Innovative Telescopic Joint to Simplify Connection and Disconnection of Subsea Modules

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Saipem

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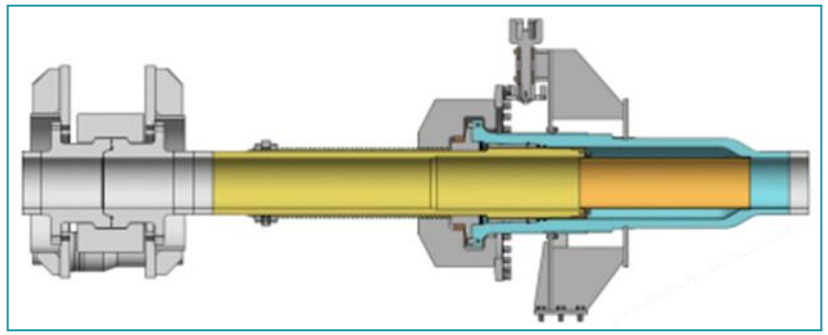
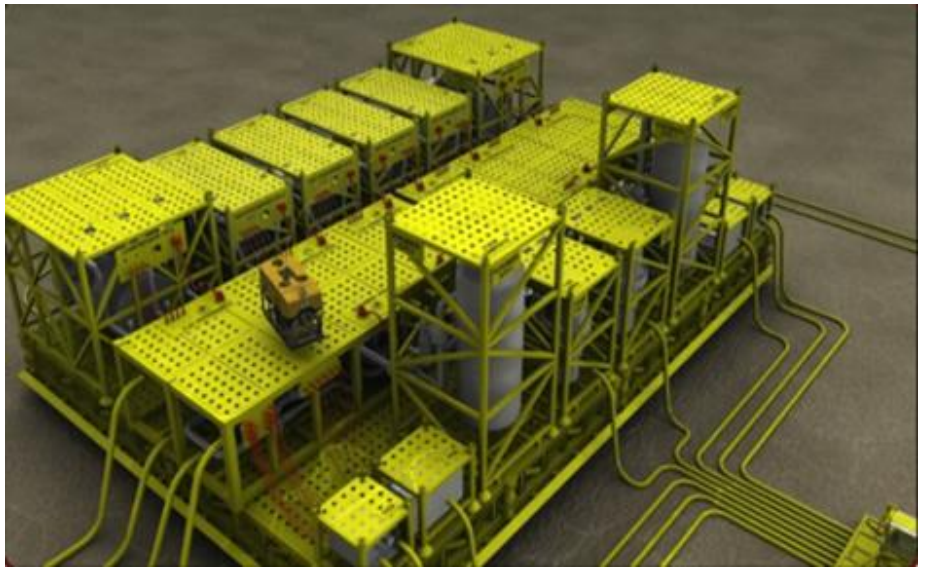
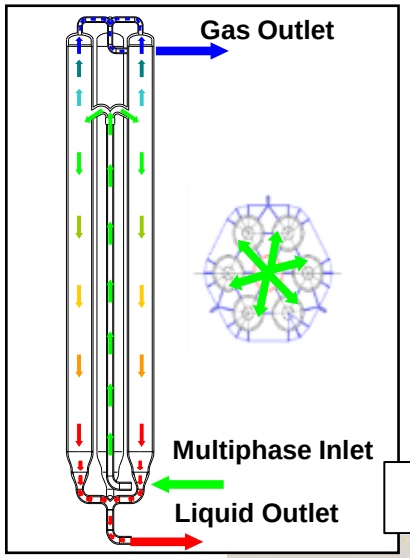




Background

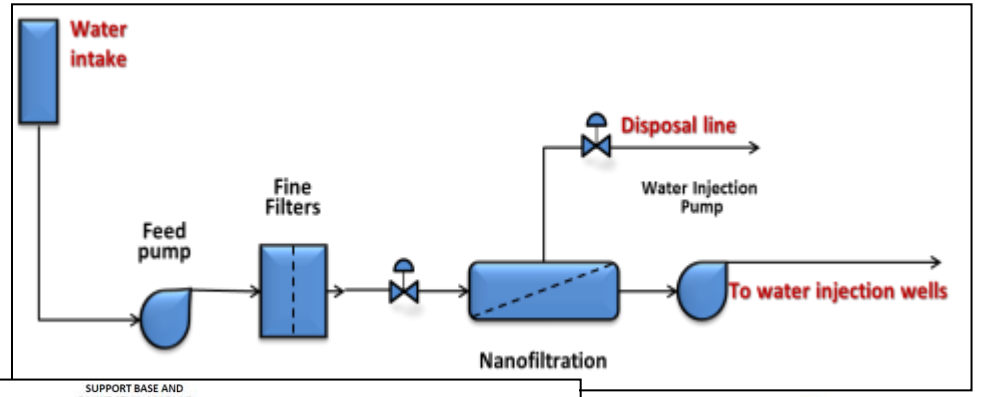
- **Subsea fields architectures are becoming more complex** integrating also subsea processing functions **in view of developing more challenging fields and/or to reduce the development costs**
- **Saipem is developing new subsea processing technologies which require modular architecture** of the subsea field **allowing easy and fast equipment maintenance**
- The need for more complex/modular subsea fields respect to the conventional approach highlights a **gap in the market for the subsea connection systems**
- The ***Telescopic Joint,*** incorporated in an **innovative connection system solution**, under development by Saipem, covers the gap and will support the modular field architecture

Saipem Subsea Processing Experience & Ongoing Activities

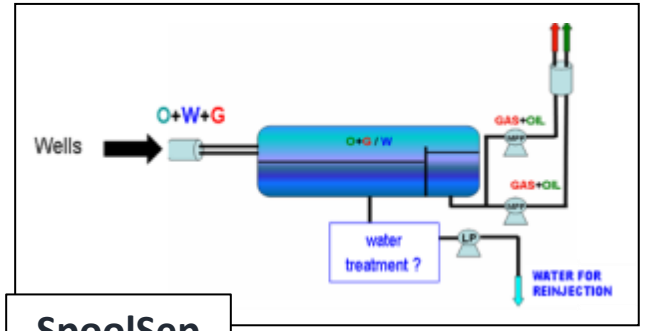


Saipem Current Developments in Subsea Processing:

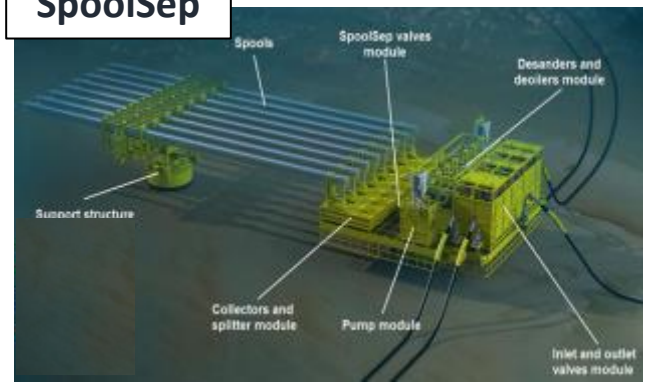
- Subsea Gas/Liquid separator : **Multipipe**
  (JIP Development completed. Studies on particular applications ongoing)
- Subsea Liquid/Liquid separator : **SpoolSep**
  (Development through JIP still ongoing)
- Subsea Seawater treatment : **SPRINGS®**
  (Industrialization activities ongoing – completion planned in 2019)

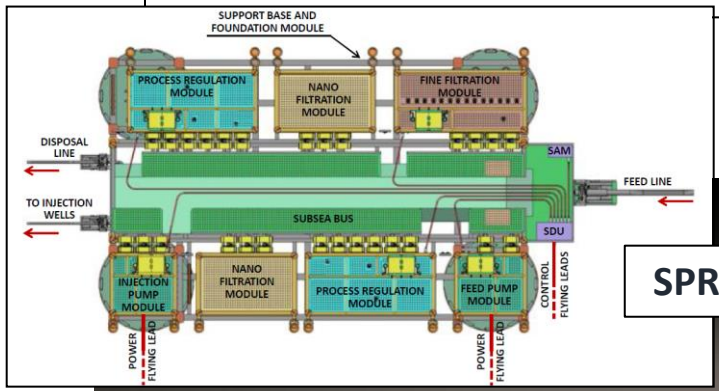


Multipipe

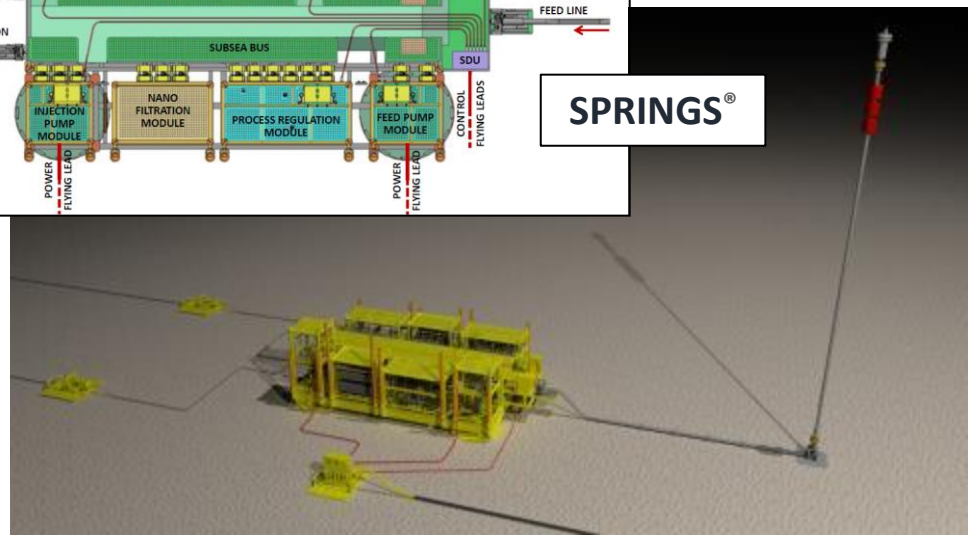


SpoolSep





SPRINGS®



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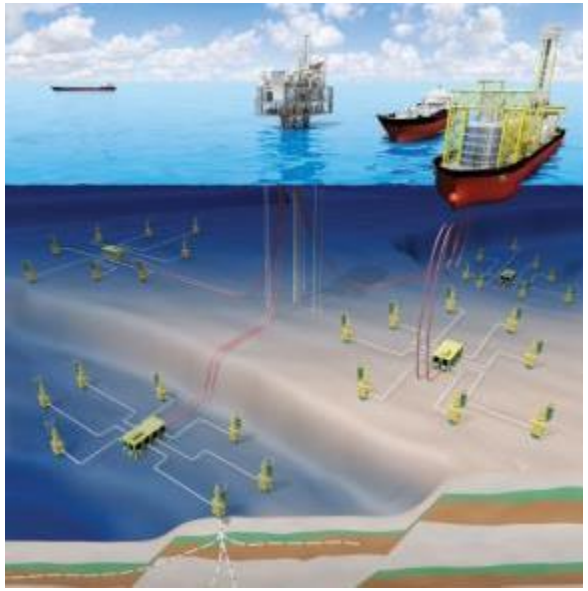
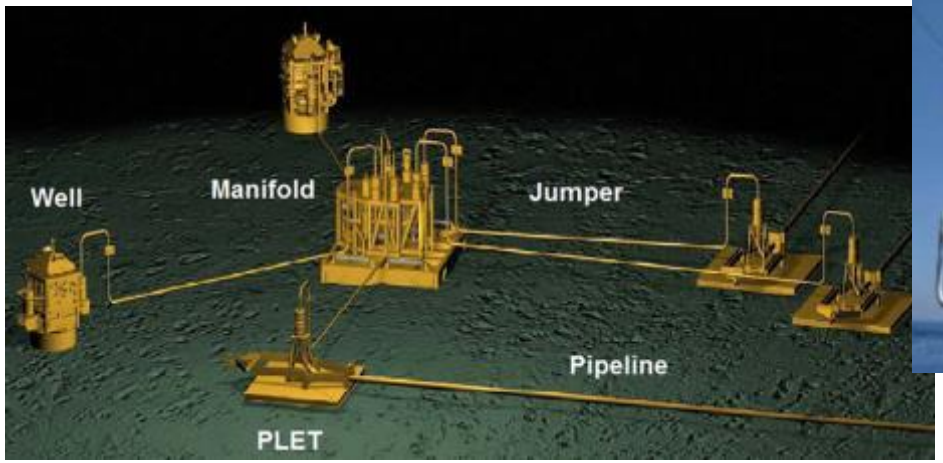
Innovative Telescopic Joint to Simplify Connection and Disconnection of Subsea Modules
Authors: F. Lucchese, A. Radicioni, G. Toso, D. Lazzarin – Saipem SpA

Considerations on Conventional & Complex Subsea Fields



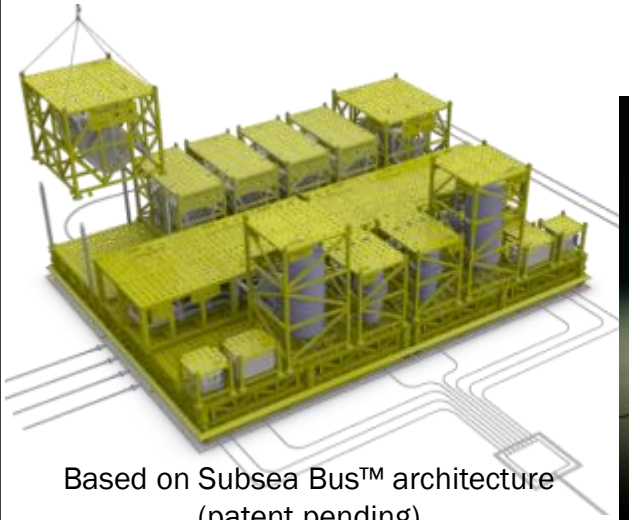
Conventional Subsea Fields

- Designed to work for the **whole field life without maintenance**
- **Heavy modules** to be deployed by construction vessel
- **Few independent modules & connections** to be performed during installation
- **Connections through Jumpers** that assure the needed flexibility

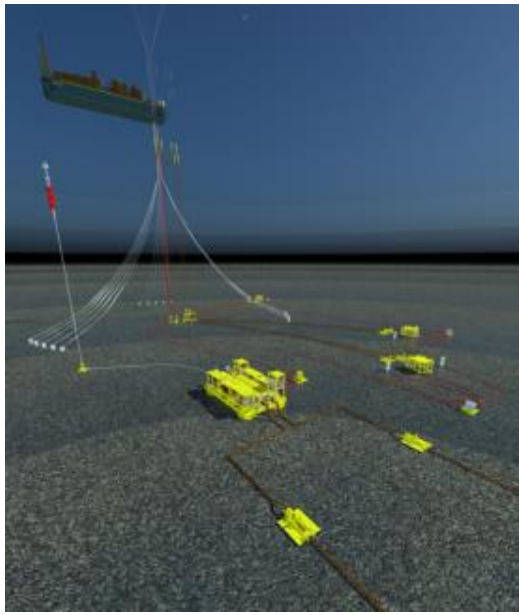


Complex Subsea Fields

- Designed for **frequent maintenance** due to active subsea equipment
- **Light modules** to be deployed by support vessel of opportunity
- **High number of small modules & connections** frequently operated
- **Module to module connections** to reduce the number of connections

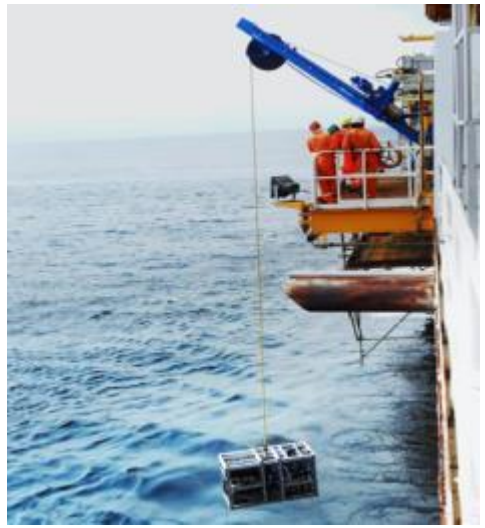


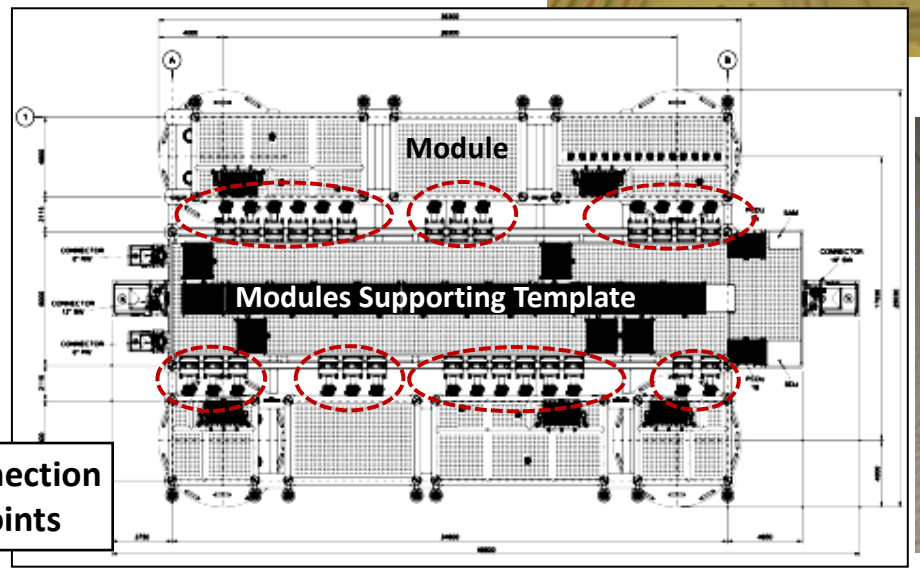
Based on Subsea Bus™ architecture (patent pending)

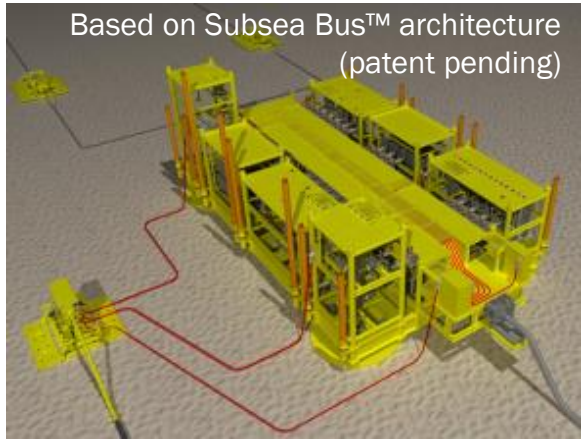


Requirements for Complex Subsea Fields Architectures

- Active and/or sophisticated subsea equipment needs **frequent maintenance** (modules recovery)
- Maintenance cost reduction calls for **small support vessels** and fast subsea intervention procedures
- Vessel limitations, due to IMR market, set the maximum **single module weight** in water to 70 t
- Requirements due to IMR and modules retrievability dictate the **modularization** philosophy
- **Subsea architecture** can consider **distributed** (independent modules connected by jumpers) **or concentrated modules** (several modules on the same supporting template)
- **Frequent process connections & disconnections** requirement (for modules recovery) call for selection of:
  - **concentrated subsea architecture,** which reduces the number of connections
  - **module to module connection** solution

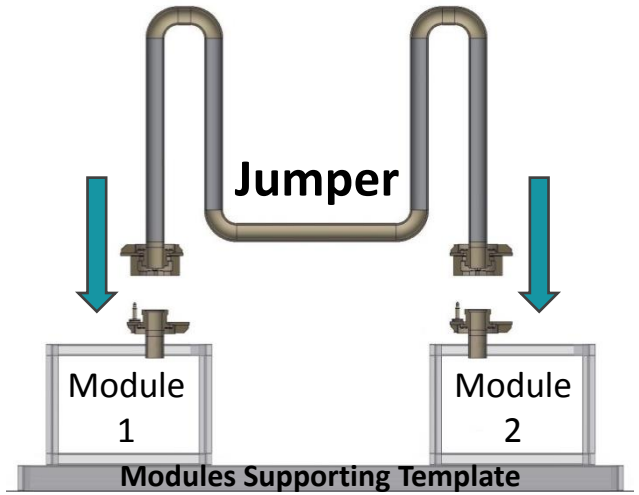




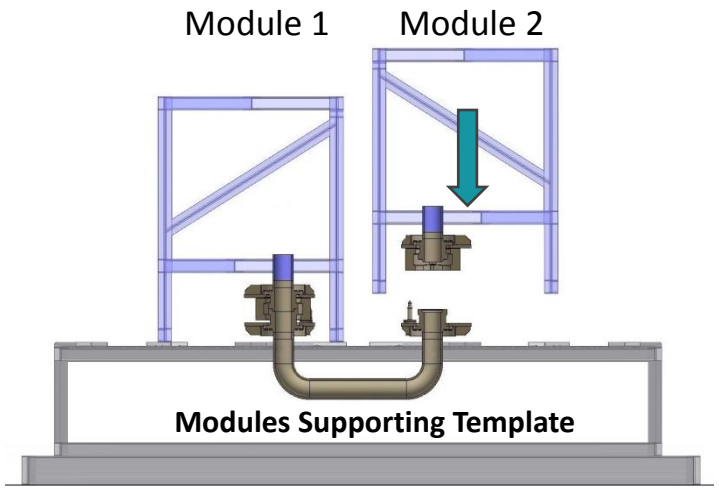


Connection Methodologies Evaluation

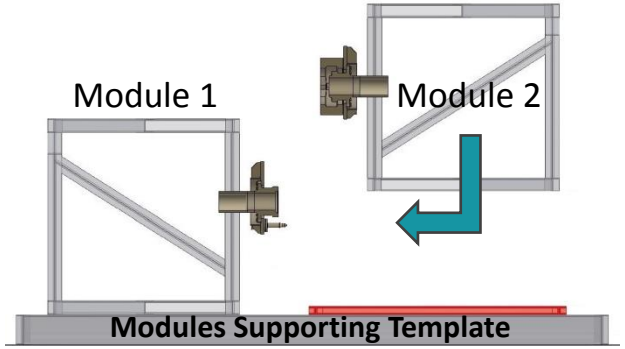
- Process connection operations requires **flexibility** to close the connector (typically ≃500 mm for protection cup, sealing change, etc.)
- Module to module process connections flexibility in a concentrated architecture can be provided with:
  - **Jumper connection** that, for each connection, requires two connectors and a massive modules supporting template
  - **Vertical connection** with high number of connections can be problematic due to weather conditions & to limited ROV accessibility
  - **Module sliding** (with horizontal connection) is a complex operation, needs complicated modules-template interfaces, can be problematic for big modules and is time consuming
  - **Piping flexibility** means to increase a lot the modules supporting template dimensions & weight and could be not feasible for piping diameter > 6" - 8"
  - **Telescopic Joint** coupled with standard connector solves the challenges of the other connection methods

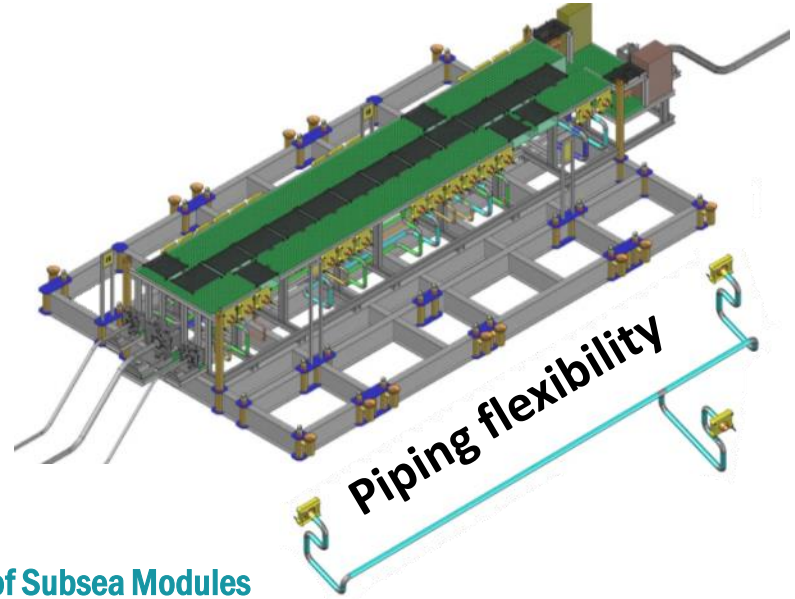


Vertical connection



Module sliding

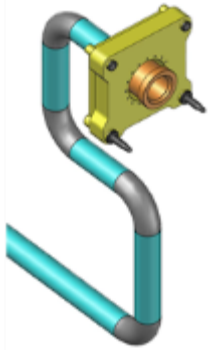


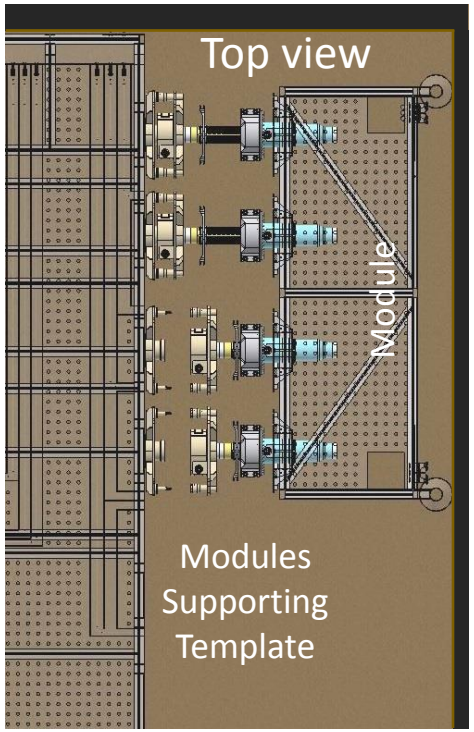


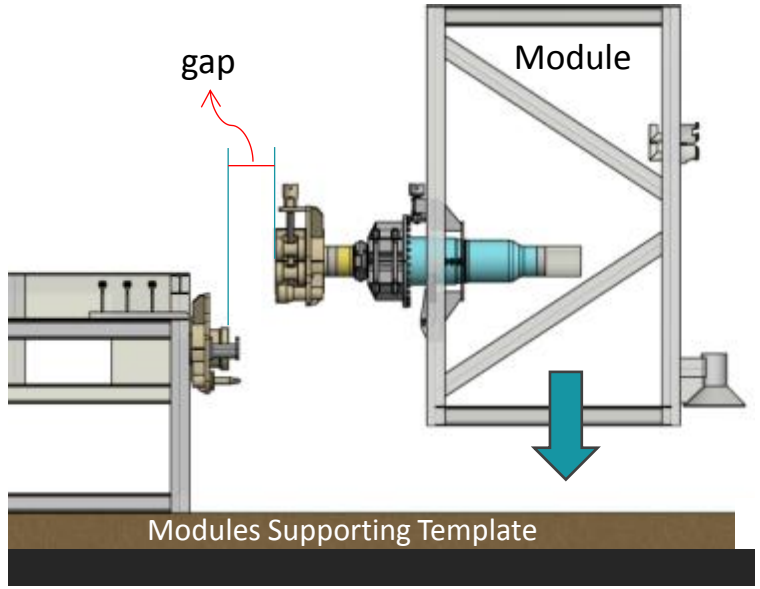
Telescopic Joint Benefits

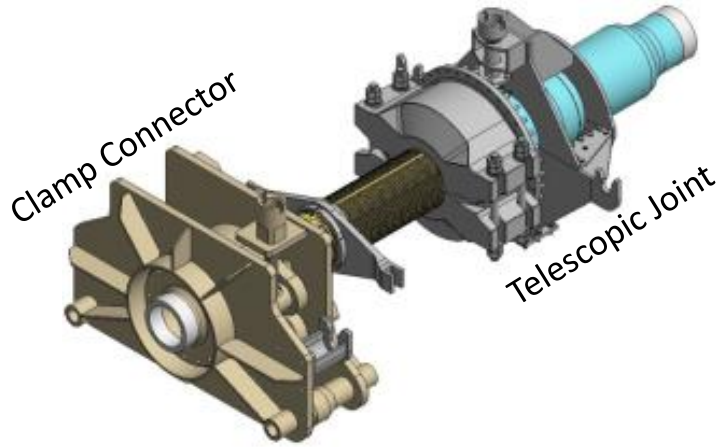
- Suitable for concentrated architecture (several modules on the same template)
- Allows the connection covering the gap between two modules piping (typically ≃500 mm for protection cup, sealing change, etc.) avoiding modules sliding or big piping flexibility
- Requires low flexibility of connecting pipe, even for large pipe diameters (e.g. by means of goose-neck shape), just to cover installation tolerances (typically in the order of ≃20 mm)
- Allows independent mating & back seal test of all connectors in the same module. Not possible with module sliding and vertical connection
- Telescopic Joint designed for 25 years without maintenance
- The telescopic joint can be retrieved with the module (in this event the seals are changed)
- Designed to be remotely operated by standard ROV torque tool (after module installation)

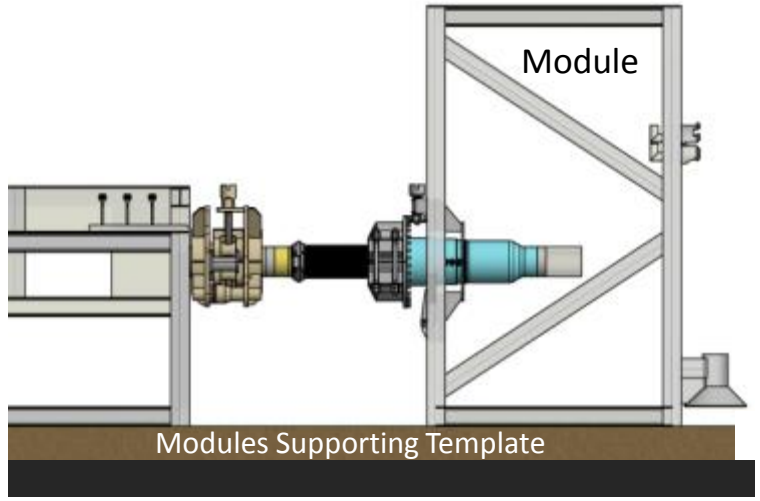
Goose-neck pipe example



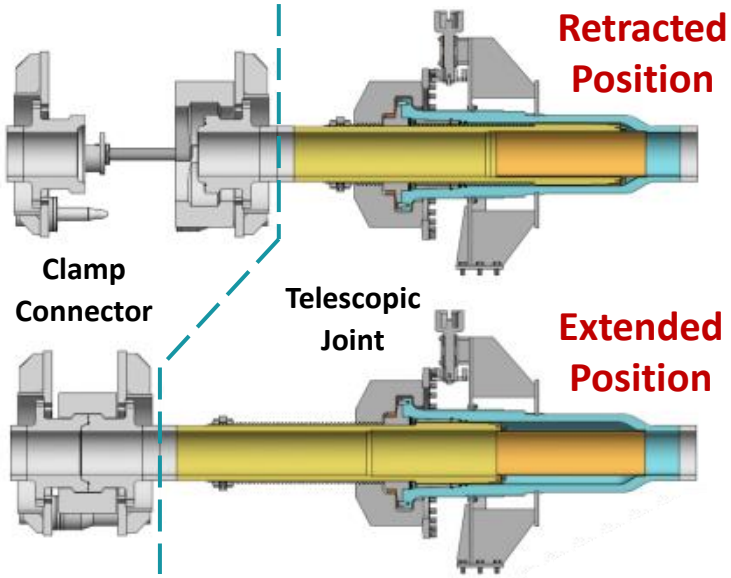


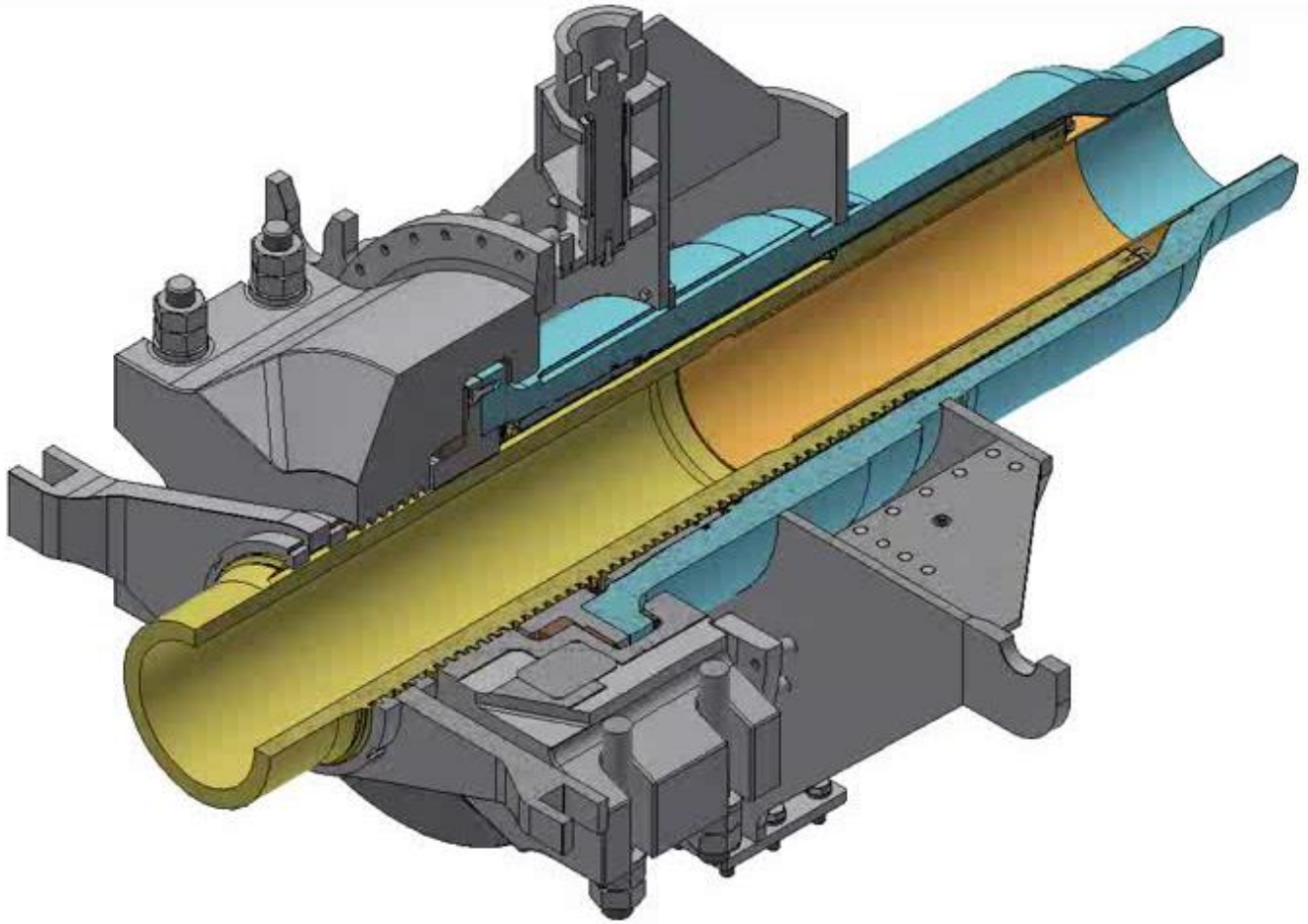






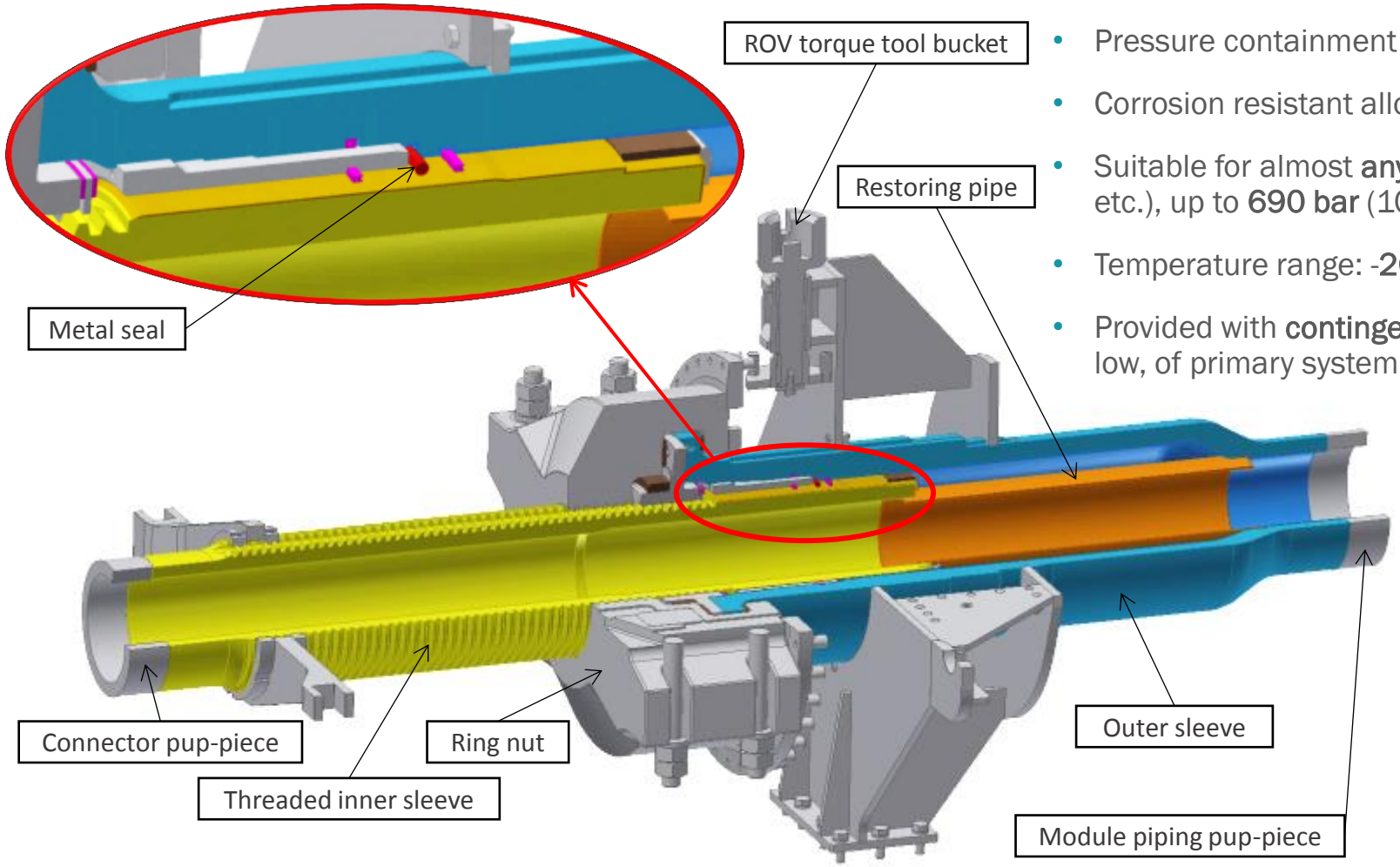
Telescopic Joint Overview





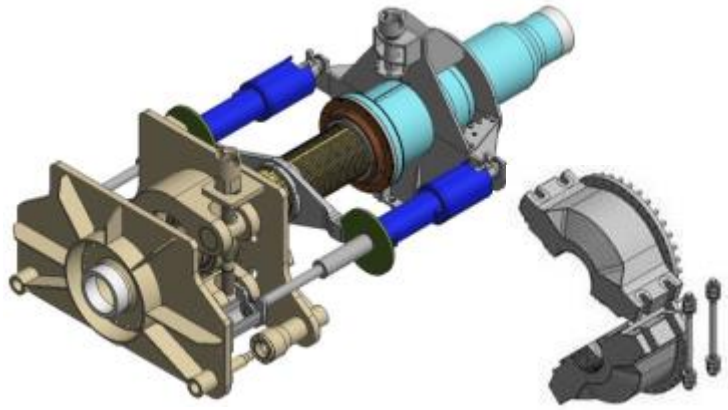
- **Patented** system (patent pending)
- Developed for **diameters** in a **range** of **4” – 14”**
- Full stroke ≃**700 mm**
- Seal active in the last ≃150 mm of the full stroke
- Capable of restoring the pipe structural integrity
- Optimized to reduce its weight at the minimum allowing for reliable connection

Telescopic Joint Description, Peculiarities and Challenges



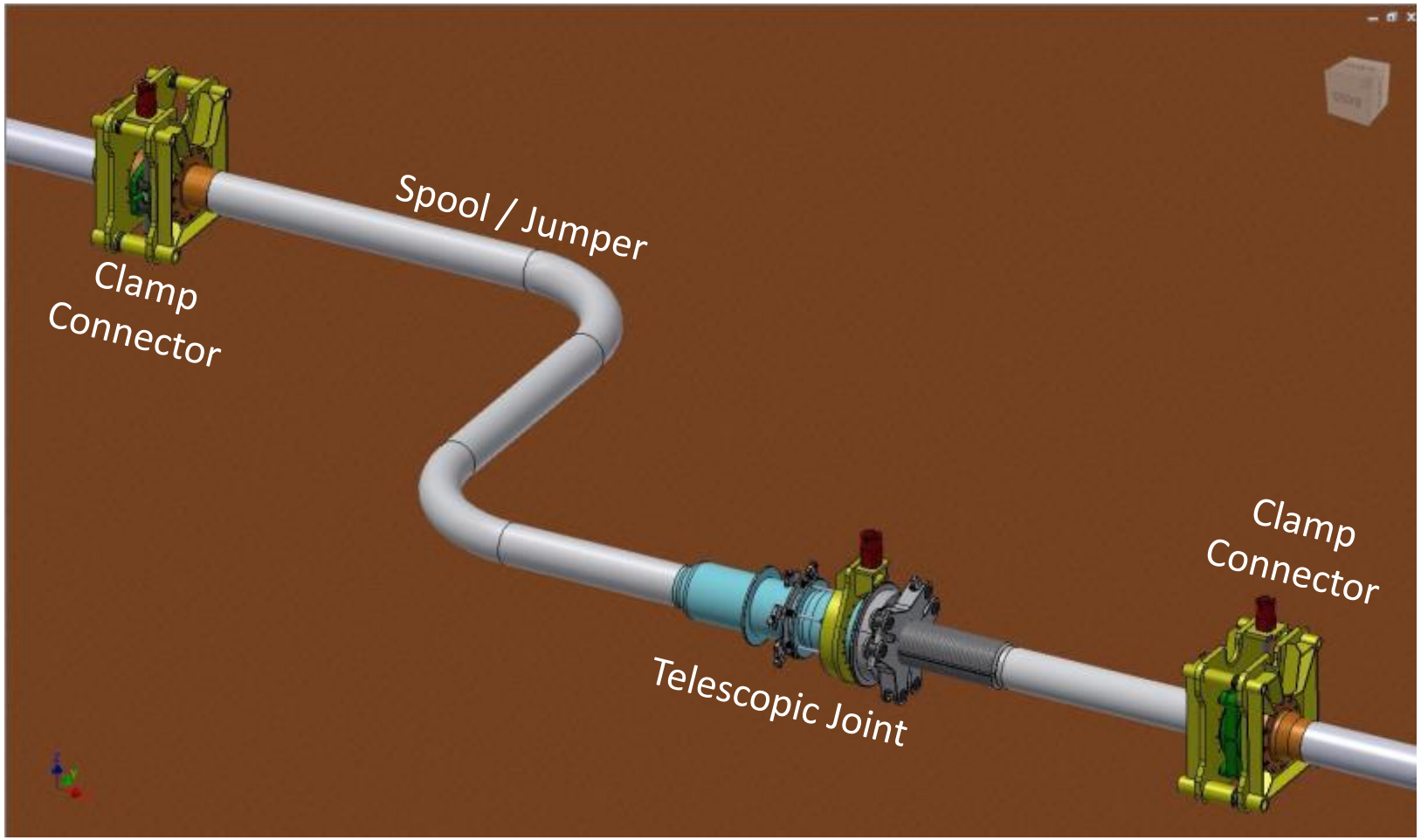
- Reliable **threaded mechanism** to extend/retract
- Pressure containment achieved by **metal-to-metal seal** (self activated)
- Corrosion resistant alloy (**CRA**) on surfaces wetted by process fluid
- Suitable for almost **any fluid** (e.g. seawater, sour hydrocarbons, gas, chemicals, etc.), up to **690 bar** (10k PSI) and down to **3000 m water depth**
- Temperature range: **-20°C to 150°C**
- Provided with **contingency disconnection system** to mitigate the risk, though very low, of primary system jammed/obstructed by corrosion or marine fouling

Contingency disconnection



Telescopic Joint Use for Other Potential Applications

- The telescopic joint gap recovery capability is useful, especially for large diameters & in different subsea applications with the benefit of:
  - optimizing the subsea layout
  - reducing overall dimensions/weight of pipes & spools
  - reducing the forces to close the connector (low demanding requirements for connection system)
  - potential reduction of metrology requirements for jumpers
- Potential applications being:
  - Jumpers connections for flowlines
  - Pipeline repair spools



Telescopic Joint Development Status

Main targets

- Technology Qualification to get TRL 4 of API 17N
- Type Approval Certificate by DNV in accordance to API 17D and 6A covering size and pressure ranges shown in the below table:

Nominal Pipe Size	max Rated Working Pressure [bar (psi)]	
	345 (5000)	690 (10000)
4"		
6"		
8"		
10"		
12"		
14"		

- Qualification will cover the following materials
  - carbon steel with CRA inner coating
  - super-duplex steel

Plan

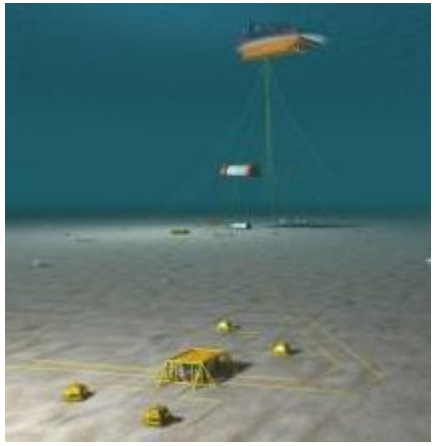
- Design and Qualification Basis definition
- Basic Engineering
- Technology Assessment with DNV
- Metal Seal screening tests
- Qualification Test Plan definition
- FMECA with DNV
- Detail Engineering
- 6” and 12” Prototype Fabrication
- Seal Qualification Test
- Telescopic Joint Qualification Test

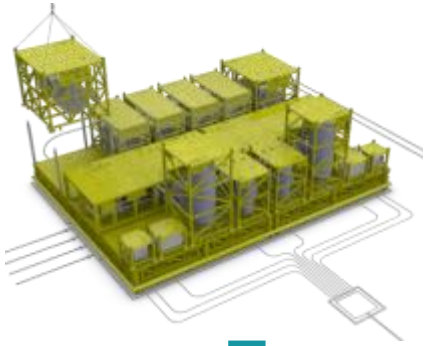
Progress

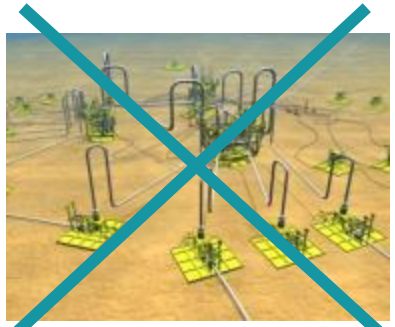
Planned development & qualification activities completion in first half of 2019

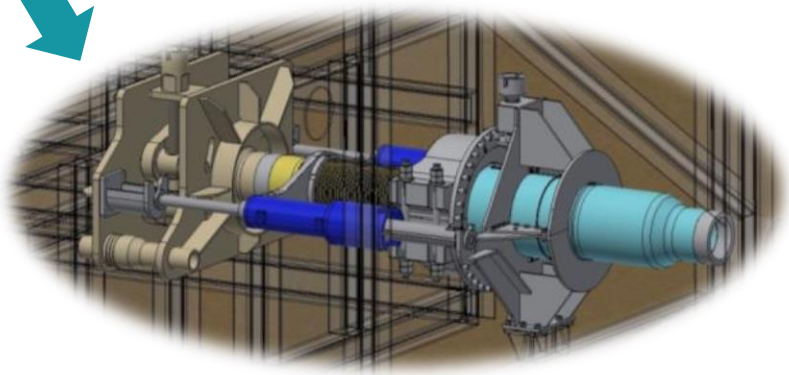
Summary & Conclusions

- **Subsea fields architectures are becoming more complex** integrating also subsea processing functions **in view of developing more challenging fields or to reduce the development costs**
- **There is the need for frequent maintenance due to subsea processing systems with active components** like pumps, separators, compressors, heat exchangers and of the relevant auxiliaries
- Consequently **the subsea production system has to be conceived with an high number of small modules easy retrievable with vessels of opportunity**
- **These modules have to be independently connected & disconnected subsea** during installation & maintenance and **normally require a number of connections** to be performed
- **Saipem**, during development of its subsea processing technologies, (SPRINGS®, Multipipe & SpoolSep) **recognized that the currently market available connection systems do not allow for efficient, reliable & cost effective intervention procedures**
- **Saipem is developing its own solution**, suitable for conventional & complex architectures, integrating a standard connector with **an innovative Telescopic Joint**









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