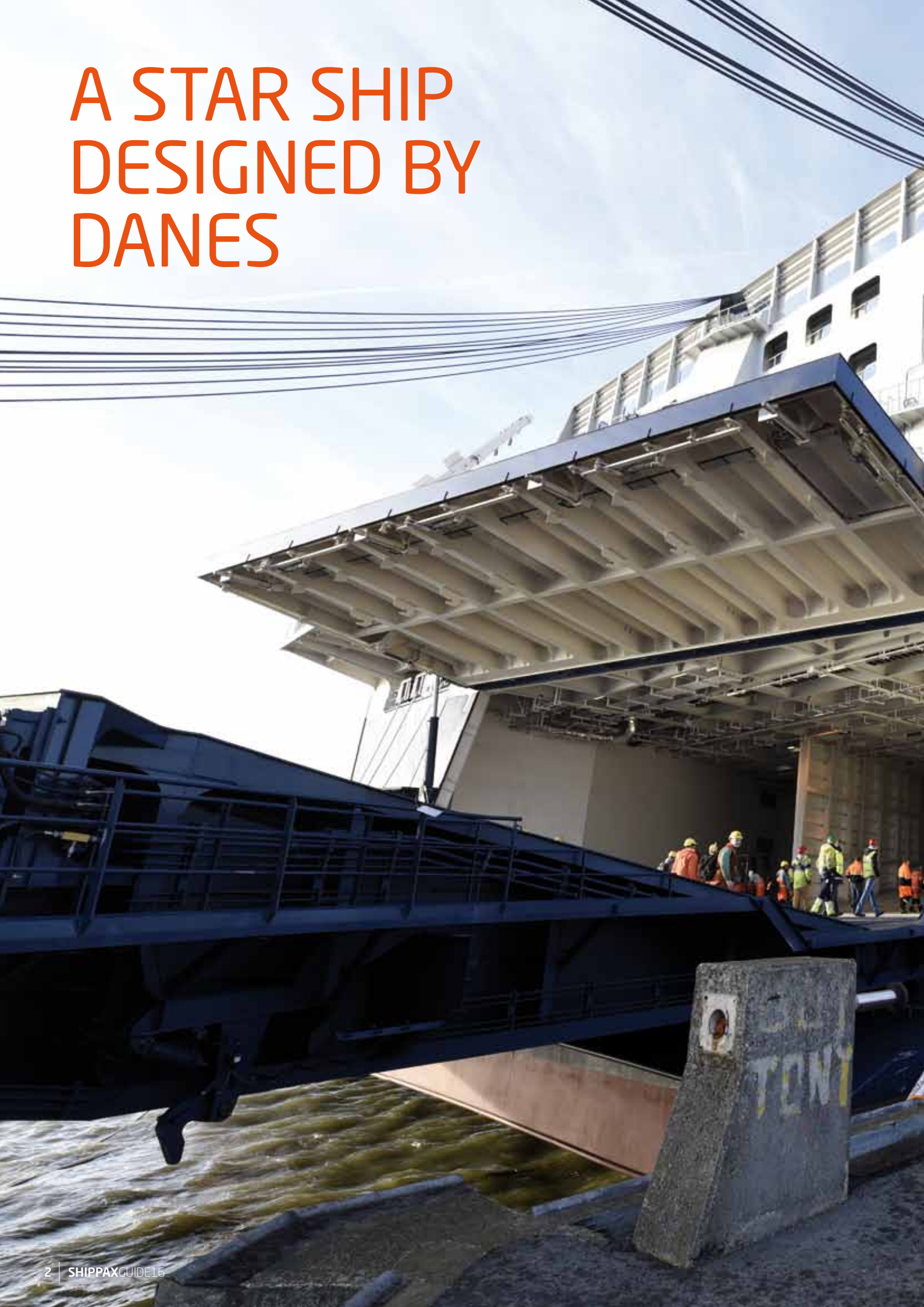
A STAR SHIP DESIGNED BY DANES



The innovative design of ATLANTIC STAR takes a radical step away from the tried and tested multipurpose con-ro concept of which ACL's G3-class was probably the epitome. ATLANTIC STAR, the lead ship of the G4-class quintet, effectively combines two different ship types within a single hull, making the series truly unique. Masterminded by Jens Nielsen of International Maritime Advisers, the project was taken to a new level by KNUD E. HANSEN who further developed and adapted the concept to ACL's requirements on behalf of Hudong-Zhonghua Shipbuilding. This revolutionary concept is an industry first, but there were many challenges along the way though.

TEXT: PHILIPPE HOLTHOF

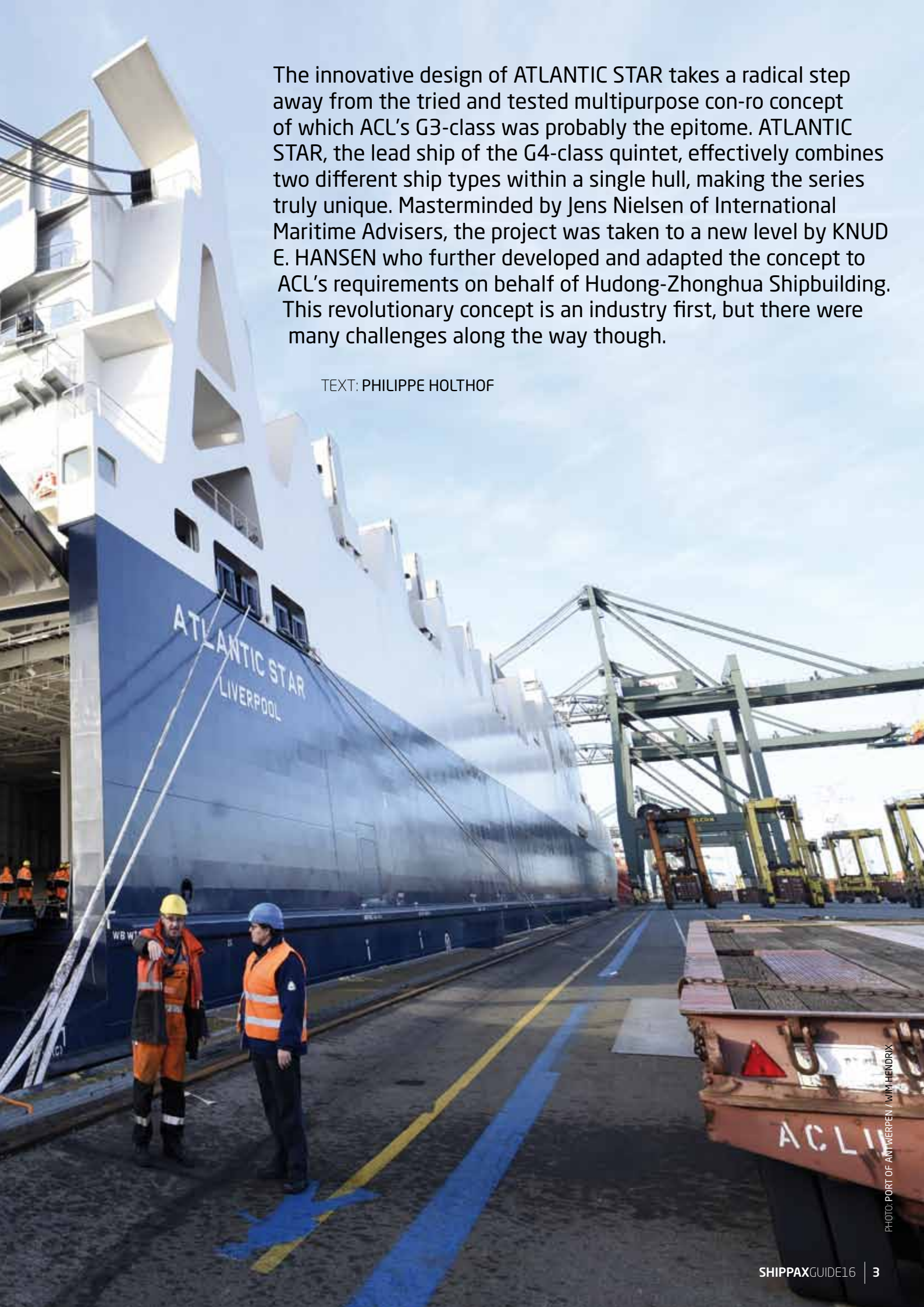


PHOTO: PORT OF ANTWERPEN / WM HENDRIX

The con-ro concept was pioneered by ACL in 1967 following the delivery of their first generation of combined container/ro-ro carriers. Although really futuristic at the time when containerization was just taking off, the principle was fairly simple: all types of (wheeled) cargo could be stowed on the enclosed ro-ro decks, whereas the weather deck was a dedicated container deck. Such was their success, that ACL's G1s were lengthened by 26 m in 1976 with the existing forebody being converted into a lift on-lift off part, complete with a cellular hold. The G2s, which entered service in the 1969-1970 period, were conceptually similar to the G1s, but boasted container holds in the forward end from the outset, flanked by car decks on both sides. The G3s incorporated all the lessons learned from the earlier generations and took full advantage of the evolution through which the con-ro had gone during the seventies. Completed in 1984-85, these giant Panamax con-ros represented a quantum leap in terms of payload and were lengthened by 42.5 m in 1987. As built, the G1s and G2s were equipped with a straight axial stern ramp which was replaced by a stern quarter ramp on the G3s – in the case of the G3s it was actually a Jumbo ramp. A stern quarter ramp was first installed on the 1970-built PARALLA. It was a big step forward as it enabled the vessels to berth at any quay and drop their ramp on the starboard side.

The G3s were a further development of the trendsetting BOOGABILLA and both concepts emanated from the design stable of the Swedish naval architects TransConsultants AB. BOOGABILLA, however, had full-length ro-ro decks and thus did not have dedicated container holds. Both containerized and wheeled cargo could be stowed on the weather deck with direct access from the stern ramp through a guillotine door. The G3s, for their part, followed ACL's proven 'ro-ro aft and container holds forward' arrangement with the superstructure block aft holding multiple car decks reminiscent of a car carrier. Unlike on BOOGABILLA, all open deck space on the G3s was allocated to containers that were placed in a cell guide system developed by MacGregor-Navire. First tested on a small scale on ATLANTIC SPAN with three different configurations of on-deck bays, these container cell guides improved cargo turnaround times by eliminating the need for lashing. Additionally, ACL has not lost a single container over the side ever since the on-deck cell system was introduced.

"The secret of the design lies in putting ro-ro cargo amidships"

The 'containers on deck, ro-ro cargo under deck' principle has been applied on virtually all con-ros. Although it has proved very popular, there is also the flipside to the coin, especially when large volumes of containers are carried on deck. The denser stowage of containers on deck in combination with the 'air-filled' ro-ro decks with relatively lighter-weight cargo, contributes to the fact that most of the weight rides high on a standard con-ro vessel. This imbalance is actually the Achilles' heel of the traditional con-ro configuration and requires thousands of tonnes of ballast which comes at the expense of deadweight. The G3s equally suffered from this drawback; even with a full load they had to take 13 to 14,000 tonnes of ballast.

THE EGG OF COLUMBUS

The G4 project started with a clean sheet of paper and its radical new layout departed from the typical horizontal and partial vertical division between containers and ro-ro space adopted by ACL hitherto. The secret of the design lies in putting ro-ro cargo amidships with containers being stowed in cells fore and aft of the ro-ro section. This effectively results in cargo replacing ballast with a much more efficient use of vessel space. The ballast requirement on full sailings is close to zero. The brainchild of Jens Nielsen, the configuration allows for a container intake double that of the G3s and an increase in ro-ro space of 55 per cent within almost the same footprint. Jens Nielsen, a Danish naval architect who became a consultant and set up International Maritime Advisers (IMA) after retiring from KNUD E. HANSEN, first presented his unconventional design to ACL in 2008. With over 40 years' experience in operating con-ros on the North Atlantic, ACL was initially sceptical about Mr Nielsen's weird idea. However, they were soon hooked on the better utilization of the hull envelope. ACL, together with Jens Nielsen, further fine-tuned the design in order to get the right mix between containers and ro-ro, subsequently presenting it to shipyards in 2008-9. Given their full order books the price the shipyards gave was initially way too high, resulting in the project being put on hold. When the shipbuilding market collapsed in the aftermath of the financial crisis, order books were drying up and ACL went out to the shipyards again for a second round of quotes in early 2011. Several shipyards declined to quote and many of those who quoted were still too expensive. ACL eventually came down to a shortlist of five yards that were

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From left to right: Senior Naval Architect Niels Georg Larsen, G4's Project Manager during the basic design, Finn Wollesen (Managing Director) and Senior Naval Architect Christian G. Damsgaard, G4's Project Manager during the contract design. During the period of the basic design, 10-15 people were continuously involved in the project, peaking to up to 30 pesons at times.

PHOTO: PHILIPPE HOUTHOF

really interested (see separate sidebar), with the five-ship contract ultimately being awarded to Hudong-Zhonghua Shipbuilding (HZS) in July 2012.

KNUD E. HANSEN PLAYING AN INSTRUMENTAL ROLE

The IMA proposal represented a ship type the like of which had never been built before. It was an ACL requirement for the potential builders to have the complex design further developed by a European naval architectural firm. HZS teamed up with KNUD E. HANSEN (KEH) of Helsingør, Denmark for the contract and basic design. In case HZS would not have won the contract, the project for KEH would have stopped with the contract design, so it was a matter of 'winning or losing together'. A household name in naval architecture, KEH are arguably the most prominent naval architects in the world, having been established in 1937. Shortly before the G4 project took off, KEH had completed the concept and tender design for a series of con-ro vessels for Bahri, ➤

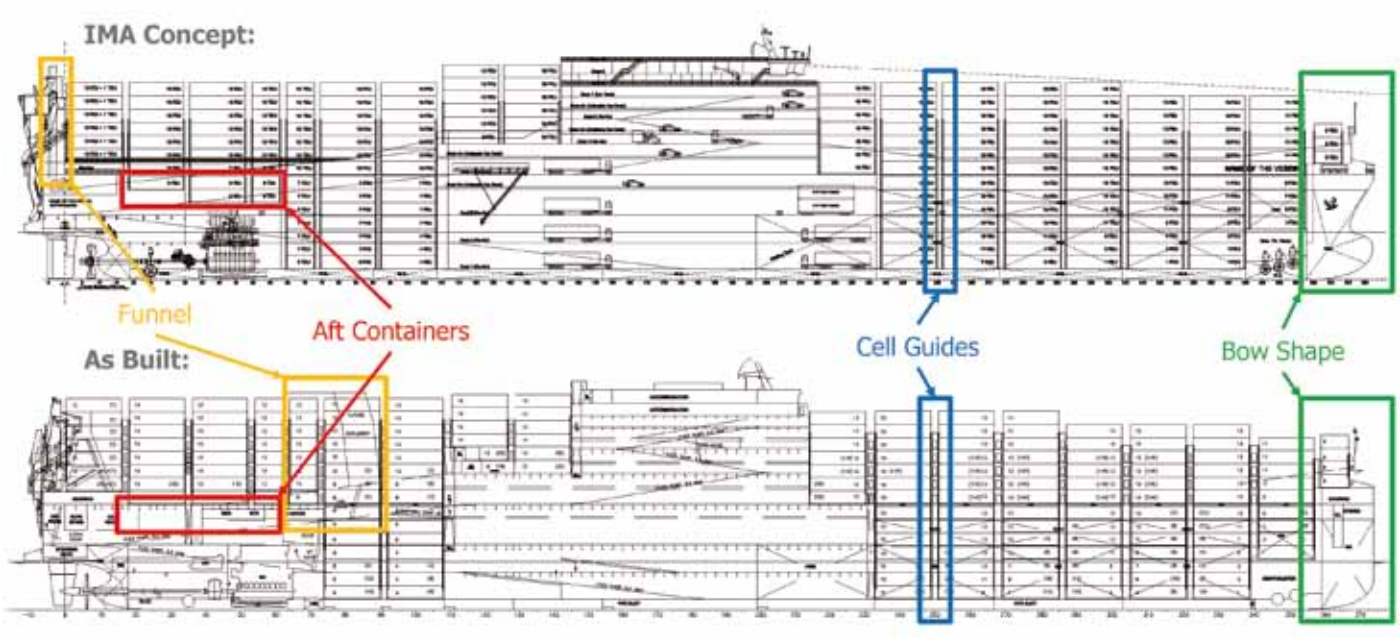

PHOTO: FLOR VAN OTTERDYK

G4: Scope of work:

The contract and basic design carried out by KNUD E. HANSEN included:

- GA and technical specification for contract
- GA and statutory documents
- Lines plan, CFD and model test assistance
- Intact and damage stability
- Noise and vibration
- Cargo Securing Manual
- Hull structure design
- FEM verification of hull structure, global and local
- Deck outfitting
- Machinery – engine room design
- Machinery – system design
- Hull engineering
- HVAC (heating, ventilation and air conditioning)
- Electric, instrumentation and automation

➤ the last in a long list of ro-ro ships and ro-pax ferries that were designed by the prolific Danish naval architects.

As pointed out, KEH's scope of work was twofold; first there was the contract design and once ACL had signed the contract with HZS, KEH was commissioned to complete the basic design. The contract design - which included the GA and all the technical specifications for the contract - proved to be a long process because the order was postponed several times. The basic design covered, amongst others, class drawings, hull structure design, machinery plant arrangement, HVAC, electrical and automation design, CFD and model test assistance, intact and damage stability and noise and vibration analyses. Following completion of this package, the project was handed back to HZS, the detailed design being outside KEH's scope of work. Engineers from HZS joined the KEH team in Denmark during the period of the basic design. This led to a smooth transition when HZS took over and KEH always remained on hand when there were issues.

While KEH had a contract with the yard - and not with ACL - there was always a very good understanding between ACL as end customer and KEH. Back then, ACL's technical staff was still based in Gothenburg which, after all, was not that far away from Helsingør. This made things easy, KEH acting as 'the glue' between HZS and ACL.

Although KEH had been tasked with adapting IMA's concept to ACL's requirements, there was only little room for compromises since ACL focused on keeping the maximum capacity that IMA had promised. "There was almost zero tolerance on payload reduction," Christian G. Damsgaard, KEH's Head of Naval Architecture explained. "In practice it was, however, hard to fully achieve the IMA concept design," he added. "It was a tough task to make it happen and we really had to convince ACL that the boundaries were too tight with modifications being unavoidable."

KEH further developed and optimized the IMA design with all the changes being made for the better. The

Innovative expedition ship

To meet ever-increasing demand for small-scale expedition cruises, KNUD E. HANSEN has recently developed a luxury 300-passenger expedition cruise vessel specifically designed for worldwide operation, including the Arctic and Antarctic regions. Special attention has been paid to seakeeping capabilities. The ship copes extremely well in rough weather and thanks to its compact dimensions (139.4 m x 20.5 m) can operate in confined waters. It is therefore able to call at small ports with narrow fairways. Propulsion and exceptional manoeuvrability is provided by two Azipod units and two bow thrusters. The diesel-electric power plant includes four medium-speed diesel generators in two separate engine rooms in compliance with SRtP rules. The concept ship has an ice strengthened hull (Ice Class 1A), the machinery and service spaces having a double hull.

All public facilities are concentrated on two decks, including an observation lounge with full 360° views. The ship follows the All Outside Cabin concept with 150 standard passenger cabins being spread over three decks. The cabins on the bridge deck come with balconies and a number of standard cabins can be transformed to luxurious suites by applying the newly developed 'FlexCabin system'.

A large sea garage with retractable overhead davit is arranged at the transom for easy launching and retrieval of up to 15 Zodiac type boats and jet-skis.

Clean and green is key; solar cells help offset the vessel's electrical load with space being reserved for battery systems to provide true emission free and silent sailing in extra sensitive areas.

According to Finn Wollesen, KNUD E. HANSEN's Managing Director, several parties have already shown their interest in this next generation expedition cruise ship.


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concept ship featured a bulbous bow. Because this is less effective on ships with a low Froude number, a knife-edge stem was favoured by KEH. The flare in the forebody was also reduced to guarantee better seakeeping capabilities with less slamming, something which is appreciated on the North Atlantic. Another major improvement made by KEH concerned the cell guides. To further increase the container intake, the cell guide supporting structure was extended in height in front of the accommodation. Not using lashings, the cell guide structure shall withstand particular horizontal forces as a cantilever beam. As a result, odd-looking triangular structures were added on the sides. Effectively acting as stiffeners, these were not included on the concept drawings of the vessel. The aft bodies on con-ros are usually very complicated and this was no exception on the G4s. This part of the ship required further surgery by KEH. The original structure was simplified as much as possible which, among others, resulted in removing a few 'single container bay' recesses above the engine room. The funnel had to be relocated too as the original concept did not allow sufficient space. This relocation further led to a more simple structure.

Worth mentioning is that the typical propeller/flap rudder arrangement was replaced by a Wärtsilä Energopac integrated rudder propeller system, offering increased propulsive efficiency and improved manoeuvrability.

STRUCTURAL AND STABILITY CHALLENGES

Probably the most difficult aspect from a naval architectural point of view was the task to combine the dissimilar structural layout of a container and a ro-ro ship, respectively, into a single hull. The area forward of the superstructure is a fully fledged open top containership. The container section with its transverse divisions abruptly stops at frame 231. This is where the ro-ro decks with their longitudinal division start, continuing all the way to the stern. However, there is a small hatchless hold aft of ro-ro Deck 4, with ro-ro space being wrapped around it. Abaft the superstructure, on top of the ro-ro decks, there are container bays extending to the stern. The structural continuity, or better the transition from the 'shoebox-like' forward end to the ro-ro decks, was a really big challenge. The ro-ro section is a very rigid part that is ➤

CELEBRATING NEARLY 80 YEARS OF EXCELLENCE

Mr Knud E. Hansen established his namesake company in 1937. Born in Espergærde (near Helsingør) the son of a skipper who commanded coastal sailing ships, Knud E. Hansen graduated as naval architect in 1925. Prior to starting his own company, Mr Hansen gained experience in shipbuilding by working in a number of yards in Denmark and abroad.

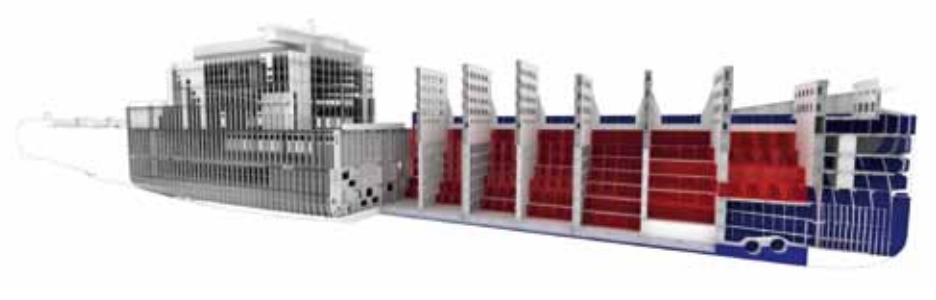
Especially during the sixties and seventies, the company received great acclaim for designing efficient passenger ships - including ferries and the first generation cruise ships - with elegant lines. A very talented man called Tage Wandborg played a key role in the great successes that were booked.

KNUD E. HANSEN has put its stamp on thousands of vessels since it was founded almost 80 years ago. More than 700 vessels were built to a KNUD E. HANSEN design, with 450 hulls being developed and model tested. Additionally, KNUD E. HANSEN designs served 300 conversions and the company also undertook more than 1,000 surveys, onsite supervisions as well as feasibility and R&D studies.

Under the leadership of Finn Wollesen, who was appointed as the company's new Managing Director in 2003, additional subsidiary offices around the globe were opened aimed at bringing KNUD E. HANSEN closer to its clients. Besides the Helsingør headquarter and an office in Odense, there are branches in the UK, Greece, USA, Australia and the Faroe Islands with a total workforce of more than 75 highly trained staff from over 20 different countries.

A selection of some significant ro-pax ferries, pure ro-ro ferries and con-ro ships designed by KNUD E. HANSEN during the past 25 years (the dates mentioned are the respective delivery dates):

1992: PRINS FILIP
1993: SPIRIT OF BRITISH COLUMBIA, SPIRIT OF VANCOUVER ISLAND
1996: GOTLAND
1998: SKÅNE, TOR SELANDIA, SEA CENTURION
1999: TOR SUECIA
2000: TOR BRITANNIA, EUROPEAN CAUSEWAY, EUROPEAN AMBASSADOR
2001: OCEANUS, PROMETHEUS, MOBY WONDER, MOBY FREEDOM, SUPERFAST V, SUPERFAST VI, SUPERFAST VII, SUPERFAST VIII
2002: EUROPEAN HIGHLANDER, ARIADNE PALACE, SUPERFAST IX, SUPERFAST X, SUPERFAST XI, SUPERFAST XII, STENA FORETELLER
2003: STENA FORECASTER, STENA FORERUNNER, NORRÖNA, VISBY, GOTLAND
2004: STENA FREIGHTER, STENA CARRIER II
2005: SMYRIL
2008: CLIPPER POINT
2009: CLIPPER PANORAMA, CLIPPER PACE, CLIPPER PENNANT
2011: BLUE STAR DELOS
2012: BLUE STAR PATMOS, URANIBORG
2013: BAHRI ABHA, BAHRI HOFUF, BAHRI TABUK, BAHRI JAZAN, MN CALAO, MN TANGARA
2014: BAHRI JEDDAH, BAHRI YANBU, SAN SHA 1 HAO
2015: VETERAN, ATLANTIC STAR
2016: LEGIONNAIRE, ATLANTIC SAIL, ATLANTIC SEA, ATLANTIC SKY, ATLANTIC SUN



➤ basically only connected on the sides to the not-so-rigid 'torsion box' front part. This transition zone between the ship's container shape and the ro-ro shape required Finite Element (FEM) calculations that were all part of the package.

Stability, notably damage stability, proved to be another big challenge, once again owing to the vast horizontal ro-ro spaces versus the vertical 'holes' for containers. The SOLAS 2009 probabilistic damage stability had to be combined with the IMO guidelines for open top containerships (MSC/Circ. 608). The G4s have rain convers for comfort's sake, but these are not watertight, the ships essentially being hatchless or open top from a regulatory point of view.

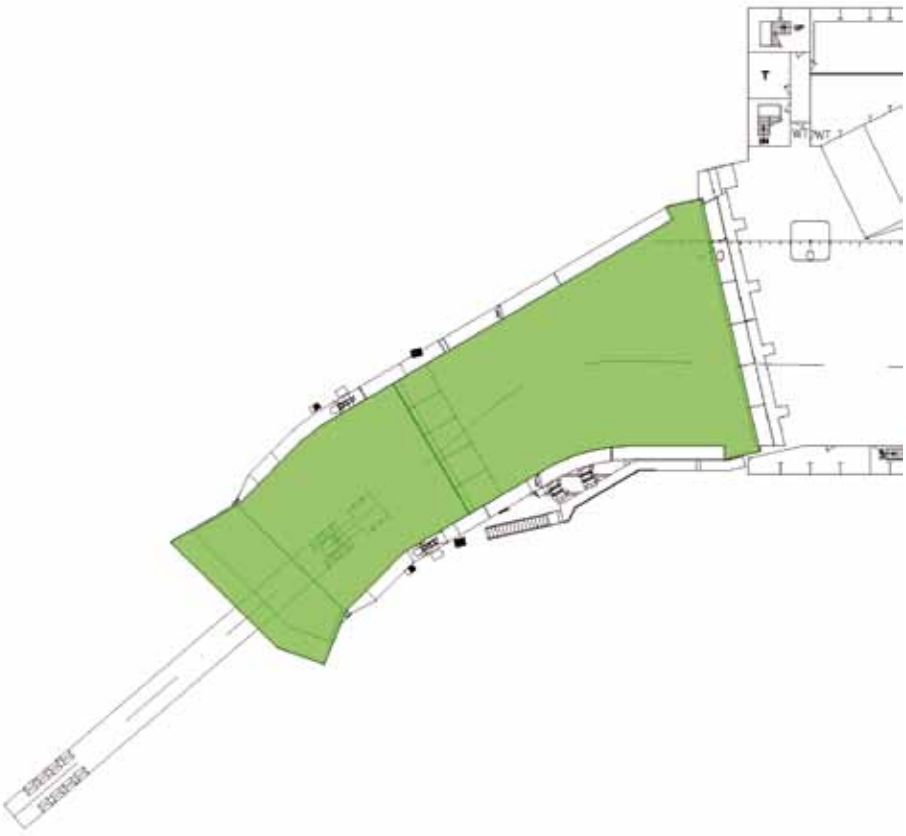
The open top principle only had a short-lived success on large deep sea containerships, but has been successfully applied on short sea container feeders, the 868 TEU 'Sietas 168-type' being one of the most famous examples. KEH already had some experience with the open top phenomenon since they were involved in the design of hatchless containerships that were built for Norasia Line in the early nineties.

To determine whether the vessel complied with the MSC/Circ. 608 guidelines for open top containerships, additional model tests were carried out at MARIN, the Netherlands. These seakeeping tests were done for a significant wave height of 8.5 m at a maximum loaded draught. It was also simulated in combination with tropical rain and all tests were extremely successful with only a minimum amount of green water entering the foremost hold in a worst-case scenario (the IMO guidelines state that the maximum water ingress should not exceed the hatch opening area multiplied by 400 mm/hour).

Another requirement concerned the ship's longitudinal strength. Nine different loading conditions typically suffice to assess a containership's longitudinal strength in flooded condition (MSC/Circ. 608 only mentions that the general and local strength of the hull should be 'sufficient'). Not content with 'only' nine different loading conditions, RINA, the ship's classification society, called for all 31 possible combinations of flooded cargo holds to be calculated, meaning that 279 different scenarios had to be investigated by KEH. Conclusion? The G4s have well exploited stability and strength margins!

UNCONVENTIONAL ARRANGEMENT OF THE RAMPS

KEH also played an important role in making the ro-ro side better. Angles of deck ramps, for instance, were adjusted and instead of two rows of pillars, there is only one set on the centreline, further easing handling of vehicles and break-



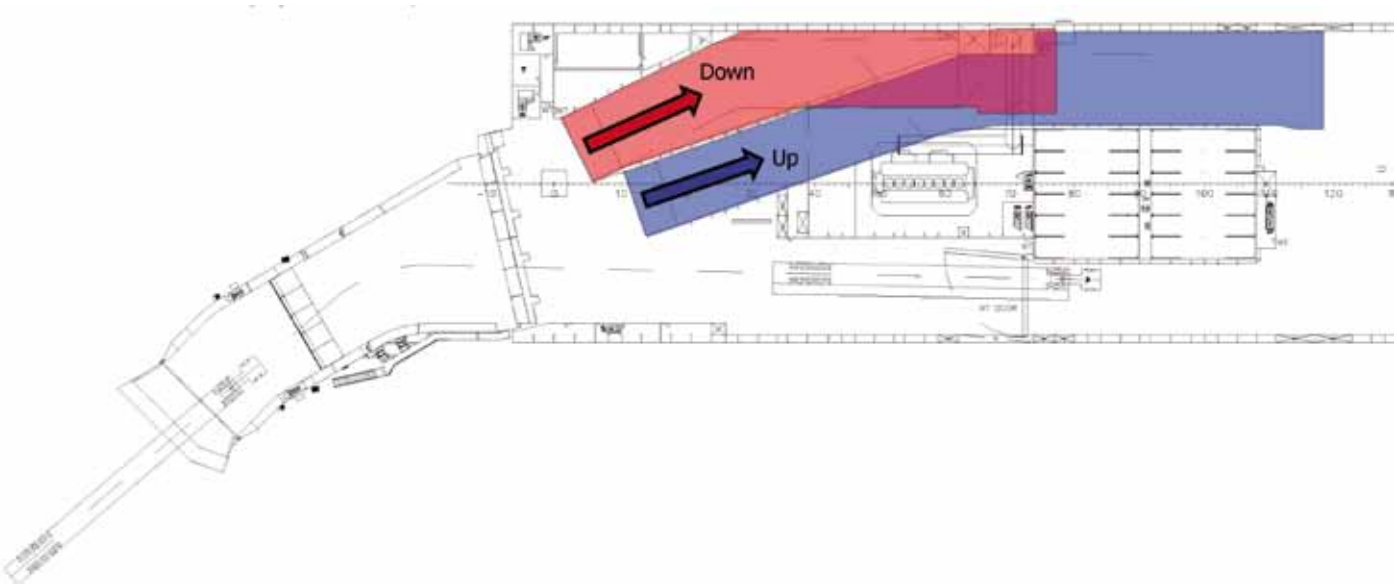


PHOTO: ACL

bulk cargo as well as increasing storage capacity.

However, there were also some design challenges, the curved internal ramps that are located close to the stern being one of them. Ramps are typically longitudinally oriented, but due to the aft container hold, the internal ramps had to be curved with both ramps being positioned to the port side.

The arrangement of the Jumbo stern quarter ramp is equally unconventional. With the container bays extending to the stern, the king posts together with the ramp they hold, had to be positioned in such a way that no container space would be lost. This could only be achieved by reducing the angle at the stern. To compensate for the softly angled connection to the main deck, the ramp sections needed to be curved, taking into account that it should be flush when in a stowed condition.

Notwithstanding all the challenges encountered during the design process, KEH wonderfully succeeded in improving the G4's capabilities without really affecting the capacities. What started out as a concept first deemed unrealistic has become a real game changer. ■

Hudong-Zhonghua Shipbuilding

Following final-round bidding against Yangfan Shipbuilding, Jinling Shipyard and South Korean contenders DSME and Hyundai Mipo Dockyard, ACL awarded the contract for its five G4s to Hudong-Zhonghua Shipbuilding. Construction was entrusted to the company's new yard on Changxing Island, near Shanghai.

State-owned Hudong-Zhonghua Shipbuilding, the result of a merger between Hudong Shipbuilding and Zhonghua Shipyard, is one of China's major shipbuilding enterprises. Part of the China Shipbuilding Group Corporation (CSSC), the yard has a reputation as one of the highest quality shipyards in China with complicated special-purpose vessels and naval ships figuring in its prolific output.

PHOTO: ACL