# Deriving data differently

**Danny Constantinis, EM&I Group, Malta,** discusses a new data gathering methodology for the floating gas industry, which uses robotics and digitised methods of data gathering and analysis to derive reliable data trends.

The monitoring and maintenance of floating gas assets is critical for successful operations throughout the working life of an asset. Common standards of safety, asset integrity and environmental protection are important for the industry, so that no major incidents occur which could damage the reputation of the rapidly growing floating gas sector. While there are distinct differences in the risks associated with floating gas and floating oil operations, there are nevertheless lessons learnt in relation to monitoring and maintenance in the floating production, storage and offloading (FPSO), drillship and semisubmersible sectors that can be applied to floating LNG (FLNG) production facilities and floating storage and regasification units (FSRUs). The trend towards monitoring as a more efficient way of planning

maintenance, depends on accurate and reliable data, gathered at low cost and preferably non-intrusively.

## Similarities and differences

FLNG and LPG assets are in many ways structurally similar to gas trading ships, although so far there are only a few in service. On the other hand, there are numerous projects in place that will increase the number of FLNG units sharply in the next few years, some based on conversions, others as new purpose-built units and possibly even novel designs such as catamaran and semi-submersible hubs.

The environmental conditions and water depths in which they operate can also vary widely, creating some operational challenges,

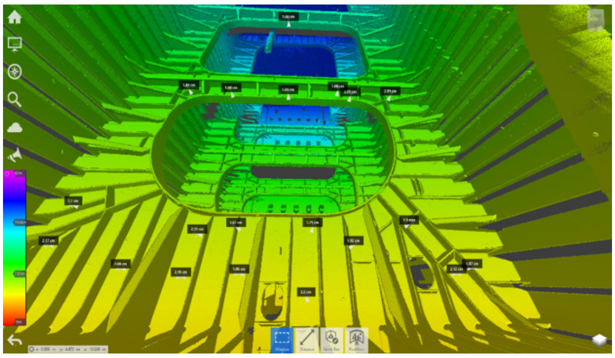


**Figure 1.** Laser image of storage tank.

**Figure 2.** Mooring chain with organic growth.

**Figure 3.** Mooring chain after cleaning.

but generally the monitoring and maintenance of these assets should not pose too many difficulties for our industry, bearing in mind the various innovative methods that are being introduced. FSRUs are perhaps more of a challenge because, while clearly similar in basic structure, machinery, piping and Ex equipment to the LNG carriers from which many of them have been converted, the conditions and location in which they operate are quite different.

FSRUs are generally associated with gas powered generating stations and are often located in river estuaries and/or near to the major conurbations where the power is required. The structures are not likely to experience the load conditions of a sea going vessel so it is likely that structural fatigue will be lower in most cases. If FSRUs are attached to a jetty for long periods, they may be affected by storms coming from directions open to the sea, which might make it necessary to move an asset a safe distance away from the jetty, or even out to sea; the latter requiring the asset to have serviceable propulsion and steerage systems. Proximity to the jetty might also have an effect on hull corrosion and protection systems interfering with any protection systems on the jetty. Marine growth could also be a challenge with respect to the need for regular cleaning, firstly to ensure that the unit remains capable of suitable sea-going performance and secondly to ensure that removal and disposal of heavy marine growth for hull in-water inspection does not create an environmental issue. Other challenges to in-water inspections include water clarity, turbidity and strong currents that can make underwater operations difficult, especially for divers carrying out inspection or maintenance tasks. Other considerations include the possibility that FSRUs located in shallow and/or tidal waters may experience the effects of increased corrosion or particles blocking piping, filters, water ballast tanks and so forth.

The fact is that floating gas is an exciting industry that is pioneering the delivery of electrical energy. Whilst we have new issues to deal with, our industry has the organisational skills and technology that can be further developed to meet the challenges.

## Meeting the challenges

The topic of reliable, non-intrusive and low-cost monitoring as the basis for more efficient maintenance points to robotics and digitised methods of data gathering and analysis. This theme has been the backbone of a number of joint industry projects (JIPs) and industry projects seeking new technology or adapting existing technology from other industries to meet our needs. It is worth mentioning that adapting technology seems to be far less expensive, and is a faster way to get new methods to the work face, rather than developing the required systems from scratch.

There are a number of JIPs that are proving to be an efficient way of improving safety, reliability and integrity assurance.

### HITS JIP

EM&I has led the hull inspection techniques and strategy (HITS) JIP on behalf of the Global FPSO Research Forum for the last six years. HITS has produced some ground-breaking innovations and technologies, many of which could also be used in the floating gas sector.

The HITS JIP formula works well because it includes representatives from most of the oil and gas majors, operators and the major class societies, making it an ideal forum for cooperation and consensus when it comes to agreeing common standards and approving new innovations and technologies.

## FloGas JIP

The Global FPSO Research Forum recently decided to set up a new JIP for the floating gas sector and held the first meeting in Singapore earlier this year with another planned for Houston in October 2019. This will explore the particular needs of the floating gas sector, both for FLNG and FSRU asset types.

The FloGas JIP will start by gaining consensus from participants on the top three challenges they wish to solve and then developing plans and budgets to encourage industry to come forward with innovative solutions that can be evaluated and improved. For example, inspecting cryogenic tanks without man entry could be one of the challenges.

Technology that allows the tanks and internal structure to be inspected without man entry could be a useful improvement. Similarly, submerged gas pumps within FSRUs need to operate pretty well continuously, so a means of inspecting or maintaining these might well be needed, for example by withdrawing them from the tank, in order to avoid tank entry.

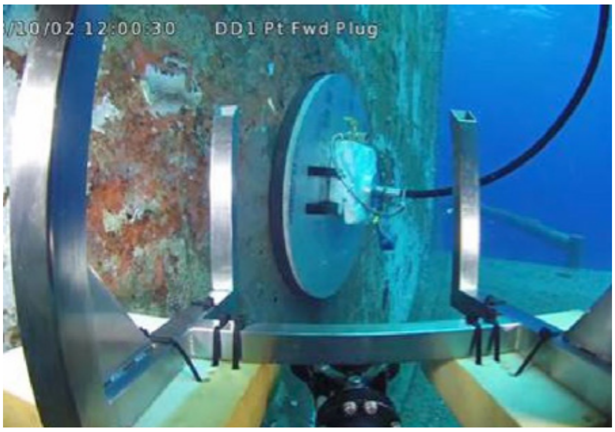



**Figure 4.** Inflatable bladder inserted by mini ROV.

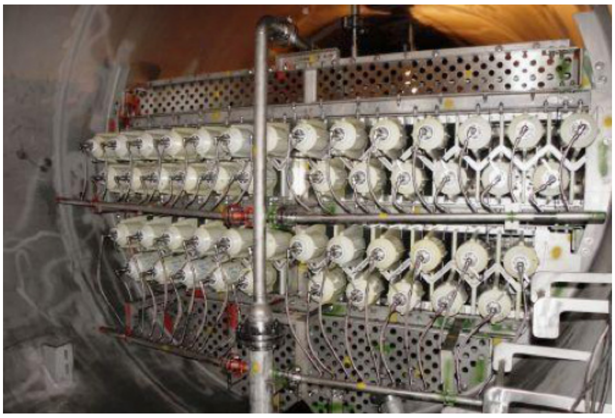
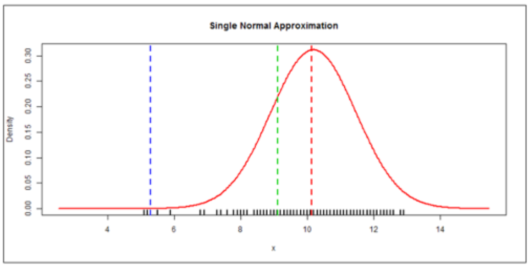


**Figure 5.** Interior of pressure vessel.

| Corrosion Circuit | Line IDs | No. Datapoints | Normality Test | NomWT (mm) |
|---|---|---|---|---|
| CC-WP2-CS-1 | Grid Scans on: 16"-WP-F24420-01C24 20"-WP-F24001-01C24 | 288 | Failed | 9.52 - 12.7 |




Probability Values:

| Alarm | Probability | Value |
|---|---|---|
| Alarm 1 = 10.113 | P( X < 10.113 ) | 0.4837 |
| Alarm 2 = 9.113 | P( X < 9.113 ) | 0.2012 |
| Alarm 3 = 5.291 | P( X < 5.291 ) | $1x10^{-4}$ |
| MAWT =1.469 | P( X < 1.469 ) | $1x10^{-9}$ |

**Figure 6.** ANALYSE curve with probability values.

## Robotics and digitisation will be the new norm

We are approaching a time when class society surveyors will not be willing (or required) to enter tanks, work at height or in confined spaces. Robots take many forms and it is already clear that UAVs, remotely operated cameras, crawlers and walkers are already being developed and used both below and above water. Wherever it is dangerous, difficult or expensive to use human intervention, there is an opportunity to use robotics. While we currently adapt robotic methods to work with existing asset designs, it is likely that new designs will be built to include features that enable much greater levels of robotic intervention.

The HITS JIP has helped introduce the use of robotic high-performance cameras for tank inspections, adapted from the nuclear industry, where the culture of 'no man entry' is well developed. These cameras can operate effectively at -50°C or less, so could be used to inspect cryogenic tanks without having to take the time to bring the tank to temperatures that make them safe for man entry.

Laser technology was also encouraged by HITS for FPSO tank inspections and this method could also prove useful for inspecting LNG containers. Moreover, this technology can assist with the creation of 3D models that could be used for monitoring assurance.

Diverless underwater inspections and repairs have also been developed for the FPSO and drilling industries. These methods are equally applicable and beneficial for the floating gas industry. Diverless under water inspections in lieu of drydocking (UWILDs) are now well developed with purpose built 'inspection class' remotely operated vehicles (ROVs) fitted with specialised cleaning tools that do not damage coatings, and therefore allow a high-quality inspection and non-destructive testing (NDT) of hull components and mooring systems. The same tools are used to remove marine growth from seachest inlet grids, risers and so forth.

Isolation valves are another critical component that can be inspected and maintained without divers. Specialised access ports are welded to the piping adjacent to the valves through which robotic cameras with integral lighting systems are inserted. This allows valves to be inspected in-situ and during normal operations, without shutting the systems down either to install the access ports or to carry out the inspections, thus saving time and cost while improving safety. Should a valve require repair or replacement, then specialised sealing systems can also be temporarily installed to allow the valves to be repaired or replaced again without diver intervention. Diverless solutions are also being developed for assets requiring significant steel renewals under water using robotic cofferdams.

Ex electrical equipment also forms an important part of monitoring and maintenance with many thousands of pieces of equipment requiring some form of general visual or internal inspection, the latter requiring the relevant systems to be shutdown.

There is a new methodology that avoids the need to shutdown systems, which can instead carry out internal inspections using a radiographic system adapted from the medical and security services world. This system provides a permanent record of the condition of the equipment and thus the ability for non-intrusive monitoring so that maintenance can be planned well in advance.

An interesting technical development on the cusp of being validated offshore is a mooring and riser system inspection system based on equipment originally designed for cutting down trees. This has now been developed to carry cleaning tools, NDT, photogrammetry and other inspection equipment, but with an eye for potential repairs in the future.

While all of the systems described fulfil the policy of monitoring using digitised reporting tools gathered by robotic methods, there are further developments which monitor continuously. One example of this is a system under development that monitors the internal condition of pressure vessel internal 'furniture' using a short-range sonar system, while monitoring the condition of protective internal coatings using methods once developed for corrosion protection.

Not all solutions involve robotics and one in particular has used advanced statistical data analysis to demonstrate that our industry has 'over inspected' equipment by as much as 50%. The technique, already proven effective on piping systems on operating assets is now being considered for structures. The method 'looks' at data both historically and while it is being collected, and tells the inspector when he has enough data to satisfy an agreed level of assurance, in line with international standards. The system also helps identify when a degradation mechanism has changed, enabling operators to monitor the condition of their equipment and plan maintenance more effectively.

Many of the technologies concerned have already been accepted by the major class societies and proven on pilot projects throughout the world, with cost savings of over 50% and persons on board (POB) savings of over 70% being the norm.

## Long-term partnerships

The benefits of long-term partnerships are considerable, particularly when it comes to realising the benefits of robotic and digital technologies for floating assets. It makes sense for operators to have a long-term partnership with organisations who understand the operator's needs and are able to introduce customised new technologies that improve safety and productivity.

## The future of monitoring and maintenance

Highly trained technicians with the sophisticated robotic equipment will gather data and liaise in real time with onshore teams to determine the current state of the asset and decide on any actions required to either further investigate or maintain any items which need repair or replacement.

Digitised data will be stored and analysed so that ongoing condition will be continuously monitored so that the risk of unexpected failures will be reduced, and maintenance better planned.

This is an entirely possible future with safety, environmental protection and production efficiency being achievable targets, which will keep our industry prosperous while meeting sustainability and social responsibility objectives. **LNG**