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| #21 | **Facility integrity and lifetime extension of fields**<br>The high-quality, efficient infrastructure on the NCS is key to the current and future competitiveness. Maintaining integrity while keeping costs down, will be important for realizing remaining reserves and contingent resources in fields, as well as for developing resources in the vicinity.<br><br>Improved knowledge on materials and material condition detection and degradation mechanisms could lead to improved operations and regularity, improved safety, and a better knowledge basis for life extensions and integrity assessments.<br><br>Integrity of existing installations could also improve development opportunities further away in combination with unmanned platforms. | Access to sufficient, high quality data, is fundamental for understanding integrity of facilities. Condition monitoring could be difficult due to e.g.: lack of sensors; limited physical access; limited availability to historical data series and failure data on equipment and structures. Documentation of present condition could involve considerable offshore scope of work which is time consuming and costly. | • Knowledge sharing between operators and between operators and suppliers on critical equipment and structures.<br>• Use of robots and drones for inspection.<br>• Improved sensory and cost-effective tools for documentation of technical condition (e.g. detection of corrosion under insulation, erosion). |
| | | To fully understand integrity, it is imperative that degradation mechanisms are understood. | • Improve tools for material conditioning and degradation analysis. Include data analytics, AI/ML.<br>• Develop knowledge and tools to analyze dynamics of electrification cables.<br>• Develop knowledge and tools to analyze integrity of flexible risers.<br>• Knowledge of and development of new materials that could replace or be used in combination w/existing. |
| | | Improved access to data and the better understanding of degradation mechanisms should be leveraged to improve cost-efficiency and safety. Risk-based approaches would focus the attention to equipment and structures that are critical to safe operations and high regularity. | • Risk-based identification of critical equipment and structures.<br>• Condition based maintenance.<br>• Predictive maintenance. |
| | | A more efficient inspection and maintenance approach would also include improvements in spare parts logistics. | • 3D printing of spare parts.<br>• Drone delivery of critical equipment.<br>• Industry collaboration on critical spare parts. |

8 These are examples. Other solutions addressing the prioritized technology areas should also be sought and developed

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| #22 | **Data collection for facilities**<br>New digital sensory technologies like robots, AUVs, drones and sensors for monitoring and inspections can improve monitoring and maintenance of offshore facilities. It forms the basis for predictive maintenance, which can improve regularity.<br><br>These technologies allow for people-less operations, reduced manual inspection, reduced maintenance costs and improved safety. | Access to sufficient, high quality data, is fundamental for operations and understanding integrity of facilities. Inspection and monitoring could be difficult due to e.g.: lack of sensors; limited physical access; limited amounts of historical data series and failure data on equipment and structures. Documentation of present condition could involve considerable offshore scope of work which is time consuming and costly. | • Robots, drones and AUVs for inspections.<br>• Increased level of autonomy.<br>• Digital sensory for monitoring and detection with sufficient quality.<br>• Data “eco-systems” that include data platforms with improved data access, data structures and possibilities for interoperability. |
| #23 | **Data management for facilities**<br>New digital platforms and software for data management could improve data access and enable new possibilities for use of available data. It could improve use of data to enable integrity monitoring, maintenance planning, improve data quality etc. | Data handling and management is often inefficient, time consuming and cumbersome due to lack of standard formats, poor interoperability, and lack of data management tools.<br><br>Data tools and digitalization can improve efficiency by automation of manual work tasks like data treatment and analyses to find patterns, optimize processes and improve understanding of a system.<br><br>This can also allow smaller service suppliers to get more easily established among operators. Standardized interfaces for communication will also make it easier for operators to start using new technology.<br><br>Improved data access and systems which in a standardized way could treat all types of data could be beneficial to improve efficiency in all organizations, as data overload is a common issue. | • Standardized Digital Twin solution based on the Industry 4.0 concept supporting engineering, construction and operation/maintenance processes.<br>• Software tools with AI and ML algorithms.<br>• Software for communication between different sensor platforms.<br>• Software for improved data handling.<br>• Software for maintenance planning.<br>• Standardized communication protocols for sensory to enable easier use of new sensory technology. |

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| #24 | **Digital tools for improved monitoring, better understanding and more efficient operations** | The efficient infrastructure on the NCS is a main reason for the competitive cost level. It is essential for realizing reserves in the fields, contingent resources in the field, and for realizing a majority of the contingent resources in the discovery portfolio that would need tie-back to a host to become economically viable. Keeping control of integrity through cost-efficient inspection and maintenance will be important in the decades to come, among others for life extension of installations and/-or re-deployment and re-use of installations.<br><br>Digitalization is however relevant through the complete oil and gas value chain, as it can provide improved efficiency, better understanding of processes and systems, automate and optimize operations and by that contribute to increased volumes, cost savings, emission reductions and improved safety. | • Improved methodology and analytics tools for condition-based, predictive and risk-based maintenance.<br>• Software for maintenance planning that provide better understanding and better control of material condition and degradation mechanisms.<br>• Data management software.<br>• Autonomous and normally not manned operations topside (like subsea). |
| #25 | **Unmanned facilities and subsea tie-backs**<br>The discovery portfolio on the NCS is dominated by relatively small discoveries, and the trend is that the average discovery size is decreasing. Cost-efficient development of small to medium sized fields is therefore important for the future of the NCS. | The dominant solution going forward to realize resources in smaller discoveries is to tie the resources back to existing infrastructure / hubs. Flow assurance and subsea processing technologies can increase possible tie-back distances and therefore unlock new volumes from discoveries which today are considered too far from existing infrastructure and not economical as a stand-alone development.<br><br>Subsea all-electric is a promising opportunity that in addition to subsea processing and power solutions, also include drilling and wells technologies.<br><br>Receiving hubs needs to be able to handle comingled production efficiently, which require tools for process simulation and optimization.<br><br>Unmanned facilities could also be a solution for developing smaller fields, either tied back to hubs or as stand-alone installations. Many of the digitalization technologies described above would be needed in addition to other types of technologies. | • Subsea toolbox: matured subsea technologies to enable configuration of optimal system solutions.<br>• Standardized subsea equipment modules and interfaces.<br>• Standardized subsea sensory interfaces.<br>• Standardized test and qualification requirements.<br>• Extended reach for multiphase transport.<br>• Multiphase pumps.<br>• Subsea separation technologies.<br>• Subsea produced water treatment.<br>• Subsea All-electric e.g. production systems, x-mas trees, blow-out preventers, downhole safety valves, compression systems.<br>• Unmanned production facilities.<br>• Power and communication distribution technology for long-range tie-backs.<br>• Process simulation and optimization w/ automatic control or real-time guidance on process optimization. |

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| **#25 cont.** | | Common for both is that a range of subsea technologies ("subsea toolbox") should be matured to enable optimal configuration of system solutions (topside and subsea) to fit specific field development needs to realize resources.<br><br>Standardized subsea templates and interfaces is important to reduce unit cost:<br>• The trend on the NCS is more emphasis on infrastructure-led exploration and discovery sizes are decreasing. Standardization of subsea satellites could (i) decrease costs, and (ii) shorten lead time on new developments which improves competitiveness on lead times and improves value due to earlier production.<br>• Standardization may require operators to accept for instance lower recovery rates as less field-specific adjustments are made; cost/benefit considerations may still favor standardization.<br>• Savings are expected in the engineering and installation phase due to fewer interfaces between SPS and SURF. Procurement cost might also decrease if standardization leads to "less steel". | • Condition based maintenance.<br>• Remote operations.<br>• Automation, autonomous systems and robotics. |