

IBC FPSO Training Course

Paris 2016

Introduction to FPSO Design and Technology

Part 2

Daniel Holman – Crondall Energy

www.crandall-energy.com

Part 2 : Introduction to FPSO Design

- ☐ New build or conversion?
- ☐ Initial hull sizing (new build)
- ☐ Design spiral

References and Glossary

Agenda Part 2 : Introduction to FPSO Design



❑ New build or conversion?

❑ Initial hull sizing (new build)

❑ Design spiral

References and Glossary

Hull - new build or conversion?



New Build

- Design flexibility
- Wider range of configuration options
- Material selection options
- Clear compliance requirements
- Incorporate structural enhancements /integration
- Optimisation of marine systems
- Pre-planned interface systems
- Enhancements for access, inspection & maintenance
- Longer procurement (design/build cycle)
- Relatively high cost

Conversion

- Fixed hull configuration
- Unknowns with respect to
 - ✓ Start point/condition
 - ✓ Upgrade requirements (structure and systems)
 - ✓ Compliance requirements
- Scope definition will be high risk
- Shorter procurement cycle
- Lower cost (purchase hull)
- Steel quality/grade e.g. HTS

More on this during the session on conversions

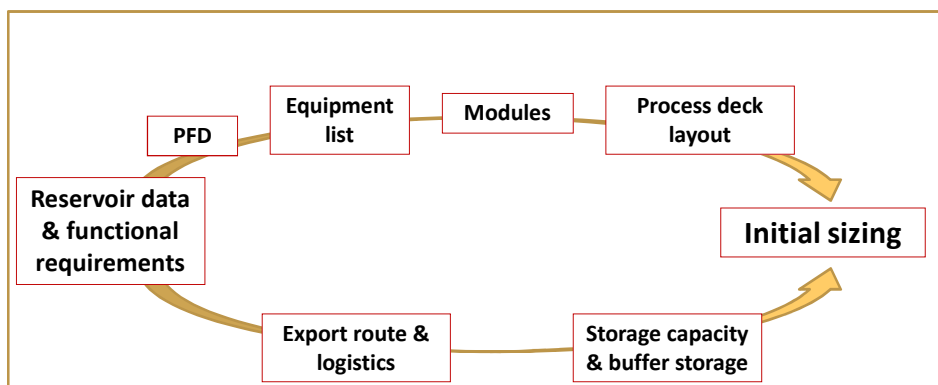
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References and Glossary

Vessel selection - sizing



Initial hull sizing should be validated by comparing the concept dimensions and key dimension ratios against basis vessel data.

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References and Glossary

Design Spiral – Global design



The process of developing the integrated “global” configuration of the FPSO.

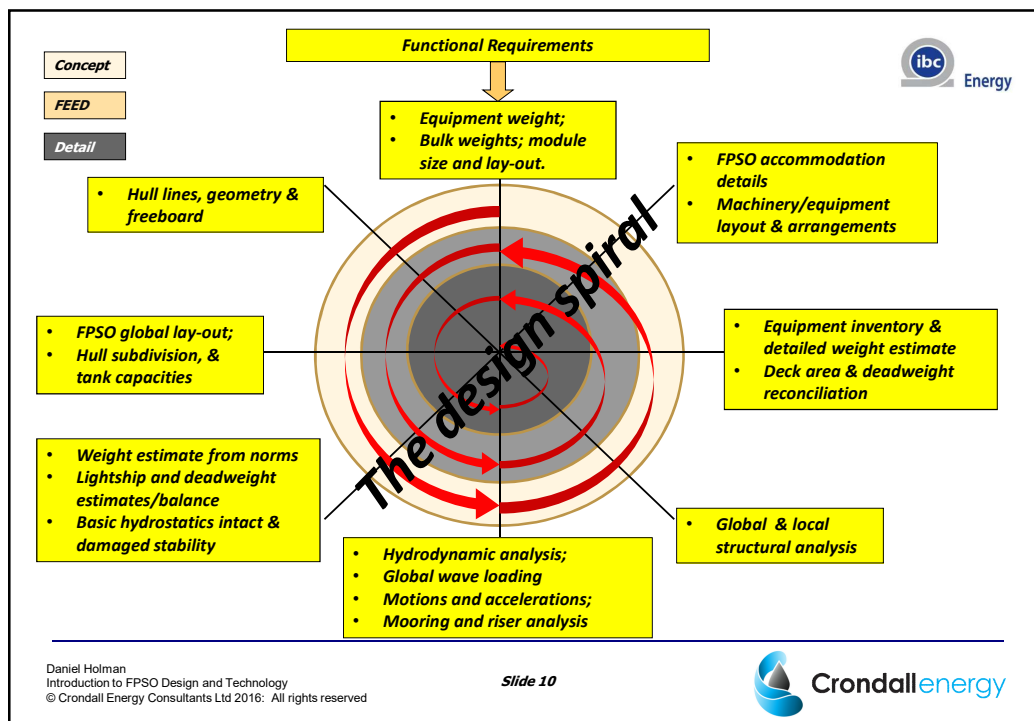
Aims & objective

- ☐ Recognize that the design process is an iterative rather than linear process;
- ☐ Investigate and refine initial sizing of hull during early concept work;
- ☐ Achieve a sound **vessel design & sizing** during concept phase;
- ☐ So we have an agreed **vessel design & sizing** as the basis for **starting** FEED;
- ☐ And achieve a **fixed** global vessel design for project sanction by end of FEED.

Design Spiral – Global design methodology



- ❑ Start by **assembling** all the **Basis of Design** and FPSO **facility functional requirements**;
- ❑ Track around the 'design spiral' **validating the initial vessel** sizing against the design requirements;
- ❑ Develop the **technical definition** required provide a "budget" for the space, weight & Centre of gravity (CoG), for topsides, turret utilities and other equipment ; de-risk the hull sizing before FEED starts.
- ❑ **Refine the topsides design definition** and confirm that it a) meets the functional and other requirements/parameters; and b) fits within the hull sizing as the project completes another lap of the design spiral during FEED;
- ❑ At the end of FEED design have **enough definition** to enter detailed design with **minimum uncertainty**, and minimum **need for any changes** to the design configuration.



Basis of design inputs

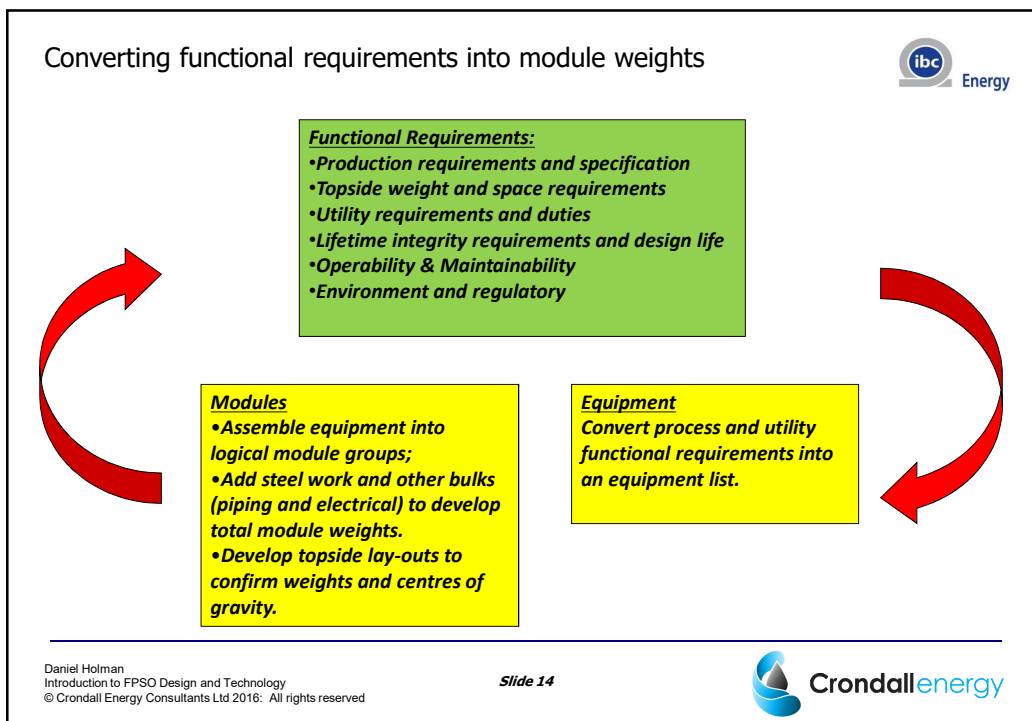
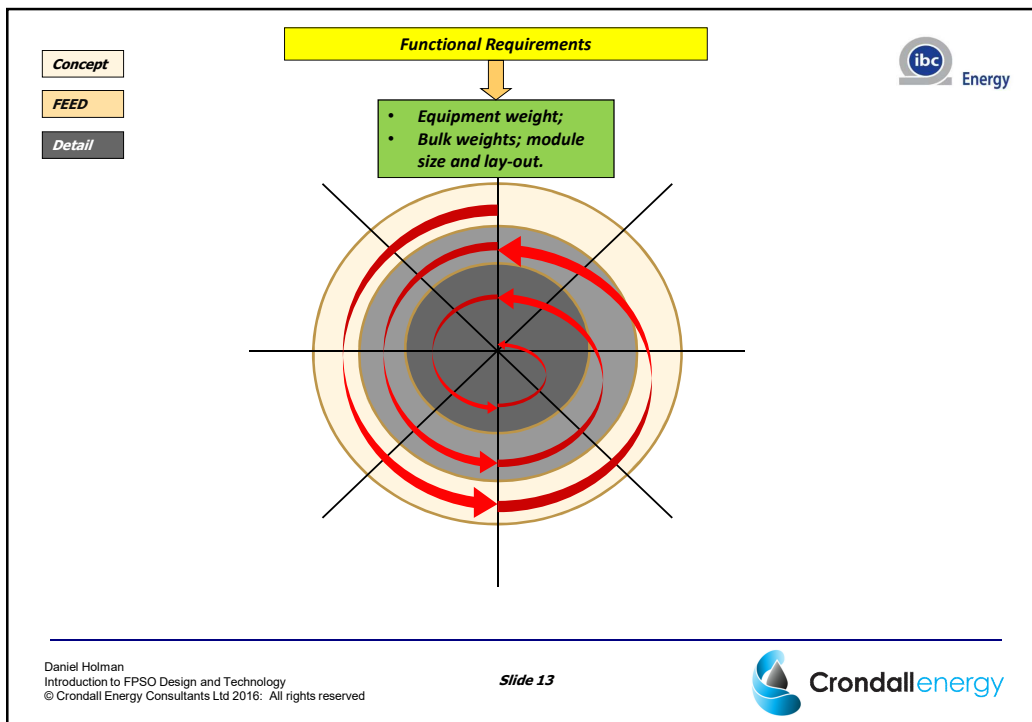


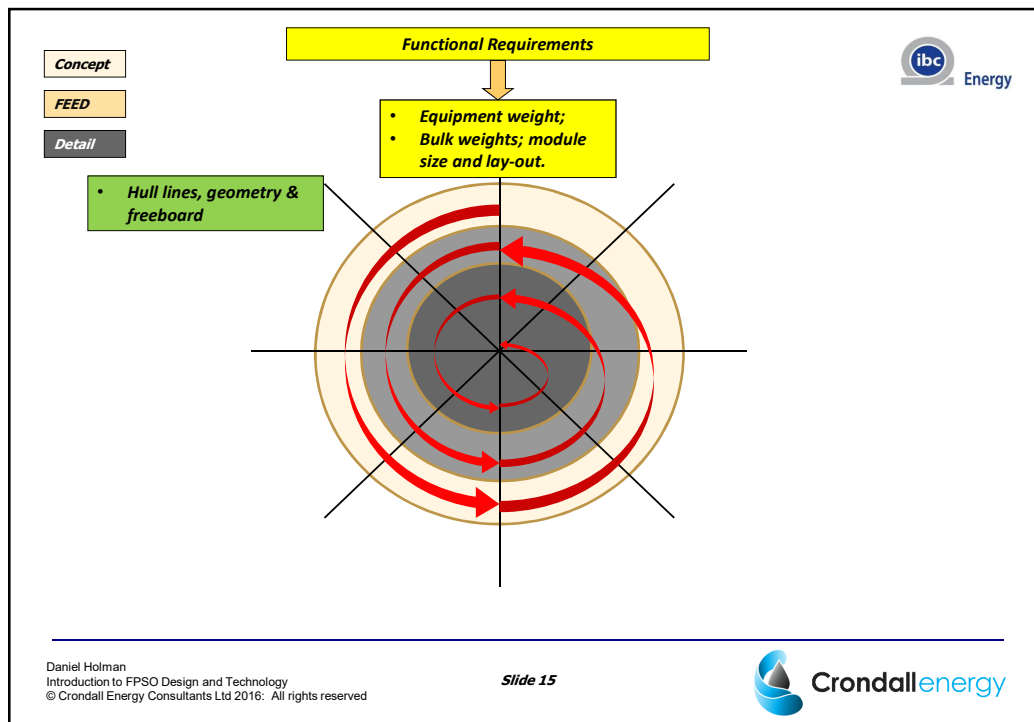
- ❑ Well fluid properties:
 - ✓ Oil gravity;
 - ✓ Gas oil ratio;
 - ✓ Oil composition;
 - ✓ Production profiles;
 - ✓ Impurities, H₂S Co₂,
 - ✓ etc.
- ❑ Metocean conditions
 - ✓ Cyclonic and non cyclonic data;
 - ✓ Wave (Hmax, Hs, directionality data);
 - ✓ Wind;
 - ✓ Current – special current phenomena such as loop currents;
 - ✓ Air and sea water temperatures.
- ❑ Soil conditions

Functional Requirements – general inputs




- ❑ Production requirements and specification:
 - ✓ Production volumes for oil, gas, water etc;
 - ✓ Export specifications etc;
 - ✓ Cargo storage volume, buffer storage requirements etc;
 - ✓ Fluid arrival conditions at the FPSO.
- ❑ Lifetime integrity requirements and design life:
 - ✓ Field life v design life e.g. 20 years
 - ✓ "No docking" requirement;
 - ✓ Design safety factors to reduce risk of integrity issues;
- ❑ Operability & Maintainability:
 - ✓ Redundancy and sparing;
 - ✓ Access for maintenance/inspection/mechanical handling;
- ❑ Safety, environmental and regulatory requirements.

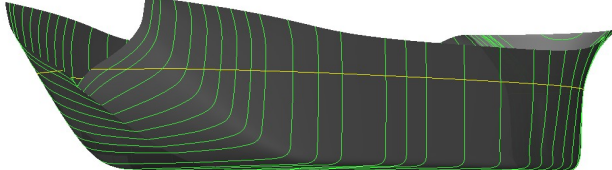




Hull lines, geometry & freeboard




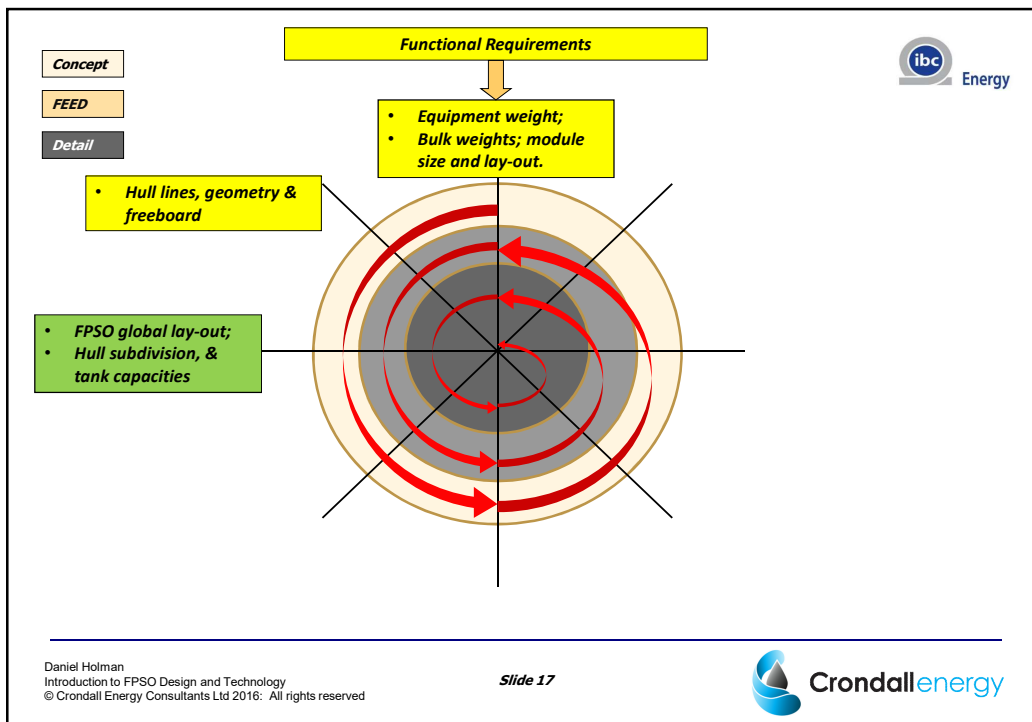
- ☐ Lines (hull-form) generated from existing (usually proven) hull-forms – may be scaled by to meet initial hull sizing requirements;
- ☐ Sizing balances deadweight & hull volume (buoyancy) while achieving the required freeboard;
- ☐ Hull dimensions can be altered at this stage to achieve required deck space, topsides payload/VCG capability, freeboard, hull machinery volume etc.



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Slide 16





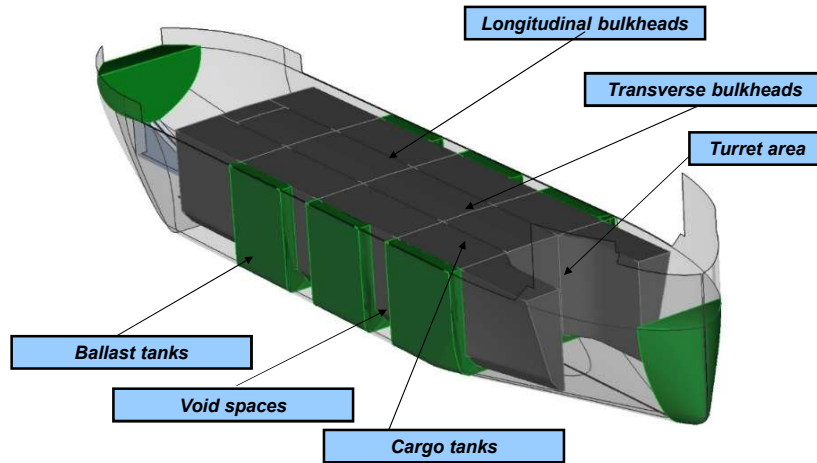
Hull layout -fwd accommodation



Forward or aft accommodation?

Factor	Forward accommodation	Aft accommodation
Release of toxic gases e.g. H ₂ S	☺	☹
Sustainability of the TR during process area or turret fire	☺	☹
Impairment of the helideck during process area or turret fire	☺	☹
Motions at accommodation and helideck	☹	☺
Ease of turret location for passive weathervaning	☹	☺
Hazards during escape by sea	☹	☺
Machinery noise in accommodation	☺	☹
Risk of green-water impact on accommodation	☹	☺
Visibility for incident management during fires etc	☺	☹
Location of secondary TR	☺	☹

Hull subdivision - structure & cargo spaces



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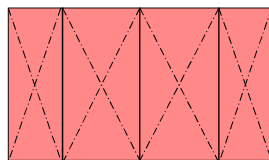
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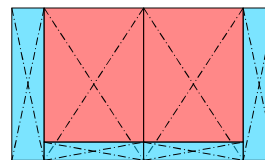
Hull subdivision - cargo tank arrangements



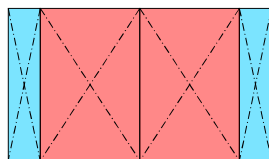
- ❑ IMO MEPC Circulars 139(53) & 141(54) specifies requirements for interpretation of IMO MARPOL Regulations for FPSOs
- ❑ Double sides are required for new builds;
- ❑ Single hulls are allowed for conversions but "appropriate measures" need to be provided to address low energy collision risk;
- ❑ Consider grounding risk for disconnectable units;
- ❑ Needs to be ratified by individual flag states; Coastal states and/or operators may have additional requirements.



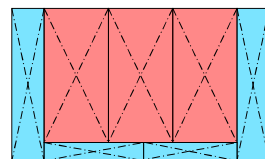
Single hull



Double side - double bottom



Double side - single bottom

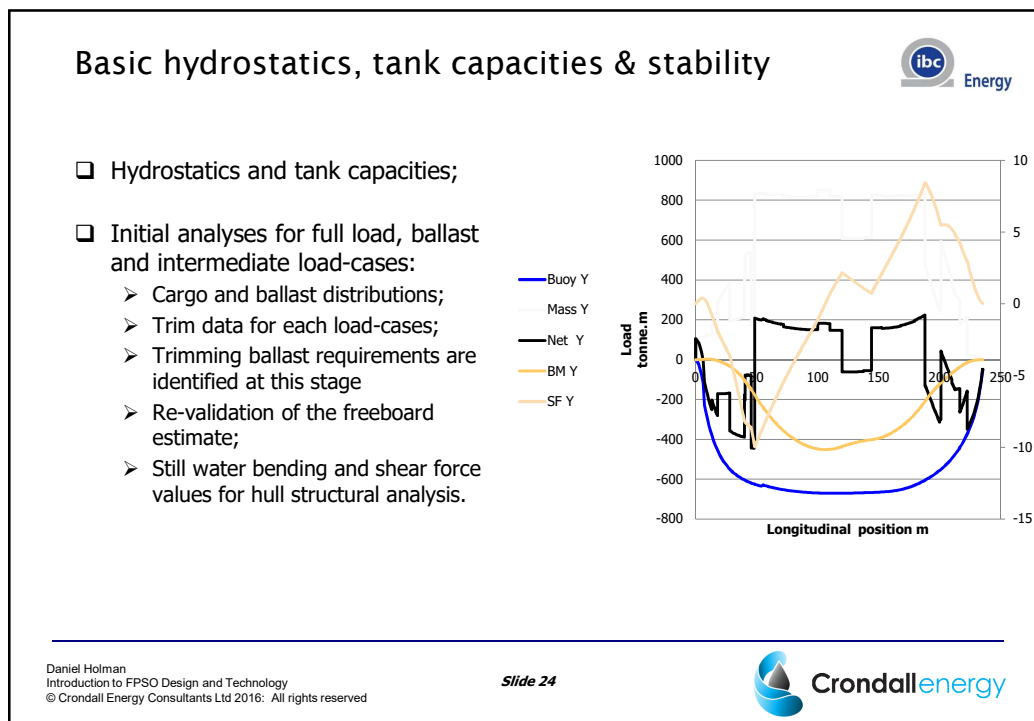
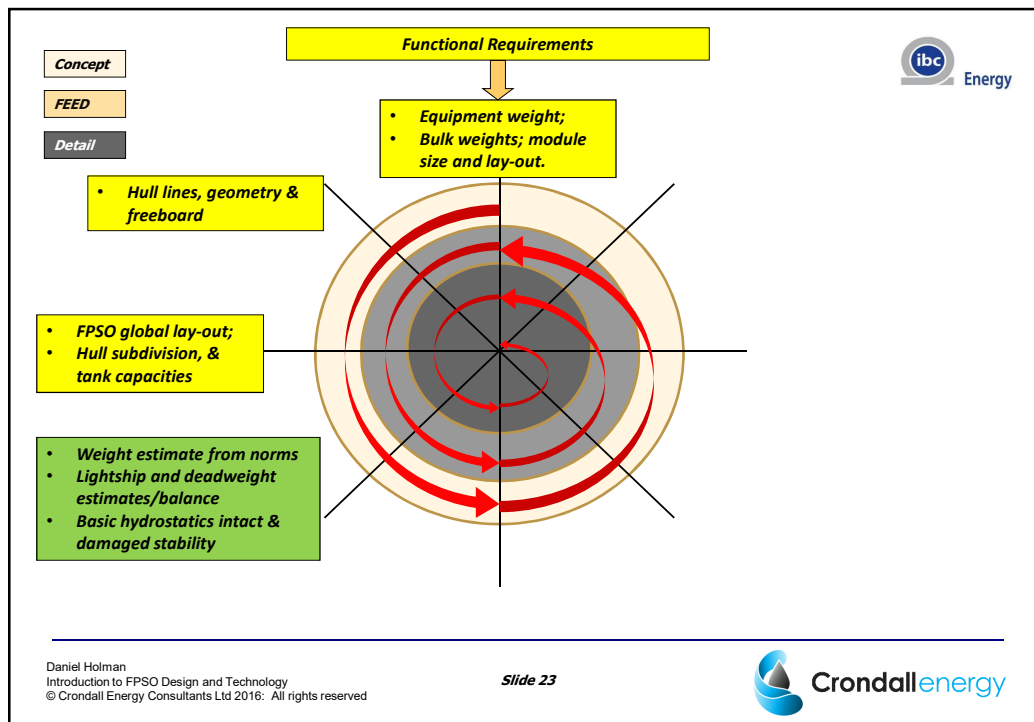


Three cargo tank arrangement

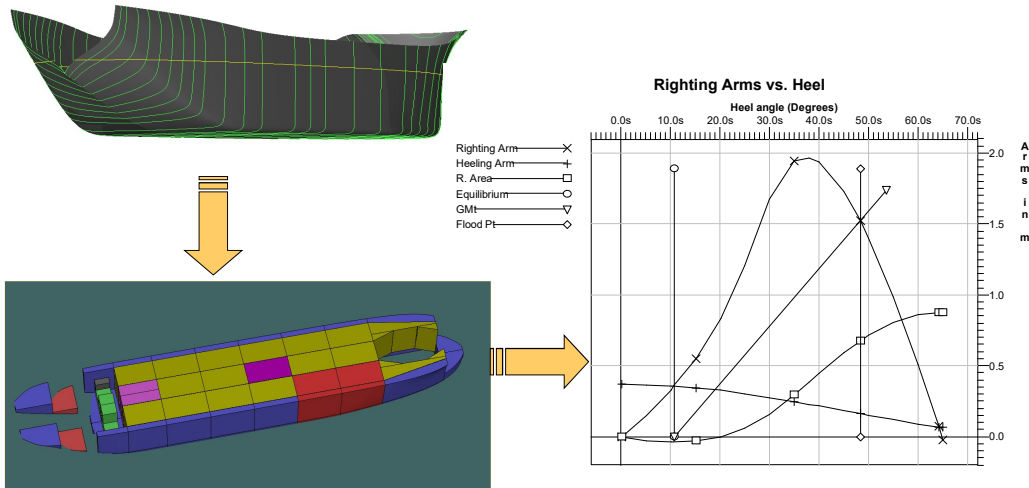
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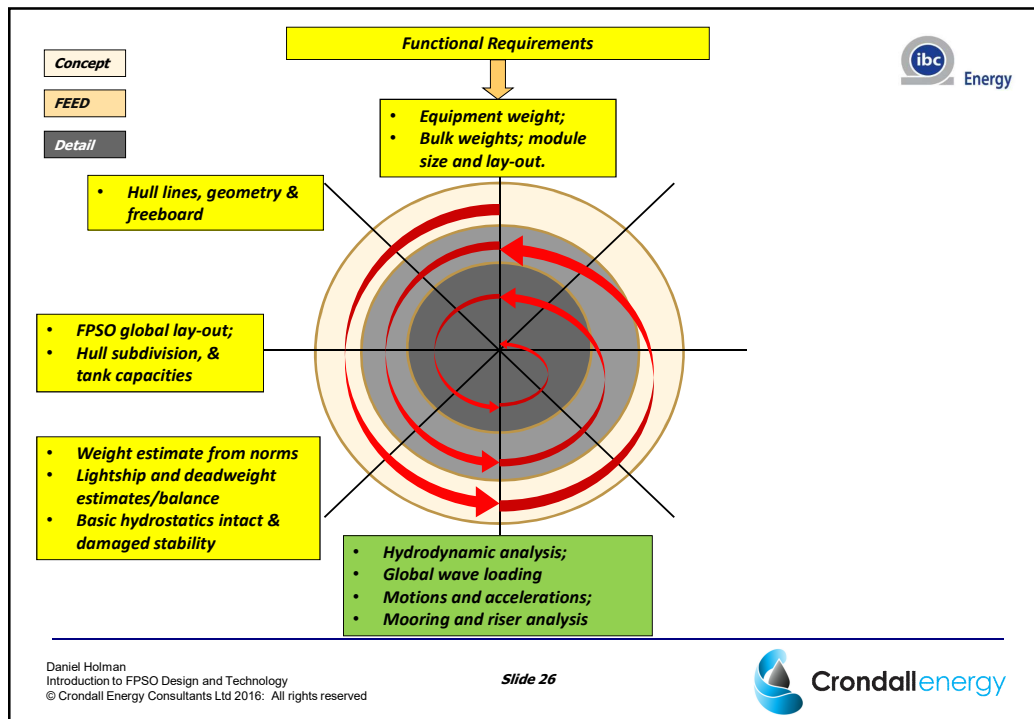


Basic hydrostatics, tank capacities & stability



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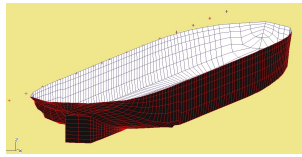
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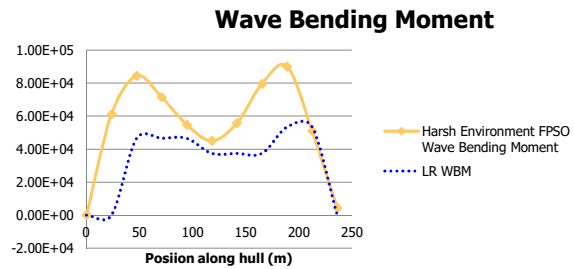
Wave loading and motions analysis



- ❑ Met-ocean data required for specific site location;
- ❑ Especially important for harsh environment FPSOs;
- ❑ Hydrodynamic analysis required to calculate site specific wave bending moment and shear forces.
- ❑ Early indication of motions & accelerations available for topside design (especially long lead items);
- ❑ Assumptions need to be made with respect to heading (weathervaning performance);



Meshed computational hull model



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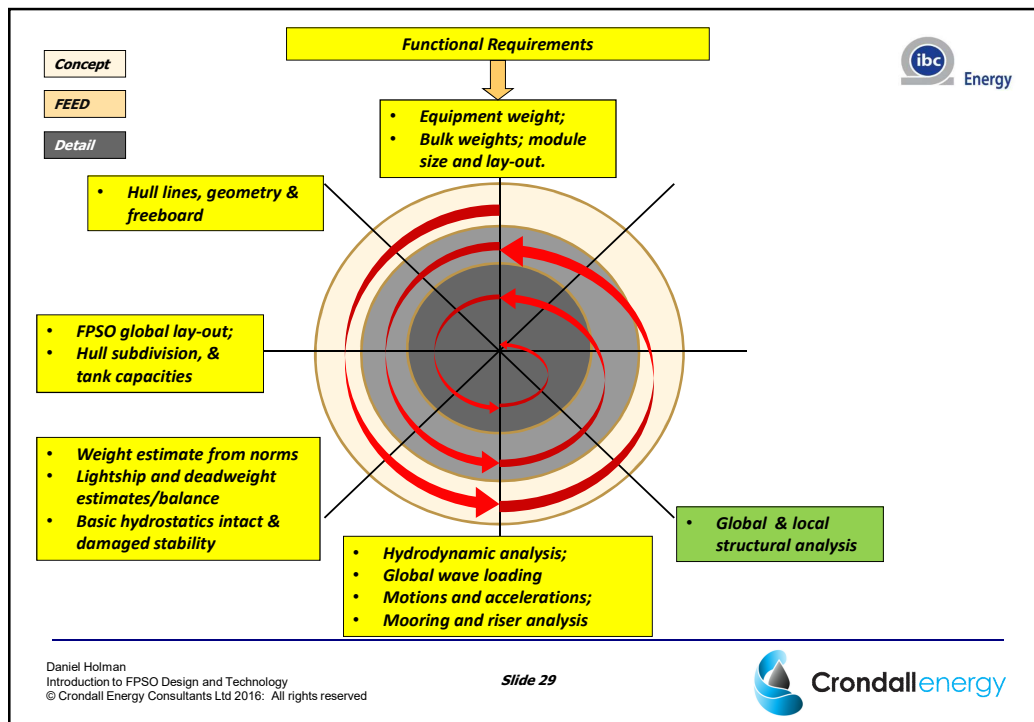
Model testing



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Slide 28





Preliminary hull structural design

- ❑ At concept stage – mid-ship section sizing driven by global loads – shear force & bending moment (still water and wave induced);
- ❑ Make use of Class developed preliminary analysis tools (e.g. Nauticus) for initial check of hull scantlings against Class requirements.
- ❑ Local loads and fatigue addressed in FEED;
- ❑ Mid-ship section provides information for shipyard to cost, and to update structural weight estimate and refine overall lightship estimate.

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MIDSHIP SECTION

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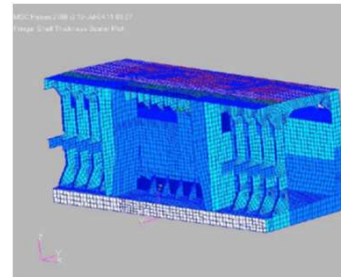
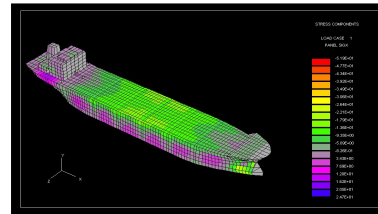
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Global strength analysis



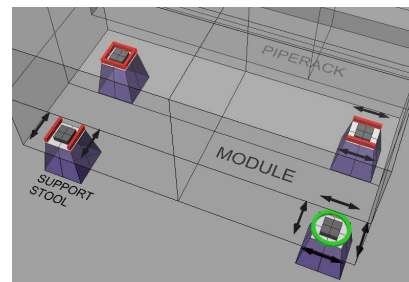
- ❑ Develop overall hull structural model based on software tools that are amenable to quick hull structure definition;
- ❑ Check longitudinal strength in a variety of still water and loaded conditions to determine preliminary scantlings (structural member sizes) and taken site specific wave bending loads into account;
- ❑ FPSO hulls are generally fatigue dominated structures – particularly in harsher conditions;
- ❑ Longitudinal strength (hull girder bending and shear forces) needs to be considered for the required range of cargo loading scenarios;

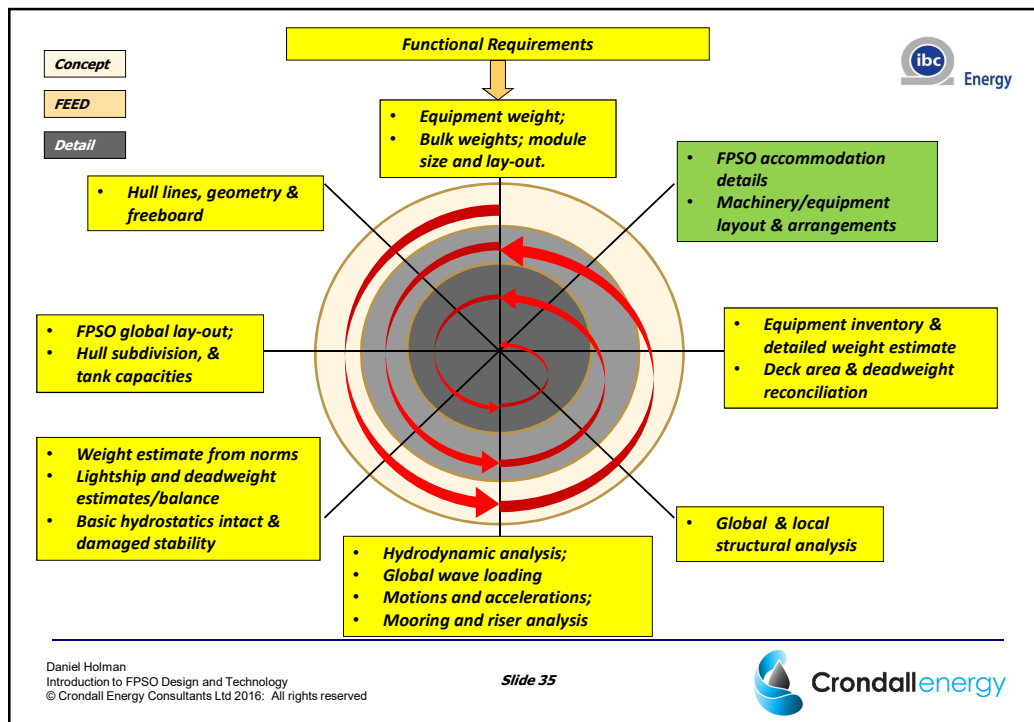


Interface with topsides equipment and systems



- ❑ Design, layout of topsides and interface issues will be covered during topsides presentation;
- ❑ However, there are a number of key issues that need to be considered within the overall FPSO design process:
 - ✓ 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);
 - ✓ Green water protection in harsh and moderate environments.





Accommodation and key marine systems & equipment

- ❑ Accommodation lay-out – define POB requirements and lay-out to meet compliance and operability requirements;
- ❑ Marine systems: define system functional requirements, operational philosophies and vendor list;
 - Cargo - Movement, distribution and offloading of crude oil cargo, tank cleaning
 - Ballast –Draught management, balancing cargo loads, and load distribution
 - Inert gas systems – provide an inert gas atmosphere above cargo – tank purging
 - Power generation & distribution –Main, emergency and essential, switchboards
 - Fuel treatment and supply
 - Steam boilers – steam for pumps and heating (cargo)
 - Seawater for cooling and firewater
 - "Hotel" services – HVAC, potable, water sewage Safety & control systems – Fire and gas, active fire protection, cargo and ballast control, power management systems

• FPSO global lay-out;

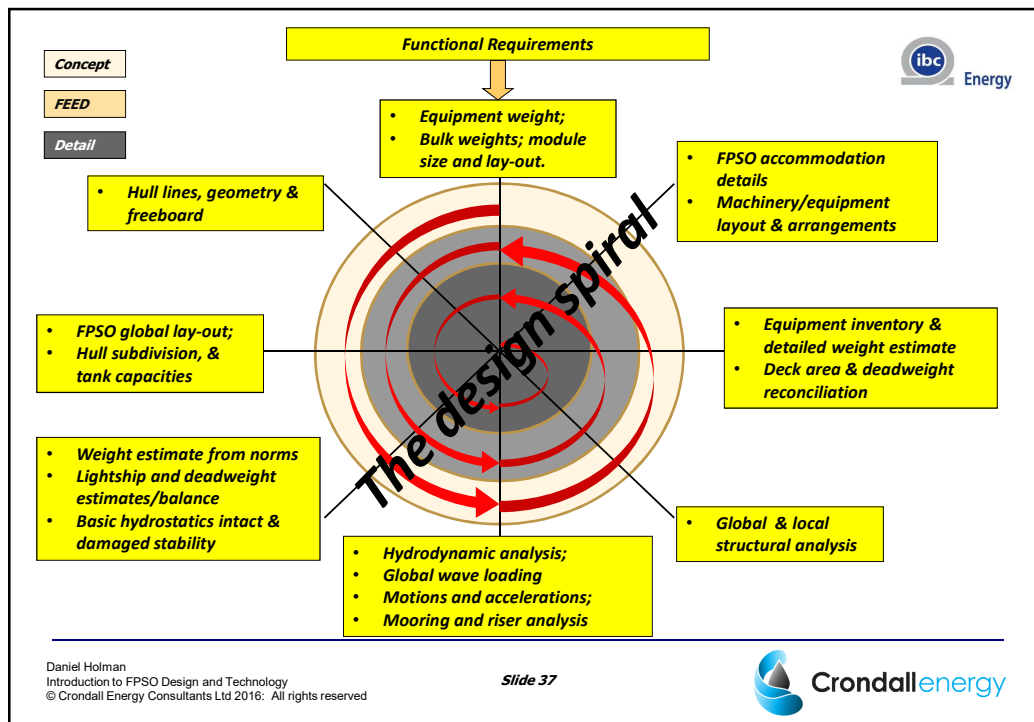
• Hull subdivision, & tank capacities

• Global & local structural analysis

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Slide 36





Agenda Part 2 : Introduction to FPSO Design

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References and Glossary

Thank you
Questions?



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Floating Production & Subsea Specialists

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Winchester ~ Haarlem ~ Aberdeen ~ Singapore ~ Perth WA ~ Houston

References, definitions & additional information.

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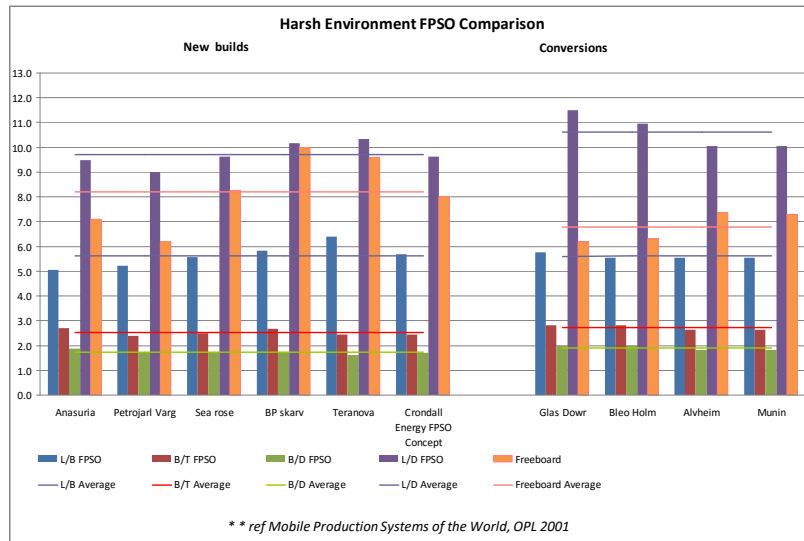
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Concept design – Initial sizing validation

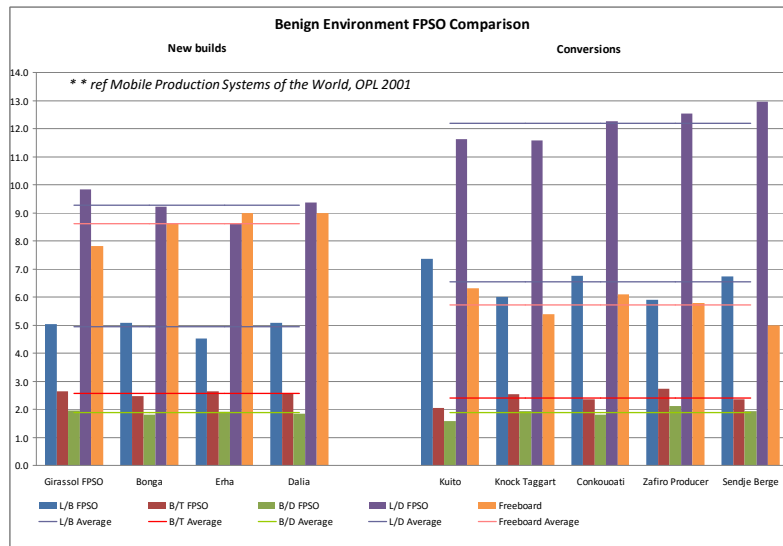


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Slide 43



Concept design – Initial sizing validation



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	TECHNICAL ABBREVIATIONS & TERMS
<i>Bbl</i>	<i>Barrel (US)</i>
<i>Bopd</i>	<i>Barrels oil per day</i>
<i>Bpd</i>	<i>Barrels per day</i>
<i>C</i>	<i>Degrees of centigrade</i>
<i>COT</i>	<i>Crude oil tanks</i>
<i>DP2 (or 3)</i>	<i>Dynamic positioning class 2</i>
<i>Dwt</i>	<i>Deadweight</i>
<i>ESP</i>	<i>Electric submersible pump</i>
<i>FPSO</i>	<i>Floating production storage and offloading units</i>
<i>FPSS</i>	<i>Floating production semi-submersible</i>
<i>FPU</i>	<i>Floating Production Unit – a general expression for all floating production units, but sometimes also used to describe units without storage such as semi-submersible units</i>
<i>Ft</i>	<i>Feet</i>
<i>FSU or FSO</i>	<i>Floating storage unit OR floating storage and offloading unit</i>

	TECHNICAL ABBREVIATIONS & TERMS
<i>GOM</i>	<i>Gulf of Mexico</i>
<i>HVAC</i>	<i>Heating ventilation and air con</i>
<i>IG</i>	<i>Inert gas</i>
<i>LBP</i>	<i>Length between perpendiculars</i>
<i>K</i>	<i>Thousand</i>
<i>Km</i>	<i>Kilometres</i>
<i>M</i>	<i>Metres</i>
<i>MM</i>	<i>Million</i>
<i>Mmscf</i>	<i>Millions standard cubic feet</i>
<i>MOPU</i>	<i>General term for mobile offshore production units, but may include jack-up units as well as floating units</i>
<i>MW</i>	<i>Megawatts</i>
<i>Sq m</i>	<i>Square metres</i>
<i>Te</i>	<i>Tonnes</i>
<i>TR</i>	<i>Temporary refuge</i>
<i>VLCC</i>	<i>Very large crude carrier</i>

	COMMERCIAL ABBREVIATIONS & TERMS
Capex	<i>The capital cost of the facility</i>
Capex lease rate	<i>As for Facility hire rate</i>
Contractor	<i>The Contractor supplying the FPSO – may also operate FPSO</i>
EPC	<i>General term for engineer, procure & construct type contracts</i>
epcM	<i>Management style contract for execution of epc scope</i>
Facility hire rate	<i>The compensation paid to the Contractor for the provision of a leased FPSO (equivalent to a bare boat rate)</i>
Lessee	<i>The user – makes the lease payment for the use of the facility</i>
Lessor	<i>The owner of the facility – receives the lease payments</i>
Operator	<i>The owner of the field – responsible for the overall field development</i>
Opex	<i>The operating cost of the facility</i>
Opex lease rate	<i>The compensation paid to the Contractor for the provision of all required operating costs</i>
Time charter contract	<i>An arrangement that combines both Capex and Opex lease rates</i>

Typical Panamax tanker

PANAMAX TANKER

FOUR SCHOONER FOR PREMUDA SPA(HN1269)



Main dimension (L_{oa} x L_{pp} x B x D x T_d)
228.5 x 219.0 x 32.24 x 20.2 x 12.2 m

Classification
ABS

Flag Registration
Cayman Island

Dead Weight
72,500 MT

Service Speed
15.0 knots

Main Engine
B&W 6S60MC

MCR
14,100 BHP at 89 RPM

Typical Aframax tanker



AFRAMAX TANKER

BRITISH FOR BP SHIPPING LIMITED (HN1430)



Main dimension (L_{oa} x L_{bp} x B x D x T_d)
250.0 x 239.0 x 43.8 x 21.3 x 13.6 m

Classification
LRS

Flag Registration
Isle of Man

Dead Weight
115,000 MT

Service Speed
15.7 knots

Main Engine
B&W 7S60MC-C

MCR
21,490 BHP at 105 RPM

Typical Suezmax vessel



SUEZMAX TANKER

FOUR SMILE FOR PREMUDA SPA (HN1272)



Main dimension (L_{oa} x L_{bp} x B x D x T_d)
274.0 x 264.0 x 48.0 x 23.2 x 16.0 m

Classification
ABS

Flag Registration
Cayman Island

Dead Weight
159,800 MT

Service Speed
15.2 knots

Main Engine
B&W 6S70MC

MCR
22,920 BHP at 91 rpm

Typical VLCC (Very large crude carrier)



VLCC
HELLESPONT HOLLY FOR HELLESPONT (HN1321)



Main dimension (L_{OA} x L_{BP} x B x D x T_d)
333.0 x 318.0 x 58.0 x 31.25 x 21.4 m

Classification
ABS

Flag Registration
Marshall Island

Dead Weight
310,000 MT

Service Speed
16.1 knots

Main Engine
Sulzer 8RTA84T-D

MCR
44,640 BHP at 76 RPM

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- Modec Inc & FMC Sofec Floating systems (Modec/Sofec)
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- Advanced Production and Loading AS
- Bergesen D.Y. Offshore AS
- Sevan Marine
- Remora ASA
- Samsung (tanker details)
- FLEXLNG
- Hoegh LNG