Latest Advancements in Drilling Riser Analysis Technology

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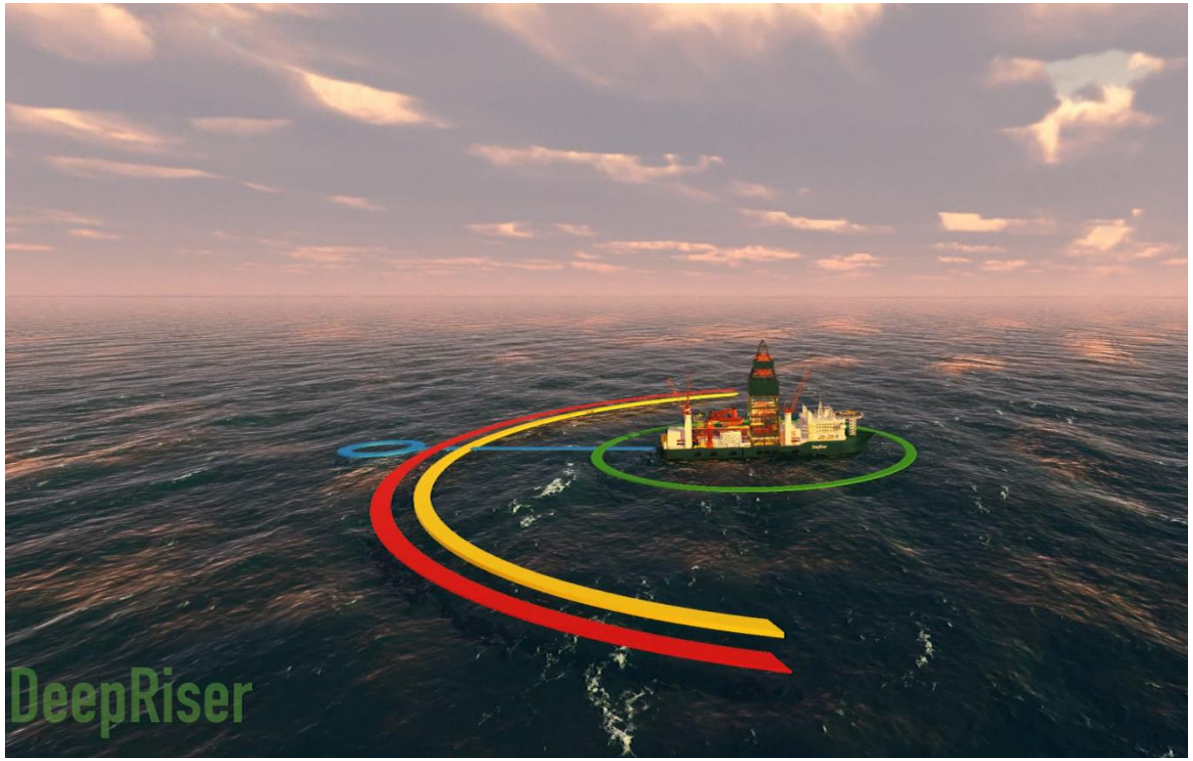
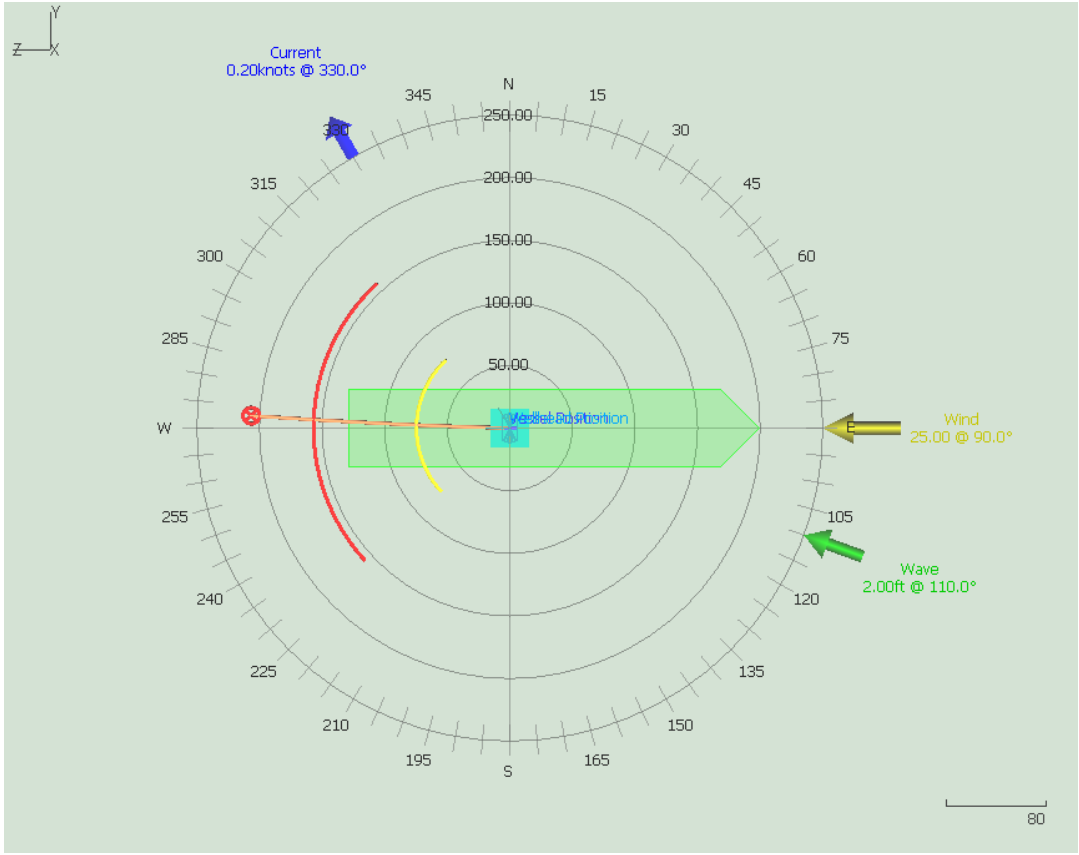
Introduction

- State-of-the-art drift-off simulator for DP drilling rigs
- Integrated drilling riser disconnect and recoil analysis capability
- Detailed wellhead and conductor/casing modelling capability



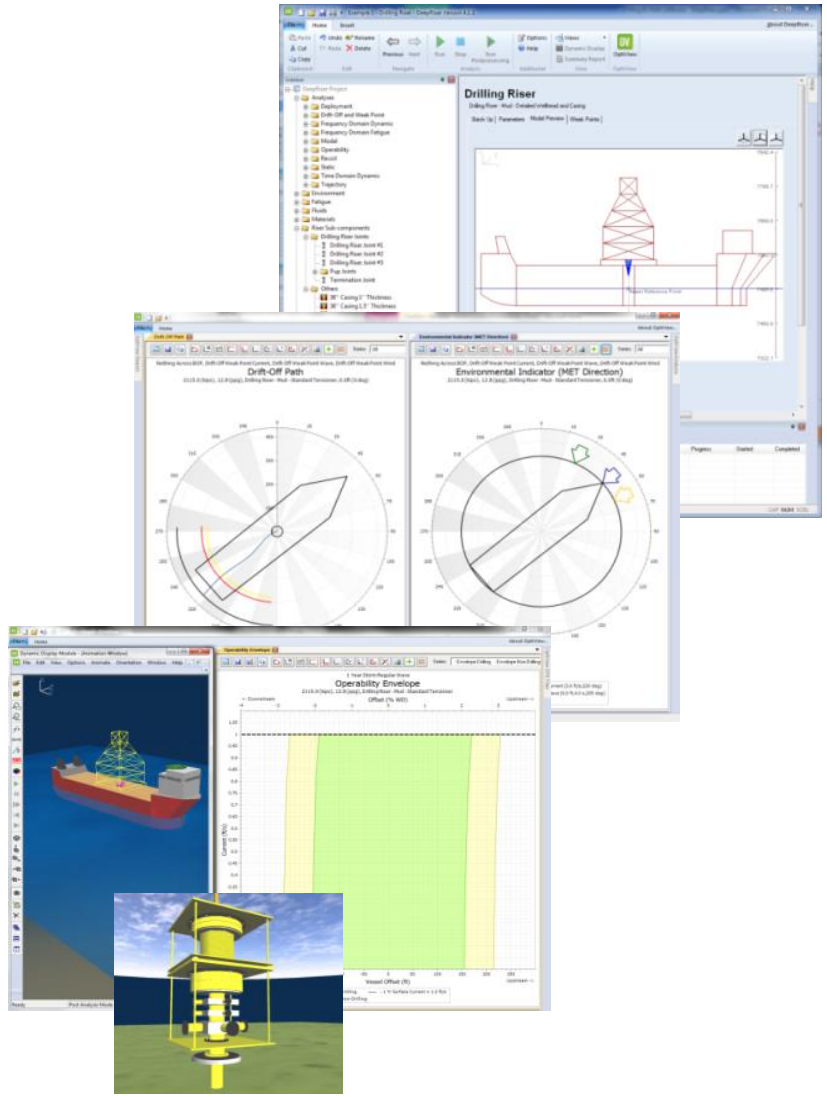
Drift-off Simulator for DP Drilling Rigs

- DP Drilling Rigs use Watch Circles to ensure safe disconnect
- Various approaches exist for calculating watch circles:
  - Fixed Percentage of water depth
  - Perform simulations to predict vessel drift (uncoupled from riser)
  - Perform coupled simulations considering both vessel and riser
- Only “coupled’ approach considers the effect of riser on vessel drift



Drift-off Simulator for DP Drilling Rigs

- The latest drilling riser analysis software calculates watch circle using a fully-coupled model
- Dynamic analysis is performed, calculating environmental forces acting on the vessel (and riser)
- System limits are monitored at each step of the simulation to determine the POD and watch circles



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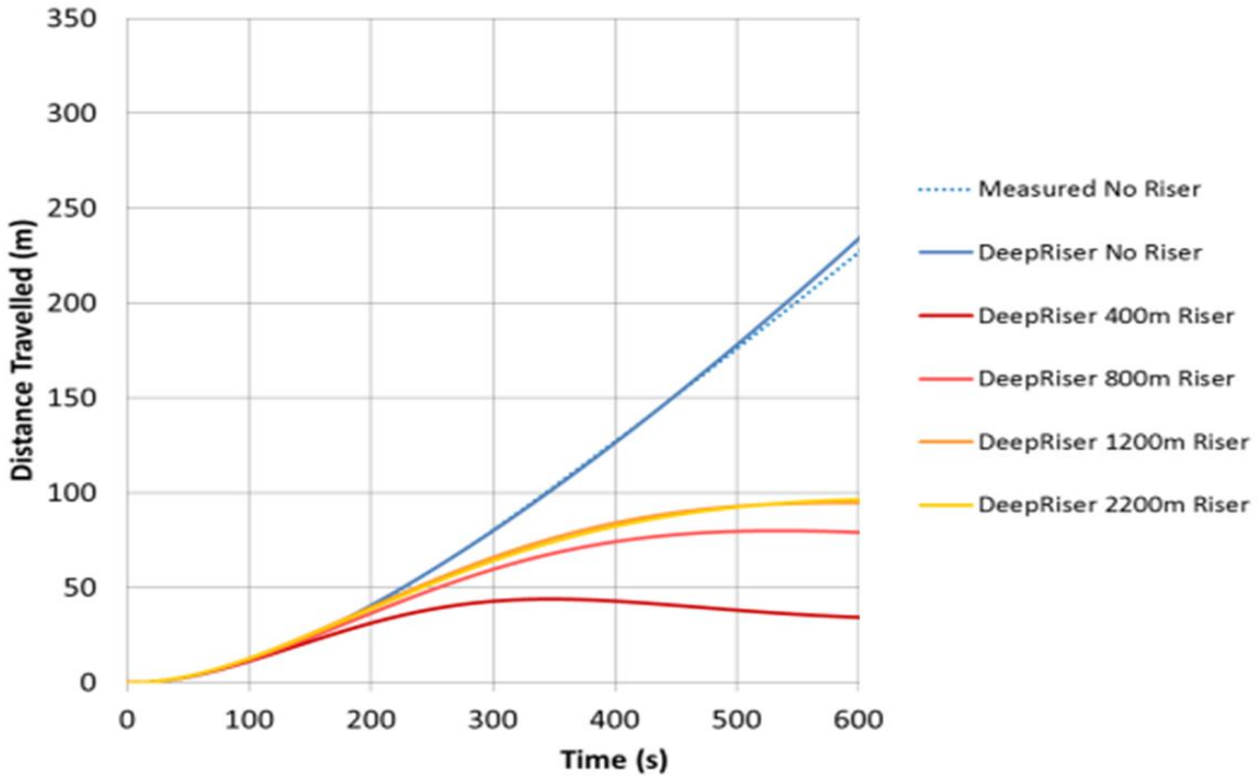
Drift-off Simulator for DP Drilling Rigs

- Advantages of fully-coupled approach:
  - Avoids potential for excessive conservatism
  - Substantially improves the economics of harsh-environment drilling
- Advantages of performing fully-coupled approach offshore, using real-time data:
  - Has lead to reduction in non-productive time and drilling costs (drillers have reported 30% increase in operability)
  - Has lead to successful drilling of shallow water wells, previously considered inoperable
  - Reported savings in excess of $2.8M in rig day rate alone on a single well



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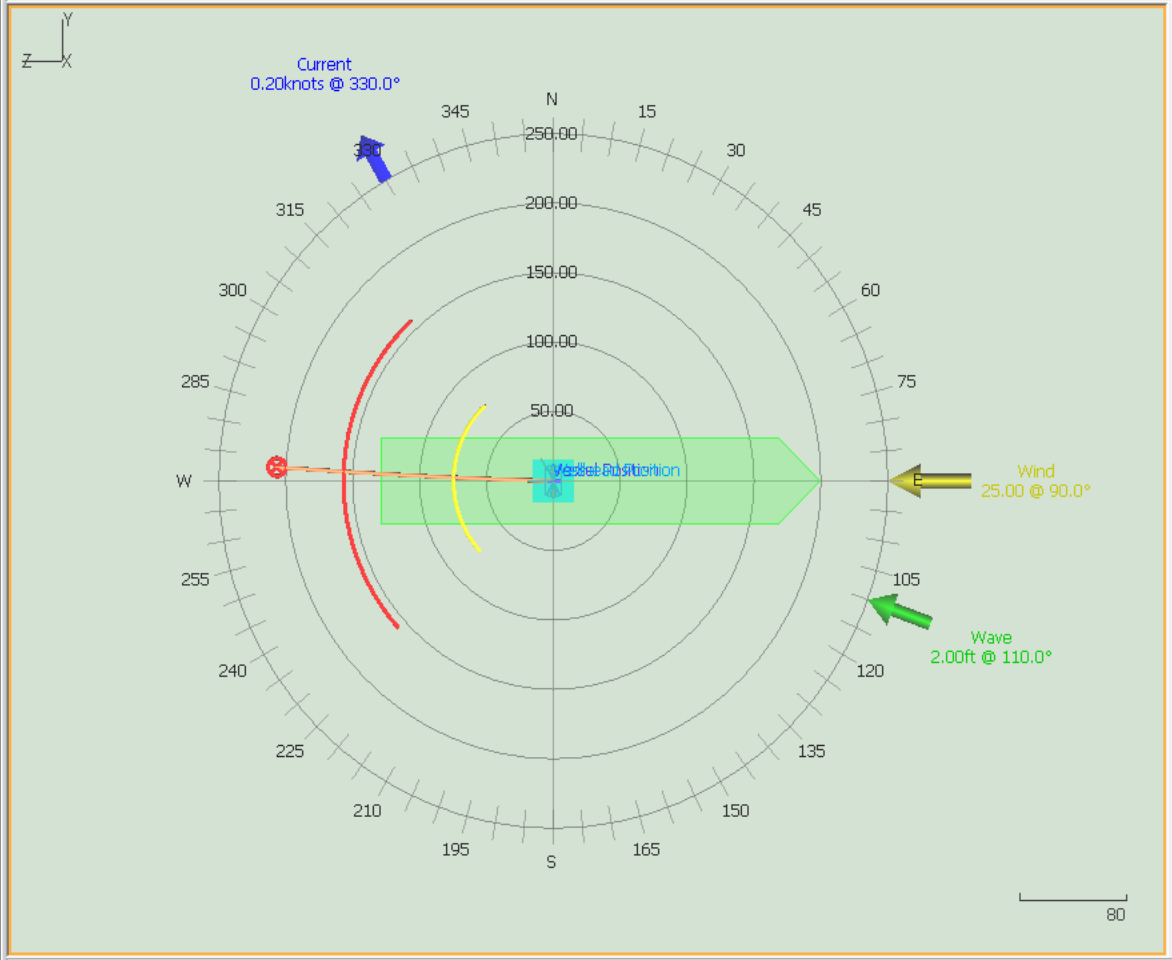
Optima - [Optima]

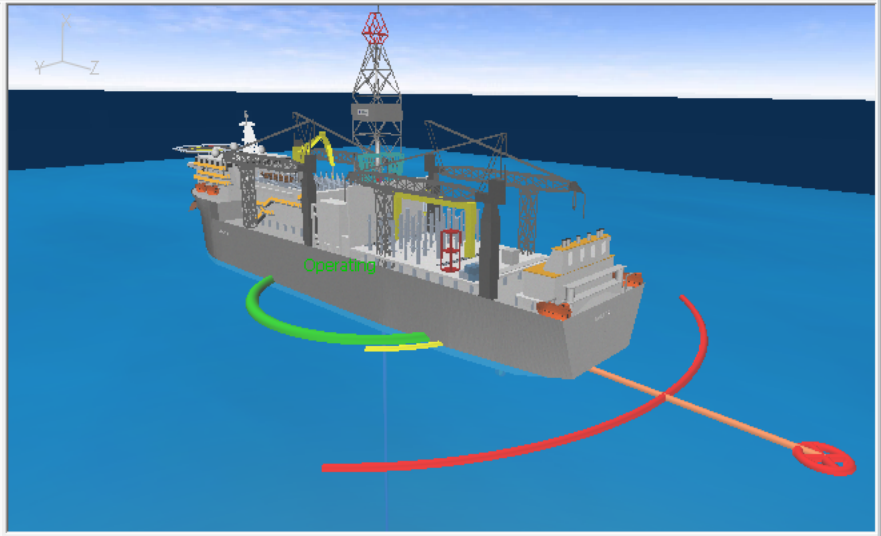
File | Optima (Offline) | About Optima... | Options | Help

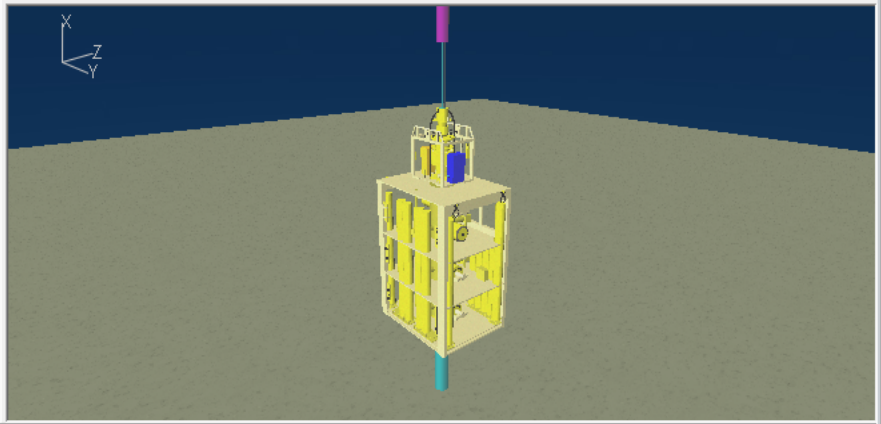
17:38:23 (Clock) | Licenced (Licence) | Offline / Drift-Off (Operating Mode) | Launch RIM | Launch DPM | Equipment | Limits + Timings (Database) | Display Settings (View)

Optima Model View | Detailed Results | Plot Results

Angle: 30







1.00 | 305.00 | Speed: 5.00 | Time: 1.00

1:1 | Line Scale: | x 3.1

Detailed Results

Drift Off Results Summary

Alert Offsets

P.o.D Limit:	Wellhead BM in 304(s)	
EDS Sequence	EDS 1	
	Time (s)	Offset (ft)
Yellow Alert:	156	74.58
Red Alert: (Loss of DP to EDS)	246	156.82
Point of Disconnect	304	206.9

Qty. @ Offset	Disconnect	Red	Yellow
Telescopic Stroke (ft)	29.30	26.28	23.13
Tensioner Stroke (ft)	31.70	28.63	25.38
LFJ Angle (deg)	4.61	3.48	1.64
UFJ Angle (deg)	3.40	2.63	1.29
WH BM (kips.ft)	4006.58	3014.99	1415.23
Connector BM (kips.ft)	0	0	0
Conductor BS (ksi)	0	0	0
Riser VMS (ksi)	25.15	22.70	22.57
Conductor VMS (ksi)	0	0	0

Signal Panel

Name	Value
Top Tension	1412.00 kips
Mud Weight	8.56 ppg
Yellow Alert Time	156.00 s
Yellow Alert Distance	74.58 ft
Red Alert Time	246.00 s
Red Alert Distance	156.82 ft
POD Alert Time	304.00 s
POD Alert Distance	206.90 ft
Significant Wave Height	2.00 ft
Wave Direction	110.00 deg
Surface Current Velocity	0.20 knots
Surface Current Direction	330.00 deg

Data Configuration

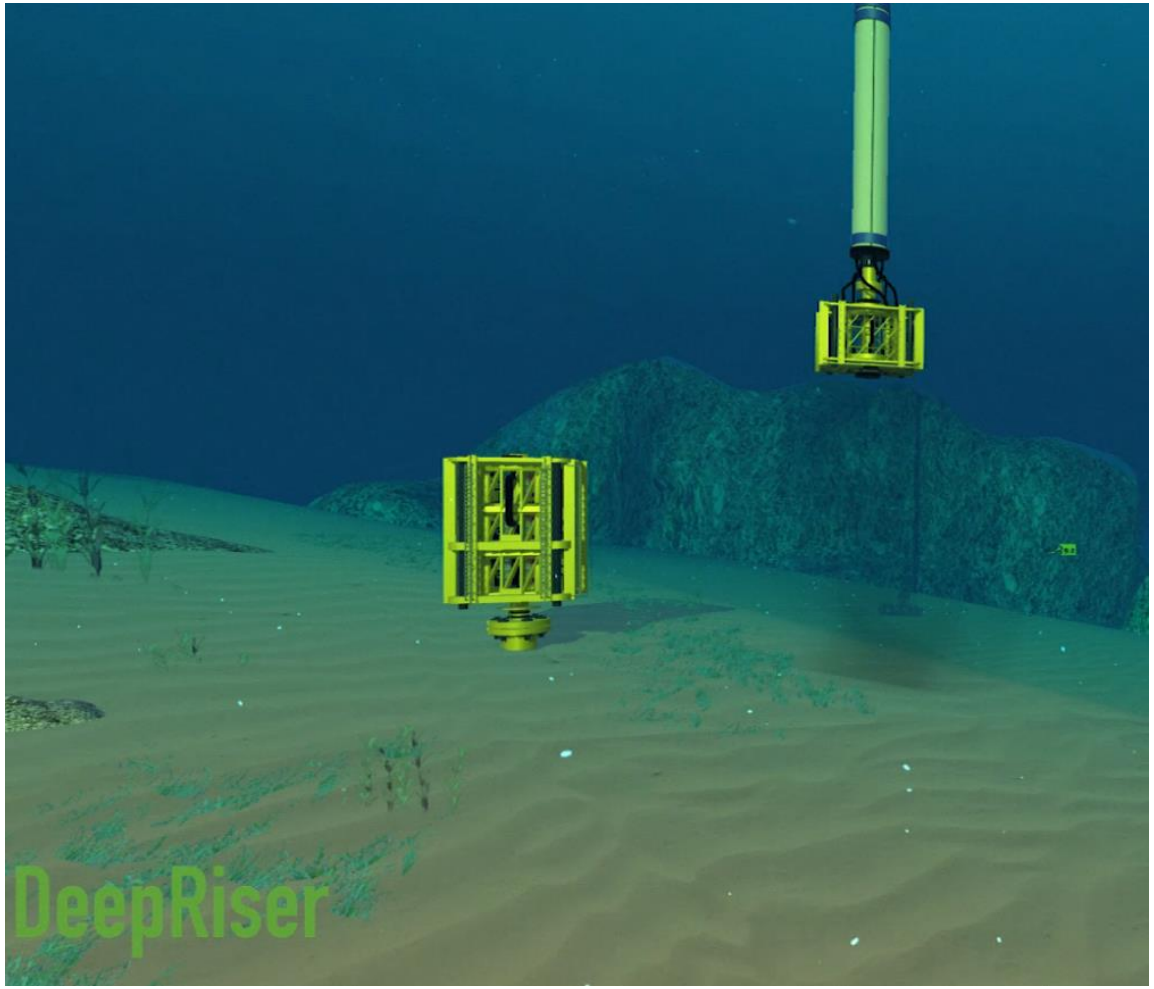
Vessel Setup | Riser Setup | Environment | Analysis

Drift-Off Analysis - Successfully Completed.

CAP | NUM | SCRL

Riser Disconnect and Recoil

- When is it necessary to perform an emergency disconnect?
- Why perform simulations of an emergency disconnect scenario?
- Simulation of this scenario requires:
  - Detailed hydro-pneumatic model of riser tensioner system
  - Anti-recoil control system modelling
  - Drilling mud flow modelling



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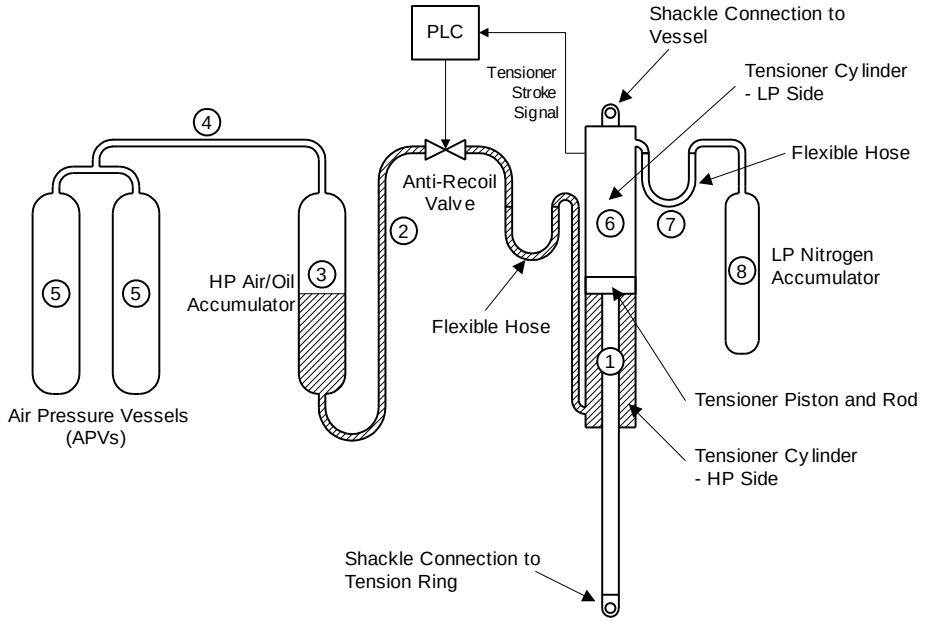
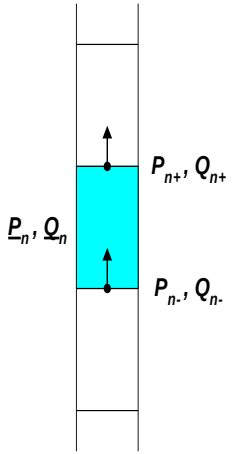
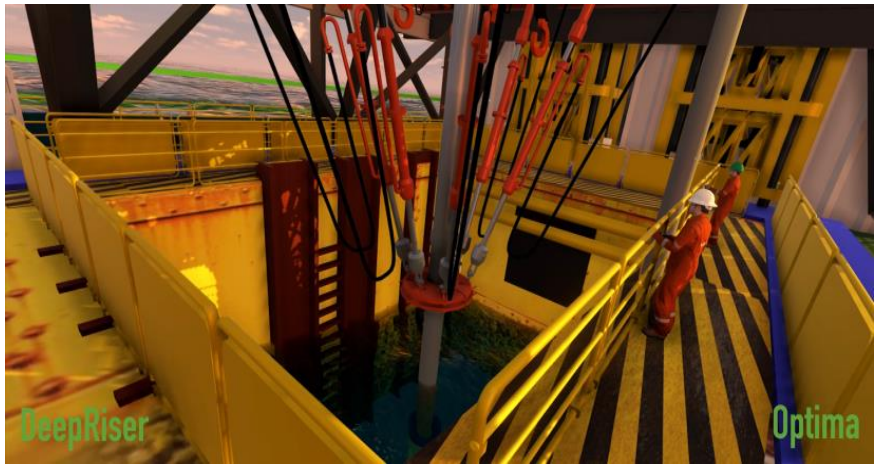
Riser Disconnect and Recoil

- Simplified approaches to tensioner modelling is not sufficient
- The latest drilling riser analysis software incorporates a detailed hydro-pneumatic model
- Mud column has a significant effect on the recoil response, imparting drag loading on the riser, counteracting upward movement
- The software integrates a finite volume (FV) mud flow model with the FE structural model of the riser







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Riser Disconnect and Recoil

- Simulated tensioner responses have been validated against measured data, showing precise agreement

- The recoil response predicted by the software has been validated against
  - Published Data
  - Tensioner Manufacturers Data
  - Disconnect test

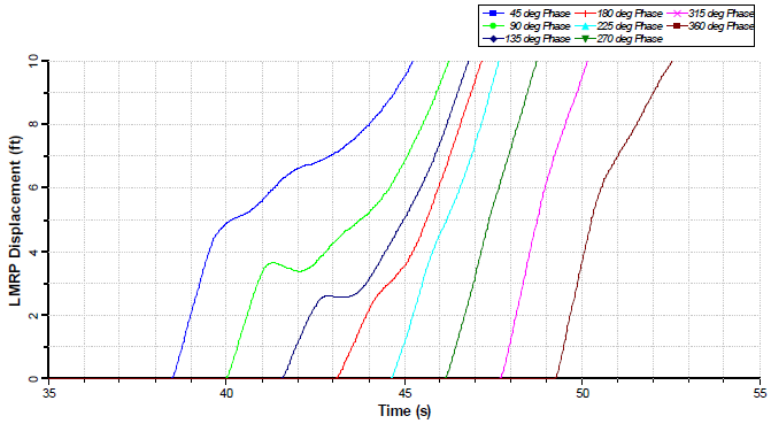

Figure 4. Validation Example – LMRP Displacement after Disconnect; Mud Weight = 10 ppg; Top Tension = 1800 kips; No Offset

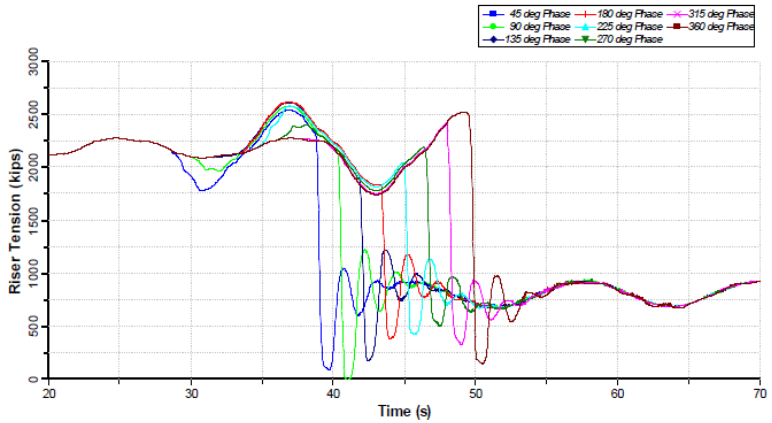

Figure 5. Validation Example – Tension Variation Caused by Riser Recoil; Mud Weight = 10 ppg; Top Tension = 1800 kips; With Offset

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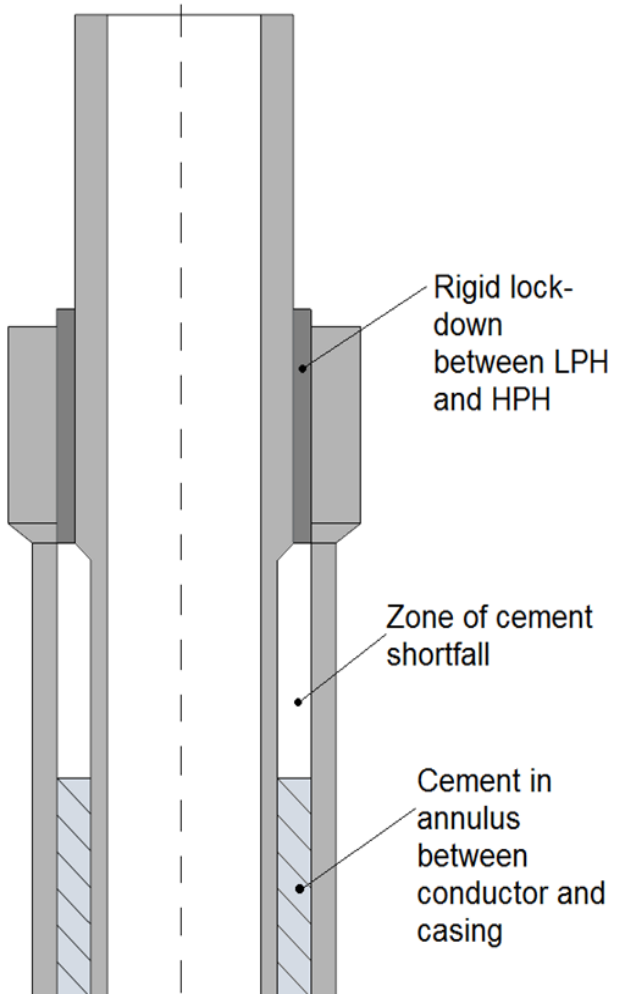
Detailed Wellhead and Conductor/Casing Modelling

- A well contains multiple intervals of casing, successively placed within the previous casing run
- Traditional modelling approaches not sufficient
- Recent developments within the offshore drilling industry have led to an increased focus on fatigue
- The latest drilling riser analysis software has been developed further to incorporate the latest modelling practices and analysis methodologies



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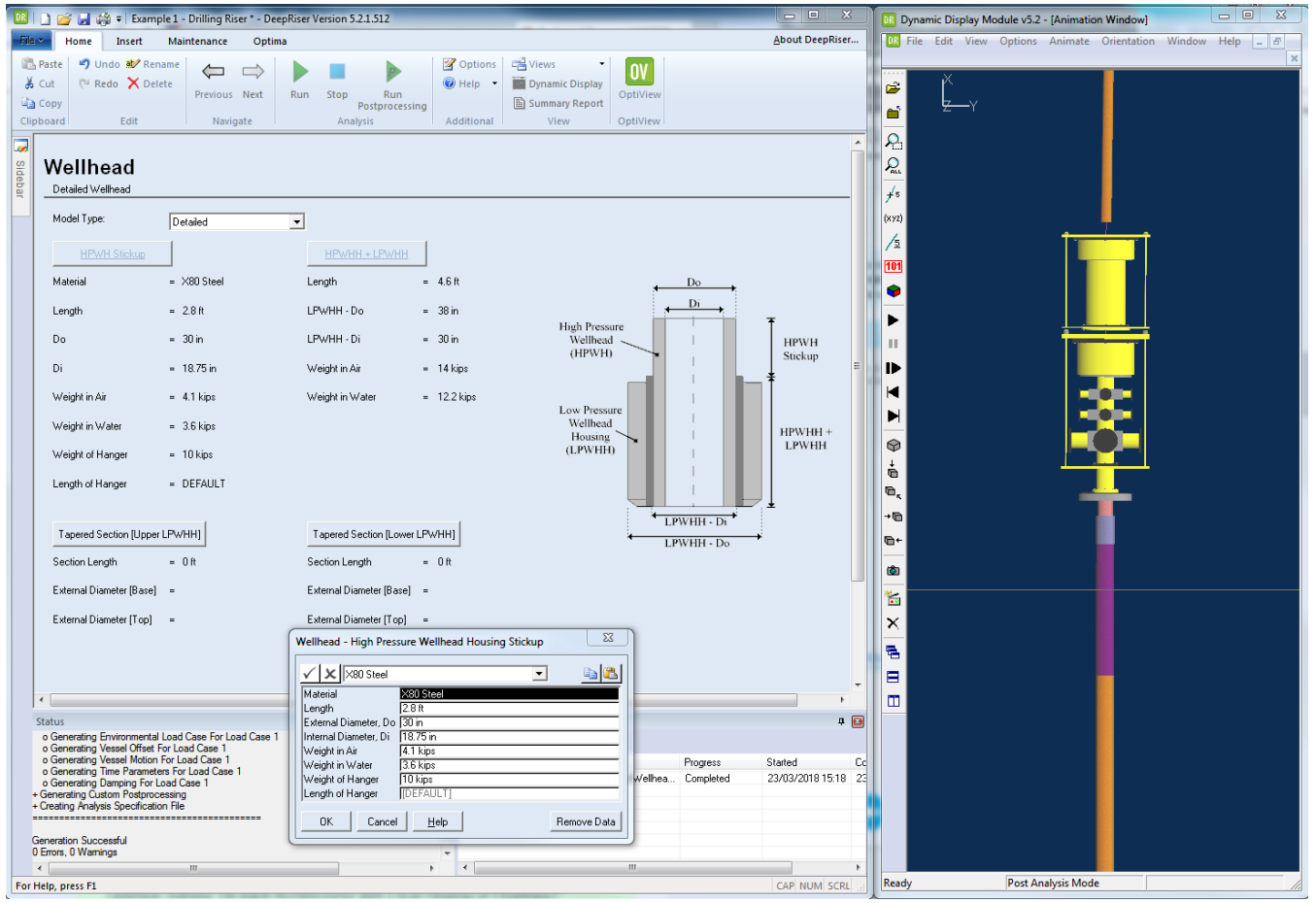
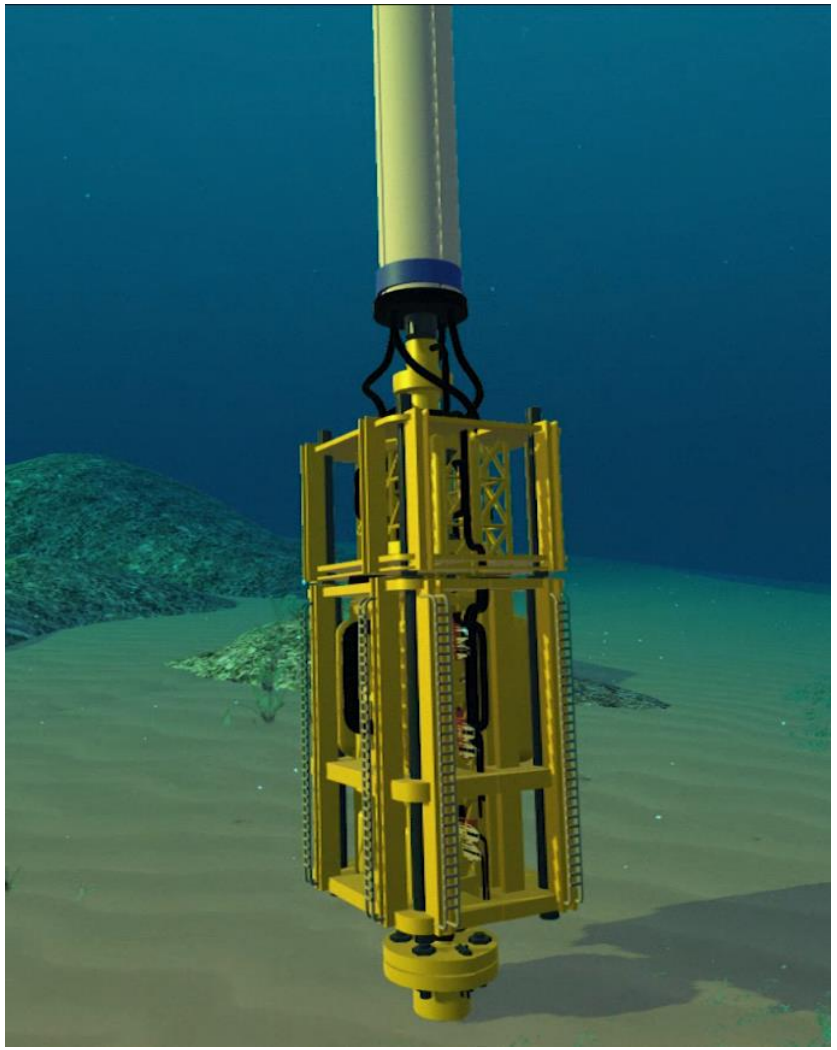
Detailed Wellhead and Conductor/Casing Modelling

- The latest software incudes advanced modelling capabilities:
  - Pipe-in-Pipe
  - Drilled & Grouted vs. Jetted installation
  - Cement Shortfall
  - Fully bonded or sheared cement
  - Soil modelling
  - High Pressure and Low Pressure Wellhead Housing
  - Tapered sections



Detailed Wellhead and Conductor/Casing Modelling

- Detailed wellhead, conductor and casing modelling bridges the gap between the older ‘composite’ models and local models
- The latest detailed global models deliver improved fatigue-life predictions
- Improved predictions are essential to demonstrating the feasibility of drilling, workover and plug-and abandonment operations



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Conclusions

- As the oil and gas industry adjusts to a new market reality, it remains clear that development of offshore reserves will continue to play an important role in meeting the world's hydrocarbon energy demand

- As exploration moves into deepwater and harsh-environment locations, new digital technologies are playing an important role in ensuring this can be done in an economically-sustainable way

- Wood's DeepRiser tool is an example of one such technology that is helping to maximize the viability of drilling operations in some of the world's most challenging environments

Authors and Acknowledgements

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Thank you!

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