MPP on the sea bed, a Technical but also Operational challenge to undertake

Brown Field Application on TOTAL operated Block 17, offshore Angola

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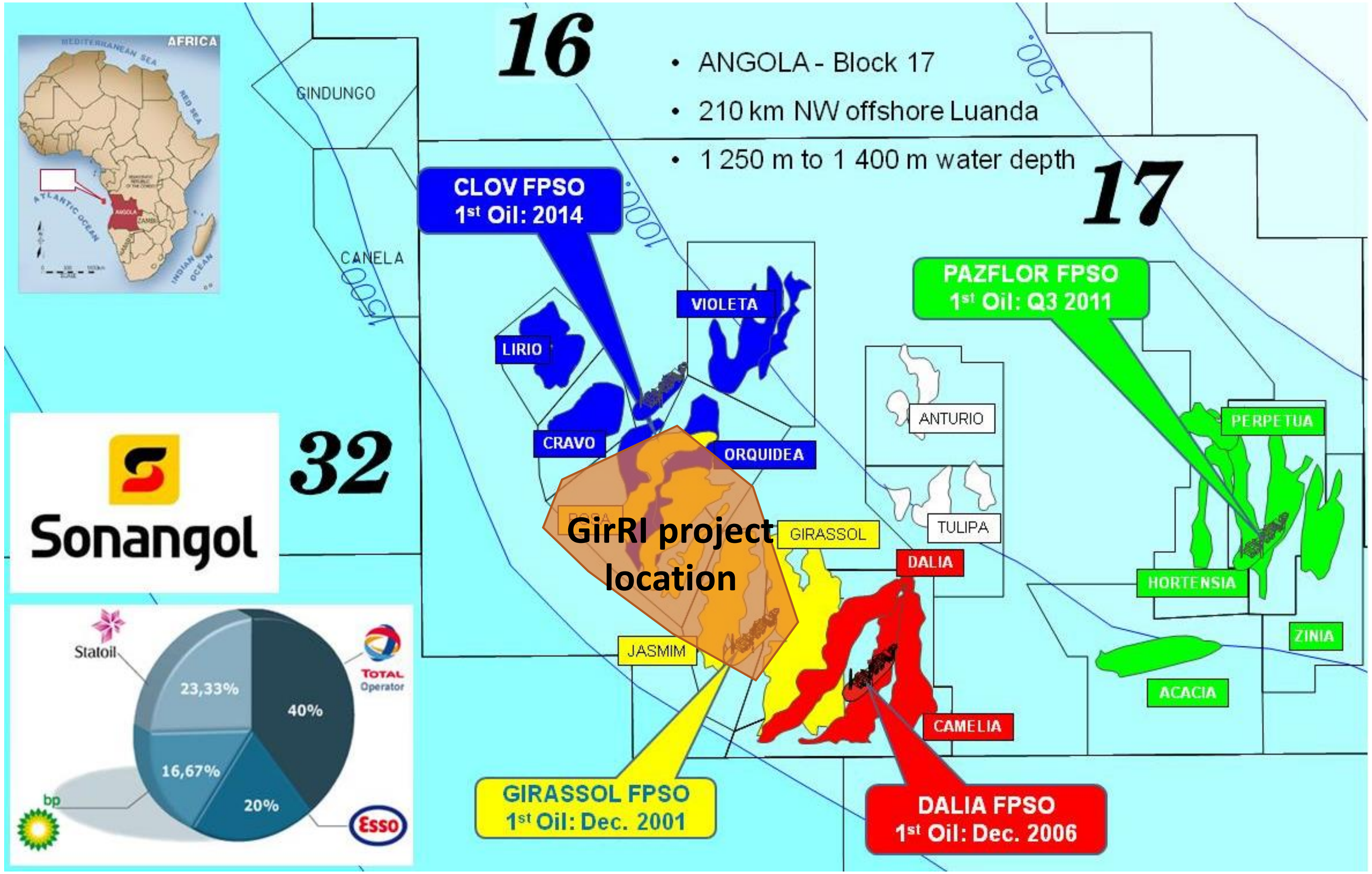
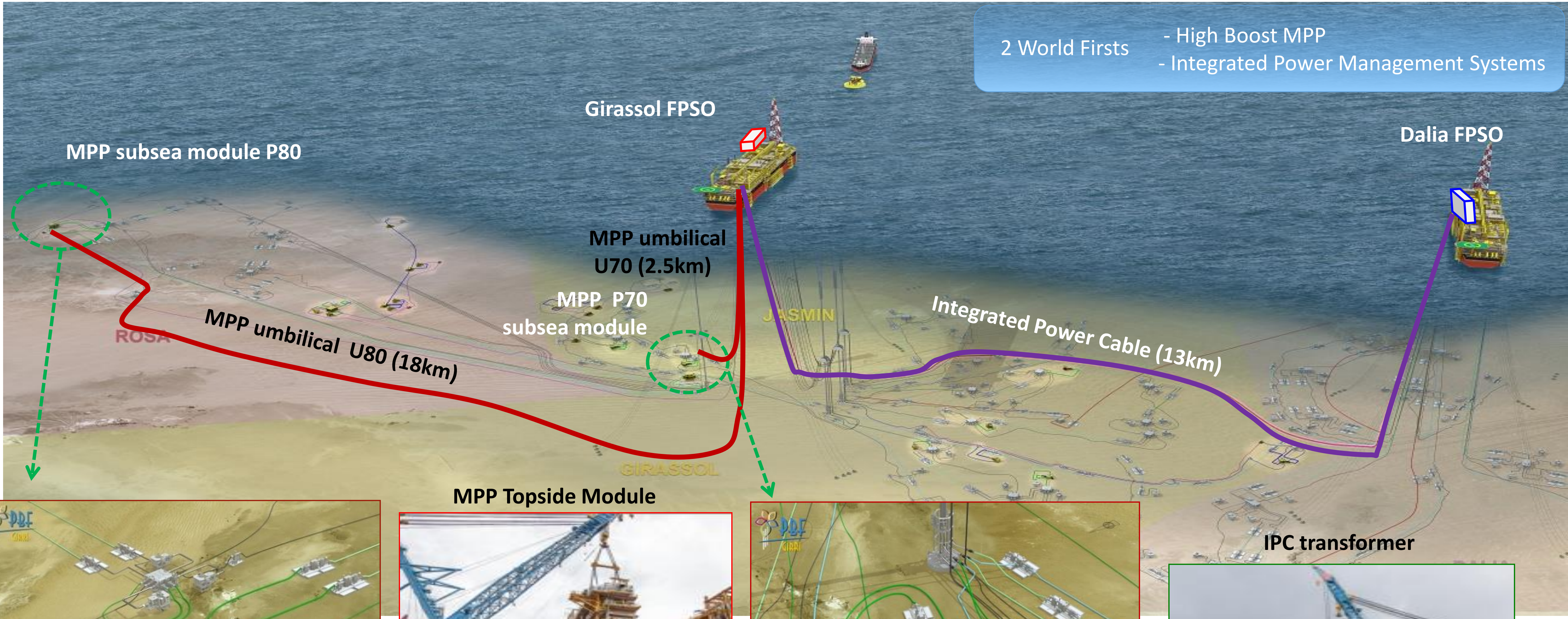
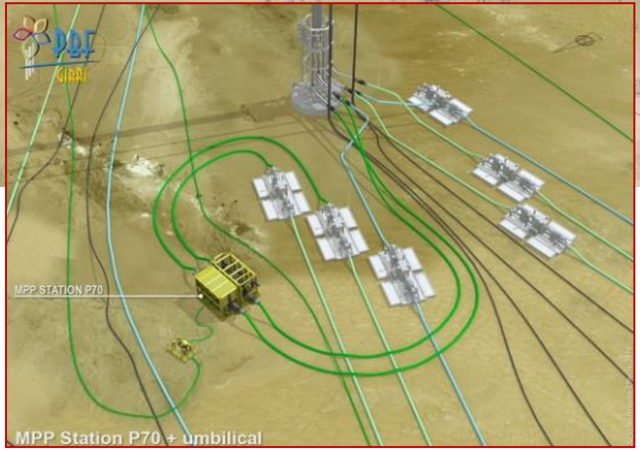
GirRI: a Brownfield project offshore Angola



GirRI: a bold multiphase pumping challenge



MPP Topside Module



IPC transformer

A Technical Challenge…

- Need for "one pump fits all branches", wide range of operating points

	Flowrate (Am^3/h)	GVF (% Avol)	ΔP (bar)
Operating range needed	200 - 550	10 - 60	15 - 105
Final characteristics	100 - 750	0 - 100	5 - 130

- High ΔP demand: 130 bar
- High shaft power requirement: 2.5 MW per MPP unit.
- World first MPP High boost application (ΔP record with 88.9 bar@ 25%GVF field proven in 05/2016 on P80L MPP).


Size: 4.5m x 3.3 m x 7m

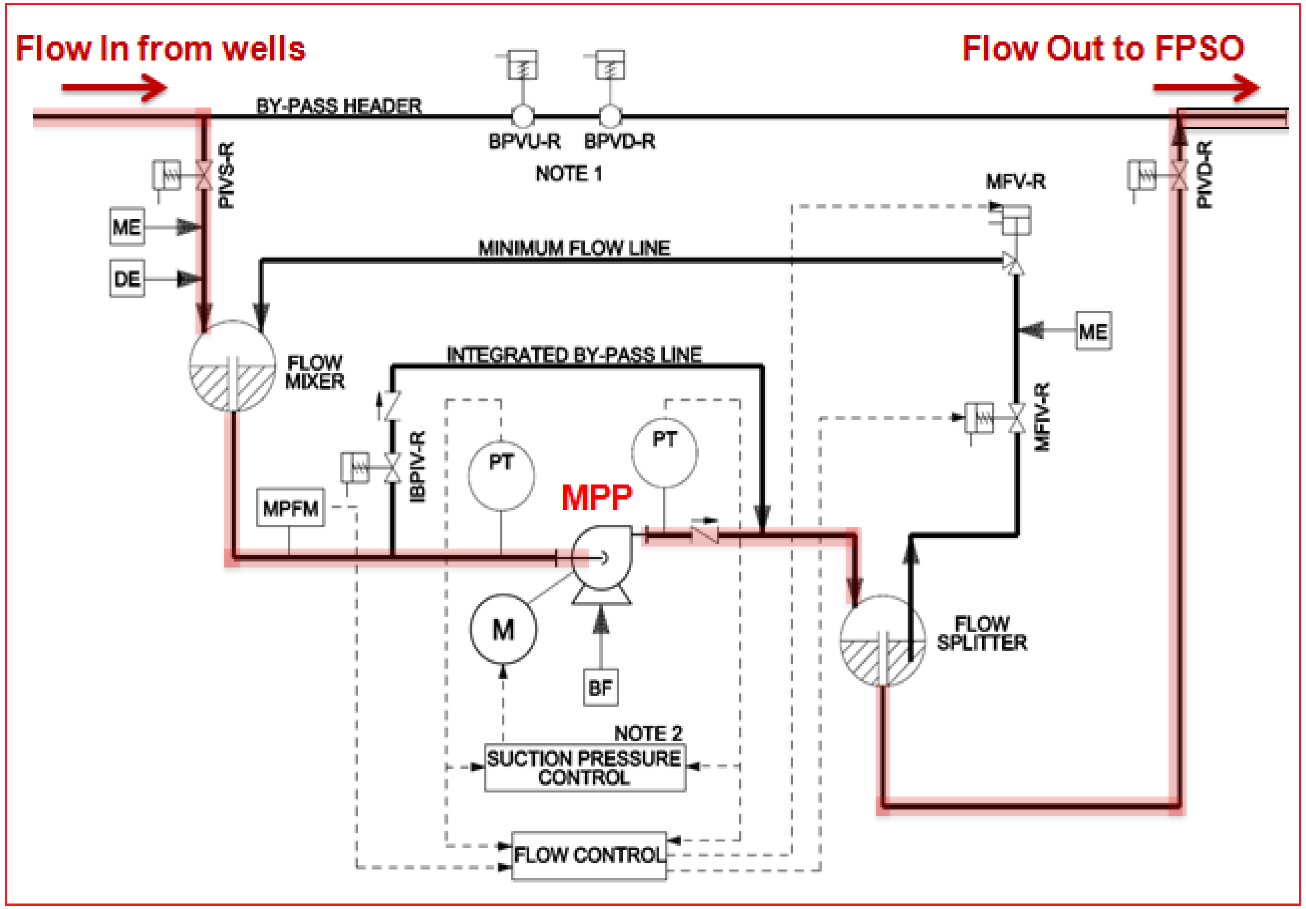
First main technical challenge was to use a brand new technology from R&D.

Risk mitigation by 1) creating a robust MPP system

- Power and speed margins.
- Increased robustness of the pump.

Coating on pump hydraulic stages

- Increased robustness of the pumping station.



Pump Station architecture

Risks mitigation by 2) Going through extensive FAT & SIT programs

System Integration Test

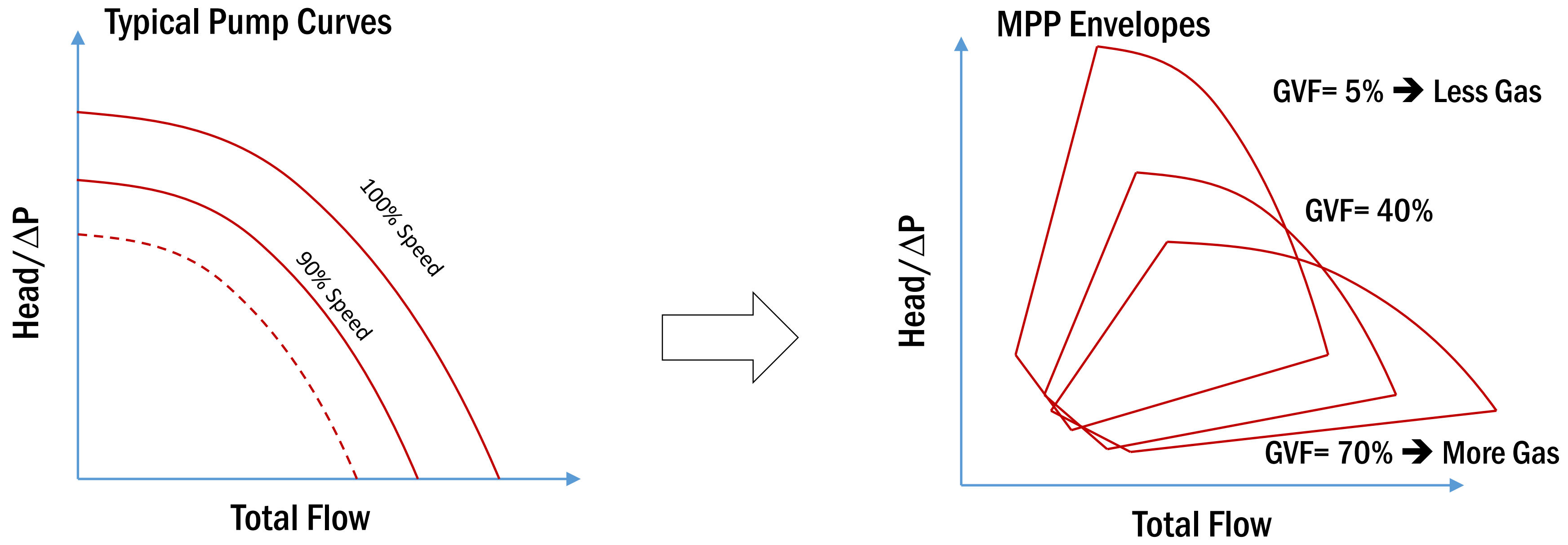
Slug Tests

…But also an Operational challenge

- MPP impacts both upstream and downstream flow regimes.
- Operators have a very good experience with their wells. However the MPP modifies the dynamic of the whole multiphase production system.
- Trade off must be found between pushing the MPP speed, choking the wells, rerouting the wells, producing with a higher suction pressure to get a more stable and at longer term a better production.

Start-up and operation of such powerful MPP equipment change many of Operators practices and ways of thinking.

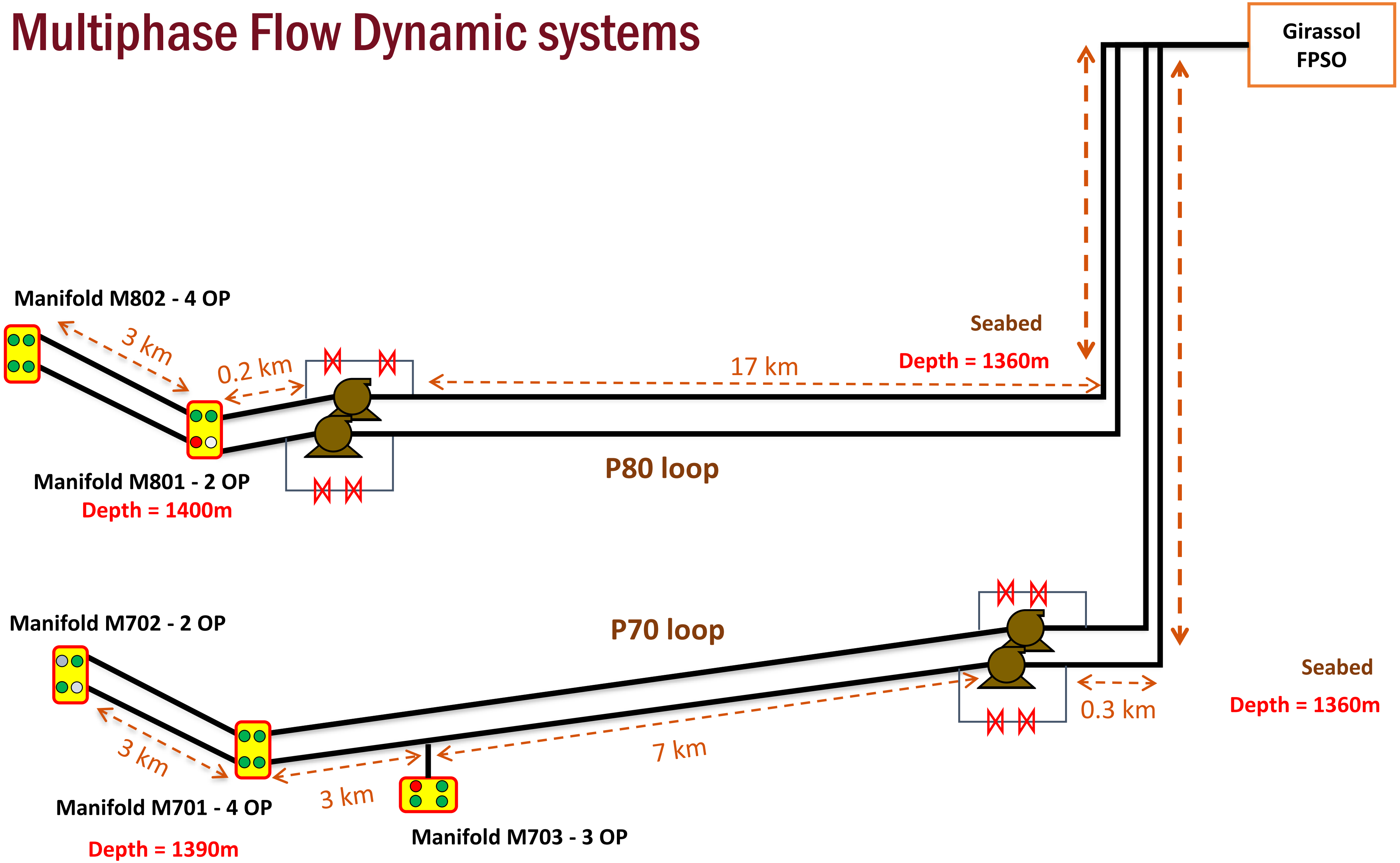
Key difference between a typical Pump and a MPP



GVF: Gas Volume Fraction

With a MPP, the operating limits are function of the GVF and fluid densities
➔ *Operating envelope is changing in real-time.*

Same MPP on 2 very different configurations :
Very different Multiphase Flow Dynamic systems



Multiphase Flow Production System Characteristics

- **Flow at inlet is independent from flow at the outlet of the pump**. System is composed of
  - Upstream : wells & flowline.
  - Downstream : riser & gas lift (process topside can also impact MPP).
    - → High inertia and limited control.

- Wells & flowline
  - Gas fraction in flowrate can reach ups and downs **very quickly** (0-100%)
    - → Slug flow conditions with high variations in flowrate.
  - Wells **very sensitive** to backpressure variations (highest impact of MPP is on P80).

- Riser & gas lift
  - **Pump needs to create ΔP to enter operating envelope** :
    - → suction pressure to be quickly reduced after start-up (valid for P70 only).
    - → rapid effect of gas lift on discharge P (valid for P70 as P80 is far from wells).
    - → Location of P80 reduces slugging, enhances stability but raises impact of start-up on wells (drawdown limit).

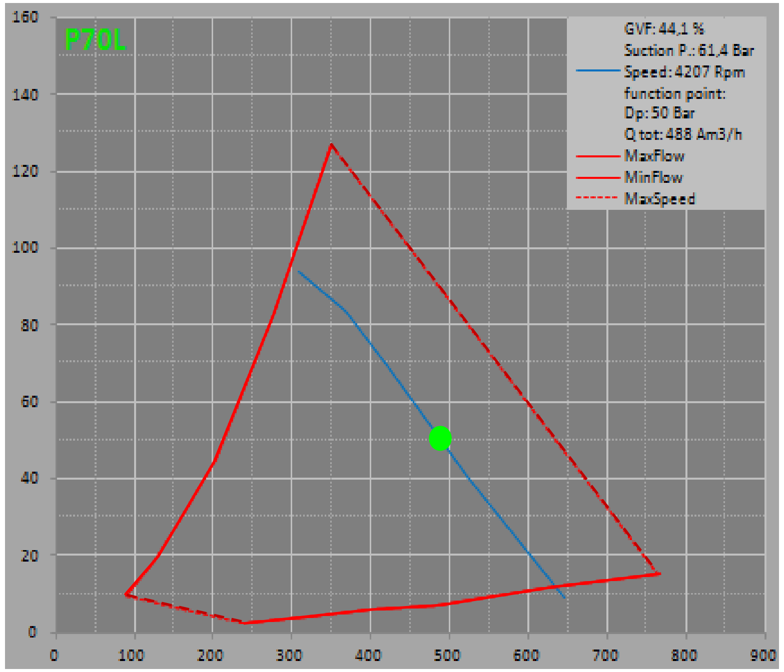
A system approach is mandatory

Main key parameters to manage a successful start-up

❖ Before start-up

- Ramp-down the wells to reach a minimum stable flow.

  → Higher flowrate would require more ΔP to enter operating envelope.
- Reducing gas lift allows to have margin to play on ΔP during critical phases (if operating point too close from mini-flow trip limit).
- Closing riser head choke is efficient to increase ΔP at riser base but disturbs the system at reopening (very sensitive on P70 branch).
- At restart, MPP is speed controlled to enter into the operating envelope.



❖ During start-up

- Wells are then reopened to gain ΔP & flow, with draw down control.
- Recycle line is used also to get higher ΔP and stabilize the system.
- Increase/reduction of gas lift allows to reduce/increase ΔP (quick effects on P70).

Takeaway Points

- MPP on the sea bed is a **Technical** but also an **Operational** challenge to take up.
- Two aspects of the equipment must be equally treated: 1) to Integrate the Equipment, 2) to Operate it.
- Operating successfully a production line with a MPP requires major changes in Operating procedures.
- During the start-up phase, the teams faced more complex flow assurance challenges than anticipated by all studies undertaken and by the Operators training system scenarios.
- Close cooperation between project, commissioning, start-up & operations teams allowed various successful optimizations to maximize MPPs availability and efficiency in restarts.

Key lesson learnt:

A successful transition to a production phase with continuous MPP boosting requires strong collaboration between all teams, Technical knowledge and a whole Subsea System approach.

Thank you for your attention !

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