The Need for the Pendulous Installation Method

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Questions

- Introduction
  - What was happening in the world scenario by 2003?
  - What proven installation methods were used by Petrobras?
- The Need for the Pendulous Installation Method
  - What was the main drive to develop the Pendulous Method?
  - What is the Pendulous Method?
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What was happening in the world scenario by 2003?

Subsea Activity

- **Development of many oil fields**
  - ✓2000m WD (offshore Brazil and GoM)
  - ✓1300m WD (offshore Angola)
- **Lowering heavy subsea hardware on drill-strings from large MODUs:**
  - ✓ Scarce drilling resources
  - ✓ Very Expensive
  - ✓ Inefficient
- **Heavy lift capacity vessels (very expensive)**
- **Studies for using small vessels**

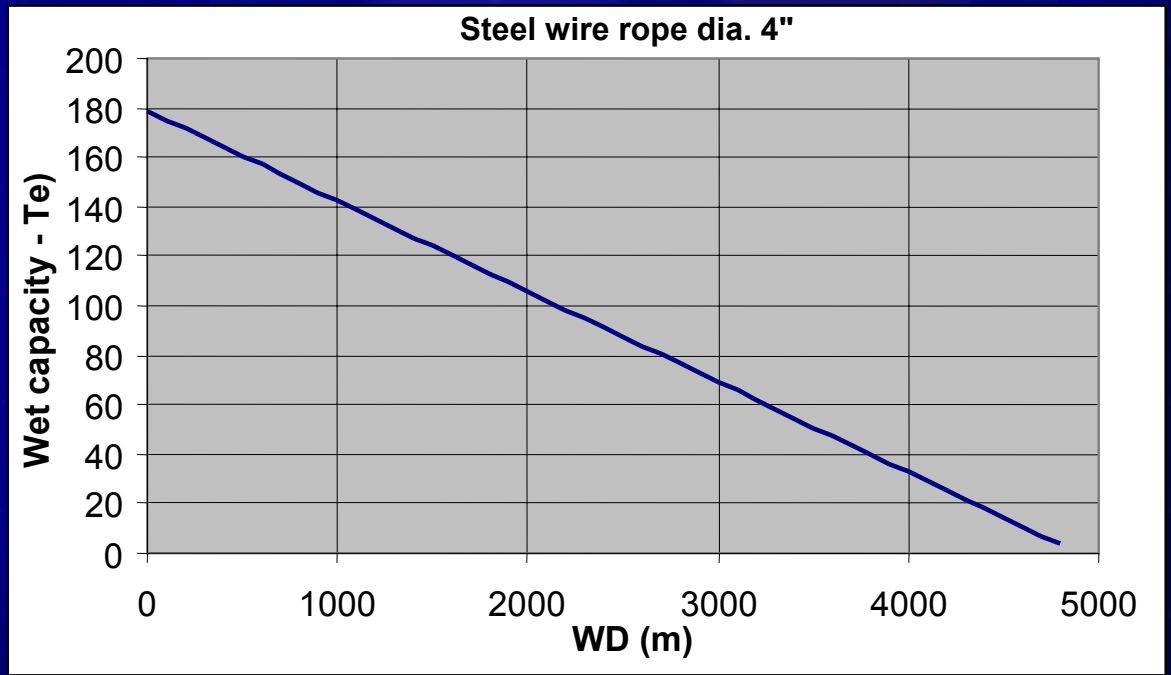
What was happening in the world scenario by 2003?

- Petrobras:Studies to develop fields in up to 3000m WD
  - ✓PROCAP 3000 Technological Program and participation in Joint Industry Projects (DISH and VP2002)
- Technical Constraints for wire rope use in ultra deep water
  - ✓Steel wire ropes lose lift capacity due to self-weight

The Need for the Pendulous Installation Method
What are the Pendulous Method benefits?

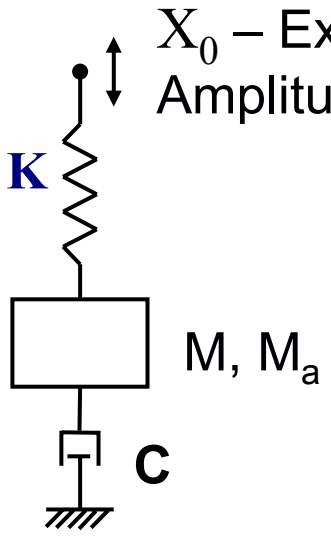
Steel wire rope wet lift capacity = f (WD)
example

- Steel wire rope diameter 4” (103mm)
- Weight 44 kgf/m
- Weight in water 36.5 kgf/m
- Minimum Breaking Load (MBL) 665 Te
- Safety Factor (FoS) 3.1 (DNV)
- Safe Working Load (SWL) 214.5 Te
- Dyn. Ampl. Factor (DAF) 1.2 178.8 Te



What was happening in the world scenario by 2003?

- Many studies were considering how to develop fields in 3000m WD or deeper
  - ✓PROCAP 3000 Project and participation in JIPs (DISH and VP2002)
- Technical Constraints for wire rope use in ultra deep water
  - ✓Steel wire ropes lose lift capacity due to self-weight
  - ✓Axial resonance problems due to very long length

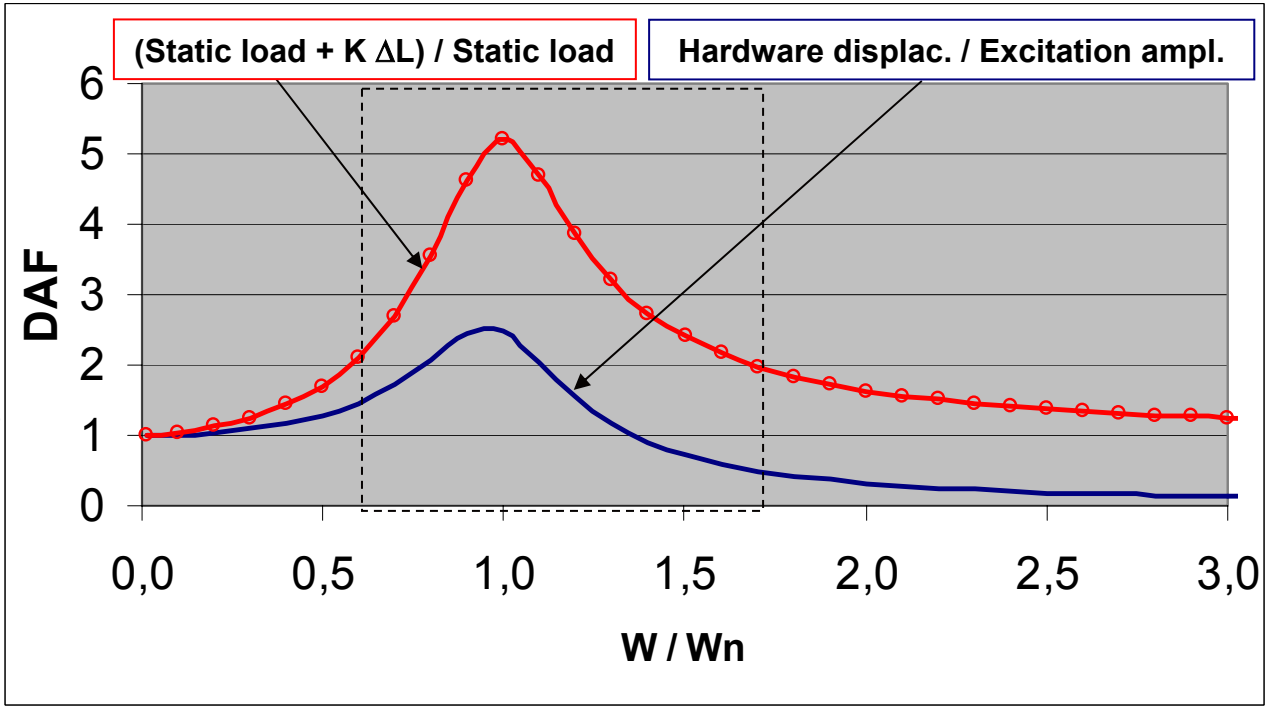


$$K = \frac{(EA)_{equiv}}{L}$$

$$W_{nat} = \sqrt{\frac{K}{M + M_a + \frac{2m}{5}}} = \frac{2\pi}{T_{nat}}$$

Frequency ratio β

$$\frac{w}{w_{nat}} = f(L_{deployed})$$



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- Technical Constraints for wire rope use in ultra deep water
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  - ✓Axial resonance problems due to very long length
- Possible Solution
  - ✓ Fiber Ropes instead of steel wire ropes

What was happening in the world scenario by 2003?

Fiber Ropes Deployment Systems

- ✓Fiber ropes – some technical problems:
  - axial resonance – due to rope stiffness (EA/L)
  - low surface friction between rope and winch surface
  - fatigue and temperature generation caused by repeated bend-over-sheave or slippage
  - high susceptibility to abrasion
  - rope crushing by compressive forces exerted on the rope successive layer reeling on the drum.
- ✓No Field Proven FRDS or prototypes were available in the market for conditions we had

What was happening in the world scenario by 2003?

JIP – VP 2002CTCU – Cable Traction Control Unit

Prototype Test and first installation – 2004 - 2005

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What proven installation methods were used by Petrobras?

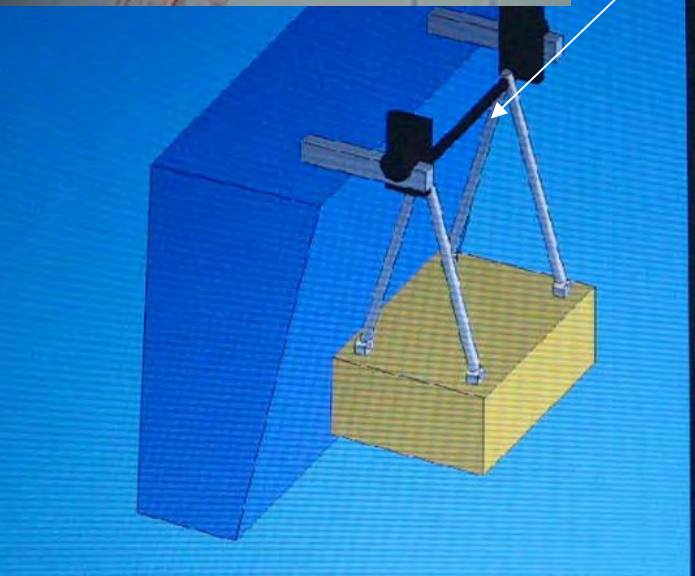
Previous installations of subsea hardware by Petrobras

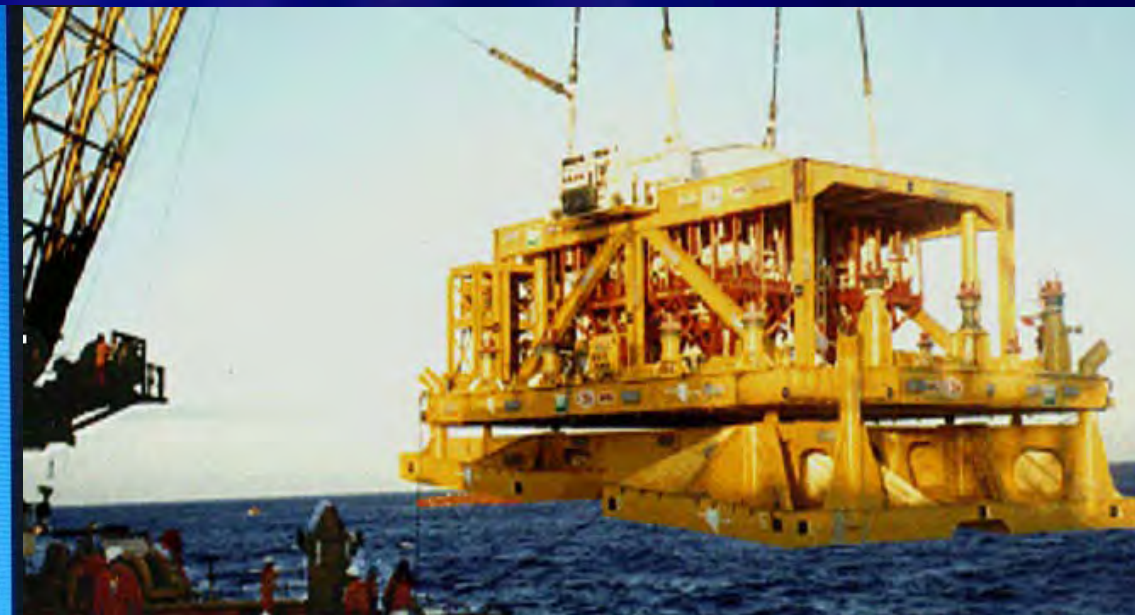
- More compact subsea hardware in shallow waters: crane barge, crane of SS, AHV with A-Frame

What proven installation methods were used by Petrobras?

Previous installations of subsea hardware by Petrobras

Crane barge and slings – 420 Te/620 m (1995)

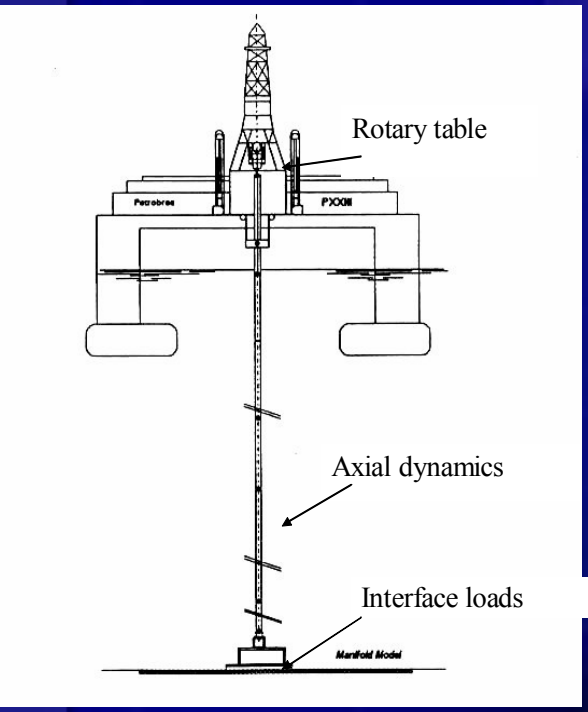




What proven installation methods were used by Petrobras?

Previous installations of subsea hardware by Petrobras

- MODU/drilling riser 240 Te/940 m (2001)



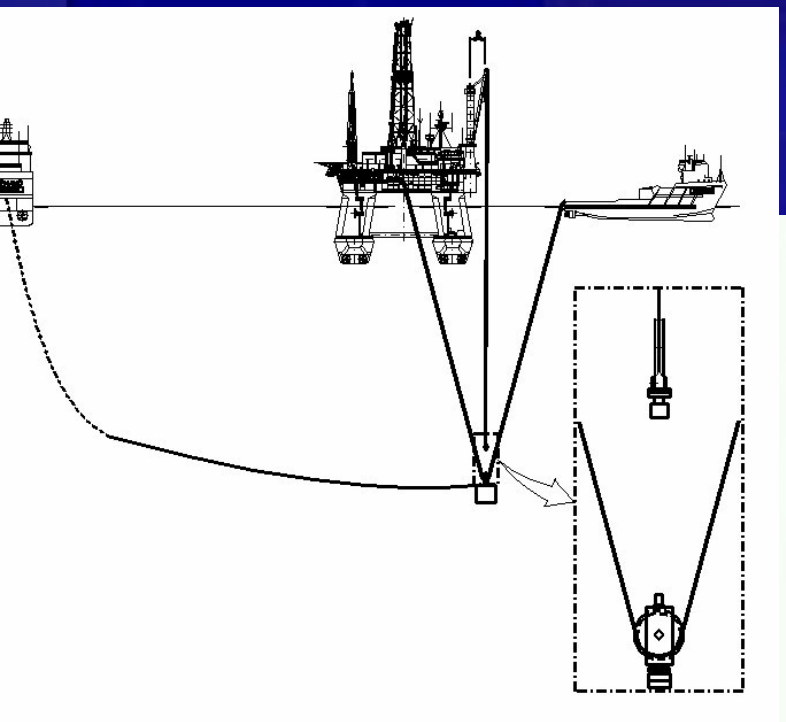
What proven installation methods were used by Petrobras?

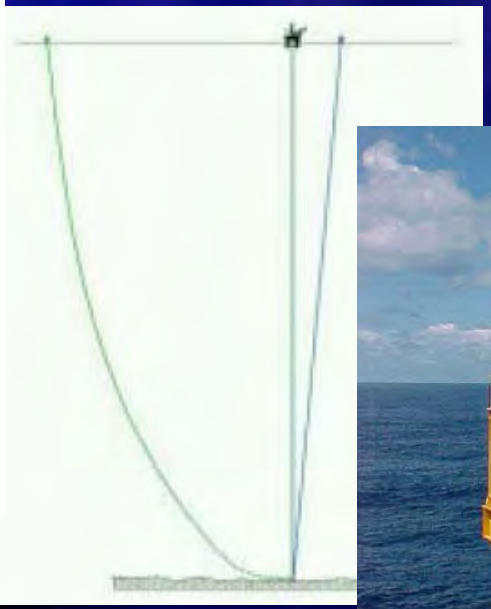
Previous installations of subsea hardware by Petrobras

Sheave Method – 175Te/1885 m (2002)

SS – Pride South America

- DP System
- Crane capacity – 300 Te
- Drilling riser limit – 1000m WD





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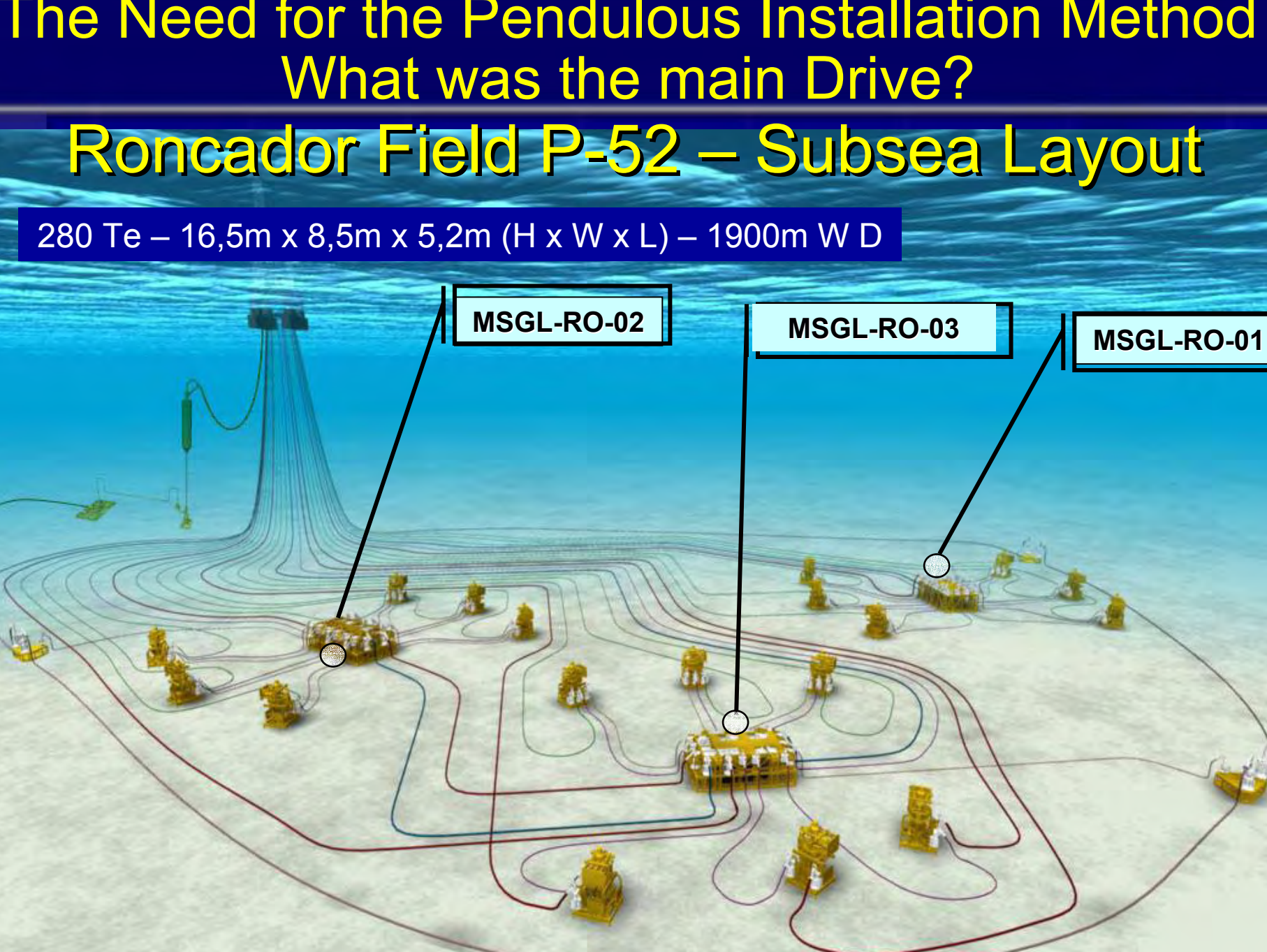
The Need for the Pendulous Installation Method
What was the main Drive?

Roncador Field P-52 – Subsea Layout

280 Te – 16,5m x 8,5m x 5,2m (H x W x L) – 1900m W D



The Need for the Pendulous Installation Method What was the main Drive?

New manifold to be installed (MSGL-RO-2)

- Alternatives
  - ✓Special construction vessels
  - ✓Sheave Method
  - ✓Using Synthetic fiber ropes

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The Need for the Pendulous Installation Method What was the main Drive?

- ✓ Special construction vessels
  - Scarce and high daily rates → high Installation cost

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New manifold to be installed (MSGL-RO-2)

- Alternatives
  - ✓Special construction vessels
  - ✓Sheave Method
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The Need for the Pendulous Installation Method What was the main Drive?

Sheave Method

MSGL-RO-2 – 280 Te / 1900m

Minimum crane capacity = 280 x 1,2 = 336 Te

- 336 Te > SS - Pride South America Crane capacity (300 Te SWL)
- Option →Petrobras Crane Barge BGL-1
  - ✓ Crane capacity 1000 Te → Ok
  - ✓ No heave compensation →more a SS of opportunity
  - ✓ No DP system → more 3 vessels for station keeping
- Conclusion → many vessels → high installation risk

The Need for the Pendulous Installation Method What was the main Drive?

New manifold to be installed (MSGL-RO-2)

- Alternatives
  - ✓Special construction vessels
  - ✓Sheave Method (MSGL-RO-1- 175 Te/1900m).
  - ✓Using Synthetic fiber ropes

The Need for the Pendulous Installation Method What was the main Drive?

- Synthetic Fiber Ropes

  No Field Proven FRDS or prototypes available in the market that would fulfill the requirements

Constraints that had to be overcome

- Self-weight of steel wire rope
- Axial Resonance (w/o heave compensator)
- Fiber Rope Deployment System Unavailability to install a subsea hardware of 280 Te in 1900m WD
- Low availability and high cost of heavy lift capacity vessel

Ways to overcome the constraints

✓ Use polyester ropes and maneuver them without tension

✓ Prevent resonance by using ropes much longer than the lengths that would fall into the resonance region and allow ropes to undergo gradual tension after completely paid

So why not use pendulous motion to deploy the manifold?

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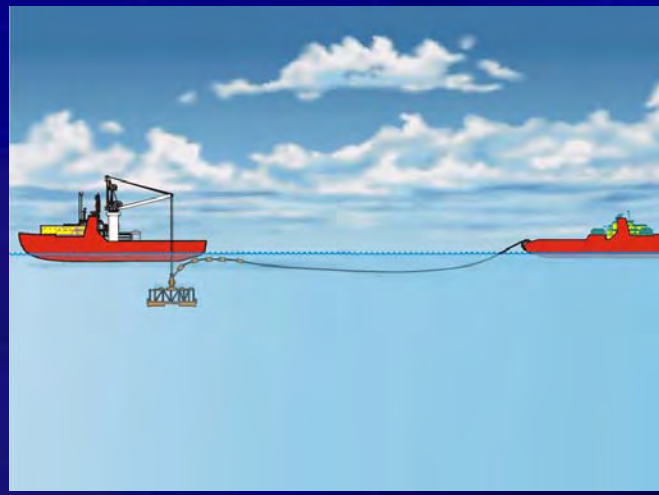
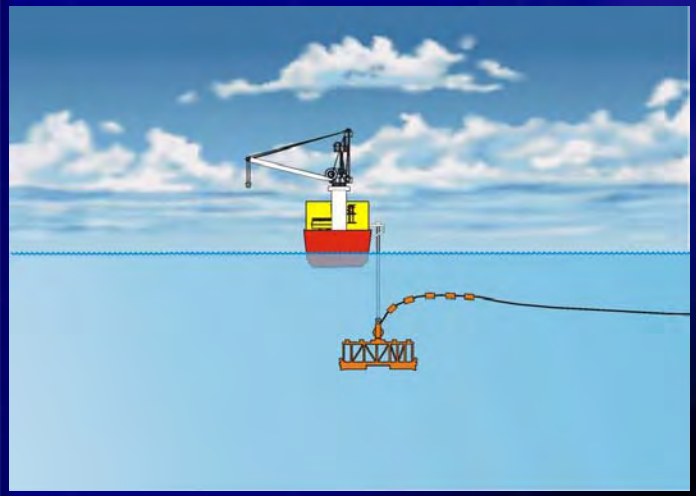
What is the Pendulous Method?

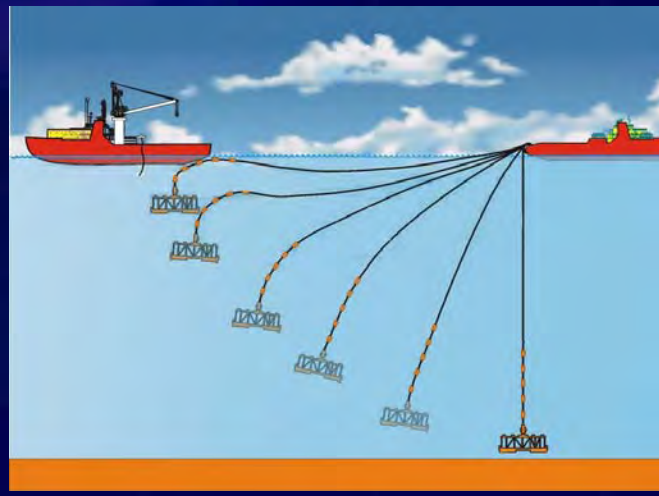
Transportation vessel



Overboarding



Hangoff



Pendulous Motion

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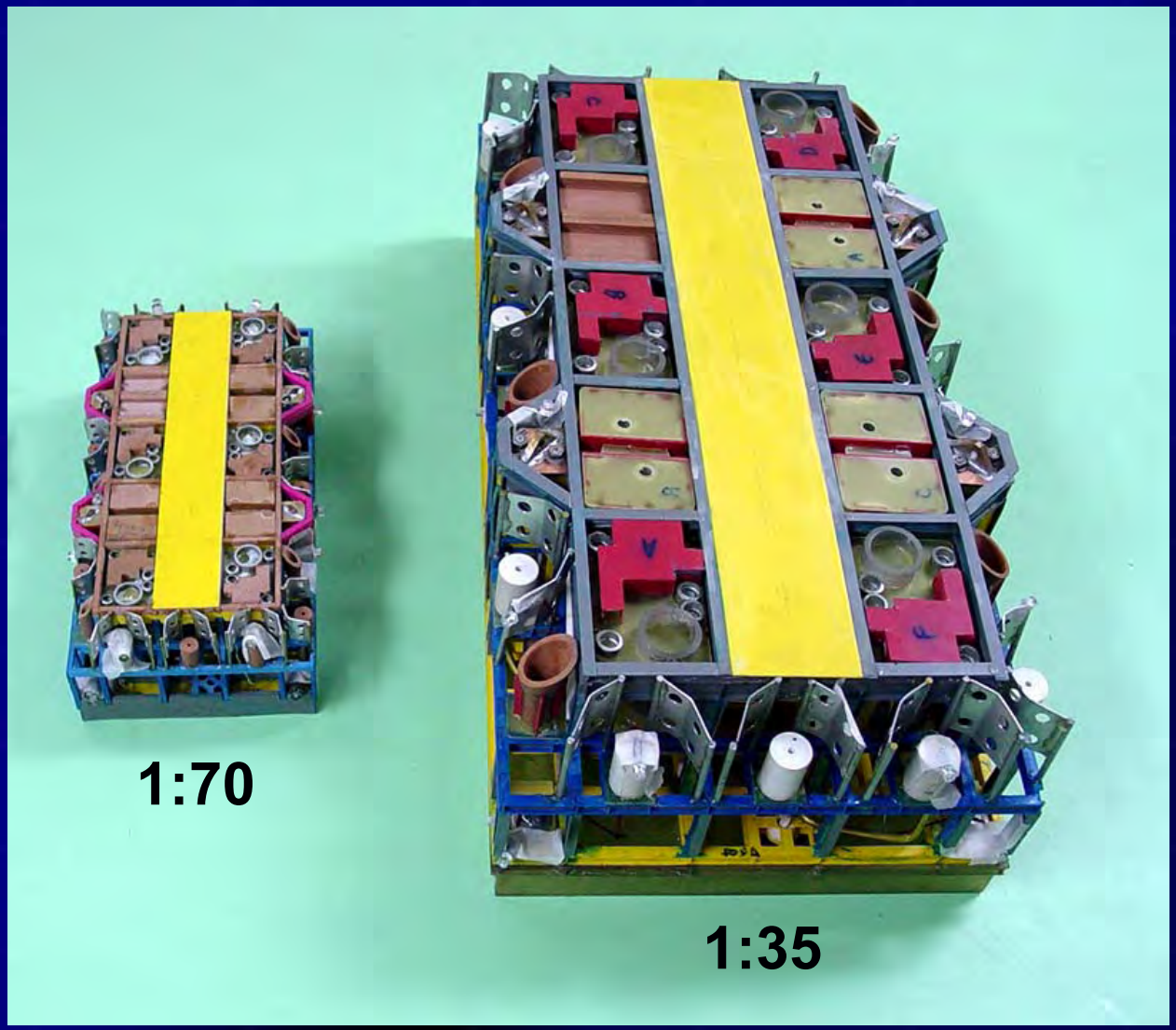
What steps have been performed to develop Pendulous Method developing?

Development of the concept

- Put into development in 2003, based on installation of torpedo pile for mooring systems;
- Numerical analyses with Orcaflex to demonstrate the feasibility
- Model tests at LabOceano in 2004 for a sphere, box, and 1:35 scale manifold to understand the influence of the rope on the damping motion;
- Risk analysis study;
- Parametric study to demonstrate robustness of the method;
- Model tests at 1:35 and 1:70 scales for manifold #2;
- Build and test a 1:1 prototype to simulate deployment of Roncador manifolds #2;

What steps have been performed to develop Pendulous Method developing?



Scales for model test


27 12 2005

Conclusions

The Pendulous Installation Method:

- Uses conventional vessels, with no special rigging and mechanisms
- Allows deployment of heavy equipment in deep waters up to 3000m
- Prevents axial resonance
- Is cost effective compared to utilization of scarce specialized installation vessels or drilling rigs
- Leaves drilling rigs free to perform drilling and completion works