



# IMPROVED OIL RECOVERY DEEP OFFSHORE

Experiences from Bloc 17 - Angola



# TOTAL DEEPWATER PORTFOLIO IN AFRICA

Pazflor



Dalia



Usan



Girassol



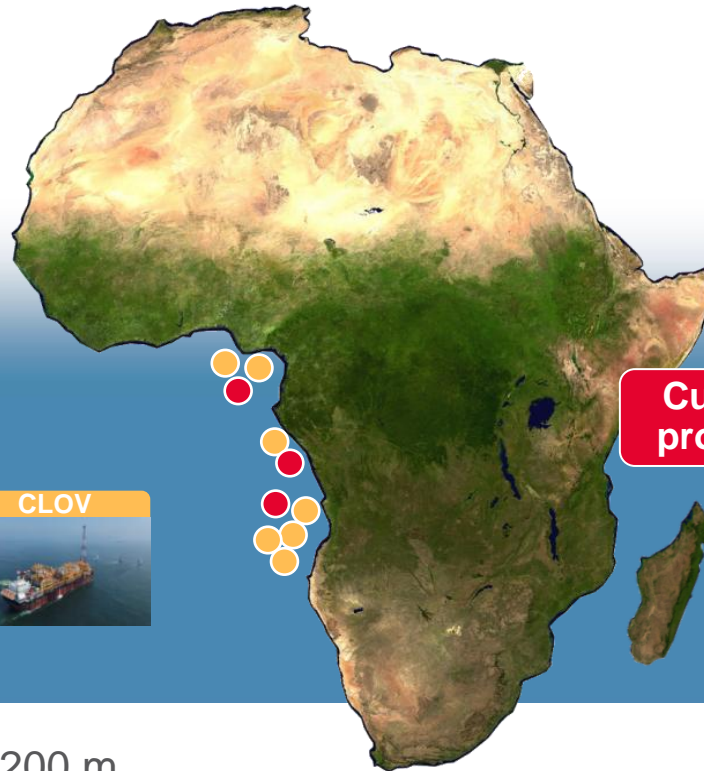
Akpo



Moho Bilondo



CLOV



Current projects

Moho North



Egina



Kaombo (2 FPSOs)



- Average water depth 1,200 m
- Total operates more than 10% of global deep-offshore production

Strong portfolio of projects

# DEEP OFFSHORE IN AFRICA

## CULTURE OF CONTINUOUS INNOVATION

**GIRASSOL**  
Angola



First giant deep offshore FPSO, innovative riser towers

**ROSA**  
Angola



20 km tie-back to Girassol FPSO

**AKPO**  
Nigeria



First all-electric FPSO, four-stage separation

**CLOV**  
Angola



Subsea multi-phase pumps, variable speed drive technology

1997

2001

2006

2007

2008

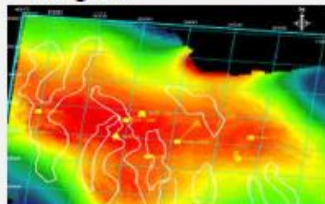
2009

2011

2014

2015

**BLOCK 17**  
Angola



Deep offshore Girassol discovery - a pioneer explo well

**DALIA**  
Angola



Flexible risers, integrated production bundles and pipe-in-pipe flow lines

**MOHO BILONDO**  
Congo



Subsea seawater treatment & injection program

**PAZFLOR**  
Angola



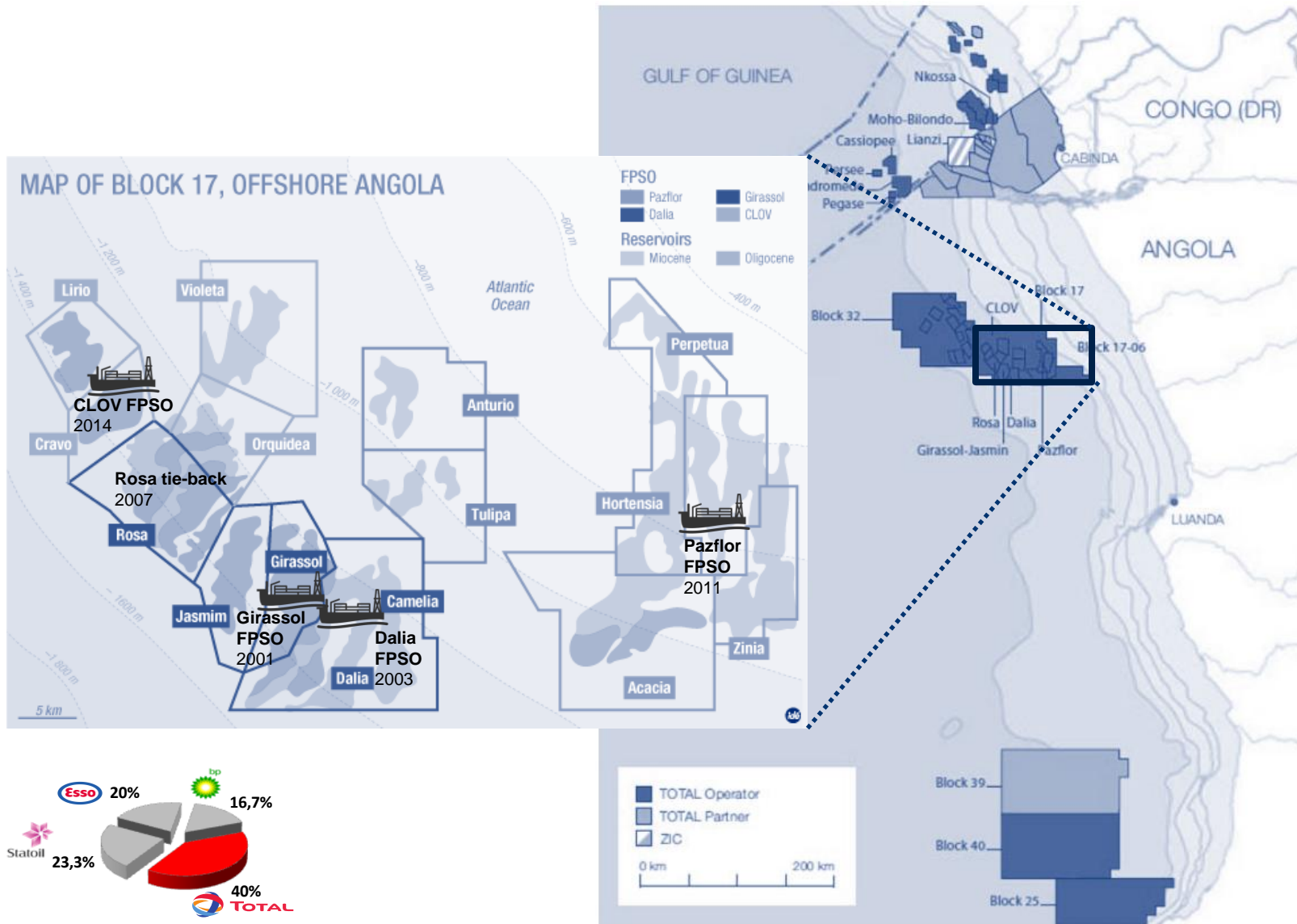
First subsea gas/liquid separation and pumping modules

**MOHO Ph 1b**  
Congo





Most powerful subsea multi-phase pumps ever installed

# BLOCK 17 DEVELOPMENT AREA



# B17 DEVELOPMENTS (EXISTING AND ONGOING)

<b>Girassol</b>	<b>Rosa</b>
	
Plateau : 250 kbopd First oil : Dec. 2001	Plateau : 130 kbopd First oil : June 2007

**Dalia**



Plateau : 240 kbopd  
First oil : Dec. 2006

**Pazflor**

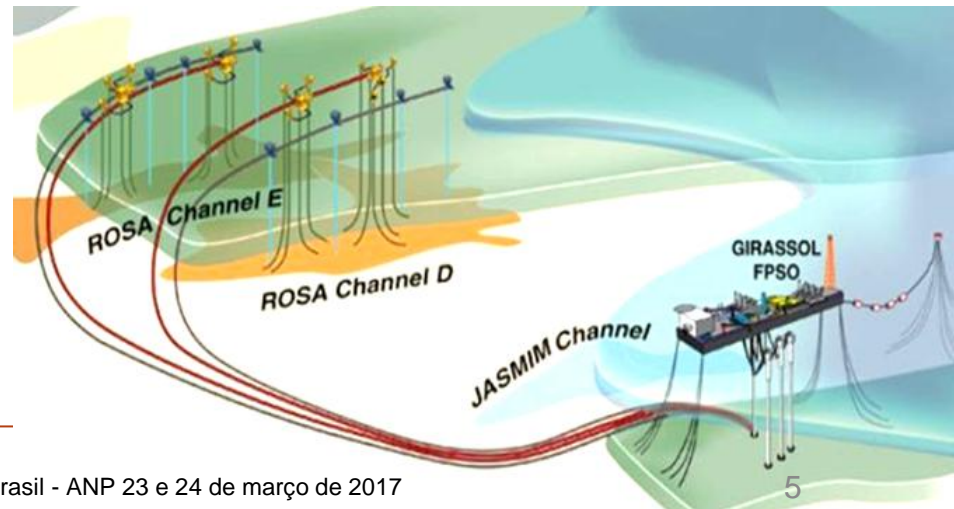
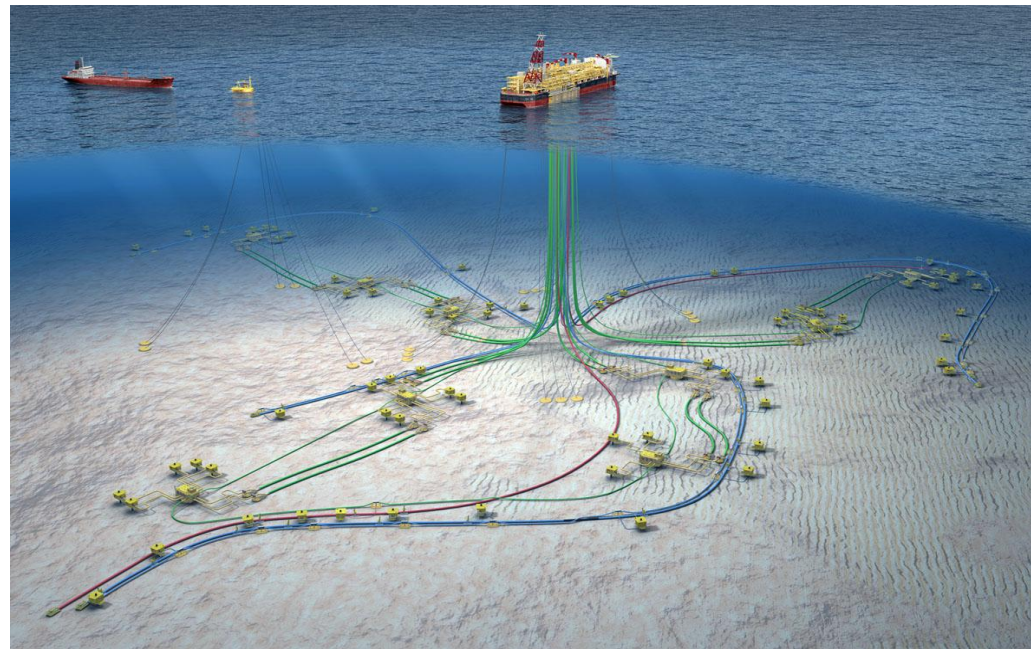


Plateau : 220 kbopd  
First oil : 2011

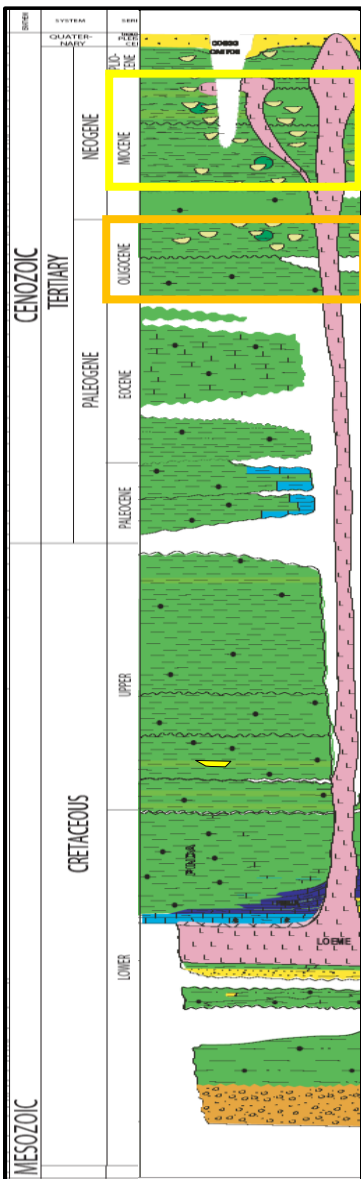
**CLOV**



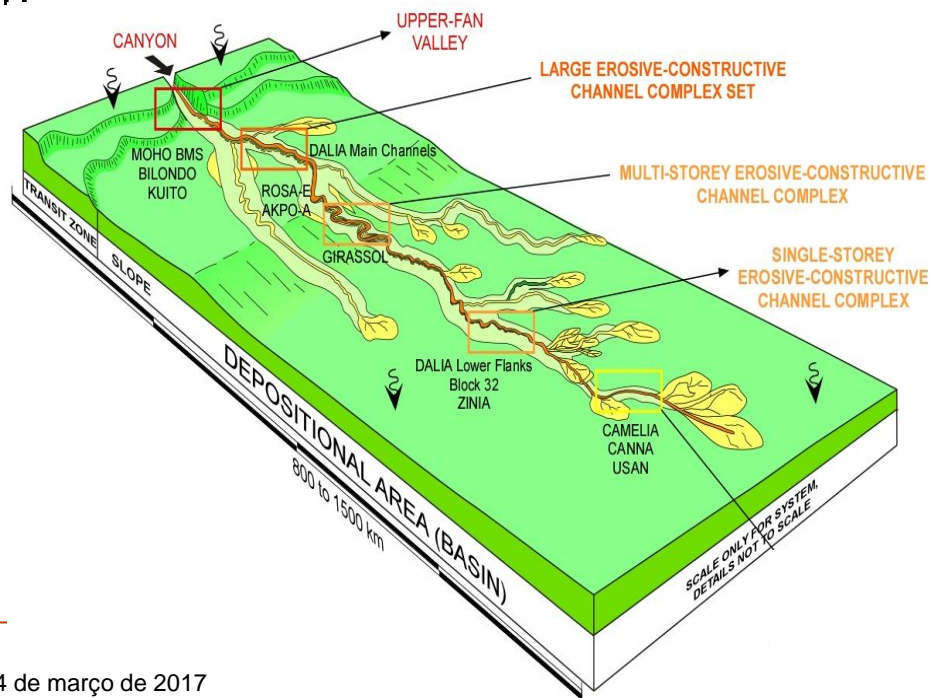
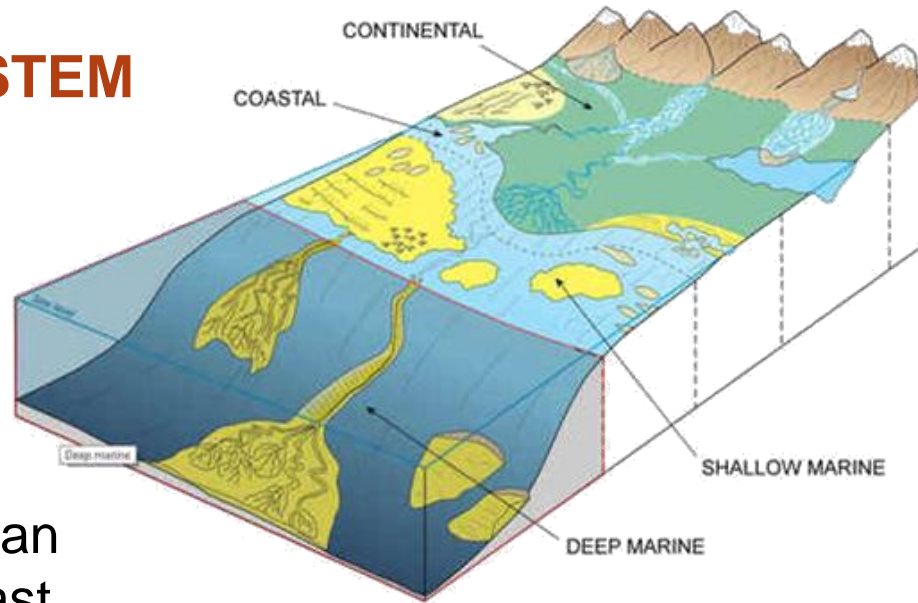
Plateau : 160 kbopd  
First oil : 2014



# SCHEMATIC TURBIDITIC SYSTEM

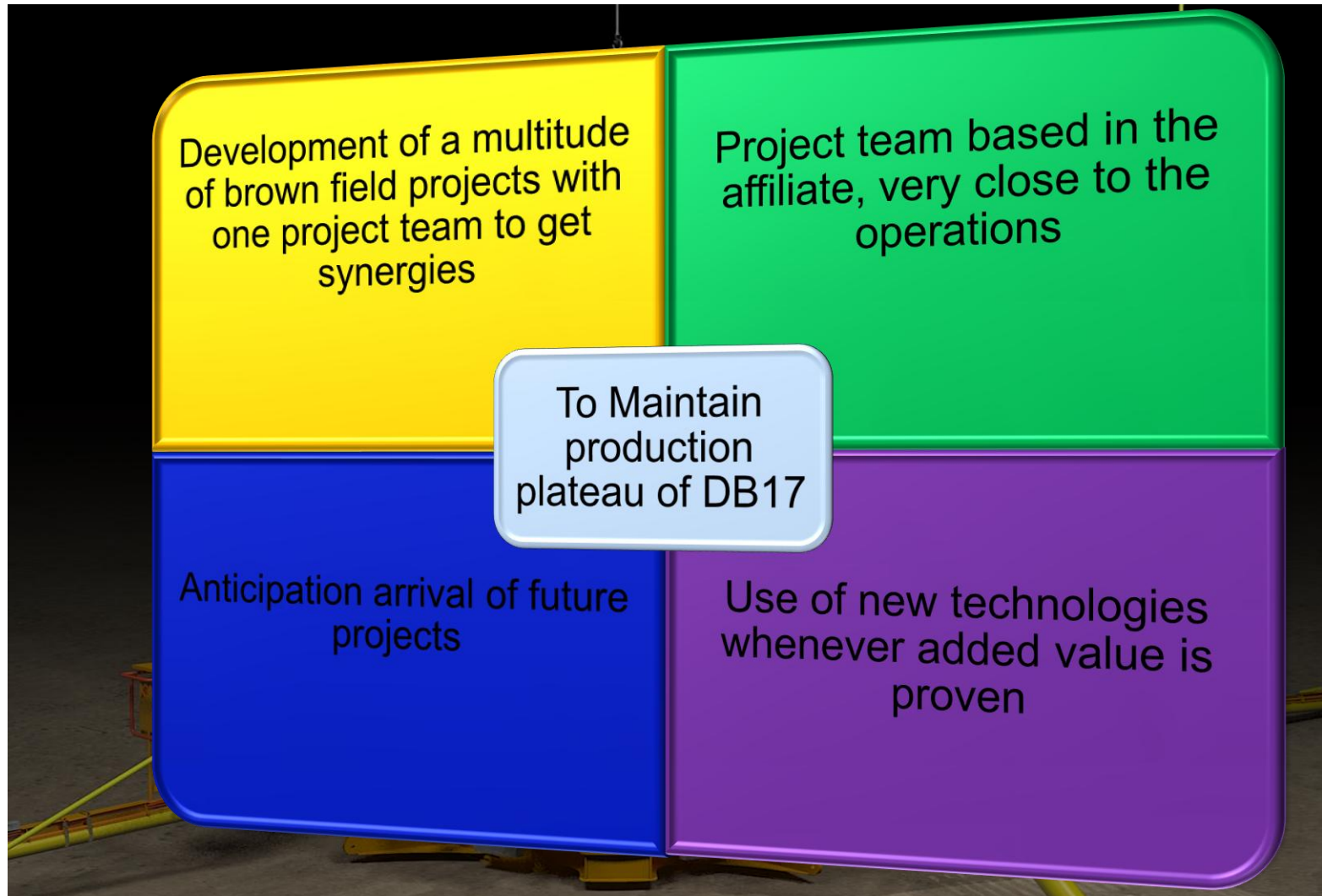


→ High quality reservoir more than 2000km from coast line in a mud rich system



# PBF : PROJECT BROWN FIELD

# PROJECT BROWN FIELDS (PBF) - OBJECTIVE & STRATEGY

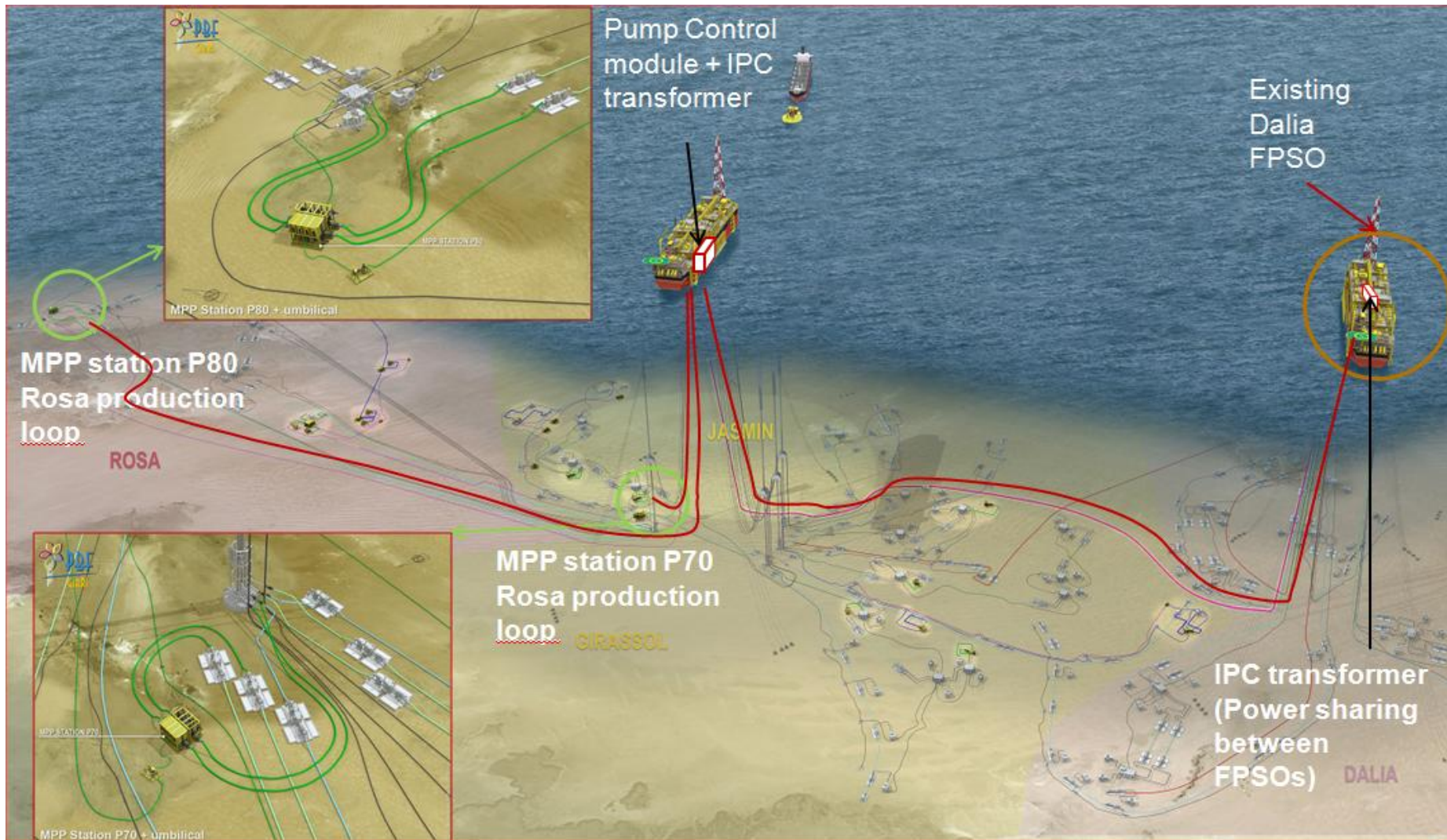




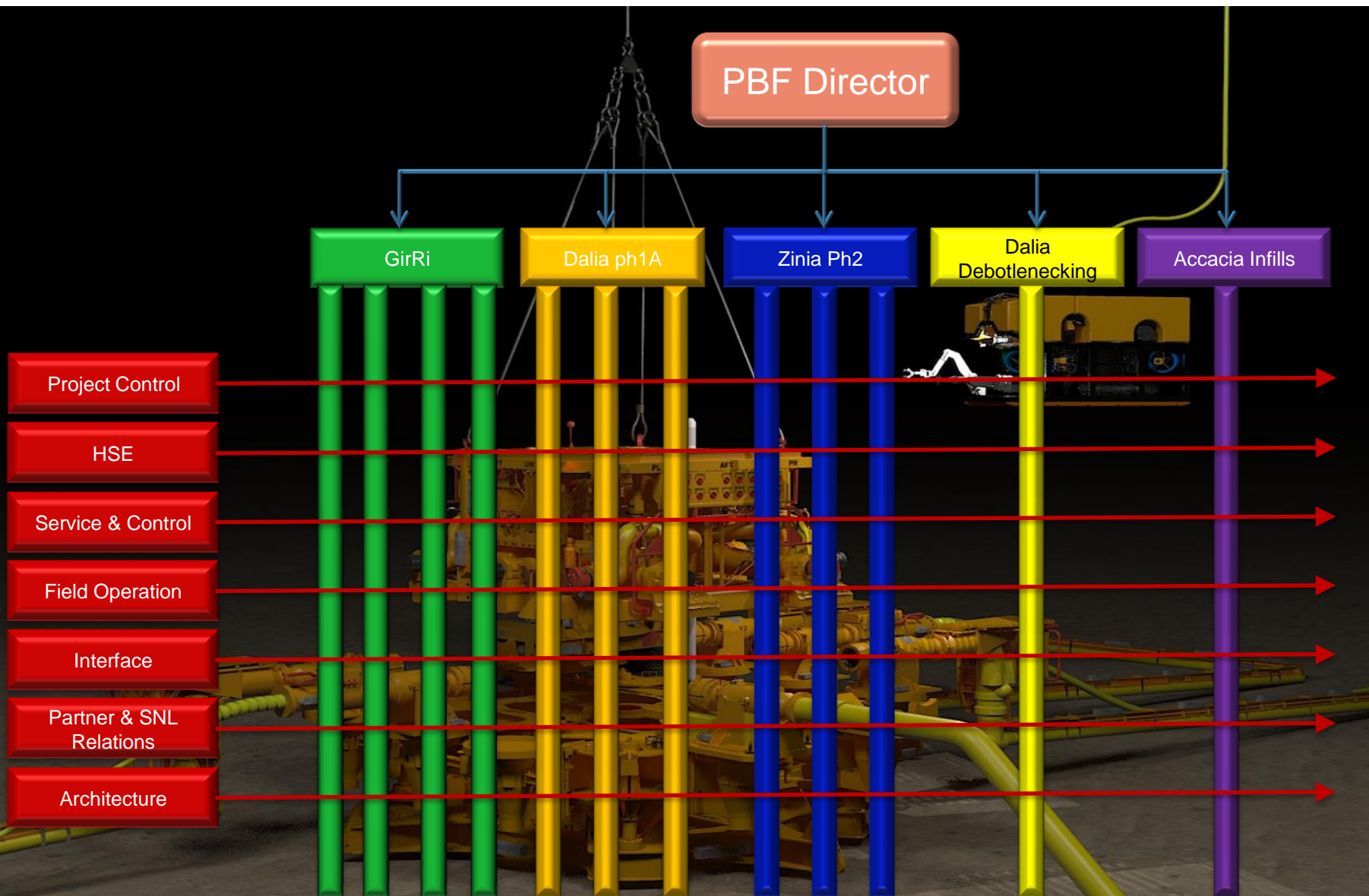
# IOR PROJECTS – BLOCK 17

- Dalia Infill Drilling
  - 6 additional oil producers
  - 1 water injector connected to the existing subsea network
  - Installation of a 4th MeOH pump and individual flow control valves on each umbilical at topsides to guarantee the preservation sequence with 6 additional producers
  - Upgrade of ICSS (Integrated control safety system)
  - Upgrade the SPS control system
- Dalia facilities debottlenecking
- Rosa Multi Phase Pumping
- Other Infills : Acacia, Zinia

# MULTI PHASE PUMPING



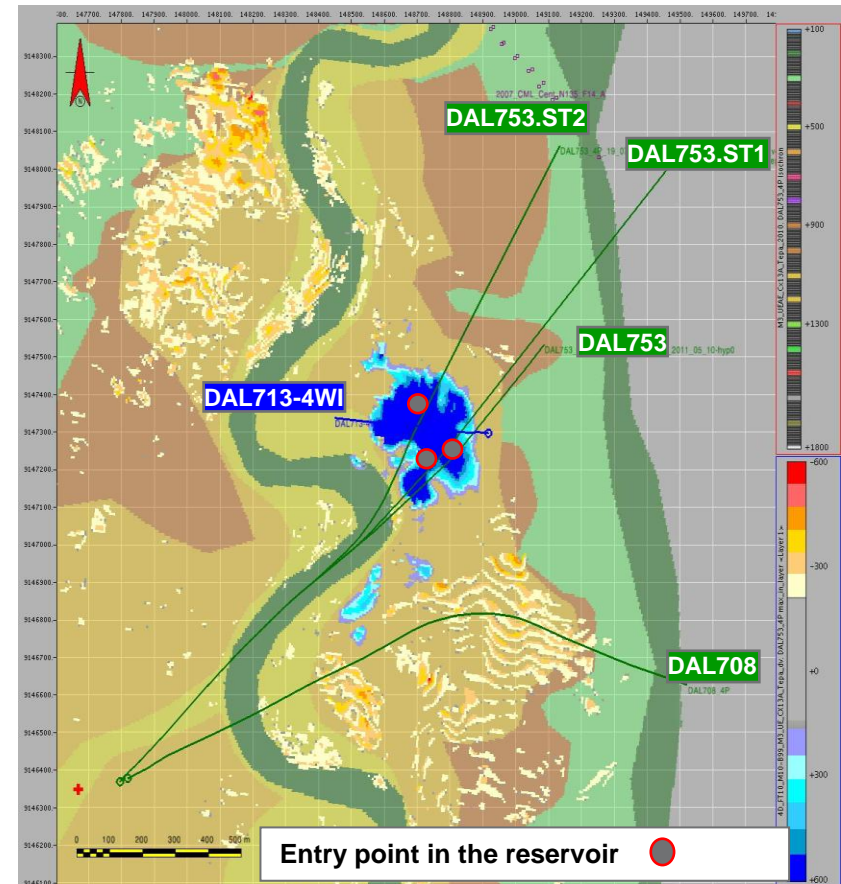
# PBF ORGANIZATION CHART



# DALIA POLYMER INJECTION - PILOT

# DALIA VISCO PROJECT – SAMPLER WELL

- Drilling of a sampler well located in the swept area
  - Location defined from reservoir simulations and 4D seismic
  - 80 to 190m away from viscosified water injector
  - Later converted to producers on bottom reservoirs
- Quantification of in situ viscosity
  - MDT sampling not conclusive
  - Bottom hole sampling relevant
    - Viscosity : 1.4cP (+/-0.2) vs expected 2.9cP



# SKID FROM THE SKY



# EOR INTEGRATED PROCESS

**Geosciences : Screening studies**

End-2002

2003 - 2008

**Total Petrochemicals :  
Physico-Chemistry**



2003 - 2008

**EOR Lab : Coreflood validation,  
Technical Support**



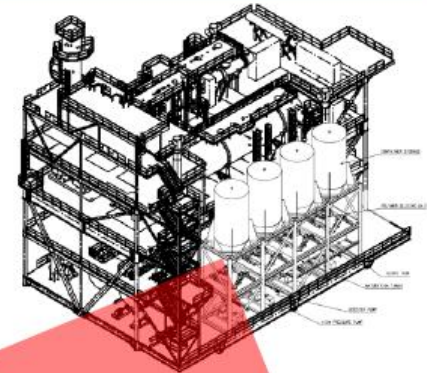
**Dec-2008**

**Dalia :**

1st World  
Deep  
Offshore  
polymer  
injection

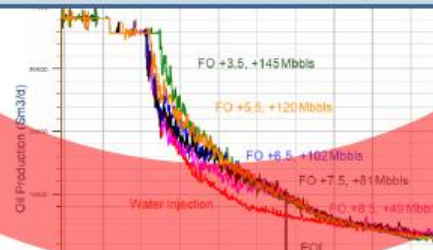
End-2003 - 2008

**APP : Architecture studies**



2004 - 2008

**EOR Simulation : Full-field  
profiles**



# MAIN TAKE AWAYS

- EOR (Enhanced Oil Recovery) as part of IOR
  - EOR: change of physical in situ conditions
  
- IOR projects on Block 17
  - Management in project mode is a must
  - Anticipation is key: Infill drilling, Satellites development
  - In B17 context, infill drilling has always shown to be of higher value
    - Role of 4D seismic
    - Relatively low cost of drilling (35 to 50 days for a well)
  - Continuous projects evaluation is needed
    - Economic context
    - Interest of concessionaire: Some projects may be a trigger for licence extension
  
- EOR project: Dalia Visco Pilot (Camelia)
  - Important lessons learned
    - Pilot project conduction during green field development (Dalia)
    - Physics of the flow in multiphase conditions