Port Development to Support Offshore Petroleum Exploration and Production

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ABSTRACT

Offshore petroleum exploration and production is a relatively young and rapidly growing industry which has impacted and benefited ports worldwide. This industry operates much differently than maritime trade and has specific channel requirements to operate efficiently. This presentation describes the channel requirements and port facilities needed to support offshore petroleum exploration and production. The combination of channel requirements and infrastructure needs can be used to determine the best port configuration for ports near offshore petroleum exploration sites.

Offshore platform fabrication requires deep and wide channels to move large platforms. Offshore supply vessels do not need the deep and wide channels that offshore platform fabrication does, but they require reliable channel access because they make frequent trips with short loading cycles. Offshore petroleum exploration ports also require a significant landside infrastructure to provide water, fuel, drilling mud, deck equipment, and supplies to offshore platforms.

INTRODUCTION

Ports that support offshore petroleum exploration and production are essential to the success of the industry. Within the United States, offshore petroleum exploration and production began in Louisiana in the 1930s, with rapid expansion beginning in the 1950s as technology improved. Technological advances are allowing petroleum exploration and production in very deep waters, and as the industry has focused on deep water exploration, the offshore platforms and the offshore supply vessels that support them have become much larger. The large capital investment required for the operation of offshore platforms during exploration is what focuses all supporting businesses, including ports, on efficiency.

Ports that support offshore petroleum exploration and production do so either by harboring a fleet of offshore support vessels (OSVs), or by servicing offshore rigs and platforms. Ports that harbor OSVs to support offshore petroleum exploration are also known as shore bases. Larger navigation channels are needed to service offshore rigs and platforms, as these ports need shipyards with dry docks. An important attribute of the offshore petroleum industry worldwide is that during its short history it has been highly cyclical.

Offshore petroleum exploration has expanded worldwide, including new regions without a history of supporting the industry. This highly technical industry has many experts with deep knowledge of specific subjects. The Bureau of Ocean Energy Management within the U.S. Department of Interior has conducted extensive historical research on the development of the offshore petroleum industry in the Gulf of Mexico. Nevertheless, literature that analyzes the attributes of an efficient offshore petroleum exploration and production port is limited. This presentation is intended to provide an overview for that purpose.

Figure 1 shows an aerial photo of the largest shore base in the United States for supporting offshore exploration and production. OSVs from Port Fourchon supply rigs throughout the U.S. Gulf of Mexico.

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Figure 1: Aerial Photo of Port Fourchon, Louisiana, USA

Figure 2 shows an aerial photo of the one of the largest shipyards constructing and servicing offshore rigs in the United States. The Keppel-Amfels Shipyard has constructed jack-up rigs and serviced semi-submersible floating rigs.

Figure 2: Aerial Photo of the Keppel-Amfels Shipyard in Brownsville, Texas, USA

OFFSHORE SUPPORT VESSELS

Decisions regarding supplies for offshore petroleum exploration and production are based upon economics and the drive for efficiency. Ports are always managed based upon economics and the need to move cargo as efficiently as possible. The difference with offshore petroleum exploration and production is that the investments in facilities and operating costs are very high. The cost of operating a semi-submersible offshore drilling platform in deep water can exceed $1,000,000 per day. Therefore, the reliability of shipments is very important as platform operators do not want to disrupt operations because of supply problems. Offshore platforms have limited storage capacity, so their ability to cope with supply disruptions is limited.

The industry's emphasis on logistical efficiency favors port locations near offshore petroleum exploration sites with transportation infrastructure and sufficient utilities. Transportation networks are a key factor in determining the viability of a port for supporting offshore petroleum exploration. The availability of barge or ship transportation allows efficient transportation of bulk materials such as drilling mud and fuel. Fuel is most efficiently transported by pipeline. Highway access should be sufficient for trucks to transport equipment and supplies efficiently if equipment and supplies are provided from inland sources. Sufficient waterworks capacity to provide potable water to offshore platforms is essential for an OSV port.

The expenses incurred during exploration, and the limited space for supplies, require highly reliable delivery of supplies. By weight, the bulk of these supplies are potable water, fuel, and drilling mud, which are carried by offshore supply vessels in tanks below deck from stockpiles onshore. Supplies and equipment are generally carried above deck on the same OSVs. Ports that support offshore petroleum exploration usually have liquid bulk storage capacity for fuel and drilling fluids. Supplies and equipment stored at shore bases are loaded as efficiently as possible onto OSVs. Some OSV ports have sufficient laydown space for pipe, anchors, chain, and wire to be stored and inspected.

Offshore Support Vessels primarily serve exploratory and developmental drilling rigs and production platforms and support offshore construction, installation, maintenance, repair, and decommissioning activities. Platform Supply Vessels (PSVs) are the "workhorses" of the offshore support fleet. PSVs generally have a large open deck for dry bulk and internal tanks for liquid bulk. PSVs in the U.S. generally range from 180 feet to 260 feet in length, but can be over 400 feet in length. PSVs leave the port heavier than they enter the port, but they do carry waste and rented equipment back from the offshore structures, so they do not return to port completely empty. Offshore Tug/Supply Ships can be used to assist in rig movements and anchor handling operations or to supply offshore structures similar to PSVs. Table 1 shows OSV types.

Ship Type	SeaWeb Ship Type
OSV	Offshore Support Vessel
	Offshore Tug/Supply Ship
	Pipe Carrier
	Platform Supply Ship
AHTS	Anchor Handling Tug Supply
Construction Vessel	Diving Support Vessel
	Offshore Construction Vessel, jack up
	Pipe Burying Vessel
	Pipe Layer
	Pipe Layer Crane Vessel
	Production Testing Vessel
	Research Survey Vessel
	Trenching Support Vessel
	Well Stimulation Vessel

Table 1: Offshore Support Vessel (OSV) Types

Anchor Handling Tug Supply Vessels (AHTS) have winches and cranes and are used to set and lift anchors used by certain types of offshore structures and to tow and position movable offshore structures. AHTS often enter and leave a port at the same depth because they haul anchors into port for inspection and then back out to offshore structures. Unlike supplies carried by other types of OSVs, such as water or drilling fluid, anchors are not divisible, so the tonnage carried by these vessels is less easily adjusted to account for changes in channel depth. Crew Supply Vessels transport crew to and from offshore structures, but generally have some capacity for deck cargo and internal tank space for liquid bulk. Crew Supply Vessels are generally smaller than other offshore vessels, and are therefore less important when considering channel requirements for an offshore supply operation.

Seismic vessels are larger than most OSV's and are the first vessels involved in exploration of a potential offshore petroleum field. These are among the most complex and technically advanced vessels and are operated by specialty firm from specialized facilities. Since these vessels are the first deployed to a potential field, before the potential petroleum production is known, bunkering of seismic vessels is done from the nearest port facility. Once shore bases are constructed, seismic vessels may call for supplies and bunkering, but they will likely remain based at their owner's home port as these vessels are typically deployed worldwide based upon available contracts. Exploration is likely to continue in and offshore petroleum field after production begins, but the deployment of seismic vessels will not be continual.

A channel closure at an OSV port could result in a significant economic impact to the operators of offshore platforms. Channel depth restrictions impact the efficiency of OSV operations and are an important consideration when OSV operators determine where to base OSVs. The tables below show OSV dimensions for the world fleet based upon year of build. As offshore petroleum exploration has move further offshore into deeper water, OSVs have become larger and more complex.

Year of Build	Design Draft	Length	Beam
1960	3.6	51.5	10.1
1970	3.2	49.5	11.1
1980	3.0	48.8	11.5
1990	3.9	62.9	13.3
2000	4.4	61.8	14.5
2010	5.2	70.6	16.0
2014	5.8	81.1	17.7

Table 2: Dimensions based Upon Year of Build (meters)

Offshore logistics is a complex system involving efficiency and productivity, inventory control, and supply reliability. Exploratory platforms require many more supplies than production platforms, since they are constantly using drilling mud, pipe, and fuel while drilling. This greater need for supplies drives the need for more OSV calls. The scheduling of OSV calls for exploration platforms is also much more uncertain than for production platforms, because drilling conditions and needs constantly change.

Offshore support vessels are generally operated by specialized charter operators. These operators are responsible for loading the vessels, maintaining the vessels, and providing crews. The vessels are used as directed by the petroleum exploration companies, which specify what cargo to carry and what offshore locations to serve. The routing of OSVs is complicated because they sometimes serve multiple platforms, but this task remains the responsibility of the petroleum companies. Offshore vessel operators design the new vessels and sometimes operate shipbuilding companies as subsidiaries. Having the most marketable fleet is important for OSV operators in this competitive market. As offshore petroleum exploration has moved further offshore into deeper water, OSVs have become larger.

An OSV port needs a channel depth of 24 feet for larger OSVs, barge access or deep draft ship access for liquid bulk, proximity to offshore exploration and production areas, highway access for equipment and supplies, and adequate water and power supply. Rail access, which is a major requirement for most commercial ports, is not generally used for offshore supply vessel ports. Most ports contain bunkering facilities, but the scale of bunkering operations for a port serving OSVs is much greater. Infrastructure availability – water, power, fuel – is vital for supporting the offshore petroleum industry.

OSVs are typically piloted by pilots employed directly by the OSV operators. Some OSV operators have company-specific rules regarding under keel clearance. In deep draft ports with channel depths over 24 feet deep these constraints are not an issue, but in shallow draft ports serving OSVs these constraints can impact operations.

Specialized services and facilities can be expected to develop around an offshore support port. The development of these facilities requires sufficient land adjacent to channels. The anchor handling tug facilities are an example of facilities requiring significant waterside land. Anchor handling tugs are used to relocate semi-submersible structures, and transport large amounts of chain and cable on each trip, which needs to be sorted and inspected at the facility. Pipe suppliers also require a significant amount of laydown land, especially if they are inspecting pipe at the facility.

OFFSHORE PLATFORM FABRICATION

Offshore platform fabrication is a highly specialized and integrated market and is the only internationally competitive type of shipbuilding in the United States. Platform fabrication is complex and performed by a limited number of specialized shipyards. Platform structures are constructed in pieces, integrated either on location or at large, deep water facilities. Platforms must be inspected, repaired, and refurbished in port based upon classification society (ABS) schedules. The inspections and refurbishments of existing offshore structures is a major portion of business and revenue for all shipyards in the industry, including those shipyards fabricating new offshore structures. Table 4 describes the different types of offshore platform structures.

Offshore Structure	Mobile (Yes/No)	Self-Propelled (Yes/No)	Exploration / Production	Maximum Depth (ft.)
Drill Barge	Yes	No	Exploration	30
Drill Ship	Yes	Yes	Exploration	12,000
Floating Production, Storage, and Offloading System (FPSO & FSO)	Yes	Yes	Production	12,000
Jack-up	Yes	No	Both	500
Platform Rig				
Fixed Platform	No	No	Production	1,300
Compliant Tower	No	No	Production	3,000
SPAR	Yes	No	Both	8,000
Tension and Mini-Tension Leg Platforms	Yes	No	Production	6,000
Semi-submersible	Yes	No	Both	8,000
Submersible	Yes	No	Both	30
Tender	Yes	No	Both	8,000

Table 3: Types of Offshore Structures

Offshore platform fabrication requires much more capital investment in facilities and equipment than a typical maintenance shipyard. Offshore platform fabrication and repair must meet international standards, as published by classification societies. A highly skilled labor force is needed and a specialized supplier network must be established. Some components of offshore platforms, such as topsides, are shipped hundreds of miles from an inland port to a platform fabricator at a coastal port.

Pilots from the harbor pilots association typically supervise the movement of offshore platforms through harbors. These slow moving structures can impact other vessel traffic as they are maneuvered through the harbor channels. Sometimes simulators must be used to ensure that the offshore platforms can safely transit the harbor channels. This significant effort and cost is incurred because the revenue to the platform fabricators can range from $2 million for inspection and minor repairs to $50 million for major repairs and upgrades. Likewise, the cost to platform operators of finding another available fabricator and transporting the platform an additional distance to that facility is very high. For each day the offshore platform is unavailable for charter, it is losing its charter rate and incurring the cost of the several ocean going tugboats needed to transport the platform.

Labor force skill and training has been a difficult issue for offshore platform fabricators. A skilled workforce takes time to develop and is difficult to maintain during industry downturns. This problem is not unique to offshore structures, but is prevalent through all aspects of the petroleum industry. During the past several decades, employment in this cyclical industry has been volatile. Skilled workers tend to disburse to other industries in need of their skills, and are not necessarily available when fabrication work increases. For this reason, platform fabricators tend to be located near cities with a large enough skilled labor force to allow increased production. Sufficient skilled labor in a cyclical industry is always a difficult issue and platform fabricators have avoided remote locations where obtaining sufficient labor is more difficult.

Ports with facilities capable of constructing & servicing jack-up structures and semi-submersible structures have at least 30 feet of channel depth. The average transit draft of semi-submersibles in the Gulf of Mexico is 31 feet. These facilities should have a reasonable proximity to open water as structures can disrupt normal ship channel traffic. At the same time, facilities should have sufficient elevation and protection from storm surge.

The depth of water for offshore drilling determines to type of structures likely to be employed, which also impacts the type of offshore supply vessel employed. Jack-up platforms are used in water up to 300 feet deep. Semi-submersible structures are prominent in deep water to 8000 feet and require a fleet of anchor-handling tugs. Drill ships are a relatively recent development, and are used for drilling in ultra-deep water. Jack-up platforms can be transported through smaller channels than semi- submersible platforms. Drill ships are more maneuverable than either jack-up platforms or semi-submersible platforms, and are also the most costly vessels to charter and operate.

Although sufficient depth is important, channel width can be just as important. The beam width of these structures can be several hundred feet wide. Table 5 shows the average beams of selected types of offshore structures in the U.S. Gulf of Mexico.

Offshore Structure Type	**Average**	**Median**
Drill Ship	39.3	38.1
Jack-up	49.7	52.1
Platform Rig	NA	NA
Semi-submersible	82.9	78.0
Submersible	54.9	54.9
All	**56.4**	**53.7**

Table 4: Average and Median Beam Size of Offshore Structures in the U.S. Gulf of Mexico (meters)

The channel dimensions required to move offshore structures are not absolute. There are steps the structure operators can take to reduce the transit dimensions, such as removing the thrusters offshore. These steps have a cost that operators must consider when determining where to service an offshore structure.

OPERATIONS AT OSV PORTS (SHORE BASES)

Drilling fluids, also described as drilling mud, is produced by mixing barite and betonite with other chemicals and water, and is most efficiently done at shore bases near offshore petroleum exploration. Much of OSV capacity is used for drilling fluids during offshore petroleum exploration, and the drilling fluids are returned to shore bases for recycling. The drilling fluids are usually prepared for use by each supply company as the mixtures are proprietary.

Ports serving the offshore petroleum industry must fuel and supply the OSVs. This is typically done at a central facility that serves multiple fleets operating from the port.

Offshore petroleum ports sometimes have associated heliports that transport crews and urgent supplies offshore. There are benefits to having these facilities adjacent to port serving the offshore petroleum industry, where supplies and expertise are readily available.

As offshore petroleum fields shift from exploration to production, pipelines may be built to bring petroleum ashore. Offshore petroleum production does not require pipelines to shore as FPSO (Floating Production and Offloading vessels are now often used to transport crude oil to distant refineries. Offshore natural gas production requires either pipelines to shore or FLNG (Floating Liquefied Natural Gas) vessels. The decision to lay pipelines to shore from new offshore petroleum fields is based upon several factors, including the distance from the offshore field to storage facilities on shore, the expected longevity of the offshore field, and the market for the petroleum within the region. Since many of the more recent offshore fields are more than 100 km from shore

The construction of pipelines from production platforms to shore is facilitated by OSVs operating from shore bases. However, construction of pipelines to shore requires specialized vessels that are much larger than PSVs, and spooling facilities that require a large area that is not always available at a shore base. Within the United States there are two major spooling facilities in Galveston, TX and Theodore, Al that prepare spool pipelines for the entire U.S. Gulf of Mexico. These facilities have access to channels 14 meters deep.

Processing waste from offshore and transporting to appropriate disposal sites is an important shore base function. Offshore rigs and platforms have limited storage space for waste. Waste from rigs is typically retrieved by OSVs when returning to port after delivering supplies. The environmental laws of the receiving nation and the business practices of the company managing the offshore exploration determine the storage methods for the waste, whether incineration, or landfills. The waste is sorted based upon hazard level before disposal and hazardous waste is sorted out and disposed of separately. The sorting and disposal is usually performed by specialized logistics firms with facilities at shore bases.

Much offshore exploration equipment must be inspected after each use including drill pipes, chains, and risers. The inspections require specialized equipment, skilled labor, and sufficient land area. The inspection of drilling pipes and risers requires specialized equipment. The efficiency of performing the inspections at shore bases rather than transporting the equipment to centralized facilities may be sufficient to warrant the investment in inspection equipment and a facility, depending upon the amount of exploration drilling in the region.

OPERATIONS AT INLAND PORT FACILITIES

The supplies and equipment needed for offshore petroleum exploration are varied and are managed by many different types of specialized businesses. Petroleum companies rely upon long term relationships with suppliers. Within the U.S., the complex machinery and equipment used on offshore rigs and platforms is assembled and maintained where skilled labor is available which is not necessarily at shore bases.

Some operations, such as spooling of pipelines, require significant land. Spooling is the manufacturing process of joining pipes together to lay offshore. These facilities must be located dock side to allow the loading of specialized vessels where pipelines are spooled onto the vessels for delivery offshore.

CONCLUSION

The reason that new petroleum exploration ports will be needed is that transportation costs for supplies to offshore platforms are very high, and the cost of transporting structures is also very high. Larger semi-submersibles platforms have a charter rate of $300,000 to $400,000 per day, and require towing vessels at an additional cost as they transit long distances at slow speeds. The investment in building a shipyard capable of servicing these platforms is substantial. Therefore, these investments are only made in a continental region after petroleum exploration findings indicate that exploration and production in the region will continue. There are many specialized businesses that support the offshore petroleum industry, and as a port develops sufficient land is needed to allow these businesses to open and expand.

REFERENCES

Aas, Bjornar, and Halskau, Oyvind and Wallace, Stien (2009) The Role of Supply Vessels in Offshore Logistics, Maritime Economics and Logistics, Vol. 2-3

Jayawardana, Jay and Hochstein, Anatoly (June 2004) Supply Network for Deepwater Oil and Gas Development in the Gulf of Mexico: An Empirical Analysis of Demand for Port Services, Final Report, Department of the Interior, Mineral Management Service 2004-047, New Orleans, Louisiana

Kaiser, Mark, J. and Snyder, Brian (February 2010) An Empirical Analysis of Offshore Service Vessel Utilization in the Gulf of Mexico, International Journal of Energy Sector Management

Kaiser, Mark, J. and Snyder, Brian (2010) Mobile Offshore Drilling Newbuild and Replacement Cost Functions, Maritime Economics and Logistics, Vol. 12-4

Koske, Rose, and Robin, Sebastion (February 2011) Future Characteristics of Offshore Support Vessels, Massachusetts Institute of Technology, Cambridge, MA

U.S. Army Corps of Engineers Galveston District (December 2010) Draft Freeport Harbor, Texas Channel Improvement Project Feasibility Study, Galveston, Texas

U.S. Department of the Interior (May 2012), Oil and Gas Utilization, Onshore and Offshore, Updated Report to the President, Washington D.C.