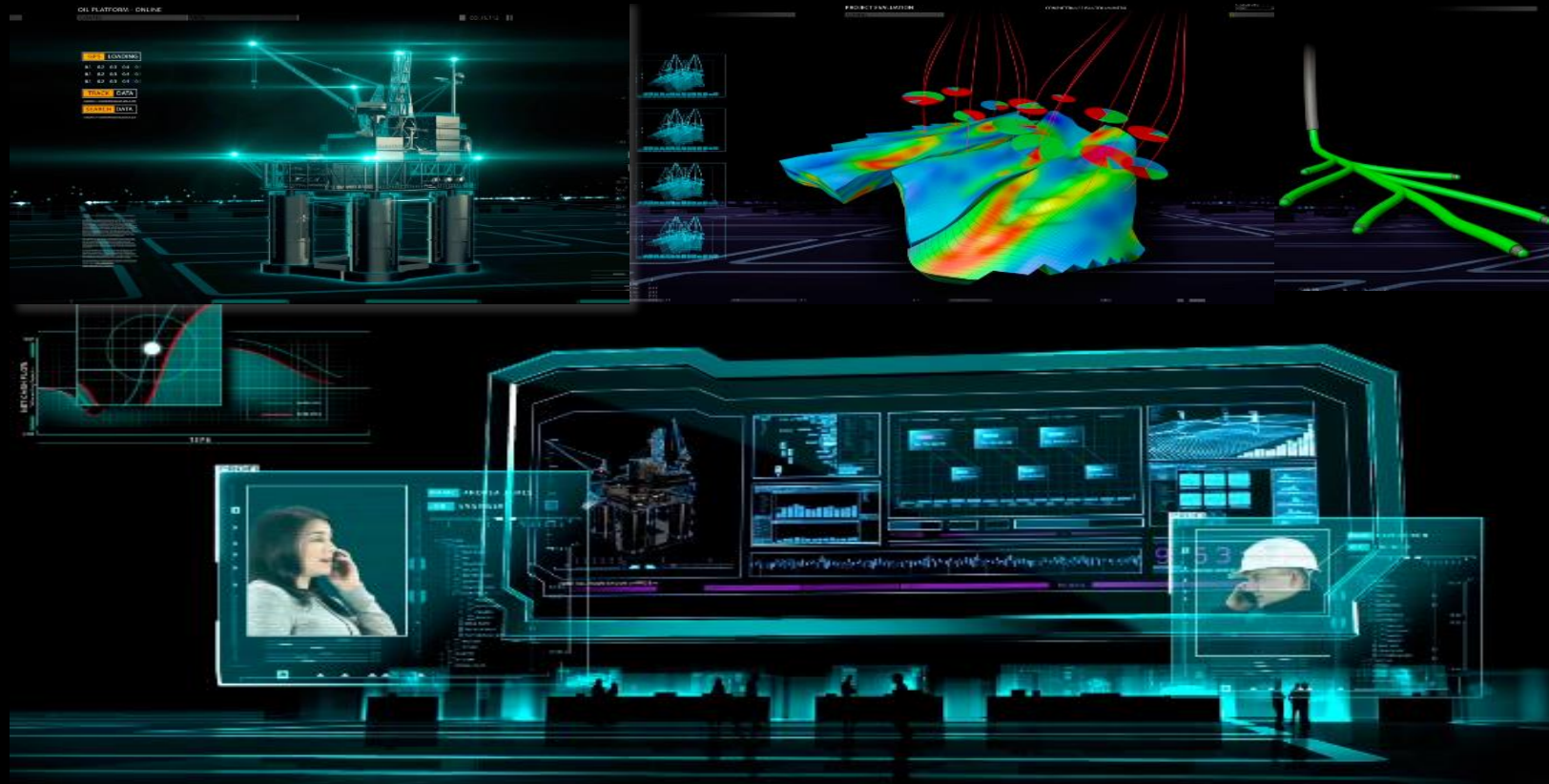


MATURE FIELD REHABILITATION: INNOVATION, TECHNOLOGY and CREATIVE BUSINESS MODELS FOR THE NEW CHALLENGES OF THE OIL INDUSTRY OF THE XXI CENTURY



By Guillermo Jalfin, Joao Vieira, Maria Augusta Cueva /
Francisco Giraldo / Adolpho Souza (Presenter), March – 2017

Schlumberger | **Production Management**

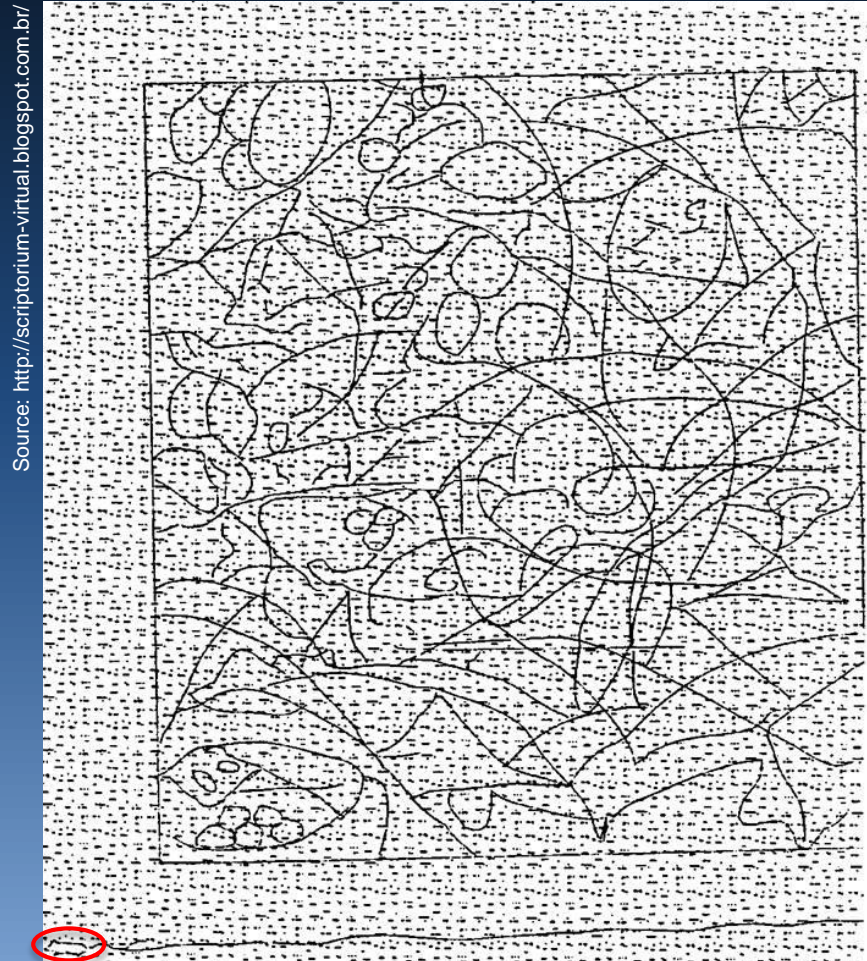
Credits to the Authors

- Guillermo Jalfin
- Maria Augusta Cueva
- Joao Vicente Vieira
- Francisco Giraldo

“This presentation is an update of the material presented in the ANP conference in 2013. It includes new material related with some real results of improvement of the recovery factor in some mature fields “

Lack of Focus on Mature Fields lead to Low RF, onshore case

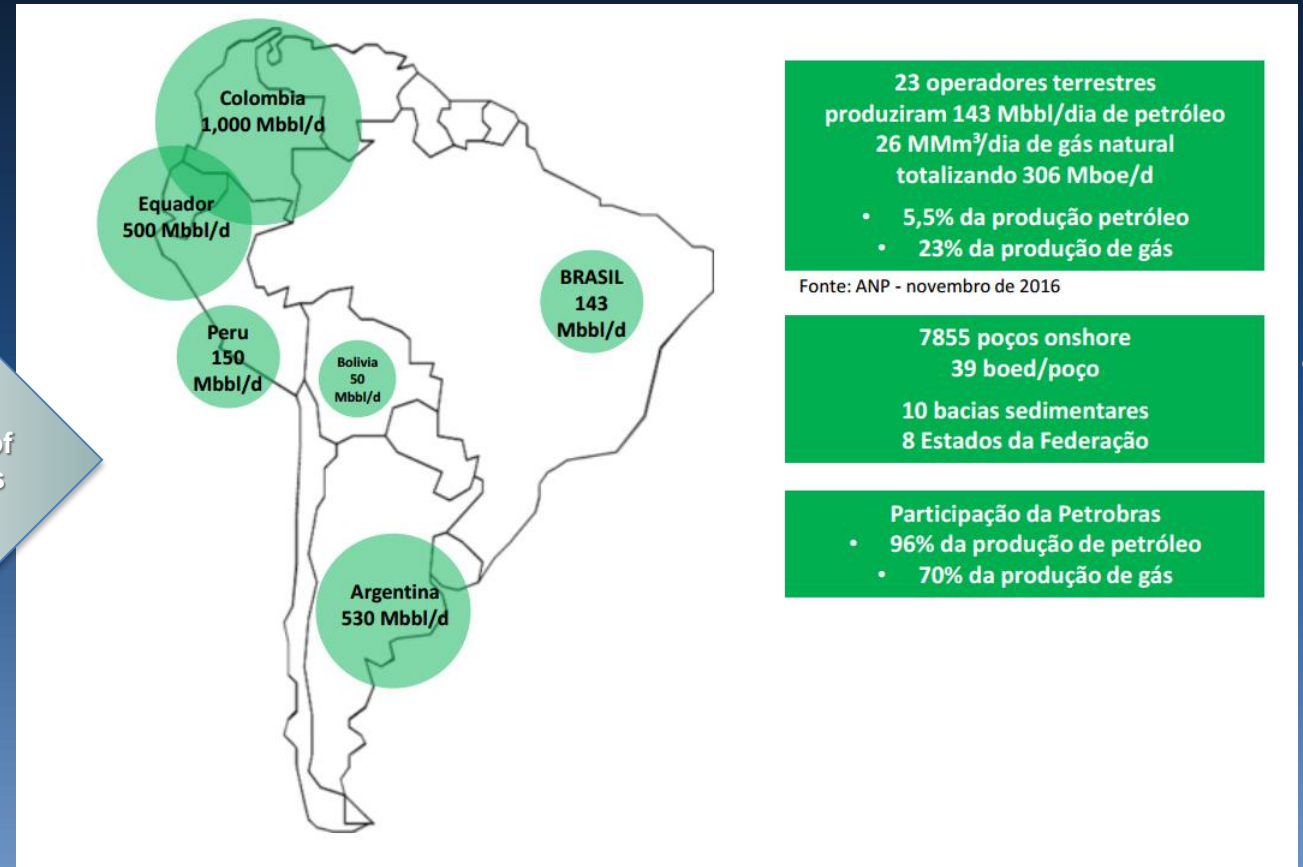
Can you see the mouse in the picture below?
There is only one!



Source: <http://scriptorium-virtual.blogspot.com.br/>



Lack of focus associated to current Framework did not enable onshore production to develop to its full potential

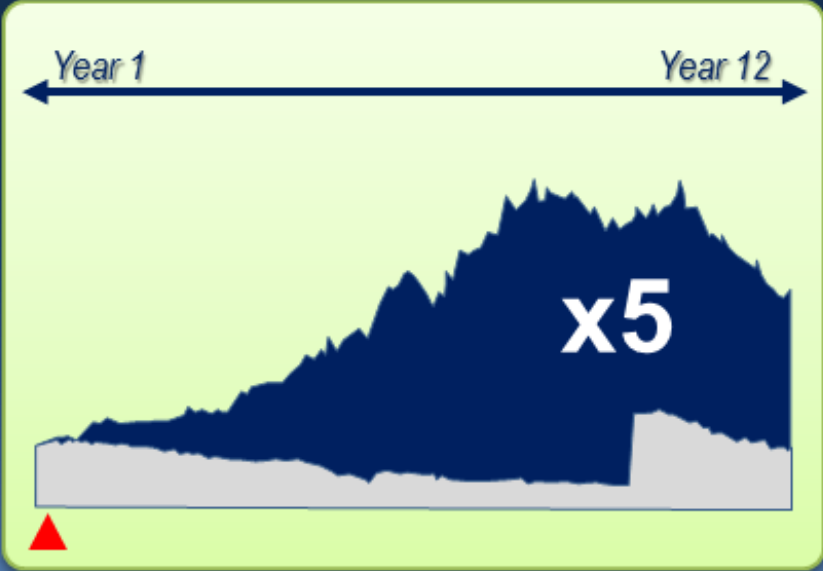


Source: REATE Presentation, MME, Jan-2017

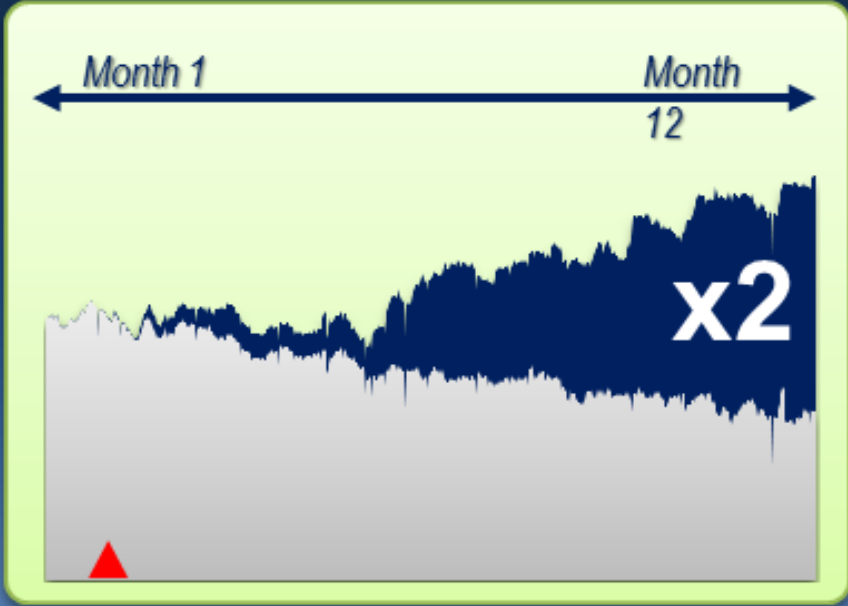
Mature Field Rehabilitation: Real Projects – Measurable Oil in the Tanks

Not far from Brazil...

Mature Onshore Oilfield



Mature Onshore Oilfield



- Incremental Production
- Past Production & Predicted Baseline
- ▲ Start of Contract

Outline

- 1 Historical Facts of Oil Industry Evolution:
Key Events, Economical Signals & Technology Challenges
- 2 3*i* Rule for Business Success in the Oil Industry:
*i*nnovation - *i*ntegration - *i*mplementation
- 3 Flexibility is the Name of the Game
- 4 Lessons Learned in Worldwide Projects
- 5 Conclusions and Final Remarks

Oil Industry transformation

20s-60s



Expansion Period

- Mass Production
- Massive Consumption
- From Monopoly to Large IOCs (Standard Oil Segmentation)
- Foundation of the NOCs
- Technology Monopolized by Large IOCs
- Concession Contracts
- No Environmental Conscious

70s-90s



Transformation Period

- Mega Merging
- Privatization and Outsourcing
- Globalization
- Reduction on Information Cost, Logistics and Overhead
- Technology Goes to Service Companies
- Production Sharing Contract
- Environmental Conscious

XXI Century



Techno-Economy

- New Players (Service Companies and Consultancies)
- Expropriation and Modernization of the State Companies
- Reserves Controlled by NOCs
- Regionalism
- Service Companies Lead Tech.
- Service Contracts
- More Environmental Conscious

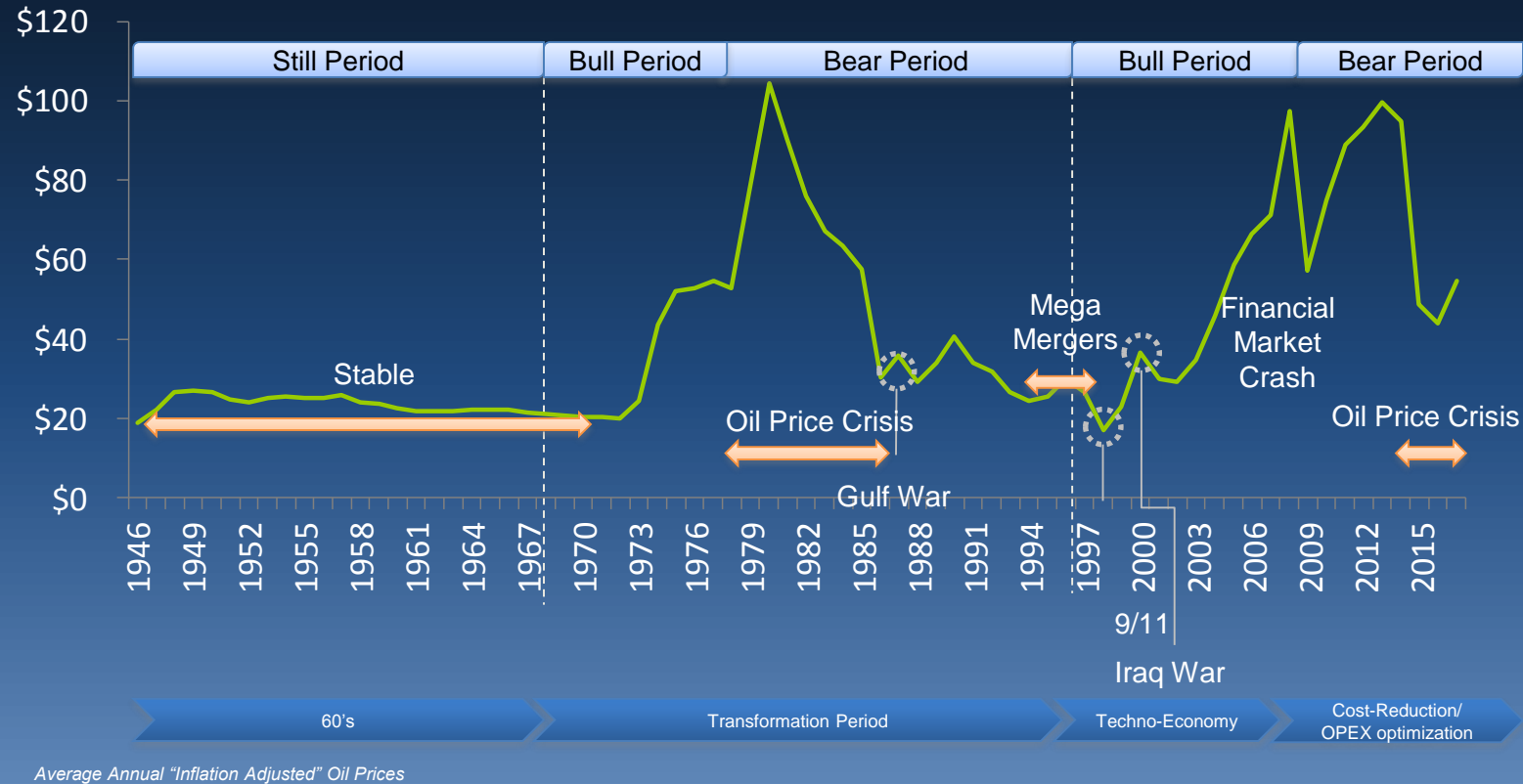
Before 70's

70's and beyond

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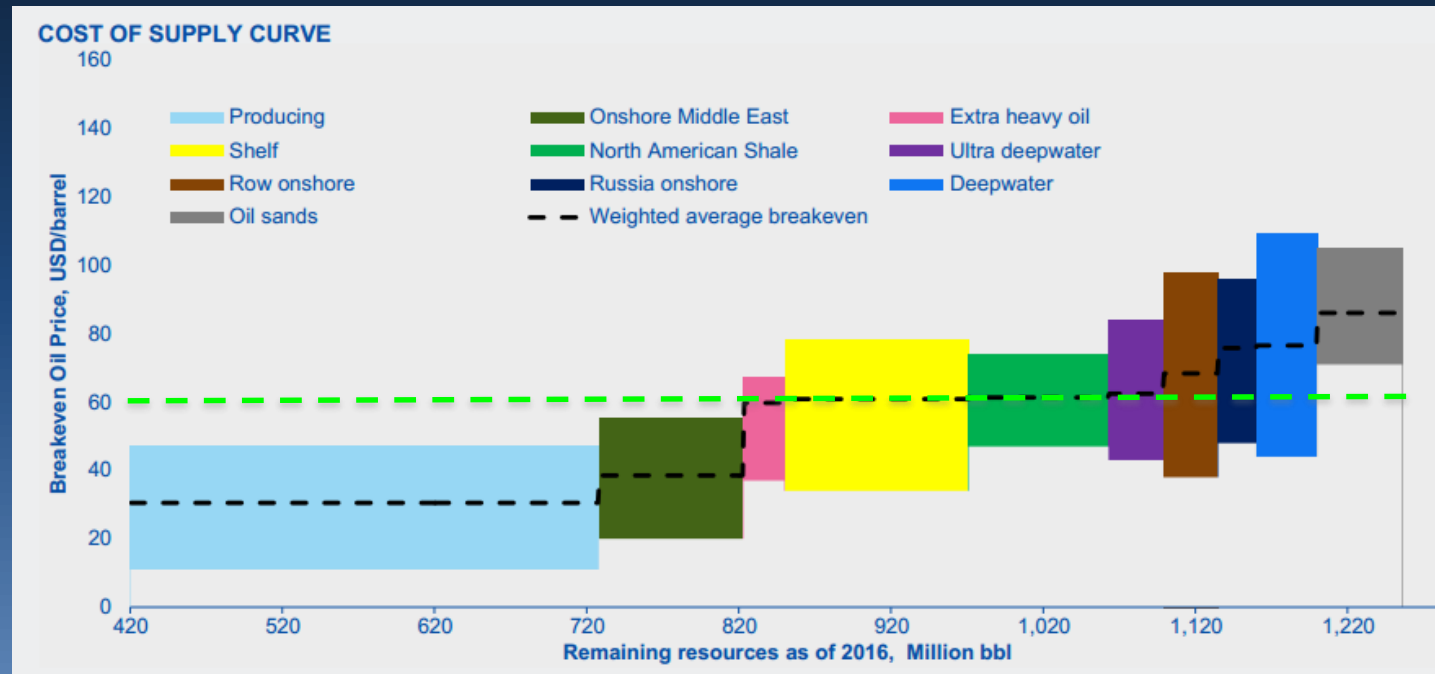
Production Management

Oil Price Volatility Punctuated by Global Macro-events



Range of the Breakeven Oil Price by Play Type

60 \$/bbl would make Economically Feasibly several projects again, however high-cost producers still be out of the race!



Source : Rystad Energy Ucube

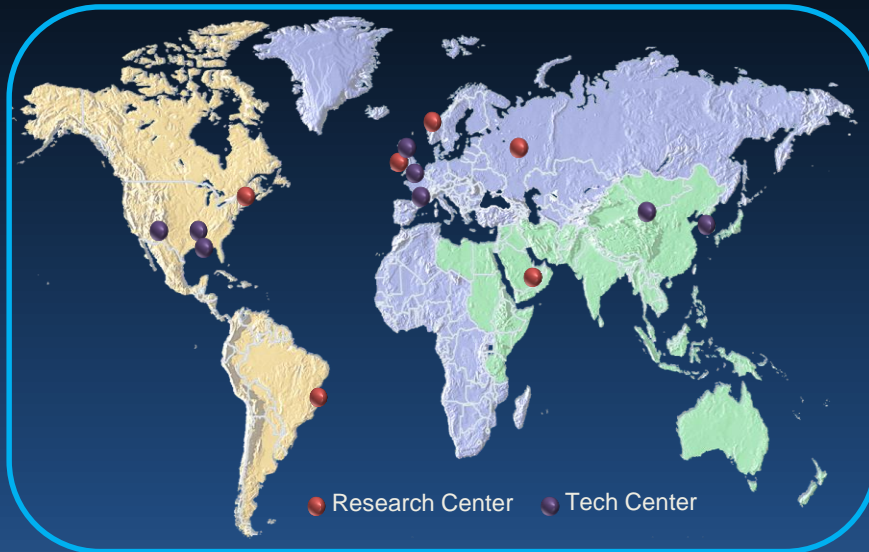
Technological Challenges

New Exploration Frontier	Geographic	Arctic Exploration
	Vertical	Pre-Salt Plays
	Technological	Unconventional Reservoirs
Rejuvenation of Mature Fields	Increasing Recovery Factor	EOR Methodologies
	Reducing Costs (OPEX & CAPEX)	Factory Drilling Intelligent Fields

Outline

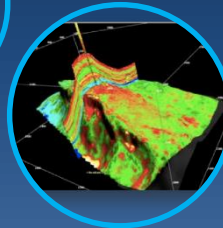
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i nnovation



- Schlumberger Brazil Research & Geoengineering Center
- Schlumberger Cambridge Research Center
- Schlumberger Dhahran Carbonate Research Center
- Schlumberger-Doll Research Center
- Schlumberger Moscow Research Center
- Schlumberger Stavanger Research Center

- Abingdon Technology Center
- Beijing Geoscience Center
- EMI Technology Center
- Schlumberger Kabushiki Kaisha Center
- Reservoir Completions Technology Center
- Riboud Product Center
- Stonehouse Technology Center
- Sugar Land Technology Centers



SLB annually invests **1 B\$ in Research & Development** through its six research centers (i.e. Boston, US; Cambridge, UK) and eight technological and training centers

Fit for purpose technologies. New ideas tailored to maximize operating efficiency, increase productivity and reduce the environmental footprint

Real Time Transmission

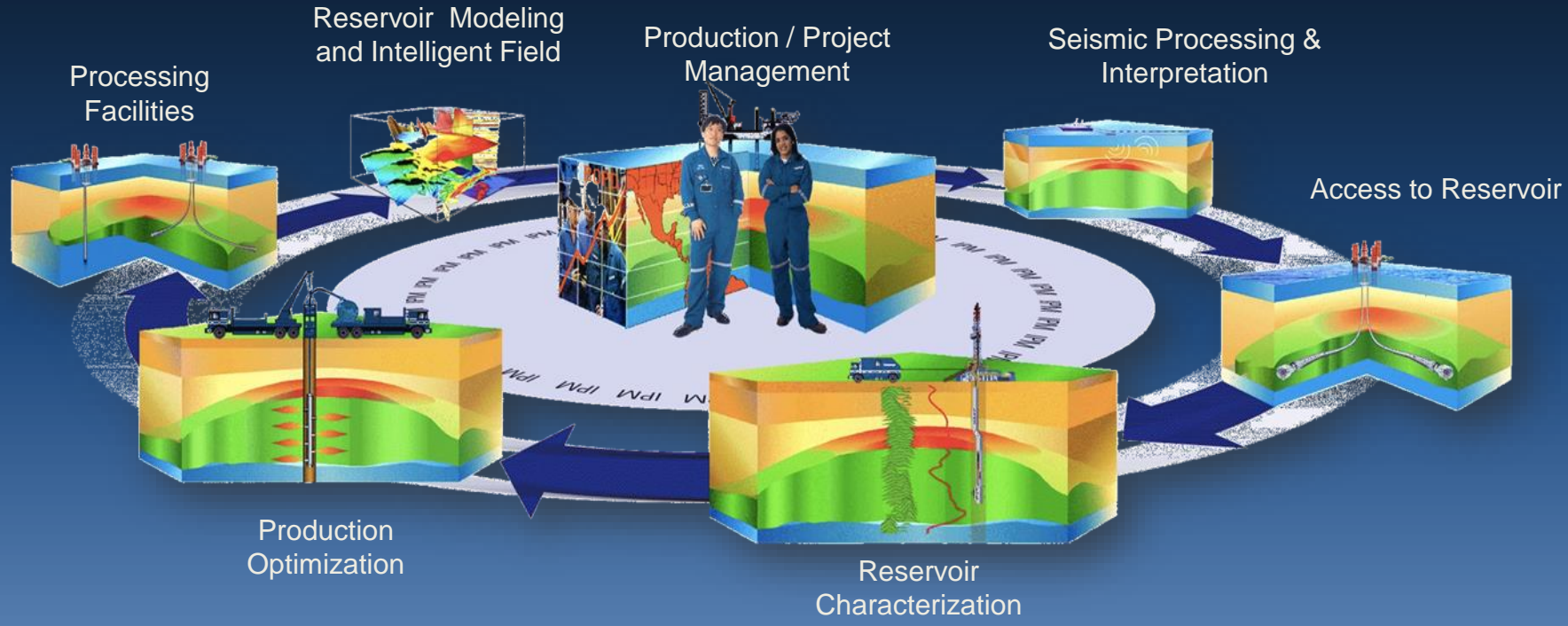
3D Geomechanical modeling

Low environmental impact testing

Environmentally friendly drilling fluids

Pore to Process Workflows

*i*ntegration



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Implementation : People + Technology to Succeed

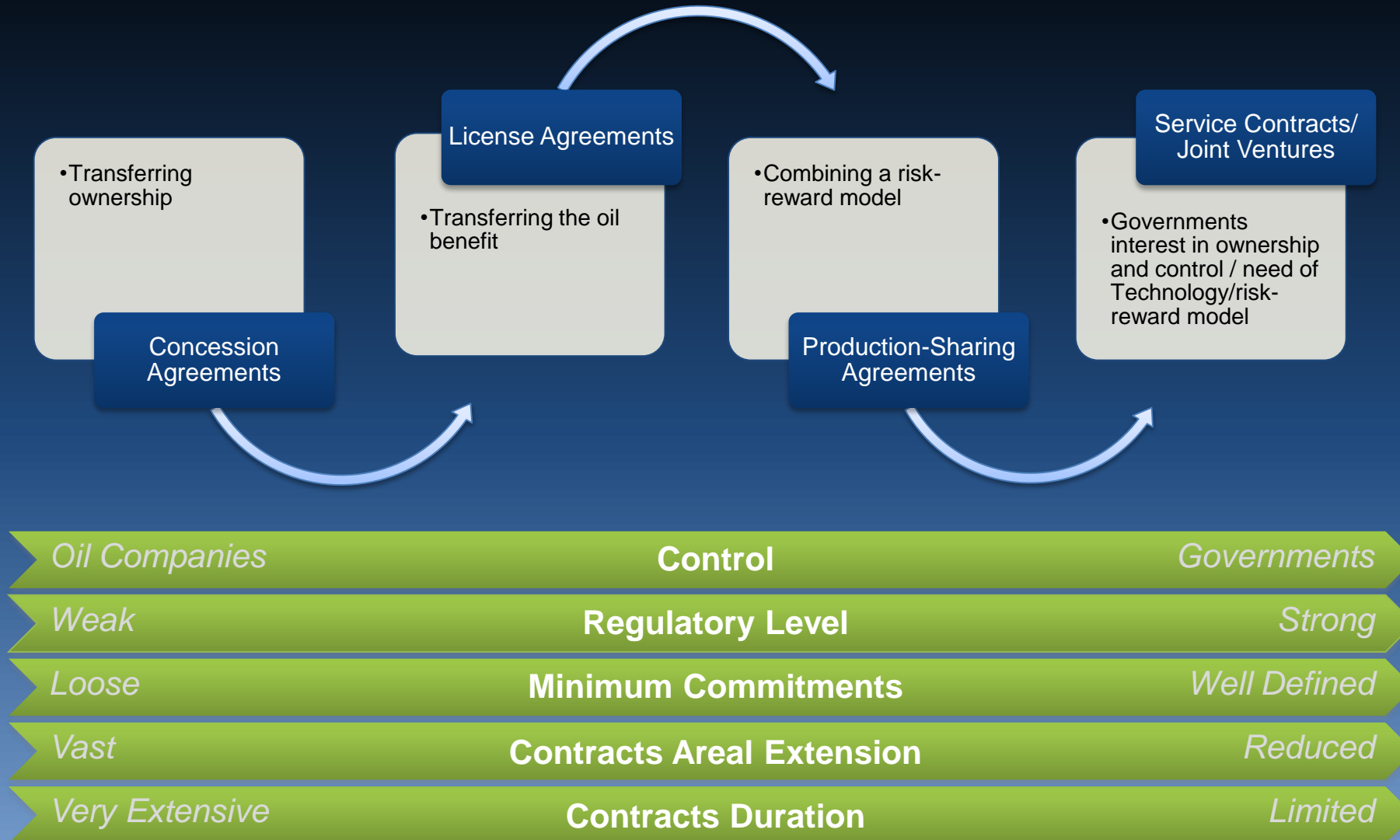
- High Q&HSE Standards
- Excellence in Execution
- Continuous Improvement Philosophy
- Training Programs
- Knowledge Management
- Technology Development and Implementation



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Evolution of Petroleum Contracts



Flexibility is the Name of the Game

Current oil price scenario demands to be more creative and efficient



All contracts to date have been "Fit For Purpose"

There are no standardized contract

Allow parties to maintain their Company identities

Service Companies remains as service providers

Allow technology deployment and development while leveraging existing workforce

Governments/Operators keep reserves ownership

Foster applied technology development

Encourages technology transfer

Compatible with entire industry

Applicable to both Public and Private companies

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Production Management

Principles of Our Business Model

Identity



Service Company

Not Booking Reserves

Not Taking Equity

Not Operators of Record

Differentiation



Full Operative Capacity

International Expertise

Leading Edge Technology

Financial Capacity (CAPEX)

Alignment



Total Alignment with Operator's Objectives

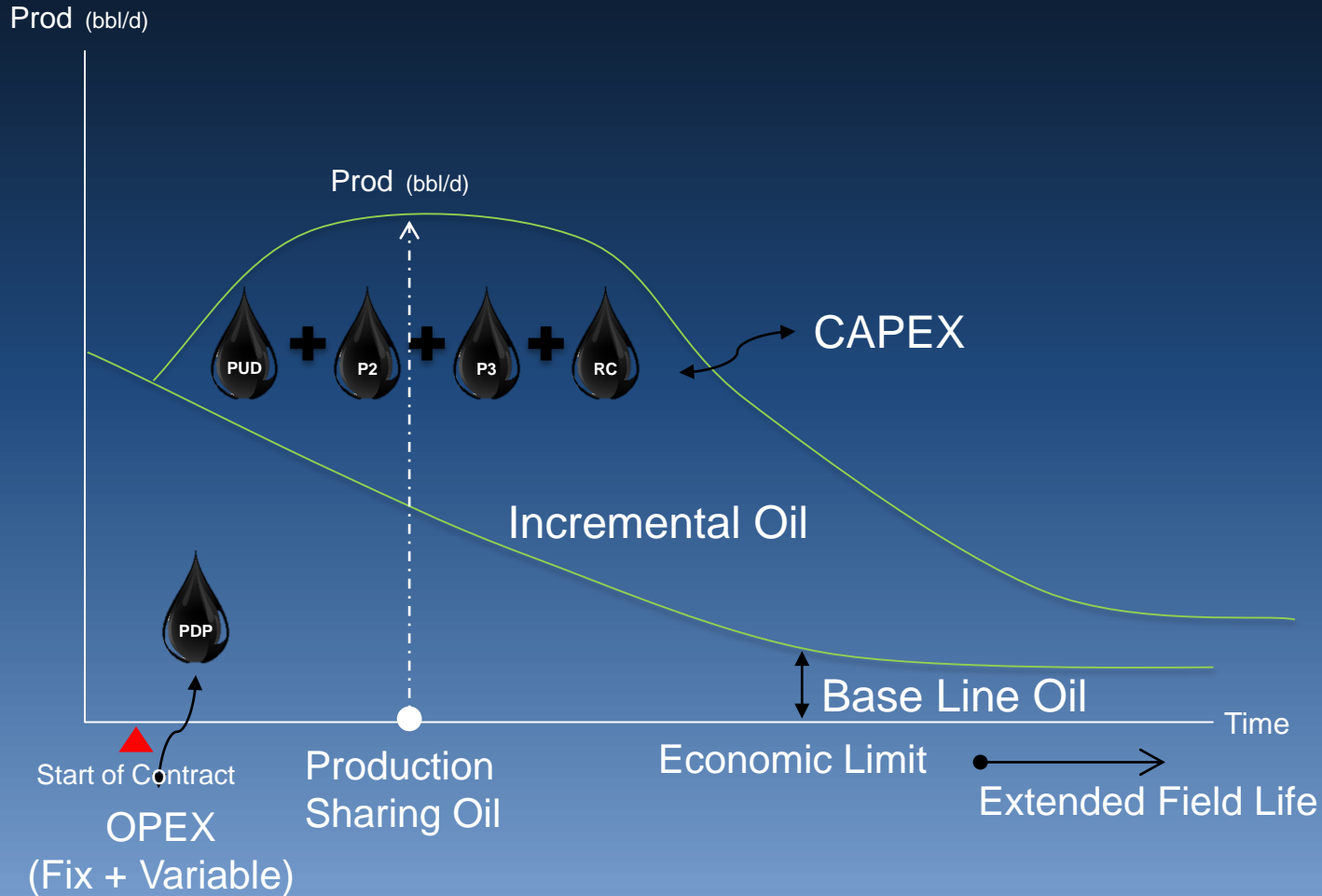
Risk / Reward Business Scheme

Continuity



Long Term Contractual Engagement

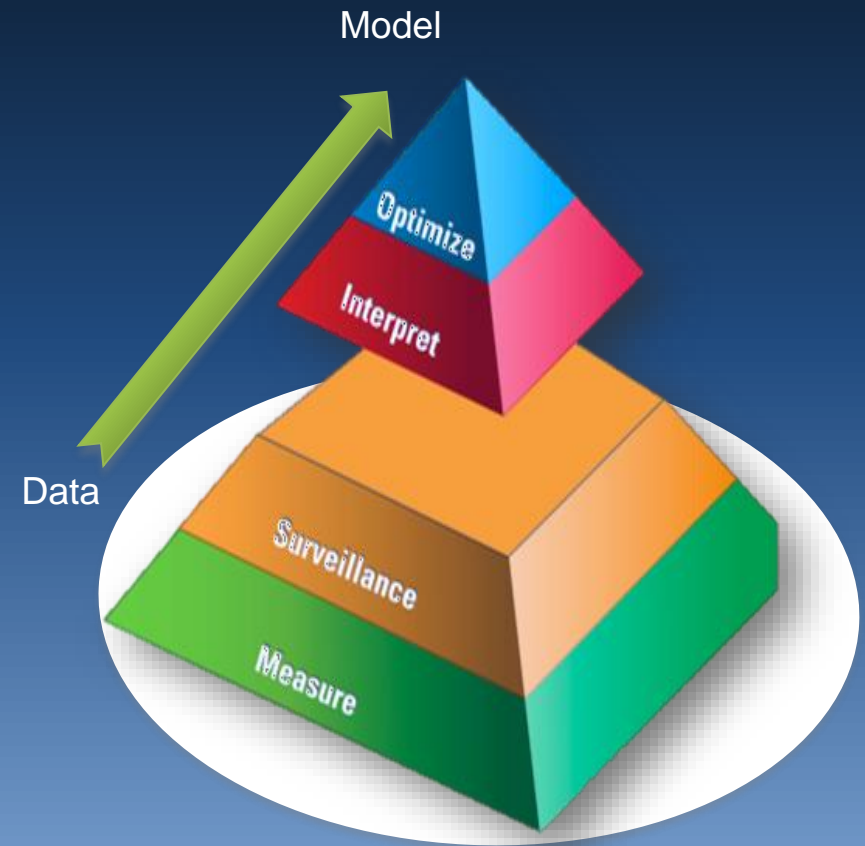
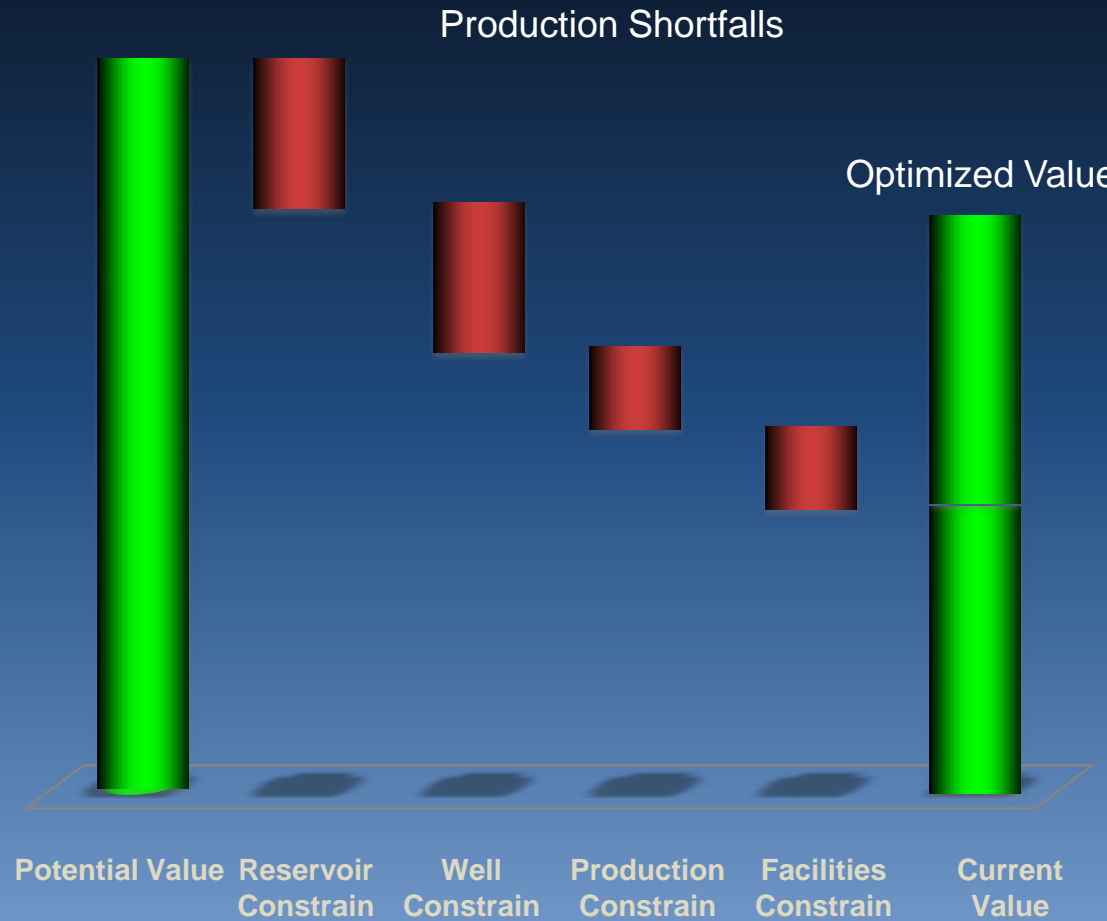
Schematic Business Model Mechanism



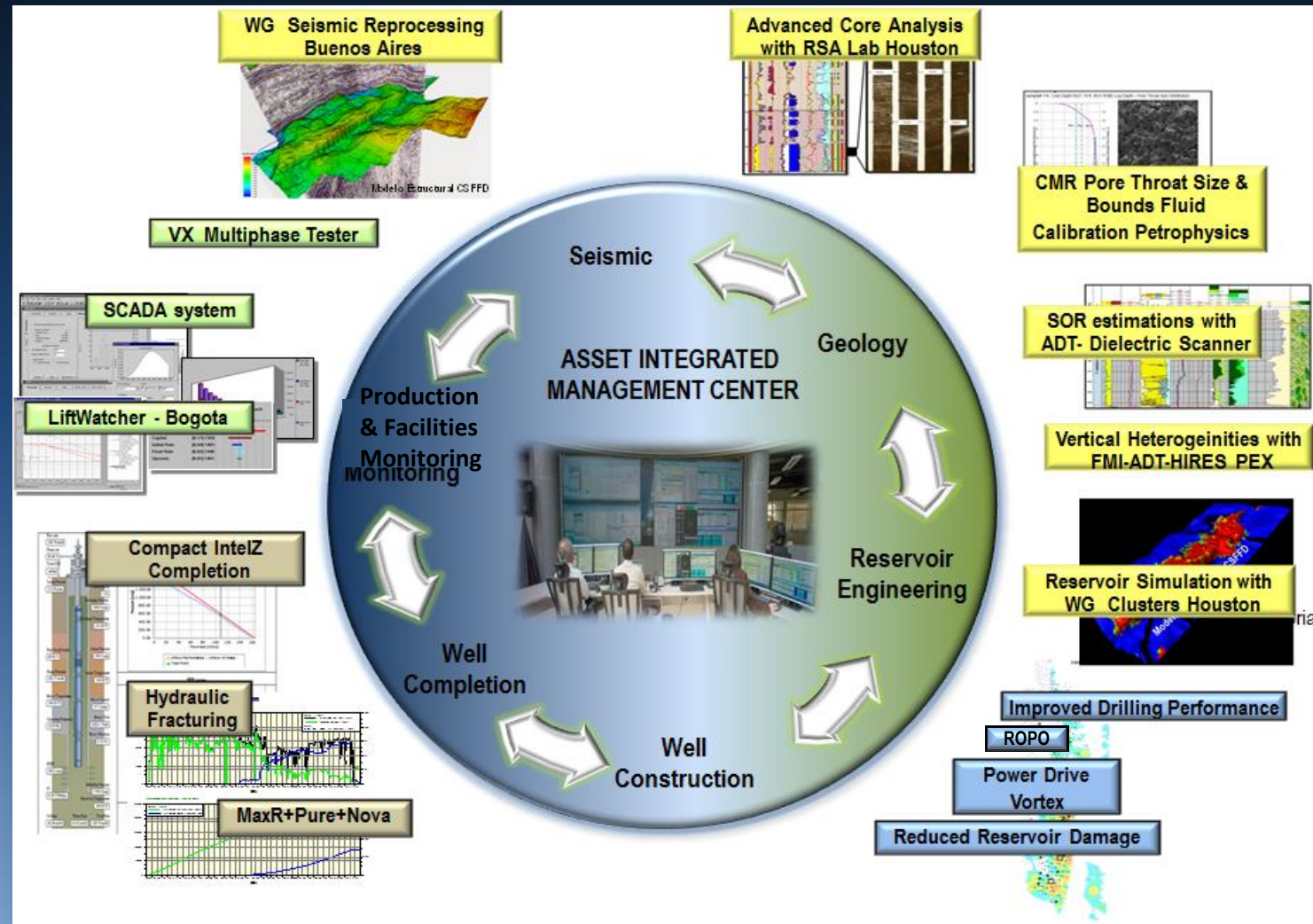
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Integrated Operations to Avoid Value Erosion



Integrated Reservoir Management and Technology Focus is Key to improve recovery factor



Historical field Issues for mature fields

Common issues

- Reservoirs Pressure decline
- Recovery factor Plateau with Primary Recovery
- Uneven drainage
- Water Fingering
- Water Coning
- Large Well spacing limiting recovering factor.
- By passed pay zones
- Overlooked discrete sands
- Scaling, Corrosion
- Formation Damage Mechanisms
- Well integrity (e.g : convert old producers to injectors in new patterns)
- Facilities constraints (field conversion to secondary recovery)
- Environmental regulations (water supply)

Why Secondary Recovery Projects Fail?

Main factors for failure

Reservoir factors

- **Lack of proper Reservoir Description & Characterization**
- **Over simplification of issues in simulation models**
- **Early water break through in high permeability streaks**
- Limited understanding of sweep mechanisms
- Improper pattern selection
- Water Under-running
- Unfavorable mobility ratios.
- Low injection Rate & Low Volumetric Replacement Rate

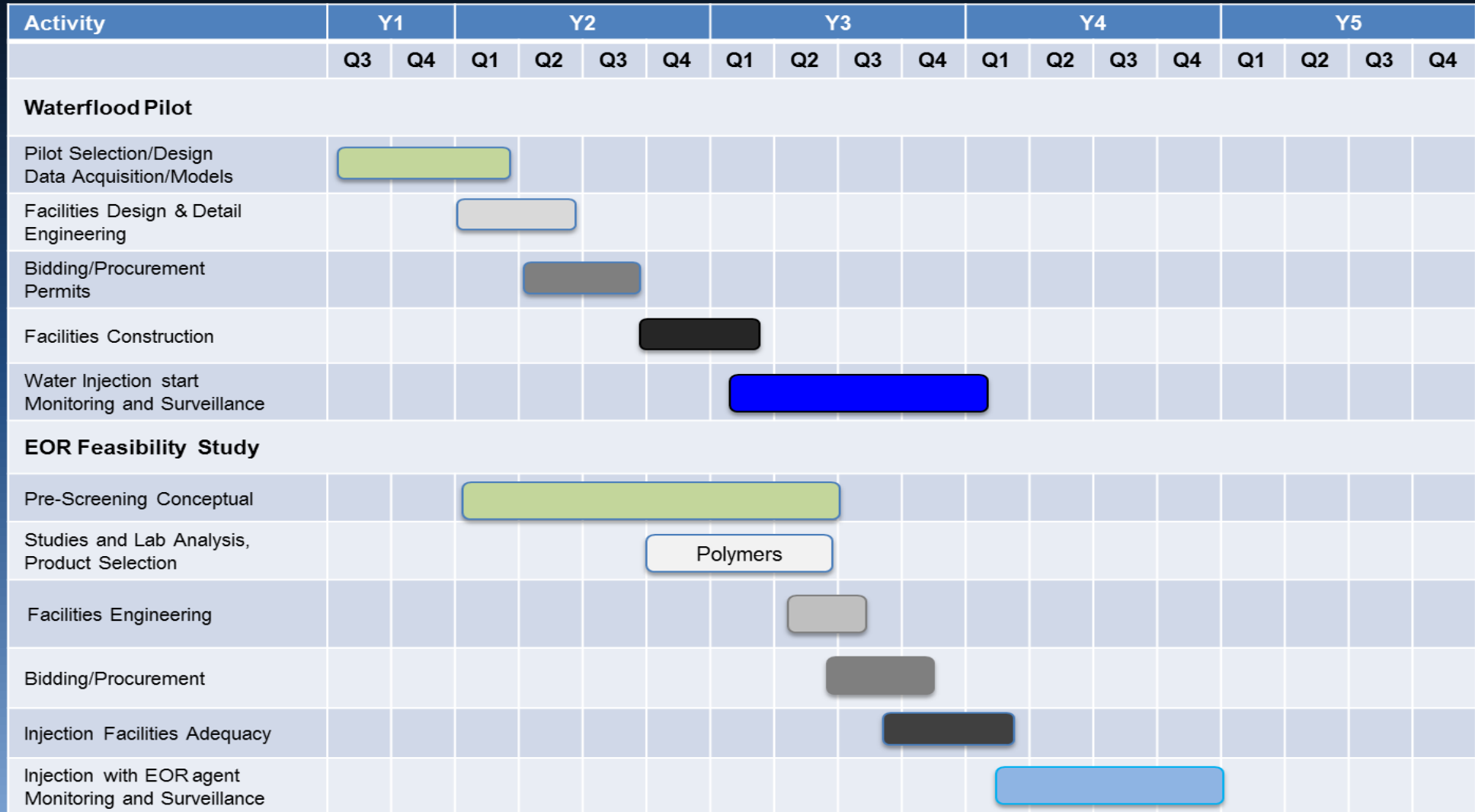
Organizational factors

- **Lack of secondary recovery concept acceptance by the Field Personnel**
- **Inadequate Water quality**
- **Lack of quantifiable surveillance system.**
- Lack of selectivity & Little Mitigation of water break through
- Scarce Water, gas, Co2 supplies in the area
- Field Implementation & management
- Budget Overrun

Revamping Reservoir Characterization

- A novel approach based on continuous logs calibrations (GR-Den-Neu-Rt) with :
 - Advanced Logs , Micro-Imaging, NMR Bin Porosities & Pore Size, Dielectric logs
 - Routine Core Analysis
 - Advanced Core Analysis (Xray, SEM, Capillary Pressures, NMR, Petrography, Formation Damage, Fine Migration,)
 - Stationary NMR & Mobility measurements in Open Hole.
- Extended Core Injection Test at Bottom Hole Condition (P, T)
- A Deterministic Geological and Petrophysical Model, Integrated and Calibrated, is used as the base for the convergence of the Analytical model and the simulation model.

Work Plan Waterflood Pilot and EOR Implementation

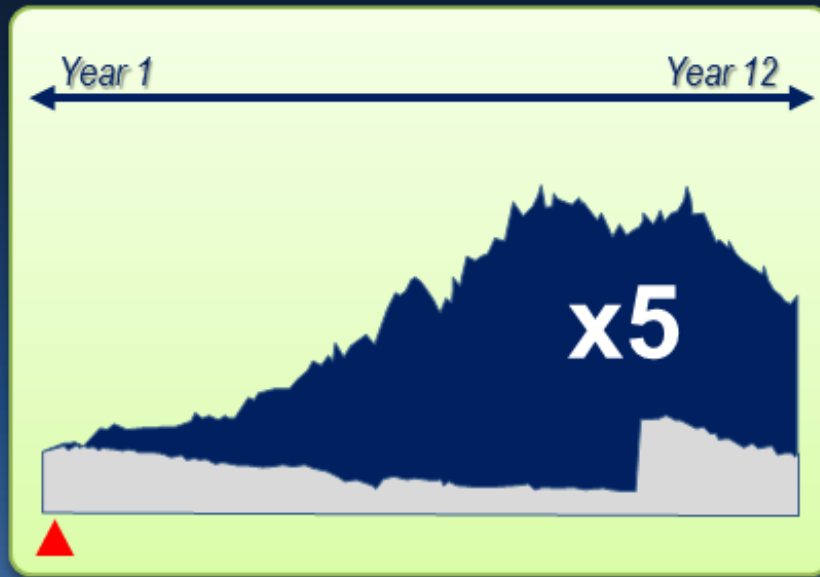


Recommendations from a Reservoir Point of View

- **Revamping of Reservoir Characterization is a must to avoid most failures previously discussed** , which will also improve the future FDP results.
- **Waterflooding is a holistic approach prior to EOR**
- **It takes time**
- **Develop Training Material & WF Concepts for Operational Personnel**
- **Developing the Surveillance, Monitoring & Reporting System is extremely important**

Mature Field Rehabilitation: Real Projects – Measurable Oil in the Tanks

Mature Onshore Oilfield



■ Incremental Production
■ Past Production & Predicted Baseline
▲ Start of Contract

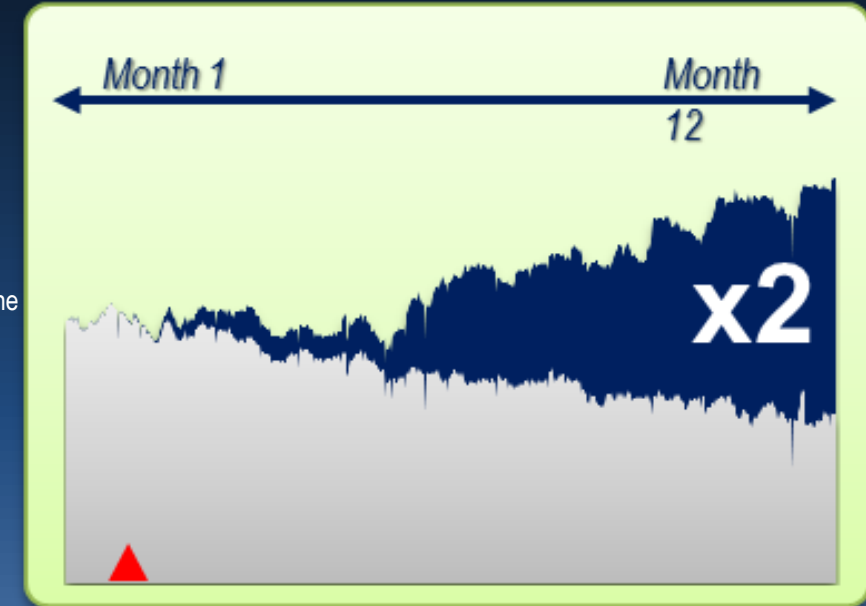
Action Plan

- Surface facilities upgrade and Fluids processing optimization
- Field wide pattern optimization & EOR expansion
- Operation philosophy (DOF, surveillance, water mngt., sand control, well test, etc.)

Impact

- **Increased Recovery Factor: 13% to 19%**
- Achieved production 500% above baseline
- Local content: 88% local staff

Mature Onshore Oilfield



Action Plan

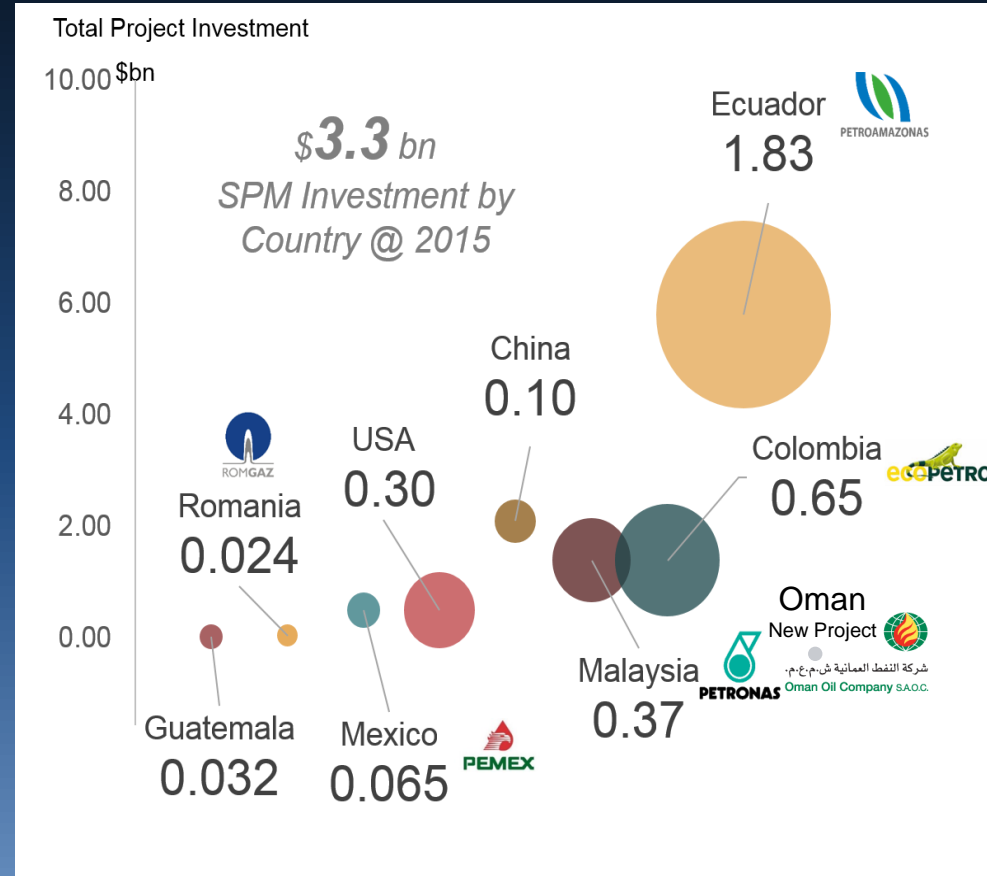
- Spud 1st well 6 weeks after signature
- Built new FDP including dual ESP
- Created operation support center (DOF)

Impact:

- **Increased Recovery Factor: 32% to 39 %**
- Production: close to 200% in 6 months vs. baseline
- Local content: 79% local staff

Our Commitment with the International Oil & Gas Industry

- 13** Oil & Gas Projects
- 11** Countries SPM Footprint
- 240** Kbbld Co-manage Production
- 100** Kbbld SPM Incremental Production
- \$ 3.3** bn Total Invested until Dec. 2015
- \$ 12** bn Total Full Life Projects Investment



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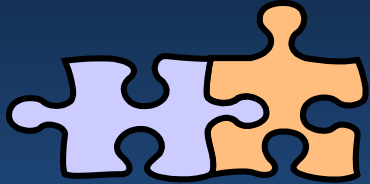
In Summary: Three important factors for the success



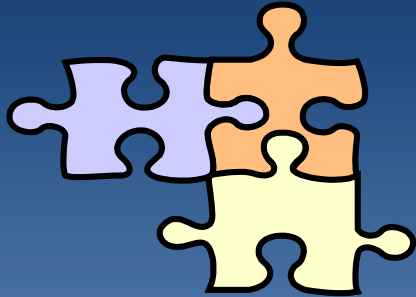
Conclusions



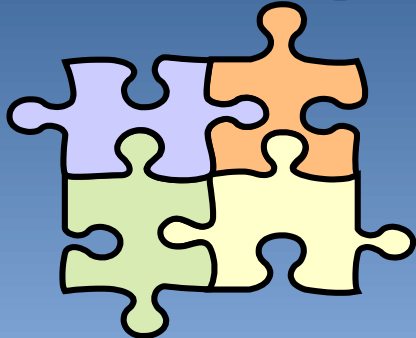
The evolution of the oil industry has created a New Business Space where **Technology and Expertise play the main role to success in mature fields**



Current and Future industry challenges transit through a New Reality that **requires new working relationships and favorable regulations**



Integrated reservoir modeling together with fit for purpose technology are key to improve recovery factor



Risk-Reward Services Contracts mark a milestone in the oil industry, bringing investments, and state of the art technology to the industry

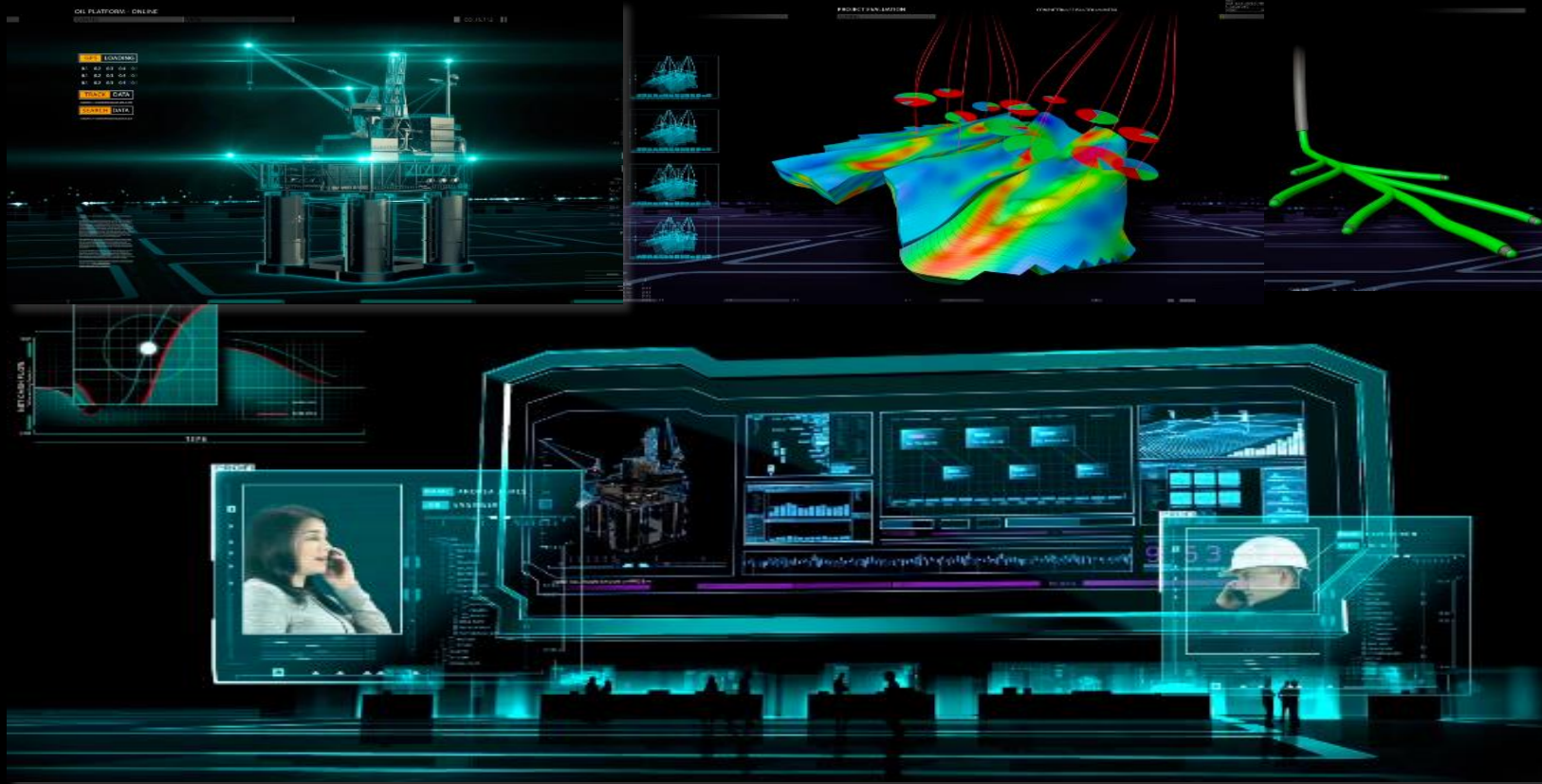
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Credits to the Authors

- Guillermo Jalfin
- Maria Augusta Cueva
- Joao Vicente Vieira
- Francisco Giraldo

Thank you!



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