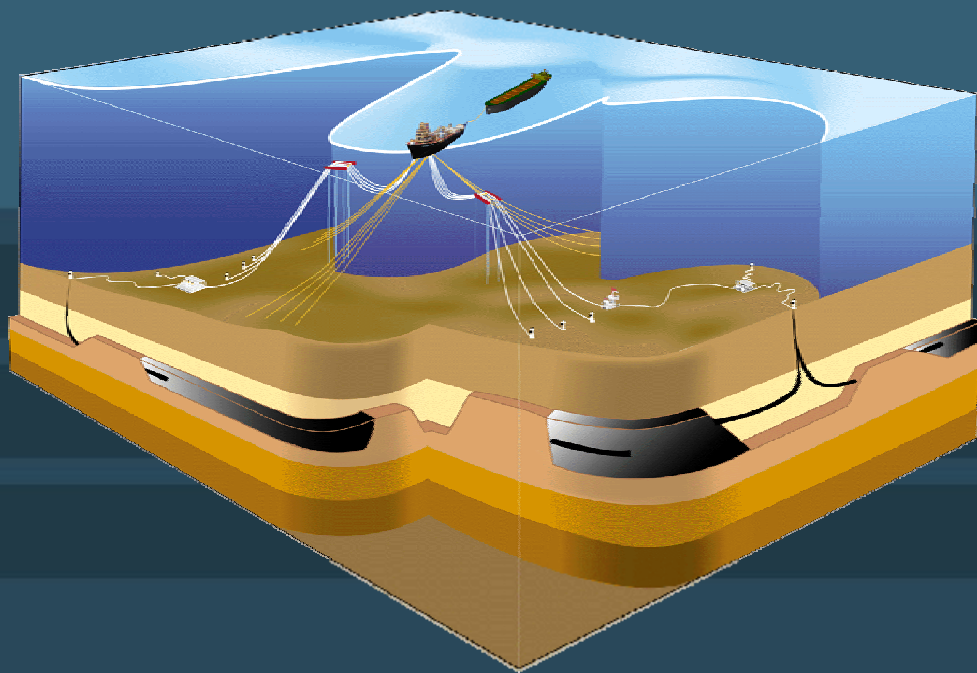


# Research for Ultra-Deepwater Production



Opening Seminar  
Marintek do Brasil

Rio de Janeiro, Apr 19, 2007

Mauricio Werneck  
PROCAP 3000 Coordinator



PETRÓLEO BRASILEIRO S.A.  
PETROBRAS

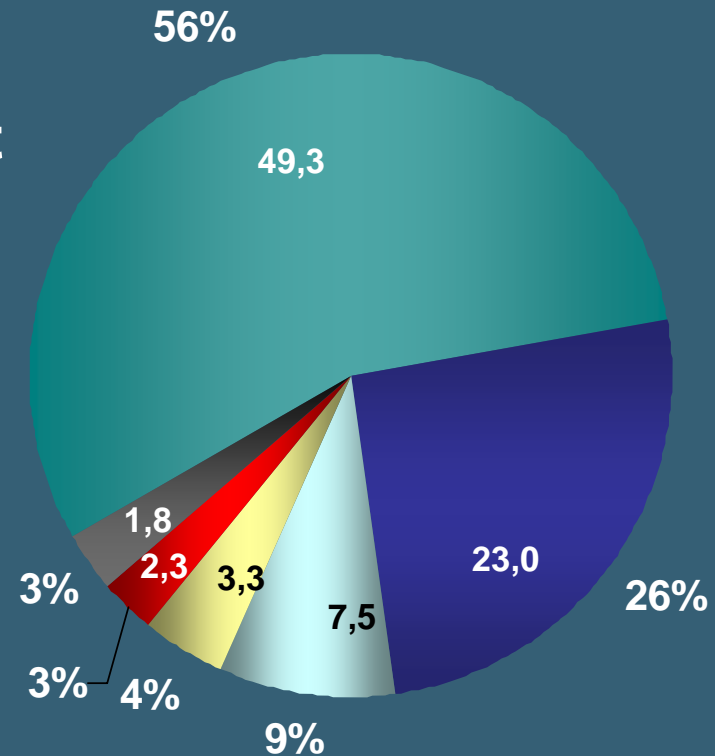
MARINTEK

# Petrobras Investment Plan

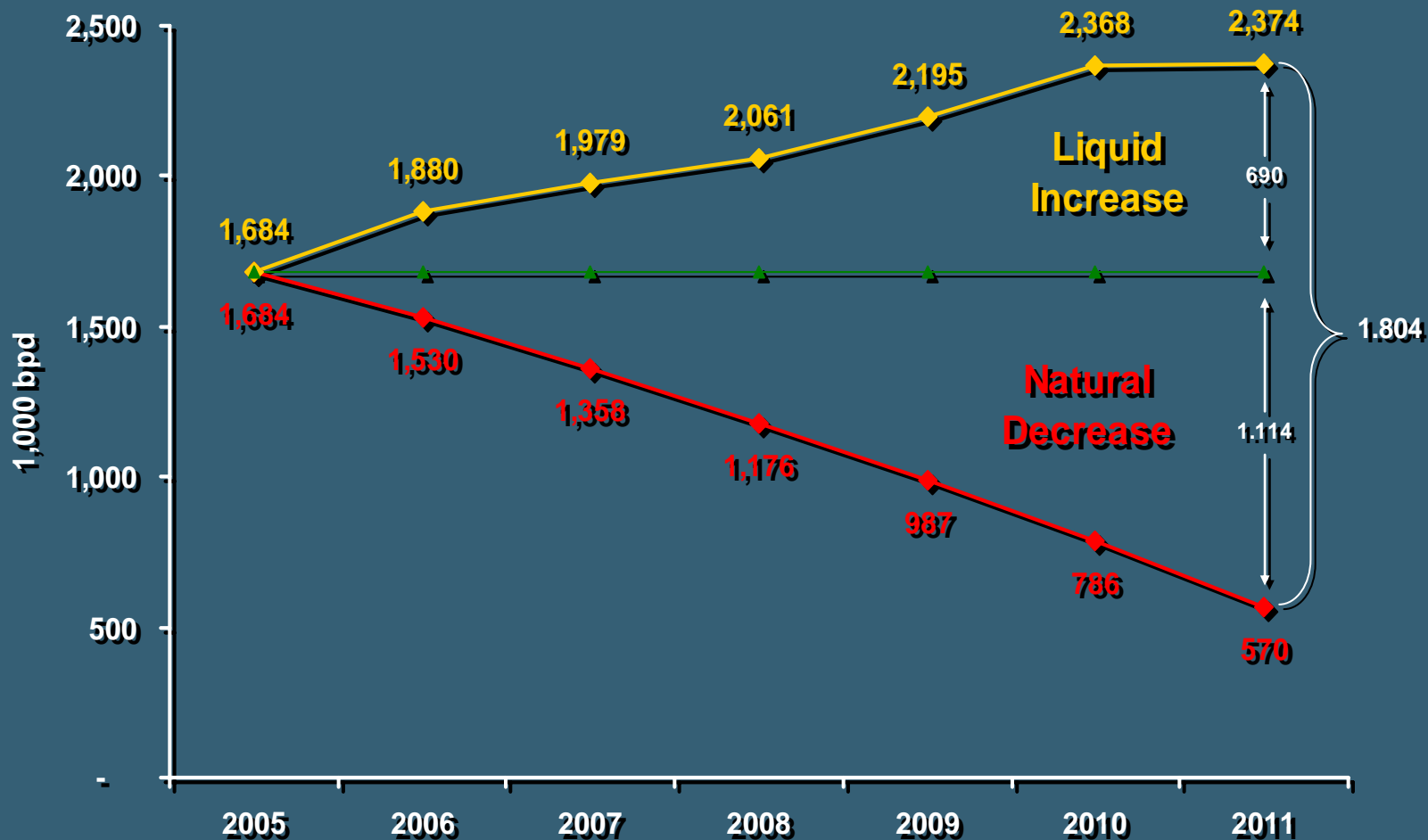
PN 2007-11

US\$ 87,1 bilhões

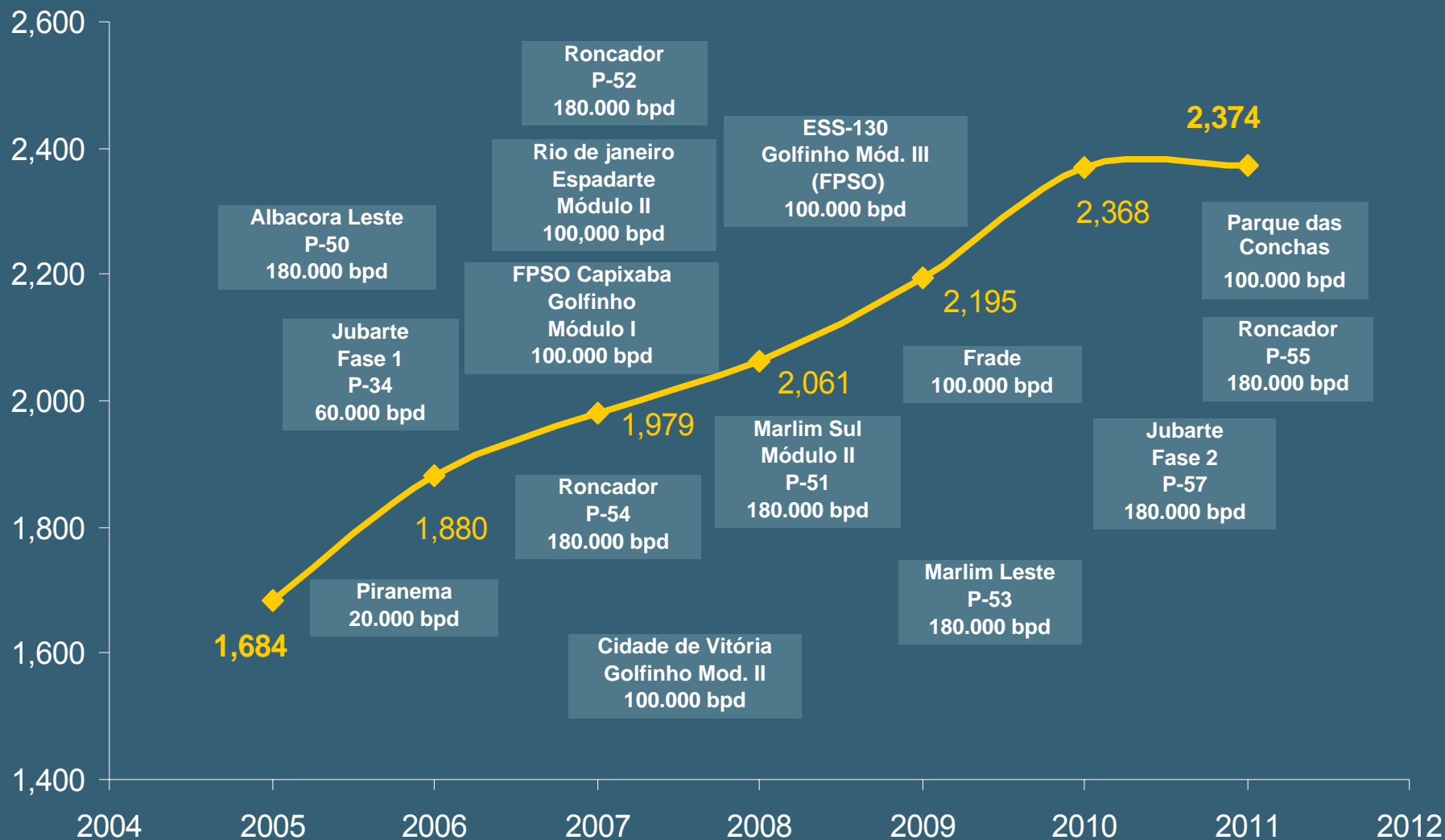
- E&P
- Refining & Transport
- Gas & Energy
- Petrochemical
- Distribution
- Corporate



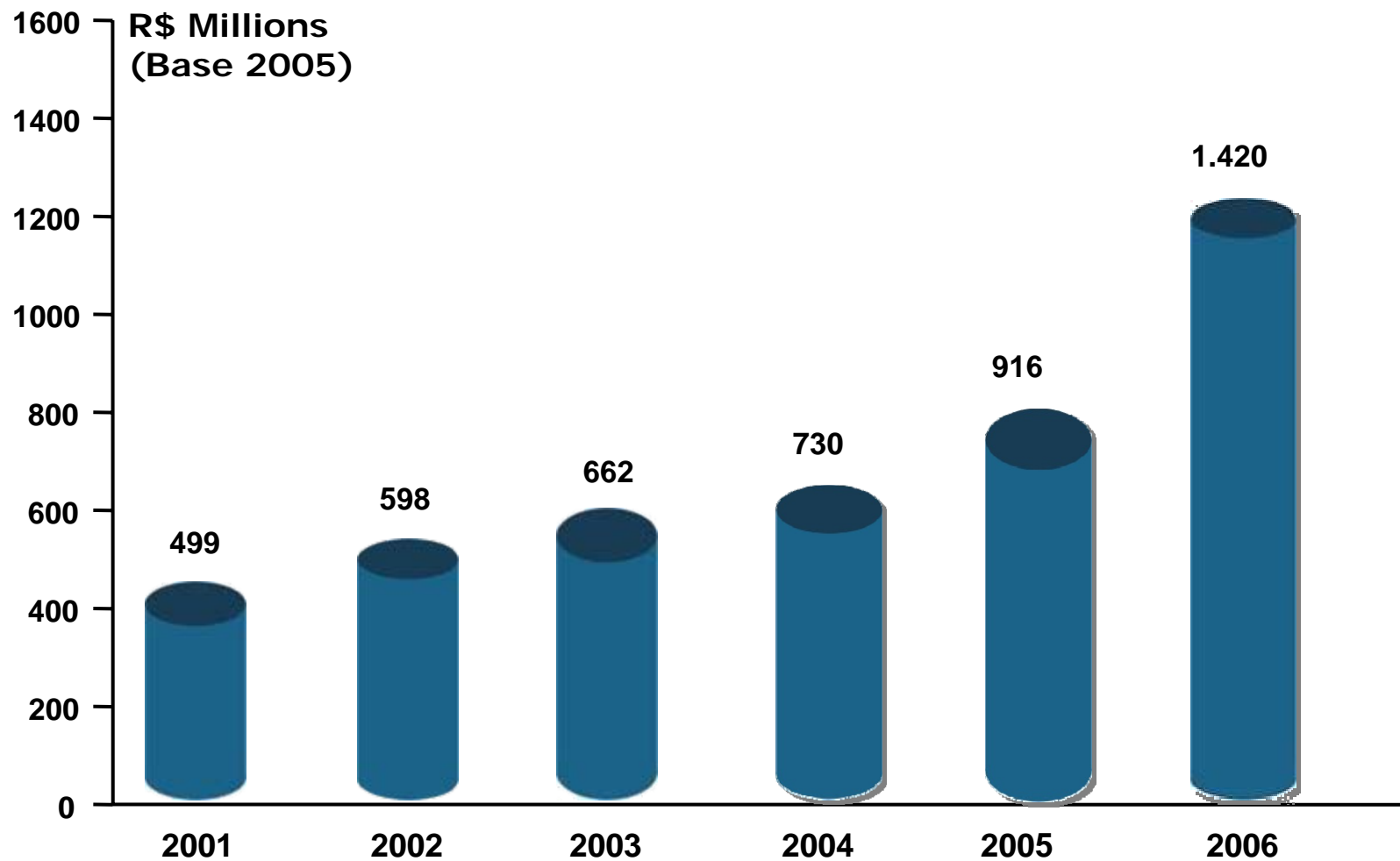
# Oil + LNG Production (Brazil)



# Oil + LNG Production and Support Projects



# R&D Investment



# R&D Center – CENPES



**Executive  
Manager**

**R&D  
Exploration**

**R&D Production**

**R&D Refining**

**R&D Gas  
Energy &  
Sustainable  
Dev.**

**Basic  
Engineering**

**Technology  
Management**

- ✓ 12 Technological Programs
- ✓ 1000 R&D Projects
- ✓ 50 Basic Engineering Projects
- ✓ 500 Production R&D Projects
- ✓ 4000 People

- ✓ Present area: 122,000 m<sup>2</sup>
  - ✓ 137 labs
  - ✓ 30 pilot units
- ✓ New Construction: 180,000 m<sup>2</sup>

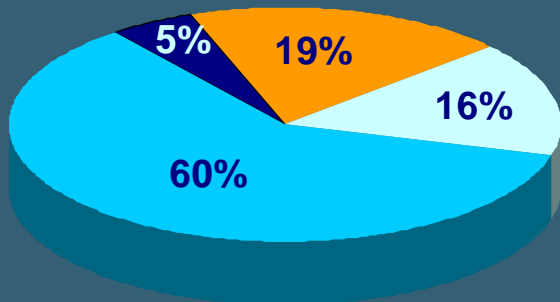
# Technological Challenges



- Ultra-Deep Water
  - Risers and Pipelines
  - Mooring Systems
  - HPHT Wells and Equipment
  - Flow Assurance
  - Subsea Boosting and Processing

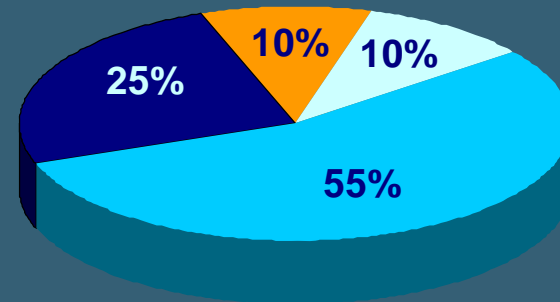
# Production and Reserves vs. Water Depth

## 2005 Production



1.958.000 boed

## 2005 Proven Reserves (SPE)



13,23 billion boe

Onshore

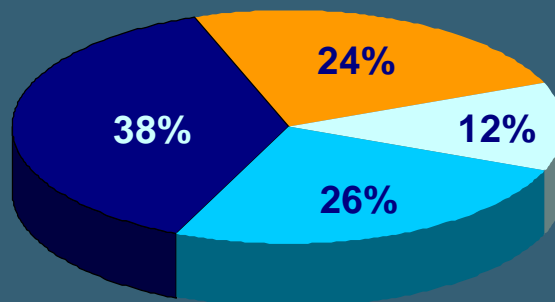
Offshore (0-300m)

Offshore (300-1500m)

Offshore (> 1500m)

## Exploratory Area

160,500 km<sup>2</sup>





# PROCAP

**1986 – 1991**



Marlim and Albacora Production  
Technological Support

**1,000m (3,300ft)**



**1992 - 1999**

Roncador and Marlim Sul Production  
Technological Support

**2,000m (6,600ft)**



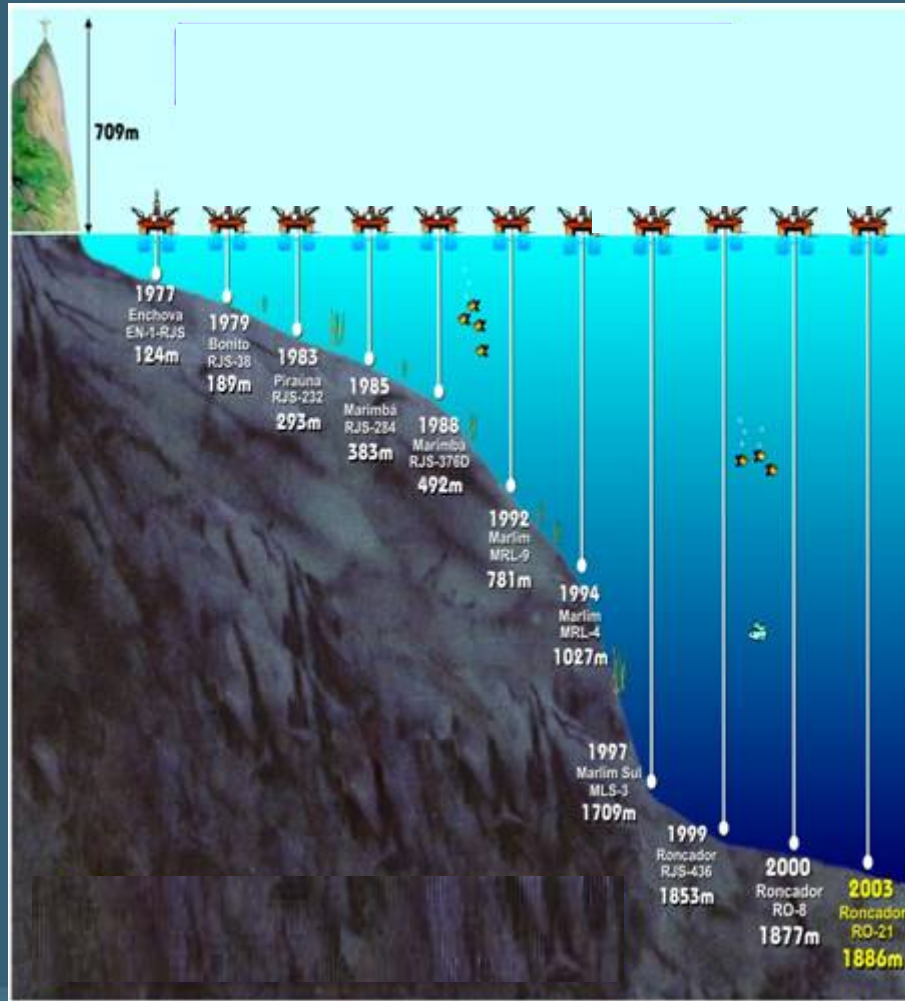
**2000 - 2006**

Production Technological Support for Ultra  
Deep Phases of Marlim Sul and Roncador,  
Exploratory Prospects, GoM and WoA  
Assets

**3,000m (10,000ft)**

# PETROBRAS Activity

## Completion Records



## Installed Equipment

Equipment	Installed Jan/2005	Planned 2005/2006
Wet Trees	548	106
Subsea Manifolds	58	02
Subsea Flexible Lines (Km)	2.534	765
Umbilicals (Km)	2.229	622
Rigid Lines (Km)	1.964	305

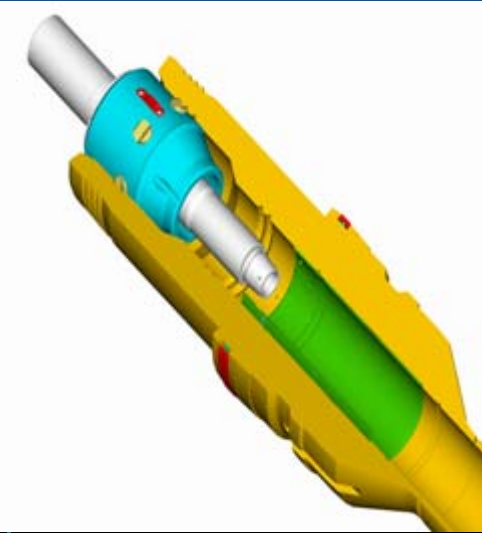
# PROCAP-3000 Main Areas

- Drilling and Completion
- Subsea Equipment
- Artificial Lift and Boosting
- Flow Assurance
- Riser and Flowline Systems
- Floating Units and Anchor Systems
- Environmental Database



# PROCAP-3000

## Drilling and Completion



### ***Drilling Equipment for Deepwater***

- ▶ Torpedo Wellhead
- ▶ Slender Wellhead
- ▶ Casing Drilling
- ▶ Surface Drilling BOP System

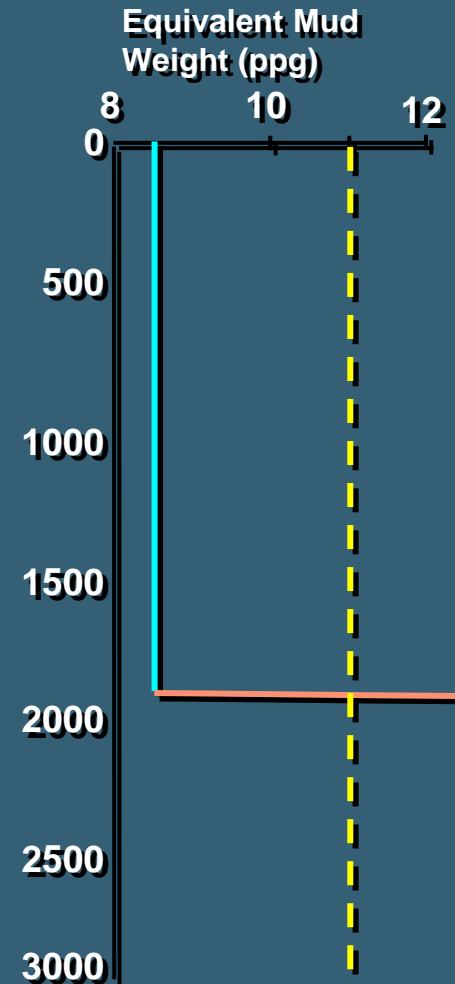
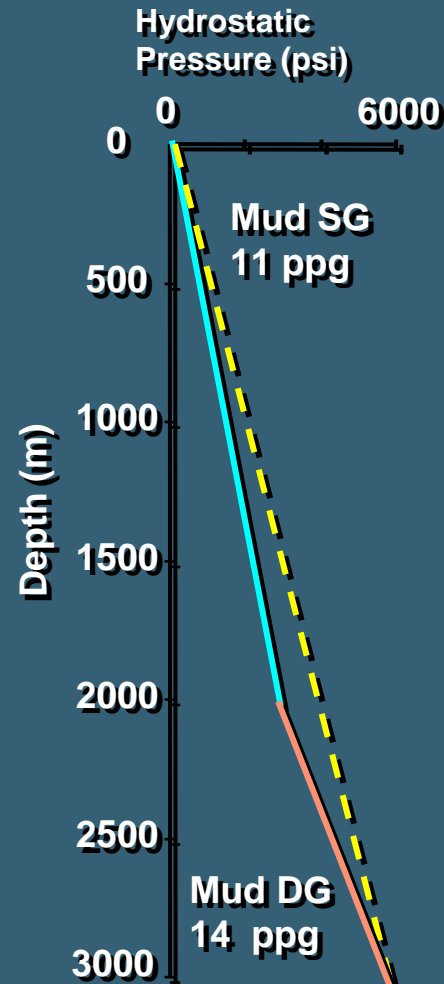
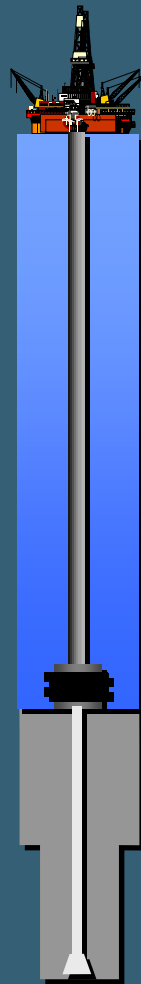
### ***Deep Horizon Drilling***

- ▶ HPHT Drilling and Completion
- ▶ Hard Formation Drilling Optimization

# Light Fluids Gas-Lifted Riser

## Deepwater

- Problem: narrow margin between pore and fracture pressures
- Theoretical Solution: Dual Gradient Drilling
- Many Practical Alternatives

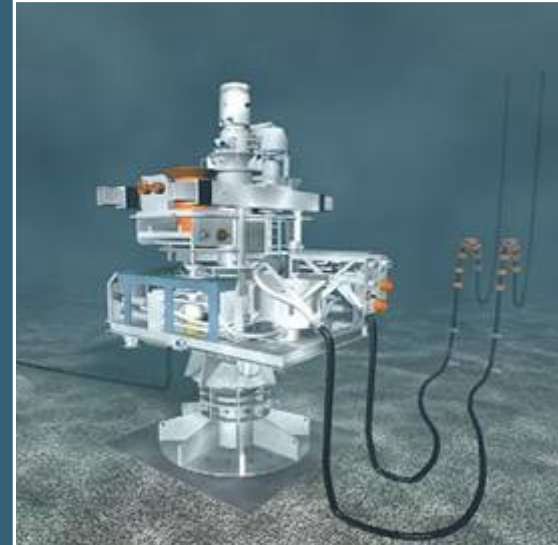
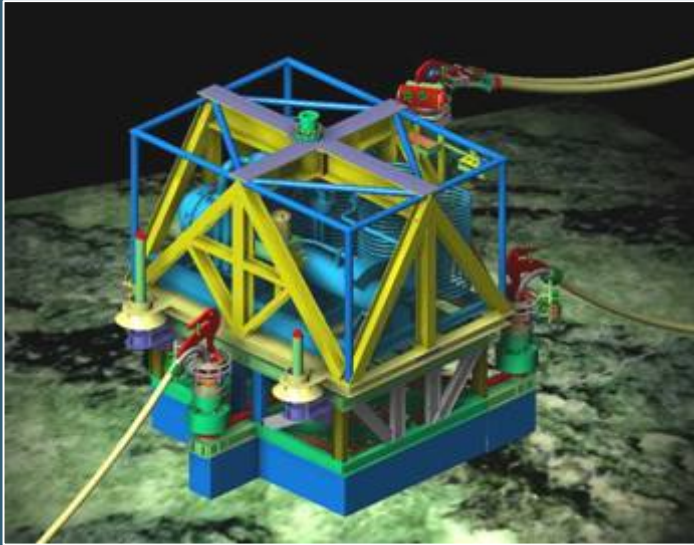


# Torpedo Wellhead



# PROCAP-3000

## Artificial Lift and Boosting



### ***Boosting Systems for Deepwater***

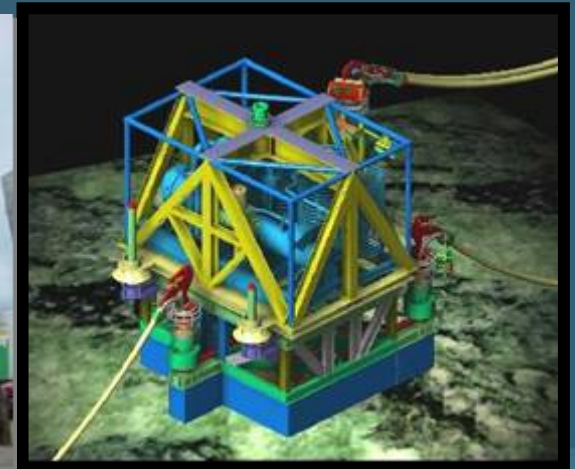
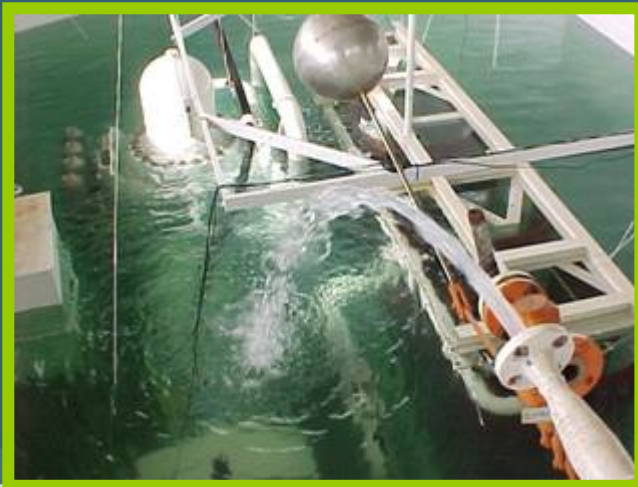
- ▶ ESP for Subsea Well - BCSS
- ▶ Subsea Multiphase Pumping – SBMS
- ▶ Gas/Liquid Separation System – VASPS

### ***Gas Lift for Deepwater Subsea Wells***

# Performance Tests

## SBMS-500

- ▶ Benefit: production increase
- ▶ Performance and endurance tests concluded at Núcleo Experimental Eng. Baruzzi
- ▶ Modules under final assembly for installation at Marlim field (Oct 07)





# VASPS

## VASPS-Vertical Annular Separation & Pumping System



Eni Agip



PETROBRAS



Mobil



THERMIE

- ▶ Marimbá Pilot (P-8)
- ▶ Production increase: from 4.700 to 6.300 bopd
- ▶ Gas lift stopped
- ▶ WD : 400 m
- ▶ Phase 1: Jul/2001 a Dec/2001
- ▶ Phase 2: May/2004 on
- ▶ New R&D project to increase flow capacity, decrease CAPEX and installation costs



# PROCAP-3000 Flow Assurance



## ***Wax and Hydrate Control***

- ▶ Multisize Pig Development
- ▶ Wax Deposit Prediction
- ▶ Hydrate Blockage in na Emulsion System
- ▶ Wax Deposit in Condensate System

# PROCAP-3000

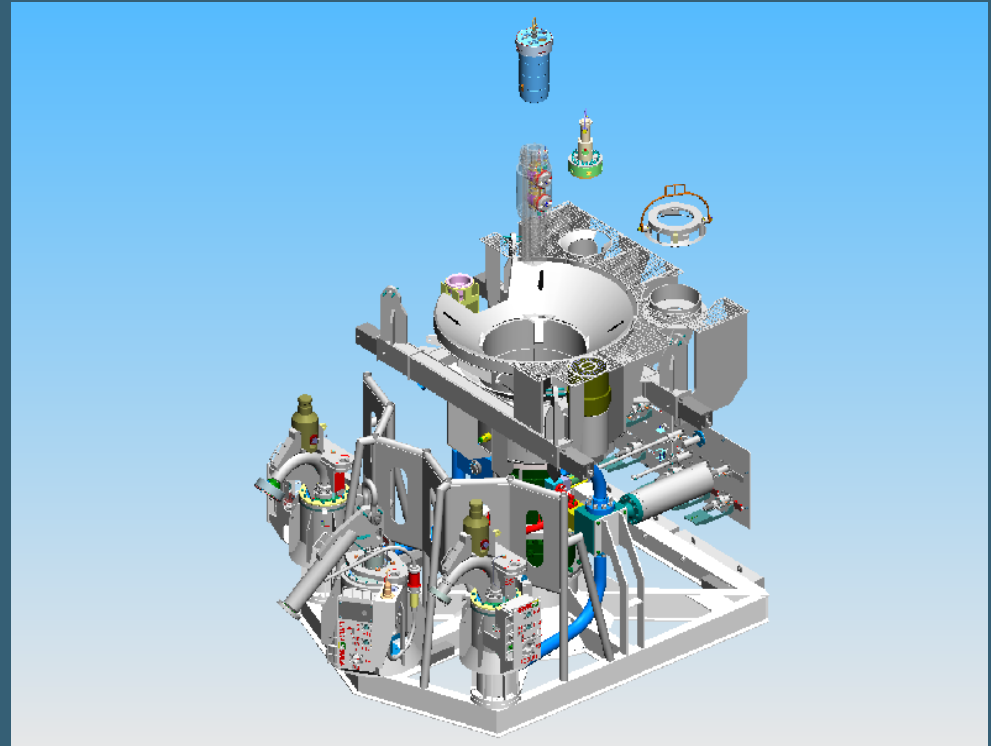
## Subsea Equipment

### *Subsea Equipment for 3.000m de WD*

- ▶ Horizontal Tree for ESP Wells with ROV Tree Cap
- ▶ Equipment Installation by Cable
- ▶ Completion Riser for 3,000 m
- ▶ Test Xmas Tree with ESP in the Riser
- ▶ Deepstar phase VIII

# BCSS Horizontal Tree for 2.500 m WD

- ▶ Benefit: short intervention time for pump changes
- ▶ Prototype installed at JUB-6 well on Dec 2005



# Equipment Installation by Cable

## Gas Lift Manifold for Roncador



Installation Procedures

System Modeling

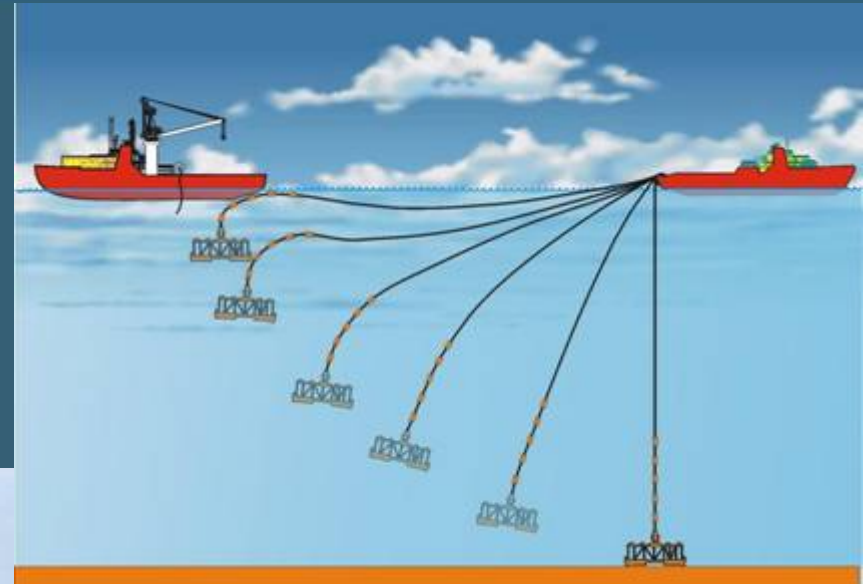
Hydrodynamic Analysis

Installation Monitoring

- ▶ Cable Installation – pioneer
- ▶ WD 1,886m – *world record* (Manifold)
- ▶ 190 ton

# Pendular Method

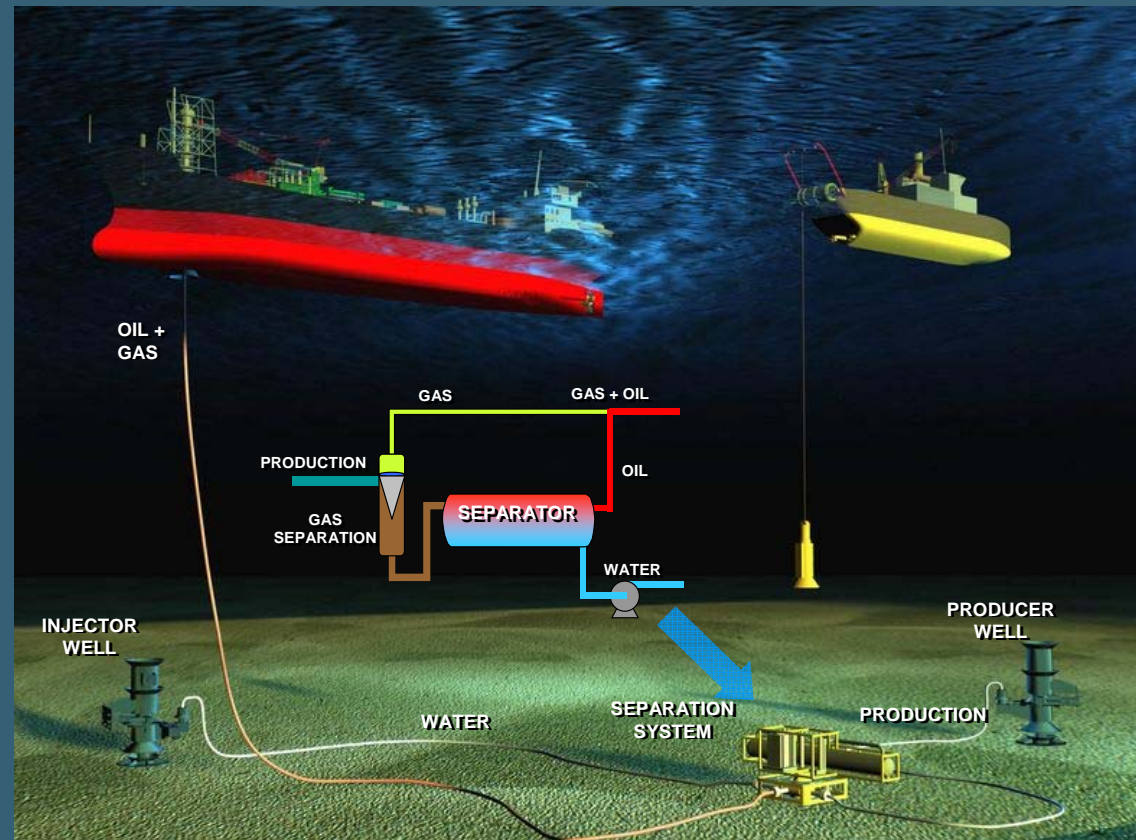
- ▶ No use of critical resources for equipment up to 270 ton



- ▶ Tests done in small scale (1:35) and with field scale model (1:1)
- ▶ Roncador Gas Lift Manifold installed (Dez 06)

# Subsea Separation of Oil/Water SSAO

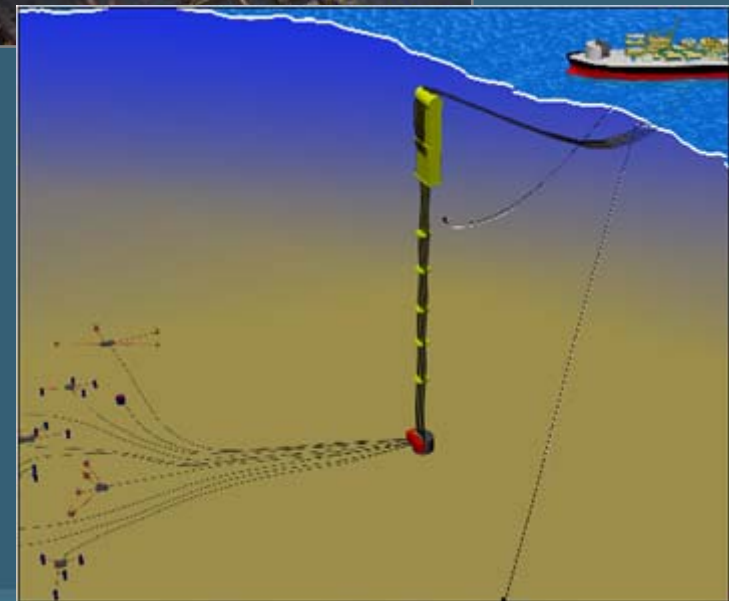
- ▶ Separation and reinjection of the separated water
- ▶ Aiming topside facilities debottlenecking



# PROCAP-3000

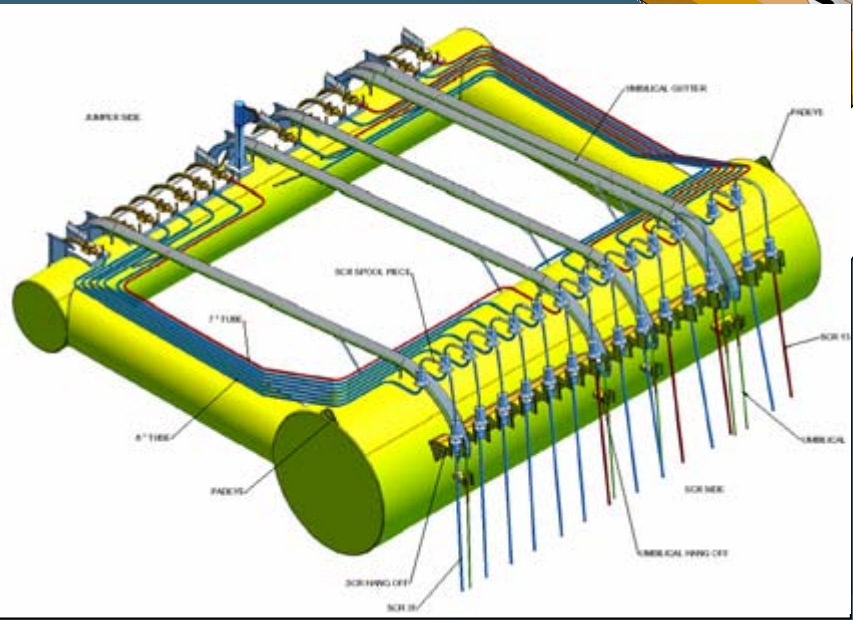
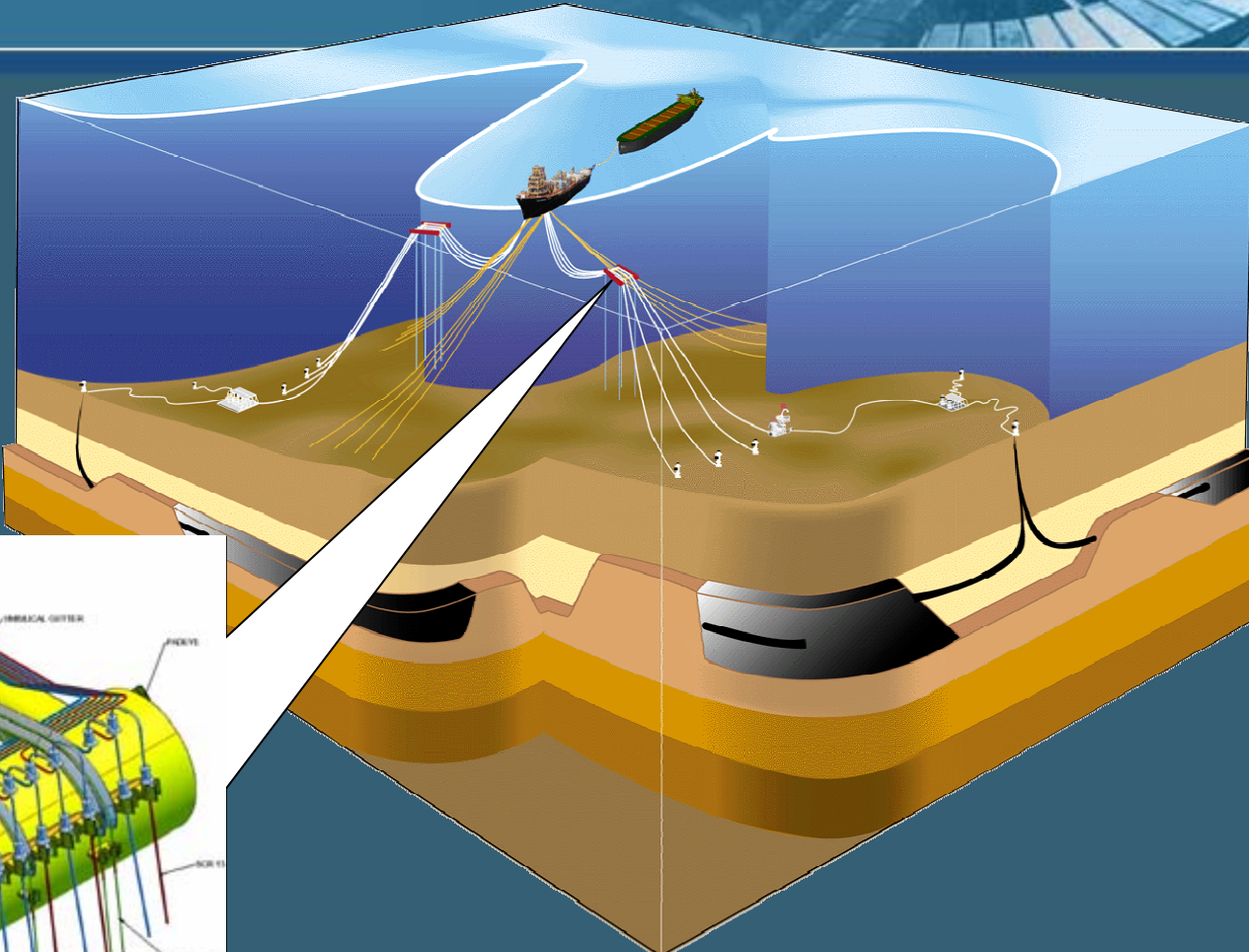
## Risers and Flowlines

- ▶ Rigid Riser System
  - SCR for FPSO and SS
  - SCR in “Lazy Wave”
- ▶ Flexible Riser System
  - Sour service lines
  - Integrated umbilical control-power
- ▶ Alternative Riser Systems
  - Tethered Riser Buoy
  - Self Standing Hybrid Riser RHAS



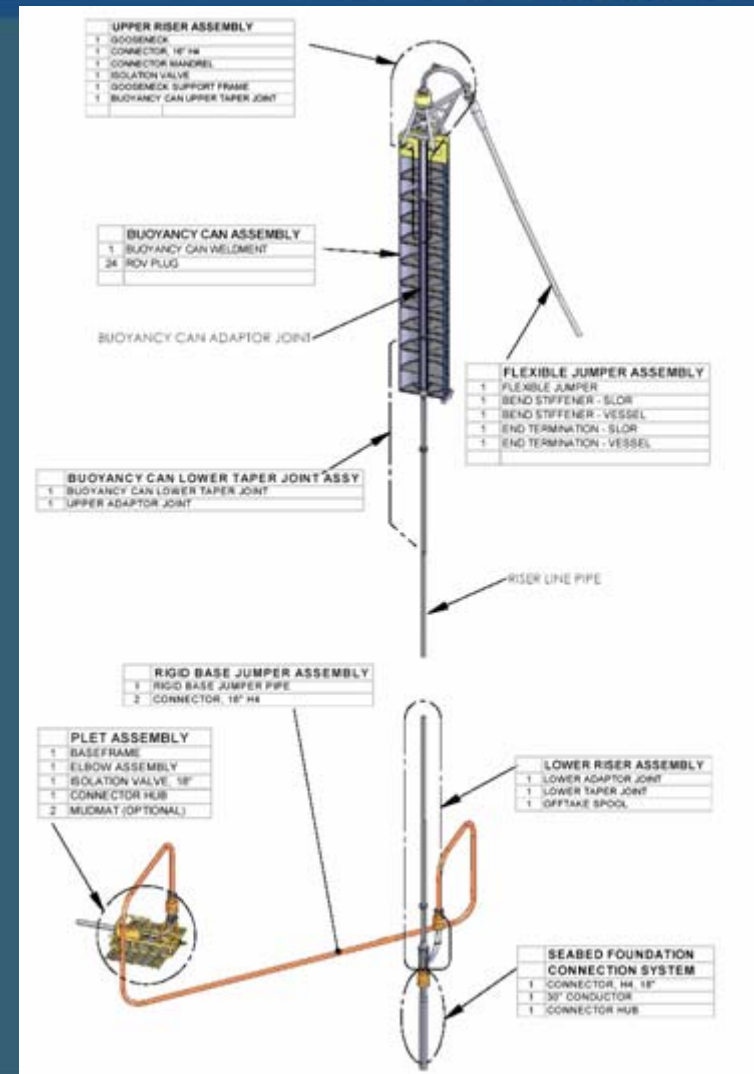


# Tethered Riser Buoy



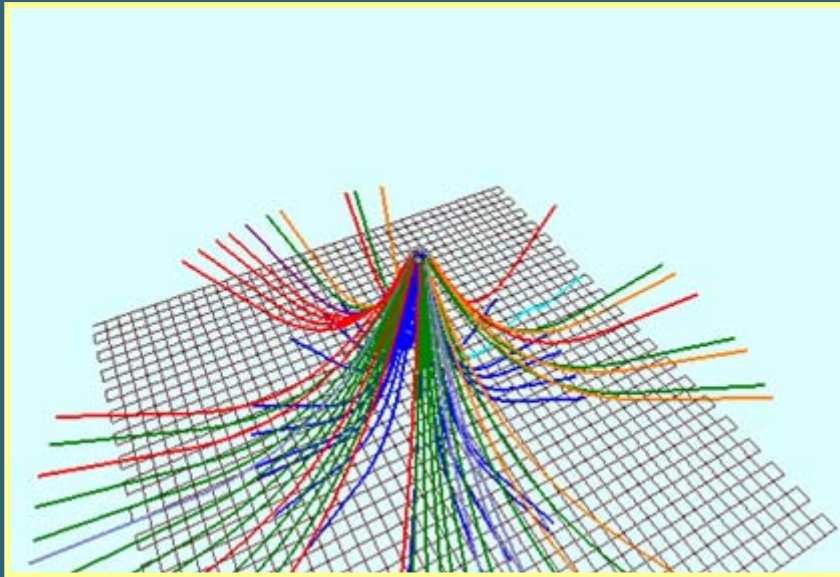
# RHAS for P-52 Export Line

- ▶ Benefit: Big diameter riser for deepwater and load reduction on the floating unit
- ▶ FEED, Contract and Patent documents issued



# SCRs for Roncador

## Project P-52 - Roncador Module 2, phase 1A



- ▶ Limits for the SS movements
- ▶ Optimized definition of the risers hanging points
- ▶ SCRs viability
- ▶ Thermal Insulation thickness limits definition
- ▶ Maximum loads in support, pull-in and anchor systems

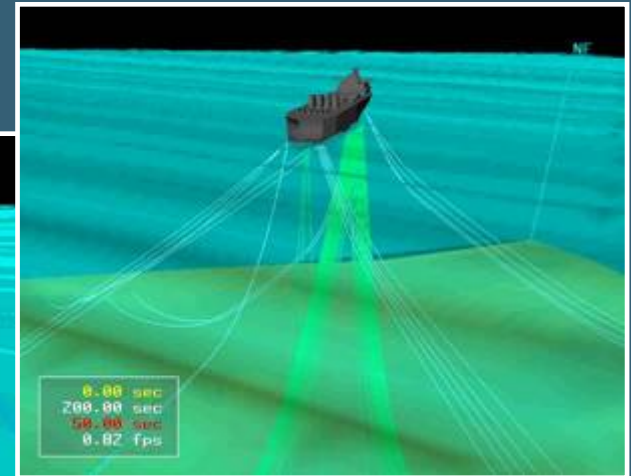
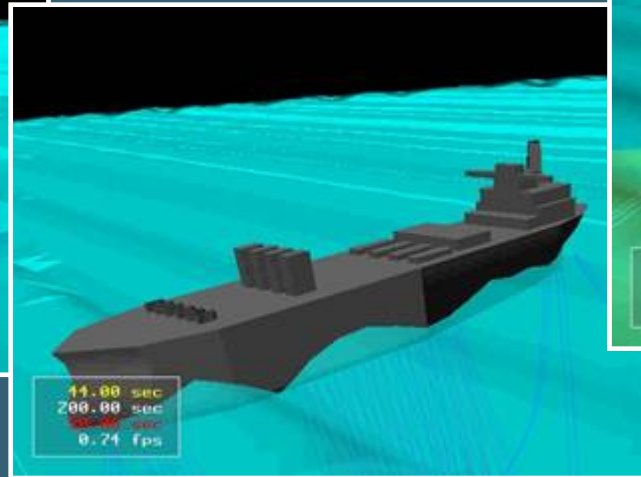
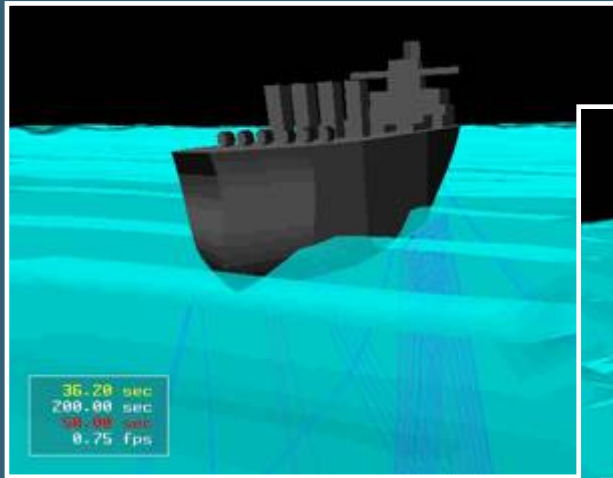
- ▶ Semi-Submersible 80.000 tons
- ▶ WD 1.800m
- ▶ 68 risers, being 47 SCRs and 21 control lines

# PROCAP-3000 Floating Units and Anchoring Systems

- ▶ Benefit: Low movement units allow deepwater risers
- ▶ FPSO-BR
- ▶ Mono-BR



# Numerical Tank

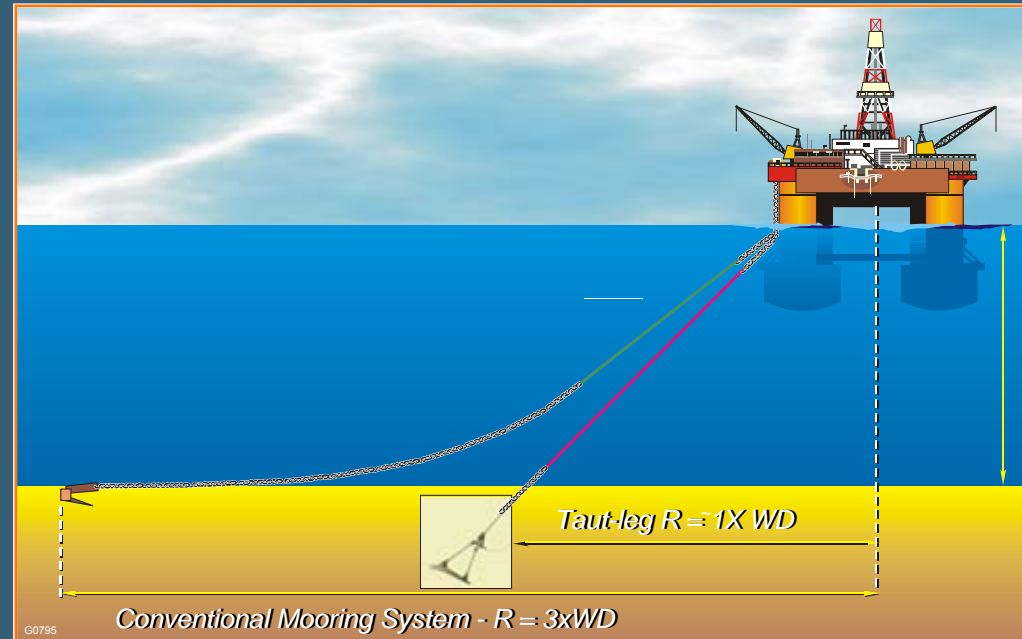


- ▶ **Hydrodynamic coupled movement analysis of the unit, risers and anchoring system**
- ▶ **Universities – USP, IPT, UFRJ, UFAL, PUC-RIO**

# Polyester Anchoring Systems

## Applications of synthetic polyester

- ▶ 4 SS (P-19, P-26, P-27 e P-40)
- ▶ 6 FPSOs  
P-34, FPSO II, P-47, Avaré,  
P-38 e FPSO Brasil
- ▶ 2 Monobuoys  
IMO 1 and IMO 3
- ▶ Total Installed: **175km** in **161** lines

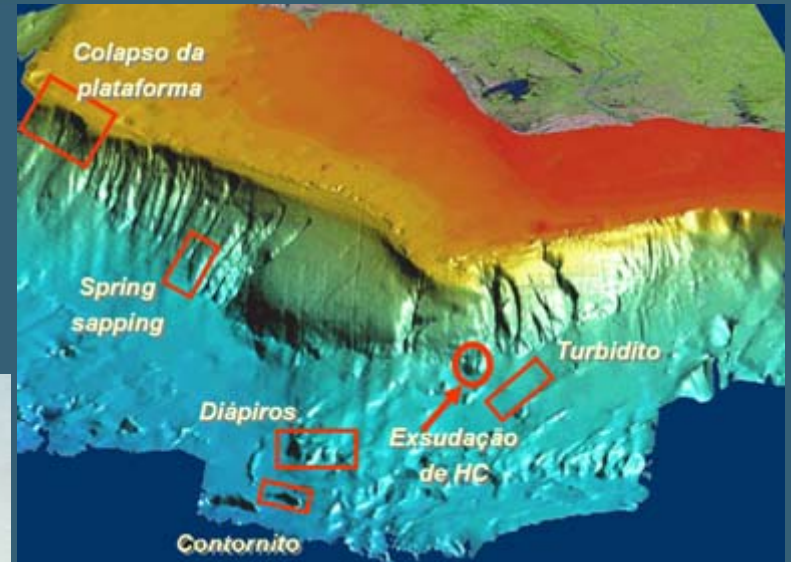
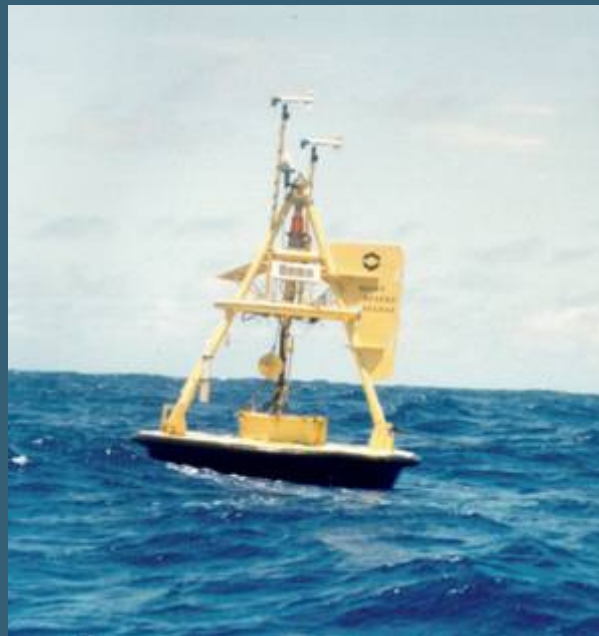


# Torpedo Anchors and Polyester Cables for Albacora Leste



# Gathering and Treatment of Geological, Geotechnical and Oceanographic Data

- ▶ Benefit: support of production development projects (drilling, anchoring, flowlines, etc.)







*Thank you*