emerging FPSO forum

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Economics, Performance - Four Options for US GoM Offloading

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Discussion here draws on work on offloading for GoM over several years

2007-2009

Tanker or pipeline? Devon had a large UDW portfolio second to Chevron and was 50:50 with Petrobras at Cascade.

Hence the assessment of oil export in UDW in US GoM by tanker or pipeline during 2006-2009, reported at DOT 09 in "The Lower Tertiary Trend and the Oil Export Economic Prize".

Then Devon exited all offshore business in 2H2009. But their experience became of value to what followed with RPSEA.

2012-2013

Which offloading system for GoM? RPSEA contracts encourage development of new technologies that may benefit the US petroleum industry, funded via US DOE and drawing on royalty revenues from US production.

One such study was on the HiLoad DP technology which would allow use of conventional tankers instead of DP shuttle tankers for offloading from UDW prospects in US GoM. Work on RPSEA project 10121-4407-01 on "Deepwater Direct Offloading Systems" was concluded days before this Forum.

Acknowledgement and Disclaimer

The author wishes to thank Devon Energy Corporation for providing the time to prepare all the work summarized in the DOT 09 paper and the approval of its presentation at DOT.

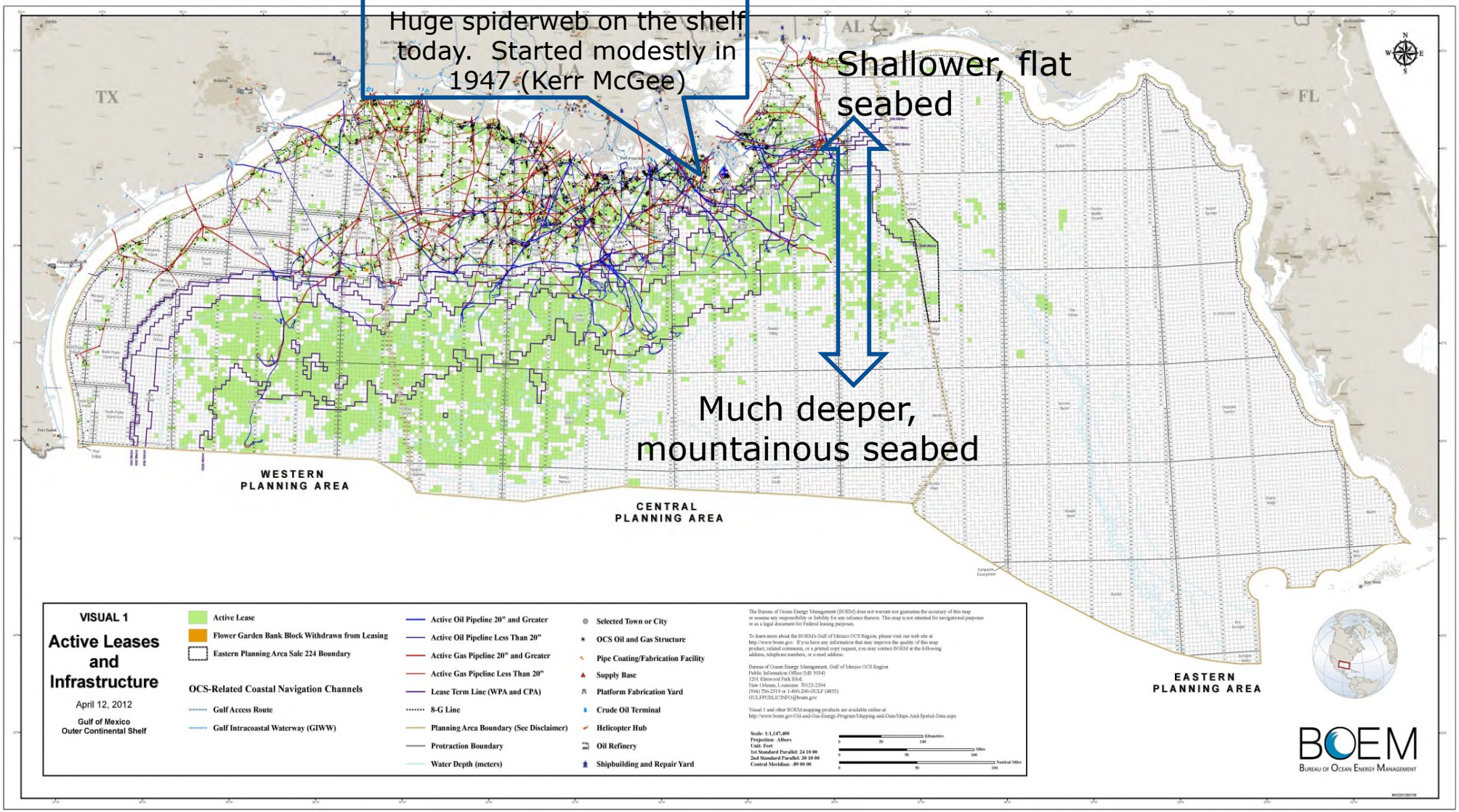
The figures used here and the opinions expressed are these of the author, are believed to be representative of the factors at play but do not imply any corporate position by Devon Energy Corporation. However Devon did endorse the principles put forward of arriving at some form of careful technical and economic assessment of all export options to enable a prudent business choice on export mode.

The author is also indebted to Research Partnership to Secure Energy for America (RPSEA) for permission to quote work performed for their project 10121-4407-01 on Deepwater Direct Offloading Systems.

The information selected here and the opinions expressed are these of the author, are believed to be representative of the factors affecting decision making on offloading systems but do not imply any endorsement by RPSEA or by the US Department of Energy.

Growth in Platform & Pipeline Infrastructure

Unlike many offshore regions with FPSOs, ALL production **IMPORTED**



In recent years development & production risks and economics been tougher than expected for very remote areas in Ultra Deep Water (UDW): not just effects of location and UDW, formations also not as well understood

The Pipeliners' Friend in Washington

No Jones Act for Trucking: Izuzu, Volvo OK, **U.S. FREE MARKET !**

No Jones Act for Airlines: Airbus, Bombardier, Embraer all OK. **U.S. FREE MARKET !**

The Jones Act applies to ships engaged in coastwise trade in US waters: requires US built vessels, 75+% US owned, US crew. CAPEX about 3X international trade for tankers transporting oil, OPEX ~ 2X.

A production platform is considered a US port, so delivery of production from a production facility to shore is "coastwise trade".

Senator Wesley Livsey Jones (1863-1932), Republican from the state of Washington, author of the Jones Act passed in 1920, intended to protect his state's trade with Alaska, a measure acceptable in the protectionist times of the 1920s.

Strong union and industry lobbies (seafarers, shipyards, railroads), have resisted efforts to repeal. Costs USA about $10billion/year (Senator John McCain, R-AZ, 2002)

The Firm and Fuzzy Factors in the Devon Comparison of Pipeline and Tanker Export

Discussions were held with leading UDW pipeline owners and operators and with tanker companies, builders and financiers.

Many opinions, much debate during 2006-2009!

Firm	1	New construction tariffs. Tanker figures include time charter as applicable, fuel & port costs
	2	Tariff on existing pipelines on shelf, booster platform to beach
	3	Equivalent of export system CAPEX in facility
Fuzzy	4	Quality bank in existing pipelines
	5	Optionality, no. of destinations
	6	Upside on marketing to wider range of destinations
	7	Guaranteed future access throughout field life
	8	Premium for prompt payment on delivery

Principles Used – "Preponderance of Probabilities"

a. Decided to go for DP 2 tankers to maximize safety and found long term overall cost effectiveness benefited;

b. Analyses were based on locations in UDW typical of Devon's portfolio;

c. Tanker employment would be calculated for say 5-16 years to fit production profile estimates, actual requirements longer for Lower Tertiary fields concerned;

d. Tankers employed would therefore all be new builds;

e. Tanker ROCE assumed 10.8% in 2008;

f. Timing of a potential project would be difficult to predict for establishing cost levels, i.e. some form of consistent screening was needed;

g. Current shipping market levels then or now unlikely to be relevant for long term commitments for some year in the future.

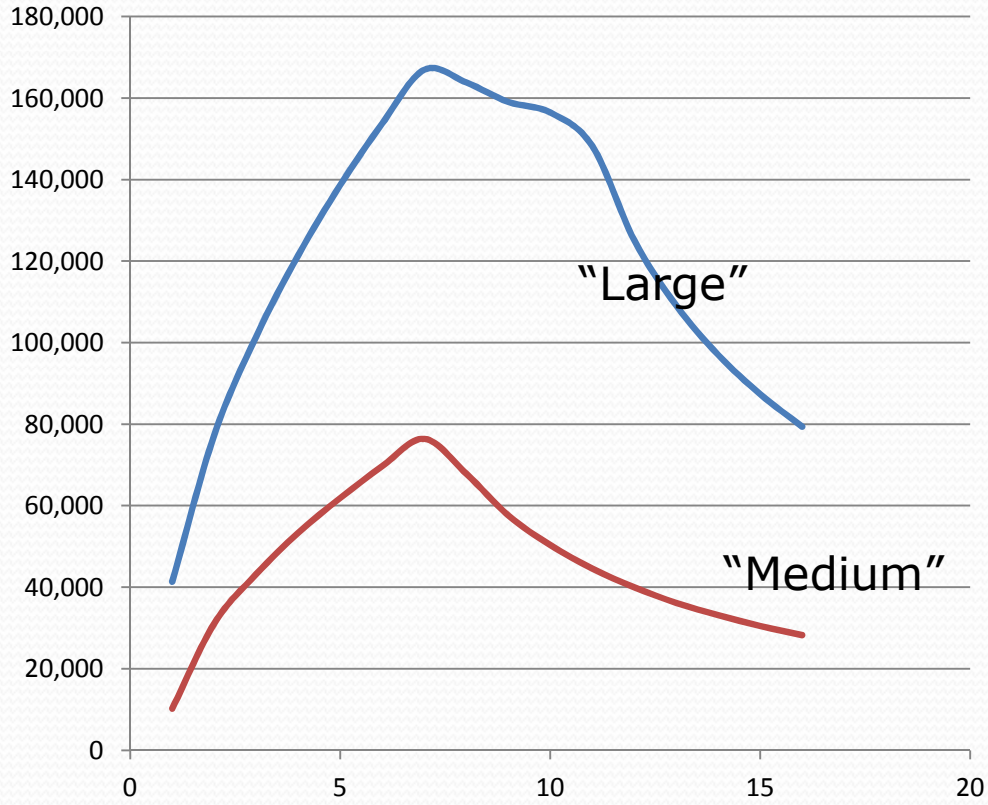
h. Used lots of educated guesses and the principle of Preponderance of Probabilities!

Oilfield Size & Tanker Requirements in Devon Work

Production and Tanker Requirements for Fields in DOT 09 Analyses

Year	"Large" Field		"Medium" Field	
	Production, bopd	Tankers required	Production, bopd	Tankers required
1	41,333	1	10,196	1
2	77,344	2	31,101	1
3	101,541	3	43,211	1
4	121,470	3	53,362	1
5	138,664	3	61,886	2
6	153,773	3	69,675	2
7	166,948	3	76,411	2
8	163,841	3	67,845	2
9	159,057	3	57,609	1
10	156,458	3	50,316	1
11	148,246	3	44,564	1
12	125,115	3	39,980	1
13	109,100	2	36,139	1
14	96,989	2	33,124	1
15	87,346	2	30,491	1
16	79,356	2	28,235	1

Tanker	Years of service	
	Medium	Large
First	16	16
Second	4	15
Third	0	10



Results of Devon Work for Remote UDW in US GoM

Only the "Firm" Cost Components included here, i.e. no quality bank, other commercial variables in this table.

	Facility without storage			Facility with Storage	
Export Option:	1	2	3	4	5
	Pipeline	FSO+ST	HiLoad+DLCT	ST	HiLoad+CT
Medium Reservoir: 268.0 mmbbl recoverable over 16 years, maximum 76,411 bopd	5.94	6.64	6.82	3.41	3.73
Large Reservoir: 703.7 mmbbl recoverable over 16 years, maximum 166,948 bopd	3.98	3.83	3.68	2.60	2.50
		Not much advantage for tankers		Advantage for tankers	

Key:

Option	Configuration	Description
1	Pipeline	New segment to nearest trunkline, multiple connections thereafter
2	FSO+ST	Storarge vessel near facility plus DP2 **S**huttle **T**ankers
3	HiLoad+DLCT	Continuous **D**irect Loading to two HiLoads using **C**onventional Tankers
4	ST	FPSO with DP2 shuttle tankers
5	HiLoad+CT	FPSO with Hiload and **C**onventional **T**ankers

2006-2009 Planning and 2012 Reality: *Pioneer*-ing for US GoM

The *BW Pioneer* in GoM waters

US construction of shuttle tankers

Conversion at KeppelFels

Source: Petrobras

Shuttle tankers owned by US company, crewed by US citizens

Factors Influencing RPSEA's Choice of "GoM Suitable" Tankers for Offloading

Limitation	Specifics	Source of restriction
Ability to enter all GoM ports	Maximum of 40 ft. summer draft	Ship channel physical limit
Ability to operate in coastwise trade in US waters	Jones Act	US Law
Safety	OPA 90 compliant, double hull	US Law
Age	Maximum of 17 years	Limitation set by some major oil companies

The Fleet of "GoM Suitable" Tanker Candidates for Offloading

By law we have to use Jones Act tankers and only in emergencies have waivers been issued for use of foreign flag tankers (2005 for hurricane *Katrina*, 2012 for hurricane *Sandy*)

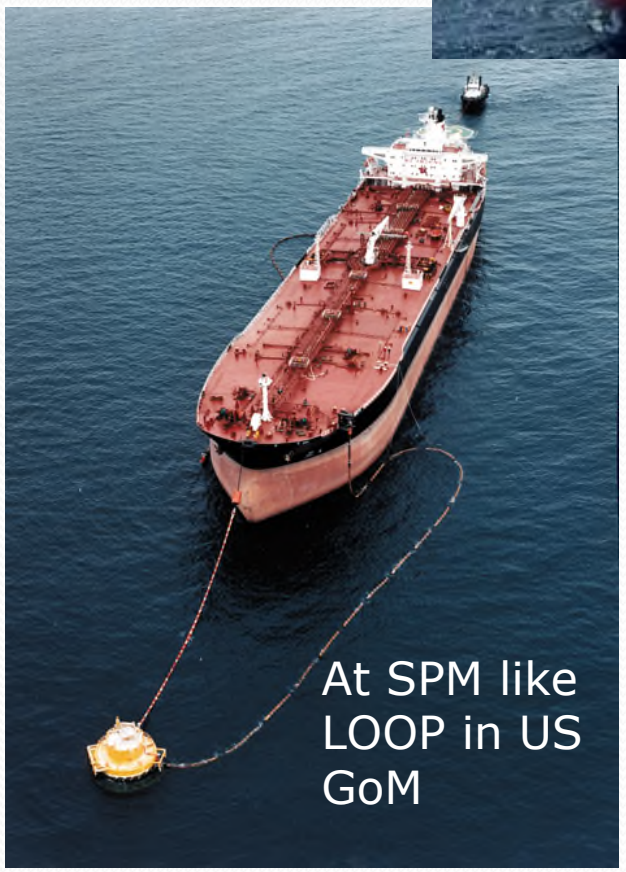
Origin	Tanker size category	World's "GoM Suitable" Fleet		Total Candidates Worldwide
		No.		
Jones Act	Handymax 40-60	25	2.4%	25
Foreign Flag	Aframax	18	1.7%	924
	Panamax	60	5.7%	419
	Handymax 40-60	951	90.2%	1,256
		1,054	100.0%	2,624
Note: "Handymax 40-60" is shorthand for Handymax tankers that are 40,000 to 60,000 metric tons deadweight				
Source: Clarksons Register as at end 2012				

The Four Options Considered in the RPSEA Study

Option	Offloading System	Comment, Precedents	Assumed Uptime, %
1	Conventional tankers, floating hose	Used in GoM at with SPM at LOOP since 1981 (uptime 97.3%), very widely used elsewhere in world. Planned by Helix, MWCC	90
2	Enhanced maneuverability, BLS, catenary hose	Used in US GoM at first FPSO since February 2012: PBR/OSG at *Cascade / Chinook* , principles well accepted	96
3	DP 2 shuttle tankers, BLS, catenary hose	Considered in 2002-2004 for GoM by Conoco's Seahorse & American Shuttle Tankers, 70+ used in N Sea, also E. Canada, Brazil	98
4	HiLoad DP with conventional tankers	Prototype underwent sea trials in Norway 2011, en route to Brazil for 2014 operation. Subject of RPSEA study for UDW GoM	98

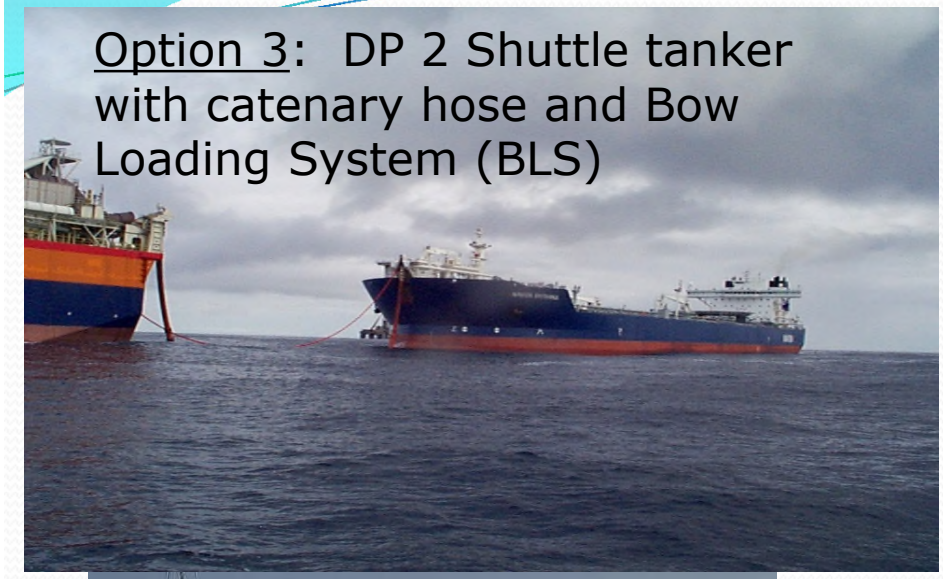
Offloading Options 1 and 2

Option 1: Conventional tankers, floating hose, hawser moored



Option 2: Enhanced maneuverability (bow thruster and CPP), BLS, hawser moored, all as used at *Cascade / Chinook by OSG/PBR* (Not Dynamically Positioned)

Bow Loading System (BLS) and Catenary Hose



A Bow Loading System and a Catenary Hose are used in both Option 2 and Option 3

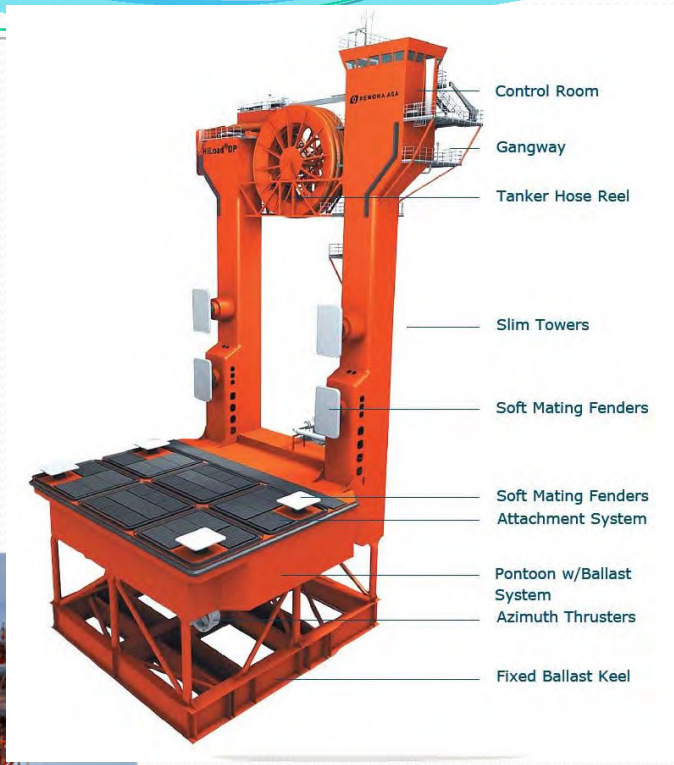
Option 4: HiLoad DP - New Technology for Offloading

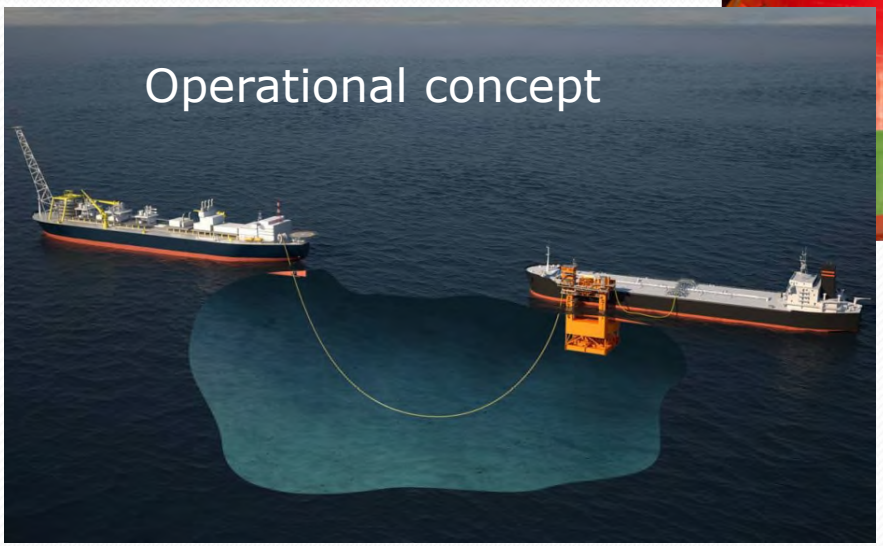
Pioneered by Remora since 2001, HiLoad DP technology acquired by Teekay in 2013.

Allows use of DP station keeping on conventional tankers without conversion.

Work for RPSEA showed the design of HiLoad DP could be adapted for UDW GoM operation – see RPSEA's Final Report to be published later in 2013

Prototype goes to work for Petrobras in Brazil in 2014.





Full scale prototype subjected to in sea trials offshore Norway in 2011

RPSEA and the HiLoad DP Saga

For a dozen years the Remora people in Stavanger developed and promoted their HiLoad DP 2 technology:

2001	Concept created by Rermoa in Stavanger
2006	Prototype engineered
2010	Prototype delivered, $150+million investment
2011	Sea trials offshore Norway
2012 Aug	RPSEA study starts in Houston
2013 May	Teekay Offshore Operators (NYSE: TOO) acquires Remora and prototype at discount, modifies for Brazil
2013 Sep	RPSEA study finished: HiLoad could be built in GoM (budget $132 million) and made to work in GoM conditions: economics and fundamental needs for not favorable for GoM
2014 Jan	Protoype starts on 10 year time charter in Brazil with Petrobras, CAPEX reported as $66million.

In August 2012 RPSEA signed a contract with Remora providing for Remora and four US subcontractors to assess suitability for UDW in US GoM: total project cost of $1.054 million running for 12 months.

Peter Lovie was the Principal Investigator on this work.

Screening Economics: Cost Build Up, Options 1-4

Cost Component	Option 1: Conventional Tanker with Tugs, Floating Hose	Option 2: Enhanced Maneuverabilty Tanker (CPP, bow thrusters), BLS + Catenary Hose	Option 3: DP2 Shuttle Tanker, no Tugs, BLS + Catenary Hose	Option 4: Conventional Tanker with HiLoad DP, Catenary Hose
Tanker, for each type, $/day:	2008 TC Newbuild rates - 15%	2008 TC Newbuild rates - 15%	2008 TC Newbuild rates - 15%	2008 TC Newbuild rates - 15%
Port & fuel costs, $/day:	2008 costs + 70%	2008 costs + 70%	2008 costs + 70%	2008 costs + 70%
Hold off tug, $/loading	40,000	40,000	- - -	- - -
Hose handling vessel,	30,000	- - -	- - -	- - -
HiLoad DP, 10 year TC, $/day	- - -	- - -	- - -	restricted (c)
HiLoad DP, fuel (MDO), $/day	- - -	- - -	- - -	restricted (c)
Notes:	(a) The hold off tug and the hose handling vessel are assumed to be available in the field or nearby, not dedicated full time to offloading operations. Costs are total for each loading, include fuel.			
	(b) Each loading is overall around 10 hours using a 35,000 bph system, i.e. less than commonly seen elsewhere in the world with larger offload tankers that may take 24-30 hours.			
	(c) Hiload figures discussed in RPSEA Working Project Group meetings but as at 22Sep13 restricted for public disclosure.			

Indicative "Straw Man" Economics for Complete Offloading System, $/day

Offloading Configuration:	Option 1: Conventional Tanker with Tugs, Floating Hose	Option 2: Enhanced Maneuverability Tanker (CPP, bow thrusters), BLS + Catenary Hose	Option 3: DP2 Shuttle Tanker, no Tugs, BLS + Catenary Hose	Option 4: Conventional Tanker with HiLoad DP, Catenary Hose	Contract Term, years
Equipment in offloading system	2 tankers	2 tankers	2 tankers	2 tankers	
	1 hold off tug	1 hold off tug	- - -	HiLoad DP	
	1 hose & hawser	- - -	- - -	- - -	
Example:	MWCC, Helix	*Cascade / Chinook*	North Sea	RPSEA Project	
Assumed uptimes, %	90	96	98	vv	
	154,909	**145,569**	169,406	www,www	16
	157,229	**147,921**	172,449	xxx,xxx	12 to 15
	166,317	**157,139**	184,373	yyy,yyy	10 to 11
	201,299	**192,619**	230,268	zzz,zzz	2 to 9

Trends on $/bbl Economics for Offloading with Jones Act v. Foreign Flag Tankers

Offloading Configuration:	Option 1: Conventional Tanker with Tugs, Floating Hose	Option 2: Enhanced Maneuverabilty Tanker (CPP, bow thrusters), BLS + Catenary Hose	Option 3: DP2 Shuttle Tanker, no Tugs, BLS + Catenary Hose	Option 4: Conventional Tanker with HiLoad DP, Catenary Hose	Contract Term, years
Indication of Jones Act transporation cost, $/bbl	1.94	**1.82**	2.12	a.aa	16
	1.97	**1.85**	2.16	b.bb	12 to 15
	2.08	**1.96**	2.30	c.cc	10 to 11
	2.52	**2.41**	2.88	d.dd	2 to 9
Use of foreign flag tankers - transportation cost, $/bbl	0.88	**0.64**	0.73	e.ee	16
	0.89	**0.65**	0.74	f.ff	12 to 15
	0.92	**0.68**	0.79	g.gg	10 to 11
	1.05	**0.78**	0.96	h.hh	2 to 9

Conclusions

1. There are links in US GoM between reservoir conditions, well established extensive pipeline infrastructure and the choice of development solutions other than FPSOs. Operator risk tolerance and field development philosophy ARE factors. Geography, pipeline networks and the Jones Act all affect offloading business in US. Heavier oils in remote UDW might dictate tanker export over pipeline. Thus multiple factors may over rule export economic comparisons here;
2. Favorable economics in UDW for tankers over pipelines are indicated for a facility with storage – could make a roughly a 2:1 difference.
3. Fields that are particularly remote, with uncertain reservoir conditions, for risk mitigation may favor another EPS plus tankers such as at *BW Pioneer*. Thus a full field development in UDW as modeled in the Devon work using an FPSO plus shuttle tankers may not be a sure thing.
4. The available fleet of GoM Suitable Jones Act tankers is small and expensive over the foreign flag alternative. US crews plus foreign built tankers may employ more Americans overall and may make business sense. But the Jones Act is US law and no change in sight!
5. If the four options considered in the screening economics here, Option 2 using tankers with enhanced maneuverability, BLS and catenary hose as used at *Cascade/Chinook* appeared the most favorable.
6. Option 4 with the new HiLoad DP technology was the high cost option for GoM with little fundamental need found for it in the three scenarios investigated by RPSEA.
7. :

Thank you

Questions?

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