Arthur D Little

Viewpoint

E&P cost reduction through systematic technology assessment and roadmapping

A case study in subsea technology identification, roadmapping and aggressive deployment

Cost reductions achieved by adopting new oilfield technologies are critical to improve the resilience of Exploration and Production margins, especially for subsea assets. However, new cost-effective technologies can only be deployed successfully with sustained and targeted R&D efforts. In this viewpoint, Arthur D. Little shows how new ways of engaging and working with technology suppliers to create technology roadmaps in one particular technology area – the subsea arena – helped to significantly reduce costs by phasing emerging technology deployment to allow technologies to mature and be deployed later along the roadmap.

The oil-price environment

The oil and gas industry has been subject to strong fluctuations in crude oil prices, with the price of Brent Crude dropping from $110/bbl in 2014 to $30/bbl in early 2016. Since then, prices have recovered, but this has highlighted the need for cost reduction to improve operational resilience. To deliver the many new development projects anticipated over the next five to 10 years in an economically viable manner, a new approach is required for the development and deployment of new technologies that can achieve sharp reductions in capital and operating costs.

A drive toward cost reduction

These cost pressures are especially felt in subsea production, an area characterized by higher initial investment and operating costs than any onshore counterpart. The trends within this segment are towards developments further from shore and away from existing production structures.

The greater investments required for these offshore developments has resulted in operators pursuing aggressive technical cost reduction strategies, which include:

1. **Use of existing structures** (e.g., an already-operational FPSO) with long tiebacks to the production area to eliminate the need for new topside facilities. This strategy may be limited by the availability of space on the existing platform, vessel and connecting lines.
2. **Increased use of subsea processing equipment,** e.g., using subsea boosters to pump oil/gas longer distances, and so facilitate longer tiebacks to existing structures or shore.
3. **Reduced diameter chemical and control umbilicals** by lowering the need for some of their functions or moving equipment subsea, closer to the well.

Umbilicals comprise a substantial cost element in any new off-shore asset development, and their budget impact increases as tiebacks become longer. In the case of a 50 km tieback, a conventional umbilical could account for 5 percent of the overall project cost (excluding drilling & completion).

As a result, oil companies are assessing ways of reducing dependency on umbilicals by moving more processes subsea, freeing space on the existing platforms and deploying smaller, cheaper equipment topside.

Cutting the cord – Towards umbilical simplification

Chemical and control umbilicals in offshore assets provide four main functions of oil & gas production systems:

1. **Electrical power:** to subsea equipment with varying power requirements (e.g., subsea control systems, pumps, compressors).
2. **Hydraulic power:** used to actuate subsea valves and provide barrier fluids required by subsea pump systems

3. **Communication:** used to communicate production data such as temperature and flow rate – also for monitoring, control and safety processes.
4. **Chemical injection:** used to provide chemicals required for hydrate formation prevention, wax solidification prevention, oil fluidization, asphaltene flocculation prevention, corrosion control and scaling control.

Subsea umbilicals provide a range of disparate functions that cannot be completely eliminated or replaced. However, ADL analysis shows that there is substantial commercial benefit to be achieved from simplifying umbilical functions, as well as from partial removal.

Simplification can be achieved using a number of technologies which wholly or partially replace the umbilical function. In our structured approach to scanning the subsea technology landscape, we have identified a range of innovative enabling technologies under development, which could support the objective of umbilical cross-section reduction.

1. **Power:** subsea power distribution (SPD) systems to simplify power umbilicals and subsea power generation and/or subsea energy storage to remove the connection altogether.
2. **Hydraulics:** removing hydraulic-power and barrier-fluid needs from all-electric equipment, e.g., electric actuators and pumps that do not require barrier fluids ("topside-less").
3. **Communication:** subsea wireless communication (SWC) as a means to rationalize expensive infield and tieback communication and power lines.
4. **Chemical injection:** flowline heating by active thermal management (ATM) reduces the need for flow assurance chemicals by heating production lines. Subsea chemical storage & injection (SCSI) systems can eliminate the need for chemical umbilicals by moving storage and boosting systems for all chemicals near to the well subsea.

The time needed for these technologies to be available for deployment depends on their technology readiness levels (TRLs), which represent how developed and reliable a technology is (in below illustration).

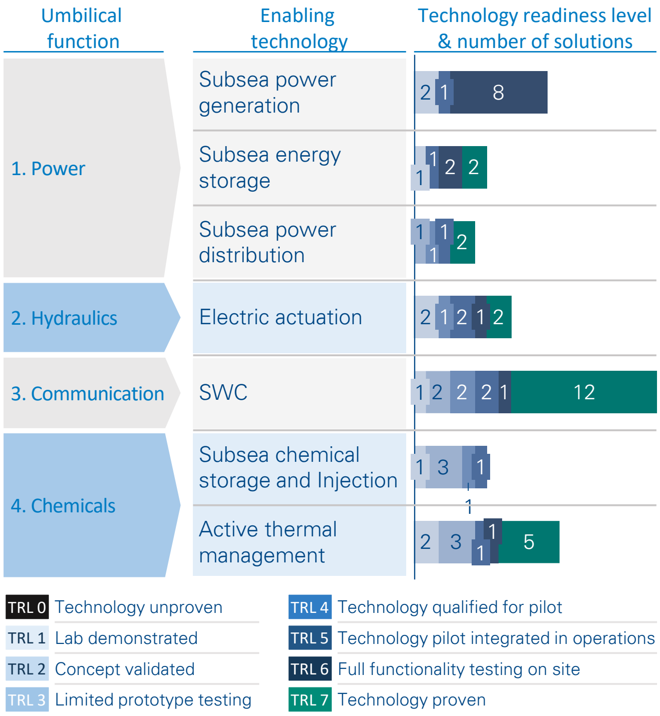
In our technology scouting, we identified a full list of potential solutions, engaging with each contractor to assess:

- The readiness level of each enabling technology and its ability to provide oil & gas operators' typical requirements.
- The strategy adopted to work on its development (i.e., independent work, joint industry programs).
- A reasonable time frame to forecast availability for infield deployment.

The below illustration shows that the technology readiness level and number of solutions available varies significantly between the enabling technologies. SWC stands as the most advanced technology currently, with 12 identified solutions at TRL 7, and many solutions having multiple years of in-field use. Despite this, many operators are reluctant to use SWC because of issues such as reliability, latency, and bandwidth.

These technologies would need to be supported with the use of additional highly innovative systems. For example, edge-computing technologies are being developed to move analytical function subsea and reduce the demands on bandwidth and latency by using communication links to send "information" rather than raw data. Artificial Intelligence could also reduce the amount of data to be transferred and enable the implementation of subsea automated safety instrumented functions, therefore relaxing latency requirements. At the lower end of the TRL spectrum lie technologies such as SCSI. Implementing SCSI would reduce dependency on umbilical chemical lines, which typically make up a large proportion of an overall umbilical cross section and weight. However, this technology is only possible when supporting technologies are implemented, to reduce the volumes of chemical needs and flow rates. For example, supporting technologies such as active thermal management and digital optimization of chemical injection to reduce the required chemical volumes can make SCSI viable.

Identified number of solutions to replace or reduce the need for current umbilical functions along with associated TRL levels



Source: Arthur D. Little

A subsea technology roadmap

Through our analysis of enabling technologies, we at Arthur D. Little propose a staged approach to reduce the dependence on existing technology (e.g., umbilicals) over time. This links with an organization's ongoing R&D program and involves engagement with subsea technology vendors from a very early stage in order to understand current capabilities and the expected evolution of enabling technologies.

Our assessment is based on structured and validated interview and data analysis from 30 leading technology vendors. Our approach considers the expected time frame of ongoing R&D activities, the TRLs of required solutions, and interdependencies across solutions and key enablers. Based on this analysis, our summarized roadmap for deployment of these technologies identifies the steps needed to achieve a challenging cost reduction target. The illustration below provides an example of a stepwise approach to umbilical simplification which specifically builds value for investments that can support increasing levels of cost reduction by recognizing the benefits of future technologies.

1. **Active thermal management** of the flow lines, powered from the topsides, can bring significant cost improvements by reducing methanol and other flow assurance chemical volumes and flow rates (40 percent+ reduction in methanol volume). **Electric actuation** can remove hydraulic lines in the umbilical. These are currently used to actuate subsea equipment valves – either all at once or in multiple steps, in order to minimize risk (first on low-pressure hydraulic actuators, and then on high-pressure hydraulics devices).

2. **SPD** is a key technology that enables the deployment of high-voltage subsea solutions, with a limited number of topside connections: due to this technology, the number of lines in the main umbilical can be reduced and subsea boosting equipment may no longer require separate umbilicals. It is necessary to enable SCSI.

3. **SCSI** systems completely remove the need for chemical lines in the umbilical; if requirements for flow assurance chemicals are high and not mitigated in other ways (e.g., MEG injection), this has to be implemented alongside active thermal management of infield lines to further reduce chemical needs. SPD is also required to carry power subsea and distribute it at the required current and voltage, especially on long tiebacks.

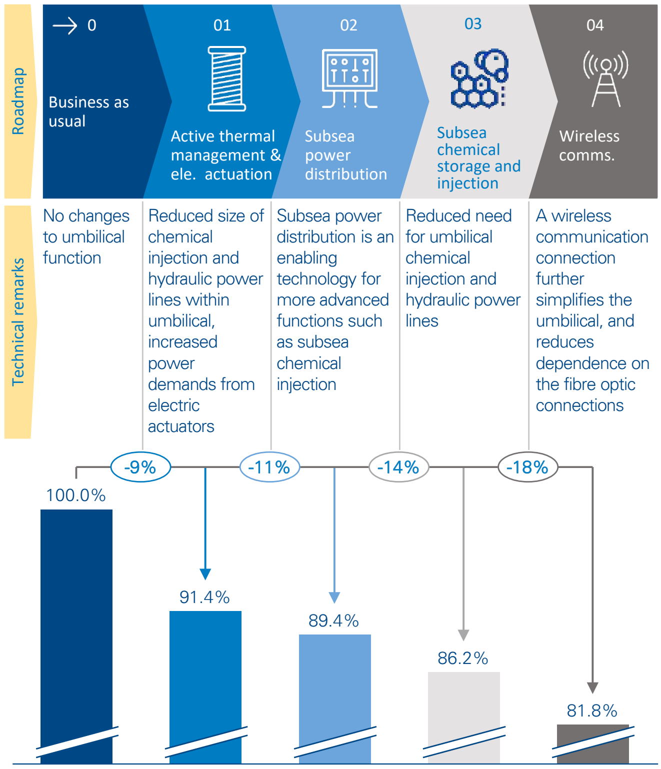
4. **Wireless acoustic vertical link** from a central hub on the seabed to a buoy, and then wireless to topside equipment (e.g., via satellite), could further simplify the umbilical. Depending on the configuration of the seabed installation, connection from the Christmas trees to the central hub could be wired or wireless. O&G operators should study the application of wireless solutions to their specific cases, e.g., as backups/secondary links, to test their dependability.

After this stepwise implementation plan, the only connection left from the topsides would be the power lines; electrical power could be supplied via diesel generators on a small floating platform (which would include the vertical link) and carried subsea to completely remove the umbilicals.

The cost reduction potential

To determine the potential cost savings associated with the proposed technology roadmap, we demonstrated the cost reduction potential based on a typical use-case scenario comprising a ~50 km tieback to an existing FPSO.

Arthur D. Little technology roadmap for umbilical simplification



Source: ADL analysis of technology vendor interviews and financial analysis of typical oil field use case scenario

Above illustration shows the estimated cost savings for each stage of the proposed technology roadmap (excluding drilling, completion and abandonment costs). The largest cost savings are found in the first phase of the roadmap: i.e., implementation of active thermal management and electric actuation. This provides capex savings of over 8 percent, resulting from significant reduction in the umbilical diameter. This initial option will be attractive for many operators due to the high technology readiness level of active thermal management solutions and the sustained interest from vendors in the development of electric actuation solutions.

Additional considerations needed to realize the benefits of aggressive technology deployment

In addition to the implementation of novel technologies in the pursuit of cost reduction, there are a number of additional considerations that operators should take into account:

1. **A shift in mind-set** is needed to effectively target cost reductions. Operators must be incentivized to move away from the conservative mentality of the previous decades. Solutions should be considered even if they do not have extensive records of accomplishments, and alternate vendor routes should be researched.
2. **Increasing joint efforts of industry players** (i.e., operators, subsea technology development organizations and smaller vendors): enhanced collaboration will be required to overcome the substantial challenges facing all players within the oil and gas industry.
3. **Embracing digital solutions** to optimize production functions, which are often over-engineered, would help to deliver further cost reduction. Examples include real-time monitoring and optimization of chemical injection, active thermal management and flow rate using distributed sensors. The effective localized application of AI solutions may also be of substantial benefit.

Conclusions

The low-oil-price environment has led many leading operators to seek out technical solutions to enable cost reductions in a range of assets. Arthur D. Little's approach to these challenges is to carry out wide technology solution scanning, systemic analysis and aggressive technology deployment.

In the case of umbilicals, the large variability in the technology readiness of enabling technologies needed to replace or eliminate the need for the four main umbilical functions meant we could identify significant and increasing potential cost savings through a stepwise implementation approach which incorporates the benefits of future technologies.

However, additional considerations must also be taken into account, such as incentives to shift away from over-conservative and costly approaches, increasing joint efforts within the petroleum industry, and embracing new digital technologies such as distributed sensors and real-time optimization.

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Arthur D. Little

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