Optimizing gas transfer: Real-world impact

PROVEN SOLUTIONS SIMPLIFYING COMPLEX OPERATIONS FOR RECEIVERS AND SUPPLIERS

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SCAN TO DISCOVER OUR LNG EXPLORER TOOL

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A CHANGE OF DIRECTION AT SHIP TERMINALS

As the global energy supply chain evolves, the maritime industry is increasingly turning to cleaner fuels to reduce its environmental footprint. Liquefied natural gas (LNG) is a proven and effective solution, reducing CO_2 emissions by around 20% and nearly eliminating NOx and SOx emissions compared to conventional fuels. This shift is driving significant investment in new vessels and the smart infrastructure required for efficient, safe, and cost-effective transfer operations.

Beyond LNG, the transition to a sustainable future is accelerating, bringing emerging fuels like liquid hydrogen and ammonia to the forefront. These next-generation energy sources present unique and complex transfer challenges, including material embrittlement from cryogenic hydrogen and the toxicity of ammonia, which demand exceptionally robust materials and advanced safety protocols to ensure asset integrity.

Trelleborg's approach is grounded in this deep understanding. We deliver complete solutions that optimize gas transfer for both suppliers and receivers, combining decades of industry insight with a comprehensive portfolio of services, support, and systems. Our expertise is built on a history of market-leading innovation—from our pioneering Ship-Shore Link (SSL) technology for large-scale LNG to our engineering of next-generation systems for the fuels of tomorrow.

This collection of case studies demonstrates our expertise in action, showcasing how we develop bespoke solutions for varied projects worldwide. Within these examples, you will see how our capabilities in operations optimization, robust equipment design, and dedicated lifecycle support come together to solve unique challenges—from extending operational windows in harsh weather to ensuring seamless vessel-terminal compatibility. Discover how Trelleborg's tailored approach ensures every gas transfer operation is not just protected, but truly optimized for a future-ready energy landscape.

Opening the door to worldwide terminals

JAPAN TERMINALS
LNGC Operator

For optimally safe berthing during LNG transfers, industry guidelines recommend that LNG Carrier (LNGC) mooring arrangements are analyzed using a Mooring Load Monitoring (MLM) system. This information is displayed in the shore control room, though best practice also recommends that this data is shown onboard the ship. The SSL is an ideal carrier of this information, as it connects ship-to-shore during LNG operations.

Some terminals, particularly in Japan, require that MLM information be provided onboard ships. However, without compatible MLM systems installed on ships and shore, data cannot be transmitted, thus preventing compliance with regulations.

Challenge: A major LNGC operator contracted the build of LNGCs at a large yard using non-Trelleborg SSL/MLM systems.

During commissioning, it became evident the installed SSL/MLM equipment was incompatible with systems at most LNG terminals, preventing the new vessels from calling at these ports and hindering their worldwide trading capability.

Solution: With tight delivery and global compatibility being major concerns, the vessel owner contacted Trelleborg, who agreed to replace the SSL systems onboard the vessels.

Trelleborg completed the delivery, installation and commissioning under extremely tight timescales to ensure that the LNGCs were fully operational once they arrived. SSLs were installed at the next available port visits, avoiding customer delays and minimizing disruption by commissioning the systems during vessel transit. The swap to Trelleborg's SSL systems ensured that vessels would be able to trade freely by successfully displaying MLM data during the berthing process.

Trelleborg delivered a globally compatible SSL system that ensured vessels could trade freely, while optimizing a safe and efficient berthing/LNG transfer operation through the provision of MLM data.

Maintaining business continuity under global constraints

LOUISIANA, GEORGIA AND TEXAS, USA
After-sales & Service

LNG has seen an increase in demand as a more environmentally friendly alternative to reduce carbon emissions and help combat global warming. In addition to being cleaner than coal and oil, LNG allows energy supplies to be diversified.

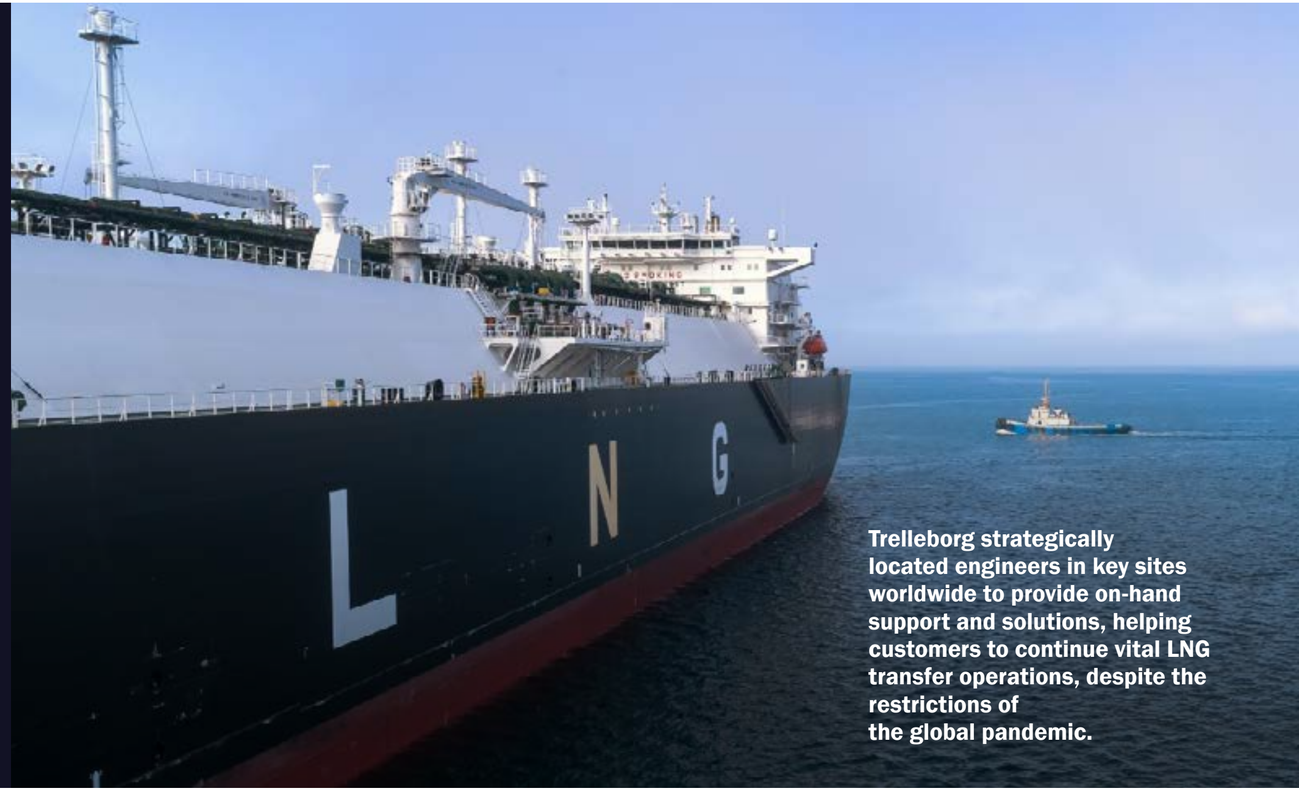
LNGCs are central to supply channels and their ongoing continuous availability for worldwide operations is critical to the supply chain. However, political instabilities and the demand for gas independence have caused a severe impact on both the ability to travel worldwide and the transporting of LNG.

Challenge: With the LNG market growing rapidly, vessels ordered and supplied in recent years have needed to be commissioned and put into service. At the same time, global events during the Covid 19 pandemic highlighted the need for more flexible and resilient LNG supply routes.

It was crucial that vessels are not delayed in becoming operational because of these challenges. Consequently, customer requirements for site commissioning and service also became more urgent with shorter time scales placing more demand on LNG operators.

Solution: As the world's leading supplier of SSL systems, Trelleborg was capable of rising to the challenge. Trelleborg reviewed engineer travel plans with increased use of longer-term secondments to key locations, reducing the impact of quarantine and allowing for work to continue despite restrictions.

Our team of engineers strategically located in key locations across the world allows us to provide excellent service to our customers even in the face of ever-changing restrictions.



Trelleborg strategically located engineers in key sites worldwide to provide on-hand support and solutions, helping customers to continue vital LNG transfer operations, despite the restrictions of the global pandemic.

Service across the globe with remote installation capabilities

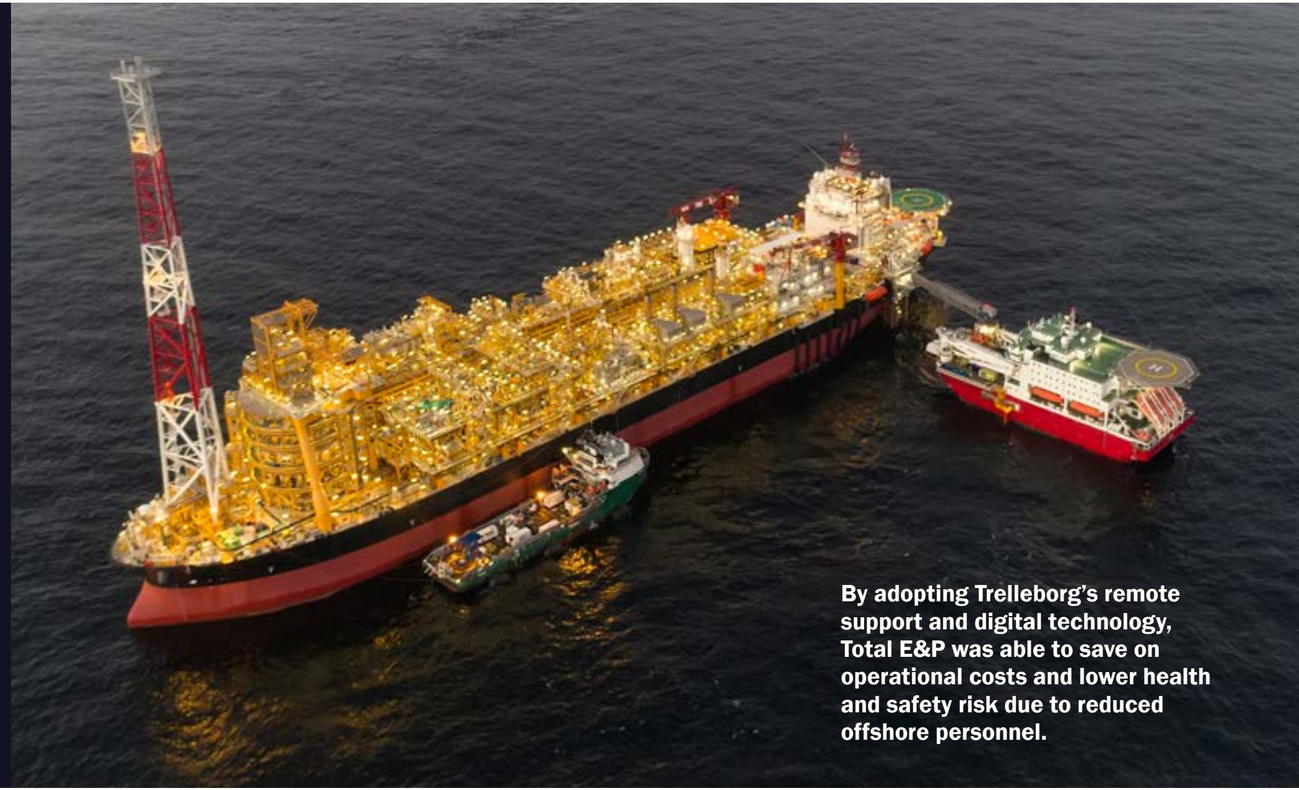
TOTAL E&P, ANGOLA
Navigation and Piloting, FPSO

The offshore facilities of Total E&P are often located in remote locations, making it difficult to access them. Yet, work was underway to upgrade the navigation and piloting systems and buoy monitoring systems for one of Total E&P's operated floating production storage and offloading units (FPSO) in Angola.

Challenge: As part of its plans to upgrade its systems and create more remote operations for its offshore assets, Total E&P required a strategic partner capable of supporting the installation, data integration, software uploading, and commissioning of the equipment. With the COVID-19 pandemic restricting travel and making it unsafe, providing remote assistance became essential.

Solution: The successful installation of Trelleborg's SafePilot Offshore solution resulted in a new standardization of equipment onboard multiple FPSOs in the Angola area. As a sophisticated navigation and piloting system designed specifically for the oil and gas market, SafePilot Offshore delivers superior situational awareness and visibility with a highly intuitive, easy-to-use touchscreen technology providing pilots with greater control, safety, and accuracy during port approaches and maneuvers. This heightened precision and control optimizes the operational window, allowing for safer and more efficient maneuvers in a critical offshore environment.

Trelleborg's remote installation capability eliminates the need for field visits. Having successfully installed the remote system in Angola, Trelleborg has since been awarded contracts for upgrading other Total E&P assets, thus strengthening the relationship and proving credibility.



By adopting Trelleborg's remote support and digital technology, Total E&P was able to save on operational costs and lower health and safety risk due to reduced offshore personnel.

Dynamic positioning in ship-to-ship transfer operations

SHIP-TO-SHIP OPERATION
Navigation and Piloting

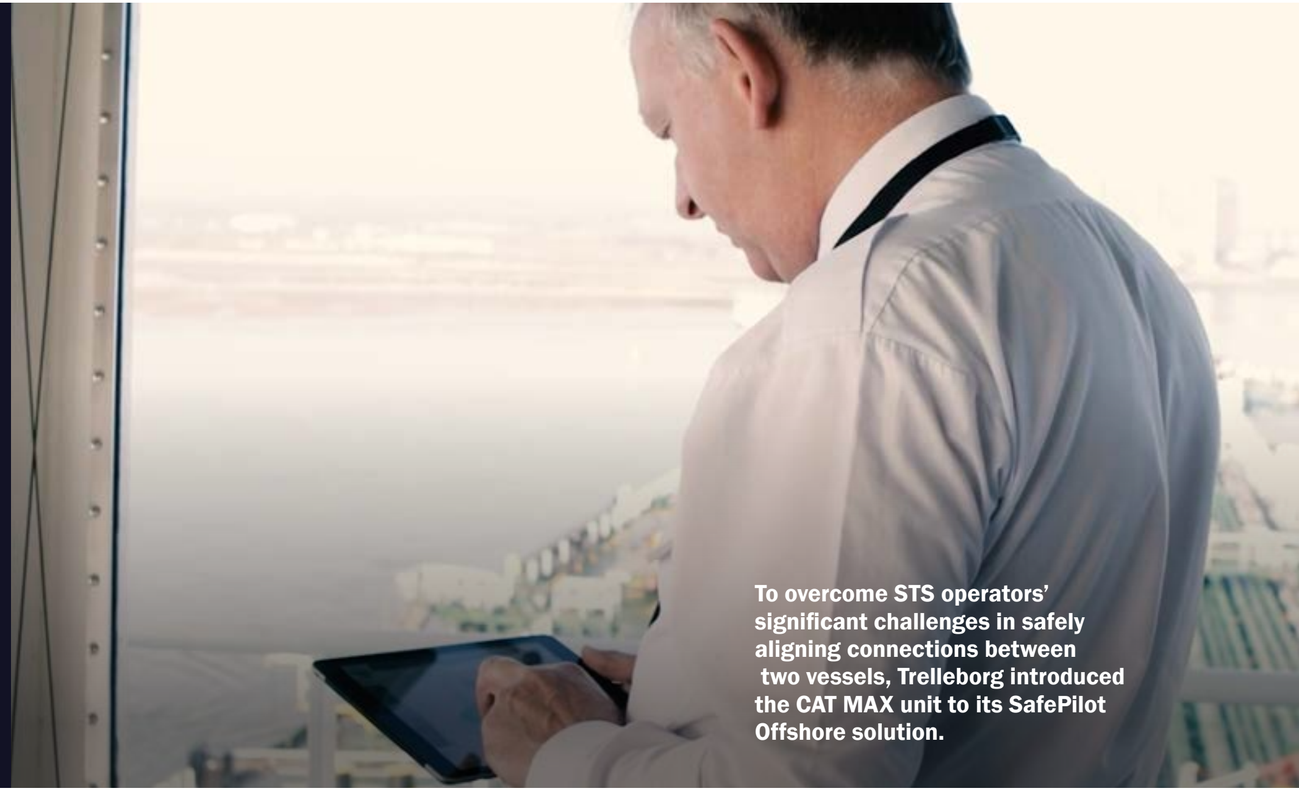
Ship-to-ship transfer operations can be challenging, whether they are performed offshore or nearshore. Assuring timely and safe operations requires precision alignment of both ships' manifolds in a single attempt, without using tugs to pull off and realign.

The ships' built-in systems are designed for open-water navigation and lack the specific overview and high precision required to perform STS maneuvers safely and accurately. However, as offshore LNG fueling becomes more prevalent, safe STS maneuverability is key.

Challenge: A brainstorming session with a major STS operator highlighted the challenge of measuring manifold alignment in real-time for safe maneuvers. Offloading and receiving ships do not have the same equipment, and the equipment does not communicate digitally with each other. Positioning the two vessels dynamically during the operation requires that both vessels have well-coordinated situational awareness.

Solution: Using Trelleborg's SafePilot CAT MAX onboard and offshore positioning unit, our SafePilot Offshore solution can accurately position a ship on the first attempt. Built-in UHF two-way telemetry connects the systems on the two ships, providing the operations on both with a birds-eye view of the operation.

Now in use all over the world, the solution's iPad display shows the distance to go for manifold alignment, closing distances, and the speed for the two vessels. And, with the display updating every second, STS operators can achieve real-time precision to within 1cm accuracy.



To overcome STS operators' significant challenges in safely aligning connections between two vessels, Trelleborg introduced the CAT MAX unit to its SafePilot Offshore solution.

Securing a new energy hub in Africa

WEST AFRICA
Chain Stopper Operations

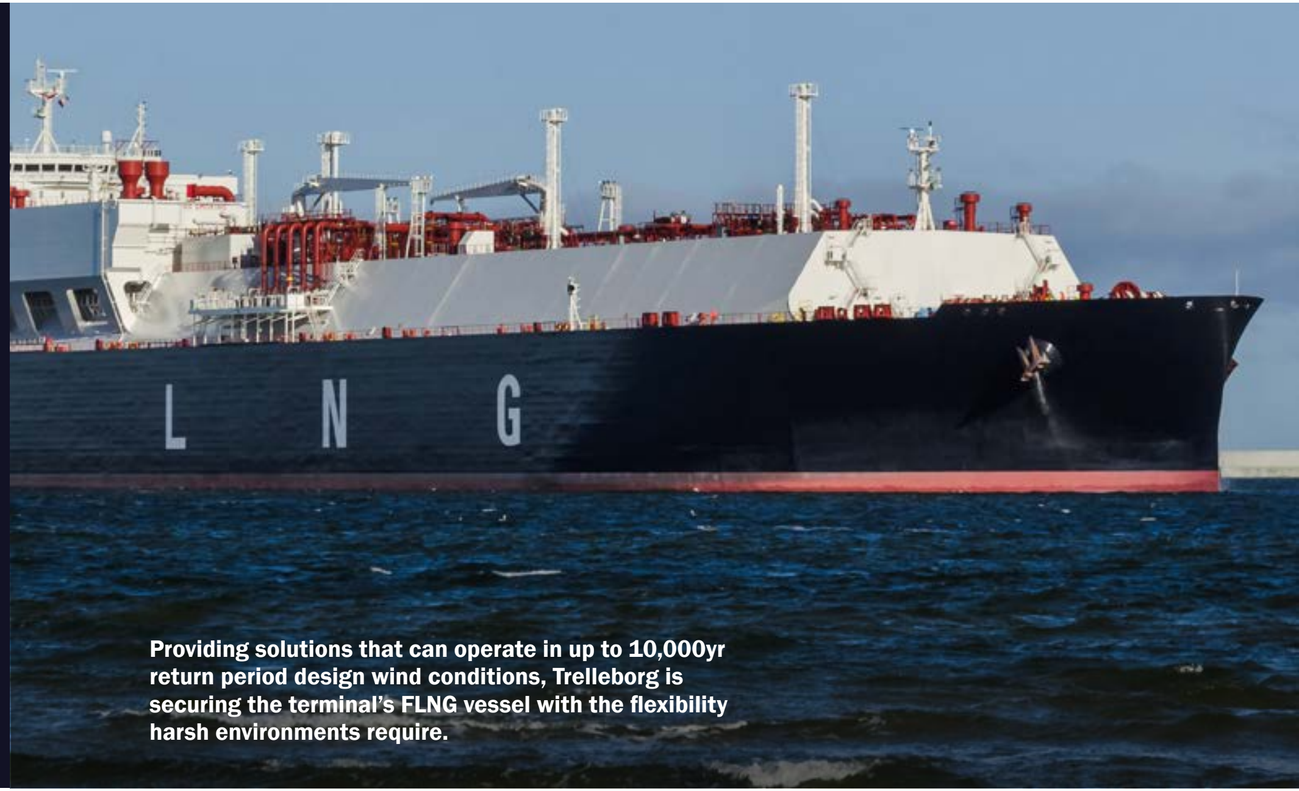
The permanently moored floating liquefied natural gas (FLNG) storage facility in West Africa experiences similar long-period, infra-gravity waves within the harbor, as act upon the LNGC vessels. However, being moored continually in the same location, the FLNG vessel must be more durable.

As a crucial element to the project's success, the FLNG vessel must be moored as rigidly as possible to enable production operations to continue. This would typically involve anchor chain systems – however, that does not enable adjustment to allow for vessel sway, surge motions and tidal or loading draft changes. Unplanned vessel excursions caused by line breakages can cause major safety hazards for personnel and disrupt product transfer operations.

Challenge: The project's FLNG vessel's mooring devices needed to be able to operate in up to 10,000yr return period design wind conditions. To keep mooring lines in tension, the chain segments required link-by-link adjustment and locking while continuously monitoring loads. This process would need to be repeated as required.

Solution: Early engagement in the project's design phase enabled Trelleborg to provide solutions to the FLNG mooring application challenges. A bespoke adjustable Chain Stopper device was developed to provide adjustment to chain tension by as little as 200mm using multiple jaws and a safe working load of 250T together with load monitoring. Additional features were developed for units specific to the project to assist in hazardous areas operation compliance, extra dynamic adjustment range, and system redundancy.

The FLNG vessel benefited from a reduction in mooring line loads and vessel movement, an improvement in mooring line safety zones, and sustainable and continuous product transfers.



Providing solutions that can operate in up to 10,000yr return period design wind conditions, Trelleborg is securing the terminal's FLNG vessel with the flexibility harsh environments require.

Using flexibility to deliver security

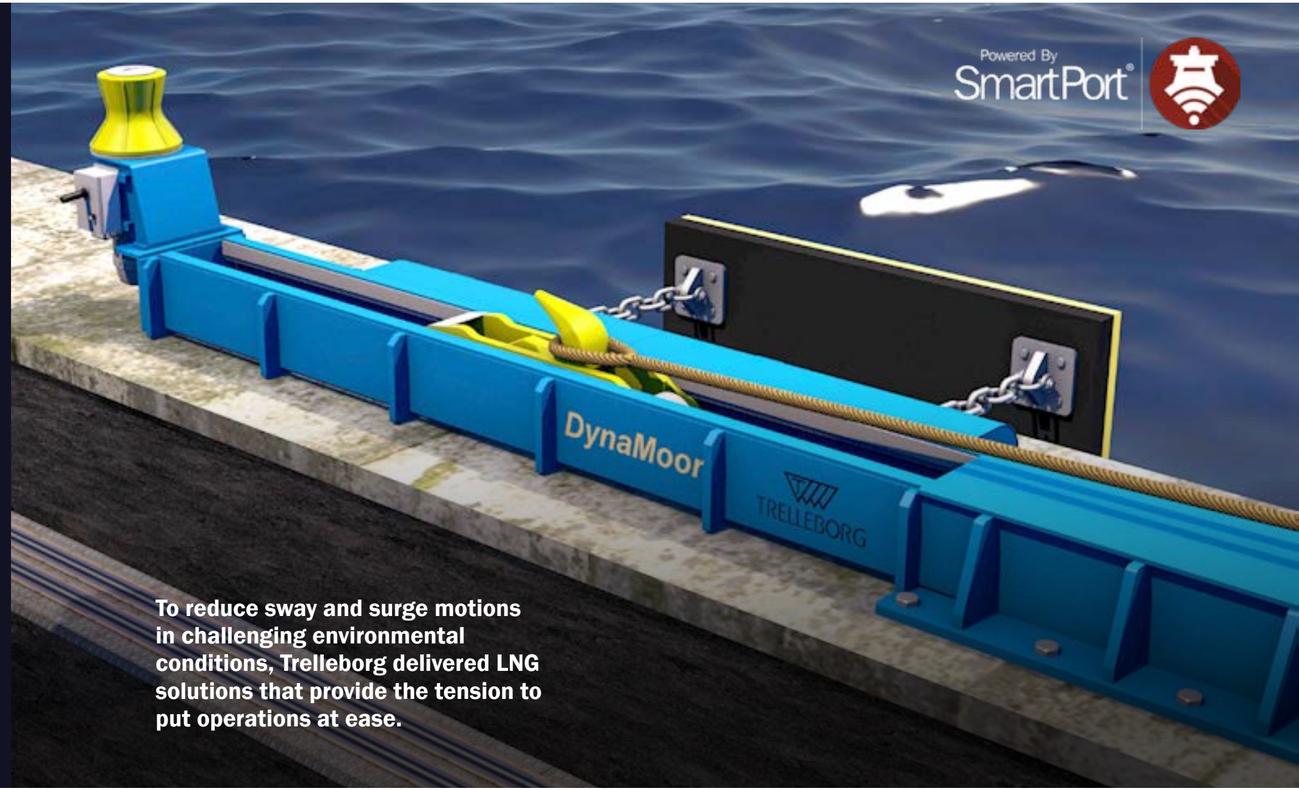
WEST AFRICA
Docking & Mooring

Bringing a new energy hub to Africa in the form of an LNG terminal was a great achievement, but it required the construction of an artificial harbor on the West African coast. Because it is an offshore facility, the harbor is exposed to long-period infra-gravity waves that can induce sway and surge motions, unsettling vessels and causing high mooring line loads. This can lead to the snapping of lines, endangering mooring crew and transfer operations.

Challenge: Vessels remaining stationary is paramount to allow for the continuous transfer of LNG from the liquefaction vessel through the terminal jetty and onto the LNG ocean-going carrier vessels. To operate in up to 1,000yr return period design wind conditions whilst running passively as often as possible to minimize power demand from the port facility, the solution would need to dampen the vessel's motions through dynamic adjustment of mooring line tensions.

Solution: As part of our jetty-based solution for dampening vessel motions, Trelleborg developed DynaMoor automated dynamic mooring devices that resist natural frequency forces and limit peak mooring line loads.

Trelleborg supplied and installed DynaMoor units that would provide the extra dynamic adjustment range and additional redundancy that the terminal required. This resulted in the reduction of mooring line loads and vessel movement, improved safety in the hazardous mooring line zones, and continuous and sustainable product transfers.



To reduce sway and surge motions in challenging environmental conditions, Trelleborg delivered LNG solutions that provide the tension to put operations at ease.

Assuring compliance with evolving safety standards

PESO ACCREDITATION, INDIA
Hazardous Area Compliance, Global Docking & Mooring Market

Safety is paramount across the oil and gas industry – with a particular focus in the LNG sector. Mismanagement of combustible materials can result in the release of gases or vapors into the environment, which can result in serious injury to personnel or equipment damage.

Regulatory bodies in many countries and regions have established standards and guidelines for equipment used in port operations so that terminal operators are able to ensure the highest safety standards worldwide.

Challenge: In India, the Petroleum and Explosives Safety Organization (PESO) sets the requirements for equipment containing electrical systems at new or upgraded LNG facilities. To meet new PESO accreditation requirements, terminals in India now need to meet highly technical local standards for electro-mechanical machinery that operates in hazardous areas.

Solution: For 12 months, Trelleborg worked with its certification agent and key supply chain partners to record technical documentation regarding all electrical systems and enclosures, which needed to be assessed by PESO for suitability for hazardous area operation. Trelleborg's Quick Release Hook mooring systems are PESO-certified for use in the Indian market, and are fully compliant with Indian laws and regulations that govern the operation of LNG facilities. Trelleborg's Ship-Shore Link also uses PESO certified equipment.

Trelleborg is the largest PESO-accredited Docking and Mooring equipment manufacturer, giving customers needing QRHs the confidence that our equipment is certified. With this accreditation, EPCs and terminal owners can avoid unforeseen budget overruns and schedule delays due to compliance issues.

Trelleborg's accreditation means EPCs and terminal owners can move forward with confidence.

Ensuring accurate, continuous performance over years

THE MIDDLE EAST
Gas Service & Maintenance Program

Over 400 QRHs, including class-leading MLM systems, were supplied to Trelleborg's key client in the Middle East and are currently used on site at various jetty facilities. However, as the installed equipment has progressed through its operational lifecycle, our customer faced the problem of regularly maintaining all of the equipment to ensure safe, accurate, and sustainable mooring operations.

Challenge: Among the most challenging aspect in this project was keeping the 400 QRHs calibrated, certified, and operating within international guidelines. Accurate MLM systems were necessary to ensure mooring lines were constantly checked for appropriate tension, keeping the vessel securely restrained at berth during LNG transfers.

Solution: Trelleborg developed a new Load Cell Exchange program to ensure regular calibration of the load monitoring system on each QRH for the customer as part of an extensive tailored service and maintenance program. A set of replacement load cells was developed for operational spares sets at the customer's facilities that allow load cell swap-outs on planned maintenance schedules. Load cells identified for maintenance are returned to Trelleborg for reconditioning and recalibration to be ready for their next deployment.

This ensures that the equipment performs at its best, ensuring operator satisfaction.

Trelleborg is delivering the LNG solutions that keep mooring operations and product transfers continuing safely and sustainably.

Upgrading links to adapt to increasing LNG demands

THE MIDDLE EAST
LNG Terminal

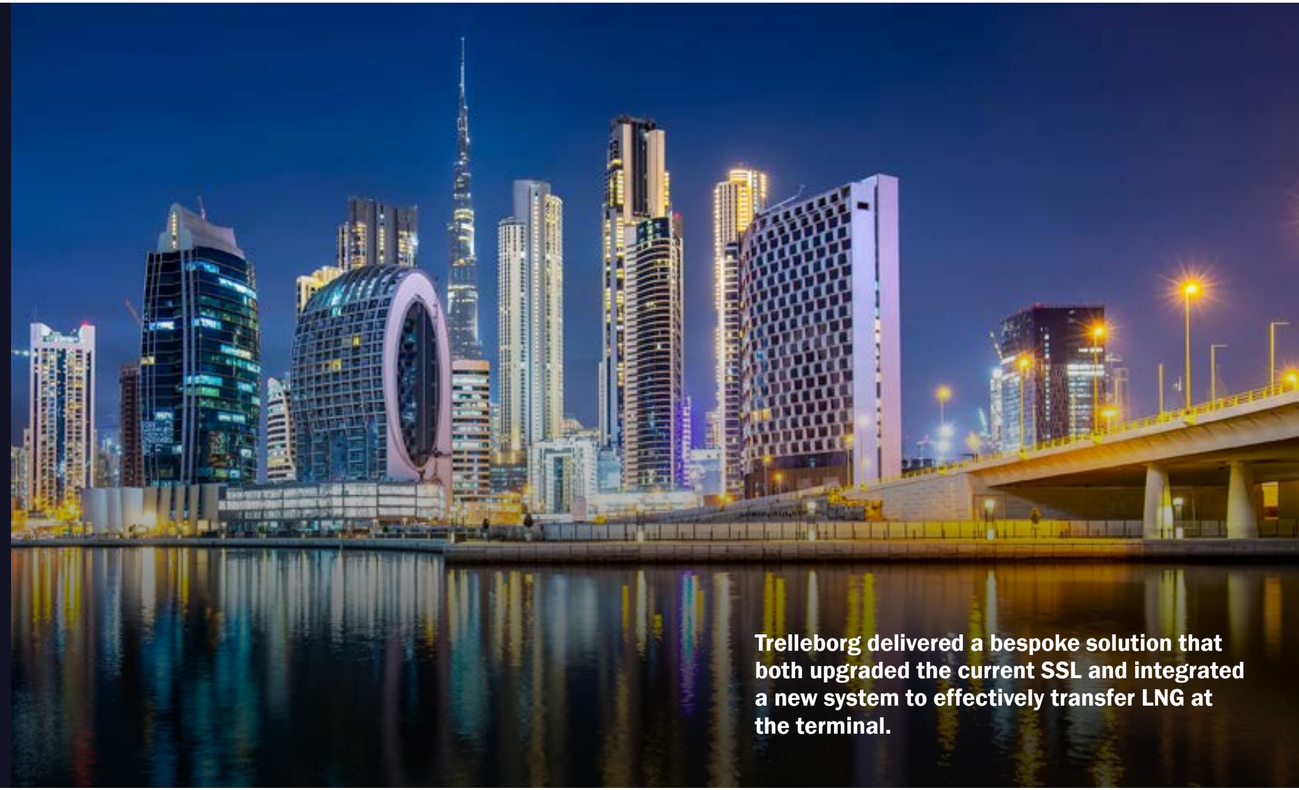
Increasing energy requirements demanded an upgrade of the existing floating storage regasification unit (FSRU) at the LNG terminal. As the FSRU would remain permanently moored at the jetty without any personnel, it needed to be capable of functioning independently. This meant that the terminal had to be equipped with a highly efficient SSL system to ensure that LNG was transferred safely and effectively.

Challenge: The previous FSRU did not have a compatible SSL system, meaning a bespoke FSRU had to be supplied that could sufficiently integrate with the existing port-side SSL infrastructure. The current SSL also needed upgrading, to move the port from a 'ship FSRU' interface, to a full 'terminal' system, allowing the FSRU to operate efficiently while unmanned.

Solution: Trelleborg provided a bespoke solution that incorporated three separate electrical links – standard SSL communications, jetty platform emergency shutdown (ESD) integration, and jetty QRH signal connections.

This involved replicating the original SSL interface and adapting it to suit the new vessel, along with upgrading the existing SSL to be capable of full ESD, telecoms, and MLM signaling. Any signals not needed by the new arrangement were removed, helping to save costs. Trelleborg also supplied fender systems and docking and mooring equipment.

Upon completion of the project, the existing jetty could continue to function with a new, more efficient FSRU.



Trelleborg delivered a bespoke solution that both upgraded the current SSL and integrated a new system to effectively transfer LNG at the terminal.

Enhanced LNG hose transfer systems

MEDITERRANEAN TERMINALS
Ship-to-Ship, LNG

With increased demand for LNG in Europe, Mediterranean terminals have become strategically more important in securing gas import. At the same time, new opportunities for small scale LNG have also risen. The combination of these factors requires LNG hose transfer systems to be as versatile as possible. For example:

- Higher frequency of transfer operations.
- Compatibility with large scale (up to Q-Max) and small scale (bunkering) LNGCs.
- Reloading capacity: from ship to truck.

Challenge: An FSRU had to be equipped with a ship-to-ship (STS) hose transfer system (HTS) capable of being connected to a wide range of large scale LNGCs for LNG import and deliver frequent operations on a weekly basis. The same HTS also needed to connect with small scale LNGCs to reload small quantities of LNG – mainly for the bunkering of ships.

Solution: Trelleborg designed and supplied state-of-the-art KLAW 10" SIL2 HTS for large and small scale loading and reloading frequent operations.

This innovative system integrates advanced diagnostic and monitoring features, requiring only minimal adjustments to ensure compatibility with different sizes of approaching vessels.

A 3" ship-to-jetty system was also supplied for truck loading. This system is unique in the world of the LNG industry and the terminal is the first to perform a complex LNG reloading operation directly from the FSRU vessel to trucks.

Custom retrofit ensures operational continuity at major Japan LNG terminal

SHIP-SHORE LINK, LNG INFRASTRUCTURE & TERMINAL OPERATIONS

For decades, Japan's LNG infrastructure has relied on standardized Ship-Shore Link (SSL) systems for the safe transfer of cargo. This nationwide uniformity ensured predictable operations but also created a hidden vulnerability. When the sole domestic manufacturer for all 36 of the country's terminals exited the market, the entire network faced an unprecedented operational risk. Without support, spare parts, or replacements for this critical safety link, any system failure could halt operations, creating costly and potentially hazardous situations.

Challenge: A prominent LNG import terminal was the first to address this problem, needing to urgently replace their aging, now-unsupported SSL system to guarantee operational continuity. However, the standard Trelleborg SSL system was physically too large for the space occupied by the legacy unit. Also, the new technology had to seamlessly integrate with multiple existing systems on-site. As the first of its kind in Japan, Trelleborg needed to provide absolute assurance of its system's reliability and demonstrate a deep, long-term commitment to the Japanese market.

Solution: Trelleborg worked in close partnership with the client to engineer a solution that addressed every unique challenge. Understanding that a standard product would not suffice, Trelleborg developed a customized, compact version of its advanced Gen3 SSL system, specifically designed to match the exact footprint of the legacy equipment.

This "plug and play" solution was engineered for a straightforward retrofit and guaranteed full compatibility with existing systems. To demonstrate its commitment, Trelleborg provided a fully localized package, including Japanese-language interfaces and documentation, alongside in-country technical support and a dedicated spare parts inventory. The swap to Trelleborg's custom-engineered SSL system eliminated the critical operational risk posed by the unsupported legacy equipment. The terminal not only secured its operations but also upgraded its capabilities with advanced features, enhancing both safety and efficiency for a future-proofed, reliable LNG transfer process.

Streamlining logistics for a major U.S. Gulf Coast LNG project

TEXAS AND LOUISIANA, USA, AFTERSALES SERVICE AND SUPPORT

A major energy infrastructure initiative is underway on the U.S. Gulf Coast, aiming to significantly boost liquefied natural gas exports. The first phase is under construction, with operations expected to begin in the next few years. A second phase is in development, which will double the facility's output. The project has attracted substantial investment and international partnerships, reflecting its strategic importance for global energy markets. It promises to enhance energy security, support economic growth, and strengthen the U.S.'s role in global energy supply chains. Regulatory approvals and construction milestones continue to advance its progress toward full operational capacity.

Challenge: The customer is facing logistical and operational difficulties due to receiving multiple equipment and fender system batches simultaneously across different project phases. Components are being moved around a large greenfield site, leading to minor damage, loss, and misplacement. There is confusion in interpreting the bill of materials, resulting in mismatched components across phases and locations. Contractor personnel lack adequate knowledge in handling, storing, assembling, and commissioning the products. These issues are compounded by a tight construction window, making timely and accurate execution critical.

Solution: To address these operational challenges, a comprehensive support plan was implemented. Onsite assistance during delivery ensured accurate verification of shipping documents and component identification, which immediately resolved discrepancies. To simplify the bill of materials and minimize mismatches, visual guides and phase-specific material kits were introduced.

Prior to installation, contractors were equipped with instructional videos and detailed manuals to aid their preparation. This was followed by hands-on, onsite training sessions covering the proper handling, storage, and assembly of the products. For the initial installations, Trelleborg provided direct onsite supervision to ensure correct execution.

For final setup and commissioning, step-by-step manuals and remote technical support were provided to validate performance and certify the systems. Post-installation, maintenance planning and product registration were streamlined via a QR code platform. This integrated approach ensures long-term support through periodic inspections, spare part assistance, and ongoing sales support, guaranteeing sustained performance throughout the system's lifecycle.

Integrated berthing systems enhance operations at French LNG terminal

NORTHERN FRANCE, END-TO-END SOLUTIONS

To bolster France's energy security, a major LNG terminal in northern France has been equipped with an integrated suite of Trelleborg's solutions to support the port's first-ever Floating Storage and Regasification Unit (FSRU). The project at this key maritime hub is designed to increase the country's regasification capacity by optimizing the critical berthing process for LNG carriers.

Challenge: The efficiency of the berthing process is paramount to the terminal's success. Any delays or errors can impact operational safety and create costly disruptions for both the port and vessel operators. The project required a comprehensive system that could ensure safe vessel approaches, secure mooring, and efficient product transfer, all while minimizing the margin for error.

Solution: Trelleborg was engaged to provide a wide range of mooring, berthing, and navigation solutions. The quay walls were outfitted with customized Trelleborg Pneumatic Fenders and inverted Superior Cone Fenders (SCN). The berthing process is managed by an integrated system that includes Quick Release Hook Units, an Environmental Monitoring System, and the SmartDock Docking Aid System. This data is fed into a Central Integrated Monitoring System for complete oversight. For vessel navigation, the solution includes SafePilot CAT PRO and SafePilot Pro Navigation with Docking software. Additionally, the existing Ship-Shore Link was upgraded to the Gen3 system to enhance data transfer during operations.

This integration of multiple advanced berthing solutions significantly reduced the margin for error, leading to smoother and safer operations. The system provides pilots and operators with real-time data for vessel approach and mooring, which helps reduce downtime for vessels and their associated loading and unloading processes. The result is a direct increase in terminal productivity and a safer operational environment.

Critical sensor upgrade restores monitoring at Indian LNG terminal

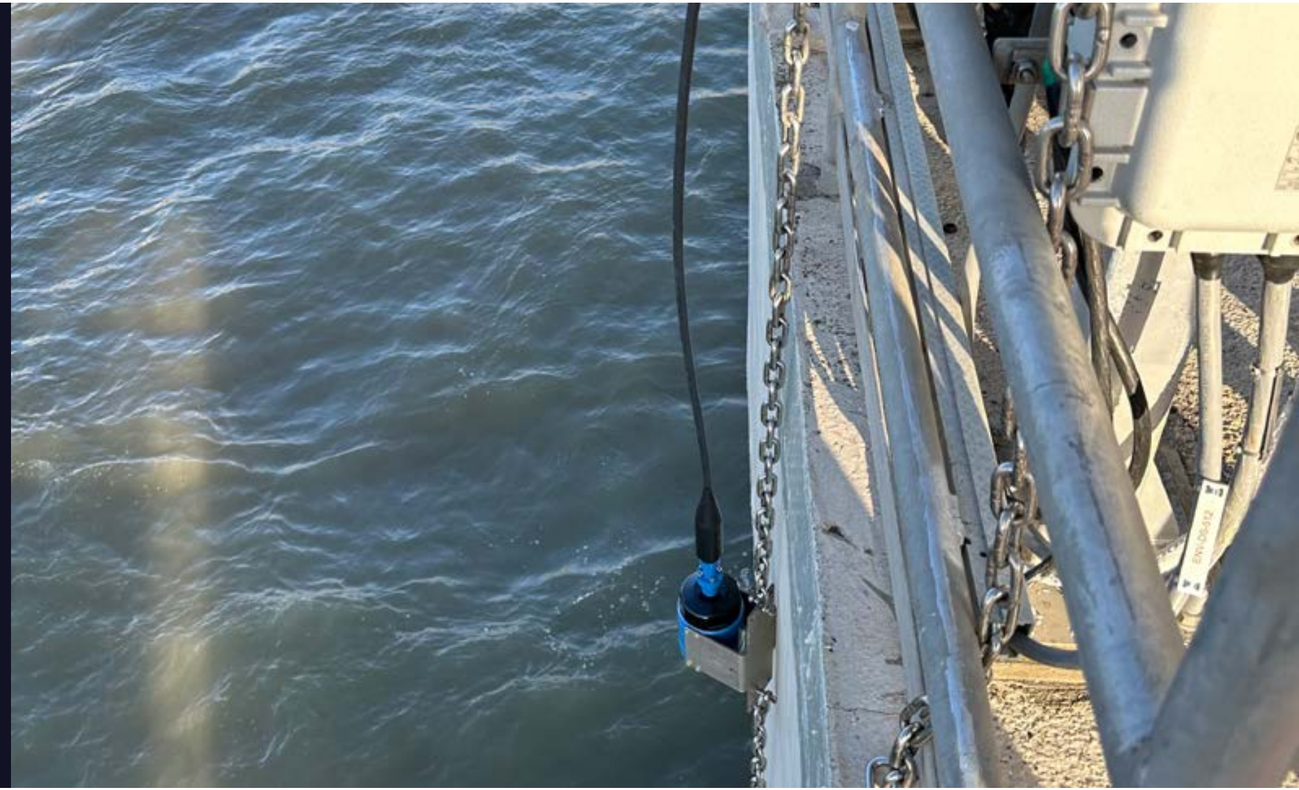
KONKAN LNG, INDIA, LEGACY SYSTEM UPGRADE

Following a recent software upgrade to its DockMaster system, a major LNG terminal in India faced a critical hardware failure when its current sensor, an older, obsolete model, became faulty. A direct replacement was not possible, requiring the integration of a newer, more advanced model with the existing legacy hardware to restore full operational capability.

Challenge: The primary technical challenge was integrating the new-generation Trelleborg current sensor (DCS5800R), which uses an RS422 interface, with the terminal's older hardware designed for a nowobsolete RS232 sensor. The Trelleborg service engineer had to perform this complex integration under challenging site conditions, including high temperatures, no internet access, and significant time zone differences with the remote software support team. With the monitoring system down, the project was under considerable pressure to restore functionality quickly.

Solution: A direct communication link to the system's embedded computer was established by connecting a laptop and configuring a static IP address. This allowed access to the DockMaster browser environment where the system parameters could be reconfigured. Working in coordination with Trelleborg's remote software team, the system was updated to recognize and process data from the new sensor. The faulty unit was then physically replaced with the new DCS5800R sensor, and the entire system was tested to confirm full functionality.

The successful integration of the new current sensor restored full operational capability to the terminal's environmental monitoring system. This rapid intervention prevented potential downtime and ensured the terminal could continue to operate safely with accurate, real-time data on current speed, direction, and temperature. The project highlights Trelleborg's ability to solve complex legacy integration challenges under demanding field conditions, ensuring asset longevity and operational continuity for its customers.



Optimizing gas transfer

COMPLETE SOLUTIONS FOR RECEIVERS AND SUPPLIERS

Trelleborg stands at the forefront with gas transfer solutions for the rapidly growing use of gas as a cleaner energy source and ship fuel. With proven expertise and an integrated offer covering operational optimization, service and support, advanced equipment systems, and crew training, we empower ports and ships to meet complex gas logistics demands and evolving environmental standards, ensuring every transfer is safe, efficient, and compliant.

OPERATIONS OPTIMIZATION
Smart and fully compatible transfers.

SERVICE & SUPPORT
Always on. Always there.

EQUIPMENT SYSTEMS
No spill. No pain.

CREW TRAINING
Competence you can count on.

Driving Safety, Efficiency, and Innovation Together

Trelleborg is your expert partner for gas transfer operations; where innovation meets precision, safety is paramount, and efficiency drives success. Our complete range of solutions and best-in-class service work together to optimize, protect, and future-proof your gas transfer operations.

SCAN FOR MORE INFO

TRELLEBORG

Trelleborg is a world leader in engineered polymer solutions that seal, damp, and protect critical applications in demanding environments. Its innovative solutions accelerate performance for customers in a sustainable way.

Trelleborg Marine and Infrastructure is a leading provider of premium solutions for critical marine, port, and built infrastructure applications. Its innovative polymer and smart technology solutions enhance operational efficiency, safety, and sustainability.

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