

Cylindrical FLNG

Technology & cost savings for Cylindrical FLNG vs Ship Shaped FLNG



FLNG
Global

2017 Amsterdam

Frank Hopen - Sevan Marine

Contents

- INTRODUCTION
- SEVAN CONCEPT
- SEVAN FLNG
- OFFLOADING
- CONSTRUCTION
- TECHNICAL COMPARISON
- COST COMPARISON



Global Fleet of Cylindrical Floaters

5 Floating Production Units (FPSOs)



Piranema Spirit

Hummingbird Spirit

Voyageur Spirit

Goliat FPSO

WIDP FPSO

4 Drilling Units (MODUs)



Sevan Driller

Sevan Brasil

Sevan Louisiana

Sevan Developer

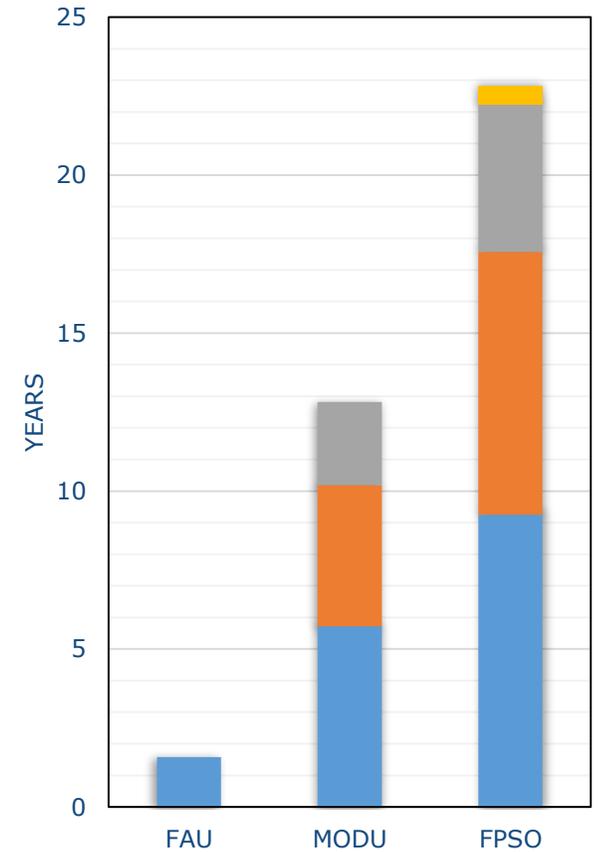
2 Accommodation Units (FAUs)



Arendal Spirit

TBN

Accumulated Ops. Experience



Sevan 1000 for Goliat - First FPSO in the sub-arctic Barents Sea



Sevan 400 for Dana Petroleum Operated Western Isles Fields



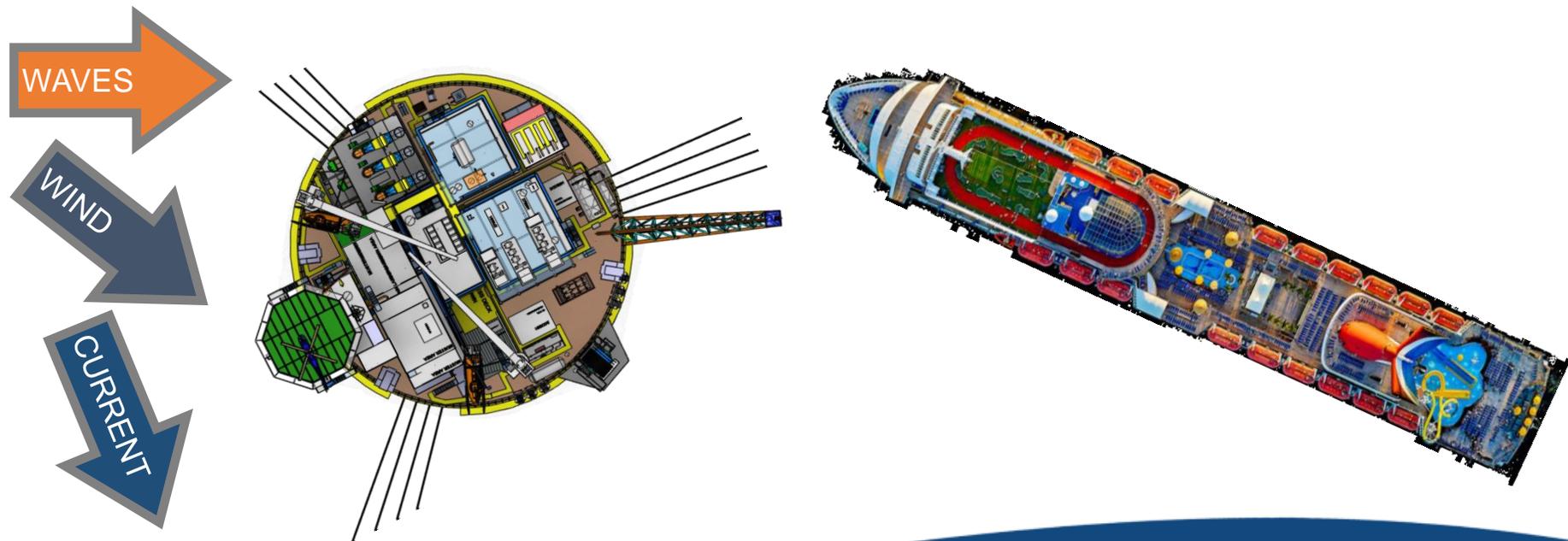
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Sevan Concept – The Basic Idea

- Geo-stationary (spread moored)
- Hull facing environment with same shape in all directions
 - No weathervaning -> Eliminating turret and swivel
 - No weathervaning -> Eliminating thrusters for heading control
- Less motions -> Tolerant for weather spreading
(waves/ wind/ current from different directions)



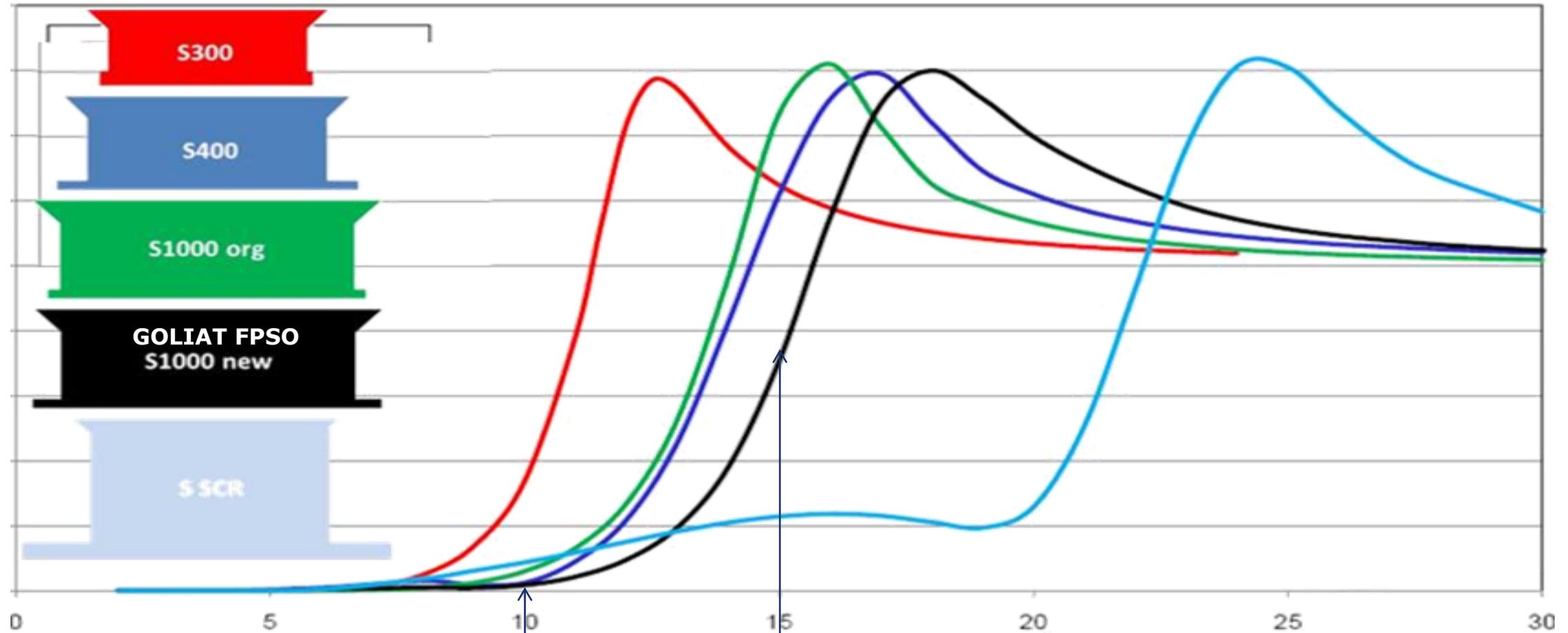
Metocean Data - Examples



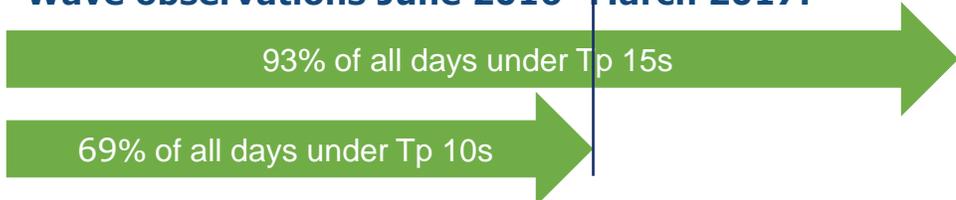
Parameter					
Hs (100 y)	5.9 m	12.6 m	13.7 m	15.6 m	15.6 m
Waterdepth	1000 m	81 m	90 m	370 m	160 m
Wind (100 y – 1 min)	26.8 m/s	50.1 m/s	43.6 m/s	44.5 m/s	49.5 m/s
Current	1.80 m/s	1.01 m/s	0.76 m/s	0.90 m/s	0.67 m/s

Goliat FPSO - Observed wave conditions and motion response

(based on preliminary analysis of daily monitored wave conditions and FPSO motions)



Wave observations June 2016- March 2017:



Motion observations June 2016- March 2017:

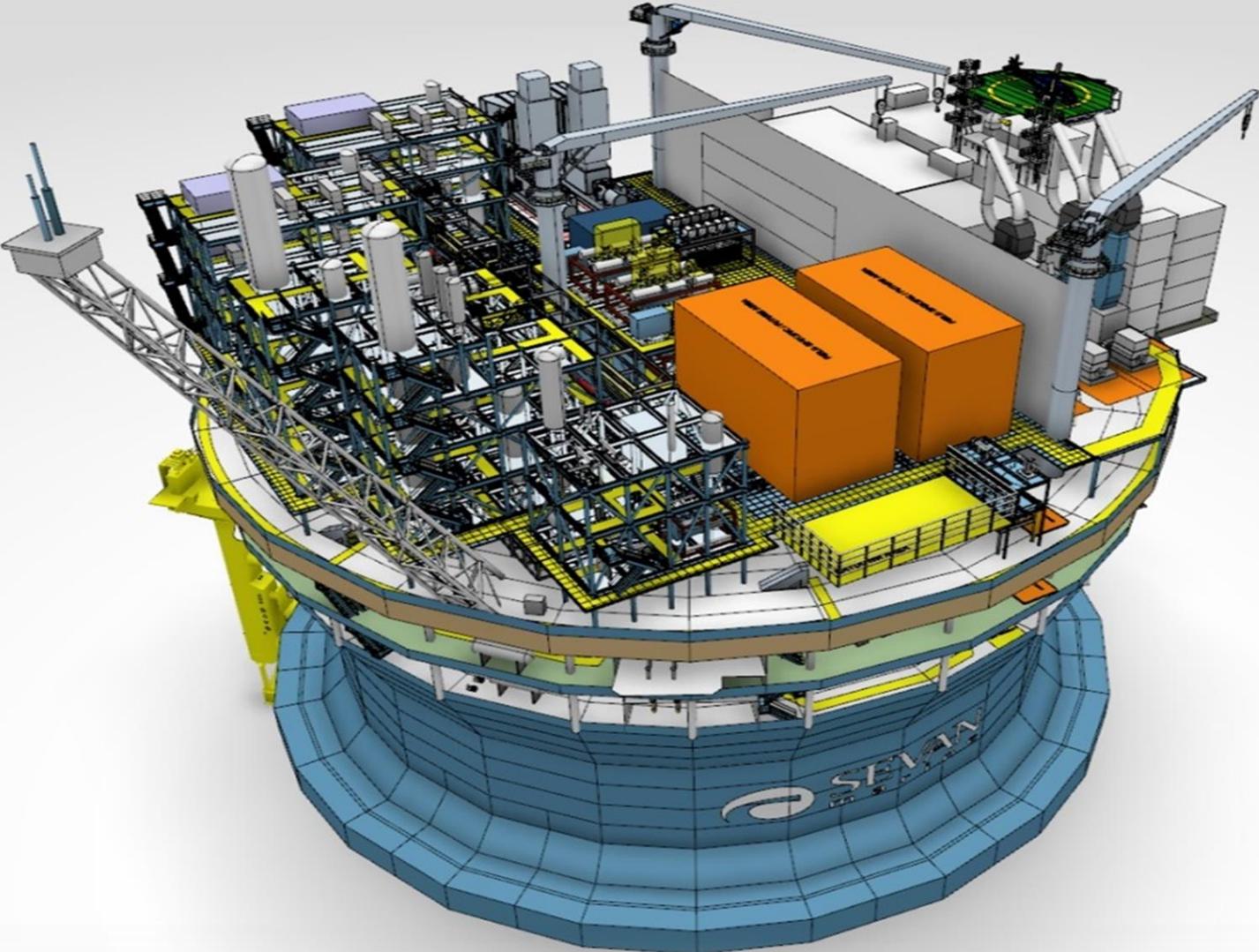
Heave < 1m - 73% of days Roll/pitch < 0,5° - 60% of days
 Heave < 4m - 95% of days Roll/pitch < 2° - 97% of days

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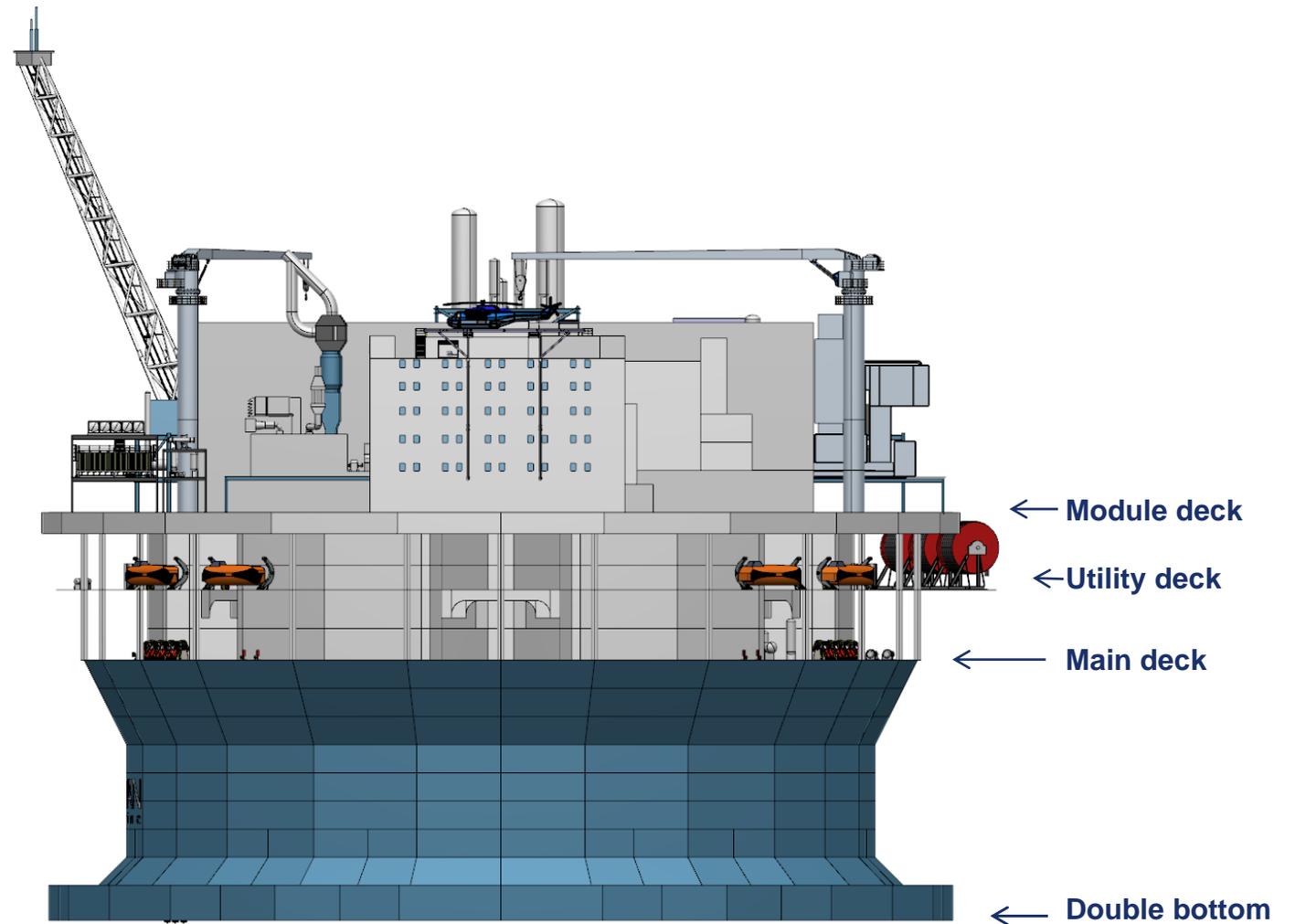
Sevan FLNG



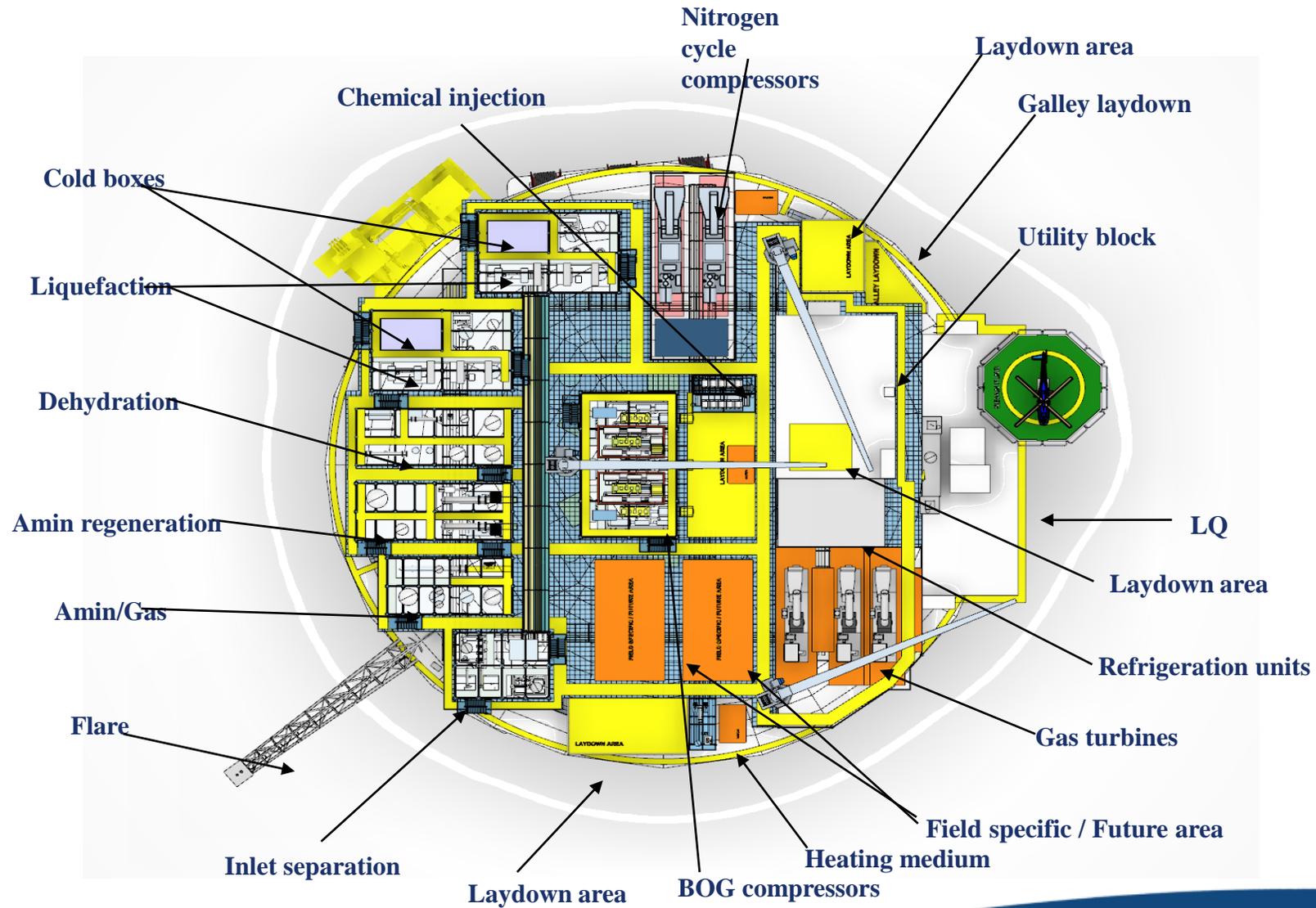
Sevan FLNG 2.4 MTPA Main Dimensions

Hull diameter: 107 m
Main deck diameter: 120 m
Module deck diameter: 130 m
Main deck elevation: 37 m
Module deck elevation: 58 m
Operating Draft: ~20 -22 m

Module deck area: ~13 000 m²
Utility deck area: ~5 000 m²
Main deck area: ~4 300 m²

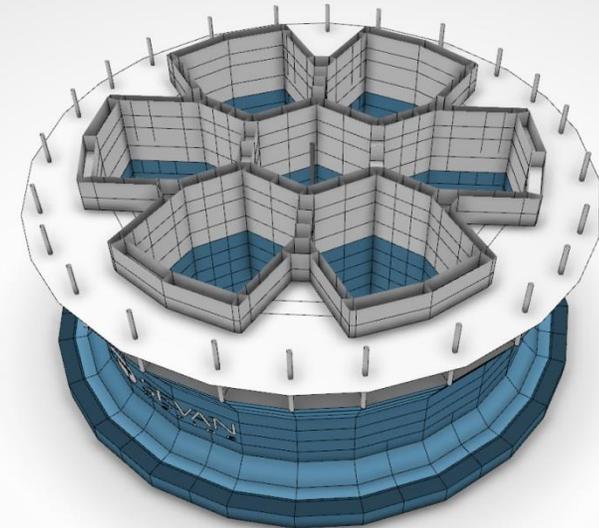
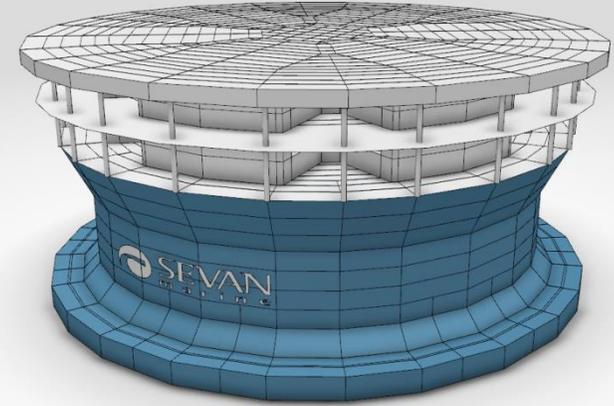
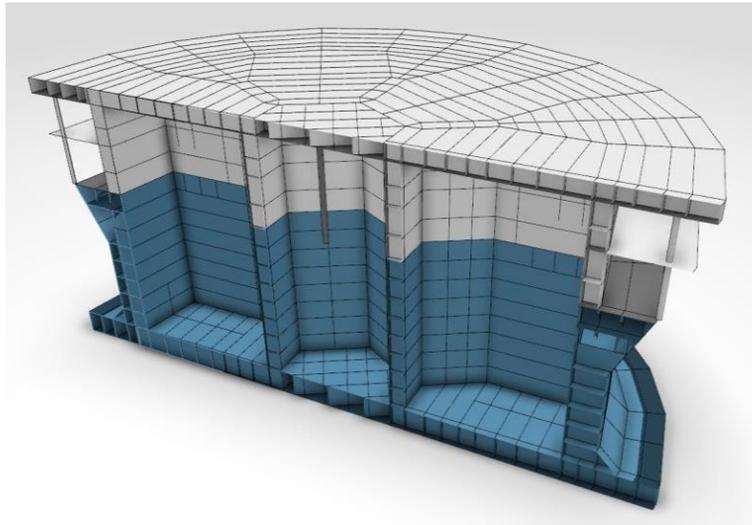


Example LNG Process Deck Arrangement Based on two LNG trains (nominal capacity 2.4 MTPA)



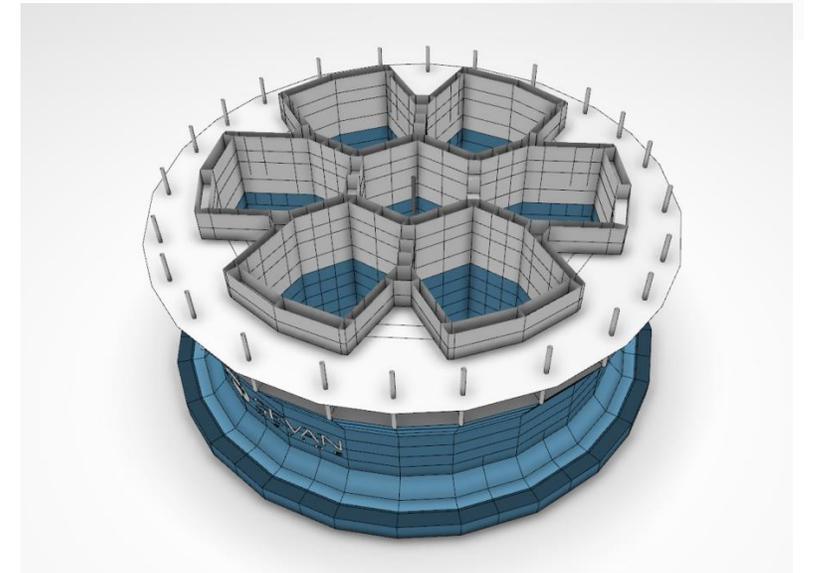
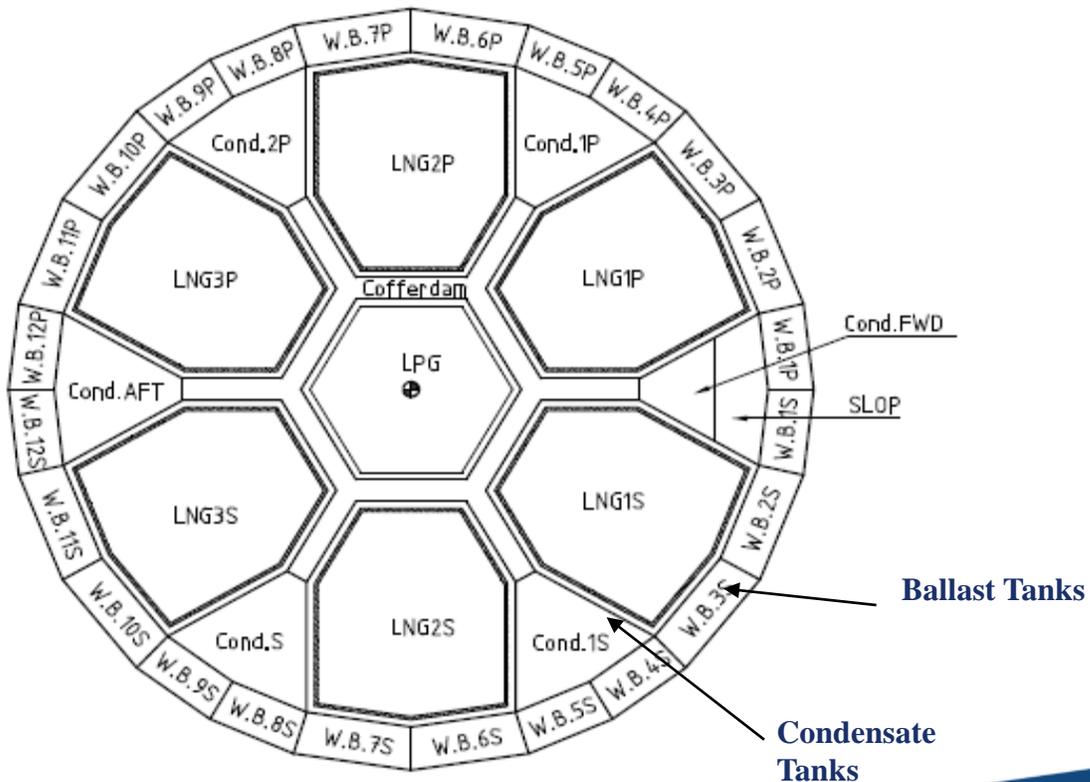
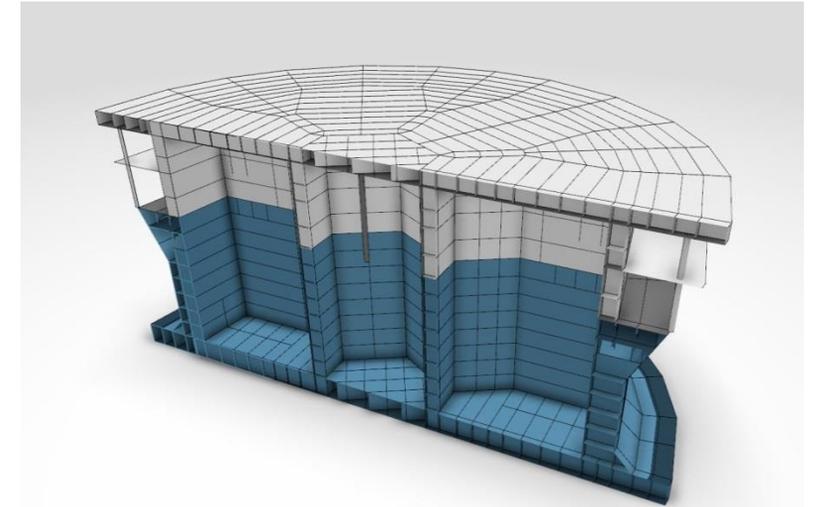
Hull Design and Arrangement

- Double sides / bottom
- Ballast tanks in double side
- Integrated condensate and utility tanks
- Void underneath hold space
- Hold space extended to module deck
- Module deck supported by columns
- No normally manned areas inside hull



Sevan FLNG - Designed for tank system selection flexibility

		IHI SPB	GTT Mark III
LNG tanks (6 tanks)	(m ³)	185 000	217 600
LPG/LNG tank	(m ³)	22 000	25 800
Total LNG/ LPG	(m ³)	207 000	243 400
Condensates (6 tanks)	(m ³)	36 360	36 360
Ballast tanks (24 tanks)	(m ³)	101 800	101 800



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Offloading systems

Side-by-side Offloading

Sea states $H_s = 1.5 / 2.5$ m



Offset Side-by-side Offloading

Sea states $H_s = 2.5 / 3.5$ m



Tandem Offloading

Sea states $H_s = 3.5 / 4.5$ m

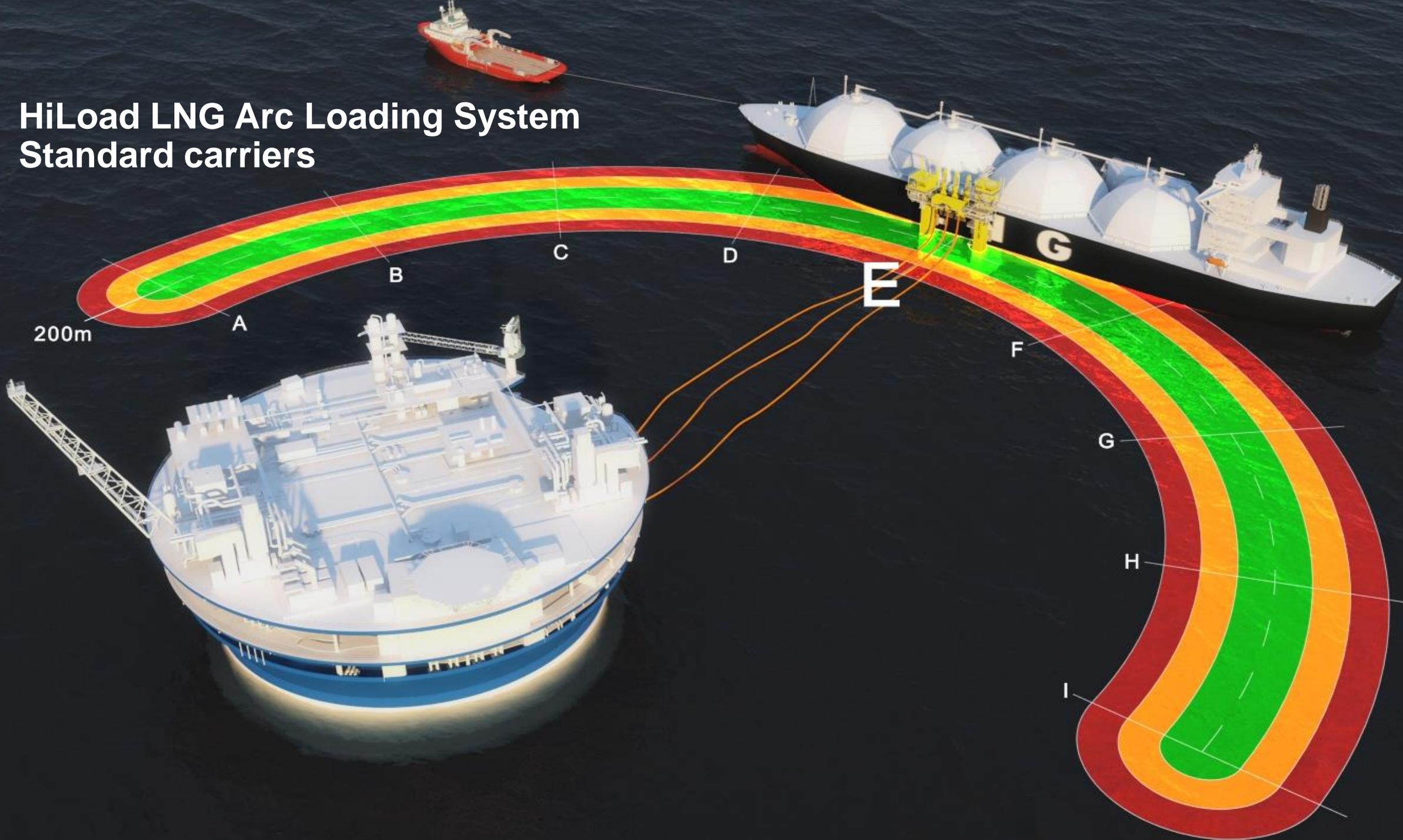


HiLoad LNG

Sea states $H_s = 4.0 / 5.0$ m



HiLoad LNG Arc Loading System Standard carriers



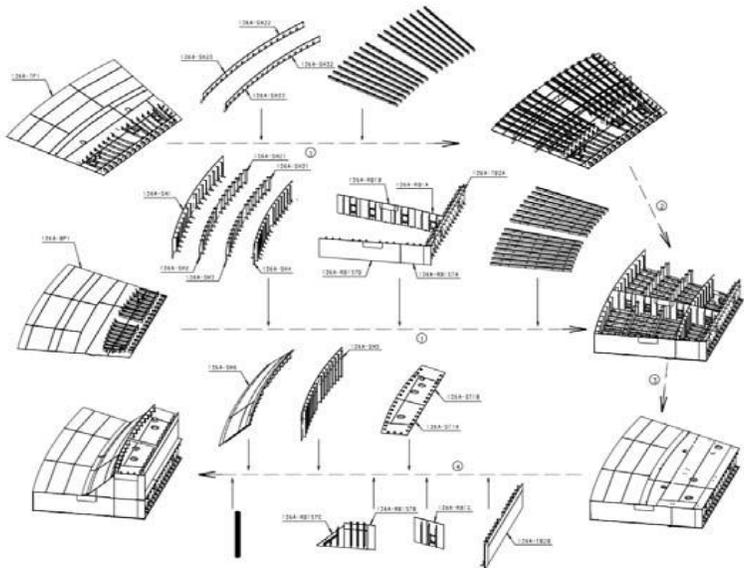
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Hull Fabrication

- Sub-blocks 100-200 t
- Paint blocks 200- 300 t
- Erection block 400-600 t
- Blocks built together on skid way or dry dock
- Typical gantry crane capacity 400 – 1600 t



Modules assembled on/in

- Skidway (Western Isles)
- Dry dock (Goliat)
- Floating dock or barge (Sevan Driller)

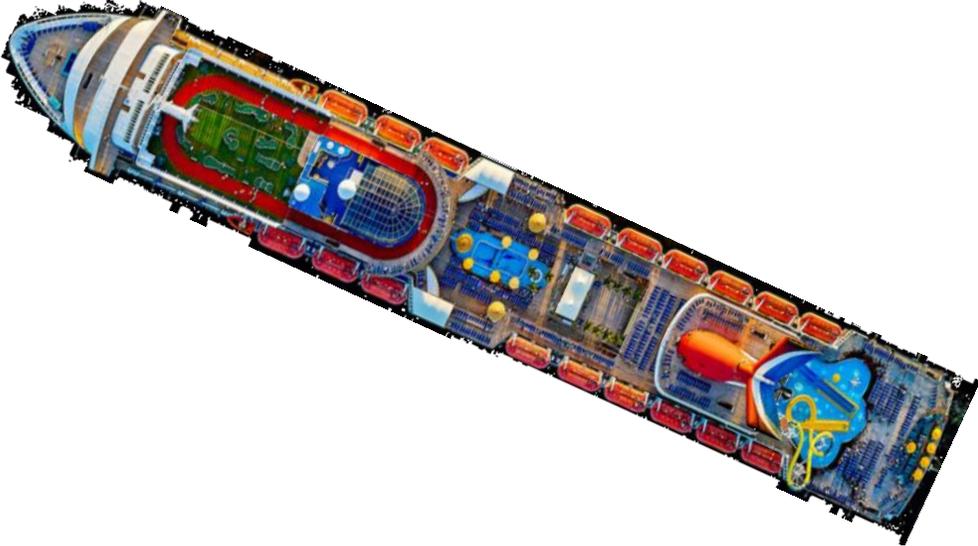
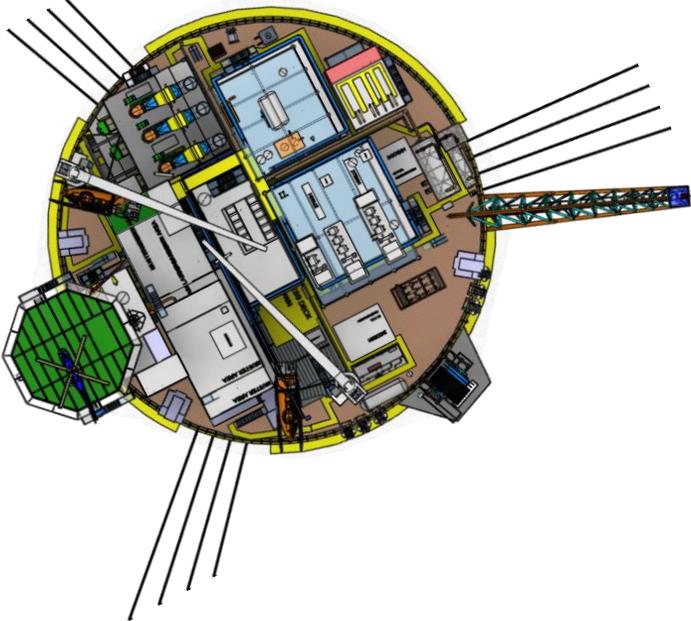
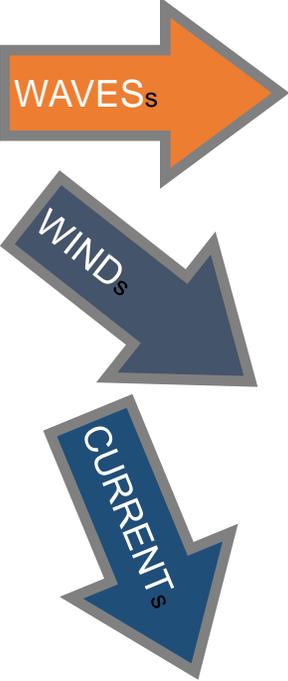


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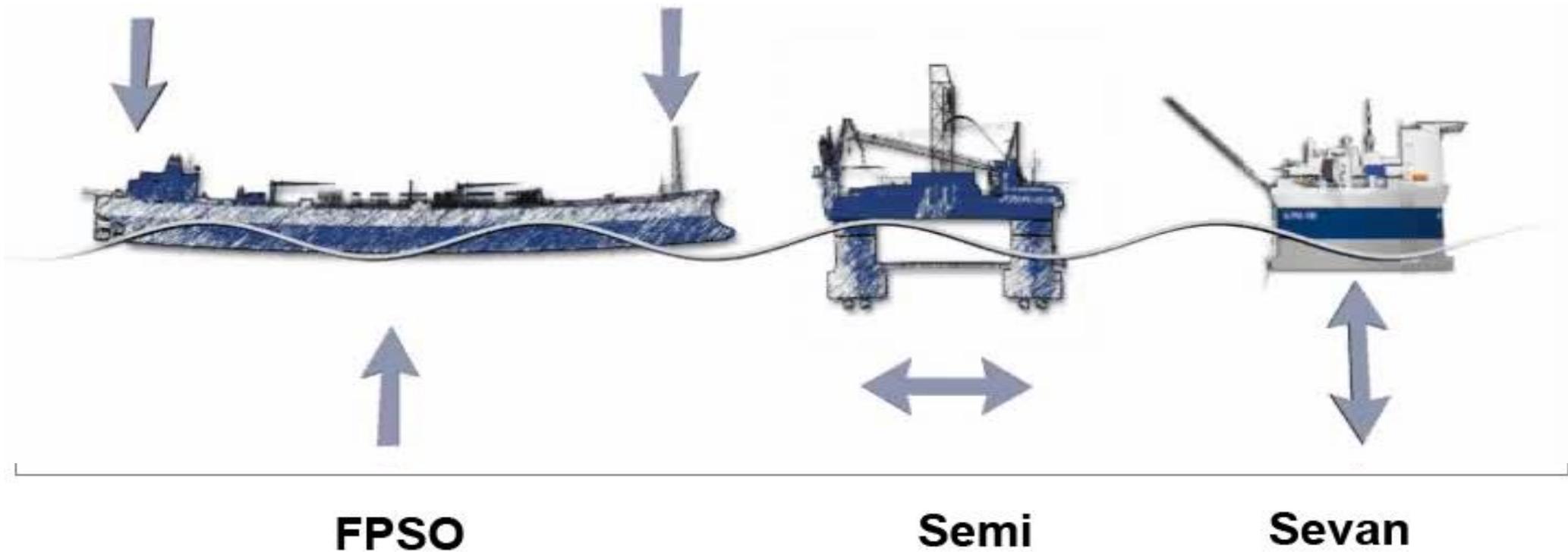


Sevan Concept – Spread moored vs Weathervaning



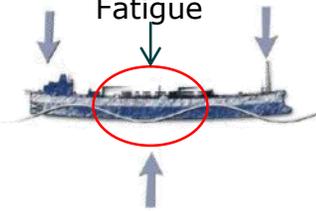
Insignificant bending stresses due to global loads on the hull

- Eliminating typical wave induced fatigue loads
- Minimal hull deflections (sag/ hog) simplifying topside design



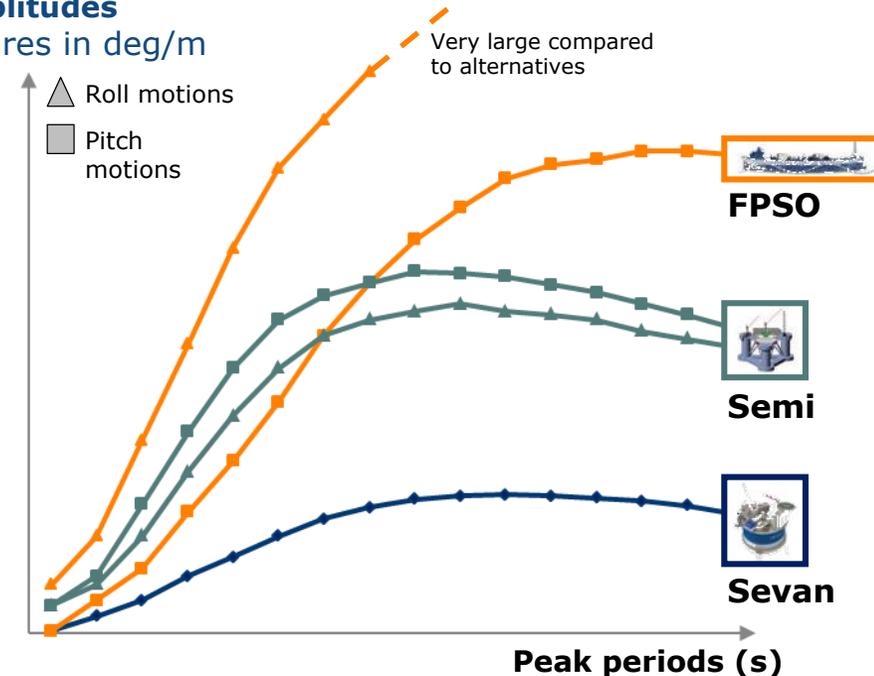
Lower pitch/ roll motions leading to reduced fatigue and stress

Roll/ pitch motions

Circular FPSO	Ship-shaped FPSO
	
<ul style="list-style-type: none"> Minimal pitch/ roll motions Suitable for permanent mooring in any location Lifetime: > 30 years 	<ul style="list-style-type: none"> Costly turret required in harsh weather – must weathervane Higher bending stress on hull and risers Lifetime: < 25years (Conversions < 15 years)

Pitch/ roll motion comparison in irregular waves: Sevan vs. FPSO and Semi ¹⁾

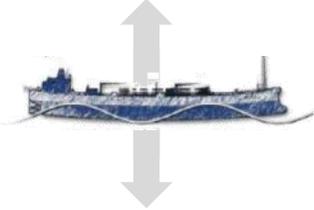
Sign. roll/ pitch amplitudes
Figures in deg/m



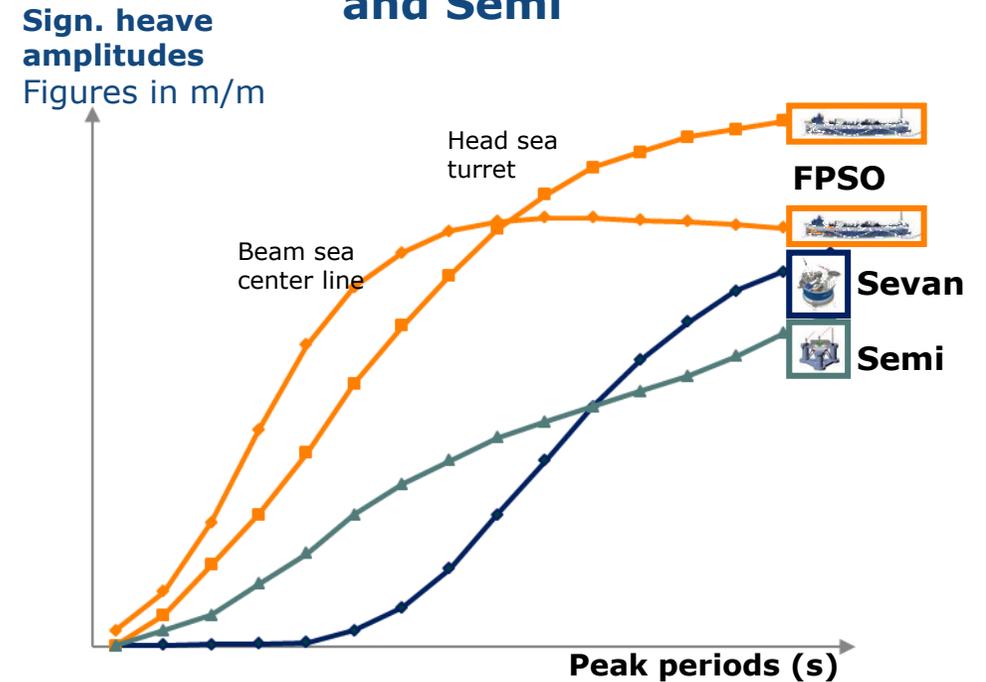
Superior pitch/ roll characteristics leading to improved uptime and longer lifetime in harsh environments

Lower heave acceleration and amplitude

Heave motions

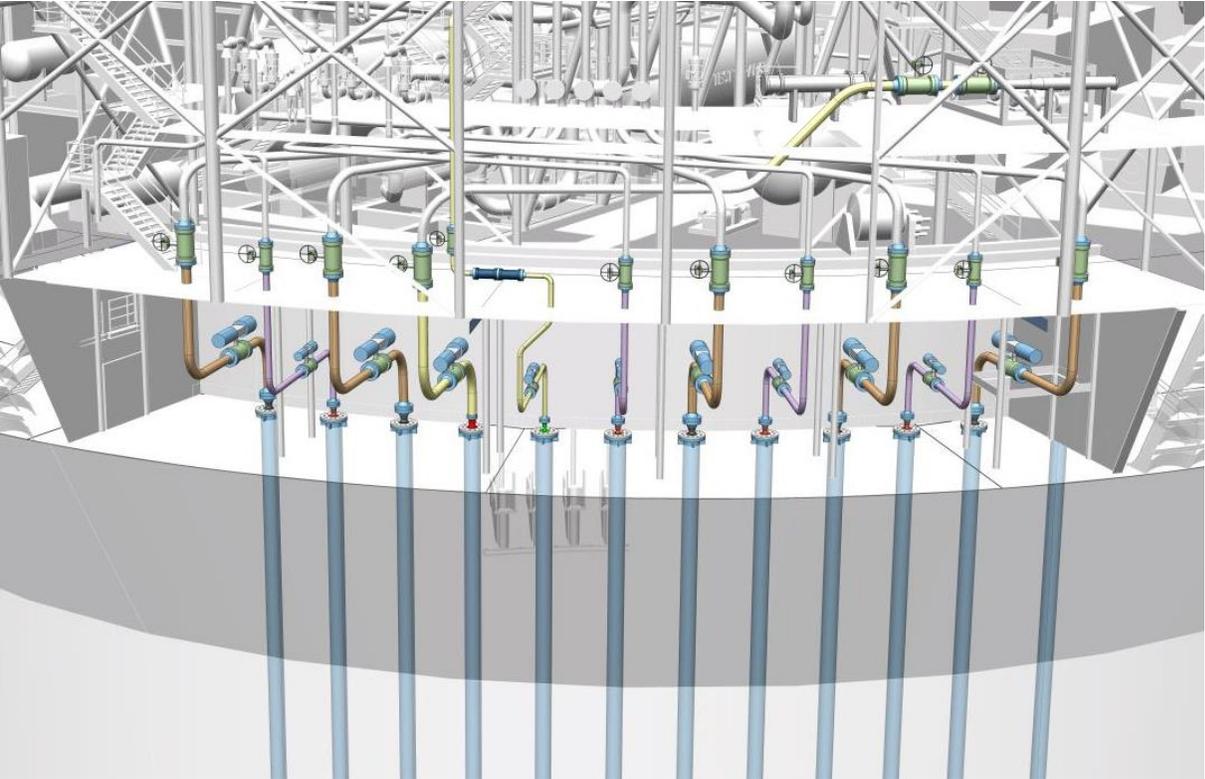
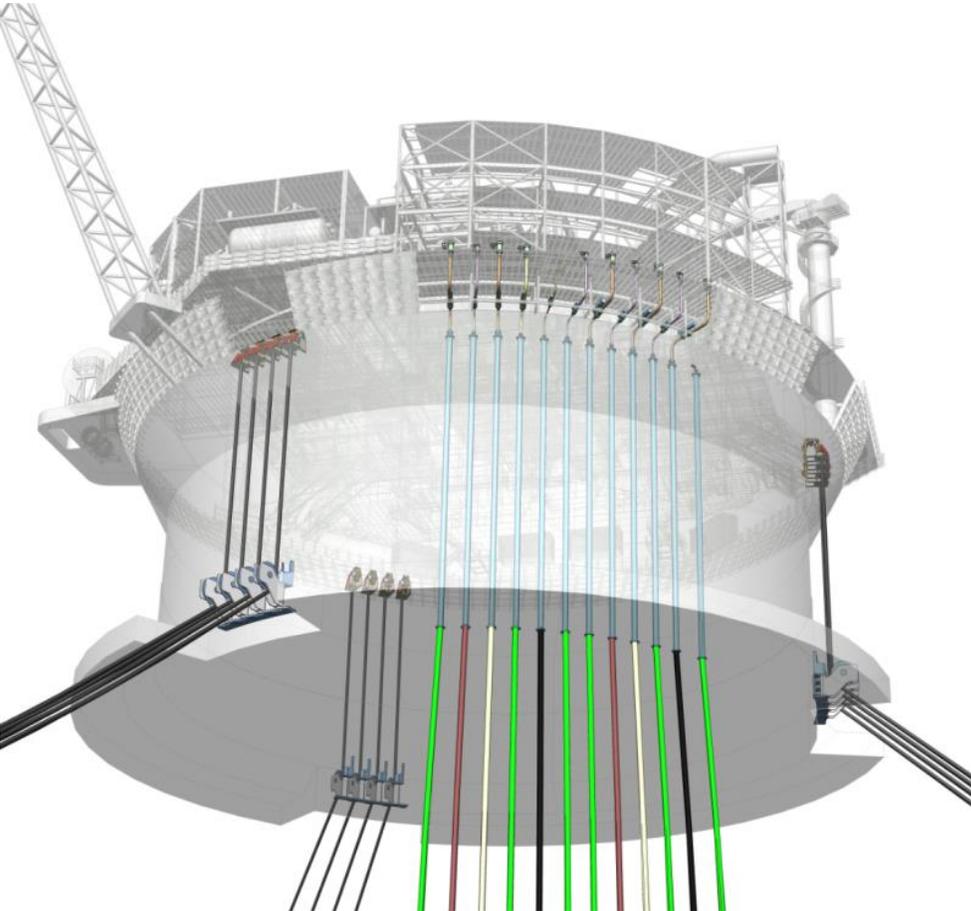
Circular FPSO	Ship-shaped FPSO
 <p>Max acceleration: 0,2 G</p>	 <p>Max acceleration: 0,5 G</p>
<ul style="list-style-type: none"> Patented solution with bilge keel at base to reduce heave Lower heave acceleration Amplitude benefits proven in studies 	<ul style="list-style-type: none"> Higher heave acceleration Heave motions limiting the application potential for SCR

Heave motion comparison in irregular waves: Sevan vs. FPSO and Semi



Lower heave amplitude and acceleration leading to higher uptime and reduced risk of sea sickness

Sevan Concept – Riser System



Goliat Power from Shore: HVAC 105km cable - 75 MW @ 110 kV



Power cable's FPSO end prior to installation



Power cable termination on FPSO

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Sevan Concept – CAPEX comparison with Ship-Shaped (from TK)

Parameter	Comparison
Steel Weight	Similar
Conversion from existing unit	Many tankers in the market..
Topside	Similar
Mooring cost	Depending of location
Turret/ Swivel	NA on Cylindrical
Propulsion/ Heading control	NA on Cylindrical
Utilities	Same

Ship shaped VS Cylindrical

Need to be evaluated for each location

Sevan Concept – OPEX comparison with Ship-Shaped (from TK)

Parameter	Comparison
Maintenance	Less equipment → Less maintenance
Production crew	Similar
Operation crew	Similar or less
Onshore support	Similar
Logistics	Similar but depending of deck area and movements
Fuel	Less consumers → Less consumption

Ship shaped VS Cylindrical

Need to be evaluated for each application

Sevan FPSO versus Ship Shaped FPSO

Description	Sevan unit	Ship shaped
Oil storage	1 000 000 bbl	1 000 000 bbl
Main dimensions	93x30 (DxT)	270x48x19 (LxBxT)
Deck area	9 500 m ²	11 500 m ² + turret (1 500)
Displacement	216 000 t	230 000 t
Light ship weight hull	37 000 t	40 000 t
Turret weight	NA	10 000 t
Topside modules	18 500 t	19 500 t
Total weight	55 500 t	66 500 t
Steel weight hull	34 500 t	37 500 t

Conclusion

Main benefits of a cylindrical FLNG solution:

- ✓ Stable platform → High regularity
- ✓ Significant CAPEX saving, no turret, swivel or thrusters
- ✓ Large OPEX savings, reduced marine crew and maintenance



Turrets

	Prelude	Quad	Itchys
Area	NW Australia	West of Shetland	NW Australia
Environment	Cyclonic	Harsh	Cyclonic
LPP (m)	488	270	336
B (m)	74	52	59
Riser slots	20	28	15
Turret weight (ton)	12 000	10 300	9 500
Turret cost (USD million)	>1,000 (unofficial)	800 (unofficial)	500 (published)



Sevan Marine



Shell Prelude

BP Quad 204

Inpex Ichthys

Cuttings by permission from Upstream Technology

Thank you!

We make the (floater) world go round!

