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Design Challenges for Terra Nova and RJS-409 Projects

User Group Meeting – Houston, October 24, 2006

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Agenda

- Roll damping due to mooring and risers in deep water
- Snap loads during pull-in of disconnectable turret mooring

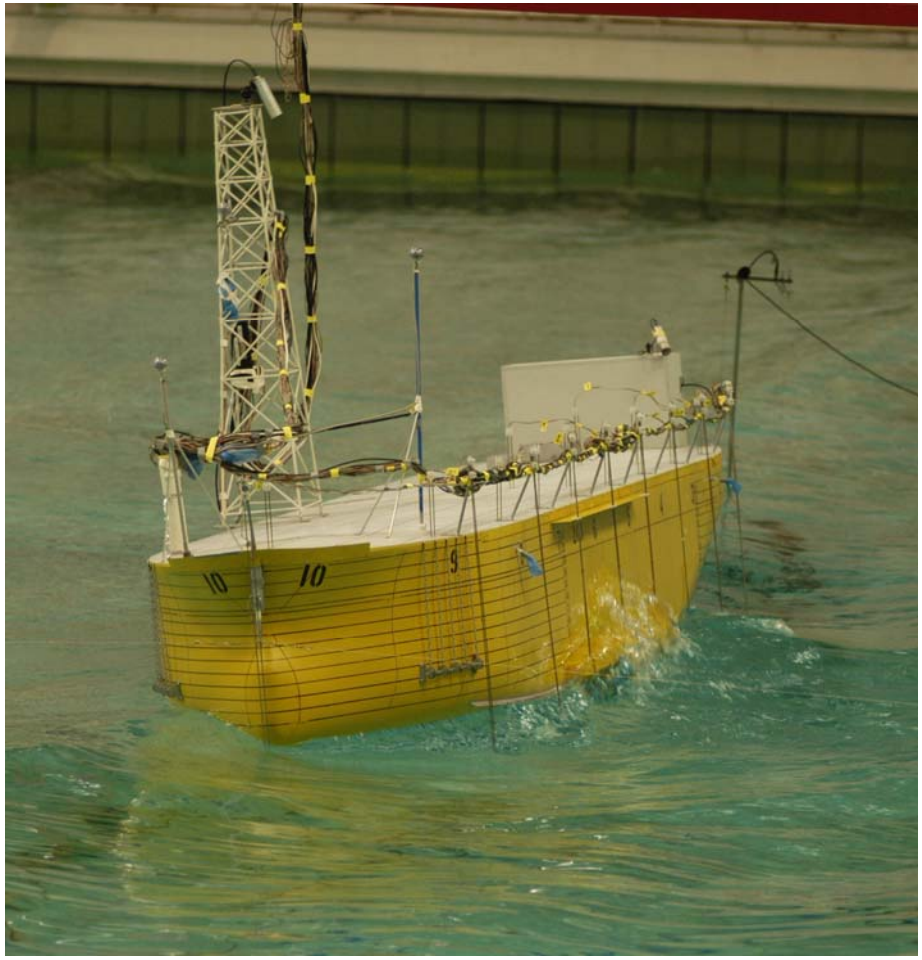
Roll Damping – System Description

- FPSO Ciodade do Rio de Janeiro
- Water Depth = 1370m
- Vessel = 362 kDWT
- Spread mooring system, 18 mooring lines, 10 bow, 8 stern
- 34 Flexible risers, simple catenary configuration

Roll Damping – Problem Definition

- Maximum Allowable 100-year roll angle = 10 deg
- 100-year beam sea: Hs = 6.7m; Tp = 11.4s
- Natural period in roll varies with draft from 10.6s to 14.1s
- Bilge keels: 1.5m wide; 205m long (66% Lbp)

Model Tests, scale 1:60 at Marintek, Norway



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Movie

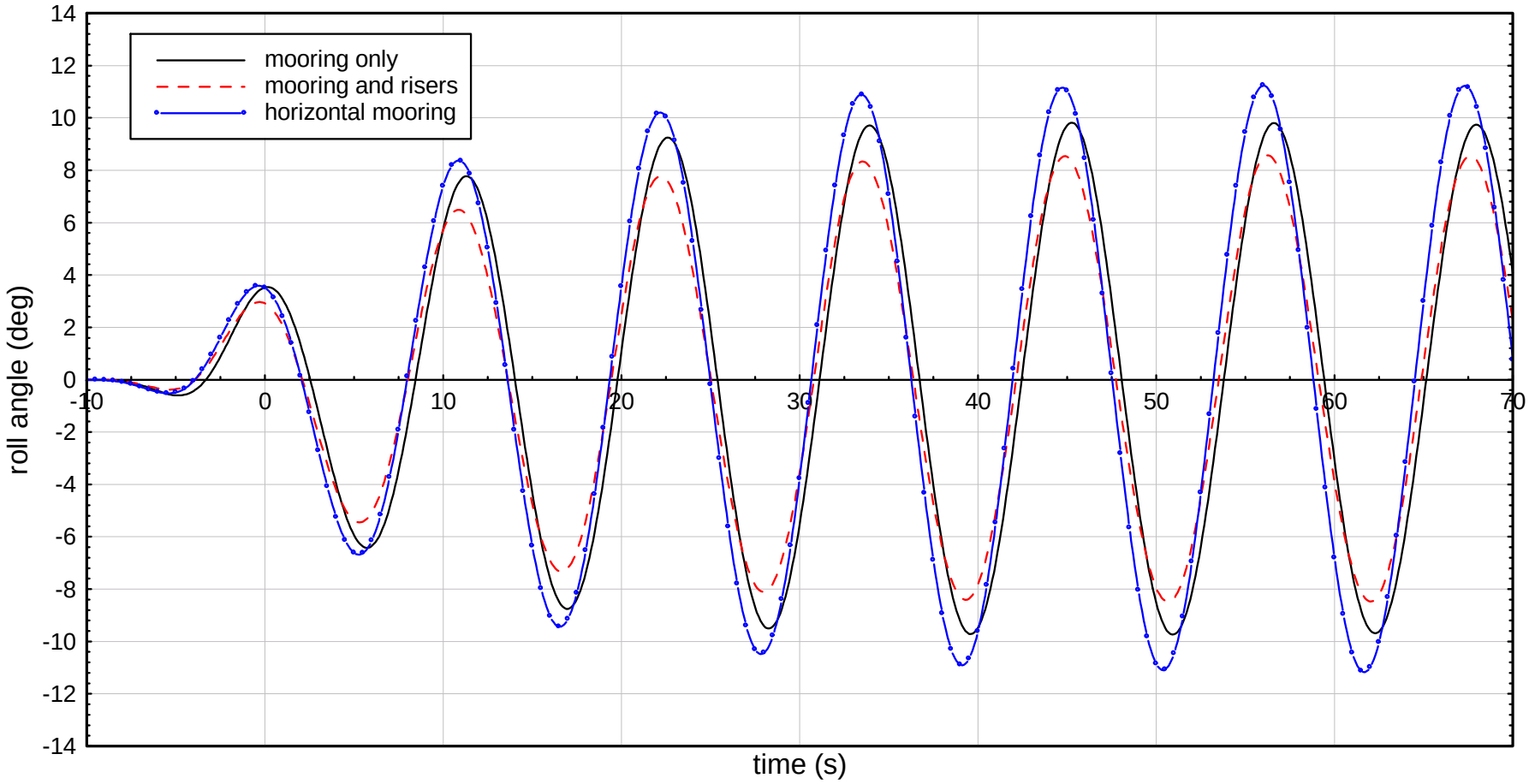
Roll Damping - Approach

- Model tests of FPSO in horizontal mooring
  - Max Roll Ballast = 11.1 deg
  - Max Roll Full = 6.1 deg
- 3D diffraction analysis (HOBEM)
  - First order wave forces
  - Added mass
  - Potential damping
- OrcaFlex calculation of vessel roll response using 6D calculated motions

OrcaFlex Calculations

Configuration	Max Roll (deg)
Horizontal Mooring	11.2
Actual 18-leg mooring	9.7
Mooring + Risers	8.5

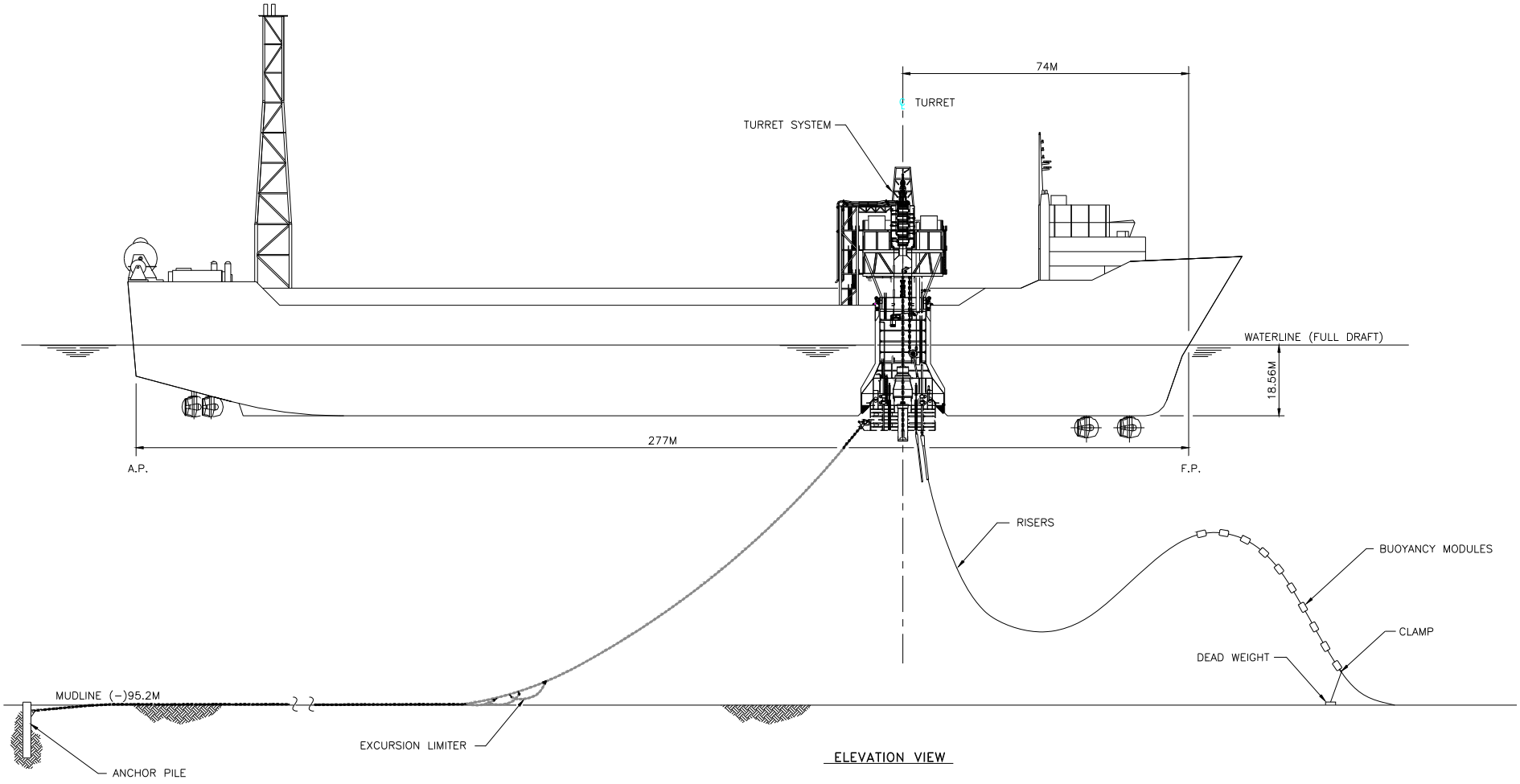
Effect of mooring and risers on max roll



Snaploading in pull-in line

- Terra Nova FPSO
- Water depth = 95m
- No disconnection in 100-yr storm (Hs = 16m)
- Disconnect for ice berg > 100,000 mt
- Reconnect in Hs = 3.5m
- Full DP system with 5 azimuthing thrusters 5MW each

Terra Nova FPSO



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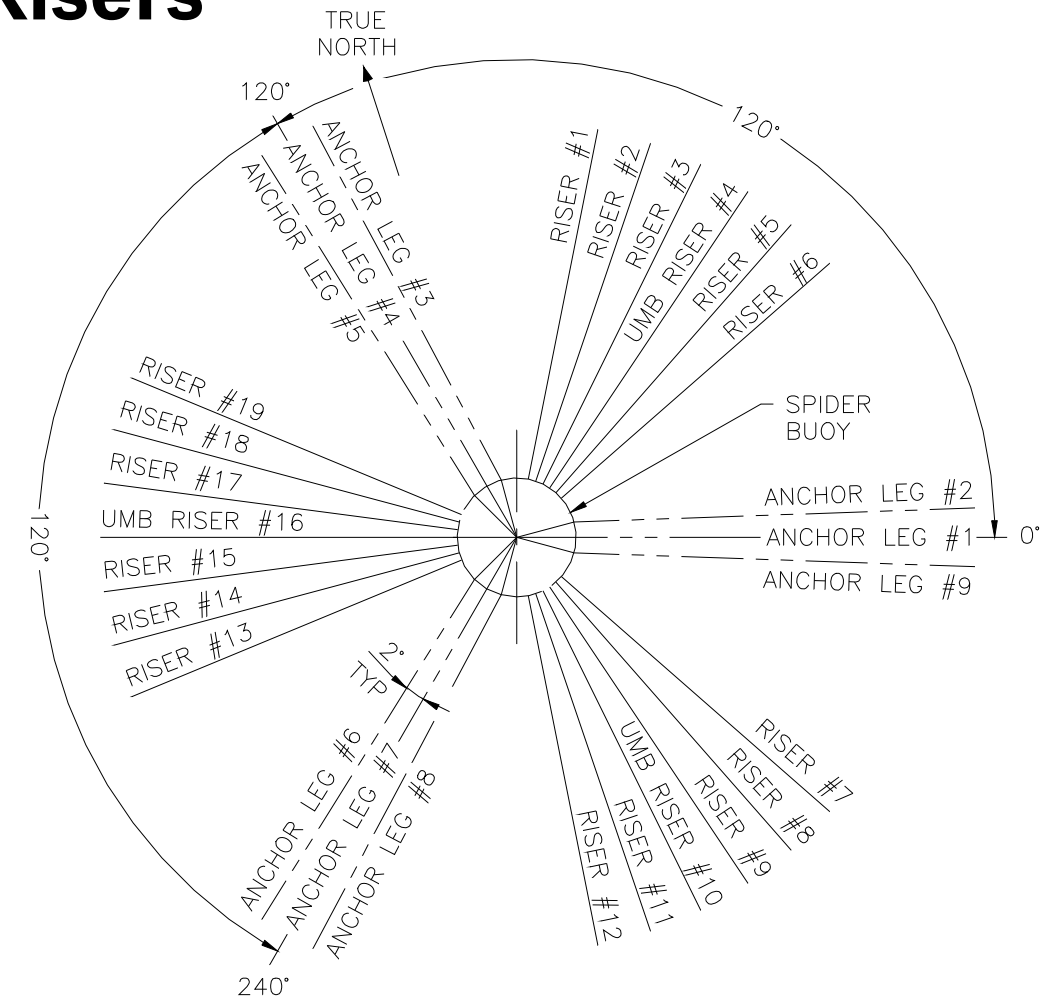
Mooring & Risers



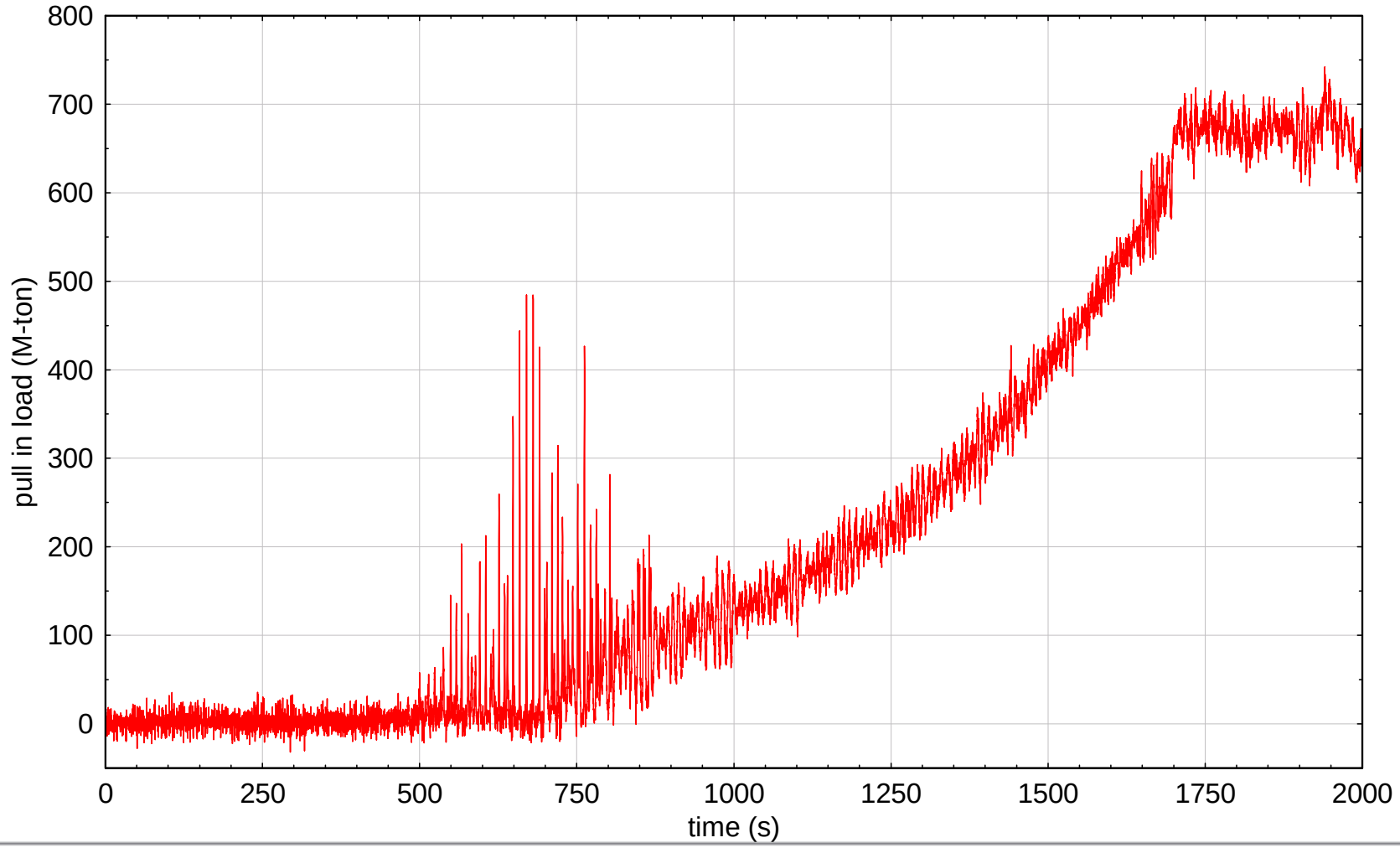
PLAN VIEW AT ANCHOR LEGS AND RISERS

Terra Nova FPSO and Spider Buoy

Model Tests

- Institute for Marine Dynamics
- Scale 1:44
- Instrumented winch
- Full DP system
- Snaploading in pull-in line during reconnect tests

Snaploading from model test



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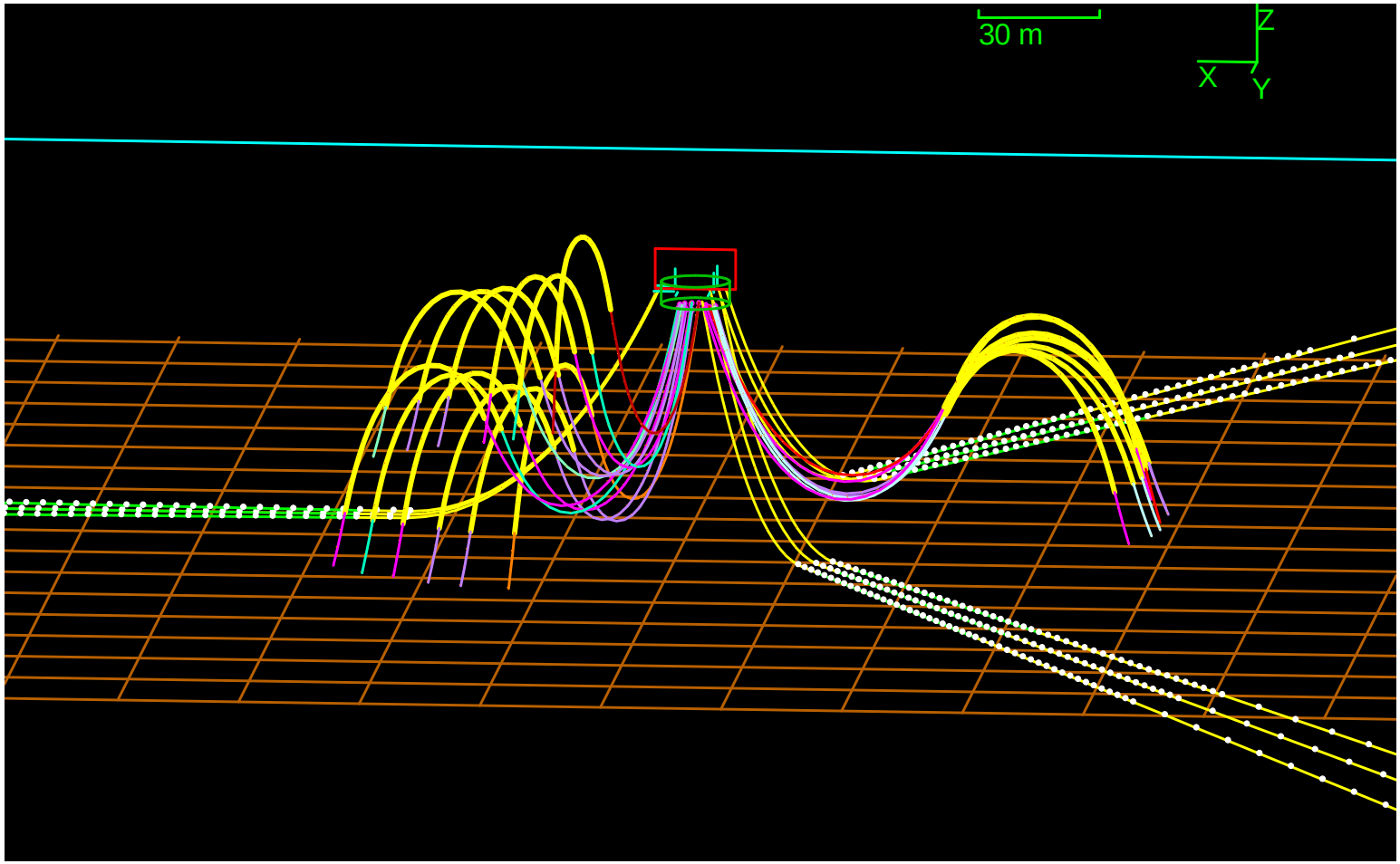
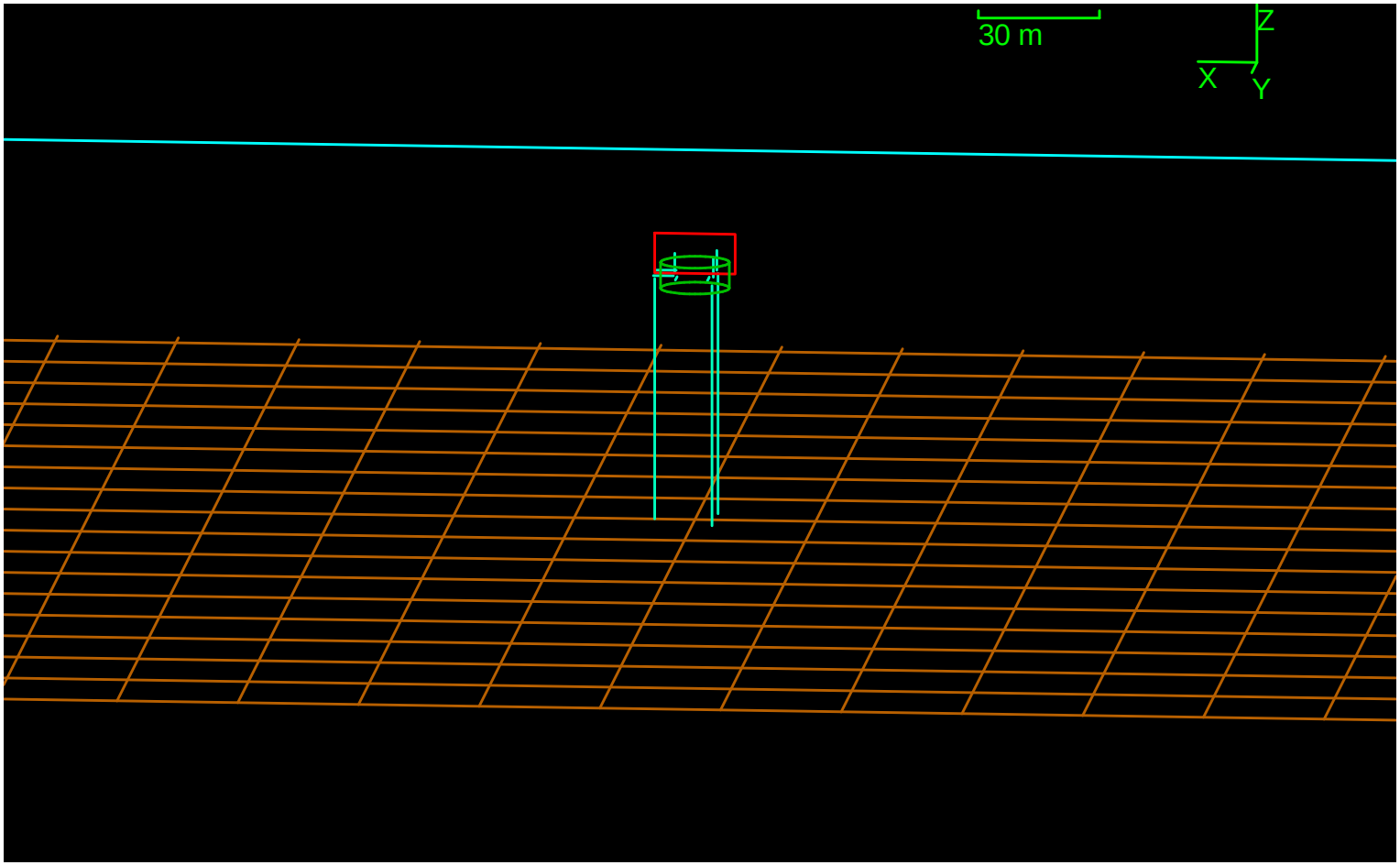
OrcaFlex Model

- FPSO – Vessel
- Spider Buoy – 6D Buoy
- Mooring Lines
- Risers
- Alternative Model with springs
- 2 Types of analysis
  - Constant length
  - Variable length

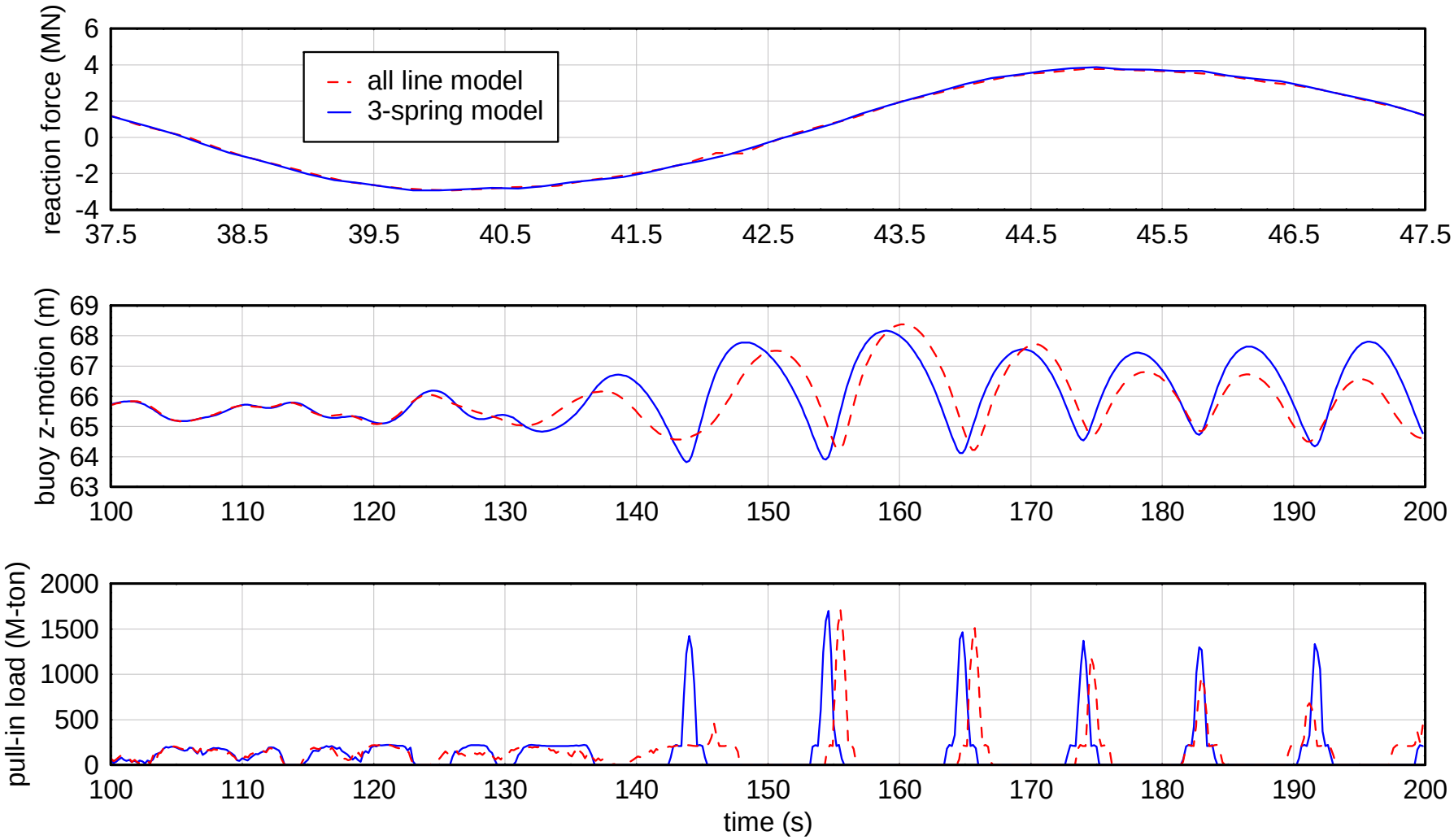
All line model



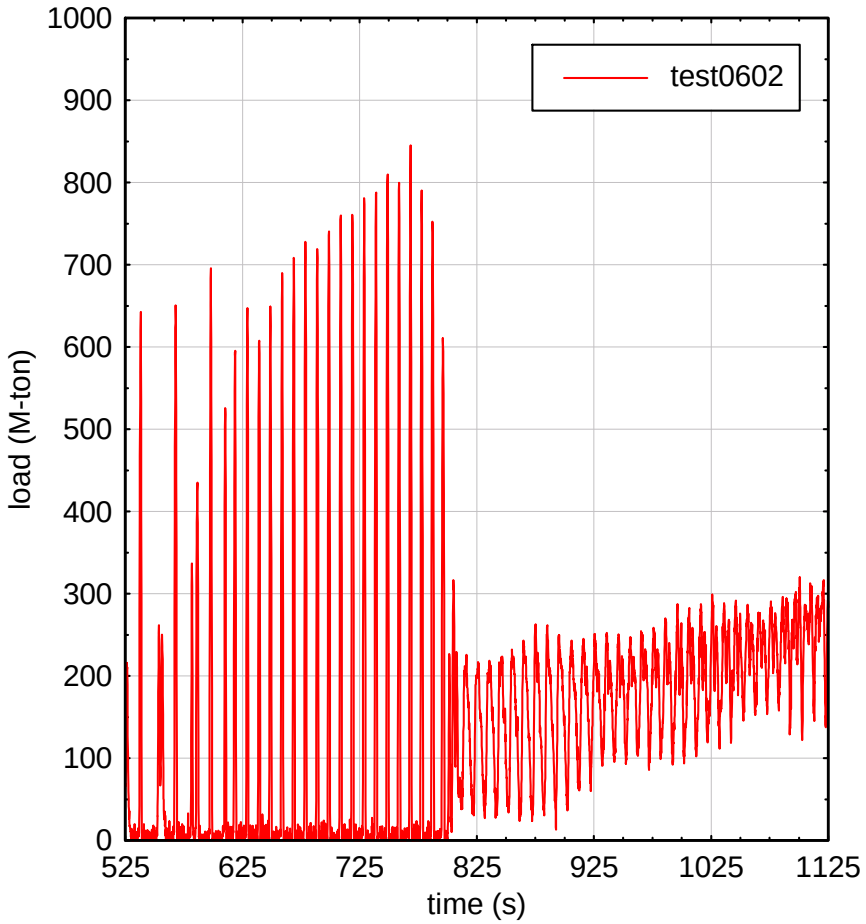
Model with equivalent springs

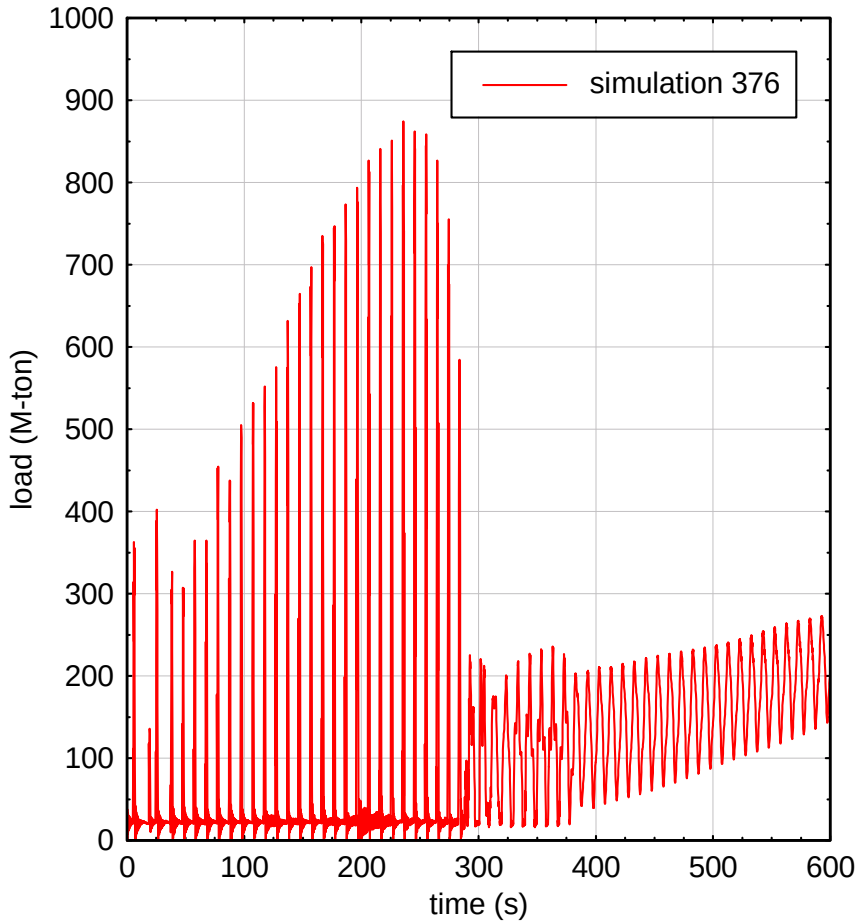


Comparison of 3-spring to all-line model



OrcaFlex simulation vs Model test results





Effect of shock absorber