Rapid CUBE – Development of a Subsea Real-Time Level Control System

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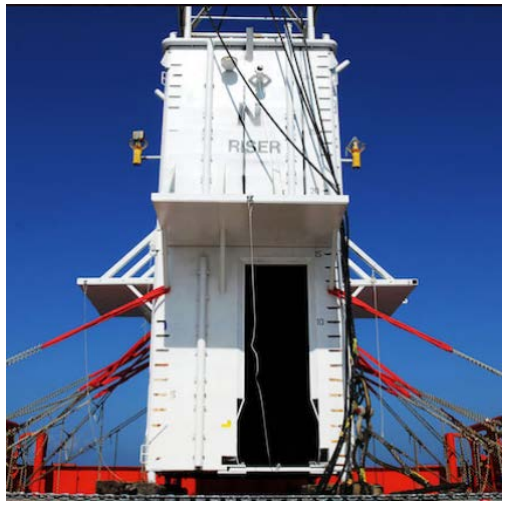
MCEDD Conference, Milano, April 9-11th

No Seal Containment System

- *Rapid CUBE is one of the tools that Eni developed to confirm its capability to prevent and react to subsea blowouts, as complement of the Capping Stack technology*
- *It is an open intervention system that does not require any interface with the leaking device*

No seal systems issues	Rapid CUBE strategies
Seawater entrainment	Limited size
Limited by topside treatment capacity	Liquid flowrate control through pump
Hydrate clogging	Liquid/gas separation



Macondo Cofferdam

Capping stack

Rapid CUBE

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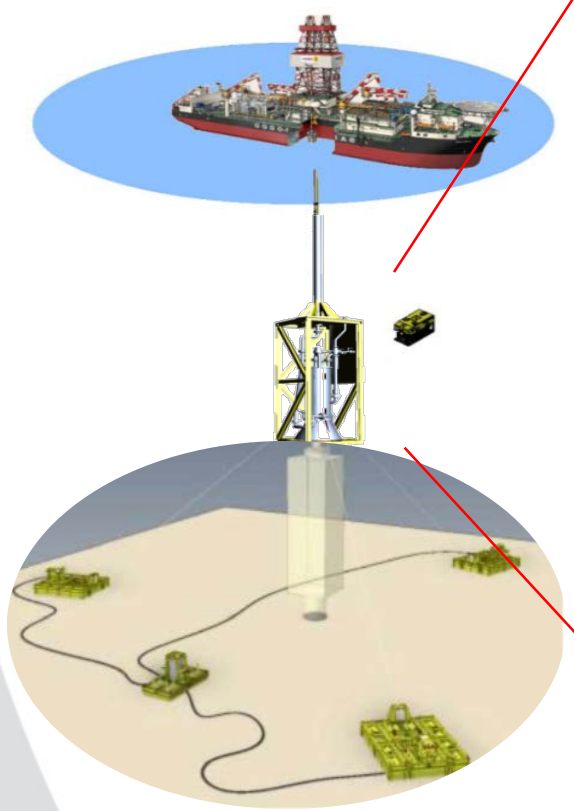
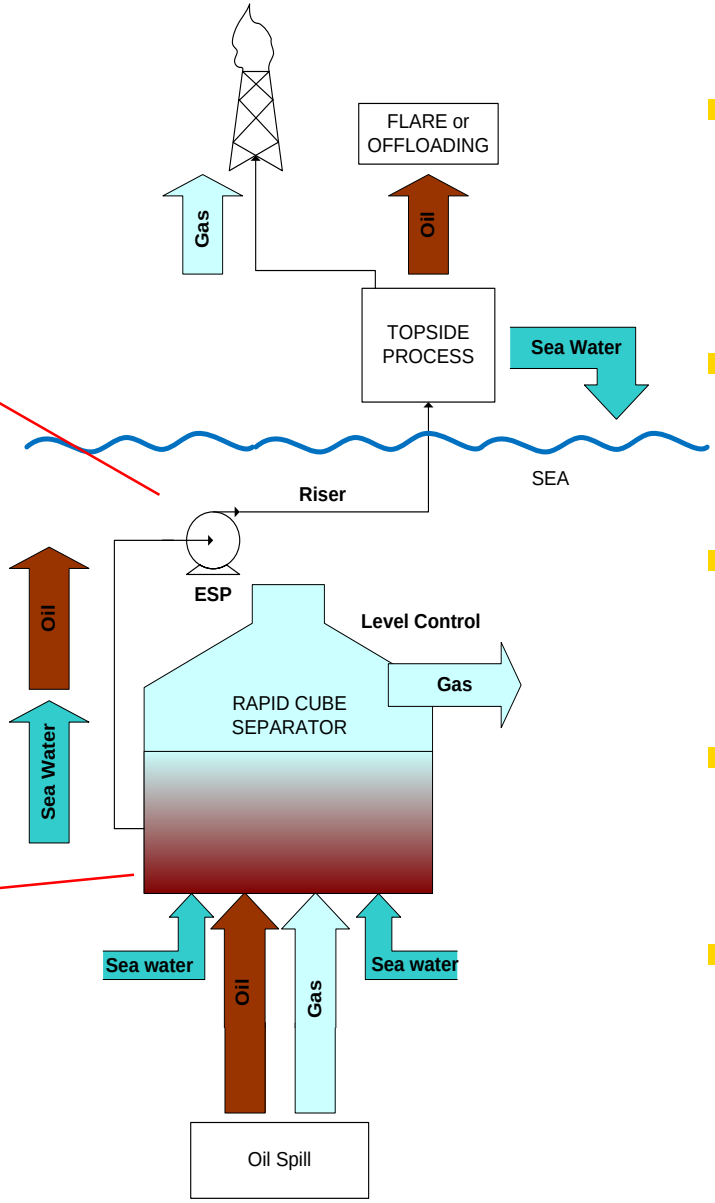
Process





- ***Capture*** *of oil, gas and entrained seawater at seabed*
- ***Fast separation*** *of gas and liquid phases*
- ***Level control*** *through gas release to the environment*
- ***Boosting*** *of the liquid phase with a ESP pump*
- *Well testing equipment for* ***topside process***

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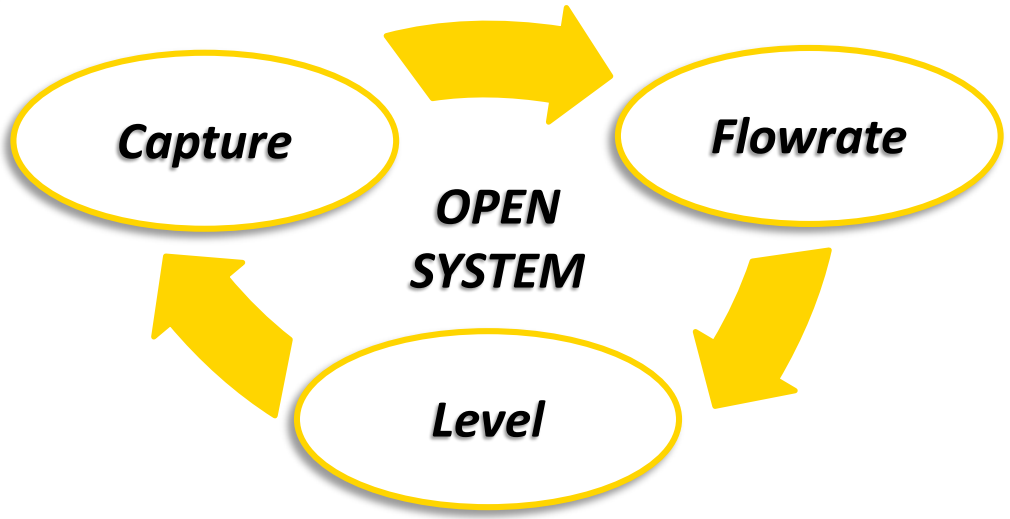
Level control: a tricky task



Small volume: *separator can be completely emptied in 20 sec at design flowrate*

A stable level guarantees the best capture and separation performance

Proportional valves on the ceiling of the separator continuously variate their opening to maintain the liquid/gas interface within design limits

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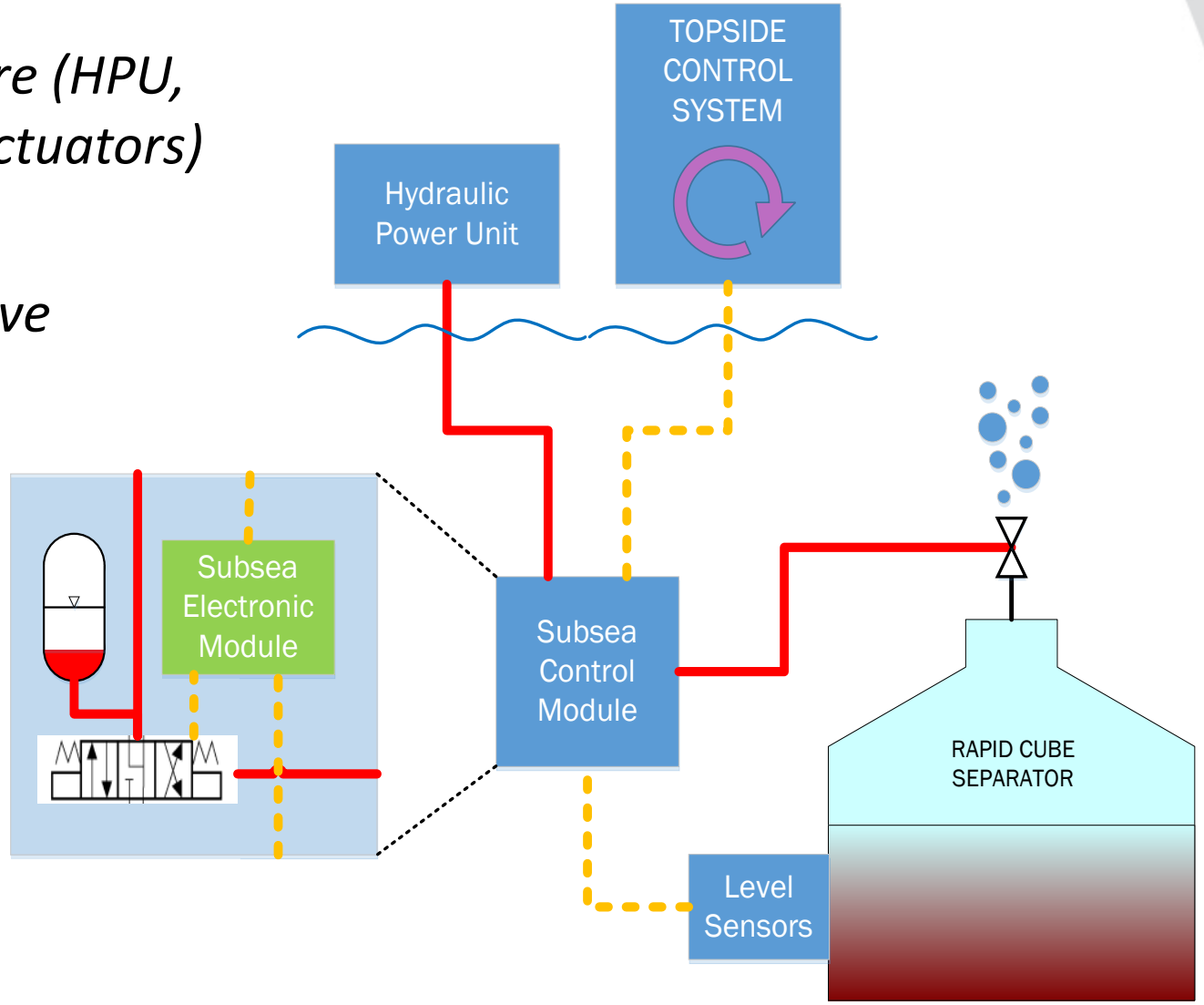
Level control system – Electro-hydraulic implementation

- *Standard electro-hydraulic architecture (HPU, directional control valves, hydraulic actuators)*
- *Topside control system to manage valve positioning and level control together*
- *The control loop rate has to meet the requirements of the most demanding system to control (i.e. valve positioning)*

SUITABLE FOR HIGH FORCE REQUIREMENTS AND SLOW ACTUATIONS



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Electro-hydraulic implementation - limitations

Limited accuracy and speed

Actuation speed depends on the HPU pressure while accuracy depends on the DCVs switching rate

To preserve position accuracy at higher speeds, the DCVs shall be able to switch at higher rate

Poor continuous operation performance

Local accumulator inside the SCM improves readiness but prevents continuous operation (time to refill)

DCVs are qualified to guarantee a minimum number of commutations, but the operative life of Rapid CUBE exceeds this design figure

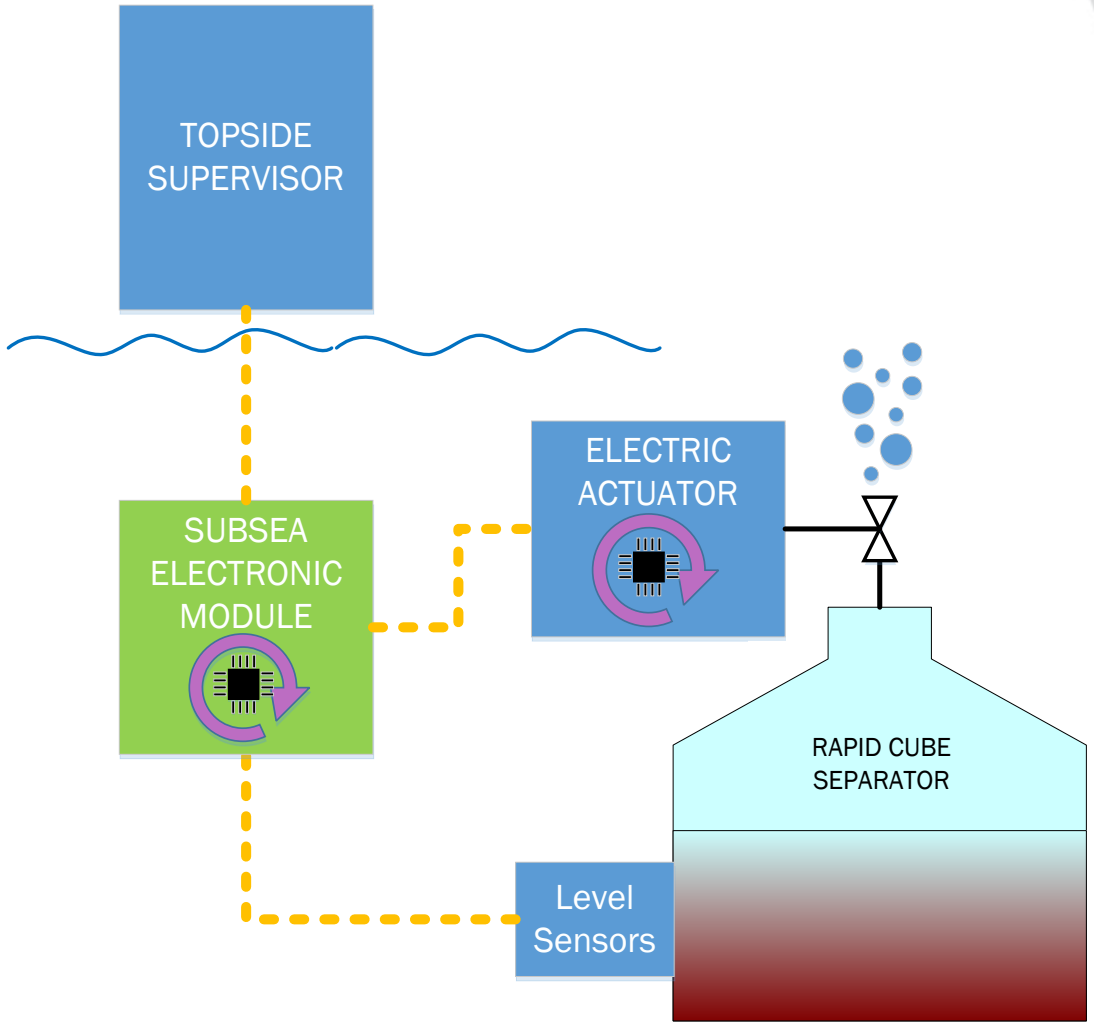
Complexity

The implementation requires HPU, umbilicals with hydraulic control lines, DCVs, local accumulators, etc.

Level control system – all electric implementation

- *All-electric architecture based on emerging electric actuation technology*
- *Topside supervisor is used only for monitoring and update of main control settings*
- *Control loops are closed subsea, by the actuator driver (valve position) and by the Subsea Electronic Module (separator level)*

SUITABLE FOR LIMITED FORCE REQUIREMENTS AND QUICK ACTUATIONS



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All electric implementation - benefits

Higher customization

The two control loops can be independently configured based on the two different processes they have to control

Readiness

Electric actuation is faster, closure of control loops subsea minimizes delays and improves stability

Simplicity

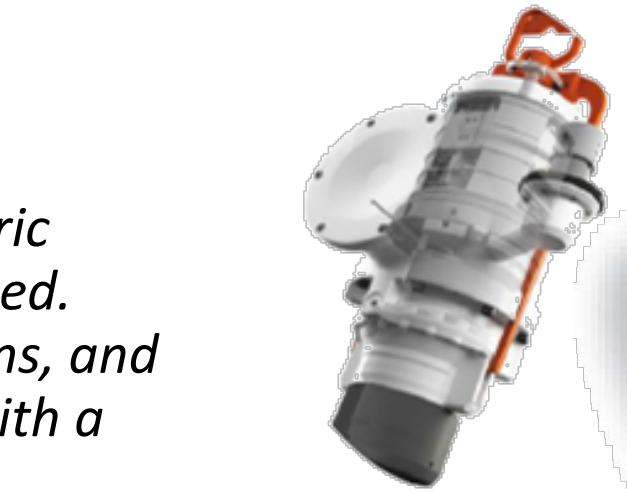
Hydraulic system and ancillaries are not required, a simple power cable is necessary (power <1kW)

Very good continuous operation performance

Electric controls are less prone to wear for continuous switching

Subsea electric actuation in the market

The potential advantages and cost savings of all-electric subsea production systems are industry-wide recognized. Hence, many actors are developing all-electric solutions, and confidence is being established over time in parallel with a successful track record



Nevertheless these actuators generally are:

- *not designed for fast process controls*
- *integrated in a turn key solution*
- *designed for high force applications, hence bulky*

In consideration of Rapid CUBE specificity and to optimize its performance, a solution from the subsea vehicles market has been selected for the implementation

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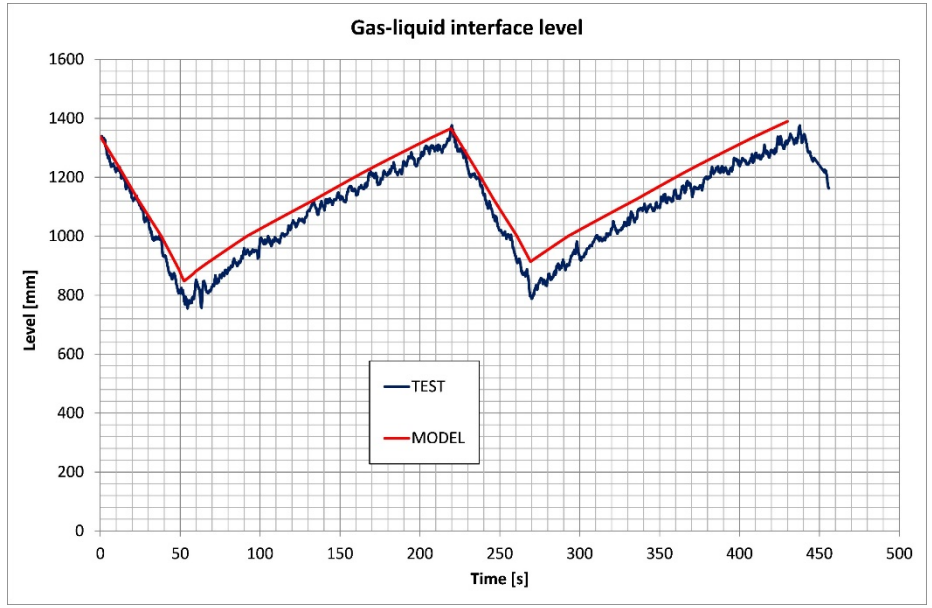
Level control system tuning and lab testing

- *During Q2 and Q3 2018 the control system will be tested on a scaled down model in a low pressure test tank in TEA Sistemi laboratory*
- *Test purpose is to validate control strategies and tune parameters against a variety of situations*
- *Test results will also validate the use of the Rapid CUBE lumped parameter model, developed during previous test campaigns, as predictive tool to simulate incident strategies*



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Full scale system dockyard test

A dockyard test campaign on the Rapid CUBE system is planned for Q4 2018

Dockyard test purpose is to:

- *compensate for hydrodynamic scale effects*
- *validate the integration of the new control system with the existing hardware*

Development of Rapid CUBE real-time level control system will be a major technical step towards subsea all electric process control systems

MCEDD
DEEPWATER DEVELOPMENT
MILAN MARRIOTT HOTEL • MILAN, ITALY • 9-11 APRIL 2018

Thank You

Authors wish to thank Eni and EniProgetti for the opportunity to present this paper

We want to thank all the colleagues in Eni, EniProgetti and TEA Sistemi who supported the project with their expertise and dedication

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