Conclusions and Discussion for Final Report Presentation on RPSEA Project 10121-4407-01 Deepwater Direct Offloading Systems

The presentation was delivered by Bill Head, UDW Program Manager at RPSEA, with Conclusions and Discussion by Peter Lovie, the Project's Principal Investigator

General

I'm here now after Bill Head's presentation on the project to address the conclusions from the work and discuss with everyone what these may mean.

Yesterday in James Pappas' opening remarks for this conference we heard how RPSEA had funded 34 technology development projects, how 5 were now well along in being commercialized, with 8 more in earlier stages of commercialization. By exploration standards in our industry, a better than one in three success rate would be a pretty good commerciality rate!

While the main thrust in this RPSEA project was technology development, serious effort was devoted to estimating capital cost and projecting economic comparison for an idea of the commerciality of this technology. It is an intriguing saga of an ingenious new idea and how the business case for it is revealed right at the end of this RPSEA project of whether we made the one in three cut.

The observations here come from my responsibility in an independent role as Principal Investigator for this project for RPSEA and do not necessarily represent the views of RPSEA or of Remora, the owner of the technology that was the subject of this work and was the prime contractor.

This RPSEA project was a year long effort about seeing if a new offloading technology - HiLoad DP developed by Remora of Stavanger, Norway - could be worthwhile for operations in Ultra-Deep Water (UDW) in the US Gulf of Mexico (GoM). In embarking on this work the hope was that we would be doing something for the good of our industry andwould make sensefrom a business standpoint in spending government funds.

Not all new technologies are created equal

Not every good idea can be developed to where it can make technical sense and also business sense. There are some ideas that are technically quite possible but for one reason or another do not make business sense. For example, three years ago RPSEA considered proposals for developing a design for an Extended Well Test (EWT) vessel for UDW use in US GoM. In years pastI would listen to our reservoir guys lobby for such a vessel, maintaining it could be great for 3-4 months producing from reservoirs where characteristics were not well known, and hence this EWT vessel would be very valuable for high risk large investment developments, reducing uncertainties to improve the viability of prospective field developments. It was not just the GoMoperator I worked for –othersavvy operators said the same.

Unfortunately lining up enough work for such a specialized vessel turned out to be very difficult to align with exploration plans and partner decision processes, which were factors that FPSO contractors had often wrestled with, usually with deal killer scope creep. Despite the enthusiasm of the technical communities in operators and in the engineering firms about to tackle the project, RPSEA decided not or go forward with government funding on that $3million proposal.

It had been a classic conflict between technology types in operator and engineering contractor communities that could see the technical way ahead but which collided with realities from the business unit types with operators and the business development types in FPSO contractors.

Some technologies move more rapidly to commercialization than others. In our projecthere when examining Technology Readiness Levels (TRLs) and how they can advance more rapidly in one technology over another, we used the example of the round FPSO hull design from Sevan that was conceived in the same year (2001) and same place (Stavanger, Norway) as Remora's HiLoad DP. The round hull FPSO at the *Piranema* development entered service offshore Brazil in 2007 after a 6 year gestation period. In contrast the HiLoad DP had a gestation period of 12 years before it will also enter service in a special configuration in Brazilian waters later in 2013.

Another technology in the marine and offshore world that comes to mind as one that never made it to "prime time" despite a seductive story on its advantages was compressed natural gas (CNG) tankers. For years the debate had raged on why this would be a needed leap forward in transporting natural gas by sea. Despite many millions of dollars invested by multiple developers and shipping companies worldwide, somehow it never caught on. I well remember the technical session at OTC in 2005 that I organized on the topic, with the Coast Guard and shipping companies on hand. The debate continued for several years afterwards too. It boiled down in my mind to a simple ratio of the weight of cargo in the CNG tanker divided by total displacement of the loadedtanker. The ratio was way lower than for LNG carriers and crude oil tankers: CNG tankers would be spending too much on moving their own steel weight around. The enthusiasts could not overcome the “dismal science”of economics andwhat straw man economic projections said!

The “lack of business case” discussion can be difficult as one can get cast in the role of telling the parents of what in their eyes is a marvelous creation that they have wasted their time. Rather than the parent metaphor, I suggest the “The Gambler” metaphor as more realistic for the business world. You may have heard these words in the chorus in Kenny Rogers’ song:

> “You got to know when to hold 'em,
> Know when to fold 'em,
> Know when to walk away,
> Know when to run . . . .”

Technically,HiLoad DP technology can be made to work in UDW GoM

The project team of five contractors showed that the HiLoad DP technology could indeed be made to work in US GoM, working with the relatively small Handymax size of tankers needed for GoM operations to deliver production from UDW production sources to GoM ports.

HiLoad DP could be designed to be able to contend with GoMmetocean conditions and operate with about 98% uptime, with the relatively high currents present in GoMbut not with the higher loop currents.

As Bill Head pointed out, late in the game once we had discovered the 3 mile limit on voyages for the prototype, it became possible to do something about it and make changes in lifesaving provisions to enable HiLoad DP to work in GoM, disconnect to avoid hurricanes (given proper advance warning) and motor away at 4-5 knots to a safer location.

HiLoad DP could be redesigned to be able to enter the relatively shallow draft (down to 40 ft. or a little less) ports of US GoM, for refuge from a hurricane, maintenance and training. And that redesign would likely save on construction cost.

The tankersit would deal with would be smaller than the prototype built in Norway that was built to handle VLCCs of 2,000,000 bbl capacity. Here in US GoM the predominatesize would be Handymax tankers of about 330,000 bbl capacity,similar to the two shuttle tankers currentlyworking in US GoM for the Petrobras operated *Cascade/Chinook* development employing an FPSO.

Significant due diligence was done to show that a HiLoad DP suitable for US GoM could indeed be built at a GoM yard andwhat might be a reliable project cost and delivery: $132million and 100 weeks.

Economic projections - conjecture based on careful best guesses

There are no big fleets of shuttle tankers operating in GoM, in fact there are only two now operating: these at *Cascade/Chinook*. The reality is that the tankers of a size and age suitable for shuttle service are almost always all working in products service (e.g. gasoline and diesel) instead of transporting crude oil.

Tanker availability is made difficult with the existence of the Jones Act, an entrenched piece of legislation dating back to 1920 that requires US flag, US built, owned and crewed vessels for trade from one US port to another. At the end of 2012 there were 25 "GoM suitable" tankers in the Jones Act fleet that potentially might serve as shuttle tankers, in contrast to 1,054 in the world's fleet of foreign flag tankers that would be "GoM suitable".

Shuttle tanker service for the life of a field may run to severalyears, conceivably up to the life span of the tankers for certain of the reservoirs in UDW GoM. So there is no easy way to look at the market and say like in home buying that the comparablesare this or that. But all of this has been encountered before. During 2002-2004 two shuttle tanker companies attempted to introduce shuttle tankers into GoM: Seahorse Shuttling owned by Conoco and American Shuttle Tankers (which I worked for) and employed experience developed by Navion, the Stavanger based pioneer of shuttling. It was not until August 2007 that the first contract for shuttle tankers in GoM was enteredinto between Petrobras and OSG, employing a shuttle tanker configuration different from either of these two pioneers.

The planning and projection of economics had been addressed extensively in that era at Devon Energy where we were 50:50 partner with Petrobras on *Cascade*. Separately from *Cascade* we had to investigate shuttling and pipelines as part of determining how we might develop prospects in a UDW portfolio that was second only to Chevron's in the Lower Tertiary. So quite avolume of work was doneback then and reported on in a paper at DOT 09 which is cited in the project here and was citedon Remora's website.

It is all a long process in making the best possible informed guess at each point, building a preponderance of probabilities. In Devon we were not alone in tacklingstraw man economics - in the course of partner meeting I would see the same kind of things done by Chevron

Shippingand others in building their "straw man" versions of economics projections for similar requirements.

What made it simpler in thisRPSEA project was that we were trying to discern if there was a pattern of offloading becoming more or less economical through the introduction of the HiLoad DP technology. By adding the HiLoad DP vessel and doing away with a hold off tug and hose handling vessel in two of the competitive options, what would be the difference? And then a simpler comparison was made against the third option of DP2 shuttle tankers: did offloading cost more or less with a HiLoad DP?

CAPEX and TC numbers for HiLoad DP for GoM

Back in January-March I was unable to get indicative numbers from Remora in Stavanger for CAPEX and a corresponding 10 year time charter.So I made them up. The cost of the prototype was never stated but believed to have been somewhere in the $150-200million range. At first I thought a HiLoad for the much smaller GoM tankers would be perhaps $80million. Later as analyses of performance under GoMmetocean conditions showed that powering for GoM conditionsupped the CAPEX, plus due diligence inassembling a realistic complete project cost, I increased it to $120million in July.

In each case I applied rule of thumb ratios to arrive at a day rate for the HiLoadwith its 4 man crew, giving the benefit of doubt that it would be a low risk venture of a proven production system, arriving at the estimate of $66k/day thatis used inthe slide shown today.

The projected $/bbl offloading rates are telling for the potential for use of HiLoad DP

What you see in the slide that Bill shows here are the projections in $/bbl for typical delivery of crude by shuttle tankersinGoM from typical UDW locations to typical refinery destinations, for both Jones Act and foreign flag tankers. It shows how the HiLoad DP spread is the high cost option for use with bothJones Act and foreign flag tankers.

The cycle times in GoM and the North Sea are both quite similar,meaning that HiLoad DP technology may not have much of a future in the North Sea, probably confirmed by the fact that HiLoad DP developed in Stavanger never did not catch on in the birthplace of shuttling!

A second telling factor in this projection is the relative economics for the production level in GoM. Here we used a steady state production rate of 80,000 bopd for FPSO operations and a somewhat higher rate (96,000 bopd) for the standby emergency applications. These were agreed with operators early in the project as being representative for US GoM. Today there are 153 FPSOs in service worldwide versus 83 ten years ago. Today the average FPSO production rate is 90,000 bopd versus 74,000 bopd ten years ago –all this according to 2013 data from industry authority IMA.

In other words, if anew offloading technology cannot show a compelling advantage at around 80,000-96,000 bopd, it is likely to be a tough sell anywhere, unless perhaps for some special situation.

Basic needfor use of HiLoad in GoM

At our first Working Project Group meeting (WPG 1 on 13Nov13) with GoM operators on hand we concluded that the outlook for more FPSOs in GoM was limited, probably one more at Shell's *Stones* development but could not see any after that, assuming a ten year outlook. Attention therefore shifted to the potential for standby applications for pipeline disruption and for oil spill loading after a *Macondo* like event. At the end of the project we could not find any industry initiative addressing the pipeline disruption requirement and could not find interest from the two drilling oil spill contractors.

We had to face the conclusion that the basic need was just not there, regardless of good economics or bad economics.

Revealing result from Googling right after the last project meeting

In the week after the last Working Project Group meeting (WPG 5 on 14 August) I Googled HiLoad DP, Remora and Teekay, out of curiosity after being sent a Reuters press story on HiLoad. Two press releases were found, one from Remora for use at OTC and one fromTeekay(NYSE: TOO) dated 21Feb13, referring to plans made the previous November (i.e. three months after this RPSEA project started) for using the HiLoad DP prototype with Petrobras(NYSE: PBR) in Brazil under an expected contract, the terms of which were still to be finalized.

From thesepress releases it became clear that: (a) the HiLoad DP prototype had been sold by Remora to Teekay at about $34million, (b) subject to satisfactory performance,itwould work on a ten year time charter at around $54k/day, (c) that Teekay had agreed to pay for modification tosuit operation in Brazil, bringing the total CAPEX to $55million, and (d) Teekay would provide a tanker as a mother ship, along with the HiLoadDP in the ten year commitment.

From perhaps $150+milliondown to $34million was somesteep discountrequired to put the HiLoad DP to work! If the only way this device could go to work was at such a discount and for a special situation, why would anyone invest in it for more normal routine offloading requirements?

Uncovering this situation led to the conclusion that we had been wasting our time onestablishing the feasibility of building a HiLoad DP in a GoM yard, withany hope for commerciality of a $132million HiLoad DP for UDW GoM.

Now the project's straw man economic projections and observations on the basic need for this technology in UDW GoMall started to fit together.

And RPSEA's humble PI concluded that a Principal Investigator also has to have talents as a Private Investigator early on in these projects!

Response to Question from Rick Fielder (Consultant):
Is there shipbuilding capacity in the US to build more of these Jones Act tankers?

Yes, NASSCO in San Diego took an order for four product tankers just a few months ago. Aker Philadelphia built the tankers now in use at *Cascade/Chinook* and several more for products service and would be another choice for new tankers for the Jones Act fleet.

Response to Question and Comment from Ming Yao Lee (Chevron):
HiLoad DP could indeed serve the need for a system to cope with pipeline breaks halting production in UDW

The need for some kind of tanker offloading system to use inthe event of pipeline disruptions of the kind that happened in 2005 still remains today. Maybe the Rapid Deployment Offloading System (RDOS) concept of 2005-2006 that Chevorn was active on could be revitalized today. There could be a place for an industry group like RPSEA or some other party to assemble interested operators in an industry project to examine solutions that could be provided as an "insurance policy"if you will,kind of like MWCC and Helix have done for a drilling oil spillemergency.

HiLoad DP might be one solution but there are other possibilities too suchas what BP did in chartering in and obtaining a Jones Act waiver for use of a foreign flag DPshuttle tanker in the aftermath of the 2005 hurricane emergency in GoM. Perhaps some kind of "call option" on the use ofone or more foreign flag tankers, pre-agreed and carefully pre-planned might provide adesired solution without incurring the CAPEX for a HiLoadDP or some other kind of special capital equipment on a standby basis. But all that is in the future and outside the scope of this RPSEA project!

Closing thoughts - different offloading systems can be made operate safely

My boss at Devon used to joke about how "we can offload to barrels in a canoe in the light of the moon, as long as we can do it safely!"

During this RPSEA project I heard criticism of the MWCC offloading plans using conventional tankers hawser moored to a DP host, with loading via a floating hose. I find it difficult to believe that the MWCC consortium led by ExxonMobil would ever toleratemanagement of anything unsafe in the midst of a recovery from a spill disaster!

The offloading system at *Cascade Chinook* (the least cost option in the economics projection) is quite unique, developed by Petrobras and employing a tanker with enhanced maneuverabilityand a Bow LoadingSystem - but not the North Sea DP2 shuttle tankerconfiguration. This precedent setting choice was made in the face of a demanding GoM regulatory environment. It offers both economy, relatively straightforward equipment availability and with careful definition and management of procedures, the necessary safe operation.

Consequently it is difficult to imagine that careful operational management and use of rigorous safetyexperience with the choice from the array of existing well proven offloading systems worldwide can indeed be trumped by a seriously higher cost offloading system.

The conclusion at the end of the RPSEA project is thus that HiLoad DP technology can be made to work in US GoMconditions but it makes little business sense to do so and one wonders therefore where this intriguing idea would actually find wide use or if it might go the way of CNG tankers.

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