

FPSO Training Course  
Radisson Blu Boulogne Hotel, Paris ~ December 2016

Session 4.1 - FPSO Conversions  
Ian Parsons – Crondall Energy Consultants Ltd.

## Agenda

- ☐ Developing a conversion strategy
- ☐ Vessel selection & inspection
- ☐ Scope definition
- ☐ Conversion activities
  - Hull structure refurbishment
  - Marine systems and accommodation upgrades
  - New vessel systems
  - Turret installation and integration
  - Topsides installation and integration
  - Harsh environment conversions
- ☐ Lessons learned and key success factors

# Developing a conversion strategy

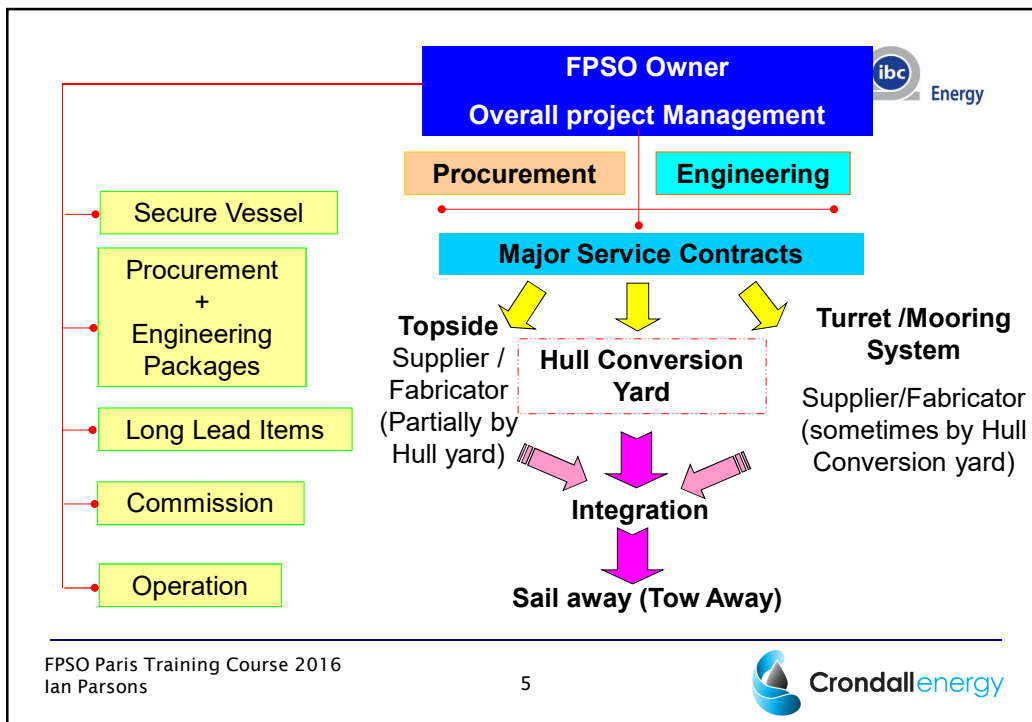
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## Developing a Conversion strategy

- ☐ Vessel selection and inspections;
- ☐ Front end and conversion engineering;
- ☐ Scope definition and limits;
  - Turret integration scope?
  - How much of topsides will be done in the shipyard?
- ☐ Conversion project execution plan (PEP) and conversion approach;
  - Which scope goes where?
  - Base on real evaluation of skills and experience.
- ☐ Yard selection;
- ☐ Conversion risk analysis;
- ☐ Yard team.



Image courtesy of Tullow Ghana Ltd and Modec.



This slide features the title **Vessel selection & inspection** centered on a white background. The **ibc Energy** logo is located in the top right corner. The footer contains the text **FPSO Paris Training Course 2016** and **Ian Parsons** on the left, the number **6** in the center, and the **Crondallenergy** logo on the right.

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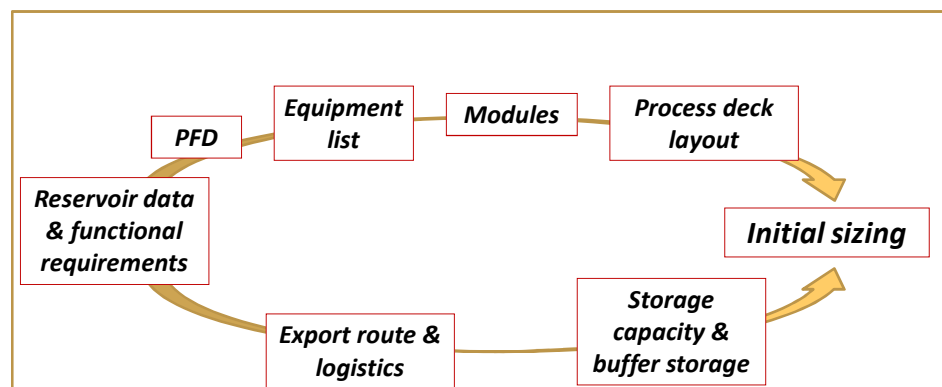
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## FPSOs and tankers are different!

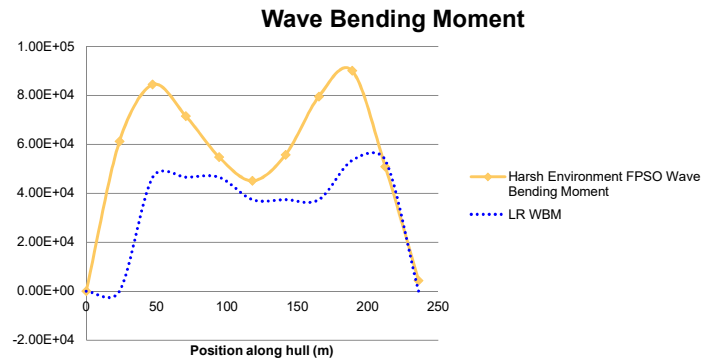


- ❑ FPSO and tanker design drivers are fundamentally different.
  - Tanker: e.g. resistance, operating economy, port access, market "sizes";
  - FPSO: e.g. Storage (parcel size and buffer storage), deck capacity, motions, robustness/longevity, operability, compliance.
- ❑ FPSOs generally plan to remain on station, (without recourse to dry-docking or at-shore maintenance) for the life of the field, in order to maintain the flow of oil and cash. Tankers dock frequently.
- ❑ Many of the problems associated with the delivery and operation of FPSOs have their origins in a failure to properly comprehend the extent of the work required to convert a tanker into an FPSO.
- ❑ Consequently, the industry has not always been able to achieve the desired higher levels of reliability and integrity, with the consequence that many vessels are now requiring major overhauls (usually involving removal from the field and dry docking), before they reach their intended design lives.

## Vessel sizing



## Vessel selection – harsh or benign environment



## Vessel selection – requirements



- ☐ What is the required design life?
- ☐ Single hull versus double hull – consider coastal state as well as IMO regulations; consider reputational risk;
- ☐ Consider Class requirements in the context of site specific wave conditions and BM/SF - will the structure be adequate?
- ☐ Age and condition – consider degree of hull steel wastage – compare with FPSO required scantlings;
- ☐ Age and condition – consider trading history and consumption of fatigue life- what modifications will be required to provide the required fatigue life. What fatigue safety factors (e.g. FMS notation) do you require;
- ☐ Overall – pick high quality conversion candidates and be realistic about the repair/replace and refurbishment scope.

## Material grades & high tensile steel



- ❑ Lower temperature applications e.g. Atlantic Canada, Barents Sea, would require special consideration of steel grades – might require steel grades that can operate at or below -20 degrees C;
- ❑ Tankers with extensive use of HTS can be more prone to fatigue cracking – impact of higher stress range may not be reflected in the design of (older) conversion candidates;
- ❑ The use of HTS in certain areas is popular, because of the opportunities for saving weight; however because of the greater stress ranges, this can lead to lighter scantlings and greater flexing; determination of scantlings based on ULS can lead to FLS problems in certain areas e.g. side shell.
- ❑ "With the increased use of high tensile steel, fatigue issues must receive constant scrutiny and attention. When the stress level is increased through using high tensile steel, attention must be paid to structural detail and stress concentration factors to maintain the same fatigue life. The problem should have been addressed at the design stage. For ships already built and in operation, fatigue life may be calculated retrospectively and an inspection program established, paying attention to detail before the fatigue life expires."  
<http://www.dnv.com/industry/maritime/shiptypes/container/sideshellfatigue.asp>
- ❑ (Note: No indication that the higher stress range has any impact on coatings – coating breakdown much more influenced by application/environmental control and formulation);

## Vessel inspection



- ❑ Detailed vessel survey and inspection
  - Structural survey and thickness measurements
  - Marine systems condition evaluation (pipe-work, valves, equipment)



## Vessel selection – condition



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## Vessel selection – condition



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## Scope definition

## Front end engineering & scope definition

- ❑ Front end and conversion engineering
  - Engineering and procurement responsibility;
  - Class approval on key (schedule or integrity critical) items;
  - System philosophies for other marine systems;
  - Identification of main interface areas/systems;
  - Identify compliance requirements (codes and standards);
  - Identify critical path engineering activities.
- ❑ Scope definition
  - Understand the starting point – be realistic about condition of existing vessel;
  - Be clear on repair/refurbish and replace choices from the start;
  - Develop detailed scope, specifications and interface documents;
  - Ensure engineering efforts supports scope definition.





## Bill of quantities for a 2 Million barrels storage FPSO



<input type="checkbox"/> Ballast / slop / COTs blasting and coating	Approx 100,000 sq m
<input type="checkbox"/> Piping – Dk,Tks, E/R, P/R, Accom	Approx 50Km (1,400 Te)
<input type="checkbox"/> Elect. Cables	Approx 350Km
<input type="checkbox"/> Steel Work – Renewal	Between 800 to 1,200 Te
<input type="checkbox"/> New Structures and Modifications –exclude turret	Between 1200 to 1800 Te
<input type="checkbox"/> Moon pool structures (for internal turret)	Approx 700 Te
<input type="checkbox"/> Turret structural	Approx 3000 Te
<input type="checkbox"/> Total weight of Modules	Approx 6000 Te
<input type="checkbox"/> Man-hours spent	About 3.5 million
<input type="checkbox"/> No of days in dry-dock	45 to 60 days
<input type="checkbox"/> No of days in Shipyard excluding lead time	11 to 16 months
<input type="checkbox"/> No of days at Anchorage	5 to 10 days

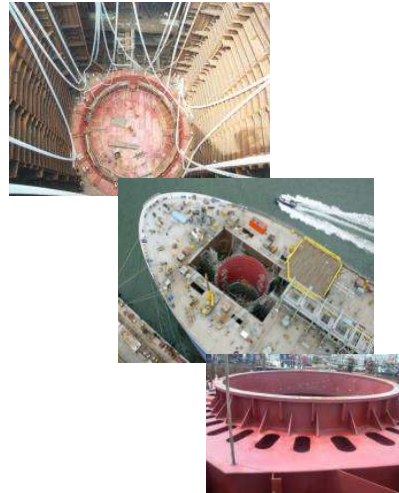
## Conversion activities



## Conversion activities - yard work overview



- ☐ Structural repairs refurbishment and life extensions;
- ☐ Refurbishment of marine systems;
- ☐ Installation of new marine systems;
- ☐ Turret and topside installation;
- ☐ Integration of hull with turret and topside;
- ☐ Construction logistics and planning.

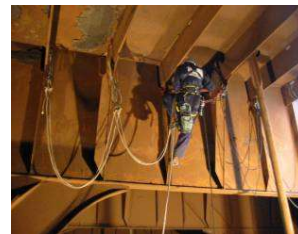


## Conversion activities – hull structure refurbishment



### Structural repairs, refurbishment and life extension

- ☐ Inspections: Full staging to gauge extent of repairs.
- ☐ Tank Blasting and coating: Ballast and Slop full blast & re-coat; Cargo blast & recoat bottom - sometimes blast & re-coat the under deck also;
- ☐ Renewals & additions/enhancements:
  - Dependent on age of tanker and life of field;
  - Expect significant deck and keel replacement in older vessels;
  - Expect significant fatigue repairs & enhancements.
- ☐ Addition of new bulkheads – wash bulkheads?



## Conversion activities - marine systems



### Pipe work

- ❑ Requires early assessment of the repair/refurbish/replace decision in order to allow procurement to proceed;
- ❑ Repair/refurbish/replace
  - Complete systems?
  - Ballast and cargo pipes;
  - Ballast & cargo valves?
  - Change-out valves to facilitate tank isolations for inspection and/or for enhanced safety;
  - IG headers and relief valves;
  - IG vent line vents.
- ❑ Consider overall cargo system architecture? Pump room?



## Conversion activities - marine systems



### Equipment

- ❑ Modify:
  - Turbo alternators?
  - Marine boilers: refurbish and convert to dual fuel (?);
  - Upgrade steam system.
- ❑ Replace:
  - Compressed & control air;
  - Evaporators;
  - Sewage plant;
  - Fixed firefighting equipment.
- ❑ Scrap redundant HFO equipment;
- ❑ Switchboards may be replaced or expanded.



## Conversion activities - new vessel systems requirements

- ☐ High voltage generators, switchboards and transformers;
- ☐ New Heli-deck – 90 ton to 120 ton structure;
- ☐ New cranes;
- ☐ New Flare tower - 50 to 90 metres height;
- ☐ New life boats and rescue boat;
- ☐ New safety fire and gas systems;
- ☐ Control air compressors and dryers.



## Conversion activities - accommodation upgrades

Upgrade to increase living space for:

- Additional POB;
- More onerous working environment regs.;
- Additional capacity for start-up, commissioning and campaign maintenance - should be 100 plus beds as a minimum;
- Production operations offices, meeting rooms etc.;
- Muster areas.



Expand hotel systems for increased accommodation;

- HVAC;
- FW generators;
- Sewage.



## Conversion activities - turret installation and integration

### Challenges of turret installation

- ❑ Interface meetings on lifting and installation procedures;
- ❑ Weight and height constrained by floating crane;
- ❑ Alignment and installation aids;
- ❑ Arrival of equipment: especially swivels and heavy components, incomplete components;
- ❑ Close tolerances to be defined;



- ❑ External Turret:
  - Determine cut line. Yard design the installation methods and provide stabbing aids guides to turret fabricator to prepare on turret;
- ❑ Internal Turret:
  - Fabricate moon pool and reinforcement – Partially need to do in dry-dock.

## Conversion activities - turret installation and integration

### Typical turret heavy lift, 1060 te





## Conversion activities – example: FPSO Falcon



Bow preparation  
for Turret Arm



External  
Turret



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## Conversion activities – example: Jubilee turret installation



*Jubilee external turret: courtesy of Tullow*

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## Conversion activities - topsides installation & integration



### Challenges: modules and lifting sequence

- ☐ Module weight and size (overall topsides lay-out decision);
- ☐ Floating cranes availability;
- ☐ Weighing and lifting arrangement;
- ☐ Careful planning and coordination;
- ☐ Dimension control for module supports;
- ☐ Pipe racks put in place before topsides;
- ☐ Look out for obstructions;
- ☐ Local Equipment Room - as early as possible.

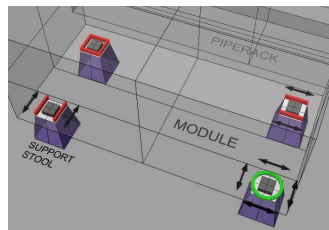


## Conversion activities - topsides installation & integration



### Topsides interfaces

- ✓ Interaction of topsides modules with hull deflections;
- ✓ Influence of hull motions and accelerations (structures, process performance, human factors);
- ✓ Structural integration of topsides support stools & module support structure into hull structure layout;
- ✓ Consideration of required maximum topsides weight and CoG (stability considerations);



## Conversion activities - topsides installation & integration



### Alternative Lifting Arrangements

- ❑ Heavy lift for options for modules approximately 2500 t include:
  - Asian Hercules II Sheerleg Crane (3200 t lift capacity);
  - Lampson Transi-Lift LTL –2600 Land Based Crawler Crane.



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## Conversion activities - topsides installation & integration



### Integration of Topside and Turret

- ❑ Accurate drawings with clear battery limits and tie-in positions;
- ❑ Ship checks (interfaces & dimensions);
- ❑ Communication between parties;
- ❑ Clear matrix on pre-commissioning activities;
- ❑ Ensure long lead items do not affect construction work;
- ❑ Preferably, turret is fully completed before lifting onto vessel.



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Conversion activities - harsh environment conversions



**North Sea Conversion - Alvheim FPSO**



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Conversion activities - harsh environment conversions



**North Sea Conversion - Alvheim FPSO**



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## Lessons learned and key success factors

### Lessons Learned - safe execution

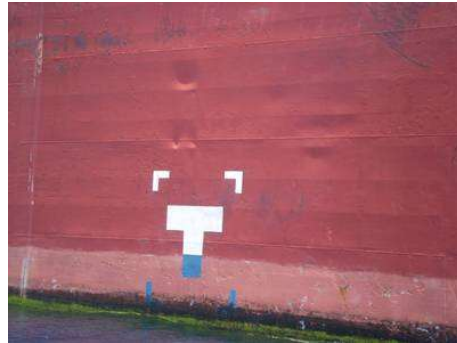
***Create and maintain a safe working environment at all time.***



## Lessons learned– vessel selection



- ☐ Take great care in vessel selection – even as the operator on a lease contract;
- ☐ Pick the best hull that your budget will allow;
- ☐ Spend enough time and money to establish the **condition of the vessel** and **define upgrade scope**;
- ☐ Don't buy on price alone!
- ☐ Caveat emptor



## Key success factors



- ☐ Reducing uncertainty and unknowns:
  - Good definition of scope and specifications;
  - Be clear on replace, repair & refurbish decisions;
  - Good hull, reliable equipment, knowledgeable teams, competent personnel;
  - Correct allocation of scope and risks to shipyard;
  - Disciplined control of schedule and costs; institute solid project controls- firm change management.
- ☐ Planning and Preparation:
  - Defining common goals: safety and work targets;
  - Develop an execution plan and identify critical activities & resources;
  - Have a common plan with agreed key milestones (aligned with Contracts);
  - Establish critical path for engineering deliverables, procurement, arrival of equipment, docking activities;
- ☐ Maintaining communications and building relationships:
  - Regular face to face communications at multiple levels;
  - Building strong relationships at all levels can resolve a lot of project issues.

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## Acknowledgements



The author would like to acknowledge the kind help and assistance of Keppel Shipyard (and in particular Mr Louis Chow) and their clients for providing permission to use the various images and material in this presentation.