fleets. In 2014 Chevron opened an LNGC officer training centre to deliver LNGC training courses that enhance competency expectations defined by SIGTTO's guidance. The courses are the industry standard for LNGC officer training, and Chevron currently has over 250 officers serving on board our LNG ships.

Today, Chevron's controlled fleet of LNG ships transport enough energy to heat approximately 10 million homes each year. Chevron will continue to develop and deliver the energy that improves lives and powers the world forward.

Looking ahead

Global LNG demand is expected to double by 2035, and LPG demand is expected to significantly increase as well. Together this means the energy industry will require talented individuals for the safe and reliable transportation of gas.

Chevron remains well-positioned to train qualified mariners to meet these future demands and will continue to work with SIGTTO to build a powerful legacy for future generations of gas shipping and gas terminal operators.

For the past 40 years SIGTTO has played a fundamental role in helping grow capabilities and push frontiers while upholding safety standards. Here's to another 40 years of driving improvements in the global gas industry.



Mubaraz, shown here in warmer climes, was delivered by KMY in January 1996 and her winter sea trials required an icebreaker escort

Career logbook abounds with gas



Samir Bailouni, Nakilat Shipping's COO, looks back on four decades of experience with gas carriers and three decades of involvement with SIGTTO

I started my seagoing career onboard tankers and gas carriers in the 1970s and, after serving in those sectors until the mid-1980s, I decided to move to a shore-based position. I joined the shipping department of Abu Dhabi Gas Liquefaction Co Ltd (ADGAS) in 1987, and in my role as a marine engineering superintendent for the company I managed five chartered LNG carriers and supervised operations at the open-sea gas export terminal on Das Island. In 1993 I moved to National Gas Shipping Co (NGSCO), Abu Dhabi's newly established LNG and LPG shipping company, as two new LNG carrier construction programmes were launched. The programmes, in Japan and Finland, featured eight ships of 137,500 m³.

After a 21-year involvement with Abu Dhabi LNG, I left my post as NGSCO's fleet general manager and moved to Qatar, where I joined Nakilat as fleet director. Qatar's drive to establish itself as the world's largest LNG exporter and its full-on approach to building an LNG carrier fleet attracted me at a time I was looking to take on a new challenge. The impending introduction of the impressive Q-max and Q-flex LNG vessels and the development of Nakilat into a fully fledged shipping company helped support my choice of Qatar as a career move.

Unflagging safety commitment

If there is one thing the LNG shipping industry can pride itself on above all others, it is the impeccable safety track record that has been achieved. The exemplary performance of the fleet over the years has not been attained by chance but, rather, by a dedication to safety and a keenness to succeed on the part of all involved in the sector. A commitment to specialised skills training and the establishment of high levels of management expertise from the outset helped ensure there have been no LNG disaster stories to whip up public fear.

My very first shipping involvement was with crude oil tankers, another sector where safety is afforded great attention. However, when I came to LNG shipping operations and the interfacing with terminals, I was blown away by the attention to detail and the extent to which the safety commitment was carried. Cargo-handling operations were characterised by a rigorous adherence to careful preplanning, established procedures and smooth communications between all parties in the supply chain. The cause of safety was further boosted by the high levels of standardisation attained with ship/shore interface equipment, arrangements and systems and, in those early days, the use of LNG carriers on dedicated projects, serving specific terminals.

In the 1980s in Abu Dhabi we worked on a project to re-manifold some of the fleet's original 125,000 m³ LNG vessels. Spurred by an earlier incident, the project involved switching from two 20-inch to four 16-inch liquid lines and introducing 60-mesh conical strainers. Other features of the work were the first introduction of the optical fibre transmission system (OFTS) umbilical for emergency shutdown (ESD) and other ship/shore interface links such as mooring tension monitoring. The project, my first exposure to the design and development aspects of all these new LNG ship/shore interface technologies, was both stimulating and challenging at the same time.

Unprecedented technological advances

There has been an inexorable growth in the cargo-carrying capacity of 'conventional-size' LNG carriers over the years, from the 25,000 m³ ships in the 1960s, to those of 125,000 m³ in the 1970s, 137,000 m³ in the 1990s, 155,000 m³ in the 2000s and the 180,000 m³ ships of today. Although Qatar's 216,000 m³ Q-flex ships and 266,000 m³ Q-max vessels, built during the 2000s to realise economy of scale benefits for Qatari exports, were a special case, they have also supported the trend of increasing vessel size with time.

The trend is continuing. More and more terminals are gearing up to accommodate LNG carriers of up to 230,000 m³, which is referred today as the 'NeoPanamax' size, for trading flexibility. The membrane cargo containment system has been chosen for the majority of modern, large-size LNG carriers for a variety of reasons, including an efficient ship dimensions-to-cargo capacity ratio, shipbuilding license arrangements, lower air draft and more advantageous Suez Canal tariffs.

The traditional steam turbine LNG carrier propulsion system, with its ability to handle cargo boil-off gas in a straightforward manner, is losing favour on fuel efficiency grounds. There have been rapid developments with gas-burning LNG carrier propulsion systems over the past 15 years, with the introduction of dual-fuel diesel-electric (DFDE) systems, enhanced steam turbines and, more recently, low-speed, two-stroke engines.

The dual-fuel, low-speed, two-stroke engines now available, most notably MAN Diesel & Turbo's M-type, electronically controlled, gas-injection (ME-GI) units and Winterthur Gas & Diesel's Generation X Dual-Fuel (X-DF) offering, have achieved new levels of fuel efficiency. In combination with either full or partial

cargo reliquefaction systems, these two-stroke engines have shown themselves to be clear leaders amongst gas-burning propulsion system options available today.

When deciding on the propulsion system for Qatar's newbuilding contingent of 45 Q-flex and Q-max ships in the 2000s, oil was relatively cheap and oil-burning, low-speed engines, in tandem with powerful cargo reliquefaction plants to ensure the delivery of optimum LNG volumes, were chosen. The nitrogen-cycle reliquefaction systems fitted on the Q-flex and Q-max LNG carriers over a decade ago, while initially challenging, have proved to be very effective and advantageous in service.

The era of floating LNG process vessels is upon us, and floating storage and regasification units (FSRUs) and floating LNG production (FLNG) vessels are good, ready-made solutions under specific requirements and conditions. I see a growing demand for these units as the use of gas continues to gain ground as a universal thermal energy source in developing countries. Realising the potential for business growth, Nakilat signed a landmark agreement with Exceleerate Energy of Woodland, Texas in 2018 to acquire a majority stake in its first FSRU. This followed the signing of a memorandum of understanding (MoU) with Høegh LNG on an FSRU strategic alliance in 2017.

As small-scale LNG and LNG bunkering go hand-in-hand with today's expanding LNG supply chain and, with the IMO 2020 sulphur cap on the horizon, I see increased interest in LNG as a viable marine fuel option for all kinds of vessels. It is not surprising that we are witnessing a growing number of affiliations and collaborations between stakeholders to make LNG available as a ship fuel worldwide.

The SIGTTO learning curve

I attended my first SIGTTO event in 1987 in the United Arab Emirates, and participated in my first Society meeting as a member of the General Purposes Committee (GPC) in The Netherlands in April 1988. The General Manager on that occasion was Robin Gray, the Society's second holder of that position. Over the years, Robin has never ceased to amaze me with his broad industry knowledge and rigorous scientific approach.

Thirty years ago SIGTTO meetings attracted smaller turnouts compared to today's attendances. At that time I was in my early 30s while those around me were seasoned and experienced maritime professionals. I mostly listened and learned

at the meetings. It was the case then and still is today that members are encouraged to share their experience of incidents, even if anonymously on a non-attributable basis, for the benefit of the industry in general.

SIGTTO has consistently brought together the key players of the gas ship and terminal community to share knowledge and address the issues common to what is still a relatively young industry. This was particularly important during the early stages as it provided an avenue for a steep learning curve, and encouraged the initiation of pertinent studies and, ultimately, the development of guidelines across a wide range of topical gas industry issues. Some of these early publications are still the only industry reference materials available today.

Today, when I see certain features on LNG vessels, I can still remember the history behind what led to their pioneering introduction many years ago and how such arrangements are now common practice. I recall, for example, the winter sea trials of one of our NGSCO LNG newbuilds from Kvaerner-Masa Yards (KMY) in Finland, definitely a challenging scenario. With an icebreaker cutting through the Baltic Sea ice and leading the way, we tested the new vessel's fresh water generators in almost fresh water seas and lost the condenser vacuum due to perfectly sized herring plugging its thousands of tubes. It was fish for dinner that night!

No resting on laurels

The LNG shipping industry has progressed at an unprecedented pace in recent years. When I started in this industry in 1987, out of personal interest I used to monitor all 71 existing LNG carriers and there were times

were there were no such vessels under construction! Today, there are over 540 LNG carriers in service and it has become challenging to remember even the names of all the vessels within your own fleet.

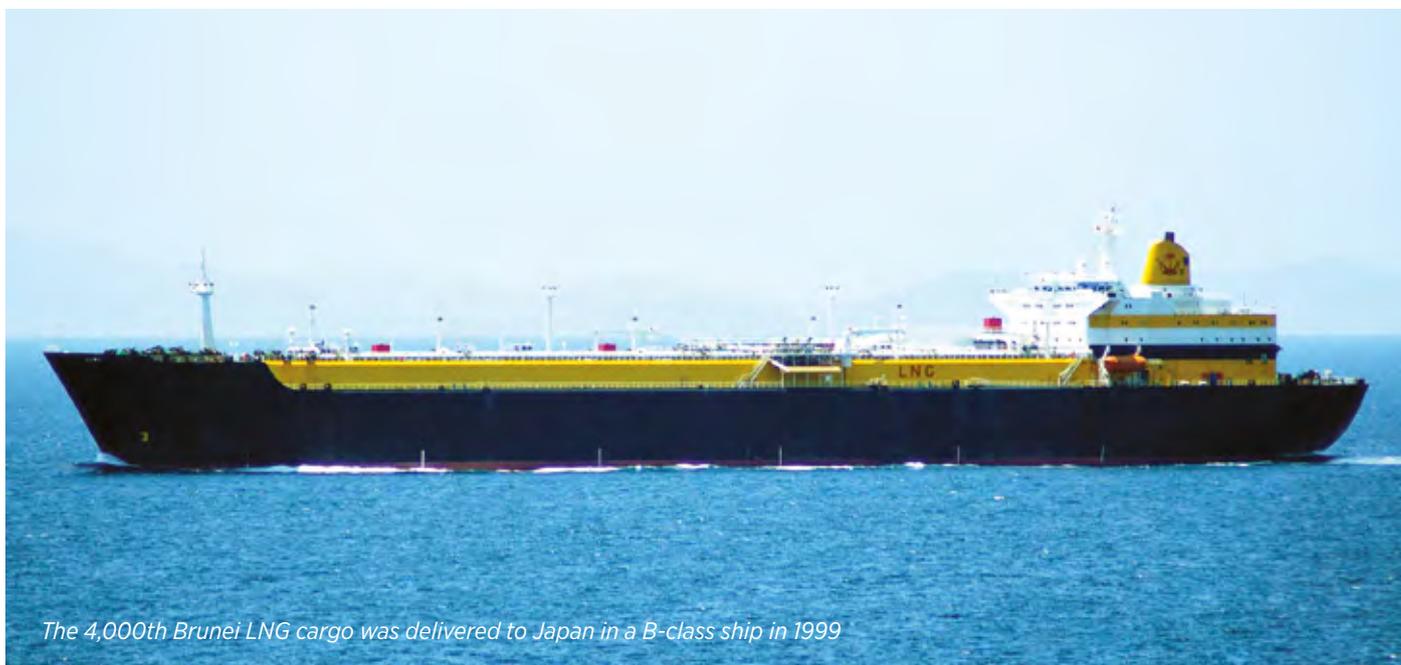
This rapid expansion comes with many serious challenges. One is the possibility of our achievements to date breeding a sense of complacency that could jeopardise industry's impeccable safety record and, as a result, create worldwide public perception problems. Another risk is that posed by having what might be inexperienced or untrained ship staff handling LNG on dual-fuel ships being bunkered. The whole question of sustaining an adequate pool of properly trained seafarers and shore staff at a time of rapid fleet growth in both the gas carrier and gas-powered ship sectors is a fraught one. Also, with the increased number of vessels and terminals of various sizes and types, standardisation becomes a challenge to the industry.

As an organisation addressing the full scope of gas shipping and terminal activities, SIGTTO performs a vital role by bringing its global membership of key players to bear on carrying out topical studies and developing whatever guidelines are deemed necessary and appropriate.

I would encourage SIGTTO, as the gas sector continues its expansion, to continue this important work and, as part of this successful approach, to make use of the lessons learned and advances in LNG technology by applying them to LPG and ethane shipping. Seaborne movements of LPG are currently growing as fast as those of LNG while ethane is a new gas carrier trade with a bright future.



The nitrogen-cycle reliquefaction systems fitted on Nakilat's Q-flex and Q-max LNG carriers have proved to be effective and advantageous in service



The 4,000th Brunei LNG cargo was delivered to Japan in a B-class ship in 1999

SIGTTO experience bolsters career path

After describing how his time as a SIGTTO Technical Adviser benefitted his working life, **Chris Snape** looks at some challenges facing a fast-expanding industry

I was seconded from Shell to SIGTTO as a Technical Adviser from May 2002 to May 2004. Although the assignment was relatively short, it was packed full of learning and relationship-building that have remained with me as my career progressed. An assignment at SIGTTO is a fantastic opportunity for those lucky enough to be selected.

Two of the biggest takeaways of my SIGTTO time were the understanding of (a) how IMO and other industry bodies all work and (b) how SIGTTO engages its membership and supports the sector. A third was the very satisfying experience of seeing the fruits of our labours making their way onto the technical bookshelves. I have found that with most jobs it's the people you work with that really make the experience rewarding. However, a tenure with SIGTTO provides that extra dimension, in that you're working with great people from many different organisations and backgrounds from around the world. Time spent at SIGTTO is especially rich and interesting.

Industry/SIGTTO cross-fertilisation

I had joined Shell as a seafarer back in 1989 and was not exposed to gas carriers until relatively late on, when I was already

sailing as master. After working through the requirements for my gas endorsement, I took over command of one of Shell's 75,000 m³, B class LNG tankers in 1999, running between Brunei and Japan. We carried the 4000th project cargo during that trip, so I had a few public relations exercises to contend with.

Following that, I came ashore and have enjoyed a variety of shore-based roles with Shell. Many of these have involved gas shipping and SIGTTO has been an important strand running through every part of this work.

My first shore-based role for Shell was an assignment in the ship vetting team, and the experience stood me in good stead later on when I coordinated the development of SIGTTO's LNG carrier vetting publication. I soon found out that the cross-fertilisation process works both ways and that my SIGTTO time was to prove invaluable in later Shell projects.

As an example, following my two years at SIGTTO, I was seconded by Shell to Qatargas, working firstly in the ship acquisition team and later in the chartering team. I was able to put my SIGTTO project knowledge to good use for Qatargas when dealing with aspects such as pre-qualification activities and LNG emergency ship-to-ship (STS) lightering preparedness. As part of

the Qatargas project I also joined a state delegation to the 57th Session of IMO's Marine Environment Protection Committee (MEPC 57). Again, my experiences of IMO whilst at SIGTTO proved extremely helpful for that task. Qatargas also hosted a SIGTTO Regional Forum in Doha during my tenure, which I helped to coordinate.

Another position I held recently was that of nautical principal technical expert in Shell's Shipping and Maritime Technology Department, dealing with LNG terminal assurances and supporting LNG projects. My days at SIGTTO came in handy once more, not least through the ability to apply guidance from both Society publications, such as *LNG Operations in Port Areas*, *Liquefied Gas Handling Principles* and *Linked ESD Systems*, and EN/ISO standards, the development of many of which SIGTTO has contributed to.

I am currently Shell's global maritime independent assurance manager, in which role I head up our internal programme for audits of Shell businesses and joint ventures with maritime risks. I've also previously been a lead auditor in the team I now manage. The role is facilitated by calling on not only first-hand SIGTTO experience but also the Society's publications and ongoing work. This knowledge pool helps me add value to our auditing activities.

Expansion challenge

While I think that gas carriers, and their associated terminal operations, continue to be the leading maritime sector when it comes to matters of safety, there is a considerable element of fragility attached to this position. Gas will be a key source of fuel in the energy transition to a greater use of renewables in the decades ahead and this means continued strong growth for the gas carrier fleet and the global network of terminals.

Industry expansion means more new entrants and, with the best will in the world, these newcomers will not possess the same depth of experience as long-term staff or established gas firms. The experience and training required to achieve the necessary systems and levels of competence takes time. A number of recent minor accidents and near-miss incidents indicate the extent to which our industry's exemplary safety performance record is at risk. So far, we have been lucky that the worst-case potential consequences have not been realised, but luck is not the kind of effective barrier we need.

Industry newcomers need to be made aware of how important the maintenance of our safety record is to everyone in the business, new and old. The logic for additional investment in technical barriers may not be immediately apparent to new entrants who have no sector experience or who may have a different time horizon or a more commercial orientation.

The current challenging macro-economic environment for the oil and gas sector only serves to increase these pressures. Without an adequate appreciation of the risks or consideration of the wider implications for the liquefied gas sector and society in general, there can be a temptation to flout rules and standards and to dance around compliance obligations in game-playing fashion.

The new technology factor

Another significant factor in today's gas shipping sector is technology. Companies are always looking for new ways to get gas to a rapidly growing market. These include sourcing gas from more challenging upstream environments; improvements to existing ship propulsion, containment and cargo-handling systems; and delivery to a widening range of destinations and customers, including small-scale terminals and gas-fuelled ships.

While new technologies are important for the evolution of the industry, the safety integrity of new designs needs to remain aligned to the rigorous approach the sector has always applied. Because a desire to avoid the full cost of introducing innovative ideas can lead to shortcuts, it is imperative that we do not allow the enthusiasm, impetuosity and rush for first-mover advantage that can accompany groundbreaking projects to allow inferior technologies to jeopardise gas shipping's safety record.

That is easier said than done in a global market eager for gas. The setting of standards always lags technology developments. In addition, there can be variances between regions and even where standards do exist, they can be, and often are, disregarded.

SIGTTO's ongoing role

While SIGTTO has made an incredible contribution to maritime safety across the gas shipping spectrum, it is critical that the Society, like the industry itself, does not rest on its laurels. As we move through the energy transition and the liquefied gas shipping and terminal industry continues with its robust growth, the SIGTTO Secretariat, its Board, Committees and membership must not only continue to develop the Society's portfolio of industry standards but also consider the effective implementation of this regime.

I think that we, as an industry, can do more to make sure that the Society's member organisations fully implement the relevant standards that have been promulgated. The introduction of a more robust implementation regime might require a bit of a culture shift, not least in how the Society treats and/or supports member companies not living up to industry's accepted standards. There are a number of different policing approaches that can be considered, and the Society needs to be able to pass the 'red-face integrity test'.

I also believe that more needs to be done on stakeholder engagement and communication of the safety message to all parts of the gas shipping sector, including new entrants, who have the potential to impact our industry's overall safety record. Meeting this challenge requires sustained effort and it is incumbent upon SIGTTO, as part of its ongoing commitment, to keep pace with the growth of the sector and make sure that funding and resourcing are appropriate to meet the needs.

The competence of front-line operational staff remains a key component for maintaining the high safety performance standards that have been achieved. All SIGTTO member companies need to continuously focus on this aspect,

including through a number of activities such as recruitment and selection, onboarding, continued professional development, career advancement and audit programmes. SIGTTO has a critical role to play in the development of suitable guidance materials in this area too.

The challenges of attracting and retaining membership also need continued efforts to make sure our industry brings the right resources to bear in meeting such challenges. Without this focus we risk losing not only important influences but also the Society's reputation and standing as the authoritative voice for the sector to other emerging bodies with similar agendas. Finally, close collaboration with other non-governmental bodies (NGOs) and related industry bodies on matters of mutual interest is also vital and requires the right level of resources to remain effective.

In closing, my relationship with the Society goes back even further than my first trip on a gas carrier ... back to a time when I was a cadet at Fleetwood Nautical College in North West England in the early 1980s. It was there that I struck up a long-term friendship with a certain Andrew Clifton. In 2004 our paths crossed professionally when I handed over the SIGTTO Technical Adviser role to Andrew, and as part of the transition we were jointly involved in organising the Society's San Francisco Panel that year.

I've been most impressed with the work Andrew has done at SIGTTO since becoming General Manager in 2012. He has followed in the footsteps of some great General Managers and he has delivered. Also knowing several of the current Board and General Purposes Committee (GPC) members personally, I believe the Society is in great hands to continue the good work and achieve the essential measures necessary for the continued and sustainable success of the sector.



A group photo of SIGTTO General Managers and Technical Advisers taken in 2013; Chris Snape is third from the right in the back row

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Reminiscences of a long-serving company secretary



Bermuda-based **Edwin Mortimer** is only SIGTTO's second-ever company secretary and has served in that role for over three decades

In July 1987 I took over the role of company secretary of SIGTTO Ltd from my good friend Alan Smith on his retirement. He had been involved since the Society's incorporation in 1979.

The gas shipping and terminal sector was an entirely new industry for me to become acquainted with. In the early years of my tenure I was to become familiar with a host of new terminology that was previously completely unknown to me, everything from descriptions used for industrial processes, ships and mechanical parts to a wide range of marine and engineering industry acronyms.

Over the past three decades I have had the opportunity to meet many outstanding and unforgettable characters that served as SIGTTO General Managers, Presidents and Directors. Because the roll call of individuals that have served in these positions is too big for a full review, I'll limit my vignettes below to a few people that stand out in my memory.

My introduction to the world of LNG and LPG safety was through the first General Manager with whom I worked, Robin Gray. I regarded Robin as a quintessential English gentleman, but one whose quiet passion for industry safety seemed to verge on the fanatical. At that stage SIGTTO was a relatively small industry association with its unassuming premises in Staple Hall in the City of London. Robin was very patient with me, as he explained the basics of LNG transport and storage. What the office and Secretariat lacked in size was made up for by Robin's enthusiasm, commitment and a belief almost approaching religious fervour in the importance of SIGTTO's industry role in building and maintaining an unparalleled safety record.

When I recall the past SIGTTO Presidents, almost all of them had an ability to open up to differing opinions, to be inclusive and to make all the Society's Board members feel that their opinions counted. At the same time they all possessed an innate ability to lead the

Society forwards as the industry grew and coped with new technologies.

Notable Presidents included Alf Clausen, courteous, urbane, immaculate and gregarious, a man who would have been at home as a diplomat. Another was Mike Jervis, a soft-spoken and proud Devonian, with a superb ability to make people feel at ease and that their opinions counted. Mike Laws was another President who was inclusive and low-key but able to bring differing opinions together, while Blair MacIntyre, with his incisive mind and ability to think quickly, could sum up problematic situations succinctly and clearly. Latterly, and about to start a second term as SIGTTO President, Steffen Jacobsen is a fast-talking, quick-thinking and articulate Dane with a nice sense of humour.

Of the SIGTTO Directors that stick in my mind, Sid Vass, usually accompanied by Mike Jervis, had a very wry sense of humour and, like Mike, was most convivial company once the business of the day was done. The irrepressible Salicath Mortensen was another Dane with a very dry sense of humour, who seemingly always asked the right, albeit awkward, question at the right time to keep the SIGTTO agenda on track. Warren Bluestein was another expert at

coming up with pointed questions that cut to the chase; he leavened his technological acumen with a full repertoire of jokes and quips as well as a passion for life.

I have an abiding memory of my good friend James MacHardy, when he was a Director and before being appointed SIGTTO General Manager, during a Society meeting in Tokyo. NYK, one of the Japanese members, had made a bridge simulator available for attendees wishing to test their skills. Stepping to the console, James almost casually steered his ship into busy harbour waters, avoiding ferries, hydrofoils, fishing boats and other marine traffic with the ease of a man who could do it in his sleep. Others, in contrast, found the task much more difficult and the session was punctuated by alarm bells and on-screen collisions.

My fond memories of characters met are augmented by those of places visited. Amongst the standouts are a nighttime cruise around Tokyo Bay organised by the Society's Japanese members and meetings at Hakone in Japan where the mountain scenery is breathtaking. Also, as an amateur painter, I was inspired by my four visits to Venice out of season, with mists over the lagoon and the buildings appearing to float on air. Other notable locations included Perth in Australia, with its views over the Swan River, and the Isle of Man, where we enjoyed a Board dinner on a steam train.

I feel privileged to have made the acquaintance of so many interesting member company representatives over the past 30 years. What is a marvel to me, considering the continuing expansion in member numbers globally and the inevitable turnover in Presidents, Directors and Secretariat staff with the passage of time, is that SIGTTO continues to speak with a single, unified voice on behalf of its worldwide membership.



Bermuda – there are worse places for a company secretary to be based



Ship-to-ship (STS) transfers, long a feature of LPG operations, are becoming an increasingly common occurrence in the LNG sector

The LNG times are a-changin'



Chris Clucas* offers his thoughts on the most recent stage of gas shipping's technology evolution and the role of SIGTTO in smoothing the industry's assimilation of technological advances

Despite the popular view that innovation has been a central feature of liquefied gas shipping over the past 10-15 years, much of this 'new' technology has actually been tried in the past! It is just that gas shipping was not quite ready for the introduction of these new concepts at the time.

Propulsion evolution

For the first 40 years of LNG shipping steam turbines were the default propulsion system choice. Steam was the logical option at the birth of the LNG industry, when over one-half the world's merchant fleet was steam-powered. However, merchant shipping switched rapidly to diesel propulsion following the oil price shocks of the 1970s. While it was inevitably only a matter of time before the LNGC fleet also made the switch to internal combustion engines, the transition was delayed by the high degree of reliability offered by steam turbines and difficulties the engine arrangements then available had in handling excess cargo boil-off gas (BOG) when the ship was at anchor.

When a number of pioneering, experimental LNGCs were built in the 1970s, various propulsion options, all running on BOG, were considered. These included medium-speed diesels, two-stroke diesels and gas turbines. None

was successful at the time, although the reasons were more commercial than technical. So, while all other ship types had abandoned steam by the mid-1980s, steam propulsion continued to reign supreme in the LNG sector until about 2006.

Today we have gas-burning medium-speed, four-stroke and slow-speed, two-stroke machinery in LNG service. Both types of propulsion have made great strides over the past 15 years and are now the preferred choice for LNGC newbuildings. The only one of the propulsion systems considered back in the 1970s that is yet to make any headway is the gas turbine, even though this option is also technically feasible.

The LNG shipping industry is now benefiting from the massive reductions in fuel consumption offered by the latest two-stroke, dual-fuel technology, while the manufacturers of such engines are currently developing designs that are even more fuel-efficient.

One interesting trend has developed in Norway. With dual-fuel diesel-electric (DFDE) propulsion systems, it is sometimes necessary to operate the medium-speed engines at low power load. This is not ideal for fuel consumption, as combustion is less efficient. So, some DFDE ships are being provided with battery power storage, a combination which offers the chance to keep the engines running in the most efficient power band all the time.

Reliquefaction challenges

Cargo reliquefaction on board LNG carriers, to help optimise delivery volumes, has always been technically feasible. However, such systems consume a considerable amount of electrical power, so the fuel efficiency of diesel generators is needed to make the operation of a reliquefaction plant commercially viable. This is why the few attempts to use cargo reliquefaction on steam-powered LNGCs were not a commercial success.

When facing the choice of whether or not to fit a reliquefaction plant, shipowners are in a dilemma. The cost of the plant is quite well known, in terms of both capital and operating costs, but the percentage of time for which the plant's reliquefaction capacity that will actually be required is difficult to predict. If it is assumed that the ship uses BOG as main propulsion fuel and that most of its time at sea is on passage rather than waiting for a berth, reliquefaction capacity will be required relatively rarely. Another way to approach the problem is to increase the efficiency of the cargo tank insulation system, so there is less BOG to handle in the first place.

Expanding supply chains

The rapid expansion of the LNG market in recent years has meant that more traders are entering the business, a trend which entails a different commercial approach. Versatility and speed-of-response are the hallmarks of trading operations, so it is likely that ships will be adapted with extra features to increase the range of operating options.

We have already seen this in the LPG sector, with many large fully refrigerated ships being utilised as floating storage terminals and retrofitted with cargo reheaters so they can discharge directly into fully pressurised ships. Although the properties of LNG are such that direct parallels do not apply, the significant increase in LNG ship-to-ship (STS) transfer and regasification operations in recent times indicates how this particular trade is set to develop in future.

For the same reasons, as the number of smaller LNG carriers increases, the reduced construction costs will open up some coastal and shortsea trades that have been uneconomic to date. If the ships are designed to be flexible, especially in respect of filling limits, then the possibility of a 'milk run' type of distribution system really starts to open up. There are several LNG trades in particular geographic areas that would suit this type of arrangement, especially in the replacement of old oil or coal-burning power stations with

gas-fired facilities. Floating LNG storage arrangements may be essential to overcome local planning objections and, once again, such a storage option becomes more economical as more vessels are built.

The new restrictions on the maritime use of high-sulphur fuels, introduced under the auspices of IMO's Marine Pollution (MARPOL) Convention, will take effect on 1 January 2020. There are many ways to comply, of course, but the availability of LNG as a fuel is attracting a great deal of attention and, most importantly, major investment.

As a result, it will soon be possible to obtain bulk LNG fuel supplies in all the traditional ship bunkering areas, and at other locations as well. The volume of LNG consumed as bunker fuel today is quite modest but, when the large dual-fuel container and cruise ships currently under construction enter service, this picture will change dramatically. Because these ship types have a high fuel demand, the volumes of LNG utilised to power vessels will increase commensurately.

SIGTTO membership

When I joined Dorchester Maritime in 1990, the company's parent, the Schulte Group, was engaged in the management of a significant number of gas carriers and the possibility of joining SIGTTO was soon on the radar. In the event Schulte joined the Society in 2002 when the Group stepped up its involvement in LPGC and LNGC management. In the meantime I had participated in some of the Society's work, including the preparation of the *LPG Cargo Calculation* book, but in those days input from non-members was never credited. So, it seems I was some sort of 'ghost writer' for a time.

SIGTTO's ability to develop standards in a proactive way is the aspect of the Society which I find most satisfactory. SIGTTO's central General Purposes Committee (GPC) meets regularly to discuss industry issues and GPC gatherings are usually followed by all-member Panel Meetings where presentations are made on the latest gas shipping and terminal developments. Many GPC decisions and Panel talks have led directly to the establishment of SIGTTO working group to tackle topical issues and prepare appropriate industry best practice guidelines.

It has been my privilege to chair both SIGTTO Panel Meetings and GPC gatherings over a number of years. The work initiated and completed by GPC is what makes SIGTTO so relevant to the work of the industry.



Providing an effective training regime for a rapidly growing and advancing LNG sector remains a challenge; SIGTTO's new Human Element Committee is poised to help meet it

Training to the fore

Training has always been a key focus for both the gas shipping industry and SIGTTO. Following on from the basic gas syllabus prepared under the auspices of IMO's Standards of Training Certification and Watchkeeping (STCW) Convention, SIGTTO developed advanced competency courses for both LPG and LNG carrier officers. The competency courses are configured to ensure that officers learn about operations relevant to them in detail.

These courses have been adopted widely, although inevitably a wide range of offerings were developed. Some training providers claimed to cover the syllabus in one day, which is not possible in my experience, while others set out to teach the same content over two weeks, which is excessive. Computer-based training (CBT) courses are now available, which overcome many of the classroom cost-related challenges.

For the future, one of the main discussion areas will surely be ensuring that the 'Experience Matrix' remains fit for purpose. As mentioned, the matrix is an important, industry-supported safety initiative in which SIGTTO sets an experience standard for gas carrier senior officers considerably above the STCW requirements. With the large increase in LNG carrier numbers in prospect, the content and assumptions behind this document will surely come under review.

At the moment, the emphasis is on 'time served', combined with the mandatory STCW training and the recommended SIGTTO Advanced Competency course. However, the underlying assumptions are that ships are much the same and voyages are similar. As a result of the changes in trade patterns and advances in technology outlined above, these assumptions are becoming increasingly incorrect.

For example, gas-burning supply pressures for propulsion units now range from 1 Bar(g) to over 300 Bar(g) while a

significant number of LNG carriers now have cargo reliquefaction plants installed. Also, many of the new trade routes are much longer than earlier voyage patterns, most notably deliveries from the US Gulf to the Far East. While all time spent on board ship is essentially a learning opportunity, in my opinion the control room touch-screen environment and the long periods between load and discharge operations limit the real 'learning opportunities', especially when everything is going smoothly.

I believe SIGTTO will have to review the Experience Matrix to take these factors into account. In particular, extra credit should be given for simulator training, when a student can go through a range of 'hands-on' experiences in a week that could otherwise take a lifetime at sea.

Shipping company personnel departments that have to implement the existing Experience Matrix have my sympathy. Compliance is complicated enough to achieve when new companies are entering the industry and sea staff have a much greater variety of choice if they wish to work on board these ships. It is, however, encouraging to note that SIGTTO has formed a Human Element Committee to focus on this key area of the industry moving forward.

SIGTTO takes a truly collegiate approach to safety issues and the great spirit of cooperation has always impressed me about the organisation. Although many of the companies that sit at the various SIGTTO tables are in deep commercial competition with each other, all that is left outside the door. Inside SIGTTO, the common good of the industry is the key focus, and that is good for everyone in the long run.

**Chris Clucas has contributed two articles to this issue. The other article, on page 101, covers his working life and amusing SIGTTO experiences. Any opinions expressed by the author are personal and do not necessarily represent those of his previous employers.*

Completed in 2006, the 145,000 m³ *Simaisma* was the third newbuilding to join the 40-vessel Maran Gas LNG carrier fleet



Greece and LNG – a brief history



Richard Gilmore*, currently Chair of SIGTTO's Panel Meetings, considers the rapid emergence of Greek shipowners as major players in the LNG sector

Pythia was the high priestess of the Oracle of Delphi, the entity consulted about important decisions throughout the ancient classical world and credited with being established in the 8th century BC. It is surmised that Pythia was able to achieve a trance-like state by breathing vapours from a chasm in the rocks beneath her throne. Many believe these vapours to have been methane gas escaping from the earth which, if true, represents Greece's first known connection to methane.

Fast forward to today and Greece is an LNG import nation that received its first liquefied natural gas cargo in 1999 at the Revithoussa terminal located about 45 km west of Athens. In late 2018 the terminal's capacity was expanded with the commissioning of a third LNG tank, a unit that boosted the facility's total storage capacity to 225,000 m³.

Greece and LNG shipping

Greece has been involved with ships since at least 7250 BC when Greeks from the mainland set out in boats made of papyrus for the island of Milos. From this humble beginning the country has developed a deeply held seafaring tradition which has given rise to the modern Greek merchant fleet. Today the country's ships account for approximately 18 per cent of the world's commercial tonnage.

In the relatively recent past Greece has expanded the mix of vessels in its merchant fleet to include LNG ships. The country's first involvement in the sector dates back to 2001 when Peter Livanos' Ceres/ GasLog LNG Services was awarded a ship management contract from BG to operate two LNG carriers. BG had purchased the pair - the 71,500 m³ *Arctic Tokyo* and *Polar Alaska* - from Marathon Oil and renamed them *Methane Arctic* and *Methane Polar*.

GasLog extended its LNG shipping capability to include vessel ownership in 2007 when it acquired a stake in the 145,000 m³ *Methane Nile Eagle*. Since then GasLog has built a substantial fleet of owned LNG carriers.

John Angelicoussis established Maran Gas Maritime Inc (MGM) in 2003 and became the first Greek shipping company to own LNG vessels when it signed a newbuilding contract with Daewoo Shipbuilding & Marine Engineering (DSME) in autumn that year. The ship, the 145,000 m³ *Maran Gas Asclepius*, entered service in 2005 under charter to Gaz de France and later RasGas. From this modest beginning, Maran Gas has steadily built its LNG fleet to more than 40 vessels.

More Greek shipping companies have since followed the country's two LNG pioneers and today there are 11 Greek shipping companies that have LNG ships in operation or on order. The Greek shipowner community is comprised of a mix of privately held and publicly traded companies. As a result of this remarkable advance, Greek-owned/controlled LNG vessels in operation and on order represent an investment of approximately US\$25 billion dollars.

In terms of ship numbers Greek vessels now account for 21 per cent of the global LNG fleet of 660 vessels in operation and on order. Furthermore, the commitment is building. Greek shipowners hold stakes in more than 40 per cent of the LNG vessels currently under construction.

This LNG orderbook now stands at approximately 120 vessels, including large conventional LNG carriers and floating storage and regasification units (FSRUs).

Greek involvement in LNG shipping has developed in tandem with the rapid evolution in LNG carrier design over the past 15 years. Technological advances have resulted in improved LNG cargo tank designs and reduced cargo boil-off gas (BOG) rates as well as fundamental changes in the choice of propulsion systems. In drive for improved propulsive efficiency the steam turbines traditionally used on these ships are now out of favour and have been replaced by tri-fuel diesel electric (TFDE) systems and, more recently, slow-speed dual-fuel diesel technology using either low or high-pressure fuel injection. As the ships have become more efficient, LNG reliquefaction plants have been installed on the vessels.

In addition, there are LNG vessels in the Greek fleet that are ice strengthened as well as ships with full icebreaking capabilities such as the Arc 7 ice class vessels owned and operated by Dynagas and utilised with the Yamal LNG project in the Russian Arctic.

Greek shipowners have taken different approaches when entering the LNG industry. Some have done so directly, extending their experience in oil or LPG shipping into LNG shipping. Others have utilised the services of established LNG ship managers such as the Bernard Schulte Group and Hyundai Merchant Marine.

Some companies, such as the Angelicoussis Group's MGM, have established their own in-house training facilities in Greece. Others have utilised the services of third party training establishments available in Greece, the UK and elsewhere.

All the Greek companies to date have exhibited a high level of

professionalism and technical proficiency in the development of their LNG shipping capabilities. They have demonstrated an ability to adapt to the technical changes in LNG vessel design and operations while maintaining the high standards of safety and reliability that have been the hallmarks of LNG shipping since its inception over 50 years ago.

SIGTTO has helped these new Greek entrants, welcoming their membership and providing a platform from which the companies can gain information on the technical and operating best practices that meet world standards. Those working in Greek shipping are determined to be long-term participants in the ongoing development of the LNG industry.

SIGTTO reflections

I have been fortunate to participate in three LNG shipping start-up projects over my career. The first was with Energy Transportation Corporation (ETC), a founding member of SIGTTO. The second SIGTTO President was Joe Cuneo, who was also president of ETC and the man who offered me the job with the company.

I joined ETC while it was building eight spherical tank LNG carriers at the General Dynamics yard in Quincy, Massachusetts. At that time I worked for Ed Tornay, ETC's vice president of engineering, and was assigned to the shipyard site team. Ed was the first person to chair SIGTTO's General Purposes Committee (GPC). He held that position for over 10 years, as liquefied gas shipping progressed from its early pioneering days to become a stable, safe and reliable worldwide industry with a growing presence. Later at ETC, I worked as a consultant to the Guangdong LNG project, China's first LNG import scheme. In that role I helped the Chinese shareholders, COSCO and

China Merchants, as they formed their LNG shipping company, CS LNG, with BP.

I joined MGM in Athens in 2004, just as the company was ordering its first LNG ships, and assisted in placing them on charters with Gaz de France and RasGas. This role also brought me back into contact with SIGTTO when, in 2006, I joined the GPC on behalf of MGM.

I have seen the industry go from its early days when you could literally name all the LNG ships in operation, to today where it is difficult keeping track of all the LNG shipping companies, let alone the 500 or so ships in operation.

Joining MGM has given me the chance to participate in the entry of Greek shipping into the LNG market as well as in its strong, ongoing development in the sector. This has been extremely exciting, working with my Greek colleagues in both building up MGM and participating in the rapid evolution of LNG ship design. Involvement with the technologies that have led to lower cargo BOG rates, much greater cargo-carrying capacities, improvements in hull design and propulsion systems of much-improved efficiencies has brought me into contact with virtually every aspect of modern LNG vessel design. I'm proud to say that MGM has stayed at the forefront of these advances during the past 15 years.

It has been a pleasure representing MGM at SIGTTO's GPC meetings and adding our voice to the ongoing good work that the Society performs in upholding the safety standards of our industry and representing the liquefied gas industry at IMO.

It is great to see SIGTTO continue to lead in the areas of safety and sharing of best practices in the guidance notes it publishes. The GPC continues to be relevant to the changing industry as it develops new guidance papers on ship propulsion, reliquefaction on LNG vessels and floating storage and regasification units (FSRUs).

MGM's status as an active Society member extends beyond my GPC participation to involvement with a number of the Committee's working groups over the years. Indeed, we have worked or are working on papers addressing the new enlarged Panama Canal locks, surge pressures, emergency shutdown (ESD) systems, manifold arrangements, floating LNG, propulsion systems and reliquefaction plants. MGM has benefited from the relationships we have at SIGTTO and look to give back to the Society in the years ahead through our continued participation.

** Richard Gilmore is director gas fleet at Maran Gas Maritime Inc.*



Boris Vilkitsky is one of five 172,000 m³ icebreaking LNG carriers operated by Dynagas in the service of the Yamal LNG project



We congratulate SIGTTO on its 40th Anniversary

In 2006, Excelerate Energy developed and implemented the world's first commercial STS transfer of LNG to enhance the capabilities of FSRUs. Having completed over 1500 transfers since then, we would like to thank SIGTTO for its support in making STS LNG operations widely accepted in today's industry, helping provide the efficient delivery of LNG to global markets. From Boston to Bangladesh, we are committed to being a safe and responsible operator within the communities in which we serve.

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SIGTTO and Gastech – arm-in-arm in the cause of liquefied gases



Gavin Sutcliffe, chairman of Gastech's governing body, charts the development of a close relationship between SIGTTO and the industry's leading conference and exhibition event

Every time I consider my own connections to SIGTTO, I think of the Society's decades-long support for Gastech and the benefits drawn from this support. No other association can match SIGTTO in delivering an industry best practice regime governing the safe transport, handling and storage of liquefied gases and no other association can match the recognition achieved by the Society as regards the extent to which its guidance has been implemented worldwide.

While many member-based industry organisations can appear to exist for the purpose of self-promotion, SIGTTO has been fully engaged in meeting the often challenging needs of its growing portfolio of members since its inception. The Society has consistently succeeded in harnessing the knowledge pools of individual members and utilising it for the benefit of not only the full membership but also the liquefied gas industry in general.

The first SIGTTO General Manager I met was Bill Wayne, back in 2010 when I took on responsibility for the Gastech event. My very first memory of walking into the old office in St Helen's Place was of Bill's immediate warmth and charm, and how he made my colleagues and I feel so welcome. He introduced us to the beautiful old tanker models that still take pride of place today in the New Broad Street offices, and enthusiastically shared the stories of the pioneering vessels *Methane Pioneer* and *Methane Princess* with my team.

Bill Wayne helped me to understand the extraordinary shared past that Gastech and SIGTTO then enjoyed. That past went back almost four decades, to 1972 when the inaugural Gastech event was launched in London (albeit under a different name) and some of the founder members of what would become SIGTTO were first considering an involvement in the nascent liquefied gas trades.

I realised quickly that Gastech and SIGTTO had walked arm in arm through the

decades and had, in fact, become a rather inseparable, yet delightful, couple! SIGTTO has keenly supported Gastech since its own establishment, and together we have watched our once-niche industry grow into something truly global and defining.

By the 1990s liquefied gas transport and trade had become a significant maritime sector, with growing influence worldwide. Another generation on and here we stand, exactly 60 years since *Methane Pioneer* sailed down the Calcasieu Ship Channel with its first trial LNG cargo for British Gas and out into the history books. In 2018 the global LNG trade topped 300 million tonnes per annum (mta), three times the 2000 level, while seaborne LPG movements approached 100 mta for the first time.

When Bill Wayne stepped down in 2012 and Andrew Clifton was appointed General Manager, the relationship between Gastech and SIGTTO went from strength to strength. I first met Andrew



Andrew Clifton, SIGTTO's General Manager, was appointed as the new technical chairman for Gastech in 2018

at Gastech 2011 in Amsterdam where he was one of our speakers and chaired a session. Unfortunately, on that occasion he was confined to a wheelchair with a dodgy leg. Chris Clucas and I would take turns to manoeuvre him around the venue, which was no mean feat as the RAI Amsterdam centre was roughly the size of Heathrow Terminal 5!

Since then Andrew has become more than just a strong supporter and advocate of Gastech. He is now a good friend and one of our most valued and trusted advisers. This was underlined in 2018 when our governing body unanimously voted him in as their new technical chairman, replacing a retiring Chris Clucas. The Society and Gastech are now closer together than ever before.

Andrew has joined us wherever we meet around the world, and he never fails to lead with our socialising and networking activities. However, nothing indicates Andrew's Gastech commitment quite like the paper voting process. This is, without doubt, one of the most onerous and exhausting tasks undertaken by Gastech's governing body, as it entails voting on over 1,000 presentation abstracts received from applicants seeking to speak at each conference.

Recently, Andrew travelled to a Gastech voting meeting in Houston with print-outs of the *entire* collection of 1,200 abstracts submitted for Gastech 2019. The sheaf was a veritable doorstop which probably cost him extra in luggage allowance! Having led the abstracts voting process and Gastech governing body meetings myself for nearly a decade, I can say with hand on heart that grading hundreds upon hundreds of papers – often wildly fluctuating in quality – can drive the best of us to drink. And I can't think of many people I'd more enjoy having a beer with than Andrew, especially if it involves sitting at the Oval, watching the England cricket team hammer the Aussies ...

Here's to the next 40 years. This, undoubtedly, is set to be an era when SIGTTO is challenged like never before, as we welcome in the strict new IMO 2020 sulphur cap and then the IMO 2050 emissions and CO2 laws, respectively. The complete liquefied gas supply chain, from gas carrier and terminal operators to charterers and their customers, will be motivated by the need to deliver on corporate social responsibilities and climate change commitments to shareholders. The good news is that plentiful and clean-burning gas should find favour over other fossil fuels over the period, leading to as-yet-unknown market opportunities and growth.



The kick-off meeting at the Baltic Exchange in February 2008 of what was to formalised as the IGC Code revision steering group

The revision of the IGC Code



Roger Roue, a former SIGTTO Technical Adviser, describes one of the most significant projects undertaken by SIGTTO in recent years, and no-one is better-placed to do so!

In the early 2000s there was much discussion in the gas shipping industry about the need to update the provisions of IMO's *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*, popularly known as the IGC Code. Over the two decades following its adoption in 1975 the Code had served the industry well. The fact that it required very few amendments over this period bore testimony to the work of the experts who drafted it, led by Bob Lakey of the US Coast Guard.

However, during the first decade of the new millennium gas carrier design and equipment was changing rapidly and it was felt by many in the industry that in some areas the design standards for gas carriers were dropping below those of conventional tankers. One example was the protective location of cargo tanks. Also, the shipboard reliquefaction and regasification of LNG were being introduced, as were commercial ship-to-ship transfers of liquefied gases, new propulsion systems and potential new cargoes. It was clear that the next revision of the Code would require a much more extensive work programme

than had previously been the case and perhaps the 'industry' itself would be best placed to undertake this task.

IMO calls on industry

Shortly before he handed over the reins as SIGTTO General Manager to Bill Wayne, James MacHardy asked me if I would be prepared to be the project coordinator for the revision of the Code, assuming that IMO would agree to an industry proposal that it would take on the responsibility for developing the revised provisions. In March 2007 Bill Wayne and I visited IMO to meet with Efthimios Mitropoulos, the Organization's Secretary General, Koji Sekimizu, Director of IMO's Maritime Safety Division, and Miguel Palomares, Director of the Marine Environment Division, for discussions on the IGC Code's revision.

Being mindful of the technical nature of the work, the IMO secretariat agreed in principle that industry should undertake a thorough review of the Code and present its work to IMO. Mr Sekimizu advised that the correct procedure was for a flag state administration to table the proposal at the upcoming 83rd Session of IMO's Maritime Safety Committee (MSC 83), to

be held in October 2007. Acceptance of the SIGTTO-backed industry proposal was formally agreed at MSC 83 and a new, high-priority item entitled *Revision of the IGC Code* was included in the work programme of IMO's Bulk Liquids and Gases (BLG) Sub-committee.

Pre-empting the outcome of the 12th BLG Session (BLG 12), to be held in February 2008, an industry steering group was assembled. The first meeting of this group was held in the opulent surroundings of the Baltic Exchange in London in January 2008 to discuss how the IGC Code revision process would be undertaken.

The participants in this meeting were:-

- David MacRae** - UK MCA
- Ari Sipila** - Aker Yards
- Matsato Nakamura** - Kawasaki Heavy Industries
- Kiyotaka Yoshida** - Mitsui OSK Lines
- Doug Brown** - China LNG Shipping
- Bernard Twomey** - LR (representing IEC)
- Gordon Milne** - Suez LNG
- Peter Justesen** - Lauritzen Kosan
- Jim Gaughan** - ABS (representing IACS)
- Manfred Küver** - TGE Marine
- Chris Clucas** - Bernard Schulte Shipmanagement
- David Jones** - BP Shipping
- Bill Wayne** - SIGTTO
- David MacDonald** - Teekay
- Roger Roue** - SIGTTO project coordinator and secretary

It was unanimously agreed Mark Hodgson of Shell, Bruno Dabouis of BV and Bjorn Lian of DNV should also be invited to join the steering group. Although it was the intention of the SIGTTO Secretariat that the chairmanship of the steering group should rotate, Chris Clucas proposed that David MacRae should be the permanent chairman. This was agreed unanimously. David's affiliation meant that it would be the UK flag administration that submitted a draft revised IGC Code to IMO for consideration.

It was also agreed that all facets of industry would be invited to participate; drafting group meetings would be held worldwide; and most steering group members would chair a working group. At BLG 12 in February 2008 IMO agreed to the proposal by the UK that the industry itself should conduct the revision. This was the first time that IMO had allowed industry to draft a document outside the Organization's direct control.

Industry calls on SIGTTO members

To initiate the revision of the Code a broad cross-section of industry representatives was brought together to establish a steering group to oversee the work, formalising the earlier exploratory group. The UK chaired the steering group and SIGTTO provided secretarial support. The steering group, consisting of 19 senior industry representatives, oversaw the work of 10 working groups, each of which examined and revised different sections of the Code. Progress with the revision of the IGC Code was to be reported back to relevant IMO committees and sub-committees on a regular basis.

The task I was faced with, as project coordinator, at first seemed rather daunting. However, I had excellent backing from the steering group and it soon became apparent

that there was enormous enthusiasm for the project. Picking working group members was like 'Fantasy Football'! I cannot think of anyone who declined my invitation to join the project.

It was agreed that there would be 10 working groups, as follows:-

- WG1** - Goal-Based Support, chaired by Gordon Milne
- WG2** - Ship Arrangements, chaired by Bruno Dabouis
- WG3** - Cargo Control and Gas Burning, chaired by Mark Hodgson
- WG4** - Electrical and Instrumentation Systems, chaired by Bernard Twomey
- WG5** - Cargo Containment Systems, chaired by Jim Gaughan
- WG6** - Pressure Relief Systems, chaired by Peter Justesen
- WG7** - Fire Hazard Management, chaired by Bjorn Lian
- WG8** - Operations and Special Requirements, chaired jointly by Chris Clucas in the Western Hemisphere and Doug Brown in the Far East
- WG9** - Application, Definitions, Surveys and Certification, chaired by David MacRae.
- WG10** - Emergency Shutdown (ESD) Systems, chaired by Keith Jones

In keeping with the strategic approach that IMO had begun to take with the development of new maritime regulations in general, the revised IGC Code was to be 'goal-based', as opposed to rule-based, in nature. However, the BLG chairman had warned that this approach should be used carefully and for this reason it was decided to have a working group to advise on goal-based approach (GBA) matters.

The membership of the working groups consisted of experts from 48 different entities, representing classification

societies, liquefied gas ship operators, shipyards specialising in the construction of liquefied gas ships and designers of ship systems and equipment. This participation translated into a wide range of industry coverage, as follows:

- Owners and operators controlling 51 per cent of the world's gas carrier capacity
- Classification societies with 98.5 per cent of the gas carrier fleet on their registers
- Shipyards responsible for 33 per cent of the world's LPG carrier construction capacity and 44.8 per cent of the world's LNG carrier capacity

A total of 37 working group meetings, plus two ad hoc meetings, were held in 14 countries during the 26-month period it took to complete the work of drafting the revised IGC Code. The steering group met six times to review progress, offer guidance and direction, and agree on the final draft to be submitted to IMO. This amounted to 1,050 man-days in meetings, plus an incalculable amount of time that members spent doing 'homework'.

Final furlong

In July 2010 David MacRae, Chris Clucas and myself met to undertake the proof-reading and final checking of the draft document, and we were grateful for the assistance provided by Witherby Seamanship International Ltd in this work. Under our remit for this task we were not permitted to make any technical changes. The draft revised IGC Code document was submitted to IMO in November 2010 and appeared on the BLG 15 agenda as "Inf. 2".

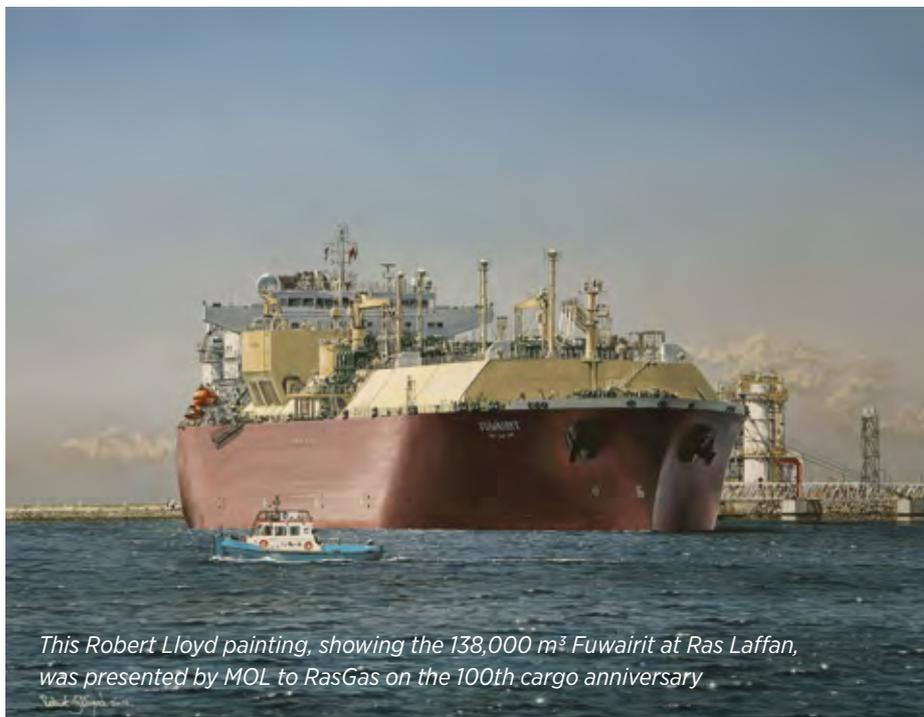
Following further discussions and some fine-tuning, the revised IGC Code was adopted by IMO at MSC 93 in May 2014. The updated Code entered into force in January 2016 and applies to ships whose keels were laid after July 2016.

It was an honour to be asked to undertake this IGC Code revision coordination task and I thoroughly enjoyed both the work and the people I was working with.

Throughout my time working on this project I cannot recall any attempt by any participant attempting to sway members to gain commercial advantage. The dedicated work of these groups portrays perfectly the words of SIGTTO's founding President Barry Hunsaker of El Paso Natural Gas back in 1979: *"We will best achieve our goals by sharing with each other our non-proprietary technical and safety information and operating experiences through open and frank discussion."*



The revision of the IGC Code marked the first time that IMO had entrusted the major upgrade of one of its instruments to industry



This Robert Lloyd painting, showing the 138,000 m³ Fuwairit at Ras Laffan, was presented by MOL to RasGas on the 100th cargo anniversary

Double 40th anniversary celebrations



Ed Carr of MOL, a former SIGTTO Board member and long-term supporter of the Society, looks back on a career in LNG shipping that also spans 40 years

I guess that it was fitting that as I was completing my 40th year working in LNG shipping, Andrew Clifton asked me if I would share some of my experiences for a publication commemorating SIGTTO's 40th anniversary.

My LNG career started in late July 1978, when I enrolled in the LNG course at the Calhoon MEBA Engineering School (CMES) in Baltimore, Maryland. MEBA was the labour union providing deck and engineering officers to both Energy Transportation Corporation (ETC) and El Paso Corporation and had an established training school. Both companies had significant numbers of LNG carriers under construction in US shipyards and needed trained personnel to operate them.

I presume that even then the seeds of what would become SIGTTO were starting to germinate in the mind of Barry Hunsaker, El Paso's president. His company had big plans for LNG and I'm told he was the driving force behind an organisation that would bind those involved in the operations of this business, which was on the threshold of very significant growth, together in the common cause of safety.

Barry Hunsaker's vision was that a

serious accident or incident involving any LNG ship or terminal would have a significant impact on the entire industry. Therefore, the entire industry needed to come together, set high standards and, critically, share information on best practices. Those seeds became SIGTTO.

Unfortunately, Mr Hunsaker passed away before he could take the helm of what became The Society of International Gas Tanker and Terminal Operators, but thankfully, his vision was bright enough that others picked up the torch and here we are 40 years later. Both ETC and El Paso were amongst SIGTTO's founder members.

Basic training

However, in the summer and autumn of 1978, there was no hint at CMES that someday an industry body would not only provide the training standards and required competencies to work on this type of vessel, but also write and publish the definitive text, i.e. *Liquefied Gas Handling Principles on Ships and in Terminals*. We had no such luxury of information in those days.

I recall the course spent a significant amount of time on automation, because LNG carriers were going to be the

most automated commercial vessels then built. There was also a significant amount of information in the course on the construction of the vessels as this was well underway, with three US-built LNG carriers already delivered and the first membrane tank ship, a Technigaz Mark I vessel, to be constructed in the US just finishing sea trials. Firefighting was also part of the course, introducing dry chemical for the first time to many.

However, information on how the ships were actually going to be operated was in short supply. The course instructor had taken a trip from Kenai in Alaska to Tokyo Bay on the 71,500 m³ *Polar Alaska*, one of the first membrane LNG carriers. The shipyards had provided basic operating manuals for the vessels, but these had not found their way to the classroom.

We exited the course with a very elementary understanding of how these ships might operate in actual practice. Frankly, it appeared to a young third mate that it was trial and error for not only the ship and shore-based staff, but also the terminals as well. However, there was a spirit of tolerance in those days that reflected the industry's infancy, and knowledge and experience grew month by month and year by year.

SIGTTO appears on the radar

For me personally, knowledge of SIGTTO didn't come until I was in charge of cargo operations as chief mate, and some SIGTTO information papers started to arrive in the mail packs. During those early years we experienced many challenges, but over time the trade and operations matured and the requirement for 'trial and error' became less frequent and the tolerance for that method of operation also ebbed.

Although information from SIGTTO made its way to the vessels and their crews through the 1980s, it did not do so in a significant way. SIGTTO Panel and General Purposes Committee (GPC) meetings, along with their proceedings and presentations, remained within a small circle of people. But then, LNG shipping was still a pretty small community in those days and the ability to share information easily was not what it is today.

When IMO's *International Ship Management (ISM) Code*, with its safety management systems, was implemented in mid-1990s, I was sailing as master on the 125,000 m³ spherical tank ship *LNG Taurus*. The formalisation of 'near-miss reporting' was something I embraced and I started to make regular near-miss reports. That brought my first real interaction with SIGTTO and set me

on a course that changed my life.

Several of those near-miss reports concerned close calls during transits of the Singapore/Malacca Straits and wound up becoming a topic at a SIGTTO GPC meeting. It was decided that SIGTTO should review the procedures LNG carriers used to make safe transits. A working group was formed and I was nominated by ETC, my employer and a founding member of SIGTTO, to participate in it.

That working group held a meeting in Bahrain early in 1998 and it was decided to write a guide to *Passage Planning for LNG Carriers transiting the Singapore/Malacca Straits* to assist new (and old) mariners make a safe passage. At that SIGTTO meeting, I was introduced to representatives of Mobil Shipping who were starting a new project in Qatar called RasGas.

Ashore in Qatar

That encounter led me to leave the shipboard phase of my LNG career behind and start a new one working for RasGas in Qatar as their first shipping operations manager. This was 1998 and at the start of what was to become another significant period of expansion in the LNG tanker and terminal business.

Thankfully, by this time SIGTTO was well established and I was able to benefit greatly from the information they shared. RasGas became a member of SIGTTO and I was one of the representatives. The business was not only expanding rapidly with many new ships and crews but the business models used for the previous 20 years were also starting to change. Short-term charters and sales contracts were entering the picture and ship/shore compatibility, something previously done only once at the beginning of a project, was now becoming a regular requirement.

Inspection and the start of LNG carrier 'vetting', an established practice for oil and LPG tankers, was poking its nose under the LNG tent. Thankfully, SIGTTO had an inspection checklist as part of its available member documents and I adapted this for the first inspections I did on behalf of RasGas for its short-term shipping requirements.

The development of new trades and new terminals, including in India and the Adriatic, as well as the expansion of the export terminal facilities at Ras Laffan in Qatar were all under consideration. These plans moved quickly to the project realisation stage and SIGTTO information-sharing was key. In particular, I recall the information shared by Total on designing Bontang Berth 3 to accommodate the largest number of vessels as being

extremely valuable in our on plans. Here was the value of SIGTTO, information sharing and passing on lessons learned for the benefit of the industry.

Focus on competencies

Time moves on and so did I, joining Mitsui OSK Lines (MOL) in London in 2003. The headlong expansion of the LNG business meant many new ship crews would need to be trained. Thankfully, training materials had improved dramatically since 1978, as evidenced by the fact that realistic cargo simulators were now in use at a number of company training schools.

However, there were no industry standards on what competencies mariners should have when they first went to work on LNG carriers and what knowledge should be used to develop those competencies. The need for such standards was urgent.

At the turn of the century there were just over 100 LNG carriers in service. By 2006 it was close to 180 and it was projected to be more than 300 when the first decade of the 2000s was over. While that fleet expansion rate might have been similar to the growth of the late 1970s and early 1980s, it was exponentially more in terms of the number of new people who needed training.

SIGTTO stepped up to the challenge. It was the Society's speediest effort to date, the required experts were brought together to produce, without delay, the competency standards that companies and schools could use to develop their training programmes.

While training is one thing, experience is another. As new and existing operators put more and more ships into service, the level of experience possessed by the crews had become a concern. Different

companies developed different standards, and this started to become not only a logistics problem but also a safety concern, as operators were moving staff from ship to ship to meet the 'experience' requirements of the different companies, on paper if nothing else. Again, SIGTTO stepped in and established a standard experience matrix that could be used by the industry.

I was proud to be part of SIGTTO's efforts over the years. When I look back and see all the changes that have happened in the last 40 years, I can't help but feel that if SIGTTO had not been there to help guide the industry as it grew, then the success we celebrate today might not have happened.

Looking forward, we have a mature industry, but also one that keeps evolving, with new trades, new technologies and new people, to whom those of us now a bit long in the tooth look to pass the baton. Despite all the changes the vision of Barry Hunsaker, for an industry body sharing information and best practices as a way to operate safely, remains as relevant as ever.

In some ways I'm envious of those joining the industry and being trained today because there is so much good information and so many ways to deliver it to those who need it. However, I also know that the tolerance for trial and error that I was given doesn't exist anymore, nor should it.

I would like to thank all those, present and past, who have made SIGTTO a success and truly hope the Society continues its good work so that this industry can continue to operate safely and to the highest standards.

Ed Carr is senior vice president LNG and Offshore – North & South America with MOL (Americas)

The spherical tanks for the ETC ships were built at a separate facility and barged up the US East Coast for installation at the General Dynamics yard in Quincy, Massachusetts



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CEO. He and our Russian partners were very committed to make Yamal LNG the success story it is now.

These examples illustrate how the LNG industry and shipping have changed over the 40 years since SIGTTO was established. And, to be very honest, the TOTAL LNG story would not have been the same and much more difficult to achieve without the existence of SIGTTO. Indeed, the Society has played a major role in providing the high levels of standardisation inherent in the gas industry, not least through defining recognised industry best practice guidelines which have helped streamline the development of the business without jeopardising the safety of operations.

The standardisation of activities at the ship/shore interface is just one of a number of key SIGTTO contributions worthy of mention. Those already involved in interface compatibility studies in the 1980s would definitely approve of the guidelines that the Society has developed over the intervening years. The role played by SIGTTO in the recently completed major revision of IMO's *International Gas Carrier (IGC) Code* is another accomplishment of special note.

From a safety perspective, the most important achievement made by the Society is its contribution to the remarkable performance record that the liquefied gas industry has built up over the years in minimising accidents. Newcomers to the business, the number of which keeps on increasing due to the growing demand for gas, are definitely able to commence operations more quickly and at a higher entry-level threshold thanks to the guidelines set up by the traditional players through the SIGTTO forum. The standards that have been developed are effectively starting-point references.

In conclusion, the past 40 years have been very exciting for the liquefied gas sector, characterised by incredible developments sustained by the continuous efforts of SIGTTO and its members. The years ahead look equally as promising for growth and technological advances. The demand for gas is increasing as is that for floating regasification, storage and liquefaction projects; small-scale LNG; and LNG bunkering. The sheer sum of the competencies and skills of the SIGTTO membership will ensure that the Society continues to play a key role in maintaining the safety and reliability levels demanded by our industry.

*Luc Gillet, senior vice president shipping, TOTAL Trading & Shipping.
Peter Justesen, vice president LNG Shipping, TOTAL Gas, Renewables and Power*

TOTAL, the gas industry and SIGTTO



TOTAL's **Luc Gillet** (left), a past President of the Society, and **Peter Justesen** (right) provide

an insight into how an energy major derives benefit from SIGTTO membership

TOTAL has been a SIGTTO member for years, but not a passive one. Indeed, through its participation on both the Board of Directors and the General Purposes Committee (GPC), our company's policy has always been to be an active member of the Society as well as one of the major players in the gas industry in general and in the LNG business more specifically.

TOTAL has also been active in the global LPG sector for quite a long time. We currently operate a fleet of about 10 LPG carriers, from fully pressurised ships up to and including very large gas carriers (VLGCs). Our presence in the LPG sector has been mainly driven by our group's network of production facilities and refineries as well as through some LPG storage terminals, mainly located in France. TOTAL's activities in the LPG segment have increased over the last 12 months, thanks to the group's new production output from Australia and the development of US East Coast export volumes.

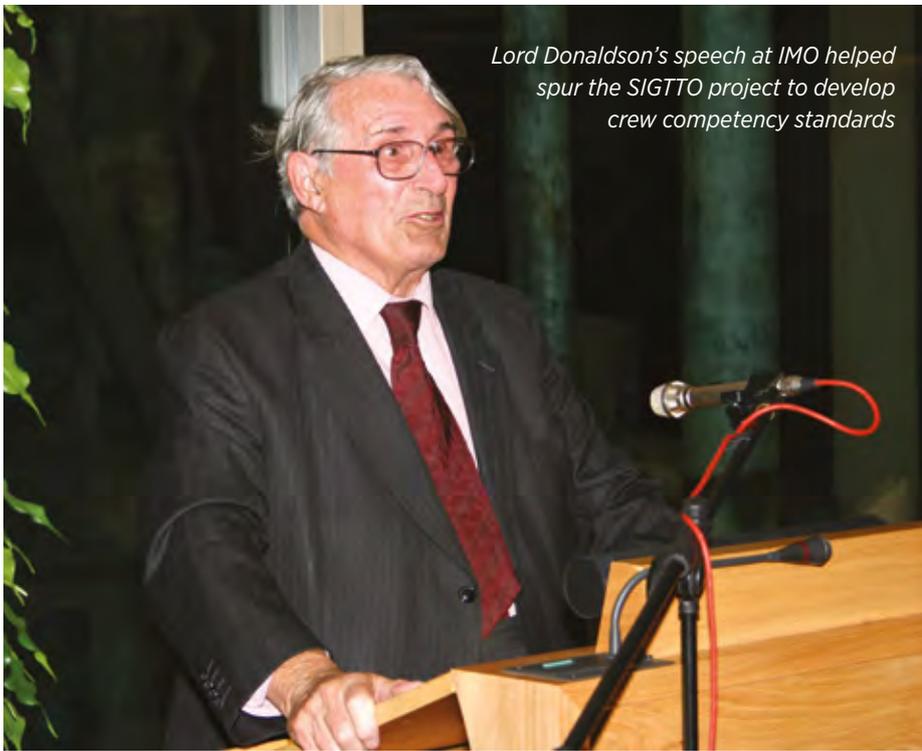
On the LNG side TOTAL is a stakeholder in a dozen large liquefaction plants, half a dozen of receiving terminals and four LNG carriers. We also manage a fleet of 15-20 LNGCs as charterer. This position is the result of a long-term involvement and strategy which, combined, have achieved some noticeable milestones over the last

20 years. These include the merger with the former French oil and gas company ELF in a deal which brought TOTAL its current share in Nigeria LNG equity and the project's related LNG carrier fleet.

More recently, the purchase of the ENGIE LNG business unit, including the ship management company Gazocean, also contributed to a significant increase in TOTAL's share of the LNG market. Thanks to this acquisition, the company inherited the people who designed and ordered; participated in the construction and delivery in 2006 of; and eventually operated the 74,100 m³ *Global Energy*, the first LNG carrier to be powered by a dual-fuel diesel-electric (DFDE) propulsion system.

A couple of years ago TOTAL also ordered the 180,000 m³ *SK Audace*, the first LNG carrier to be propelled by X-DF two-stroke, low-pressure, dual-fuel engines supplied by Winterthur Gas & Diesel (WinGD). It was not a straightforward decision, as it took three days to convince our management, three weeks to convince the shipyard and three months to convince the shipowner of the merits of this innovative propulsion system. But we made it!

TOTAL has also been very active in the development of the first icebreaking LNG carrier, proudly named *Christophe de Margerie* as a tribute to our former



Lord Donaldson's speech at IMO helped spur the SIGTTO project to develop crew competency standards

Notes from the start of the modern era



James MacHardy, SIGTTO's sixth General Manager, looks back 15 years to the time when liquefied gas shipping commenced the great transition to the modern era

Michael Grey, the esteemed columnist and one-time editor of *Lloyds List*, described SIGTTO as "a curious organisation, but one which is the repository of all that is known in the world about the marine transportation and terminalling of gas. Its members willingly share their information; one reason, it is said, why the sector is so extraordinarily safe."

A profound statement to read during your first week as General Manager in February 2003, sitting at a desk looking out onto St Helen's Place in the City of London, the cobbled street, the entrance gate, the security men and the gas street lamps. Michael's words about the willingness of the Society's members to share information were very comforting, as that feature is, of course, the essence of all SIGTTO meetings.

Early SIGTTO contacts

My first SIGTTO meeting, attended some years before taking up the General Manager role, was a gathering of the General Purposes Committee (GPC) and a Panel Meeting at Dhahran in Saudi

Arabia. That was in February 1992 and, interestingly, SIGTTO has not had another meeting in Saudi Arabia since then.

I never visited SIGTTO's old Staple Hall office but I was present at the reception held to mark the opening of the 17 St Helen's Place premises on the evening of Friday, 23 April 1993. The Society's then General Manager was Capt Bruce Keer, a former seagoing colleague of mine, while Dick Chadburn of Shell was, in those days, SIGTTO's sole Technical Adviser. The remaining core member of the Secretariat was Adele Ball, the Office Manager. A dedicated and conscientious member of staff over many years, Adele had provided a beautiful spread that evening to enable SIGTTO's friends and guests to celebrate the official opening in convivial surroundings. It was a very pleasant affair and everyone there wished SIGTTO well in their new abode, close to the historic offices of the Hudson Bay Company.

Of course, what happened nearby early the next morning has also gone down in history. The Bishopsgate bomb planted by IRA terrorists was detonated outside St Ethelburga's Church, a near neighbour to

St Helen's Place. The damage to the SIGTTO premises was extensive but, fortunately, no-one was present at the time. Bruce was given clearance to visit the office the next day only to encounter severe water damage and the shattered remnants of what had been a very good welcome party the night before!

Silver Jubilee

In 2004 we celebrated the 25th anniversary of the establishment of SIGTTO with a notable evening reception at the IMO building on London's Albert Embankment. The SIGTTO membership was present in force, as the event coincided with London gatherings of the Board of Directors and the GPC as well as an Annual General Meeting.

We were pleased to have Efthimios Mitropoulos, the IMO Secretary General, and Lord Donaldson of Lymington as the principal guests at the IMO reception. Also present was Sir Denis Rooke, chairman of British Gas. In his younger days Sir Denis had been a member of the technical team that had sailed on board *Methane Pioneer* in February 1959 when it carried the first-ever seaborne cargo of LNG from Lake Charles in the US state of Louisiana to Canvey Island in the UK.

In his address Lord Donaldson concentrated on the responsibilities of shipowners and operators and also noted the sometimes undervalued role of terminal operators in the safe handling of LNG and LPG. He said that in these days of agency manning (then pertaining in 2004) shipowners should demand one very important crew requirement which is in danger of being overlooked. This is that there must be a common shipboard language for both officers and crew, even if individuals have different tongues. It is a fact of life that in an emergency we all panic in our mother tongue.

It was Lord Donaldson's well-chosen words that prompted SIGTTO's GPC to commission and publish *Competency Standards for Officers on LNG Vessels*. The publication was well received by the maritime industry and endorsed by IMO at their Standards of Training Certification and Watchkeeping (STCW) conference.

Floating technology

Around the time of the SIGTTO Silver Jubilee celebrations a considerable number of new LNG receiving terminals were under construction in the US, in anticipation of a growing demand for gas imports in the country. In addition a new technology was being developed – ship-to-ship (STS) transfers of LNG cargoes and onboard regasification as part of commercial operations – again with the

gas import needs of the US in mind.

In March 2005 a full cargo of LNG was regasified by the 138,000 m³ *Excelsior*, the world's first floating storage and regasification unit (FSRU), and transferred to shore as natural gas via a submerged turret loading (STL) buoy positioned 185 km off the coast of Louisiana in the US Gulf and a subsea pipeline. The offshore facility, called Gulf Gateway, had been constructed by Excelerate Energy, the ship's charterer. Excelerate had developed the FSRU technology in tandem with Exmar, the ship's manager.

The principals were congratulated on a safe operation and the hugely successful FSRU era was born. At the time SIGTTO was heavily involved in beneficial discussions on ship and terminal safety with the US Coast Guard (USCG) and the Federal Energy Regulatory Commission (FERC).

These discussions were successful in convincing the US authorities that, through SIGTTO and its membership, the liquefied gas ship and terminal industry were self-regulating to a high degree. The excellent safety record achieved by gas carriers and terminals over many years of operation bears testimony to this ability to self-regulate.

The downside is, of course, that in the event of any serious incident, the regulators would have a field day. The industry bible, IMO's *International Gas Carrier (IGC) Code*, recently updated with invaluable assistance from SIGTTO and its membership, and the raft of Society publications, including *Liquefied Gas Handling Principles on Ships and Terminals*, all help to maintain the high standards required across the global gas shipping industry.

SIGTTO has always had the benefit of enthusiastic members, all of whom are always willing to contribute their knowledge, their time and their facilities. No 'quango' can exist successfully without that freely given assistance, and long may it continue.

Thanks for the memories

The meetings, the forums, the friends, the characters and the members all make SIGTTO different and successful. Memories come flooding back. The SIGTTO Panel Meeting in Nagoya in September 1992, for example, gave members the opportunity to visit the 87,500 m³ *Polar Eagle*, one of a pair of LNG carriers that were the first to be built with the IHI self-supporting, prismatic-shape, IMO Type B (IHI SPB) containment system, then under construction at the IHI yard in Kobe.

The following year, in September, SIGTTO held its GPC and Panel Meetings

at Kuching in the Malaysian state of Sarawak. We had an interesting river boat trip up the Sarawak River and I'm not sure if I have ever experienced so much rain, either before or since.

I also recollect those early Panel meetings where the then General Manager Bruce Keer was giving the SIGTTO update presentations and Dick Chadburn, his Technical Adviser, was down on his knees changing the acetate sheets on the overhead projector! We're lucky that audio-visual technology has also moved on.

In autumn 2003, under my watch as General Manager, SIGTTO's Japanese members hosted the Board meeting at Hakone. At that time of year Hakone was a truly remarkable place, what with the autumn colours and the views of Lake Ashi and Mt Fuji. I was fortunate enough to be able to repay some of the Japanese hospitality by inviting six Japanese members to our house for Sunday lunch during SIGTTO's 25-year celebrations in London in 2004.

Our other Panel Meeting in 2004 took place in San Francisco. There was much discussion during the proceedings on the looming world energy crisis, prompting one member to suggest that if the US turned off the office and street lights at night there would not be an energy crisis! That Meeting included an excellent 'technical' visit to the Napa Valley where we had the opportunity to sample liquids stored in impressive 'containment' systems somewhat different to those encountered in our industry.

A SIGTTO Regional Forum meeting in Copenhagen in June 2005 lives long in the memory. At that event our Danish members kindly took participants out for an evening sail on what was undoubtedly the coldest night of the year. A month earlier the SIGTTO Board had enjoyed a technical visit to a much warmer location

- the Atlantic LNG export facility at Point Fortin in Trinidad. For me, it meant a return to a place where I had spent a very happy year before joining SIGTTO.

In September 2006 our Panel Meeting in Vancouver was held at a venue which happened to be in the city's red light district. I'll say no more here. Moving swiftly on, we visited the Hudong-Zhonghua Shipbuilding Co shipyard in Shanghai in November that year. SIGTTO members were allowed access to the 147,200 m³ *Dapeng Sun* which was under construction. The vessel was the first LNG carrier to be built in China and was set for operation by China LNG Shipping International Co Ltd.

No resting on laurels

The UK's Lord Justice Sheen, in one marine incident inquiry, famously described shipping management failures as "the disease of sloppiness". That was some years ago but today the improvements in LNG and LPG design, construction and operational standards are measurable and visible. In our industry we have an enviable record where our ships and terminals are safer, more secure and more environment-friendly than ever before. This is a record that nobody wants to spoil.

Nevertheless, accidents do occur. The risk of accidents increases with the growth in fleet size and the diversification of the liquefied gas supply chain. We must continue to work hard to minimise the risk of accidents occurring and to reduce and contain the impact of those that do occur. As part of this effort, we must all go that little bit further to ensure that our operations on board and at the terminals are conducted to the highest standards at all times and in all circumstances.

The stakes are too high and the consequences too dire to accept anything less than a perfect record in our industry.



I had the opportunity to repay some of our Japanese members' hospitality by hosting a small group for lunch at home during our London Silver Jubilee

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The LNG bunker barge *Clean Jacksonville* following successful cold trials in Orange, Texas

SIGTTO and the regulator of the world's fastest growing gas trades enjoy close ties



LCDR Dallas D Smith of the US Coast Guard reports on the partnership that has been developed between SIGTTO and his agency's team of liquefied gas specialists

The US Coast Guard's Liquefied Gas Carrier (LGC) National Center of Expertise (NCOE) is a hand-selected team comprised of liquefied gas subject matter experts. The LGC NCOE was developed to serve the Coast Guard as in-house consultants on all aspects of liquefied gas carriers, liquefied gas terminals, liquefied gas-fuelled vessels and liquefied gas bunkering operations.

This team provides technical advice to industry and the Coast Guard while striving to increase and maintain the Coast Guard's collective competency and capabilities. The LGC NCOE serves as the link between the Coast Guard and the liquefied gas community by always remaining up to speed on current and often innovative liquefied gas projects.

We work diligently to guide industry's engagement with appropriate field and staff personnel. As a Coast Guard headquarters unit, the LGC NCOE works to identify gaps within the maritime governance of the liquefied gas industry and provides recommendations for Coast Guard regulations and policy. As certified instructors, LGC NCOE personnel are leading the effort to achieve consistency in the Coast Guard's application of safety, security, and environmental

standards by improving the availability and relevancy of training for the Coast Guard's community of gas carrier and gas-fuelled ship marine inspectors.

The Coast Guard was invited to become a member of SIGTTO and the LGC NCOE is designated as the Coast Guard's official liaison with the Society. Through an approved Mutual Training Agreement (MTA), the Coast Guard is able to partner with SIGTTO and its members to facilitate Coast Guard training opportunities within the liquefied gas shipping industry. The MTA helps Coast Guard marine inspectors and port state control officers increase their competency through ship rides, industry training and participation in technical meetings. This has also afforded the Coast Guard the opportunity to be transparent with industry, share findings and developments, and broadcast the Coast Guard's regulatory position in various mediums.

This mutually beneficial relationship has enabled the LGC NCOE to participate in SIGTTO Panel Meetings and Regional Forums, and to assist with technical working groups. Most notably, the LGC NCOE continues to present at SIGTTO's biannual Pan American Regional Forums (PARFs).

In December 2018 the LGC NCOE collaborated with SIGTTO, Society for Gas as a Marine Fuel (SGMF) and Riviera Maritime Media to hold the fourth annual Liquefied Gas Senior Executive Forum in Houston. As with the three previous meetings in the series, the latest event was a huge success. The fourth Liquefied Gas Senior Executive Forum covered an array of topics that included LNG exports, LPG and chemical gases, the use of LNG as a marine fuel and LNG bunkering.

The US liquefied gas industry is currently experiencing tremendous growth, with more to come in the next few years. As a result, the US is expecting to be playing host, within the next two years, to more than double the annual number of liquefied gas carrier port calls, with especially high volumes in the US Gulf of Mexico region.

With the rising volume of gas carrier traffic comes increased operational complexity, necessitating, in consequence, additional training to ensure operations are executed safely. Operations associated with liquefied gas carriers, LNG-fuelled vessels and LNG bunkering operations are amongst the most technologically advanced within the maritime sector. Against this background, the international forums that we participate in with SIGTTO are key to an effective sharing of insight and best practices between the industry and the regulators.

An example of this advanced technology is the successful construction in the US of the bunker barge *Clean Jacksonville*. The 2,200 m³ *Clean Jacksonville* is the world's first LNG bunker barge to use membrane tank technology. In 2018 the world's LNG community witnessed a critical milestone when the vessel successfully loaded its first LNG cargo. *Clean Jacksonville* is currently homeported in Jacksonville, Florida where she bunkers Tote's LNG-fuelled containerships.



The Kairos gas-handling system provides an unrivalled operating envelope which facilitates, amongst other things, LNG bunkering

Schulte gas shipping and SIGTTO commitments closely linked



David Furnival, current SIGTTO President and Bernhard Schulte Shipmanagement COO, looks back on his company's 50-plus years in gas shipping and almost 20 years of working with SIGTTO

Bernhard Schulte was established as a shipping company in Papenburg, Germany in 1883, long before gas carriers entered service. Some 85 years later, in 1968, the company took on management responsibility for the semi-ref LPG carrier *Cap Roland*, newly built, coincidentally, in Papenburg. That transaction sparked an interest in the liquefied gas sector that has continued blossoming to the present day.

The company's second LPG carrier, *Fritz Haber*, joined the fleet in 1972 and this vessel was followed by three owned, LNG-ready IMO Type C tank ethylene carriers in 1974. The 2,420 m³ *Anna Schulte*, *Sophie Schulte* and *Lissy Schulte* were advanced vessels for their time, capable of burning

natural gas in their medium-speed main propulsion diesel engines. However, the construction of a gas pipeline between Libya and Sicily at the time obviated the need for their use with an anticipated LNG project and resulted in the vessels being employed in the LPG and ethylene trades.

Management specialists

The establishment of a number of wholly owned third-party ship management companies, commencing with Cyprus-based Hanseatic Shipping Co in 1972, accelerated the growth of the Schulte LPG fleet.

The provision of crew management services to Chemtrans, BP and Abu Dhabi's National Gas Shipping Co (NGSCO) in the

early 1990s paved the company's way into the LNG sector. The LNG commitment was then developed into other services, including training for National Gas Shipping Company (NGSCO)/BP in the late 1990s and consultancy for Petronet in 2000.

Plan approval and newbuilding supervision services were added in 2001 when another Schulte Group company, Dorchester Maritime, was contracted by Spain's Naviera Tapias, a new entrant to LNG, to support their 140,000 m³ membrane tank vessel newbuilding programme. The new Tapias fleet included one of the first LNG carriers to be built in Spain for over 30 years. Soon after the delivery of these vessels Tapias sold its LNG business to Teekay.

In 2000 Dorchester Maritime was engaged by Navigator Gas to take over the supervision and full management of their 22,000 m³ ethylene carriers being built at Jiangnan Shipyard in Shanghai. These were the world's largest ethylene carriers at the time and established a relationship between the two companies that lasted more than 15 years.

At the same time Bernhard Schulte was building its own LPG and ethylene carriers at the Jiangnan yard. The fact that the group is still operating these ships 20 years later bears testimony to the fundamental quality of not only the yard's first series of gas carriers but also the vessels' gas-handling plants which were supplied by Tractebel Gas Engineering.

Training focus

Crew training has always been a priority for the Schulte Group and the LNG sector has received a great deal of focus. This is particularly true during intensive periods of newbuilding deliveries when strong programmes of cross-training from the LPG and tanker fleet sectors are implemented to supplement the limited pool of LNG-experienced officers.

In 1991 Hanseatic Shipping formed a joint venture with Chemikalien Seetransport to adapt their 35,000 m³ LNG carrier *Annabella* as an operational training school. The vessel already had generous accommodation, and this was supplemented by classroom training facilities that allowed students to see both the theoretical and practical aspects of liquefied gas handling.

Benefiting from short voyages and frequent loading and discharge operations, and with the Schulte Group's acknowledged gas industry expert Chris Clucas among the tutors, the school was a highly effective training facility that continued for more than a decade.

Having a large fleet of LPG carriers under management has provided Schulte with a strong pool of officers for cross-training in preparation for service on LNG ships. However, while liquefied gas handling was adequately covered with in-house computer simulators, the transition of navigating officers from small to large ships requires a different approach. In 2005 Dorchester Maritime collaborated with the Ilawa ship-handling centre in Poland to build a scaled manned model of a large LNGC.

The result was *Dorchester Lady*, a model provided with an interchangeable stern to enable the simulation of both single and twin-skeg propulsion arrangements. It is also possible to set steam turbine, slow-speed diesel and dual-fuel diesel-electric (DFDE) propulsion system configurations for *Dorchester Lady*. As a supplemental training to full mission computer simulation, the manned model has proven to be an effective and valued tool by the participating officers.

LNG packages

The number of LNG carriers for which the Schulte Group provides crew management services continued to expand when MISC awarded a contract for part of its LNG fleet in 2003 and NGSCO added four more in 2004.

In 2005 Dorchester Maritime partnered with Maran Gas, then another new entrant to the LNG sector, to provide a contracted service package which includes

newbuilding supervision, specialised gas training for shore staff and crew and technical and crew management. Part of Greece's Angelicoussis Shipping Group, Maran Gas places great emphasis on maintaining the high standards expected of LNGC operators by the industry at large.

As a result, the assimilation of the Dorchester Maritime service package by Maran Gas was a straightforward process. It included the cross-training of Greek tanker officers who have performed excellently in LNG service. The collaboration has helped Maran Gas develop into one of the industry's leading independent LNG carrier owner/operators.

In 2007/8 Bernhard Schulte Shipmanagement (BSM), the new name for the four previously independent Schulte ship management companies, was awarded full management of four 216,000 m³ Q-flex LNG carriers jointly owned by Nakilat and OSG. The collaboration was successful and OSG, another new LNG sector entrant at the time, took control of the technical management of the vessels in 2012. BSM remains as crew managers of the quartet to this day. Similar collaboration arrangements were contracted with Greek shipowners Thenamaris in 2013 and Alpha Gas in 2015.

The Schulte Group acquired Pronav, the Hamburg-based LNG specialist ship manager, in 2017. Pronav has a long history of faultless operations in the LNG sector, including the newbuilding and full management of four Q-flex ships from 2004 to the present day. The Pronav fleet was supplemented with two full management steam turbine LNG carriers in 2012.

The completion of two notable LNG vessels in 2018 made it a milestone year for BSM. The company took delivery of both its first large LNG carrier, the 174,000 m³ *Marvel Hawk*, jointly owned

with Mitsui and Co, and the innovative 7,500 m³ gas supply vessel *Kairos*, jointly owned with Babcock. *Kairos* is equipped with a patented gas-handling system that provides an unrivalled operating envelope. The award of a contract covering the full management of four 174,000 m³ LNG carriers owned by Flex LNG added to the success achieved by BSM in 2018.

Schulte and SIGTTO

The Schulte Group's relationship with SIGTTO dates back to around 2002 when we first became members. Various of the company's employees have been keen and consistent contributors to the Society's work programme ever since.

Schulte staff have held the positions of Human Element Committee (HEC) member, General Purposes Committee (GPC) chair, Panel Meeting chair, Board Vice-President and President. We have also participated in numerous SIGTTO working groups, including those dealing with the revision of the *International Gas Carrier (IGC) Code*, emergency shutdowns, advanced competency training for LPG and LNG officers, the SIGTTO Matrix, the use of mercaptans, fire hazard management and steam engineer training.

The future of gas shipping continues to look bright for the Schulte Group, with confirmed contracts for the full management of both LPG and LNG vessels under construction. The current gas fleet comprises of over 100 owned and managed vessels and this is expected to rise to 130 by 2021/22.

It will be a challenge to develop the required resources both on board and ashore while meeting the high operational and safety standards defined by our clients, charterers, SIGTTO and the gas shipping industry as a whole. Nevertheless, it is one we are determined to deliver.



Delivered in 1973, the 2,420 m³ Anna Schulte and her two sisters were originally built for a small-scale LNG project that never materialised



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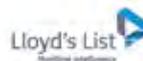
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The first meeting of SIGTTO's Human Element Committee, held at London's Baltic Exchange in 2016



Boosting the human element focus



Stephen Allibone, Chair of SIGTTO's Human Element Committee, examines the work of the Society's newest plenary body

Over the years I have had the opportunity to work with and meet many people that have been associated with SIGTTO. On my first trip to sea, as a very hesitant cadet with BP, the chief officer was James MacHardy. I learned a lot from James and I would like to think of him as a role model. Once he even sent me to the Vatican from Gaeta to get him a postcard! That remains a treasured memory. Later I met him in the BP Shipping office when he was the gas manager there, before he moved on to become the SIGTTO General Manager in 2003.

I also worked with Marc Hopkins, Paul Steele, Chris Snape and Andy Murray. All of them became significantly involved in the work of the SIGTTO Secretariat as Technical Advisers. All four can be considered experts in their field.

My first trip on a gas vessel was on board the 70,500 m³ LPG carrier *Gas Enterprise* as chief officer. I moved into the LNG carrier sector in 1990 when I stood by during the construction of the 127,500 m³ *Northwest Shearwater* at Kawasaki in Japan as part of

preparations to join the ship. I have been involved with LNG, more or less, since this time. In my first appointment when I came ashore in 1995 I was seconded into Abu Dhabi's National Gas Shipping Company (NGSCO) as health and safety adviser but returned to BP Shipping in 2000.

During my time as LNG marine superintendent at BP I came to know more of SIGTTO and the high standards that it applies. I had a strong working relationship with Roger Roue, another Technical Adviser, and I would often contact him for his advice or just to 'bounce' ideas off him. We often discussed the standards of designated LNG tugs, terminal stand-by requirements and evolving designs. Part of our discussions also concerned LNG marine terminal projects. Later I attended SIGTTO General Purposes Committee (GPC) meetings as an observer.

In 1990 there was somewhere in the region of 125 LNG carriers and all were involved in designated LNG projects. All the major players were SIGTTO members and well known within the industry. Since then the industry has evolved

dramatically, including through rapid increases in ship and fleet sizes. Long-term LNG sale and purchase agreements are no longer the norm and vessel time charters have reduced in length. Floating storage and regasification units (FSRUs) and floating storage units (FSUs) are also now well established.

Throughout this period of growth and diversifying supply chains SIGTTO has been a great source of knowledge and a provider of expert advice whenever sought. It has ensured that liquefied gas operations remain one of the safest in the shipping industry.

I joined Mitsui OSK Lines (MOL) in 2014. I saw it as a major player in LNG shipping and a company which prides itself as a leader in safe operations. As a lead investigator I have always been interested in the human element. This came to a head in 2015 when one of our vessels experienced a venting incident in Barcelona. A number of human failings were identified. As a company we reviewed these failings and set about initiating a number of new practices, including our LNG Cargo Control Room (CCR) Resource Management Course and CCR CCTV Audits. The incident and our follow-up were shared with SIGTTO and the industry.

In 2016 SIGTTO established its Human Element Committee (HEC) which I was privileged to join. HEC set up a number of working groups that report to it, including the CCR Ergonomics and Competency group, of which I am a member. I firmly believe that the HEC and its working groups will have a positive impact on liquefied gas operations.

I have recently been appointed as HEC Chairman and it is a challenge which I am looking forward to. Coming from a variety of backgrounds, the members of HEC and its groups are a very knowledgeable bunch. Each individual has had an input to the work we are doing and the inherent progress being made. From these members it is possible to identify industry best practices and incorporate these into the SIGTTO publications and guidelines that we are working on. It is a pleasure to work with this team.

SIGTTO's move to its new office in the City of London in 2018 has also been a positive step, allowing expansion and more staff to join an increasingly busy Secretariat. I have seen how busy the office is and the need for extra staff. SIGTTO is a respected organisation which has adapted to the change in the industry. Its work is diversified and challenging, yet the original concept of the Society has not changed. This can only be a good thing for the industry.

Guiding a fit-for-future SIGTTO



Mark Hodgson, currently chairing SIGTTO's General Purposes Committee, outlines the steps being taken by that body to ensure continued and future success for the liquefied gas sector

My present role in SIGTTO is as General Purposes Committee (GPC) Chair. I took up the position in late 2016 and, following an extension to the tenure earlier in 2019, I am not due to step down until end-2022. My appointment as Chair came after being a SIGTTO GPC member on behalf of Shell since 2009.

I believe that SIGTTO has had and continues to have an enormous positive benefit in the success of the liquefied gas industry. In addition, the Society's role in ensuring the future success of our sector is set to become increasingly important.

Privileged position

I have great memories of my decade with GPC and of the people I've met during the course of the Committee's work – everyone from the GPC members themselves and the SIGTTO Secretariat staff to countless other industry participants who contributed to our projects. Like other SIGTTO members, I have a long-standing passion for the gas shipping industry and it has been a blessing for me to have been associated with the Committee representatives. I have the utmost professional and personal respect for my industry colleagues and the work they have done in the cause of safe, quality and environment-friendly liquefied gas operations.

My own liquefied gas experience since joining Shell in 1981 has been mainly focused on LNG, from sailing on the fleet vessels as an engineer through to superintendent and fleet manager roles. More recently the technology teams with which I've been involved have been concerned with the design and delivery of new, more efficient LNG carriers, floating regasification and storage units (FSRUs), floating LNG production (FLNG) vessels and even recycling older LNG vessels according to the Hong Kong Convention. Almost a full house I guess.

I owe my colleagues and mentors

who guided me in the early days a debt of gratitude for inspiring my gas shipping passion. I still occasionally see some of these early guiding lights, even though almost all are now retired.

Underpinned by the huge success of our industry to date, we are now looking forward to further changes in gas shipping technology as the drive for a cleaner environment and a decarbonising future gathers pace. Such advances encompass liquefied carbon dioxide (CO₂) and liquefied hydrogen (LH₂) shipping, both of which I'm fortunate to be involved with at Shell.

IGC Code revision

What stands out for me over the years? Too many individual things to mention, but amongst several GPC working groups, such as those devoted to ship-to-ship (STS) LNG transfer and the effects of fire on LNG carriers, two notable experiences will stay with me forever.

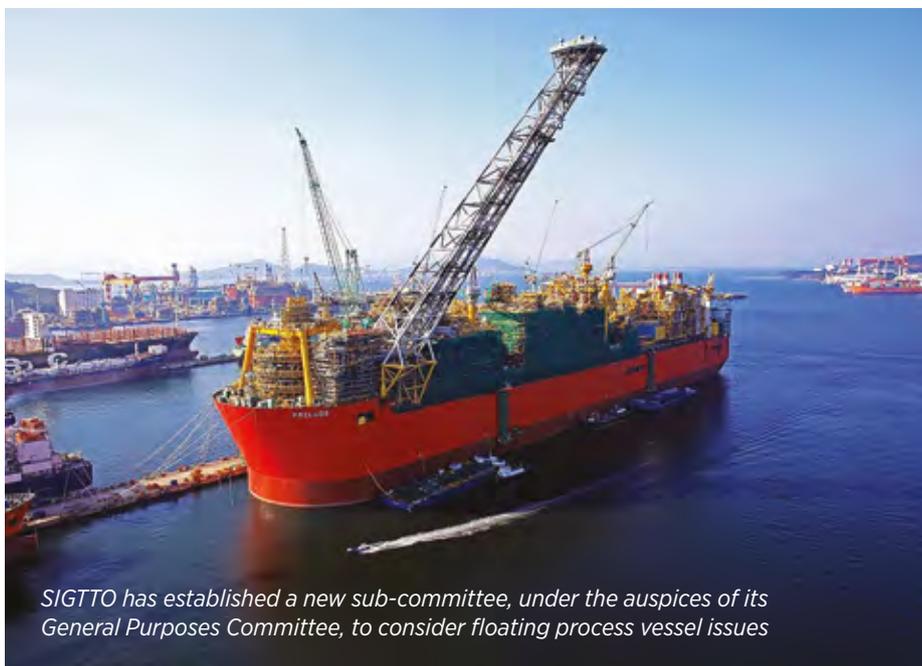
The first is leading the *International Gas*

Carrier (IGC) Code revision as Chair for two of the new IGC chapters. My group was but a part of a larger SIGTTO team dedicated to carrying out the revision of the entire IGC Code on behalf of IMO. To align a large number of stakeholders in developing new and revised provisions and then bringing the resultant package through the IMO process required the input of hundreds of contributors and thousands of man-hours in arriving at the agreed, draft texts.

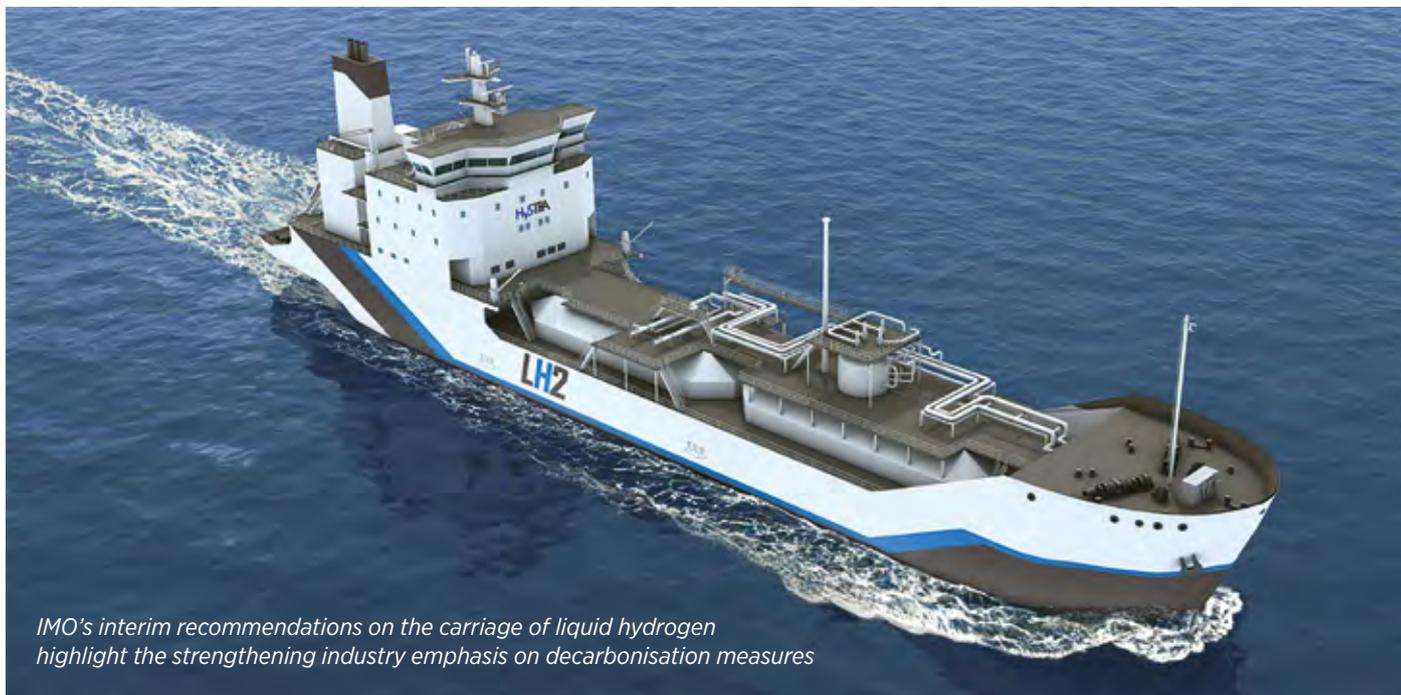
What impressed me most with this project was the dedication, commitment and professionalism of the participating organisations and the individuals that SIGTTO managed to coordinate. It still fills me with admiration for those in the industry as well as pride that I had the chance to be part of it.

I recall chairing the IMO Editing Group at what used to be known as the Organization's Bulk Liquids and Gases (BLG) Sub-committee, working into the early hours with colleagues and IMO representatives from several of the national marine administrations, notably the UK and Japan, to make sure the draft revised IGC Code submissions were ready for IMO plenary sessions.

All in all, my association with this task and achievement stretched over six years. It was very fitting that during this period the 50th anniversary of the first delivery of a commercial LNG cargo was celebrated in October 2014. The industry landmark included recognition of Roger Pfooks, one of the leading lights in LNG shipping from the outset. Roger was a Shell naval architect and the author of *Natural Gas by Sea*, a must read for anyone in our industry. Although I didn't know



SIGTTO has established a new sub-committee, under the auspices of its General Purposes Committee, to consider floating process vessel issues



IMO's interim recommendations on the carriage of liquid hydrogen highlight the strengthening industry emphasis on decarbonisation measures

Roger Ffooks personally, I had the signal honour of attending his funeral, on behalf of Shell and SIGTTO, to say goodbye to a gentleman and true industry pioneer.

Establishing SGMF

My second abiding SIGTTO experience was my participation, as a founder Board member, in the creation of the Society for Gas as a Marine Fuel (SGMF) as a sister organisation to the Society. In 2013 the SIGTTO Board took the momentous decision to establish SGMF in order to address the safe application of gas-fuelled propulsion for vessels that are not gas carriers. Until recently, LNG carriers were virtually the only ships to utilise gas as a propulsion system fuel.

The chance to help replace heavy fuel oil in ship propulsion systems, as part of the drive to reduce atmospheric emissions, by creating a whole new Society from scratch was an exciting, if challenging, undertaking. The SIGTTO Board and Secretariat have played a key role in setting SGMF on a successful path as a viable, credible and sustainable industry association. The SIGTTO commitment covered the early development meetings where the new organisation and its employees were established; growing its Board of Directors; and developing its bye laws and articles of association.

I'm happy to say that I'm still a member of the SGMF Board of Directors and that, six years on, the organisation is now stronger than ever despite some initial survival worries. The birth pangs in the early years were due to concerns that SGMF might fail to attract sufficient members but the initiative has continued to gain strength and momentum ever since, bearing testimony to SIGTTO's original vision of the need for such a body.

GPC challenges

When I took up the role of SIGTTO GPC Chair in 2016, in addition to feeling rather overawed at following those noted figures from the liquefied gas sector who had previously occupied the seat, I looked forward to working closely with some of the foremost industry experts, pioneers and leaders. I also saw an opportunity to note the industry signposts for change, growth and diversity - to look forwards and set a path for the GPC to influence and guide the exciting and emerging changes currently taking place in the marine transport of liquefied gas.

Rapid technological advances have added a portfolio of new subjects to those that have traditionally filled the Committee's industry best practice development agenda. New topics include floating gas terminals, small-scale gas shipping, propulsion system advances, refinements in cargo-handling equipment and systems and future decarbonising concepts of the type with which I've been involved with at Shell. In my GPC Chair role I also need to be able to recognise and leverage the paths ploughed by my industry colleagues in their new businesses that involve these new topics.

I decided to undertake a survey of SIGTTO's GPC membership in order to gauge their views on what are the important and urgent subjects and themes in the growing gas shipping business that we should be looking at. Any new areas agreed and incorporated in the GPC working agenda would then have to align with a revised SIGTTO strategy with key performance indicators (KPIs) to demonstrate and illuminate this alignment.

I wasn't sure how this canvassing exercise might develop, but I need

not have worried. The response from the GPC membership was fantastic, with so many valuable ideas and suggestions arriving from across the full spectrum of our business.

In fact I had difficulty assimilating the overwhelming wave of energy and enthusiasm that I was faced with. With the help of the SIGTTO Secretariat, I broke down and categorised the feedback for assessment by the GPC. Committee deliberations, in turn, led to a prioritised, long-term plan which was headlined by the creation of the first SIGTTO GPC Subcommittee. The new group, dealing with floating gas terminals, necessitated a revision to the GPC constitution to enable its inclusion. I am indebted to the SIGTTO Board for their indulgence, flexibility and support in allowing me to change some of GPC's longest established constitutional ways of working.

So what of the future? In addition to contributing to and rigorously maintaining the enviable safety record of gas shipping and terminalling attributable directly to past and present GPC members – a weighty honour that the present GPC carries - the environmental and decarbonisation agenda will grow and dominate.

Building on our early leadership and involvement in these sectors and having helped contribute to the development of emerging standards such as the IMO's *Interim Recommendations for the Carriage of Liquid Hydrogen in Bulk 2016*, GPC is setting the foundations to lead the way in guiding safe and sustainable use and application in many of these areas.

Having had some exciting and valuable times with SIGTTO and its GPC, my passion for a fit-for-future SIGTTO GPC direction continues to grow.



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BV and DSME colleagues together on the occasion of the naming of the four Teekay-managed Arc 7 icebreaking LNGCs at the yard in April 2019

Bringing class to bear in maintaining safe operations



Bruno Dabouis* of Bureau Veritas examines the challenges facing a leading LNGC class society as it keeps pace with developments and advances in an ever-evolving sector

The seaborne carriage of LNG - ongoing now for more than 50 years - has only been enabled by significant levels of creativity.

We have gone from prototype LNG carriers that looked like general cargo vessels, e.g. *Beauvais*, a converted Liberty ship which was fitted with three small independent LNG tanks for testing purposes in 1962, to modern icebreaking LNG carriers with podded propulsion systems.

To take natural gas, and reduce its volume 600 times by liquefying it, before shipping it across the oceans at a cryogenic temperature, was a major undertaking that required a significant leap in technology development to get started and then subsequently to evolve over the last 50 years. To have had the opportunity to witness, and play some small part in, the evolution of LNG carriers from the start of my career in the mid-1980s has certainly made for an interesting working life.

Finding the right balance

If the evolution of marine LNG has been marked by levels of creativity, particularly in containment and propulsion systems, the most significant is the relationship between the two. How do you find the right balance between retaining cargo and consuming boil-off gas? How do you most efficiently allow for flexibility in charter markets so that, for example, a ship can change routes and terminals to adapt to a new operating pattern?

In the early days, with ships contracted for long periods – for an LNGC to spend 20-25 years on a specific route was not unusual, individual ships could be tailor-made for the specific requirements of seller and buyer. Ship speed, voyage duration and quantity of landed cargo were pre-determined.

However, the emergence of more speculative newbuilding orders covered by relatively short term charter contracts

in today's market, has increased the need for greater built-in flexibility in terms of ship size, propulsion systems and cargo management. This is where we at Bureau Veritas (BV) now spend a lot of time as a classification society. Our experts help clients find the right ship design solution, addressing the related safety, regulatory and risk aspects as part of the exercise.

BV focus on gas

Liquefied gas has been a focus for BV from the very beginning of the transport of such cargoes by sea and we have never stopped investing time and effort in the sector. We can look back with some pride on an industry where safety always came first and the sector's track record in safety speaks for itself.

BV was often first in classification terms in the seaborne carriage and marine storage of LNG. This was partly based on the initial leadership of France in LNG ship construction and in the design of LNG containment systems. It is true to say that the leadership in the construction of LNGCs has shifted over the years, from France first to the US, followed by Japan and, now, Korea while China is currently building a growing presence in the sector. Throughout this movement of the LNGC construction axis, BV has remained to the fore wherever the ships are built.

After the early prototype LNG containment system technologies were investigated, two dominant families rapidly emerged. These were the French membrane type containment systems proposed by Gaz Transport and by Technigaz on the one hand and, on the other, the self-supporting IMO Type B tank systems developed by Moss in Norway and IHI in Japan. The Moss technology embraces spherical cargo tanks while the IHI tanks are prismatic in shape, as indicated by the company's Self-supporting, Prismatic-shape, IMO Type B (IHI SPB) name for its design.

Today, Gaztransport & Technigaz (GTT), the merged entity of the two original French companies, promotes its NO96 and Mark III membrane tank containment systems. The two variants are extremely popular and either one of the two systems is being installed in most ships being built and entering operation today.

BV classed the first Korean-built membrane LNG carrier, the 130,600 m³, 1995-built *Hanjin Pyeong Taek*, and the first dual-fuel diesel-electric (DFDE) LNG carrier, *Global Energy*, delivered in 2004. BV was again first with the introduction of floating gas terminals, classing both the inaugural floating storage and regasification unit (FSRU), >



BV has classed the 263,000 m³ MOL FSRU Challenger, the largest floating storage and regasification unit (FSRU) ever built

> the 138,100 m³, 2005-built *Excelsior*, and the first floating LNG production (FLNG) vessel, *Tango FLNG*, in 2013.

Ice class challenge

In 2017 BV classed the 263,000 m³ MOL FSRU Challenger, the largest FSRU ever built and, most recently and jointly with the Russian Register, the 15 Arc 7 ice class LNG carriers contracted to load cargoes at the Yamal terminal in the Russian Arctic. The latter are the first icebreaking LNGCs ever built.

In the autumn of 2019 the 15-ship newbuilding phase should be completed on a project that many, perhaps, thought would not see the light of day. The Arc 7 LNGC construction programme is yet another demonstration of the creativity that has characterised the development of seaborne LNG.

Construction of the Yamal vessels has involved a number of significant LNG shipping industry firsts. Notable amongst these is the combination of icebreaking capability (including stern-first operations in heavy ice), winterisation features and podded propulsion with which the ships have been provided. The Yamal ships are designed to operate not only in the some of the harshest conditions to be found anywhere but also as conventional LNGCs in ice-free waters. The size of the ships, at 299 metres in length, 50 metres in breadth and a cargo-carrying capacity of 172,000 m³, required that they be capable of fully autonomous, i.e. escort-free, operations in ice.

As a result, providing an assurance that the risks, including the ability to navigate autonomously in ice, could be effectively addressed was always going to be vital to

the success of the icebreaking LNGC design. The podded propulsion, hull structure, containment system, winterisation features and issues related to vibration all had to be addressed and their interdependencies recognised and understood.

The joint classification partnership with the Russian Register, with which BV enjoys excellent relations, has been a key factor in achieving a successful outcome, not least by combining the Russian ice expertise with BV's structures and gas leadership. Testing of the Arc 7 design at Aker Arctic's ice towing tank in Finland was another critical area of activity.

Although the Bureau Veritas Arc 7 site team at Daewoo Shipbuilding & Marine Engineering (DSME), the builder of all 15 ships, is not yet winding down, they are perhaps more relaxed than they were. A massive undertaking, the ship construction programme has benefitted from the excellent feedback on the classification aspects received from both yard and the owners and the aforementioned close cooperation between BV and the Russian Register.

Responding to evolving technologies

BV continues to refine and upgrade its rule regime across a number of other fronts to keep pace with evolving technologies. For example, our class society recently issued its first set of dedicated FSRU and floating storage unit (FSU) rules the need to cater for the different technical and regulatory options opening up today for operators in the floating gas terminal sector.

Options considered by the rules encompass conversions versus newbuild facilities, nearshore and offshore locations,

ship and barge configurations and the conditions where the choice of a storage-only unit works best. The new rules have helped keep BV prepared and ready to handle a full range of enquiries as the demand for floating gas terminals grows.

Meanwhile, on the LNGC propulsion system front, the evolution from steam turbine ships to DFDE-powered vessels and now two-stroke, gas-powered ships has been relatively quick and delivered significant advances in efficiency. However, the search for optimal systems in terms of overall ship efficiency continues, and the key issue remains the relationship between propulsion and containment. For example, does an LNGC need a reliquefaction plant, or can the owners and charterers manage without one?

The LNGC market continues to expand in tandem with the increasing demand for cleaner fuels. At the same time that there are some major orders for conventional-size LNG carriers in prospect, interest in small-scale LNG and the LNG supply chain is also being extended. The LNG industry faces important decisions going forward and BV stands ready to help stakeholders make the best safety and commercial decisions.

Key SIGTTO role

From the perspective of BV as a class society, SIGTTO has played a major role in establishing and reinforcing industry best practices for the liquefied gas sector over the past four decades. The Society's openness, high level of technical understanding and goodwill of the membership have been instrumental to its success.

An important step was taken in 2004 when SIGTTO membership eligibility was opened to class societies. The step proved to be mutually beneficial by creating a new two-way dialogue. The availability of the experience of SIGTTO members has helped class develop its rules and guidelines in an appropriate manner while the preparation of the Society's best practice guidance publications has similarly gained advantage from the in-depth experience of class.

The close relationship between SIGTTO and class societies proved particularly useful in 2008 when IMO sanctioned a SIGTTO-led industry initiative to undertake a major revision of the *International Gas Carrier (IGC) Code*. IMO's adoption of the updated Code, after several years of intense activity by a range of working groups, was the rewarding outcome of this industry-wide cooperative effort.

** Bruno Dabouis is vice president, South Europe and North America with Bureau Veritas Marine & Offshore*



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Risk in LNG projects



Bill Wayne*, SIGTTO's seventh General Manager, outlines the key elements of risk attendant on mounting an LNG project

For any large-scale project, the main decisions are driven by economic factors, but behind these major decisions lie a raft of perceptions of 'risk' issues. All business ventures entail some risk and one of the key requirements for managers is to understand and mitigate these risks.

In major LNG projects these risks naturally divide under various headings. These are discussed in turn below, beginning with the most significant. It is also important to understand that each risk category should not be considered in isolation; there can be complex interactions between the risks and the impact may differ for the various partners.

Host country risk

The highest risks for a project may lie in this category. For a major undertaking like an LNG project the promoters are exposed to a range of risks and uncertainties. These run from the fundamental political stability of the host country through risks associated with the ability of the country's government and society to support such a project in terms of legal environment, banking services, communications, infrastructure

and such like, to the provision of a secure living and working environment for staff.

There is also a range of challenges which may arise around management of the expectations of the political elite, the business community and the general public. Management of these critical risks is best approached by a concerted effort to know and understand the political system in the host country and to assess carefully the strengths and weaknesses of all the 'players' in the country. Good practice is to prepare a detailed 'Stakeholder Engagement Plan' so that the issues can be addressed systematically.

Market price risk

The major revenue stream comes from the sale of LNG. World commodity prices seem to be increasingly volatile. This introduces uncertainty when assessing future revenue flows from major LNG projects. These risks are to some extent mitigated by long-term sales contracts, with some pricing mechanisms embedded therein. These mechanisms typically have the effect of smoothing out rapid swings but may have less impact on long-term depression in the market.

Joint-venture partner risk

Typically, large LNG projects are initially developed by joint ventures (JVs). Clearly, there is some level of risk introduced as to whether the JV partners can fulfil their commitments to the project, be they related to financing, provision of expertise or even personnel. Before entering into a JV partnership, some due diligence investigations on potential partners is essential in order to mitigate the risk of non-performance by a partner.

One of the common ways of managing some of the host country risks is to invite local companies, possibly state-owned, to participate in a JV. Typically at some stage, usually around the time of the final investment decision (FID), the joint venture is incorporated to form a project company. It is important that the interests of the partners are closely aligned by the time the project company is established.

Counter-party risk

As previously noted, LNG projects are mainly underwritten by long-term sales contracts with gas buyers. Typically, buyers are state-owned, or former state-owned, major utility companies. While undoubtedly companies of some substance, there is no absolute guarantee that their market predictions are correct and that they can always take the full contracted quantities.

Some counter-party risks are mitigated by 'take or pay' clauses. However, there is nothing to say that a major company cannot go bankrupt and disappear – and in such circumstances it would be problematic to enforce a 'take or pay'

clause on a bankrupt company!

There must be a common position among the seller partners on such aspects as incorporating destination flexibility terms in the sales contracts and the effect these may have on the risk profile and the sales price. The best protection is a clear understanding of your counter-parties and their business models, coupled with having a diverse range of buyers.

Financing risks

Typically, major JV LNG projects use 'non-recourse' financing, i.e. bank loans, to pay for the projects. In demonstrating the financeability of the project, the partners will need to convince the lending banks that the risks as set out in this document are understood and mitigated as far as reasonably practical.

One risk that often gets overlooked is that of the security of the banks themselves. Prior to the bank crash of 2008, large banks were generally thought of as infallible but the crash proved otherwise. Therefore, the JV partners should do some due diligence investigation on the lending banks, not only the lead banks but also the second tier or mezzanine lenders. It only takes one hiccup at a critical moment in a syndicated loan for the whole loan to collapse.

LNG plant design and construction - technical risk

LNG plant design is well established and the risks in this area are largely mitigated by strong project management coupled with careful selection of contractors. There is a well-established plant realisation process, starting off with a front-end engineering and design (FEED) study and progressing through to an engineering procurement and construction (EPC) contract, with a number of variations. The contractors typically form consortia for major LNG projects. The project developers will need to look at each proposed consortia to ensure that the necessary skills and experience are available to the project.

One common occurrence is for a project partner (or a lending bank) to make some statement, maybe in the form of a requirement for a covenant, along the lines that their support is predicated on the employment of 'no novel technology'. This is usually a mistake. Because design development tends to be evolutionary in nature rather than occurring as major technology leaps, the makers of such statements may be committing the project to repeating known errors made on other similar recent projects. The project should have its own technical resource to assess any such proposals for 'novel technology'.

Gas supply risks

Normally, gas reserves are proved up for the duration of the planned LNG project prior to FID. If the project is the sole or the major offtaker from the gas fields, the risk of supply failure is mainly risk of a technical nature and should be low. However, if, for instance, the same resource is supplying a growing domestic market, there may be a political risk to the continuity of supply to the LNG project. This is really a subset of the 'host country risk', but can have a major impact on the project.

LNG carrier design and construction - technical risk

The LNGC design and construction process is well established and the risks should be considered as low compared with those set out above. One key choice which is different from that of the LNG plant is that of whether the project will own and manage the ships themselves or contract out to a third party ownership/management. A third option is to go for free-on-board (FOB) contracts, where the gas buyer effectively takes the responsibility for the shipping arrangements.

This decision may be driven by an analysis of risk. If a project has no significant LNG marine operator experience among its partners, then the logic tends to drive the project towards third party arrangements via either some sort of charter agreement with an experienced third party ship operator or with a ship management group. If either of these options are chosen, due diligence investigations must be performed on the parties contracting to the project.

If the FOB route is taken, then the partners need to assess the capabilities of the buyer and the risk of non-performance of the buyer's shipping arrangements. And, as is the case for LNG plants, beware of 'no novel technology' strictures.

Technical risks during operations

Technical risks during operations tend to fall into two categories: mechanical failure and/or operator error. The expectation is that the LNG plants and associated shipping must be operated to the highest standards since the smallest hitch can lead to shutdowns and costly delays to the production schedule.

For mitigation of the mechanical failure risk, the best strategy is to take care when selecting machinery and to institute effective planned maintenance schemes. For the operational mishap risk, the mitigation lies with careful selection and training of staff, coupled with effective operation manuals and guidance.

Conclusions

This brief note has examined the risks inherent in LNG projects and suggests appropriate mitigation strategies. The risks cover a wide range of potential consequences, from those that can threaten the viability of the project, such as those under host country risk, to those which can be broadly banded into technology and operational risks, which are relatively minor compared with the former.

**This is Bill Wayne's second contribution to this issue. His CV can be found on page 40.*



Host country risks hold the greatest potential to upset the smooth running of an LNG project



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The lessons learned in the cryogenics lab stay with you the rest of your life



The call of the sea and the allure of gas



Chris Clucas*, Chair of many a SIGTTO meeting, looks back on a wide-ranging career that should inspire potential newcomers considering a commitment to liquefied gases

Like many a Manxman – my birthplace is Douglas on the Isle of Man – I guess the call of the sea exerted a pull on me from the outset. During my undergraduate studies in chemistry at the University of Sheffield, I worked during the summer months on the Dover/Calais ferries. Following graduation, good fortune brought me to the International Chamber of Shipping (ICS) in London. The foundation stones for my career path were set.

Invaluable start

My background in science took me to work in the chemical tanker section at ICS, a department which also covered liquefied gas carriers. After a couple of gas ship meetings, including with the 'Lakey Group' that was writing the original *International Gas Carrier (IGC) Code*, I was smitten with liquefied gas shipping.

Bob Lakey had assembled an amazing group of industry experts to compile the Code. Their achievement owes much to his persuasive personality as well as his excellent grasp of the whole subject. Although I was the junior of the pack, Bob latched on to my fresh qualifications and involved me in the work of compiling the special requirements for individual cargoes.

The other major IMO project at the time was the development of the Standards of Training Certification and Watchkeeping

(STCW) Convention. Once we had finished the IGC Code, the Lakey Group had the task of writing the syllabus for STCW's Basic and Advanced Gas Courses. The most recent update to the Convention contains much the same gas courses, so it looks like we produced a sound base.

Recognising the need for a document that colleges could work with to develop gas courses for the industry, ICS produced the new *Tanker Safety Guide (Liquefied Gas)*. This complemented existing ICS guides for oil and chemical tankers, and I compiled the main text as well as the special appendices and cargo data sheets. These were conceived as background training material for people joining the industry who wished to gain an understanding of gas-handling principles, especially the application of gas laws and the laws of thermodynamics.

Highlights of my time at ICS include the following:

- Working with the Gastech conference in its very early days - I am still an active supporter to this day!
- Admission to the memberships of the Institute of Marine Engineers and the Institute of Refrigeration
- Persuading ICS and the Oil Companies International Marine Forum (OCIMF) to jointly develop a Ship-to-Ship Transfer Guide for Liquefied Gas, following on from the oil STS booklet; this initiative

predated the start of STS operations in either the LPG or LNG sectors

- The convening of an ICS study group on linked ship/shore emergency shutdown (ESD) systems and, in particular, on the very fast closure requirements for gas ship ESD valves laid down in the inaugural IGC Code. The initiative resulted in a relaxation of time allowed for ESD valve closure, thus reducing the risk of pressure surge. One of the ICS study group was Robin Gray, who later became SIGTTO's second General Manager and who took the idea and developed it into the 'SIGTTO Link'.

From cryogenics to LPG

At the age of 25 I decided to return to the hallowed halls of higher learning, to Southampton University for a postgraduate degree at its venerable Institute of Cryogenics. Particularly inspiring on this course was the opportunity to apply the cryogenic principles we had learned in the classroom in the Institute's laboratories. Amongst other things, we liquefied nitrogen, helium and LNG, the latter using mains supply natural gas.

A contact made at the Cryogenics Institute led to my next job, with the Low Temperature Engineering Group of British Gas in London and work on the design of peak-shaving liquefaction plants. Such facilities liquefy mains natural gas during the quiet summer months and regasify the LNG in the winter season to meet high peak demands. Unfortunately for the project, the discovery of large volumes of North Sea gas at the time reduced interest in LNG peak-shaving but the experience of working with such an expert team was highly educational for a young process engineer.

Around that time I was approached by the boss of Copenhagen-based Kosan Tankers, a pioneering LPG carrier operator, to sound out my interest in working for him. I had first met him as a fellow member of the Lakey Group and was intrigued by Kosan, the gas supplier to the Isle of Man >



I developed the on board training courses run on the 35,000 m³ Annabella as she carried LNG cargoes from North Africa to Spain

> and many other exotic locations as well as the operator of the first purpose-built LPG carrier, which I looked after for a while.

I packed my bags for Denmark and my arrival coincided with a fleet expansion programme. One of my first jobs was the design and construction of two new semi-ref vessels, to which we fitted 'cascade' reliquefaction plants provided by Liquefied Gas Equipment (LGE) to handle high-ethane C3 cargoes. Some 35 years ahead of their time, the ships proved to be a great experience for a process designer.

There were many memorable experiences during my time with Kosan Tankers, notably:

- Selling several older ships and buying newer vessels second-hand
- Repairing a pressure vessel cargo tank where deep cracks were found in the dished-end circumferential welds
- Upgrading the cargo pumps on many of the older ships, which called for some ingenuity
- Managing a nearshore grounding incident which involved the offloading of LPG cargo to road tankers using long hose strings
- Working closely with the chartering department to optimise cargo-handling procedures and improve commercial performance
- Introducing Burckhardt compressors to the fleet, which had previously only used oil-lubricated, piston-type compressors

Back to Man

Family priorities indicated a return to the Isle of Man but I was able to remain with the Kosan Group, thanks to an opening with the local company Kosangas (IoM) Ltd on LPG

shore storage plant and distribution duties. During the following eight years I helped build up the LPG road tanker distribution trade; construct new storage tanks; install a jetty-mounted loading arm to replace the hoses used previously; extend the LPG cylinder filling facility; and provide a major new distribution main to serve the growing area around Douglas. And, of course, I stayed in contact with the company's LPG carriers that regularly delivered our fuel.

In the late 1980s several ship managers opened offices on the Isle of Man. One of these, Dorchester Maritime, part of the Schulte Group, was looking for someone who understood the operation of semi-ref LPG carriers, and my successful application signaled the start of some 28 years with this organisation.

At the time Dorchester Maritime looked after several elderly LPG carriers, the most difficult of which had been built at the La Ciotat yard in France by another old Lakey Group friend. A series of phone calls enabled us to get to the bottom of several mysteries, including the extensive use of loose-fill perlite insulation around the independent prismatic fully refrigerated cargo tanks. This had been a retrofit to overcome the excessive boil-off gas rate caused by the yard's decision to insulate the inner hull rather than the cargo tanks. The professors at Southampton taught us to always consider heat transfer by convection as well as conduction.

My work at Dorchester Maritime, which was renamed Bernhard Schulte Shipmanagement in 2008, included the following:

- Setting up and teaching gas courses in

various Schulte Group shore offices, and developing the on board courses run on the 35,000 m³ Annabella, an LNG carrier trading between North Africa and Spain

- Developing an LNG course for BP Shipping that integrated classroom and a specially developed liquid cargo operations simulator (LICOS)
- Newbuilding cargo plant design for various semi-ref LPG, ethylene and LNG carriers
- Developing training courses and 'entry into LNG' schemes for companies new to the industry
- Investigating different cargo-handling simulators and implementing their use across the Schulte Group training centres
- Developing the 'ride-on' ship-handling LNG carrier scale model at Ilawa Centre in Poland to assist deck officers in learning the differences between LPG and LNG carrier manoeuvring
- Making training films with Videotel to explain the chemistry and physics of liquefied gases
- Patenting a cargo boil-off gas (BOG) control system for LNG carriers involving azipod propulsion
- Participating in industry events such as Gastech; a Gastech high spot was the founding of the 'Young Gastech' section to interest new entrants to our industry
- Working as an expert witness and consultant for various third-party clients
- Joining SIGTTO Working Groups, Panels and the General Purposes Committee
- Assisting in the establishment of the new Society for Gas as a Marine Fuel (SGMF) and becoming the Society's inaugural president

On retiring from full-time BSM employment at BSM, I established my own consultancy

company and continue my expert witness and training activities as well as work with BSM as required. In 2018 I was privileged to receive two Lifetime Achievement Awards, one from the Gastech organisation and the other from Riviera Maritime Media's Ship/Shore Interface Conference. Even my long-suffering wife was impressed with those honours!

SIGTTO tales

The serious business of liquefied gas shipping is not without its amusing asides and some of my most abiding memories involve SIGTTO get-togethers, not least because they involve large groups of great people from diverse backgrounds.

At one Panel Meeting the delegates had gathered in the hotel lobby after a busy day of presentations, looking forward with great anticipation to our scheduled river cruise, gala dinner and, of course, 'refreshments'. Unfortunately, both SIGTTO and our host were under the impression that the other had organised the coaches to get us across town to the cruise vessel jetty.

When the awful realisation dawned, the legendary resourcefulness of seafarers quickly kicked in. With such delights awaiting, and in a city with a plentiful supply of taxis, we were all on board before anyone could say "down the hatch". I'm pleased to report that we then enjoyed a particularly memorable evening and coaches were awaiting our return to take us back to our hotel. Most people had probably forgotten all about the earlier glitch.

On another occasion, a SIGTTO GPC meeting I was chairing in Houston, we had the honour of a visit by the Admiral of the US Coast Guard (USCG). The senior people from our side were invited to meet him personally at a private function, an arrangement that required us to clear various security hurdles, including filling in lots of different forms attesting to our standing as upright citizens.

Just when we thought the entire process was finished, we received a last-minute, panic e-mail from Linda Murray, SIGTTO's Secretary in London, stating that the Coast Guard had requested "a recent photo" from each of us. I don't know if I mentioned it, but us Manx people have a wicked sense of humour. By this time some of us were already in Houston. Minutes earlier my daughter had e-mailed me a wonderful picture from home, so I quickly forwarded this portrait on to the SIGTTO Secretariat in London.

Fortunately, Linda was most resourceful, double-checking my 'portrait' rather than simply forwarding it on to USCG Supreme Command Headquarters in Washington,

DC. If she hadn't I might have soon been enjoying an extended vacation at Guantanamo Bay. My daughter's picture was actually of my dog... although, to be fair, it was an American spaniel and it was indeed a *very* recent photo. And the message never said the recent photo had to be of me!

Semantics count

At another SIGTTO Panel Meeting there was an animated discussion about the pros and cons of diesel-powered LNG carriers. While gas-burning, medium-speed engines were in sight then, the prospect of two-stroke, dual-fuel machinery was rather further over the horizon. Nevertheless, experienced shipping people who had used these machines for years on other types of commercial vessels were extolling the virtues, especially the fuel economy. At which point, one exasperated LNGC operator exclaimed, "I do not want a slow-speed diesel LNG carrier; all my ships must be able to do 19.5 knots!" Amidst the silence that ensued, I made a mental note to describe such machinery as "a low-rpm, two-stroke propulsion system" in future for the benefit of a sometimes-isolated LNG shipping community.

During a similar discussion an experienced naval architect opined that to achieve the same reliability as a single-shaft steam turbine system, any two-stroke diesel powered LNGC would need to have twin propulsion units. Over coffee I asked him to elaborate and he patiently explained that steam turbines had independent high and low-pressure stages. If one developed a fault, then it could be bypassed and the ship could at least continue at reduced speed.

He seemed blissfully unaware of the possibility of isolating individual cylinders on a large two-stroke engine and, again,

operating the vessel at reduced speed as a result. It is interesting to note that the first LNG-fired, two-stroke propulsion systems featured a single engine and were fitted not on an LNG carrier but, rather, the two 3,100 TEU container/ro-ro (con-ro) vessels that TOTE operates on the route between Florida and Puerto Rico.

As we know, the seaborne transport of LNG is an orderly process with an outstanding safety record. A veteran gas ship master once told me he is often asked "Is it exciting on board an LNG carrier?". His stock reply is "If it gets exciting, it means we have done something wrong!"

It is salutary to also remember the equally wise words of an LPG master of similar vast experience who was attending a gas course as a 'refresher'. He sagely told his fellow students that "it is only if we ever forget that liquefied gas cargoes are dangerous that they become really dangerous".

Looking back over the various twists and turns along the professional road since joining the Chamber of Shipping in 1973, I can honestly say it has always been a fascinating journey. Maybe it's because my science-inspired curiosity finds outlets in unusual ways. Maybe not surprisingly, I was known as the 'the Scientist' by some of the more polite ship staff I worked with, while several of my colleagues during my student days called me 'the Sailor'. Adaptability is often noted as a trait of the Manx people.

**Chris Clucas has contributed two articles to this issue. The other article, on page 72, deals with technical issues and SIGTTO work. Any opinions expressed by the author are personal and do not necessarily represent those of his previous employers.*



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My liquefied gas career started out on the LPG carrier *Gas Enterprise*, BP's only gas ship back in 1990

The call of the 'SIGTTO' wild!



As **Marc Hopkins** explains, the Society has exerted quite a pull on him over his gas shipping career; amongst other things, he's served as a Technical Adviser and chaired Panel Meetings and the General Purposes Committee

I started my career in 1970 as a deck cadet with BP Tanker Co, joining my first ship at the old BP oil refinery on the Isle of Grain in Kent in a thunderstorm and dressed in full uniform. I don't think that any first-trip cadet, at the time, realised that full uniform was not compulsory!

I continued my seagoing career with BP, through company name and employment changes, until 1990. The majority of my time was spent in the oil fleet, mainly on product carriers, with the final four years of my seagoing career as master. My last trip as master was on the 'world famous' LPG carrier *Gas Enterprise*.

Gas ship expert

At the time the 70,500 m³ *Gas Enterprise* was BP Shipping's only gas ship. This was immediately prior to the arrival of the first 127,500 m³ LNG carriers for the North West Shelf Shipping Services Company (NWSSSC) fleet and the management of the *Northwest Shearwater* by BP Shipping.

My experience on *Gas Enterprise* was a series of 'adventures', including being caught in two typhoons, one at sea and one at anchor, immobilised. The fact that

this LPG veteran was the first Allied ship, including navy vessels, into the Northern Gulf, to load at Juaymah in Saudi Arabia, after Iraq invaded Kuwait persuaded me that it was time to find a shoreside job.

When I first came ashore, I became BP Shipping's 'gas expert'. Whilst engaged with other marine tasks, I managed to complete sea trials on two of the new NWSSSC LNG carriers. In 1994 I was seconded to Abu Dhabi's National Gas Shipping Company (NGSCO), a shipping company established to manage a new fleet of LNG carriers on behalf of Abu Dhabi Gas Liquefaction Co (ADGAS).

I also continued to operate the existing ADGAS fleet while the newbuildings were under construction, and all the LNG vessels with which I'd had contact up until that point were spherical tank ships. The then existing ADGAS fleet comprised *Hilli*, *Gimi*, *Khannur*, *Golar Freeze* and *Norman Lady*. All these fine ships were built in the 1970s and all but one are still in service, although not as conventional LNG carriers. Two of the quintet have been converted into floating storage and regasification units (FSRUs) while the other two are enjoying a new lease of life,

following major modification work, as floating LNG production (FLNG) vessels.

During my initial year at NGSCO I had my first contact with SIGTTO, attending a Panel Meeting in Boston and participating in a technical visit to the Everett terminal, the first US LNG import facility. Following on from this introduction to the Society, and while still with NGSCO, I attended all the SIGTTO Panel Meetings. One of these was held at Bontang on the Indonesian part of the island of Borneo. Although Bontang played host to what was then the world's largest LNG export terminal, 25 years ago I remember it being a particularly difficult place to travel to.

Into the inner sanctum

All that contact with the Society must have rubbed off because at the end of 1997 I was seconded to SIGTTO as a Technical Adviser. The General Manager at the time was Alain Vaudolon, followed a year later by John Gyles. The two were very different characters but both most effective in their own inimitable ways. Sadly, both are now deceased.

When I joined the Society, all communication with members was either by fax or post. The agendas for all Panel and General Purposes Committee (GPC) meetings were printed and then copied and sent out to every member in advance. SIGTTO was Kall Kwik's best customer, with innumerable boxes of copied papers being delivered and then posted. We had a franking machine that calculated the postage for worldwide delivery and it had to be 'funded' with several thousand pounds prior to each postage event.

Because the only internet access was 'dial up', only one person at a time could access the internet. There were constant cries about the office to the effect of "Who is online?" and "Let me know when you come off!" During my tenure as Technical Adviser we were fortunate to be able to upgrade arrangements through the provision of a server with high-speed access throughout the office, a new website and a new logo. The overall office environment itself was given a millennial boost through revamped decorations and furnishings.

I led the information technology (IT) aspect of the upgrade and became, officially, a Microsoft network administrator and 'help desk'. The current website looks very similar to the one we set up in the late 1990s and the logo that was developed during this transitional period remains the same.

The addition of the website revolutionised SIGTTO's communications with its members. Initially, meeting papers were put on to CDs and sent in >

> the mail but before long we transitioned to posting the material to the web, saving time and postal costs in the process.

In addition to my IT responsibilities I was involved in the preparation of a number of publications during my time as a Technical Adviser. Some of these are still around today, either in their original form or updated. They include *Site Selection and Design for LNG Ports and Jetties*, an industry study on *Lifeboat Safety and Passage Planning Guide - Straits of Malacca and Singapore*. The latter was compiled after some SIGTTO members had experienced near-misses with their gas carriers while transiting the Singapore Straits.

Starting in 1997, I also represented SIGTTO at IMO. Perhaps most notable was my participation in the Ballast Water Management Committee. It has taken 20 years for IMO to develop and bring an agreed Ballast Water Convention into force!

Moving towards the US phase

Following my time with SIGTTO, I returned to BP to assist the company's LNG development team with new projects. These included Atlantic LNG, Taichung, Guangdong, Damietta, Angola, Bilbao, AES Andres and the restart of the Cove Point import terminal on the US East Coast.

There was also an involvement with a number of proposed US LNG import projects, two of which, Crown Landing and Pelican Island, became public. Although these possible additional US schemes called for much development work, they never materialised. Even at that stage it was becoming apparent that the anticipated surge in US LNG imports was not going to materialise to quite the extent envisaged. In any case far more import terminals had been proposed than would actually be needed.

During this BP project work my involvement with SIGTTO was limited. However, I was fortunate enough to attend a Panel Meeting in San Francisco and the attendant technical visit to the Napa and Sonoma Valleys where the end results of their famous GTL (Grapes-To-Liquid) process could be sampled!

I moved to the US in 2003 when BP began recruiting additional personnel as part of a drive to cover the company's growing worldwide commitment to LNG. I was part of the initiative configured to accommodate developments in the US where the number of LNG import projects was increasing and more attention was needed.

In early 2005, to be able to remain in the US, I resigned from BP and joined BG. Although all the LNG shipping for

the BG Group was coordinated from its Houston office, there were only three or four people on site at the time. I was made responsible for the operations of the fleet and marine terminals.

Our team grew as the fleet expanded rapidly, from two owned vessels – the 71,500 m³ *Methane Arctic* and *Methane Polar* – and four, time-chartered LNG carriers – again *Hilli*, *Gimi*, *Khannur* and *Golar Freeze* – to over 32 ships by 2011. Of the vessels in the 2011 fleet, 12 were owned. Also, BG was operating the Elba Island, Georgia and Lake Charles, Louisiana terminals at the time and by 2007 both facilities had become extremely busy, with Lake Charles alone discharging a record of 17 ships per month.

Between 2005 and 2011 BG was also involved, either as a partner or offtaker, with the startup of liquefaction terminals in Equatorial Guinea and at Idku and Damietta in Egypt. On the regasification terminal side of the equation BG served as either a partner or supplier to the Quintero facility in Chile, Dragon in the UK and Singapore LNG. BG's presence at these various terminals required a considerable amount of assistance and oversight.

During my time with BG I also chaired the Shipping Committee of the Washington, DC-based Center for LNG (CLNG), advocating the safety of LNG shipping operations in the US, as well as the 'Membrane Owners Group'. The latter informal, international working group was formed because there was no consensus across the license holder, classification society and shipowner spectrum on issues relating to membrane tank containment systems. Our particular

focus was on the performance of secondary and primary barriers on Technigaz Mark III LNG carriers, where some problems had arisen concerning the proper bonding of the materials involved and deformation of the primary barrier.

Into the GPC hot seat

As soon as I joined BG my involvement with SIGTTO escalated once again, to a marked degree! In 2005 I was nominated to the GPC and became GPC Chair in the same year, remaining in this position for the next six years. I thoroughly enjoyed this renewed involvement with the Society and was able to see some major SIGTTO projects through to implementation. Although I stepped down as GPC Chair in 2010, I continued to serve on the Committee until 2016.

One of the GPC projects we brought to fruition was the ship-to-ship (STS) transfer of LNG. I remember a very heated discussion at our meeting in Barcelona in 2007 which lasted about seven hours. Many questioned a proposal to call the industry best practice guidance we were developing STS Guidelines as the industry at that point had had no experience of commercial STS operations and thus the word 'guidelines' was inappropriate.

After a heated back-and-forth discussion, I suggested that instead of STS Guidelines we could call them 'STS Considerations'. The proposal was passed, unanimously, and these Considerations were eventually incorporated into the OCIMF/SIGTTO/ICS publication *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases*.

Throughout my GPC time there was a concern at the rapid expansion of the LNG shipping industry and the dilution



Outgoing GPC Chair Marc Hopkins (left) receiving a gift from his successor Chris Clucas in 2011

of the skill pool. Coincidentally, BG was expanding its fleet rapidly, and BG and Ceres (now GasLog), the managers of our ships, led a GPC working group that reflected our concerns and that of the industry. This initiative led to SIGTTO's original *LNG Shipping Suggested Competency Standards* publication.

The continued expansion of the LNG fleet worldwide further concentrated SIGTTO's attention on seafarer competence and experience, to the extent that a working group was established to develop the LNG and LPG Experience Matrix. I was privileged to chair this group. Initially, our attention was directed at LNG carriers but we soon realised that a lot of the skill pool would be coming from the LPG fleet, thus diluting experience in that gas ship fleet. Thus, we also developed the LPG Matrix. At the same time, due to these fleet-wide competency concerns, an additional, 'sister' publication, *LNG Steamship Suggested Competency Standards for Engineers* was compiled and published.

More human element focus

My final SIGTTO working group chairing role was again focused on competency and the human element. It turned out to be a major project and one for which we had a problem developing terms of reference because we could not identify, completely, what the objective was!

The starting point revolved around concerns about major incidents and competency. We polled over 1,000 personnel either working on gas ships or supporting gas shipping in shoreside roles to assess the current levels of competence and training. From the results it became apparent that competence assessment in training establishments needed to be addressed and the document *Suggested Quality Standards for LNG Training Providers* was developed. In addition, the SIGTTO website was extended with links to an external Major Incident Resources section.

The working group also concluded that human factors constituted such a large subject in its own right that a permanent SIGTTO body should be formed to consider all human interface aspects. That body now exists as SIGTTO's new Human Element Committee (HEC), with a status within the Society equivalent to GPC's.

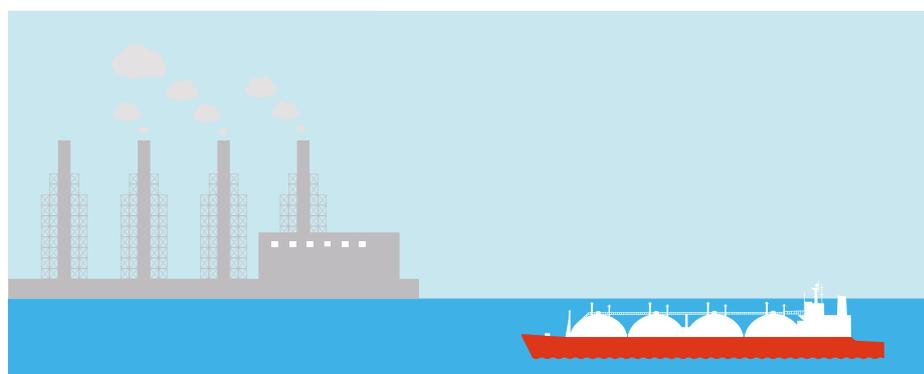
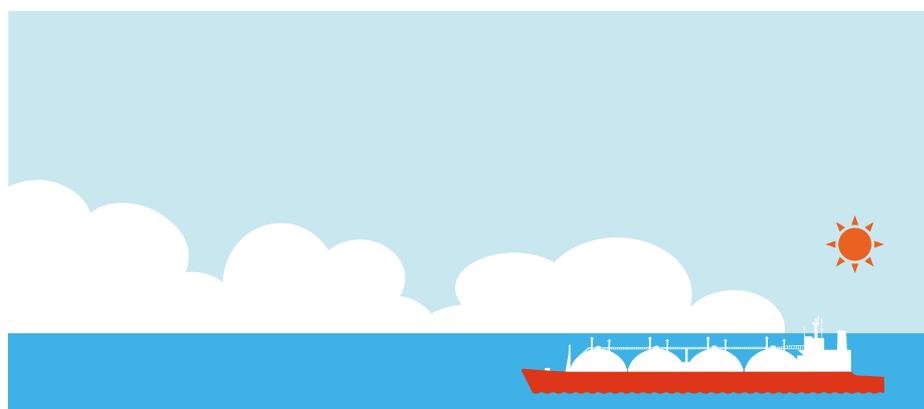
I was also involved in the preparation of two further SIGTTO publications. Following an incident involving a BG ship, I led an initiative that led to the publication *LNG Marine Loading Arms and Manifold Draining, Purging and Disconnection Procedure*. Then, with the opening of the

expanded Panama Canal pending and concerns raised over the safety aspects of LNGC transits of the new waterway, I encouraged and sat on the working group that developed *Guidance for LNG Carriers Transiting the Panama Canal*. The document also serves as an educational tool for the Panama Canal Authority.

In 2012, when the current General Manager, Andrew Clifton, was appointed, there was a vacancy for someone to chair the Society's Panel Meeting. After being approached I accepted the invitation and enjoyed fulfilling the role until 2016 when BG was acquired by Shell and my direct

involvement with SIGTTO was terminated. However, the severing of the link was not before my attendance at the GPC meeting in September 2015 in Edinburgh which I was able to work into my honeymoon!

Although now retired from full-time employment, I continue to remain involved with the industry, following developments closely and, as always, promoting safety and industry best practices. SIGTTO was formed to introduce these best practices and acceptable standards and I am proud of being able to play a small part in assisting the Society and the gas shipping Industry in achieving this goal.



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In 2018 a total of 50 LNG carriers and FSRUs with GTT membranes were ordered, the most in a decade

Focus on skill sets for GTT membrane vessels



Philippe Berterottière, CEO of GTT, examines how his company's close links with SIGTTO have intensified since the establishment of GTT Training Ltd

GTT is a technology and engineering group specialised in membrane containment systems utilised in the transport and storage of liquefied gas. We have been developing solutions for the liquefied gas industry, in particular for liquefied natural gas (LNG), for more than 50 years. Over that time top priority has been given to building trusting relationships and lasting partnerships with every stakeholder in the liquefied gas transport supply chain, from shipyards, shipowners and gas companies to terminal operators and classification societies.

A commitment to safety underpins the establishment and maintenance of trusting relationships, and GTT is able to call on the know-how of our experienced team of engineers and our continuing research and development efforts in the drive to provide safe and efficient systems and minimise risks.

GTT membrane systems are fitted on LNG carriers, floating LNG production (FLNG) vessels, floating storage and regasification units (FSRUs) and multi-gas carriers. We also offer LNG bunker tank and onshore storage tank solutions, as well as a wide range of services, including engineering, support in emergency situations, consultancy, training, maintenance support and

the production of technical studies.

Since the 630 m³ *Pythagore*, a pioneering prototype LNG carrier, was fitted with a Technigaz membrane tank in 1964, GTT membrane containment systems have gained great favour amongst shipowners. Of the more than 500 conventional LNG carriers and FSRUs now in service, approximately 75% are equipped with GTT membranes of either the Mark or NO type. The fleet is fairly evenly split between the two families. In 2018 50 LNG carriers and FSRUs with GTT membrane systems were ordered, making it the best year of the decade for our core business.

Emphasis on training

Over the past 50 years membrane tank LNG carriers have successfully delivered shipments without a single breach of a containment system or significant loss of cargo. The exemplary cargo delivery record of GTT membrane vessel systems stems from not only our rigorous risk prevention programme but also the training packages we offer to customers.

GTT has been involved with SIGTTO for many years, actively contributing to a number of the Society's working groups engaged in developing industry best practice guidelines. That commitment has intensified in recent years, following the establishment of GTT Training Ltd as a subsidiary

company and SIGTTO's decision to formalise its focus on human factors through the creation of a Human Element Committee.

GTT launched GTT Training Ltd in 2014 to undertake the Group's external training activities, with the specific aim of increasing LNG-handling skills and expertise. The company's team of experienced instructors provide training worldwide at both GTT locations and customer premises, and course subjects range from GTT technologies to different aspects of LNG handling.

Developed in-house, the Liquid Gas Handling Simulator (G-Sim) provides a powerful tool that helps deliver GTT's LNG cargo-handling operations and LNG bunkering training packages. A number of ship operators, administrations and training establishments have installed G-Sim simulators at their premises.

When it was welcomed in August 2015, GTT Training became the first company to join SIGTTO under the Society's then new training providers membership category. The company was honoured to host SIGTTO's 63rd Panel Meeting, which was held in Houston in October 2017.

GTT Training's director and general manager Ray Gillett was a founder member of SIGTTO's recently established Human Element Committee (HEC) and chairs the Cargo Control Room (CCR) Ergonomics Working Group, one of HEC's inaugural sub-groups. The CCR Ergonomics Working Group's first publication, *Recommendations for Management of Cargo Alarm Systems*, has recently received SIGTTO Board approval.

Ray's group is now pressing on to consider cargo control room layout and ergonomics, including aspects such as control station layout, physical environment, operator interface, controls, displays and the human/machine interface (HMI).

Meeting the skills challenge

We at GTT believe that one of the biggest challenges for the LNG industry is to maintain the high levels of skill and expertise required for safe and reliable operations at a time of rapid fleet expansion, technological advances and the extension of the supply chain into small-scale LNG and LNG bunkering.

SIGTTO has a key role to play in the development and dissemination of the guidance required to maintain high skill levels across the growing number of industry participants. In this respect it is good to note that HEC working groups are now contributing to that knowledge pool and augmenting the output from the working groups formed by SIGTTO's General Purposes Committee.

A selection of photos from the Society's past



1. Pictured in 1998, SIGTTO's fourth General Manager Alain Vaudolon (centre) with his two Technical Advisers, Roger Roue (left) and Marc Hopkins **2.** The Swiss Re tower, otherwise known as the 'Gherkin', takes shape just beyond St Helen's Place, in summer 2002 **3.** A 2013 gathering of SIGTTO Technical Advisers **4.** A day after the opening ceremony the 78,945 m³ LPG carrier Lycaste Peace became the first gas ship to transit the enlarged Panama Canal **5.** Another SIGTTO Board and another approval for a new set of industry best practice guidelines

Liquefied gas shipping & terminal timeline

A century of major developments in the LNG, LPG, ethane and chemical gas sectors

1913

Walter Snelling awarded a US patent for his method of liquefying propane fraction in the gasoline then being sold; later in the year Frank Phillips, the founder of what was to become ConocoPhillips, bought the patent for US\$50,000

1915

Godfrey Cabot patented concept for “handling and transporting liquid gas” by river barge

1917

The main output of a small gas liquefaction plant built in West Virginia was bottled ethane and propane

1931

UK shipbuilder Hawthorn Leslie delivered to Shell the 3,552 gt *Agnita*, a tanker able to carry gas oil and up to 2,100 m³ of either sulphuric acid or LPG in 12 cylindrical pressure vessel cargo tanks

1934

Shell converted oil tanker *Megara* to also enable carriage of up to 1,463 m³ of LPG in 24 vertically mounted, cylindrical pressure cargo tanks

1940

Hope Natural Gas built a pilot liquefaction plant, with a cork-insulated storage tank, in West Virginia

1941

First commercial LNG liquefaction plant, a peakshaving facility, built, in Cleveland, Ohio

1947

Converted LPG carrier *Natalie O Warren* became first ship to carry LPG in bulk, with the addition of 68 vertical, cylindrical pressure vessel tanks totalling 6,050 m³

1950

The first underground storage cavern for propane was commissioned, in the US state of Texas

1951

William Wood Prince launched idea of barging LNG from Louisiana up Mississippi River to Chicago for use in stockyards

1952

Great London Smog, and its 4,000 directly linked fatalities, set North Thames Gas Board on overseas search for natural gas

1953

The 600 m³ *Rasmus Tholstrup*, the world’s first purpose-built, fully pressurised LPGC, was delivered to Denmark’s Kosangas

1956

French government authorised Worms Group to research transport of Algerian natural gas by sea

1957

Gazocéan established by Renè Boudet

1958

CB&I built flat-bottomed, aluminium LNG storage tank in US

January 1959

The 5,000 m³ *Methane Pioneer*, a converted cargo ship, carried first of seven trial LNG shipments from Louisiana to Canvey Island

In 1959 Methane Pioneer carried the first-ever seaborne shipment of LNG



The 931 m³ *Descartes*, built for Gazocéan by La Ciotat, was the first semi-pressurised/semi-refrigerated (semi-ref) LPG carrier

1960

Shell took 40% stake in Constock; company renamed Conch

November 1961

UK signed 15-year LNG sales contract with Algeria

1961

DNV engineer Bo Bengtsson developed concept of waffled membrane containment system; technology later acquired by the Gazocéan technical department, later to become Technigaz

Saudi Arabia began exporting LPG, from its Ras Tanura terminal; initial shipments to Japan were carried in combined oil/LPG carriers

Liquefied Gas Shipping & Terminal Timeline

1962

France signed a 15-year LNG sales contract with Algeria

Built by Mitsubishi Heavy Industries, the 28,875 m³ *Bridgestone Maru*, fully insulated and with prismatic tanks, was the first purpose-built, fully refrigerated LPG carrier; the ship's first cargo, from Kuwait, was discharged at new Kawasaki terminal of Nippon Petroleum Gas

May 1964

The 630m³ *Pythagore*, a prototype LNG carrier with a Technigaz membrane tank, was completed

October 1964

The 27,400 m³ *Methane Princess* transported first commercial LNG cargo, from CAMEL plant in Arzew, Algeria to Canvey Island

October 1965

BP discovery of gas in UK sector of North Sea scuppered Conch plans for Nigeria/UK LNG project

Gaz Transport established

March 1965

France received its first LNG cargo, an Algerian shipment delivered to Le Havre by the 25,000 m³ *Jules Verne*

1965

Built in Japan, *Ethylene Maru No 1* became the first purpose-built ethylene carrier to enter service

1966

Canada began exporting LPG

1967

The 6,310 m³, La Ciotat-built *Pascal* became first LPGC able to load LPG in either a 'warm' or fully refrigerated state

December 1968

Methane Pioneer delivered first US LNG import cargo, from Algeria and discharging direct to LNG road tankers in Boston

1968

Delivered by La Ciotat, the 6,310 m³ *Humboldt* was the first LPGC with a flexible gas system, enabling up to six different products to be carried simultaneously in its six horizontal cylindrical tanks

November 1969

Japan, and Asia, received first LNG cargo, a shipment from Kenai, Alaska to Negishi terminal of Tokyo Gas

1969

Italy commenced LNG imports, at Panigaglia terminal

1970

Libya's Marsa el Brega terminal opened, dispatching cargoes to Panigaglia in Italy and Barcelona in Spain in four 41,000m³ LNGCs designed by Esso



Libya became the world's third LNG export nation in 1970

TEPCO's Minami-Yokohama thermal power station became the first such facility in the world to run on LNG, from Alaska.

LPG export terminals at Westernport, Australia and Bandar Mahshahr, Iran commenced operations

November 1971

Distrigas LNG opened first US import terminal, at Everett

December 1971

GIIGNL, with 19 members, held inaugural meeting

1971

Qatar's North Field discovered; deposit proved to be world's largest non-associated gas field

The 7,400 m³ *Bow Elm*, the world's first combination ethylene/liquid chemical tanker, was built by the Moss yard

November 1972

Three-train Skikda plant in Algeria began producing LNG

December 1972

75,000m³ *Gadania* discharged Brunei's first LNG export cargo, at the Senboku 1 terminal of Osaka Gas

1972

Fos Tonkin LNG terminal commissioned

February 1973

Tokyo Gas commissioned Sodegaura LNG terminal

February 1973

Fire during repair of empty LNG peakshaving tank on Staten Island dislodged concrete roof, killing 40 workers; "construction, not LNG accident"

November 1973

The 88,000m³ *Norman Lady*, first Moss tank LNGC, was delivered

1973

The first two US LPG import terminals, at Providence, Rhode Island and Chesapeake, Virginia, were commissioned

Liquefied Gas Shipping & Terminal Timeline

Opened in 1973, the Providence facility was one of the first two US LPG import terminals



January 1975

La Ciotat completed 120,000m³, Technigaz Mk I vessel *Ben Franklin*, first LNGC over 100,000 m³

1975

Built with a prestressed concrete hull, the 60,000 m³ *Ardjuni Sakti* was the world's first floating LPG storage and offloading (FSO) unit

1976

IMCO published *Code for the construction and equipment of ships carrying liquefied gases in bulk*

Gazocéan reached its peak involvement in the LPG sector, with a fleet, including chartered vessels, that moved 2.4 million tonnes of LPG during the year

January 1977

Abu Dhabi became first Middle East LNG exporter when 125,000m³ *Hilli* loaded inaugural Das Island cargo, for Tokyo Electric

July 1977

LNG *Aquarius*, of 125,000m³, loaded first Indonesian LNG export cargo, at Bontang for new Senboku 2 terminal of Osaka Gas

1977

La Ciotat completed the 101,000 m³ *Esso Westernport*, the largest LPGC ever built.

September 1978

Elba Island LNG terminal opened, with *El Paso Paul Kayser* cargo

October 1978

Arun, Indonesia's second export terminal, loaded first cargo

March 1978

Cove Point LNG receiving terminal commissioned

US Natural Gas Policy Act lifted price controls on domestic natural gas discovered after 1977

May 1979

Insulation faults found on first of three Conch 125,000m³ LNGC newbuildings at Avondale; trio declared constructive total losses

June 1979

Laden 125,000m³ *El Paso Paul Kayser* ran aground in the Straits of Gibraltar at full speed; no breach of LNG containment system

1979

SIGTTO established in London with 10 founder members

April 1980

El Paso contracts terminated when Algeria and US fell out over gas pricing; Cove Point mothballed in 1981, Elba Island in 1982

November 1980

Brunei LNG delivered 1,000th LNG cargo, to Sodegaura terminal

1980

LNG purchases by Japan, world's leading LNG importer, reached 17 million tonnes per annum level

July 1981

Panhandle opened Trunkline LNG receiving terminal in Louisiana

September 1981

The 125,000m³ *Golar Spirit*, first Japan-built LNGC, completed

1981

UK ceased importing LNG on regular basis, until 1996 when new long-term contract with Algeria was agreed

1982

Montoir LNG receiving terminal at St Nazaire commissioned

February 1983

First Malaysian LNG export cargo, from MLNG complex, arrived at Sodegaura terminal onboard *Tenaga Satu*

May 1984

Indonesia shipped 1,000th cargo; new No 1 LNG exporter

1984

Japan purchased 72% of world's LNG

1985

Tokyo Electric's Futtsu LNG terminal opened

May 1986

10,000th LNG cargo loaded, all but 20 under long-term contracts

June 1986

IGC Code entered into force for new gas ships

1986

No LNG imports arrived in the US, for first time since 1974

Korea received first LNG shipment, at Pyeong Taek

Liquefied Gas Shipping & Terminal Timeline

July 1987

Zeebrugge LNG receiving terminal in Belgium opened

June 1988

Huelva LNG import terminal in Spain received first cargo

1988

Trunkline LNG terminal reopened; Algerian purchases resumed

Indonesian exports accounted for 40% of world LNG trade

July 1989

Australia exported first LNG cargo, from North West Shelf project on 125,000m³ *Northwest Sanderling* to Sodegaura terminal

1989

Cartagena terminal in Spain commissioned

1990

Taiwan received first LNG shipment, from Indonesia onboard 137,000m³ *Ekaputra* at new Kaohsiung terminal

1991

The Jiangnan yard delivered the first Chinese-built LPG carrier, a 3,000 m³ fully pressurised ship; the following year Jiangnan completed China's first ethylene carrier, the 4,200 m³ *Max Planck*; today the country is the world's leading builder of semi-ref gas carriers

February 1990

Delivery of Algerian cargo to Canvey Island by *Methane Princess* was to be last LNG shipment to UK for 15 years

March 1993

Delivery of *LNG Flora* marks first involvement by Japanese utilities in LNGC ownership

June 1993

IHI delivered 87,500m³ *Polar Eagle*, first LNGC with SPB tanks; sistership *Arctic Sun* completed in December

November 1993

Saibu Gas became first mid-size Japanese utility to import LNG direct; Malaysian cargo arrived on 18,900m³ *Aman Bintulu*

June 1994

Hyundai Heavy Industries delivered 125,000m³ spherical tank *Hyundai Utopia*, first Korean-built LNGC

June 1994

Gaz Transport and Technigaz merged operations to create Gaztransport & Technigaz SA (GTT)

1994

Turkey began importing LNG, with Algerian shipment to Marmara-Ereglisi terminal under long-term contract

June 1995

Enron claimed it had achieved its goal of becoming "the world's first natural gas major"

September 1995

Daewoo and Hanjin jointly completed their first LNGC and first Asia-built membrane ship, 130,000m³ *Hanjin Pyeongtaek*

1995

Three-train MLNG 2 complex at Malaysia's Bintulu terminal commissioned

November 1996

Incheon, Korea's second LNG import terminal, opened

December 1996

The 135,000m³ *Al Zubarah* loaded Qatar's inaugural export cargo, for shipment to Chubu Electric's Kawagoe terminal



Al Zubarah had the honour of lifting Qatar's first-ever LNG cargo

1996

Japan inaugurated three new LNG import terminals, Hatsukaichi, Kagoshima and Sodeshi

Pyeong Taek in Korea became world's busiest LNG receiving terminal, overtaking Sodegaura in Japan

February 1997

Methane Princess scrapped

25,000th LNG cargo delivered

March 1997

Algeria recommenced deliveries to Italy, to upgraded Panigaglia terminal under 20-year contract

July 1997

The 54,000 m³ steel-built *Escravos LPG FSO*, with IHI SPB tanks and using tandem offloading hose, became the second purpose-built LPG FSO to enter into service

October 1997

Small-scale Tjeldbergodden facility, Norway's first LNG liquefaction plant, opened

1997

China's first large LPG import terminal, the Taicang facility at the mouth of the Yangtze River, opened for business

January 1998

Tokyo Gas commissioned Ohgishima LNG terminal, its third

Liquefied Gas Shipping & Terminal Timeline

July 1999

Atlantic LNG in Trinidad, western hemisphere's second LNG export project, came onstream

August 1999

RasGas 1, second Qatar LNG export project, inaugurated

September 1999

Nigeria LNG Train 2 commenced production; Train 1 came onstream in February 2000

December 1999

Samsung completed 138,200m³ *SK Supreme*, its first LNG carrier and largest Technigaz Mark III ship yet built

1999

Bontang Train 8 onstream; Indonesian LNG production peaked, at 28.5 mta level

April 2000

Oman LNG plant opened; Oman is 12th LNG exporter

July 2000

EcoElectrica LNG terminal in Puerto Rico received first cargo

2000

Revithoussa LNG import terminal in Greece commissioned

2001

Elba Island terminal received first LNG cargo in 20 years



Elba Island resumed LNG imports in 2001 after a 20-year gap

February 2002

Wärtsilä won first marine order for its 50DF dual-fuel engines, for four six-cylinder units for 71,400m³ *Gaz de France Energy*

September 2002

Tongyeong, Korea's third LNG terminal, received first cargo

November 2002

Nigeria LNG Train 3 commenced operations

March 2003

MLNG Tiga complex at Bintulu terminal dispatched first LNG cargo, to JAPEX

July 2003

Kawasaki delivered 2,500m³ *Shinju Maru No 1*, world's first pressure buildup type LNG carrier

The 138,000 m³ *Berge Boston* (now *BW Boston*) received shipping industry's first ever International Ship Security Certificate

October 2003

Moss spherical tank 145,000m³ *Energy Frontier* became largest LNGC on delivery from Kawasaki

2003

Cove Point in US received first LNG cargo in 23 years; it had reopened for storage and peakshaving operations in 1995

Sines LNG import terminal in Portugal commissioned

Devon Energy in US launched shale gas era by drilling first well combining horizontal drilling and hydraulic fracturing technology

Bilbao, Spain's fourth LNG terminal, was inaugurated

Japan's Asakawa yard delivered *Kendal* and *Keswick*, at 11,000 m³ the largest fully pressurised LPGCs yet built



The 11,000 m³, 2003-built Keswick is amongst the largest fully pressurised LPG carriers ever built

January 2004

Petronet imported India's first LNG cargo, at Dahej

December 2004

Hudong Zhonghua began work on first China-built LNGC

2004

The LPGC fleet of very large gas carriers (VLGCs) topped 100 vessels for the first time

January 2005

138,000m³ *Excelsior*, world's first LNG regas vessel, commissioned; in May the vessel inaugurated Gulf Gateway, the first deepwater LNG port

Singe-train SEGAS plant at Damietta, Egypt commenced operations, with cargo lifted by 138,000m³ *Cádiz Knutsen*

April 2005

Shell's Hazira LNG receiving terminal in India inaugurated

May 2005

Two-train, 7.2 mta Idku LNG plant in Egypt commissioned

The 135,000 m³ *Sanha LPG FPSO*, went into operation as the world's first purpose-built LPG floating production, storage and offloading (FPSO) unit, in Angola

Liquefied Gas Shipping & Terminal Timeline

July 2005

Grain LNG reopened as import terminal, receiving first UK LNG cargo in 15 years

Posco's Gwangyang LNG import facility, Korea's fourth, opened

Daewoo delivered the 145,700 m³ *Maran Gas Asclepius*, the first LNGC to be built for a Greek shipowner

December 2005

Qalhat LNG, third Omani LNG train, dispatched first cargo

January 2006

Mizushima, Japan's 26th LNG receiving terminal, opened for business

February 2006

3.5 mta Darwin LNG export terminal loaded first cargo

April 2006

Dapeng LNG, China's first import terminal, entered service

SAGGAS LNG receiving terminal in Sagunto, Spain inaugurated

August 2006

Altamira terminal opened, making Mexico 17th LNG importer

December 2006

Egegaz LNG import terminal at Aliaga, Turkey's second, opened

2006

Qatar overtook Indonesia to become No 1 LNG exporter

February 2007

Excelerate and Exmar carried out first commercial ship-to-ship (STS) LNG transfer, at Scapa Flow

Teesside GasPort, world's first jettyside, regas vessel-based receiving terminal, inaugurated

Small-scale Hachinohe LNG distribution terminal opened in Japan

May 2007

First LNG cargo loaded at Equatorial Guinea's Bioko Island plant

El Ferrol, Spain's sixth LNG import terminal, received first cargo

October 2007

4.3 mta Snøhvit LNG project in Norway loaded inaugural cargo

December 2007

Al Gattara became first Q-flex LNG ship to lift a cargo

2007

Panama Canal expansion project launched

April 2008

Sabine Pass and Freeport LNG import terminals commissioned

Costa Azul, Mexico's second LNG terminal, received first cargo

Dapeng Sun, first Chinese-built LNGC, delivered, by Hudong Zhonghua

June 2008

Bahia Blanca GasPort, South America's first LNG import facility, commissioned; first jettyside LNG STS transfer carried out

September 2008

Mozah, first Q-max LNG carrier, delivered by Samsung

November 2008

Shanghai's small-scale Wuhaogou LNG import terminal opened

January 2009

Brazil imported first LNG cargo, at FSRU-based Pecem terminal

February 2009

Russia's Sakhalin 2 LNG export terminal dispatched first cargo

March 2009

FSRU-based Guanabara Bay LNG terminal opened in Brazil

The UK's South Hook LNG import terminal commissioned

April 2009

Excelerate opened Northeast Gateway offshore LNG import facility

May 2009

Fujian LNG, China's second LNG import terminal, opened

June 2009

7.5 mta Canaport LNG import terminal came onstream

Chile commenced LNG imports, at Quintero LNG terminal

Cameron LNG received first commissioning cargo

July 2009

Taiwan opened second LNG import terminal, at Taichung

Tangguh LNG in Indonesia loaded first cargo

August 2009

Mina Al Ahmadi GasPort in Kuwait, Middle East's first LNG import terminal, entered service

Adriatic LNG, first offshore GBS-based terminal, opened

September 2009

Decision taken to proceed with 15 mta Gorgon LNG

October 2009

Fos Cavaou (Fosmax) received first LNG cooldown cargo

Liquefied Gas Shipping & Terminal Timeline



Shanghai LNG, China's third baseload import terminal, opened

November 2009

Yemen became 17th LNG export nation with loading of first cargo

December 2009

Decision made to proceed with Papua New Guinea's 6.6 mta PNG LNG project

May 2010

Mejillones, Chile's second LNG terminal, received first commercial cargo

June 2010

Peru LNG export terminal entered into service

Nakilat took delivery of 266,000m³ *Rasheeda*, last of its 54-ship LNGC newbuilding programme

October 2010

Golden Pass LNG import terminal in Texas received inaugural cargo

November 2010

Queensland Curtis LNG (QCLNG) partners agreed to proceed with the first LNG export project in Australian port of Gladstone

December 2010

Golar Freeze, converted to FSRU, commissioned at Dubai

January 2011

Gladstone LNG (GLNG) partners agreed to proceed with second LNG export project in Australian port of Gladstone

Grain LNG Phase 3 expansion boosted capacity to 14.8 mta

February 2011

Qatargas Train 7, 14th and last Ras Laffan train in current programme, commissioned

March 2011

Japan's Fukushima prefecture hit by magnitude 9.0 earthquake and tsunami; country's nuclear plants closed for safety checks

April 2011

Rudong LNG terminal in China received first commissioning cargo

May 2011

Shell sanctioned Prelude, first floating LNG production project to get green light

N-KOM yard carried out first LNGC repair job, on *Simaisma*

Sweden's small-scale Nynäshamn LNG receiving terminal opened

June 2011

GNL Escobar GasPort, Argentina's second regas vessel-based LNG receiving terminal, commenced operations

Dunkirk LNG import terminal project in France sanctioned

July 2011

Australia Pacific LNG (APLNG) partners agreed to proceed with third LNG export project in Australian port of Gladstone

September 2011

Map Ta Phut, Thailand's first LNG import terminal, opened

Gate LNG terminal in Rotterdam received first cargo

Wheatstone partners agreed to proceed with 8.9 mta LNG export project

October 2011

The 0.3 mta Skangass LNG liquefaction plant at Stavanger opened

November 2011

First cargo discharged at PetroChina's Dalian LNG import terminal

January 2012

Impex and Total sanctioned 8.4 mta Ichthys LNG export project in Australia

March 2012

Mexico's third LNG import terminal, at Manzanillo, commissioned

April 2012

Australia's Pluto LNG project loaded its first cargo

Japanese island of Okinawa received first LNG cargo

May 2012

Nusantara Regas Satu, the converted LNGC *Khannur* and Indonesia's first receiving terminal, inaugurated

July 2012

Cheniere decided to proceed with Trains 1 and 2 of Sabine Pass LNG export project; Trains 3 and 4 given go-ahead in May 2013

Liquefied Gas Shipping & Terminal Timeline

September 2012

CNOOC's Zhejiang LNG import terminal at Ningbo commissioned

October 2012

The 150,000m³ *Ob River* completed first passage of Northern Sea Route by a laden LNGC

Hokkaido Gas commissioned Ishikari LNG import terminal

2012

Thanks to the shale gas boom, the US switched from being a net importer of LPG to a net exporter; by 2014 the country was the world's largest LPG exporter

January 2013

Inaugural LNG cargo discharged at 5 mta Dabhol terminal, India's third

February 2013

Operations at Egypt's Damietta LNG plant ceased due to lack of feed gas

March 2013

Singapore LNG's terminal received first cargo

May 2013

Malacca LNG's jetty-based LNG import terminal received first cargo



The Malacca receiving facility in Malaysia features a jetty-mounted regasification unit

June 2013

Angola LNG dispatched first commercial shipment

July 2013

New 4.5 mta train at Skikda, Algeria commenced operations

August 2013

Italy inaugurated *FSRU Toscana* LNG import project

Kochi, India's 4th LNG import terminal, received inaugural cargo

October 2013

Zhuhai, CNOOC's sixth Chinese LNG import terminal, opened

November 2013

PetroChina opened third LNG import terminal, at Tangshan CNOOC's Tianjin facility, China's first regas vessel-based terminal, started up, using 145,000m³ *GDF Suez Cape Ann*

December 2013

Yamal LNG partners agreed to proceed with 16.5 mta Russian Arctic LNG export project

Inpex commissioned 1.5 mta Naoetsu LNG receiving terminal

January 2014

Bahia, Brazil's 3rd FSRU-based LNG import terminal, opened

May 2014

Papua New Guinea became 20th LNG export nation with entry into service of PNG LNG project

July 2014

Kogas opened its fourth LNG import terminal, at Samcheok

Regas vessel *PGN FSRU Lampung* went on station off southern Sumatra

August 2014

Hainan LNG, CNOOC's seventh Chinese LNG import terminal, opened

Cameron LNG export project gets green light to proceed

January 2016

APLNG project in Gladstone, Australia loaded its first LNG shipment. The 163,000m³ *Methane Spirit* transported the inaugural cargo.

The revised *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)* entered into force on 1 January and was fully implemented on 1 July 2016

February 2016

The new Train 1 at Sabine Pass LNG, a facility built originally as an import terminal, dispatched its inaugural cargo; it's also the first LNG export consignment from the lower 48 US states

Daewoo delivered to Teekay the 173,400 m³ *Creole Spirit*, the first newbuilding LNGC to be propelled with a two-stroke, dual-fuel propulsion system with fuel gas supplied at high pressure



Completed in 2016 *Creole Spirit* was the first LNGC fitted with a two-stroke, dual-fuel propulsion system

The in-service VLGC fleet reached 200 vessels, up from 100 vessels in 2006

Liquefied Gas Shipping & Terminal Timeline

March 2016

A new global gas carrier trade was inaugurated when the 27,500 m³ *JS Ineos Intrepid* lifted the first shipment of ethane from Sunoco's Marcus Hook terminal near Philadelphia

Chevron's Gorgon project in Western Australia dispatched its first LNG export cargo

April 2016

Sinopec's 3 mta Beihai facility, China's 14th LNG import terminal, commenced operations

May 2016

The Benoa LNG receiving project on the Indonesian island of Bali, utilising a floating storage unit (FSU) and a floating regasification unit (FRU), opened for business

Shizuoka Gas commissioned an LNG cargo reloading capability, the first such in Japan, at its Sodeshi import terminal

June 2016

The 79,000 m³ LPG carrier *Lycaste Peace* became the first gas ship to pass through the Panama Canal's new expanded locks

July 2016

The laden 163,700m³ *Maran Gas Apollonia* became the first LNGC to transit the Panama Canal expanded locks

LNG imports were received for the first time at the Dunkirk terminal in France and the Pori terminal in Finland

BP announced it will build Train 3 at its Tangguh export terminal in eastern Indonesia

August 2016

Rotterdam's Gate LNG opened its breakbulk terminal, complete with a third jetty, for handling small-scale LNGCs

Abu Dhabi commenced LNG imports utilising the 138,000 m³ FSRU *Excelsior* moored at Ruwais

October 2016

Jamaica commenced LNG imports by making use of the 138,000 m³ *Golar Arctic*, as a floating storage unit (FSU) and the 6,500 m³ *Coral Anthelia* for coastal distribution

November 2016

Colombia commenced LNG imports using the 170,000 m³ FSRU *Hoegh Grace* moored at Cartagena

The 180,000 m³ *PFLNG Satu*, the first floating LNG production (FLNG) vessel to go into service, started processing gas on the Kanowit field off Sarawak in Malaysia

The Bontang export terminal in Indonesia's East Kalimantan shipped its 9,000th cargo. The facility started operations in July 1977 and is currently running four of its original eight LNG trains

Daewoo delivered the 172,000 m³ *Christophe de*

Margerie, the world's first icebreaking LNG carrier, to Sovcomflot, and the first in a series of 15 such Arc7 ice class ships being built to lift Yamal LNG cargoes

Christophe de Margerie was the first icebreaking LNG carrier to go into service



December 2016

The fully refrigerated, 87,000 m³ *Ethane Crystal*, the world's first very large ethane carrier (VLEC), entered service on the US Gulf to India route

January 2017

The International Code of Safety for Ships using Gases or other Low-Flashpoint Fuels (IGF Code) entered into force on 1 January 2017

The FSRU-based Etki LNG import terminal in Turkey's Candarli Bay on the Aegean Sea received its inaugural cargo

Malta, making use of the 1985-built, 125,000 m³ floating storage unit (FSU) *Armada LNG Mediterranea* (ex-*Wakaba Maru*) received its first LNG cargo

Petronas and JX Nippon Oil & Energy started up the ninth train at Bintulu in the Malaysian state of Sarawak

March 2017

Sabine Pass LNG produced the commissioning cargo from its third 4.5 mta LNG train

April 2017

Qatar lifted its self-imposed moratorium on developing the North Field, the huge deposit which accounts for nearly all Qatar's gas production and 60% of its export revenue

The Hanjin yard in Korea completed the 5,100 m³ *Engie Zeebrugge*, the world's first purpose-built, seagoing LNG bunker vessel

Engie Zeebrugge marked another first – the inaugural purpose-built, seagoing LNG bunker vessel



Liquefied Gas Shipping & Terminal Timeline

May 2017

The 216,000 m³ *Al Kharaitiyat* delivered the commissioning cargo to the 2 mta Yuedong terminal, CNOOC's eighth Chinese LNG import facility

RasGas of Qatar shipped its 2,000th cargo to Korea on board the 138,000 m³ *SK Summit*, the ship that carried the first RasGas cargo to Korea, in August 1999

Nigeria LNG (NLNG) exported the 4,000th cargo from its Bonny Island terminal, to Turkey, also the recipient of NLNG's 3,000th consignment, in 2014

June 2017

Guanghai Energy opened its 0.6 mta Qidong LNG receiving terminal north of Shanghai; the terminal has no regas facilities, all the LNG being trucked to end-users

Panama Canal Authority (ACP) celebrated the first anniversary of its new enlarged locks; VLGCs transporting LPG accounted for 31.5% of the vessel transits over the first 12 months and LNGCs 9.1%

Eni and its partners in the Coral South LNG export project in Mozambique agreed to proceed with the scheme, based on the use of a 3.4 mta FLNG vessel newbuilding

July 2017

The 172,000 m³ *Christophe de Margerie*, with a cargo loaded at Norway's Snøhvit terminal for South Korea, completed the first unescorted voyage by a laden LNGC along Russia's Northern Sea Route (NSR)

November 2017

Operations commenced at Pakistan GasPort (PGP), Pakistan's second LNG import terminal; both are based on the use of an FSRU stationed at Port Qasim

Total agreed to acquire Engie's portfolio of upstream LNG assets for US\$1.49 billion. The new group will manage an overall LNG volume of 40 mta by 2020, making it the second largest global player in the LNG market, with a 10% share, after Shell

Petronas received the first commercial LNG cargo at its newly commissioned 3.5 mta Pengerang regasification terminal in the southern Malaysian state of Johor

The Manga LNG terminal in the Finnish port of Tornio, at the head of the Bay of Bothnia and the largest such facility in the Nordic countries, received its first cargo

December 2017

The icebreaking LNGC *Christophe de Margerie* loaded Yamal LNG's first cargo

The Soma LNG import terminal of Japan Petroleum Exploration (Japex) in Soma Port received its first LNG commissioning cargo

Total agreed to supply CMA CGM with 0.3 mta

of LNG, commencing in 2020, for use as bunker fuel for nine 22,000 TEU, LNG-powered container ships currently under construction

Exmar chose LPG-burning, dual-fuel engines to propel a pair of VLGCs being built by Hanjin Heavy Industries & Construction at Subic Bay in the Philippines; they will be the world's first LPG-fuelled vessels on delivery in 2020

Nicaragua and Myanmar imported seaborne LPG shipments for the first time

January 2018

Qatar Petroleum merged Qatargas and RasGas, its affiliated gas operating companies, into one entity, Qatargas

February 2018

Total and MOL ordered an 18,600 m³ LNG bunker vessel at Hudong-Zhonghua in China for use in fuelling the nine LNG-powered, 22,000 TEU box ships under construction for CMA CGM

The freshly delivered 50,000 dwt dual-fuel bulk carrier *Ilshin Green Iris* has a 500 m³ IMO Type C LNG bunker tank constructed of a new cryogenic high-manganese steel developed by POSCO

March 2018

The new liquefaction train at Cove Point, built originally as an import terminal, produced the facility's first LNG export cargo

April 2018

Japan's Hokuriku Electric Power Co inaugurated its Toyama-Shinko LNG receiving terminal in Toyama Bay on Japan's west coast with a shipment from Malaysia

July 2018

Yamal shipped first LNG cargo to China via Northern Sea Route

The 35,000 m³ ethylene carrier *Navigator Aurora* became first gas ship to have its slow-speed diesel engine converted to enable it to also run on ethane

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Liquefied Gas Shipping & Terminal Timeline

August 2018

Panama became an LNG import nation with the commissioning of the Costa Norte terminal at Colon

The FSRU *Excellence* began regasifying Bangladesh's first LNG import cargo

CNOOC's new Shenzhen LNG import terminal commenced operations

Conrad Industries delivered the non-propelled barge *Clean Jacksonville*, North America's first LNG bunker vessel

ENN Group's Zhoushan LNG receiving terminal received its first commissioning cargo

September 2018

Tema LNG approved an LNG import scheme based on the use of a barge-based FRU in combination with an FSU moored at Tema in Ghana

October 2018

Ichthys LNG shipped the first export cargo from its new terminal at Darwin in northern Australia

Shell and its partners in the LNG Canada export terminal planned for Kitimat in British Columbia decided to go ahead with the project

After three years of importing LNG, making use of two FSRUs, Egypt ceased its LNG purchases

November 2018

Yamal LNG completed the first of a significant number of ship-to-ship LNG transfer operations at Honningsvåg fjord in northern Norway

On the basis of monthly volumes, Australia overtook Qatar as the world's leading LNG exporter

December 2018

BP and its partners gave the green light to their FLNG-based Tortue export scheme for the coastal waters of Senegal and Mauritania

Cheniere Energy's greenfield Corpus Christi LNG export terminal in Texas dispatched its first commissioning export cargo

The Russian enclave of Kaliningrad commenced LNG imports with the arrival of the FSRU *Marshal Vasilevskiy*

Excelerate Energy officially withdrew from its long-running plan to provide the FSRU-based Aguirre Offshore GasPort LNG import project in Puerto Rico; similarly, ExxonMobil stated it will not proceed with its West Coast Canada (WCC) LNG export project planned for British Columbia

February 2019

ExxonMobil and Qatar Petroleum gave the final investment decision (FID) to proceed with their project to add three

liquefaction trains at their Golden Pass import terminal in eastern Texas and give it a bi-directional export capability

Excelerate Energy completed its 1,500th STS LNG transfer operation, at the Engro Elengy terminal at Port Qasim in Pakistan

March 2019

India, world's second largest LPG importer, received shipments of the product for the first time from the US, the world's largest LPG exporter

The FSRU *Golar Nanook* arrived at Sergipe with a commissioning cargo for the new Brazilian LNG import project

India started up its fifth LNG import terminal and first on the east coast, at Ennore, with a shipment delivered by *Golar Snow*

The Novatek-led small-scale LNG project in the Russian Baltic Sea port of Vysotsk loaded its first cargo

May 2019

The LNG carrier fleet lifted its 100,000th cargo since the start of commercial LNG shipping operations 55 years ago

The new Altagas LPG export terminal on Ridley Island in British Columbia dispatched its first cargo

The FSRU *Excelerate* arrived in Bangladesh with a commissioning cargo for what will be the country's second LNG import project

The Cameron LNG terminal in Hackberry, Louisiana, originally built as an import terminal, began loading its first export cargo

June 2019

Anadarko and its partners in Mozambique LNG agreed to proceed with the scheme

Argentina became the world's 21st LNG exporter with a shipment from the floating LNG production vessel *Tango FLNG*



The *Tango FLNG* floating production barge has enabled Argentina to commence LNG exports

Cheniere Energy agreed to press ahead with the construction of a sixth train at its Sabine Pass LNG terminal

The Prelude FLNG vessel, in deep water off Australia's coast, loaded and dispatched its first LNG cargo

A selection of photos from the Society's past



1. SIGTTO moved to its new office at 42 New Broad Street in July 2018 **2.** There's plenty of room for working group sessions at the new premises **3.** The 53rd SIGTTO Panel Meeting in Boston attracted a good turnout **4.** There were 200 registered attendees at SIGTTO's Doha Panel Meeting in March 2012 **5.** Foam is used to tackle an LNG pool fire during a firefighting training exercise

L LONG TERM

Vessels that land at our berth hold the equivalent of nearly four billion cubic feet (Bcf) of natural gas as liquified natural gas (LNG). This LNG travels the globe and has been delivered to more than thirty countries. Each vessel delivers enough LNG to power some of the largest cities and factories in the world.

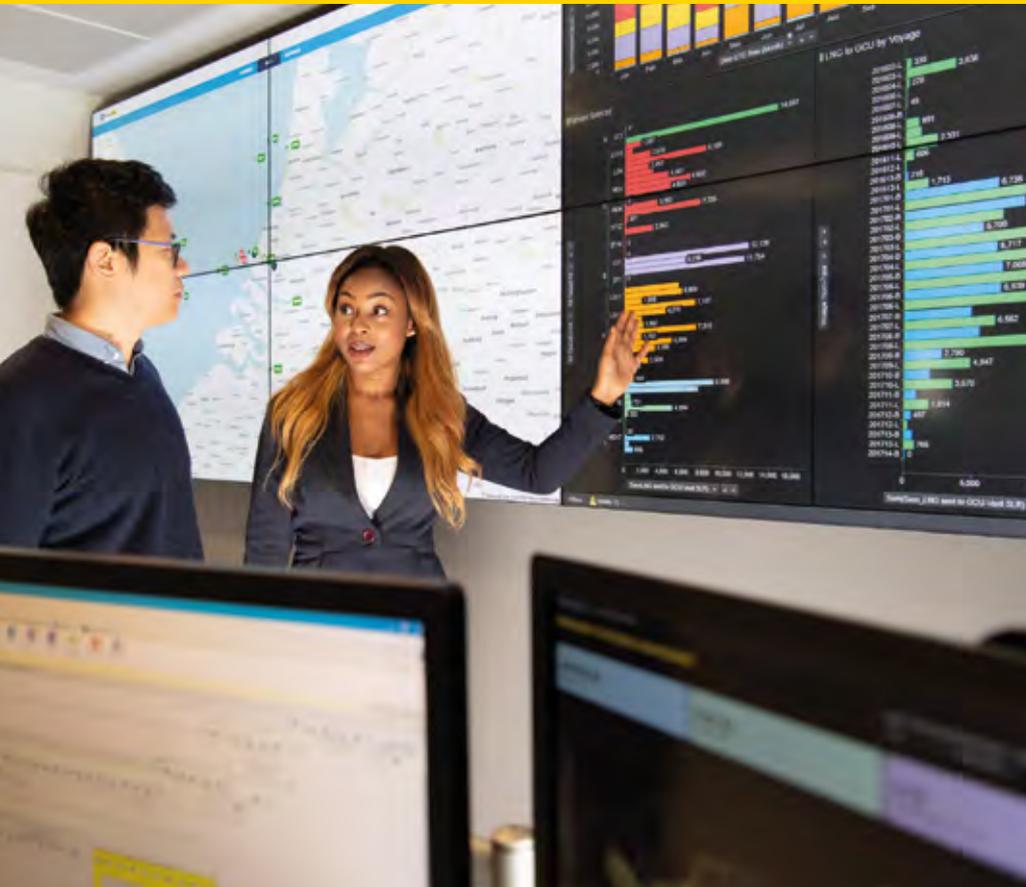
Delivering clean energy. Reducing carbon emissions. Flexible and transparent delivery options. Innovation at every turn.



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AT SHELL SHIPPING & MARITIME, THE SAFETY AND WELLBEING OF SEAFARERS IS OUR TOP PRIORITY.



With over a century of experience in shipping, we know that innovation and collaboration are essential to achieving our goal.

That is why we manage a fleet that includes some of the most technologically advanced vessels in the world, and why **we have been proudly working alongside SIGTTO for the last 40 years to promote safe, responsible shipping.**