

# Avoiding the Disconnect



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## Executive Summary

The use of liquefied natural gas (LNG) is now a mainstream, commercial reality, as the demand for energy continues to rise. With natural gas being a reliable, clean burning fossil fuel and one that is in plentiful supply, it has become a truly viable, global resource.

To maximize the opportunities offered by natural gas, Floating LNG (FLNG) projects are increasingly being considered as the optimal project configuration, both for liquefaction and regasification. However, with these complex projects comes the need to re-examine docking, mooring and fendering solutions in order to meet the requirements of all stakeholders and provide the most safe and efficient operation.

Combining elements of both conventional jetty mooring and docking and offshore ship-to-ship mooring systems, and with more than two entities required to interface with each other, systems integration naturally becomes more complex and there is no “generic” docking, mooring and fendering package that can be applied to FSRUs.

## The Growing FSRU Market

Floating Storage and Regasification Units (FSRUs) represent the majority of FLNG projects currently being executed or in the pre-FEED stage, as they provide an attractive “fast track” solution for small markets and emerging economies. In particular, the Asian market is driving the rapid increase in uptake of FSRU solutions as fast-industrializing countries such as Indonesia, India and China step up their investments to expand LNG import capacity. Furthermore, traditionally isolated markets such as island economies are deemed to be a good fit for floating regasification.

## Holistic Considerations

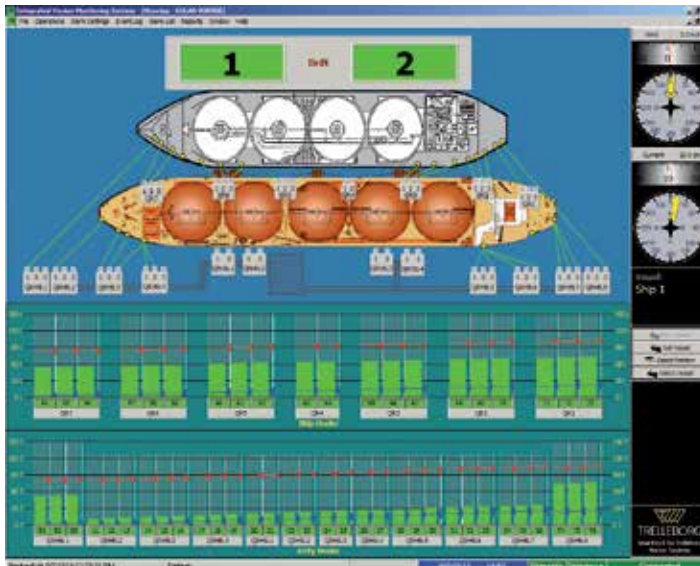
Systems integration becomes more complex in the FSRU market, thanks to the need to combine elements of conventional jetty mooring and docking, as well as offshore ship-to-ship mooring systems.

Additionally, with more than two entities required to interface with each other, there is no “generic” docking, mooring and fendering solution that can be applied to FSRUs. Historically, civil engineering practices associated with the jetty and traditional marine design practices associated with the vessel have been considered in isolation. A precedent has yet to be established to consider these mutually dependent systems holistically; however owner/operators are quickly realizing the necessity for this to ensure compatibility.

In the more complex case of FLNG mooring configurations, a comprehensive overview should be undertaken and the design requirements of all stakeholders aligned and coordinated. However, because of the timelines and execution methodologies typical to these projects, the jetty requirements and FSRU docking and mooring requirements often suffer from splitting the scope, resulting in system fragmentation and compromising safety and operational efficiency.

The Ship-to-Ship docking and mooring scope is a shipyard led activity, with a brief purely focused on the conversion of the vessel or a new build specification. The Civil Engineering EPC responsible for the design and construction of the jetty has an emphasis on site cost control, rather than the need to integrate the overall docking and mooring systems.

Through no fault of the shipyard, or the EPC, considering these two elements in isolation jeopardizes the entire integration of the overall system. Subsequently, it’s important that an experienced third party is present to provide oversight of the total integration requirements of the system.



An experienced third party can provide valuable systems integration oversight to ensure the three entities are aligned with all requirements met.

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## Class and Regulations

In terms of the regulations on design requirements for the three components, Marine Classification Societies, such as ABS, Lloyds, BV, DNV and RINA are focused on the FSRU and traditionally treat an FSRU project as a shipbuilding activity. As such, they provide design review and approval, oversight during construction and undertake hull and machinery surveys to assure compliance with a view to ensuring vessels fit for purpose as ships.

Although these organizations have specific requirements from a material and design standpoint for the mooring system hardware, Class does not comment on fitness for purpose in terms of the vessels' ultimate use in an FSRU project. Mainly, compliance is assessed from the standpoint of material selection, acceptable stress levels and a "fail safe" design philosophy.

On the other hand, regulations around the onshore, or jetty, side of the project are more operationally focused, with review from local or national authorities and organizations that represent vessel operators, such as OCIMF, SIGTTO and PIANC. However, these organizations are focused on guidelines for operational best practice and the recommendations they make for onshore considerations do not take into account the needs of the shipbuilder.

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## FSRUs from the Feed Stage

Thanks to the unique set of challenges and differing regulation requirements that FLNG projects bring about, a comprehensive approach to the design and functionality of the system, from the FEED stage, is required.

So, what exactly should be considered? The docking and mooring system for FSRUs consists of mechanical, instrumentation and control and monitoring elements - all of which must function together to assure safe and efficient operation across the three constituents: jetty, FSRU and LNGC. Compatibility at each interface ensures improved operational control, data sharing and flexibility for the FSRU.

There are numerous considerations to take into account for the instrumentation, control and monitoring systems. Design should begin with an assessment of the mooring, berthing and MetOcean data requirements of the jetty, the FSRU and the LNGC, as any information shared between them must be consistent and easily accessed.

So, what are the requirements of these diverse stakeholders?

- **The jetty:** may require plant operations and process oversight, as well as load monitoring data, MetOcean data and berthing data. Alternatively the jetty control room may be unmanned with all jetty operations such as loading, ESD, Mooring Tension and Emergency Release being transferred to the FSRU control room.
- **The FSRU:** require plant operations and process oversight, as well as load monitoring data, MetOcean data and berthing data. In many cases the FSRU may be used as the primary control centre for the monitoring of mooring line tensions from the jetty and those to the LNGC (in the case of STS mooring). The instigation of emergency mooring release of jetty and/or LNGC mooring lines will also be required from the primary control centre.
- **The LNGC:** needs to monitor and maintain the mooring system during cargo operations, so access to mooring line data is essential.
- All of the above rely on a compatible SSL for Emergency Shutdown control, Emergency Mooring Release and load monitoring data transfer, hot line communications and, increasingly for FSRU operations, a common data link between the 3 platforms.

Terminal operations during berthing, un-berthing and cargo operations will also require berthing aid data, MetOcean monitoring and mooring system load monitoring. Additionally, in some cases, a passive workstation may be required in a remote location to allow asset owners access to the current status of the combined operation. The system architecture should allow for such a situation.

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## Centralizing Communications

The various subsystems that constitute the overall monitoring system need to be considered comprehensively, so that all information can be accessed from single work stations in multiple locations.

The consequences of on-shore process project and counterpart shipbuilding practice philosophy are designs which treat each subsystem in isolation, resulting in multiple workstations and potential difficulty in gaining a clear picture of the operational environment during normal and emergency situations.

International Standards now address principles for the development and use of electronic systems in marine applications. While in each project, a different solution considered in isolation may be preferred, the standards address the need for interoperability to permit repaid deployment of alternative assets to maintain production at the facility.

It might be preferable to centralize on the FSRU, the jetty or elsewhere. In the case of side-by-side moored configurations it's also important to consider how the LNGC will interact with the jetty, with the FSRU located between the two.

Overall control of the system also needs careful consideration. Operationally, this should take into account both routine and emergency communication, as well as emergency shutdown functionality. Control should be centralized, but where and how needs to be determined to ensure that only the desired vessel is released.

## Ship Shore Link for FSRU and Floating LNG

International Standards and code requirements require that the LNGC and shore emergency shutdown systems are linked. As well as mutual ESD signals, the system supports the transfer of mooring tension and Met Ocean information between the ship and shore.

An fLNG facility, acting as the equivalent of a shore terminal will be equipped with the same link facilities as above.

For FSRU facilities, the discrete process involving jetty, FSRU, and LNGC will require an enhanced and interoperable SSL system to control LNG and send-out transfer safety and relevant mooring tension and Met Ocean information. The inter-compatible integrated system has been successfully applied to all FSRU projects since 2008, and will be the subject of a forthcoming whitepaper from Trelleborg Marine Systems.

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## Mechanical Measures

Physically, a compact footprint for the mooring equipment on the FSRU is necessary, to save valuable deck space and simplify the under-deck reinforcement requirements. High salt-spray ingress protection is also required for mechanisms, load cells, capstan motors and electrical control boxes.

## Mooring Capacity

Quick Release Hooks (QRHs) are an essential part of the docking and mooring system. However, we've seen a disconnect between the civil engineering EPC and the ship designers in the consistent specification of QRH Safe Working Load (SWL). This can potentially mean that the hooks selected for the Ship-to-Ship mooring arrangement have a different rating than the jetty based hook - a good example of the need to align the requirements of the different statutory bodies involved in jetty design and ship design, because this can become problematic when the jetty mooring equipment is shared by both the FSRU and the LNGC.



Understanding operational and information sharing requirements means a different solution may be required in each project.

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## Maintenance Considerations

The semi-permanent nature of the FSRU to jetty mooring typically means that the Quick Release Hooks are not operated as frequently as they would be at a conventional terminal, so special attention needs to be paid to using a low maintenance hook design to ensure that the release function operates properly when required.

In many cases of semi-permanent mooring, jetty mooring lines may incorporate short chain tails which may terminate on board the FSRU within chain stoppers. In this case, load monitoring becomes critical in managing the FSRU mooring.

## Mooring Lines Considerations

FLNG ship-to-ship (STS) operation requires the LNGC to be berthed with about five meters separation from the FSRU, so the design of the QRHs also needs to take into account the reduced mooring line length in this Ship-to-Ship configuration, as this effects shock absorption capabilities and the high transient loads may damage mooring lines particularly due to chafing through chocks. In this respect, deflections of the lines mooring the LNGC to the FSRU should be kept to a bare minimum. Layout of mooring hooks on the FSRU requires careful planning.

Another consideration is the fact that, in the Ship-to-Ship mooring arrangement, the mooring lines may be provided by the transient LNGC carrier which may result in lines of unknown condition and capacity. Consideration could be given to using dedicated lines stored on board and provided by the FSRU.

## Fenders

The fender system must also be considered as part of the mooring system, and on the FSRU, their associated deployment and retrieval systems. Here, the smaller footprint that's essential on the Ship-to-Ship operations needs to be considered.

Pneumatic fenders with chain tire nets have been the traditional choice for Ship-to-Ship operations. The downside of pneumatic fenders is that they cannot offer flotation redundancy, once punctured they will sink and, if filled with water, may overload the fender deployment system if lifted.

However, foam fenders can be manufactured without chain tire nets and provide lower frictional resistance since the fender skin can be of a low friction polyurethane material rather than rubber. Virtually unsinkable they could be considered a heavy duty alternative solution to pneumatic fenders and better suited for some FLNG projects. Foam-filled fenders can offer similar reaction and energy performance to pneumatic fenders and can be engineered to offer low hull pressure. Importantly, in the event of an LNG spill, foam fenders have been shown to be much more resistant to damage from low temperatures than pneumatic fenders.

Effective routine inspection of pneumatic fenders is needed as the tire protection and chain net can suffer considerable punishment. Consideration should be given to this, keeping in mind that fenders will be located along the edge of the deck, or even stored overboard.

High frictional resistance of the tires under compression can contribute to significant hull coating abrasion. Damaged fender tires potentially expose the chain net which can damage the painted steel hull.



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## Fender Retrieval Systems for STS

The effective deployment of fenders will be a “mission critical” operation for Ship to Ship (STS) berthing. Fender deployment systems require a number of special considerations relating particularly to operational safety, Factors of Safety against failure, operational redundancy and damaged state integrity.

The above issues are currently not adequately addressed by Class Rules or design codes specific to fender handling machinery. The use of offshore crane codes in determining design load criteria in our view provides a better fit to ensure an adequate level of safety is available to personnel operating the machinery. Consideration of the imposed dynamic loads from sea state conditions, retained water load in the fender tire net and snatch loads on machinery while deploying or lifting fenders from an aggressive sea state are addressed by an offshore crane code such as API 2C 7th Ed.

## Fenders for FSRU - Semi Permanent Jetty Mooring

The FSRU in many cases will be moored over the long term. The vessel will normally be hard up against fender panels due to the requirement to keep the mooring lines tensioned.

This subjects fenders, fender panels and associated chain and hardware to constant stress. Fender loads will be magnified during STS berthing and also with the LNGC alongside the FSRU. Other considerations such as low ambient temperatures and fender response from the effect of passing vessels must also be examined.

Selection of the correct fender is therefore not limited to Energy and Reaction performance requirements. Other factors such as rubber composition, aging, UV exposure, temperature and immersion must also be considered if longevity of the fender and its hardware is to be guaranteed. Likewise, reducing abrasion between fender facing and ship's hull and easy change out of damaged facing sections are also relevant considerations for semi permanent FSRU mooring.

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## Conclusion

With the growing prevalence of FSRU projects, it's essential that a more holistic approach is taken to docking and mooring systems, in order to pre-empt potential operational design problems. Learning from an industry leader, we will use the example of the work that we undertook with a major energy company, which is leading the way in considering the regasification terminal and its companion FSRU holistically and gives us an example of how docking and mooring systems might become more aligned in future.

One challenge that had to be overcome in this project was the amount of data that would be created through the various monitoring systems and how best to share this between the three components and the admin hub, which was located remotely. Although there was some commonality in the data the stakeholders required, some of their information needs were different.

All common data had to be shared efficiently and accurately, so that all parties had access to the same information, at the same time. In times of critical decision making, it's essential that every party has access to consistent data over a common interface to remove potential complexities that could cause serious disruption in time sensitive situations.

As such, the project became a total systems integration piece. On the FSRU, a permanent monitoring system was required for oversight of the complete mooring system.

An added complexity was the need for control of the outer Jetty QRHs used for mooring the LNGC from the FSRU, a function that would traditionally be performed by the jetty operators. The FSRU also has access to all Met Ocean data as measured from shore side systems, and controls the remote release of all LNGC lines, terminating on both the FSRU and the jetty.

The FSRU is able to view both the mooring loads from the LNGC and the total loads in the same way as they are viewed from the jetty. The system also has provision for a RTK GPS STS docking system which adds additional flexibility if an FSRU is relocated offshore, or in an environment in which traditional laser based berthing systems are not appropriate.

Thanks to the comprehensive approach that was taken, data can now be viewed from any suitably equipped remote workstation on the network.

This white paper is based on a presentation given at OTC Houston, May 2013.

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## About the Author

Stephen Woolway has devoted over three decades of his career to the marine, oil and gas sector. Before joining the Marine Systems division of Trelleborg in 2012, Stephen worked in commercial ship operations, shipbuilding and repair, marine machinery sales, ship management, design and related shore side infrastructure development. Stephen also holds an honors degree in Marine Engineering alongside a Masters in Business.

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