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The Impact of Composites on Future Deepwater Riser Configurations

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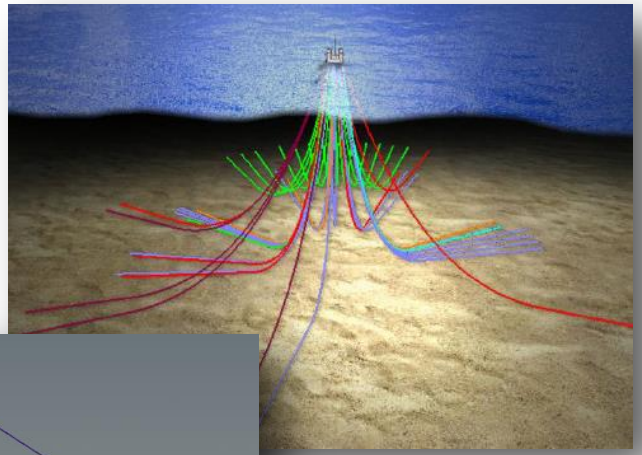
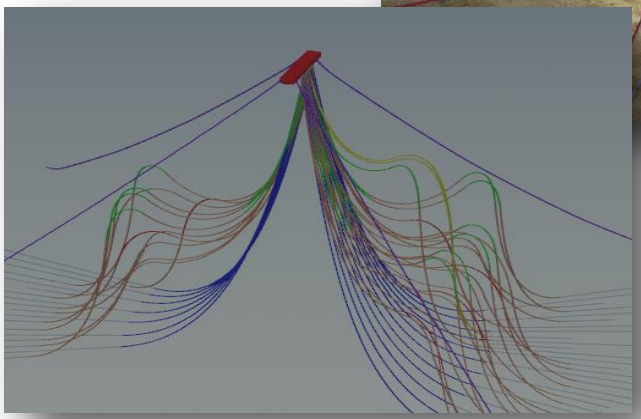
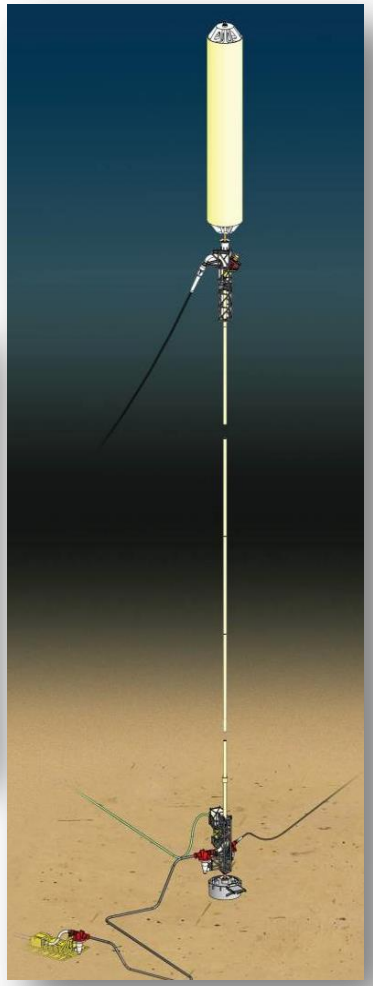
Deepwater Riser Technology

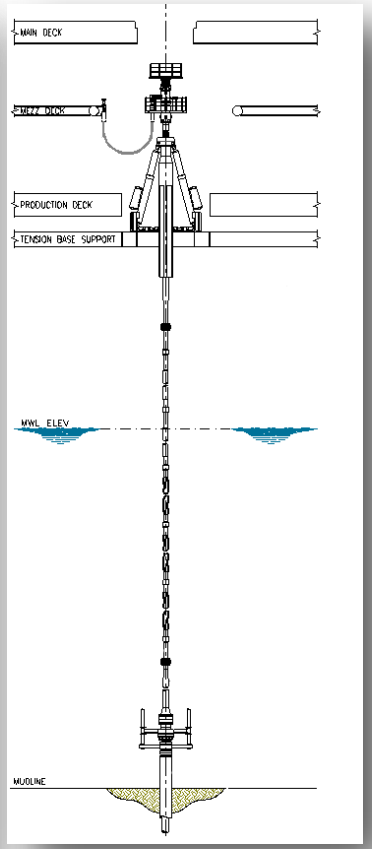
Today's deepwater risers:

- Flexible (many configuration options)
- Steel Catenary (including lazy wave)
- Top Tension
- Hybrid



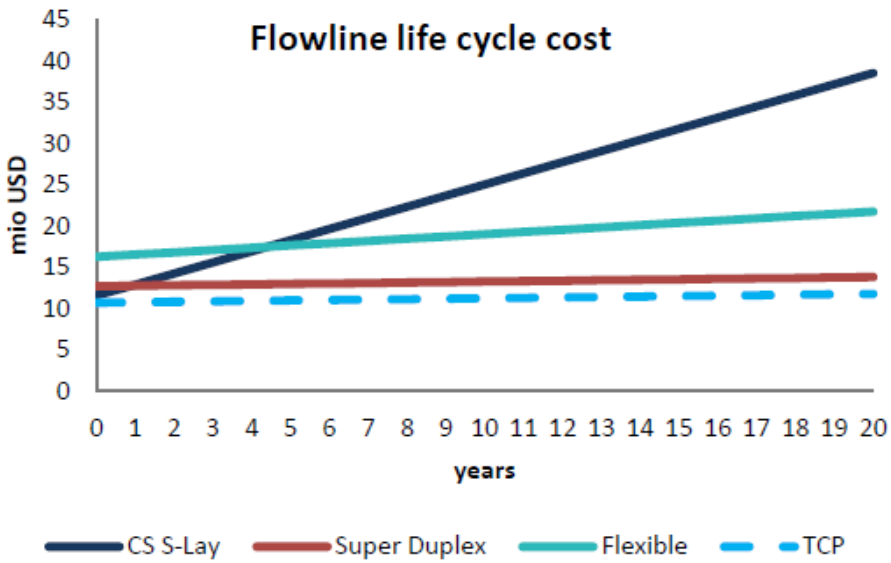


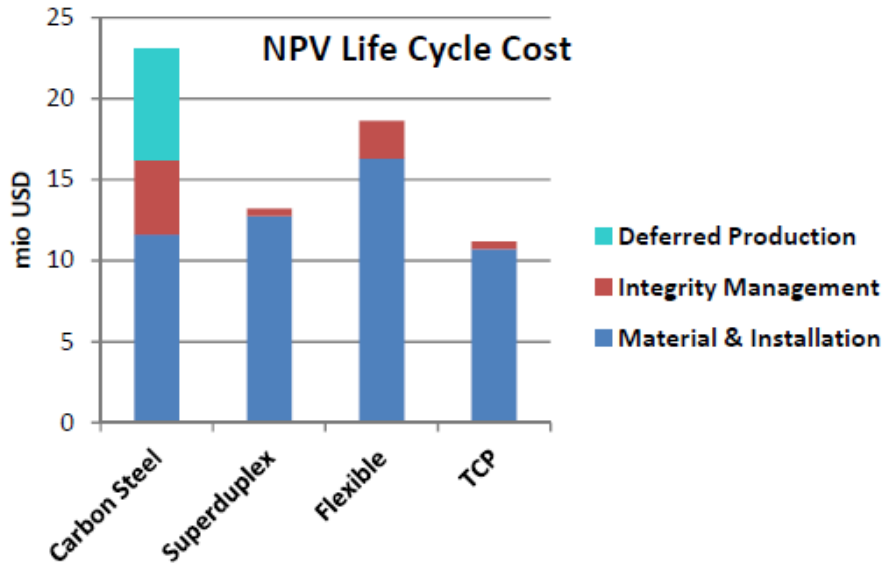




Composite Riser Technology Benefits

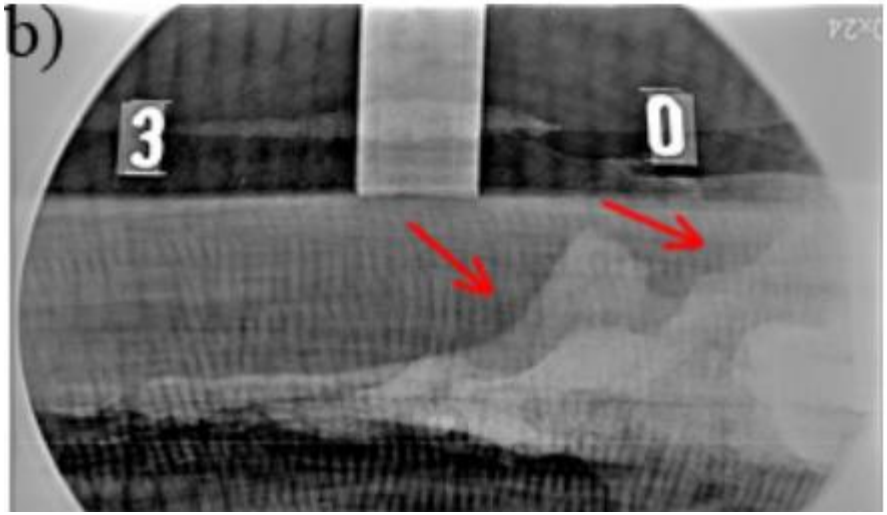
- Composites are light – High specific strength
- Potential ease of installation (i.e. Reeled pipe)
- Low maintenance claimed – good fatigue and corrosion resistance
- High flowrates





Composite Riser Technology Challenges

- Composites are light
- Hard to inspect sub-laminar damage
- High material cost
- Limited qualification and offshore track record
- Limited codes and standards
- Limited number of pipe vendors



Composite Pipe Technology Today

- In the past composite materials have been used offshore in a range of applications, mainly in secondary structures; Pipework, J-tubes, Riser protection, Walkways and Ladders.
- Improvements in structural integrity led to the 1st composite drilling riser joint which was developed for Statoil's Heidrun TLP in 2001.

- Magma Global (2008) and Airborne (2007) now leading the market with fully bonded Thermoplastic Composite Pipe:
  - Jumpers / spools
  - Intervention lines
  - Flowlines
  - …risers
- Flexible manufactures are replacing tension and pressure armour layers with composites.

Composites Today: Intervention

Key advantages:

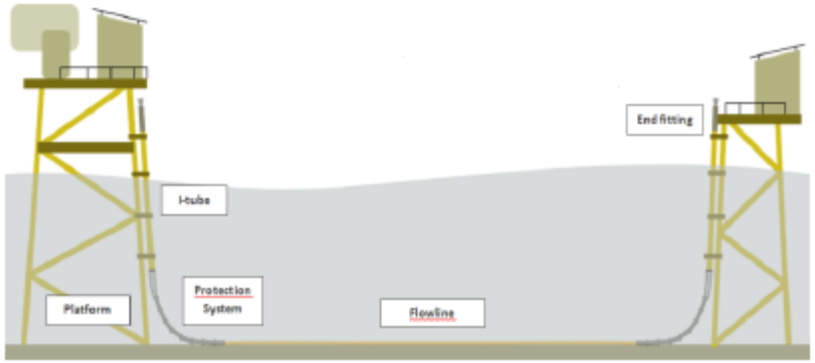
- High flowrates
- Reduced cost (~30%)
- Superior fatigue performance (more deployments)

Composites Today: Spools and Jumpers

- Complex design
- Metrology
- Slugging
- High risk
- Thermal expansion
- Long lead item

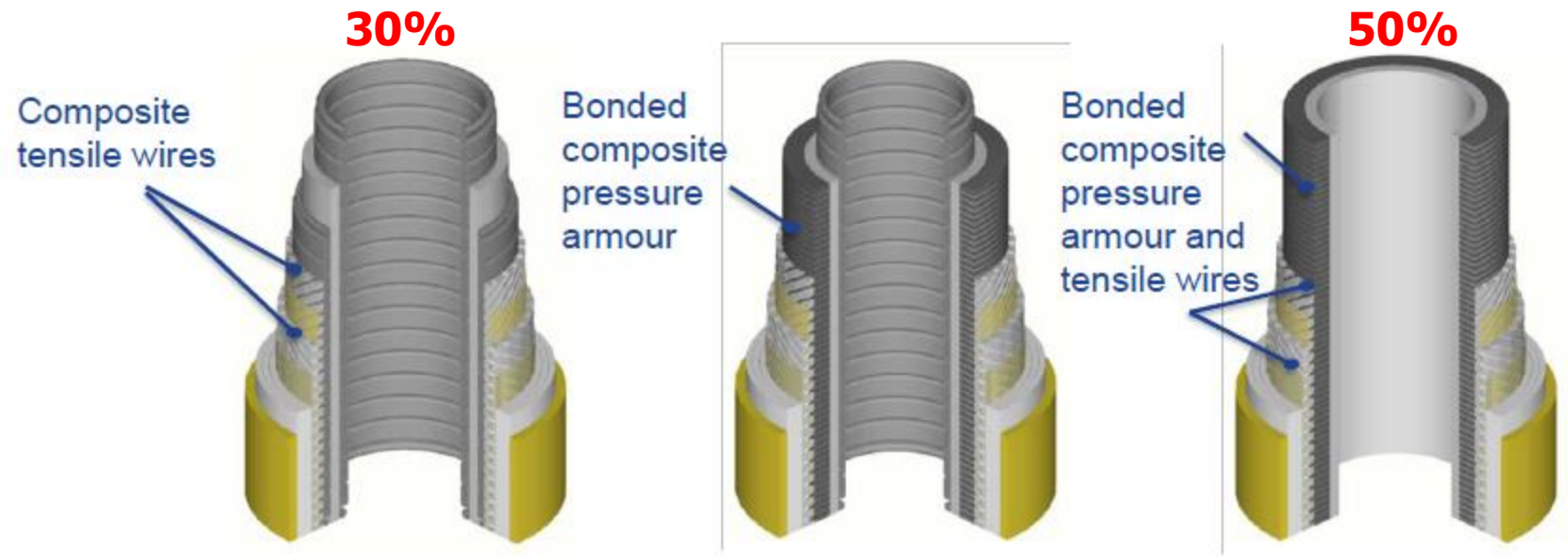
Composites Today: Flowlines

- No Metrology or seabed preparation
- Possible mitigation of pipeline end terminations
- Smaller vessels for installation
- Pipeline crossing present less of a challenge due to pipe flexibility
- Airborne have installed the first TCP flowline for hydrocarbons for Petronas
- On-bottom stability can be an issue as the pipe is light weight



Composites Today: Flexibles

- Weight reduction can result in cost saving on tensioning systems and buoyancy modules
- Sour service environments
- Composite armour is ideal large OD pipes
- Economically feasible in water depths > 2000m
- High fatigue resistance and corrosion resistance
- Annulus may flood without the fear of corrosion



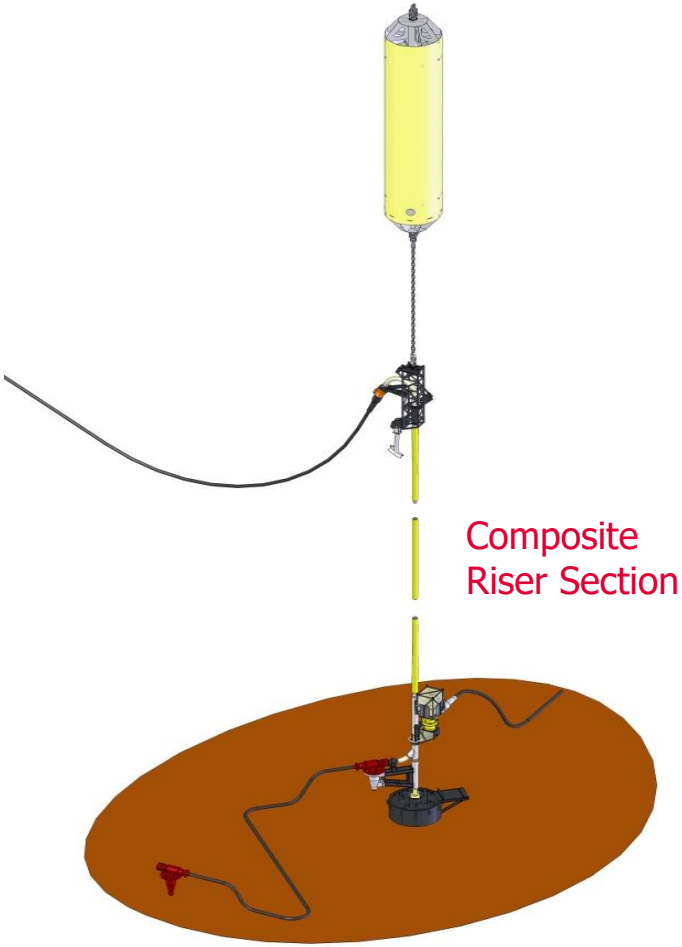
Composite Pipe Application on Existing Riser Technology

Two Single Lined Hybrid Risers (SLHRs) were compared:

- SLHR with a steel riser leg,
- SLHR with a composite riser leg.

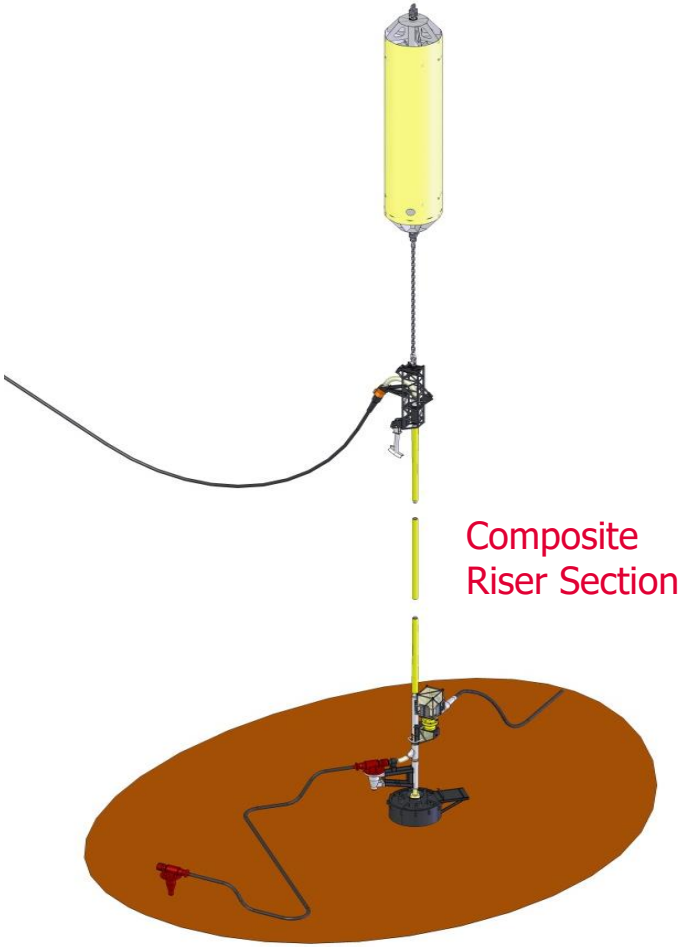
The considered water depth was 2,000 m. This was selected as the SLHR riser concept is already established for this water depth.

The internal diameter for the composite pipe was selected to be of a matching size to the steel pipe.



Composite Pipe Application on Existing Riser Technology

- Found to perform well
- Reduced system size:
  - Buoyancy Tank
  - Upper Riser Assembly
  - Lower Riser Assembly
- Found not to be economic at 2,000 m. However, at 4,000m the system became viable.



A Clean Slate

Objectives:

- Assess the global system performance of the application of composite pipe in a production riser scenario.
- Develop a number of simple (although not necessarily conventional) riser arrangements.

A Clean Slate

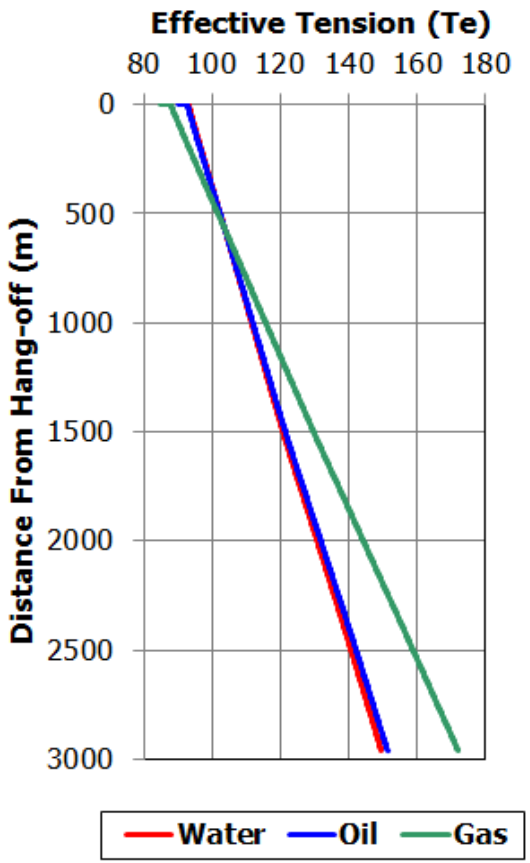
Design Premise:

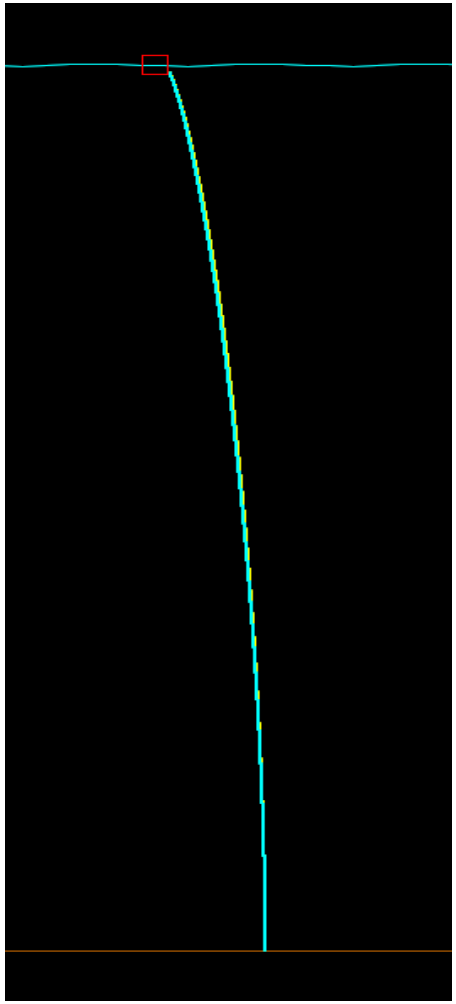
- 1500 m and 3000 m water depths.
- FPSO & Semi-submersible - offsets up to ±8 % of water depth.
- West of Africa (WoA) environment up to 100 year event (current and wave).
- 4.5 ” insulated production riser.
- Varying internal fluid densities.
- Fully fixed connections at both ends (e.g. SCR hang-off porch).

Configuration A – keep it simple, keep it economic

Composites strain further than steels – does this positively impact the feasibility of a simple riser configuration of a composite top tensioned pipe in a WoA environment?

- Insulation properties are important
- Buoyant tension profile
- Maximum tension at the foundation
- Low vessel loads
- Potential challenges for installation

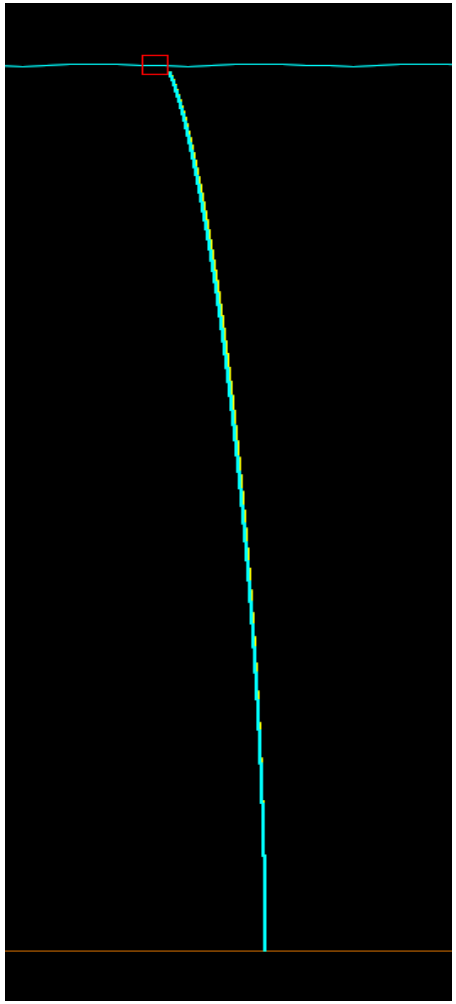




Configuration A – keep it simple, keep it economic

- Operation assessment with a Semi-sub & a turret-moored FPSO

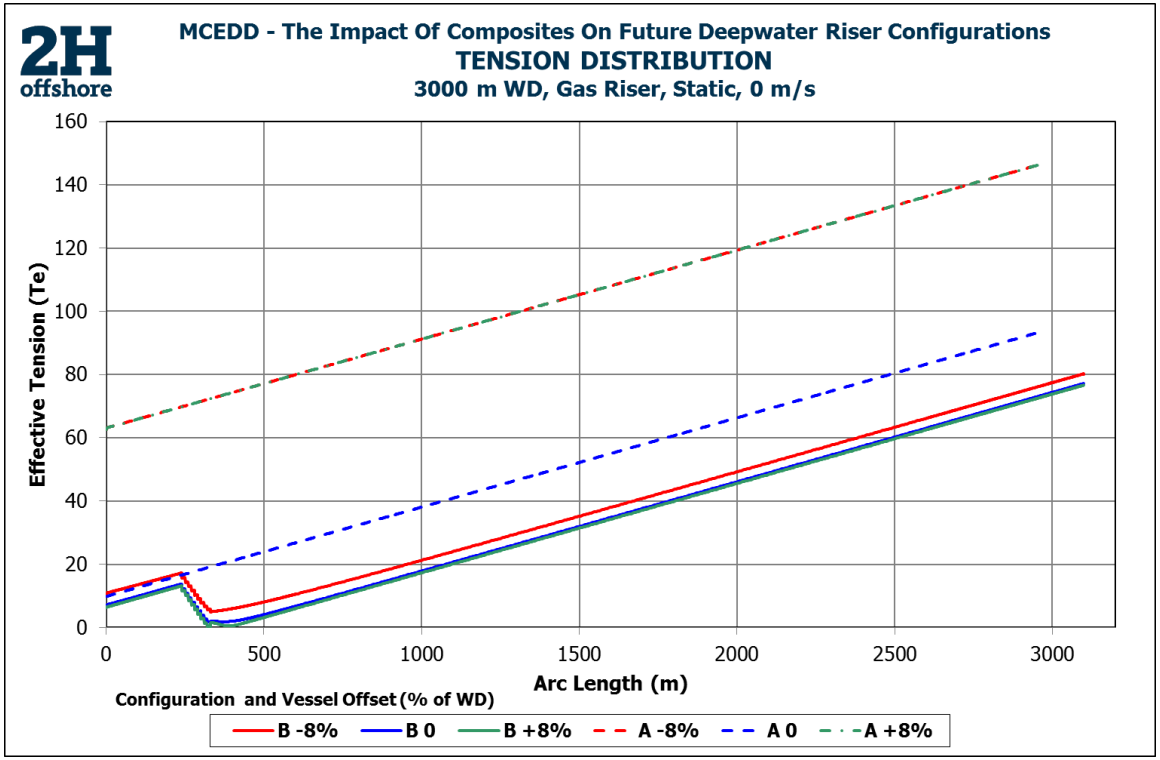
Vessel	Water Depth	Effective Tension (Te)		Vessel Hang-off Load (Te)	Foundation Load (Te)
		Minimum	Maximum		
Semi-sub	1500	16	132	92	132
	3000	6	172	90	172
FPSO	1500	-10	213	163	213
	3000	-7	212	115	212



- Pipe Tension limit = 266 Te
- Acceptable tensions with a Semi-sub
- Challenging tensions with higher dynamic loading from an FPSO
- Meeting allowable bend radius found to be challenging, however this can be addressed with bend stiffeners and bend restrictors.
- Pre-tension used to mitigate low bend radius at vessel

Configuration B – add some flexibility

- Ballast applied to decouple vessel motion.
- Increasing the ballast weight reduces hang-off angles and bending but increases hang-off loads.



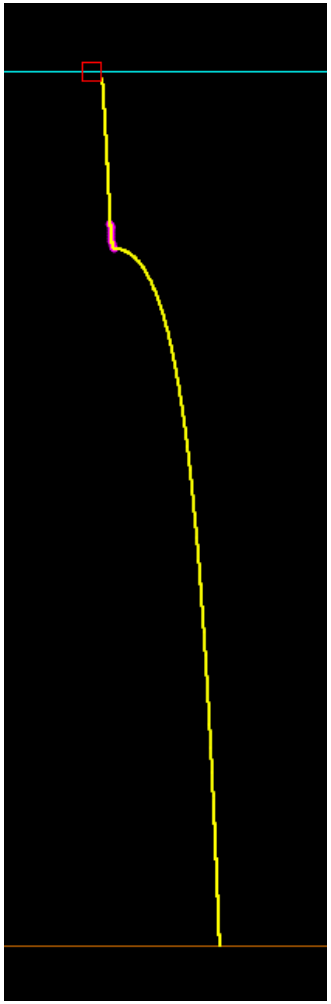
Configuration B – add some flexibility

Configuration A:

Vessel	Water Depth	Effective Tension (Te)		Vessel Hang-off Load (Te)	Foundation Load (Te)
		Minimum	Maximum		
Semi-sub	1500	16	132	92	132
	3000	6	172	90	172
FPSO	1500	-10	213	163	213
	3000	-7	212	115	212

- Configuration B:

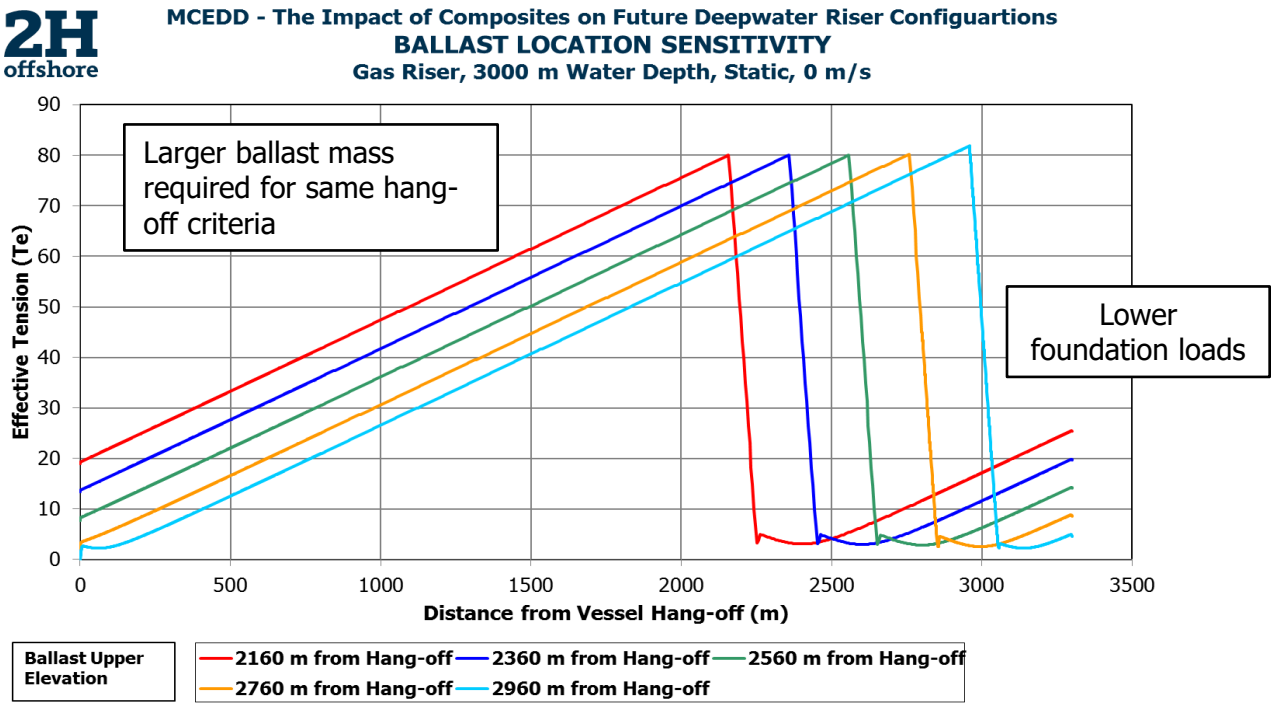
Vessel	Water Depth	Effective Tension (Te)		Vessel Hang-off Load (Te)	Foundation Load (Te)
		min	max		
Semi-sub	1500	-1	65	55	36
	3000	0	81	45	81
FPSO	1500	-14	112	95	86
	3000	-2	97	62	97

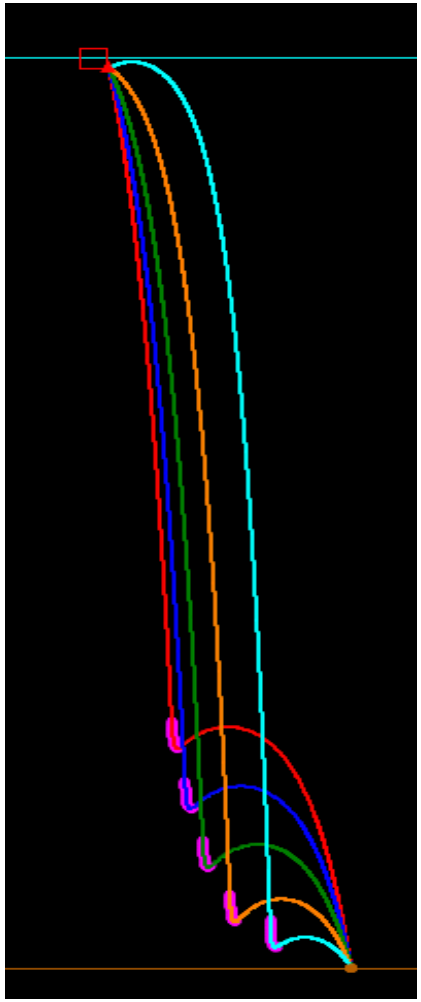


- Maximum tensions and hang-off loads reduced.
- Ballast size and depth should be considered carefully.

Configuration C – manage the loads

- The ballast elevation was relocated to the bottom of the riser.





- May be favourable as pipe arch is out of the high current zone.

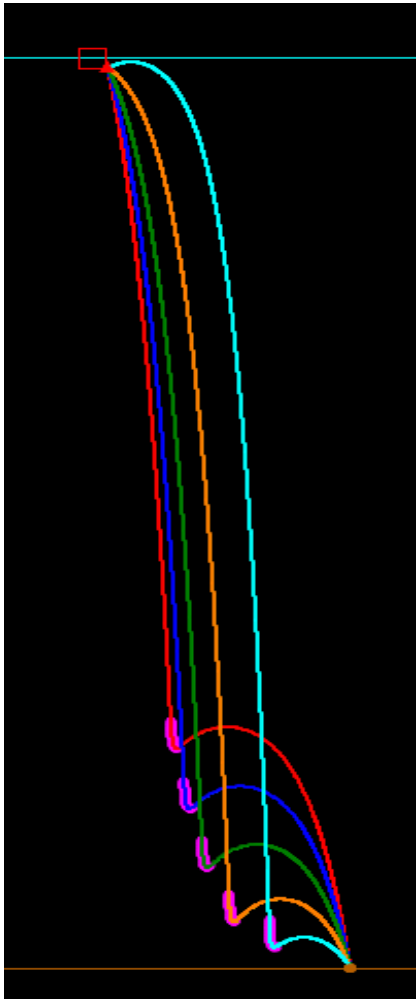
Configuration C – manage the loads

Configuration B:

Vessel	Water Depth	Effective Tension (Te)		Vessel Hang-off Load (Te)	Foundation Load (Te)
		min	max		
Semi-sub	1500	-1	65	55	36
	3000	0	81	45	81
FPSO	1500	-14	112	95	86
	3000	-2	97	62	97

Configuration C:

Vessel	Water Depth	Effective Tension (Te)		Vessel Hang-off Load (Te)	Foundation Load (Te)
		min	max		
Semi-sub	1500	0	50	33	34
	3000	-1	101	33	71
FPSO	1500	-28	75	65	30
	3000	-5	147	108	52

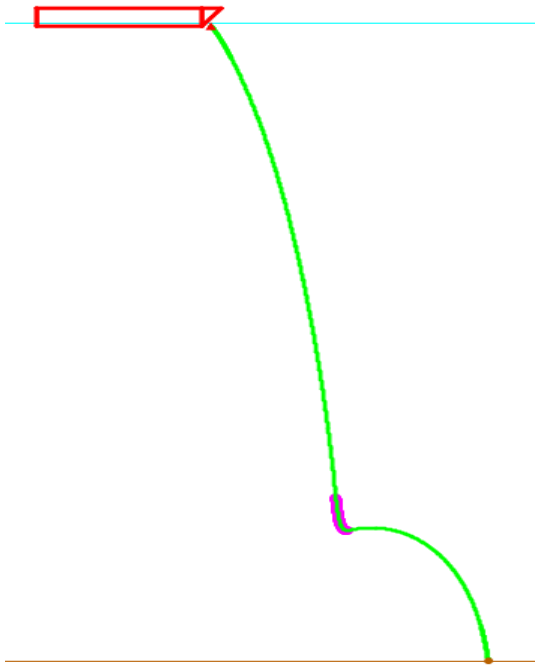


- Reduced termination loads
- Ballast position may not be optimal for ultra-deep water

Configuration C – manage the loads

Potential benefits include, but are not limited to:

- Low vessel and foundation loads.
- Tension can be managed at key locations.
- Reduced dynamic loading due to riser elbow.
- Vessel offsets are easily accommodated.
- Potentially redeployable over variable water depths during riser life.



Configuration C – installation

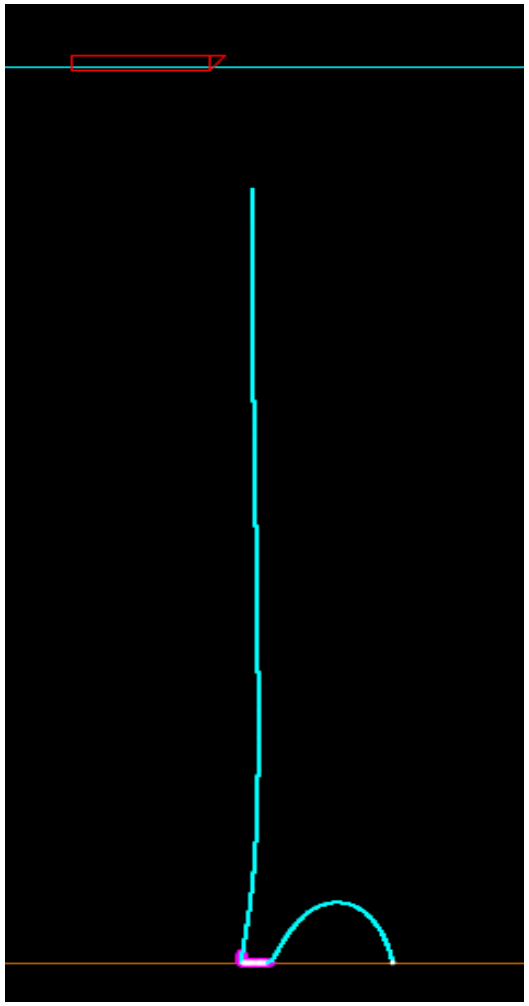
- Vessel head on to the current
- Clump weight required – may be PLET/foundation

- 3 stages of installation considered
- 3,000 m water depth
- 0-1.5 m/s surface currents (up to 1 year WoA)
- 0-3.5 m Hs (up to 100 year WoA), 0 & 90°

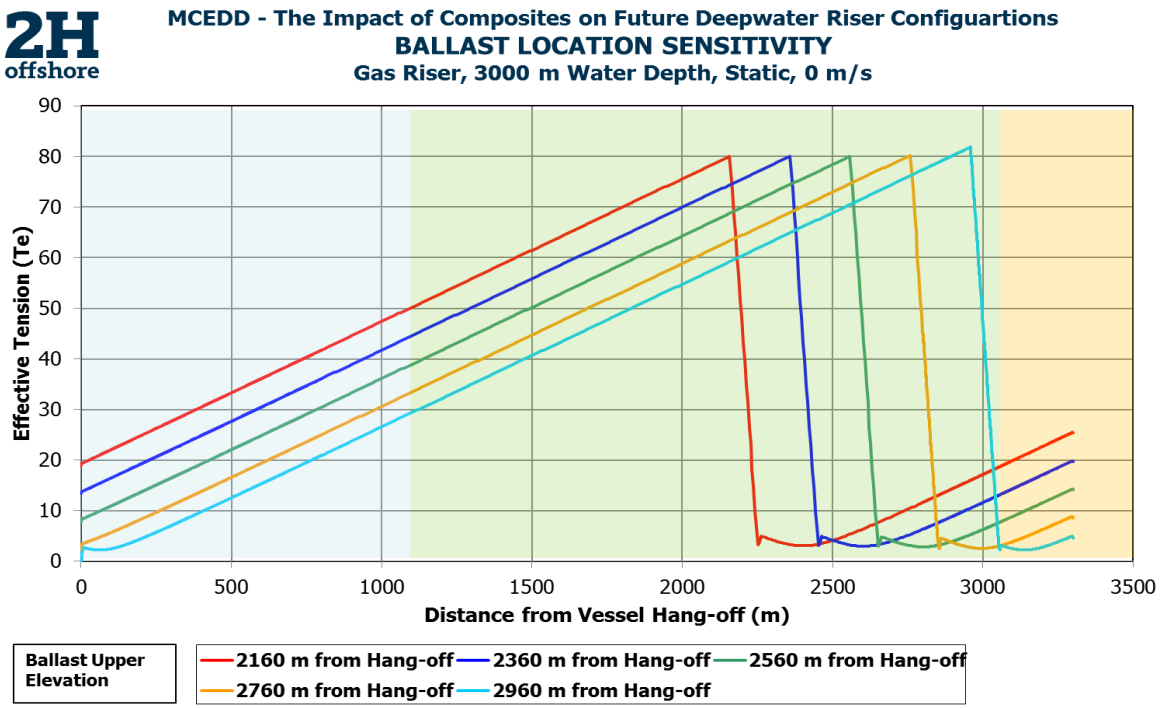
- Loads no worse than observed during operations
- Most onerous loading after the ballast has been deployed

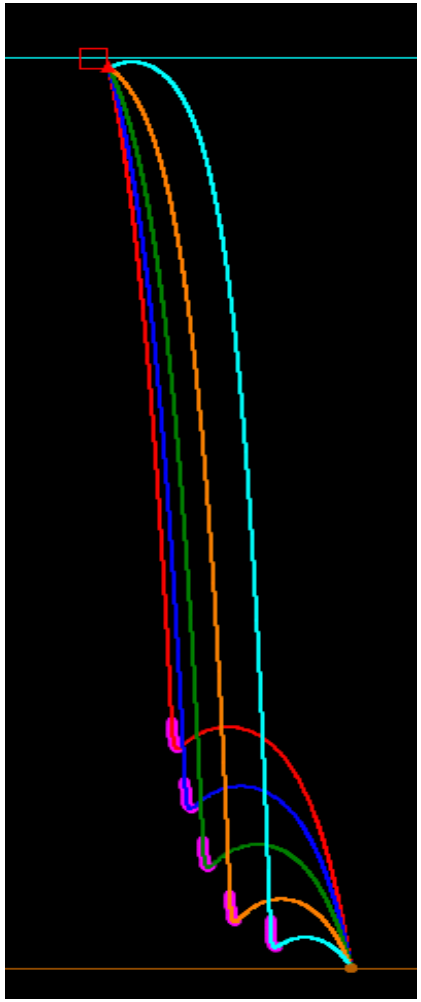
Configuration C – wet parking

- Low ballast region may make pre-installation of Configuration C possible.
- Highest tension is above the ballast and is lower than operational loads.
- Ballast touchdown may require management.
- Riser is taken off the critical path.



Riser Optimisation

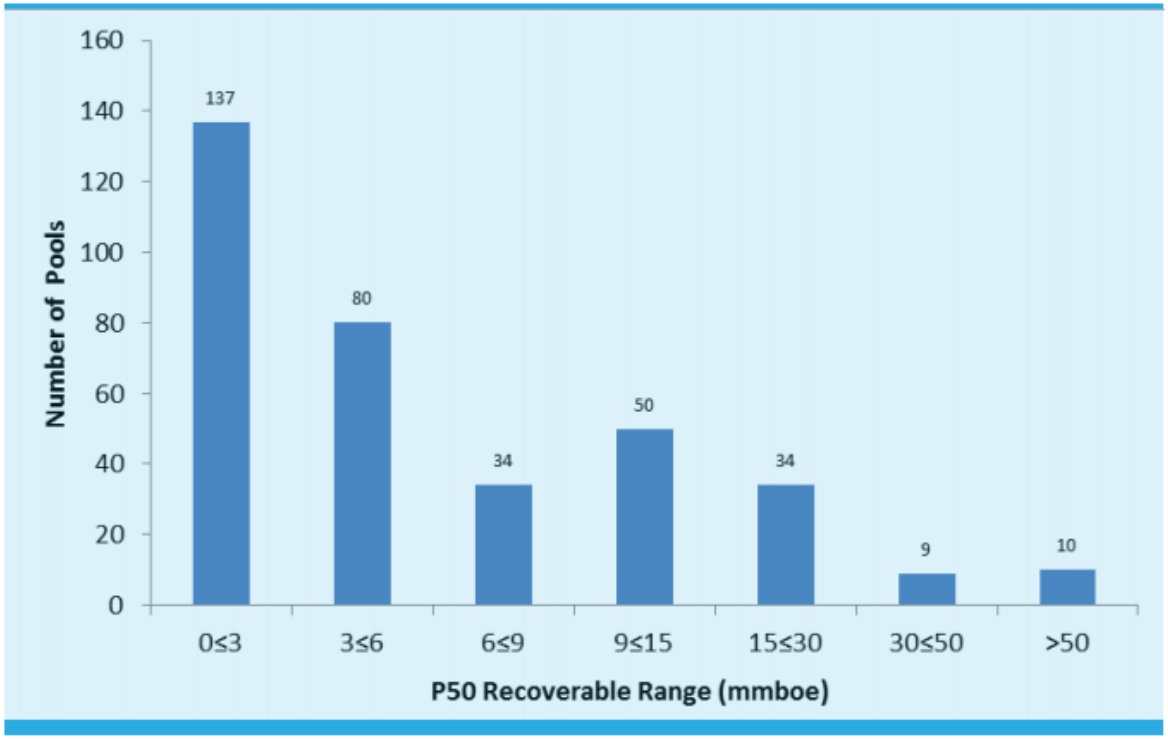




- Intermediate connections
- Weight management

Configuration C
Marginal Deepwater Fields

- UKCS Small pools
- Smaller vessels
- Short field durations
- Mobile



Source: OGA PARS 2015 database, PEARS

Summary

- Composite pipe is a key technology for innovation.
- Thermoplastic composite pipes are already exhibiting their benefits in offshore applications (flowlines, downlines and jumpers).
- By utilising thermoplastic composite pipe, simpler ultra-deep water riser configurations are possible.
- Vessel and foundation loads can be reduced for ultra-deep water.
- Through design the maximum tension along the riser may be located away from regions of higher bending.
- Composite risers may be taken off the critical path by wet parking and potentially redeployed.
- Further industry collaboration is needed in order fully realise the benefits of the technology.

Questions?

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Thank you

Thank you to SUT for allowing us to present this evening

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