Gulf of Mexico

THE FIRST FPSO IN THE US GULF OF MEXICO: THE 14-YEAR JOURNEY

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Editor's note: This is the first of two articles on the technical challenges and regulatory hurdles that were overcome to allow the use of floating production, storage, and offloading vessels (FPSOs) in the US Gulf of Mexico (GOM). The FPSO that will be installed at Petrobras' Cascade-Chinook development in the deepwater GOM is planned for mid-2010 startup.

The practical start of the journey of the first floating production, storage, and offloading (FPSO) vessel to the US Gulf of Mexico (GOM) came in 1996, when an operator thought that an FPSO might be a viable candidate to efficiently develop a deepwater prospect. Back then there were a number of FPSOs in operation in different parts of the world, so the idea was not revolutionary. Several conference papers at the time showed potential arrangements for an FPSO at Texaco's Fuji development. As events unfolded, estimates of reserves were not as good as initially expected and the Fuji prospect was abandoned, but the idea of considering an FPSO in the GOM had taken hold.

During 1998–1999, Shell and its partner BP conducted feasibility studies for using an FPSO at its Na Kika development, involving study work by leading FPSO contractors. These studies were not just simple paper exercises, although traditional paper studies were made. Groups of facilities and subsurface experts met, examining every aspect of proposed candidates for field development and debating the pros and cons of solutions. Many in the industry may not appreciate the rigor of these debates unless you were in the middle of them. And in the middle of all this was a patient, objective participant, bringing out the best in everyone, George Rodenbusch of Shell (see sidebar).

Despite every consideration given to the FPSO option, all these debates and studies led to the conclusion that for the particular field at hand an FPSO was not the best solution, and today a semisubmersible is the centerpiece of the Na Kika development.

Again in 2000–2001 a supermajor looked exhaustively at the FPSO option but, weighing the regulatory uncertainties at the time and competitive pipeline economics, the FPSO and shuttle-tanker combination lost out to spars and semisubmersibles. About this time another development for another operator prompted presentations at an SPE lunch meeting in Houston showing shuttle tankers and an FPSO as the way to go. But that development became a tension leg platform (TLP), exporting via pipeline to produce that asset.

During this period some operators—often from outside the US—concluded that there was prejudice in the US against FPSOs, but the evidence of these repeated considerations of FPSOs over the years does not bear this out. Regulatory expert Rick Meyer of Shell summed it up in a presentation at an SPE workshop in 2002: "Economics, economics, economics." It was more a matter of just not having the right project for an FPSO in the GOM.

REGULATORY HURDLES, INDUSTRY COLLABORATION

DeepStar's Regulatory Committee, working on behalf of its GOM operating oil company members, recognized

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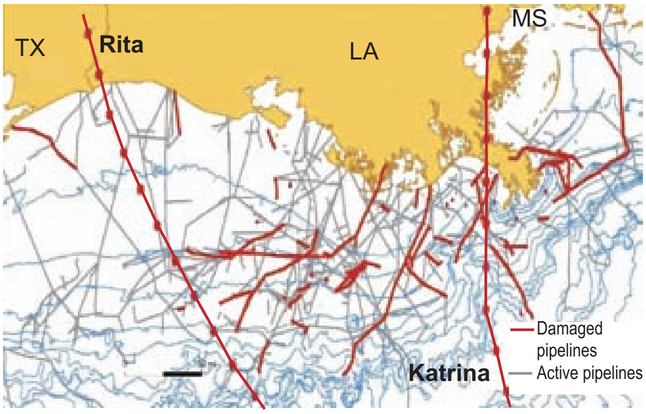


Fig. 1—Pipeline damage in 2005 boosted the FPSO and shuttle-tanker alternative.

Widespread platform damage in 2005 led to a reassessment of design codes for all facilities, including FPSOs.

that an FPSO could not be used in US waters without an environmental impact statement being prepared by relevant regulators. It was an exhaustive process usually taking 2 or more years, a delay that would effectively exclude FPSOs from consideration in the deepwater field development "tool box." Industry support was mustered through DeepStar for a generic environmental impact statement funded by DeepStar's participants.

It was a really remarkable tale of industry collaboration. Just a few years earlier DeepStar was established to develop technologies to better exploit deepwater fields. Otherwise fierce competitors agreed to work together even though they normally kept research-related matters to themselves. Now they were collaborating on the sensitive matter of gaining regulatory approval in principle for FPSOs in the GOM. Not only were there basic competitive instincts to reconcile, but there was also the "cat herding" thing—more than 20 different oil companies participated in DeepStar, each often with their own agenda.

In agreeing to the content in the environmental impact statement, the views of these 20-plus oil companies had to be listened to, as well as those of specialists from FPSO contractors and designers elsewhere in the world where FPSOs were already in use. All had somehow to be brought to a consensus about the technical, regulatory, and commercial conditions that would apply in the US GOM.

Allen Verret chaired the Regulatory Committee of DeepStar and piloted the FPSO approval effort through DeepStar, coordinating this effort with the US Coast Guard and the US Minerals Management Service. Unlike regulators in some parts of the world, there was a remarkable openness on the part of the US regulators in considering something new: they had their values and rules they were dedicated to and rigorously enforced, but there was a refreshing willingness for discussion.

During 1998–2000, the environmental impact statement effort received extensive industry support in addition to the roughly USD 2 million in funding from DeepStar. Public hearings were held at cities around the Gulf Coast where all kinds of comments were made and recorded. Terrorism was one issue raised, although in 2000 it was not considered much of a risk. Finally, the exhaustive examinations were completed on the physical and economic impacts of FPSOs, their effects on the GOM environment, and everything that lived in it. In December 2001, the US Department of the Interior approved the use of FPSOs and shuttle tankers in the GOM, subject to certain restrictions.

SPE ENCOURAGES OPEN DEBATE

Right after the Interior Department decision, rumors flew about the potential for the first FPSO being used at Unocal's recently announced Trident discovery in 9,700 ft of water in remote Alaminos Canyon. A room had been reserved at the Offshore Technology Conference (OTC) in May 2002 for Unocal's briefing on the project, with an audience on hand excited at the prospect of a possible FPSO project so soon after Washington's approval. But further appraisal of that prospect was not favorable and Unocal shortly thereafter became part of Chevron. It became clear that Trident was not a standalone project and became one of the reservoirs considered later in the Shell-operated Great White development, now the Perdido complex.

A step forward came when SPE launched a 2-day FPSO workshop in October 2002, addressing what was next for FPSOs in the GOM. Everyone present recognized it was entirely possible to use FPSOs in the GOM, but no operator came forward with plans for one. A similar workshop by SPE in the fall of 2003 addressed what was next for deepwater export, including pipelines or shuttle tankers that would become necessary in the use of FPSOs. Other than vigorous debate and discussion—as had happened in the workshop a year earlier—nothing happened on the use of shuttle tankers. It seemed that all the work by so many people might be for naught.

Contractors were not idle during this time, readying concepts for what might be needed for an FPSO in the gulf. No longer was it an approval exercise, but questions arose on just what practical steps would be required to secure regulatory approval. Operators were not idle either. Devon Energy, which had grown rapidly to be one of the largest independents, had been amassing a huge acreage position in the remote deep waters of the Lower Tertiary where an FPSO could readily be the development tool of choice and export by shuttle tankers could make great sense. Factors that Devon observed early on included the opportunity for aggregating and export via tankers, the

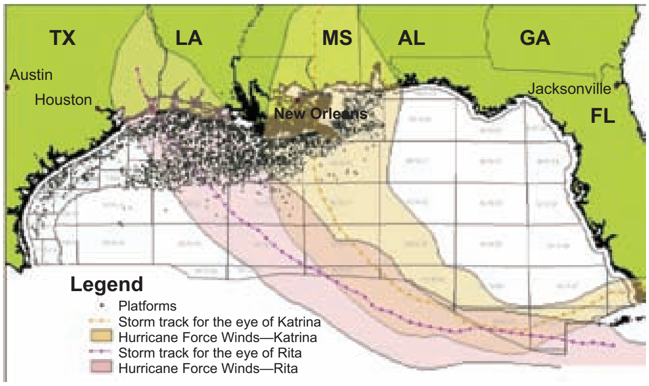


Fig. 2—The game changers of 2005, hurricanes Rita and Katrina, August–September 2005.

	Ivan	Katrina	Rita
Platforms raised	7	46	65
Platforms severely damaged	20	20	32
Rigs destroyed (JU's)	1	4	4
Rigs severely damaged	4	9	10
Rigs adrift (Semi's and JU's)	5	6	13

Fig. 3—Destruction caused by the three hurricanes.

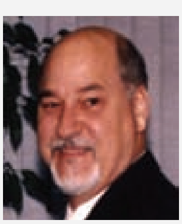
potential for a step by step development with the FPSO as one of the more profitable development tools. The pioneering efforts of 2002–2009 were not publicized and, with Devon's November 2009 announcement that it would exit the offshore business, may never be fully heard about.

HURRICANES CHANGE THINKING

It was quiet on the FPSO front in 2004. But it was not quiet on the transportation front: hurricane Ivan caused platform damage but surprised everyone by the extent of pipeline breaks caused as mud-slides swept away miles of pipe that had been delivering oil and gas smoothly and unobtrusively for years. Operators scrambled to restore interrupted production. There was talk of using tankers to transport oil during the down-time period—something unheard of previously. It was a foretaste of what was to come.

In 2005, operators for two different deepwater developments contemplated using some form of FPSO, both considering the use of an FPSO in an extended well test or early-production system. Both developments were located fairly close together in GOM deepwater in Walker Ridge, one operated by a supermajor (Chevron) and its partners, the other operated by Petrobras with partners Devon and Total. Each development involved two fields with different partners: the Chevron-operated Jack and St. Malo complex and the Cascade and Chinook complex operated by Petrobras.

By 2005, the industry began to reach consensus on an FPSO design for the US GOM, and a technical paper delivered at the OTC sponsored by DeepStar reflected that collective wisdom. Then hurricanes Katrina and Rita arrived and changed that thinking; there were extensive breaks in pipelines delivering oil and gas from offshore and major disruptions in production **(Fig. 1).** There were dramatic photographs of damage to offshore platforms. More menacing to the FPSO enthusiasts were the unmanned



Verret

Allen Verret *is a 30-year veteran of Texaco's Offshore Gulf of Mexico Operations and is currently executive director of the industry's Offshore Operators Committee and technical adviser to the Deepstar CTR 9100 Regulatory Subcommittee.*

The DeepStar Regulatory Committee was created to follow the ongoing developments, challenges, and solutions posed by deepwater environment and to provide guidance in light of the regulatory framework. The group followed the activities of the various technical workgroups working on potential solutions and provided frequent feedback on the effect current regulations might have on those proposals.

During many of these information-sharing meetings, regulatory representatives from the US Minerals Management Service (MMS) and the US Coast Guard (USCG) participated in the review and feedback given to the scientists and contractors involved. In some cases, the group identified regulatory gaps in providing the framework that an operator might need to apply for a permit to utilize a process or an enabling tool. This gaps analysis helped develop guidance and references that the agencies might use to address new technology and the qualification of that new technology. Because the technology was developing so quickly, the regulatory process was continuously being tested by new recommended solutions.

While the use of a floating production, storage, and offloading vessel (FPSO) to develop deepwater fields was a proven tool in international waters, the use of an FPSO in Outer Continental Shelf waters was considered a major departure from the current tool box approved for oil and gas exploration and development. Specifically, the agencies charged with approving the implementation were concerned about the environmental impact of this new tool in US waters. They expected that permitting might delay implementation up to 2 years.

The agencies recommended carrying out a programmatic environmental impact study so that any prospects that might be developed post-environmental impact statement (EIS) could use the programmatic study as a basis. Once this model was clearly identified, DeepStar participants developed a work team made up of MMS, USCG, industry, and contractors to develop a model FPSO and retained third-party environmental contactors to carry out the EIS. The industry-funded, MMS-managed EIS was carried out and concluded that the tool was acceptable within the parameters outlined in the study. This gave potential users an example of the "acceptable FPSO" that might be used in specific deepwater development areas in the GOM.

semisubmersibles and jackups broken loose in the hurricanes that drifted for miles driven by winds and waves **(Figs. 2 and 3).** It raised the specter of one of them in a future hurricane colliding with an FPSO laden with a million barrels of crude oil in its hull and the potential nightmare of a mega disaster.

Widespread platform damage in 2005 led to a reassessment of design codes for all facilities, including FPSOs.

So just when the engineers were deciding how to best design, build, and operate the first FPSO in US GOM, the game changed:

• The industry had always thought that an FPSO in the GOM would be permanently moored but now it was obvious that it had to be disconnectable to get out of the way of a hurricane and the hazard of drifting mobile offshore drilling units.

• The damage to existing platforms was so widespread that there had to be something wrong with the design criteria used: Had design codes underestimated the severity of hurricanes?

• The transportation network of interconnected pipelines had always been reliable and economical but now there were widespread disruptions as segments were knocked out in mudslides. Had we forgotten something on redundant systems and design? Would the versatility of tankers offer an answer?

Design practices were called into question. Industry experts convened on how to better frame design parameters and recommend changes in recommended practices. The good news was that the spirit of collaboration in the offshore industry in the US GOM was strong. Revisions to design codes and practices for designing FPSOs for use in the GOM were debated and worked out. **JPT**

Rodenbusch

George Rodenbusch *led a number of early studies at Shell on floating production, storage, and offloading vessels (FPSOs) for Gulf of Mexico (GOM) during 1998–1999, involving a large multidiscipline team from Shell and partner BP in assessing the feasibility of an FPSO and other field-development solutions for the Na Kika deepwater development in the GOM.*

Shell considered ship-based production systems for the Na Kika and Brutus developments in the late 1990s. BP (Amoco at the time) was Shell's partner on Na Kika. Shell already had a tradition of pioneering the use of floating production, storage, and offloading vessels (FPSOs) outside of the Gulf of Mexico (GOM), so it was natural to consider the concept for a system such as Na Kika, which would host numerous satellite developments. The main attraction of a ship-based system was the relatively low structural cost for the hull and lower facility cost offered by single-level layouts. For the most part, we did not consider storage and offloading except as a contingency should pipeline export be interrupted. This was due largely to the fact that export via pipeline needed to be solved for gas and the fact that there seemed to be no economic advantage to shuttle transport given the long field life and the proximity of infrastructure.

The system-selection team for Na Kika evaluated multiple host and subsea layout configurations. Host types included tension leg platforms (TLPs), spars, ship-shaped, and semisubmersibles with and without direct vertical access to the wells. For ship and semi-shaped hosts, both new-build and conversions were examined. Distributed multiple host options were also evaluated. Subsea system layouts included both central and distributed drilling centers, single and multiple flowline loops, deployment of subsea multiphase pumps, and flowline/riser configurations.

Of these systems, the TLP was quickly discarded because of cost. The spar was discarded because it did not provide any clear benefit over the semi option and had several limitations. The selection team then concentrated on the tanker and semi systems as providing technically feasible solutions that were fundamentally different in nature.

The principle novelty of the ship-based system in the GOM was the turret. The turret creates a bottleneck that demands careful consideration of system requirements and thus a basic understanding of how a turret works is needed by all disciplines involved in the design and operation of the facility. To expedite the necessary learning, we conducted a number or workshops that brought together experienced North Sea FPSO designers/operators with project team members to learn while actively addressing concerns including:

- Manifold and metering requirements to support multiple fields and flexibility
- Storage and handling of chemicals such as methanol
- Manning levels
- Bearing and structure maintenance and access
- Special requirements for electrical systems in the US
- Motion influence on helicopter operations
- Equipment layout for hazard mitigation including turbines and exhaust
- Operability due to vessel sloshing
- Structural fatigue and repairs

The tanker system was attractive because it had the lowest initial cost. However, the uncertainty surrounding conversion and maintenance costs, added costs for steel lazy wave risers vs. steel catenary risers, and lack of flexibility to bring future risers through the turret/swivel reduced its attractiveness. The semisubmersible host eliminated these concerns; however, at a higher initial cost.

For Brutus, the non-DVA options considered were spars and ship-based floating production facilities. The ship system was conceptually based on conversion of an existing Aframax-class tanker. The concept did not plan to store or offload oil. An export oil pipeline would be used that avoided regulatory concern with FPSO operations in the gulf and allowed conversion of a single-hull vessel. The converted ship-based system was selected as the best non-DVA option based on the previous evaluations for Na Kika. The ship-based facility provided the lowest-cost deck space and payload. However, the tanker systems did have technical concerns with turret and swivel designs when faced with numerous subsea tiebacks. Pipeline and flowline riser design for a tanker in hurricane conditions were areas of concern. Ultimately, a DVA development system, the TLP, was selected.