Open Source Architectures Development for Subsea Factory
Operator’s expects increased subsea systems complexity, due to high degree of technical challenges to find feasible and/or economically viable solutions. Future scenarios being:
– fields that are marginal or in deep water or in remote areas;
– long step out distances from host facilities or from shore.

Subsea processing equipment are integrated in a so called “Subsea Factory” to:
– allow or enhance the hydrocarbon production or
– to reduce the topside process facilities.

Various Building Blocks provides the functionalities & support functions to enable the implementation of cost-efficient field development concepts. The targets being:
– short term: brownfield subsea factory;
– medium and long term: subsea-to-host; extended reach; deep water; heavy oil; arctic.

Subsea Factories design targets: achieve reliable operation; life extension of existing production systems; IOR from subsea wells; access to new areas; standardization to increase utilization; reduce delivery times & life cycle costs.

Objective: “open source architectures” through the “SUBSEA BUS & standardization principles, integrating a system independent from any proprietary products/equipment and exclusive interfaces.
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SUBSEA PROCESSING - KEY DRIVERS & ATTRIBUTES: THE ...ILITY

CLIENT’S ULTIMATE GOAL

COST: Minimized lifecycle cost (CAPEX and OPEX)

UP TIME:
• Reliability
• Availability

CHANGEABILITY REQUIREMENTS
• Interchangeability
• Re-configurability
• Expandability

INSTALLATION & IMR REQUIREMENTS
• Installability
• Inspectability
• Retriveability

Key drivers governing the subsea system configuration

- changeability: allowing expansion or re-configuration, in response to performance requirements changes (through modularization)

- robustness: maintaining production up-time (through redundancy, IMR practices,...)

- sustainability: containing life cycle costs while complying with constraints and future development (through interface standardization)
THE BASIC QUESTIONS

✓ Can we establish an inclusive industry standard?
✓ Can we achieve plug and play?
✓ What requirements shall we align on?

THE ROAD MAP

- to develop an open source system architecture,
- to provide a full cycle system integration capability,
- be independent from any products, proprietary technologies, exclusive interfaces,
- managing interfaces by inclusive industry standard,
- leveraging on the supply chain to the maximum extent possible,
- mastering process and system integration,
- standardisation of interfaces: inclusive vs. exclusive,
- control of certain building blocks.
THE PHILOSOPHY: THINKING OUT OF THE BOX

- redefine system architecture to achieve standardization of modules and interfaces through open source approach,
- define the minimum number of functional building blocks covering the different factories requirements,
- standardize functional building blocks within the different subsea factories vs. number of interfaces reductions and optimization,
- characterize the functional building blocks to fit state-of-the-art of the supply chain and future evolution of equipment and technology,
- distributed control system at building block level (slave) and bus level (master) with standard interfaces and protocol,
- distributed power transportation system with dedicated building blocks & standard interfaces.
OPEN SOURCE ARCHITECTURE BY “STANDARD BUILDING BLOCKS”

Open source configuration and plug & play made possible by:

- functional building blocks configurations, conceived and optimized to fit with the selected overall architecture principles, valid for all the subsea factories,

- the whole concept allows for functional building blocks interfaces optimization, in view of frequent IMR tasks:
  - location and configuration vs. subsea operation,
  - reduction of their number vs intervention time.

- standardized functions and interfaces at building blocks level,

- what is project specific is confined into a bespoke SUBSEA BUS,

Standard installation & IMR procedures consequently simplify the offshore & subsea operations and reduce the associated risks.
Functional Building Blocks Families: product types associated to specific attributes, quantitative duties & maintenance requirements: e.g. Pump (Liquid or multiphase), Compressor, Scrubber, Cooler, SCM;

Interfaces are standard as per nature of fluids, power requirements, chemical injection, field architecture: e.g. Separator, Manifold, SDU, EDU;

Families become a catalogue containing a number of standard functional building block sizes covering the whole envelop of requirements;

Interfaces between functional building blocks and the connecting subsea system are imposed to any project;

The bespoke element to be designed as “project specific” is the SUBSEA BUS;

SUBSEA BUS features:
- The same Functional Building Blocks can be accommodated in different architectures;
- Incorporates the distribution system for process, chemicals, service fluids, control;
- Allows significant reduction of interfaces with the retrievable functional building blocks;
- Integrates manifolding functions including inlet and outlet facilities;
- It is integrated and tested onshore before deployment.
CONTROL SYSTEM  OVERALL ARCHITECTURE

L3 - System/Process Control level: Distributed Open source architecture based on SUBSEA BUS modularization and standardization

L2 - Module control level: Distributed Open Source architecture based on SUBSEA BUS modularization and standardization

L1/L0 - Equipment and Sensor control level: SiiS

LEGEND:
- Module CU: Control Unit (potentially coming from different vendors)
- SUBSEA BUS Control: SUBSEA BUS, integrator control system
- Communication with topside equipment
- Ethernet based subsea communication network
- Fieldbus, subsea bus network
STANDARDIZATION & PROJECT EXECUTION PHASES LOGIC PATHS

- From PFDs
- Technology Status & trend

Attributes:
- System sizing
- Mainten. frequencies
- IMR requirements
- Interfaces optimization

- Families Catalogue
- Standard IMR Procedures
- Standardization Specifications

Outcome of the standardization Process

Equipment & Components → Functional Building Blocks → Blocks & Interfaces Standardization

Standardization Project Execution

From CATALOGUE

- Project specific
- Input: standardization specs.

- Project Design Premises
- Project Design Activities

- Functional Building Blocks Selection
- Functional Building Blocks Supply

- SUBSEA BUS Design
- SUBSEA BUS Supply

- System Integration
- Installation & IMR

Input: standard procedures from CATALOGUE
EXAMPLES OF FACTORIES WITH OPEN SOURCE ARCHITECTURES

- Subsea Separation
- Subsea Compression
- Subsea Boosting
Saipem Current Developments in Subsea Processing:

- **Subsea Gas/Liquid separator:** Multipipe
- **Subsea Liquid/Liquid separator:** SpoolSep
- **Subsea Seawater treatment:** SPRINGS®
SPRINGS SIMPLIFIED BLOCK FLOW DIAGRAM & TYPICAL FIELD LAYOUT

Water intake

Feed pump

Coarse Filter

Water Injection Pump

Nanofiltration

Water Injection wells

Disposal line

To water injection wells

Disposal line

Sea Water Intake System

Sea Water Disposal Line

Sea Water Injection Line

Power & Control Umbilical

UTA

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SPRINGS ® SUBSEA ARCHITECTURE vs. SUBSEA BUS CONCEPT
CONCLUSIONS

Open source architecture & standardised functional building blocks selected from catalogue allow:

- optimization & simplification of subsea factories vs. installation and IMR:
  - Standardization of functional building blocks;
  - Reduction and simplification of subsea interfaces;
  - Simplification and Standardization of subsea intervention procedures.

- expandability and changeability requirements:
  - Functional building blocks replacements with others from different suppliers;
  - Changes of functional building blocks with others of different duties or functionalities.

- “unlock” the supply chain:
  - Be independent from suppliers;
  - Promote the use of the best technologies available or their development.

- system integration being independent from any proprietary products or equipment and exclusive interfaces:
  - Different suppliers can supply the various functional building blocks;
  - A System Integrator Contractor can be responsible for the system & interface EPC activities.
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Thank You For Your Attention

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Questions ?