deep 7

SUBSEA 7
TECHNOLOGY MAGAZINE

TRANSFORMATIVE TECHNOLOGIES

IN-DEPTH INNOVATIONS AND SOLUTIONS

SUBSEA PROCESSING
Creating new and more cost-effective subsea development solutions

SUBSEA ELECTRIFICATION
Subsea power distribution and renewable marine energy harvesting

THE ROAD TO AUTONOMY
Digitalisation and robotic technologies deliver smart IRM services

DEPLOYING DIGITALISATION
Superior decision-making from fresh insights into design and operating environments

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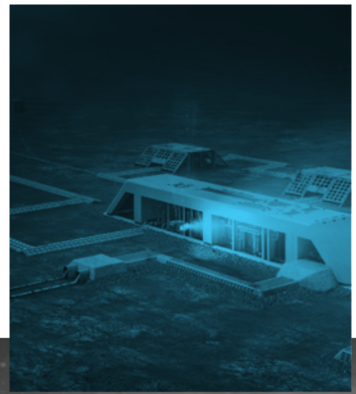

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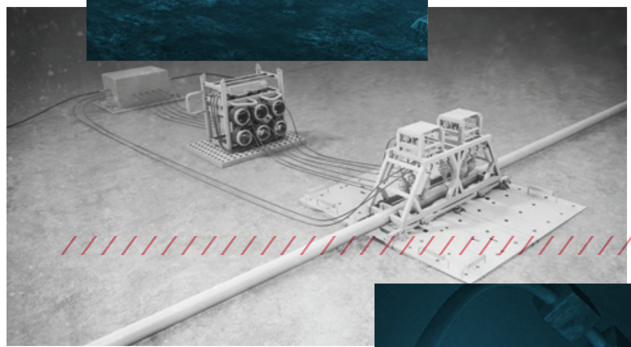

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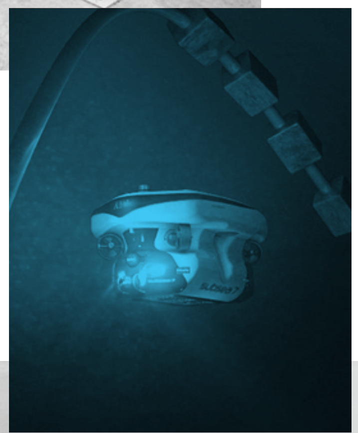

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THOMAS SUNDE
Vice President Technology

SHARING OUR TRANSFORMATIVE TECHNOLOGIES

The pace of technological change in the early 21st century is now so rapid that every industry is being radically transformed by innovations which are imported, adopted and commercialised from other sectors.

This is especially true of digitalisation technologies, which have led to spectacular advances in many different sectors: Augmented Reality in training, Artificial Intelligence and robotics in manufacturing, 3D printing in applied design, materials optimisation in aerospace, sensor and imaging in industrial inspection, energy efficiency in every sector.

As you will see in these pages, transformative technologies are equally at work in the subsea energy industry, challenging our cost base and setting new standards in reliability, productivity and sustainability.

Subsea 7 is playing a key role in this process, especially in such critical technologies as subsea processing, electrification and digitalisation.

Some years ago, we recognised that the technological challenges facing us required knowledge beyond our extensive in-house expertise. Our 7INNOVATE programme gives us unparalleled access to technology intelligence through an interconnected partner ecosystem of over 45 million solution providers. Many of the results of these collaborations are for the future, but some are already here and market-ready.

We have launched our Submerged Production Unit (SPU), a configurable system that enables the cost-effective transport and installation of large subsea processing plants without the need for heavy-lift construction vessels. The SPU supports a game-changing flexibility in how subsea structures are designed, manufactured and installed.

In subsea processing, we have developed an effective Wax Control System which enables Cold Flow long-distance tie-backs and transforms the economics of subsea development in remote fields.

To support power-hungry subsea technologies and reduce our CO_2 footprint, we currently have a versatile Subsea Electrical Power Distribution Unit (SEPDU) under development to drive subsea processing, heating and control systems, and have invested in market-leading providers of multi-source renewable marine energy.

In digitalisation, we are using data management technologies adopted from other industries to implement automation, visual recognition and on-demand autonomous subsea inspection and implementation services.

Being able to monitor and predict the health of subsea assets through these technologies not only delivers major reductions on inspection costs, but also gives fresh insights to support superior decision-making in addressing perceived risk or life-extension assessments.

We can see oil and gas already transforming itself into a knowledge industry that uses shared data to create new ecosystems and business relationships.

For this reason, we welcome the opportunity to open up and share expertise with clients, suppliers and partners in a new culture.

Technologies are under development which will completely transform our industry. We look forward to meeting the challenges – and sharing the rewards – together.

OIL AND GAS IS TRANSFORMING ITSELF INTO A KNOWLEDGE INDUSTRY THAT USES SHARED DATA TO CREATE NEW ECOSYSTEMS AND BUSINESS RELATIONSHIPS.

LONG-DISTANCE TIE-BACKS:
THE 'TOTAL SYSTEM' APPROACH

THE INDUSTRY CHALLENGE: To ensure reliable and economic flow of well streams from reservoir to the receiving facility over increasing distances without costly host modifications.

BENEFITS: Reduced field development costs, revitalisation of existing facilities, extended reach of tie-backs.

OLIVIER LODEHO
Technology Development Manager – GPC Strategic Development Manager – Flowline Systems

In previous issues of *deep 7*, we outlined solutions to the challenges of temperature and pressure in oil-dominated flowlines over 50km. In this issue, we highlight the growing importance of new subsea technologies in systemic design innovation: flowline technologies, subsea processing hardware, data management and the increasing significance of subsea electrification.

Traditional approaches to flow assurance become inefficient or uneconomical for longer distances.

In order to maximise production and ensure operational integrity at the lowest possible overall cost, Subsea 7 has taken a 'total system' approach and is developing enabling technologies to deliver better, more reliable and more cost-effective tie-back solutions.

We have established the strongest portfolio of flowline systems in the industry, ranging from passive insulated and active heated flowlines to market-leading Pipeline Bundle systems. With the deployment of our Electrically Heat Traced Flowline (EHTF) technology on the AkerBP Ærfugl Project, we have introduced a step-change in both field economics and production assurance.

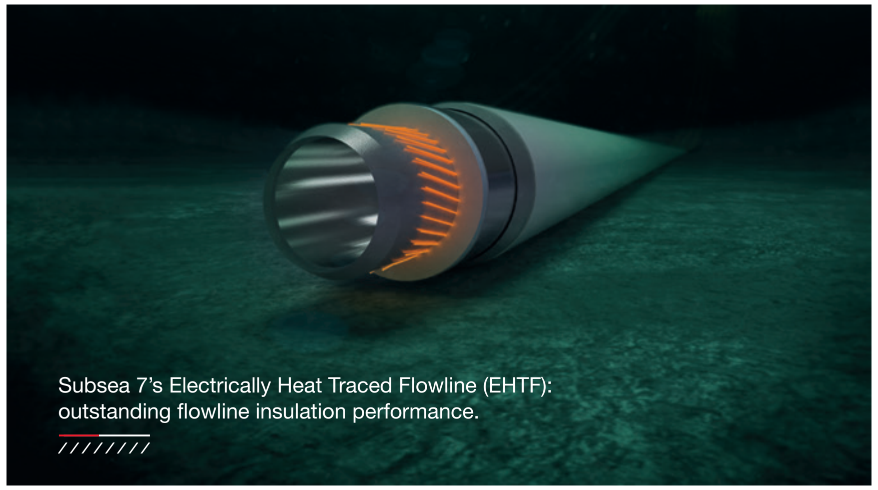
Subsea 7 technology development is now focused on the conditioning of well fluids for longer transportation, enabling us to realise a number of promising opportunities:

- Cutting the costs of subsea field development by connecting new reservoirs to existing facilities
- Revitalising and de-bottlenecking existing facilities by introducing subsea processing modules
- Extending the reach of tie-backs to eliminate the need for an offshore host and to transport well streams via direct connections to onshore facilities
- Reducing the manning and associated risks of production and Life of Field activities
- Lowering the overall environmental impact of offshore activities

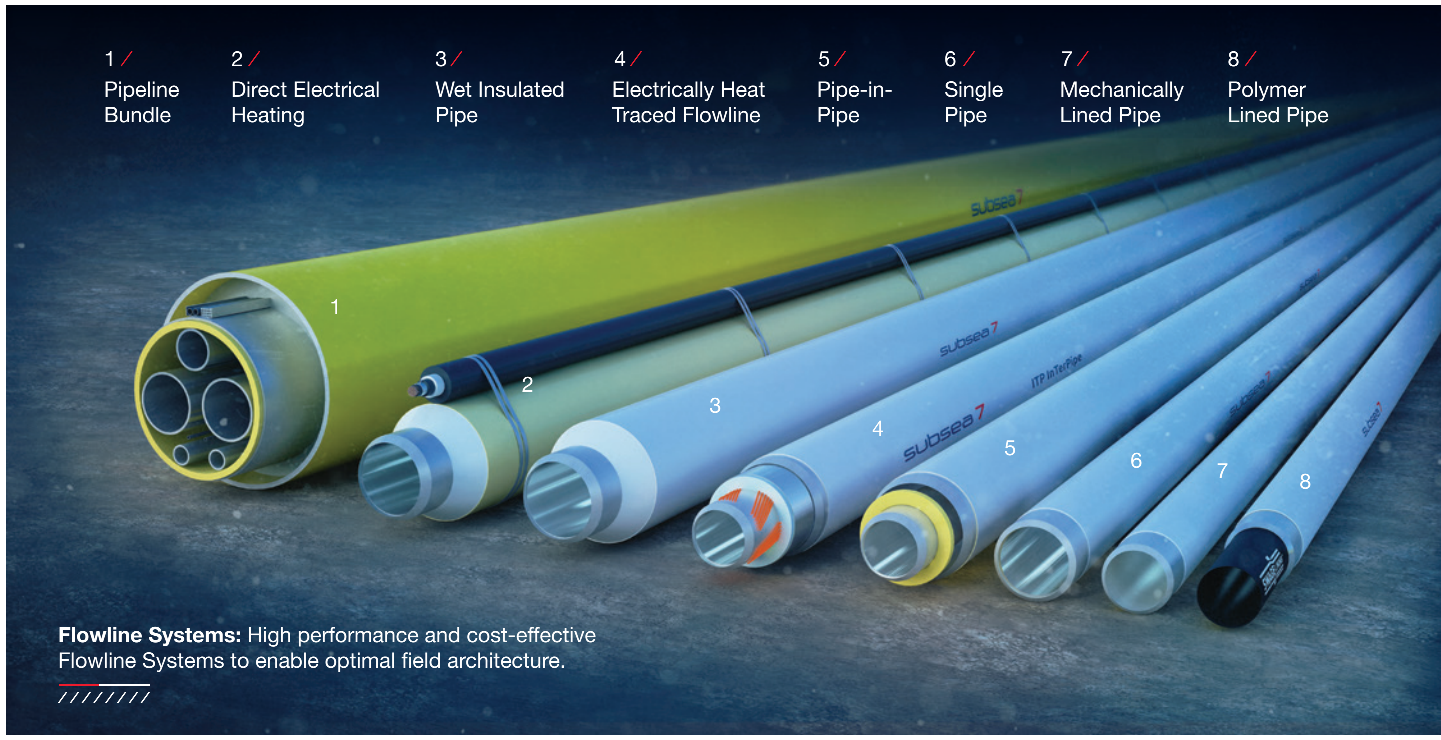
OPERATING PHILOSOPHIES

Unmanned subsea production can transform the economics of field development, but will require live monitoring, remote access and operations, and in-situ Inspection, Repair & Maintenance (IRM) capabilities.

> Subsea 7 is building on our industry-leading portfolio of flowline systems to focus on the conditioning of well fluids for longer transportation.



Subsea 7's Electrically Heat Traced Flowline (EHTF): outstanding flowline insulation performance.



Flowline Systems: High performance and cost-effective Flowline Systems to enable optimal field architecture.

In addition, shut-down and restart operations will require alternative considerations for chemical management and pigging operations.

With monitoring in place, large volumes of logged data can be collected and modelled for production optimisation and field life extension. Preventative maintenance will enter a new era of efficiency based on the continuous monitoring of key components coupled with digital 'twins' to anticipate equipment failure.

This will require the construction of robust models scaled with logged data to reliably predict production duty and therefore potential failure modes.

NEW DESIGN METHODOLOGIES

The design of new unmanned subsea production facilities can be based on a holistic, systemic approach for the selection of field architecture. The design phase will be accelerated by drawing upon collected data from past and existing equipment experience, and by working from a collaborative digital design platform shared with clients, contractors and suppliers.

Design efficiency can be enhanced by using standardised components and modularised equipment platforms for individual client field developments. When operating loads and conditions have been monitored on a continuous, live basis, this standardised approach also allows the reuse of subsea equipment.

> **THE NEXT PHASE OF DEVELOPMENT WILL INVOLVE THE CONDITIONING OF WELL FLUIDS FOR LONGER TRANSPORTATION.**

New codes and standards will need to be introduced to regulate the progress of emerging technologies in remote monitoring, machine learning and data management.

The general trend towards a probabilistic design approach will reduce design conservatism with significant savings in fabrication costs.

FABRICATION AND INSTALLATION METHODOLOGIES

A major contributor to cost reductions in future subsea field developments will be the increasing deployment of highly efficient methodologies in both construction and installation, including:

- The standardisation of components and their interfaces
- The modularisation of equipment based on standard components and assemblies
- The expansion of low-cost installation methods including the controlled tow of onshore-prefabricated structures rather than in-field heavy-lift and construction
- The ability to recover and reuse equipment once production has ended

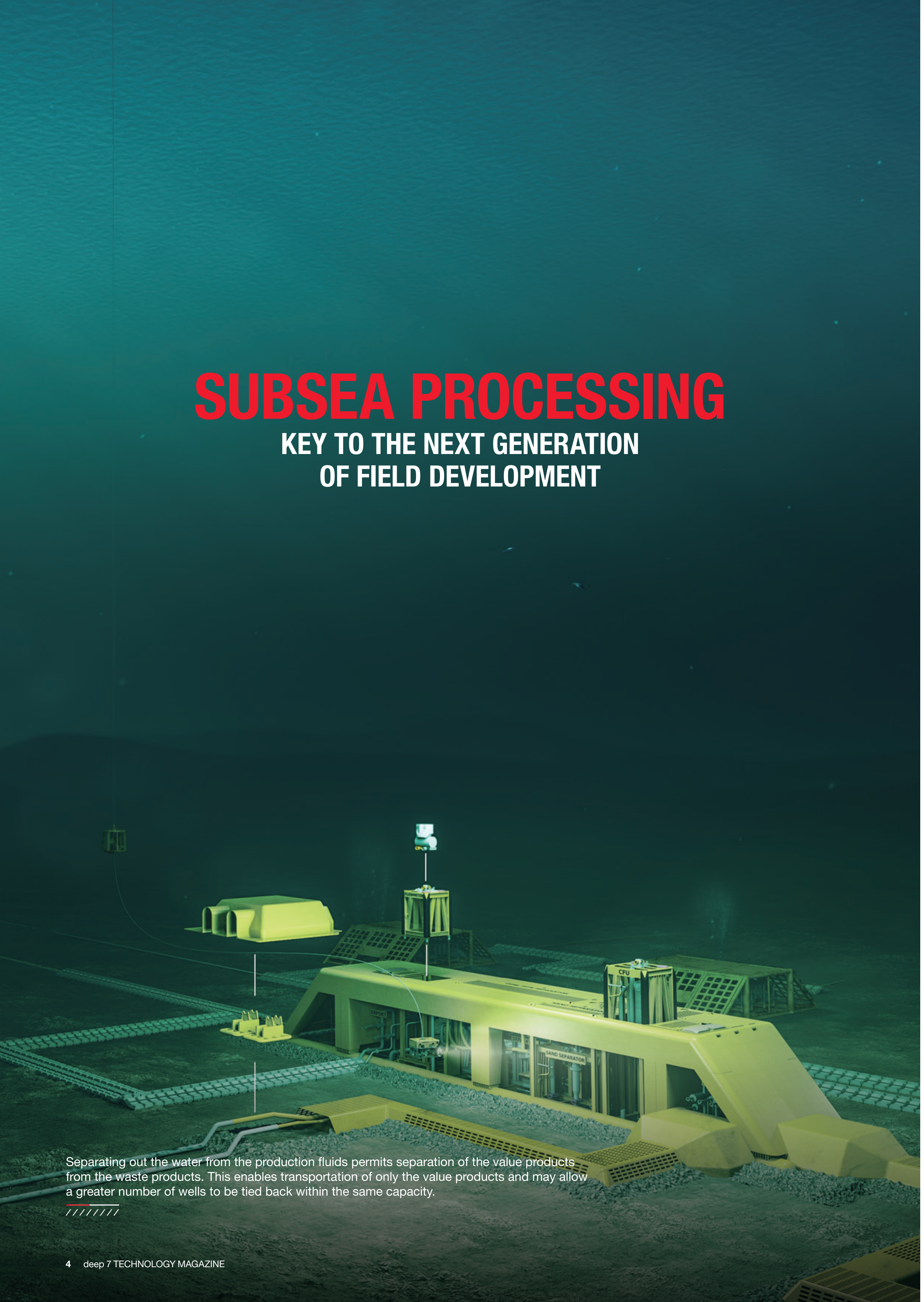
In addition, we will see the increasing adoption of new materials and manufacturing methods, including lightweight composites, high-strength steels, intelligent materials and 3D printing.

THE POWER CHALLENGE

Especially in remote locations and with long-distance tie-backs, a major technological challenge in effective subsea field development design is the increased demand for electrical power distribution and transmission systems.

We already have an advanced Subsea Electrical Power Distribution Unit (SEPDU) under development which can deliver reliable on-demand power to an actively-heated flowline.

Other power sources being trialled through Subsea 7's technology investment strategy, include storage batteries and subsea current, wave and wind generation along with local power transportation techniques to enable the incorporation of electrical architecture into designs.



SUBSEA PROCESSING

KEY TO THE NEXT GENERATION OF FIELD DEVELOPMENT

Separating out the water from the production fluids permits separation of the value products from the waste products. This enables transportation of only the value products and may allow a greater number of wells to be tied back within the same capacity.

THE INDUSTRY CHALLENGE: The installation of subsea processing plants enabling longer tie-back distances.

BENEFITS: Significant move towards full subsea field autonomy, making marginal, deepwater or long-distance field developments economically viable.

SIGBJØRN DAASVATN
Strategic Technology Programme Manager for Subsea Processing

THE BACKGROUND TO THE SUBSEA PROCESSING STORY

The principal role of offshore oil and gas production activities is to condition the multi-phase fluid to enable safe single-phase transport to the facilities. Traditionally, the processing activity has been performed topside on platforms, but subsea processing moves it onto the seabed.

As subsea plants are installed at greater tie-back distances, the challenge of managing wax- and hydrate-related pipeline issues also increases.

Conventional solutions used to reduce pipeline heat loss, such as improved wet insulation or Pipe-in-Pipe (PIP) configurations, are no longer sufficiently efficient to achieve the product arrival temperature.

The cost of actively heated flowlines also increases proportionately with distance. In contrast, Subsea 7's Electrically Heat Traced Flowline (EHTF), developed in conjunction with manufacturer ITP Interpipe, delivers market-leading flowline insulation performance and greatly extends the economic length of heated flowlines.

However, as planned long-distance tie-backs extend beyond 50km for oil fields and 100km for gas, heated flowlines become an uncompetitive option.

These remote tie-back challenges require a transition of processing functions from topside to subsea, a move anticipated by Subsea 7 since the inception of our strategic technology development programme for subsea processing.

Subsea processing plants will greatly influence how both hydrate and wax problems are managed in the future with a whole new suite of tools available to handle these problems.

Increasingly, subsea processing will be the key enabling technology for making marginal, deepwater or long-distance field developments economically viable. This transition is already well under way, with many of the individual elements required for subsea processing having been developed, qualified and field-proven during the last 15 years.

Subsea processing methods including separation, produced water treatment, water injection and boosting have made a positive impact on the producing capacity of many fields by increasing recovery and ultimately accelerating production.

By separating out water, the fluid also becomes more favourable for long-distance transport, and the need for chemicals is reduced.

Separating the fluid down into the components of water and oil prior to transportation and therefore only transporting the value component of the fluids, and not the waste, improves efficiency. Greater efficiency may be further achieved by utilising water at source for reinjection. As a consequence of separation, a reduction of pipeline diameter is achieved.

Produced water may be cleaned for disposal at the seabed, or mixed with treated seawater for reinjection into the reservoir. Together with our partner Mirmorax, Subsea 7 is qualifying a reliable oil-in-water meter to meet stringent monitoring requirements for re-injection and disposal, enabling this process to be a reality in the near future.

Subsea 7 has developed an effective Wax Control System (WCS) which will transform the development of subsea processing plants in remote fields.

As with most technological advancement, the first in-service uses of subsea processing are more expensive than the incumbent approaches which they displace. Adoption costs will now continue to reduce as the proving and pioneering work has been carried out.

As tie-back distances increase beyond the cost-effective capability of active heating systems, Cold Flow becomes a more attractive flow assurance option, enabling the transportation of pre-conditioned fluids at ambient seawater temperatures.

In the future, subsea processing will also be further developed to meet the specific challenges of Arctic field development, in particular reducing the cost of subsea individual developments and operations to compensate for increased infrastructure costs. The Arctic will also pose unique challenges of physical access and technical conditions which have never been previously encountered.

The potential of Cold Flow to enable long-distance deepwater tie-backs has been recognised for more than 15 years.

The mechanisms of hydrate formation and precipitation of solids in terms of wax and scale are widely understood, and a number of different approaches have been taken within the industry to tackle these challenges.

The Subsea 7 approach has been to develop and qualify an effective Wax Control System (WCS) based on our industry-leading towed Pipeline Bundle technology in combination with single-phase cooling water pumps and traditional pigging technology with remotely-controlled pigging.

WAX CONTROL SYSTEM

A product of our strategic technology development programme for Subsea Processing, our new WCS technology will transform the development of remote fields which lack significant subsea infrastructure.

Designed for the next generation of subsea field development, WCS is based on Subsea 7's extensive applied research into wax deposition physics and decades of engineering and operational experience.

Subsea processing plants are custom-built because no reservoirs are the same, and draw upon a wide range of component technologies which are assembled into a processing plant to suit each individual field development.

The development of some subsea processing functions has been ongoing since the 1980s, many of them as integrated functions built up within Subsea 7's towed production systems.

At that time, many subsea processing technologies were not suitably qualified, but today most subsea processing functions have been individually qualified. We are bringing them all together, integrated into our deployment platforms.

Today, our field development focus is on incorporating and integrating subsea processing functions and hardware into a complete subsea plant, based on our product modularisation strategy to ensure maximum flexibility and operability at the lowest cost.

This is an area in which we are particularly well qualified. Subsea 7 has decades of invaluable subsea experience not only in engineering and construction, but also in vessel and operational support functions.

THE ERA OF SUBSEA PROCESSING IS NOW HERE AND WILL SIGNIFICANTLY CHANGE THE FIELD DEVELOPMENT CONCEPTS OF THE FUTURE.

PIPELINE BUNDLES:
READY FOR RE-CONFIGURATION AND REUSE

THE INDUSTRY CHALLENGE: Meeting the demand for reusable subsea infrastructure which reduces CAPEX and decommissioning costs.

BENEFITS: Enables economical reuse of existing Pipeline Bundles re-configured to meet specific field requirements.

In recent publications, we have profiled Pipeline Bundle technological developments which successfully extend the depth and delivery ranges of this specialist product, including temperature and monitoring systems for HP/HT applications. In this article, we focus on the potential of our new multi-bore connector system to enable reuse of existing Pipeline Bundles.

The reuse of subsea infrastructure is the key to unlocking many challenging fields – marginal fields, stranded reservoirs and longer tie-backs – by reducing both CAPEX and decommissioning costs.

Although the commercial model for reuse and re-purposing is widely understood and utilised for FPSOs, an equivalent approach is yet to be adopted for subsea production infrastructure.

Subsea 7's Pipeline Bundle technology is by its nature readily suitable for reuse. The towed installation method is low-stress and low-fatigue, eliminating one of the major technical challenges for the reuse of traditional pipelay systems.

We have already installed a Pipeline Bundle with the functionality for re-floating and re-positioning for a marginal field. This Pipeline Bundle is still in service in its original position 11 years after installation.

Drawing on 40 years of expertise and technical knowhow in the onshore prefabrication of Pipeline Bundles, we are actively researching the technical viability of re-floating and re-purposing this unique product.

The development of modular and interchangeable systems within the towhead structures opens up the opportunity for re-configuration and re-tasking of the towheads to meet specific field requirements.

The key question for the reuse of Pipeline Bundles is – are there tie-backs of the same length? We believe that all other technical challenges associated with reuse are easily resolvable.

Our solution is a multi-bore connector for the serial connection of multiple Pipeline Bundle sections. This latest product enables longer tie-backs of any desired length without intermediate towheads and tie-in spools.

This allows for changing the length of Pipeline Bundles in the future or changing out the complete towhead – both of which are approaches with significant potential for next-generation field development.

MULTI-BORE CONNECTOR

The multi-bore connector development is based on existing and proven technologies being packaged together in a new application to enable direct connection of Pipeline Bundles.

The connector will enable the connection of a combination of three pipelines and multiple control tubes in a single operation. The numbers of flowlines and controls tubes are dependent on bore sizes.

An additional technical benefit of the connector is improved insulation through having a direct connection, compared with conventional tie-in spools that generally offer lower insulation properties. We have effectively eliminated any potential cold spot.

The connection will be carried out by ROVs, in line with our diverless operations philosophy for Pipeline Bundle installation. This reduces dive vessel time and also enables the installation of long, deepwater Pipeline Bundles.

The multi-bore connector development is being conducted and funded by the strategic Subsea Integration Alliance (SIA) and OneSubsea.

MARTIN GOODLAD
Strategic Technology Manager
Pipeline Bundles R&D

Subsea 7 has developed a multi-bore connector which permits longer Pipeline Bundles and opens up their potential for reuse by re-configuring their length.

FIT FOR GLOBAL MARKET

80+
PIPELINE BUNDLES COMPLETED

140.97cm
LARGEST CARRIER PIPE DIAMETER

7,681m
LONGEST SINGLE PIPELINE BUNDLE

42–410m
NORTH SEA INSTALLATION DEPTHS

1,000km
LONGEST TOW

547t
HEAVIEST INTEGRATED STRUCTURE

9,154t
HEAVIEST SINGLE PIPELINE BUNDLE

28km
LONGEST TIE-BACK

Pipeline Bundle being launched at Subsea 7's fabrication facility at Wick, Scotland.

MODULARISED SUBSEA PRODUCTION SYSTEMS NOW MARKET-READY

THE INDUSTRY CHALLENGE: Accommodating the increasing size and weight of subsea production structures and reducing their manufacturing and installation costs.

BENEFITS: The Submerged Production Unit (SPU) is a structure that enables: cost reductions and de-risking development schedules; local manufacture anywhere in the world; a full-year installation window; flexible integration of third-party subsea production equipment; full system onshore testing, commissioning and local assembly.

Subsea 7's Submerged Production Unit (SPU) is a configurable system that allows the cost-effective transport and installation of large subsea processing plants. In this article, we explain its significance as a market-ready solution for immediate use.

Subsea 7 has built on our established strengths in subsea design and installation to qualify and launch a new range of SPUs which combines the versatility and efficiency of modular design with the cost-effectiveness of the towed structure delivery methodology.

The first adoptions are planned for less complex structures, such as manifolds and riser bases, although the towed SPU has the capability for the cost-effective transport and installation of larger processing plants from 300 to several thousand tonnes with no need for heavy-lift construction vessels.

Based on a steel deck structure and with a high utilisation of buoyant Glass Reinforced Plastic (GRP) and lightweight polymers, the SPU supports a game-changing flexibility in how subsea structures are designed and manufactured.

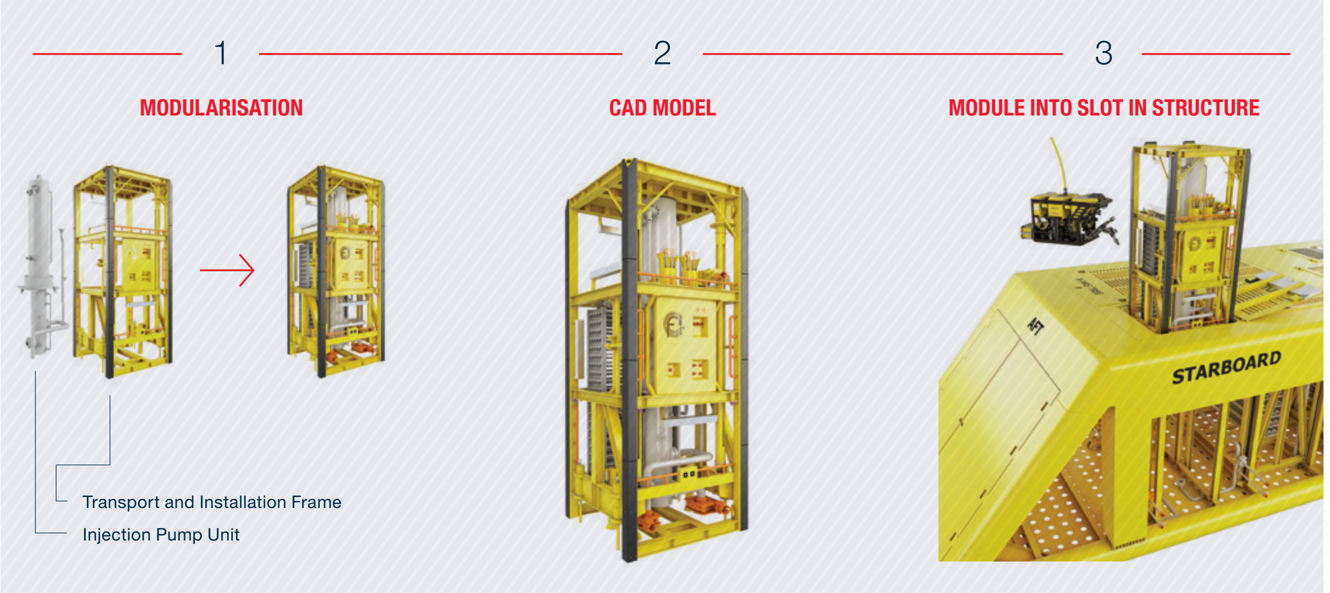
The towed delivery is based on our long-established and reliable Controlled Depth Tow Method (CTDM) which was pioneered for the installation of our prefabricated Pipeline Bundles.

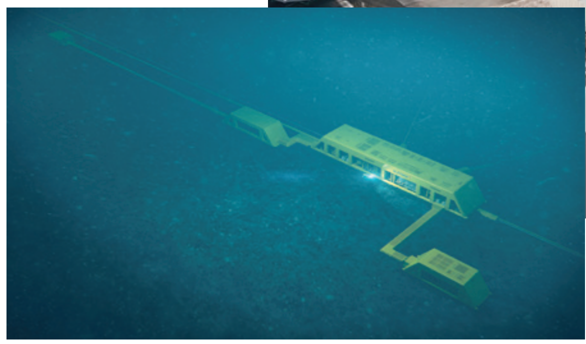
The subsea structure or Pipeline Bundle is towed at a controlled depth by conventional anchor-handling tugs, and requires no specialist pipelay, construction or heavy-lift vessels for fast, accurate offshore installation.

The seamless integration of third-party subsea production equipment is enabled through a set of standard interfaces built into our Transport and Installation Frame (TIF) system, allowing us to integrate pre-qualified subsea processing modules and services from a range of vendors.

SIGBJØRN DAASVATN
Strategic Technology Programme Manager for Subsea Processing

STANDARD MODULARISATION OF NEW COMPONENTS





The modular Subsea Production Unit.

Each module typically consists of several different assemblies, sub-assemblies and components which can be provided by clients or sourced from within our qualified network of partners and suppliers.

Digital design and product modelling, robotics and automated production have become increasingly important as we adapt to this new paradigm.

In practice, we are moving from a simplistic approach based upon standardised products towards individually configured subsea plant solutions incorporating standard modules which deliver cost savings through their design and assembly efficiencies. This approach also has the considerable technical merits of reducing complexity and maximising flexibility.

From a system optimisation perspective, the most cost-effective solutions are developed by considering the requirements of the field development strategy at a very early design stage, at which time alternative flow concepts can be proposed, investigated and selected.

From the optimised solution, we are able to configure the payload as a digitalised representation of the plant and construct an SPU around it to provide a towable structure that enables installation.

While providing a cost-efficient delivery vehicle for the payload, this structure also provides protection and intervention capabilities during field operations. We see the SPU as an efficient vehicle for recovery of the plant at the end of its service life, as it can be re-floated and towed back to shore for subsequent re-engineering or re-manufacturing before further deployment – a potential new lease of life.

By applying platforming and modularisation principles including standardised interfaces, we are able to establish new solutions much faster than before.

Digital product modelling makes it possible to tune and optimise designs to fit specific requirements and local field architecture. We are now capable of generating realistic cost estimates of field developments within a matter of days.

Our new approach ensures full compatibility throughout the system and provides an efficient workflow through engineering, procurement and fabrication phases.

The SPU, which has recently been environmentally trialled in test tanks, is the key to developing a new generation of subsea production systems that can be installed quickly, reliably and cost-effectively, with build quality, further enhanced by repeatability at component and sub-system level.

The configurable SPU is a market-ready solution that allows the cost-efficient manufacturing and installation of manifolds, riser bases and subsea processing modules.

SUBSEA ELECTRIFICATION

POWERING FUTURE FIELD DEVELOPMENT

Power distributed through a subsea power cable to a Subsea Electrical Power Distribution Unit (SEPDU), which in turn transfers power into the heated production pipeline via an In-Line Power Inlet Structure (ILPIS).

THE INDUSTRY CHALLENGE: Developing subsea power distribution and local offshore energy harvesting and storage solutions to support advanced, all-electric technologies, minimising cost and reducing the CO_2 footprint.

BENEFITS: Increased deployment of boosting and separation processing equipment, superior electric controls, longer tie-back distances, economics of off-grid renewable energy.

ESKIL HØYVIK
Flexible and Umbilical Discipline Manager – North Sea and Canada

The establishment of subsea power distribution networks is the key to enabling many of the tools that we will need for the next generation of subsea field development.

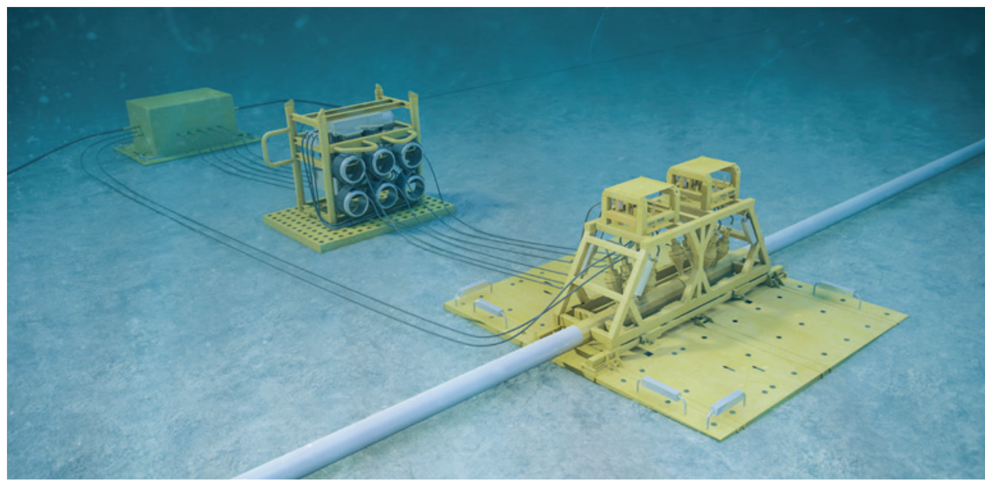
Operators are currently assessing a range of new development opportunities, some in deepwater, remote and challenging locations, others as existing fields undergoing a life extension and whose viability can be transformed through the adoption of new technologies.

The economic case for new breakthrough technology to displace conventional methods is particularly strong when, as with subsea power distribution, much of the enabling architecture is already qualified and has experienced selected early adoption.

POWER DEMAND

The increase in subsea power consumers is creating demand for more advanced subsea power distribution. The drive towards more environmentally sustainable solutions requires local energy harvesting and subsea energy storage. Subsea 7 is actively leading the way in both of these areas as part of our technology investment programme.

The introduction of more advanced subsea functions is leading to greater demands on subsea power distribution systems and stimulating new considerations on how they can be powered. For brownfield developments, the focus is generally on functions such as boosting (pumps and compressors) which can increase the recoverability of fluids from existing wells, but which have relatively high power requirements. This may require the installation of new umbilicals as existing umbilicals are



generally under-rated in their present capacity to meet the additional demand.

Greenfield developments incorporating full subsea processing complete with local storage and boosting technologies have higher power requirements. Oil heating is required to ensure de-gassing and stabilisation of oil before subsea storage. Boosters are energy-demanding rotating equipment with power requirements which could conceivably require up to 10MW.

The introduction of true subsea production, including subsea processing, gives two export options: tie-backs to an existing host and onwards via existing export lines; or the introduction of SPSO facilities to complete the export via shuttle tankers.

ELECTRIFICATION OF PIPELINES

Another heavy consumer of electrical power is the active heating of flowlines.

Several different technologies and field architectures are now available to enable long-distance tie-backs, with active heating of flowlines being one of the most promising from a development cost perspective.

This technology allows the carried fluid to be maintained above hydrate appearance temperature along its journey from the wellhead to the host facility. This enables simplification of the field architecture by removing the second leg of the production loop by eliminating pigging with dead oil for preservation.

Three different technologies can be deployed to keep the fluid warm in long tie-backs:

1. Direct Electrical Heating (DEH)
2. Hot Water Circulation
3. Electrically Heat Traced Flowline (EHTF)

Subsea 7 has extensive experience in the design and delivery of active heating flowline solutions, and has also successfully pioneered the development of EHTF in partnership with ITP Interpipe, culminating in its completed qualification. In December 2017, Subsea 7 was awarded a substantial Engineering, Procurement, Construction and Installation (EPCI) contract for the AkerBP Ærfugl Project which includes the design, manufacturing and installation of a 20km EHTF flowline system. Building on this in December 2018, we saw the award of BP Manuel, the first US project to use EHTF.

EHTF requires very little power compared to the alternatives, typically between 0.5-2MW for the cold-start/heat-up case, while DEH typically demands between 1-10MW for the same conditions.

TYPICAL SUBSEA HIGH POWER CONSUMERS FOR SUBSEA PRODUCTION, STORAGE AND OFFLOADING (SPSO) DEVELOPMENT

DESCRIPTION	POWER	LOAD TYPE
Wet Gas Compressor	2-3 MW	Continuous
Heater	2-3 MW	Continuous
Tank Loading Pump	0.5 MW	Intermittent
Water Removal Pump	0.5 MW	Intermittent
Water Injection Pump	2.5 MW	Continuous
Seawater Feed Pump	0.5 MW	Continuous
Subsea Chemical Storage and Injection	0.6 MW	Continuous
SUM SPSO	**8-10 MW**	**Continuous**

Hot water circulation is normally powered by gas heaters on board a host facility would, on comparable tie-back lengths, require equal power in the 1-10MW range when using electrical heaters. For comparison, this is the maximum load for heating water and is only required for a short period until the water has reached the required temperature.

Successfully commercialising EHTF gives Subsea 7 a comprehensive suite of heating solutions for all client drivers and constraints in terms of CAPEX/OPEX, operating procedures for maintaining temperature, shutdown or restart, and topside restrictions such as power availability or deck space.

In collaboration with our alliance partner OneSubsea, a Subsea Electrical Power Distribution Unit (SEPDU) is under development to supply power at different stages along a heated flowline from an umbilical. This offers the flexibility to heat parts of the flowline as required, and maintains the reliability of the overall system at the same time.

POWER SUPPLY AND STORAGE

The offshore environment is energy-rich with options to generate or purchase power. The purchase option calls for proximity to an existing supply, either a host system or connection into a nearby renewable energy network.

With local power generation, the key decision is whether to make power on the surface or subsea.

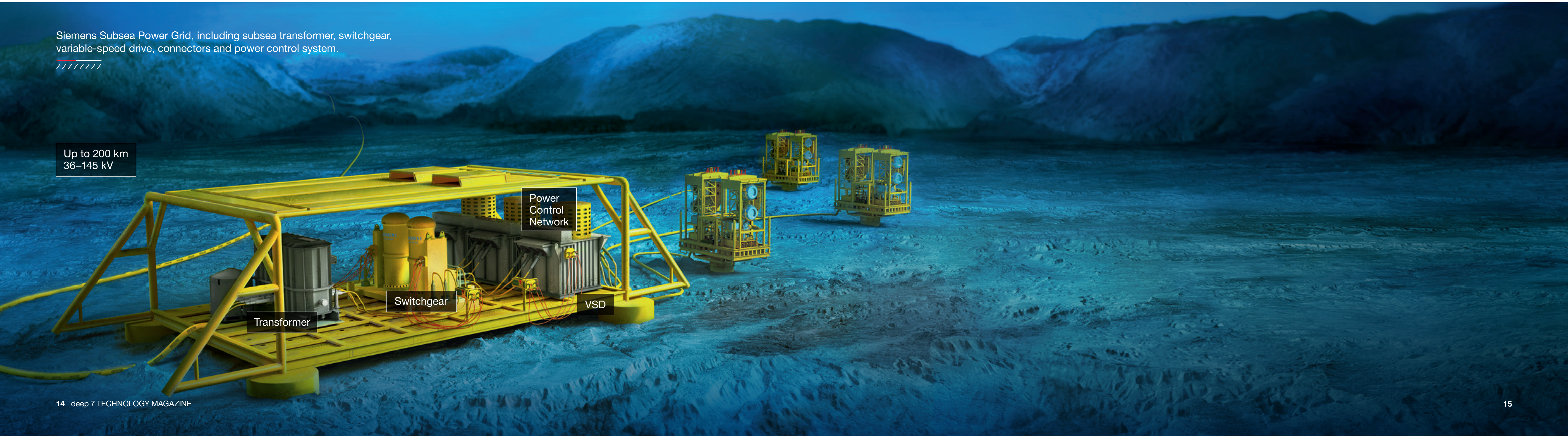
Surface technologies can be based on either wave or wind generation – a recent DNV GL joint project known as WINd-powered Water Injection has demonstrated that offshore wind turbines could be used to power water injection techniques to enhance recovery in offshore oil fields. Gas has also been used to generate power on a buoy, as is already proposed on the new generation of unmanned production buoys.

Subsea technologies may use subsea currents to generate power or exploit potential differences, such as salinity or thermal gradients.

Energy storage is required because of the intermittent nature of subsea power demand, and a number of options are already under active development, including subsea batteries, kinetic flywheels and thermal sinks.

The rapid growth in lightweight high-capacity onshore storage batteries for electric vehicles has given impetus to this particular segment of energy storage, but may have less significance for subsea applications which do not share similar weight constraints. The subsea sector is, however, benefiting overall from wider energy storage R&D momentum.

Subsea 7 is developing a Subsea Electrical Power Distribution Unit (SEPDU) and has invested in new concepts in off-grid marine renewable energy.



Siemens Subsea Power Grid, including subsea transformer, switchgear, variable-speed drive, connectors and power control system.

THE INTRODUCTION OF MORE ADVANCED SUBSEA FUNCTIONS IS LEADING TO GREATER DEMANDS ON SUBSEA POWER DISTRIBUTION SYSTEMS.

HARDWARE

The building blocks of subsea electrical infrastructure are already in service, most notably umbilicals for light power transmission and heavy power export cables used in the offshore renewable sector.

As long-distance tie-backs increase in length, the potential for cost savings on the umbilical increases. Conventionally, supply to high-power consumers (e.g. boosting and heating equipment) has been distributed using one cable per consumer within the umbilical.

For long-distance tie-backs over a certain distance, it becomes more cost-effective to position the distribution of power at the well end of the cable, thus significantly reducing the number of components in the umbilical.

The development of subsea transformers and switchgear has been significantly advanced in recent years and has been environmentally tested by suppliers such as Siemens and ABB. Similar progress has also been made with other subsea electrical distribution components, including variable speed drives and medium/high voltage connectors.

In the future, the size and cost of these components will reduce through increased adoption, making subsea distribution of electrical power a more cost-effective alternative.

TRANSMISSION SYSTEMS

Long-distance tie-backs increase the challenge to transmit the required power from the host to the field, the choices being whether to use direct current (DC) or alternating current (AC).

The primary disadvantage of DC is the size and weight of the conversion equipment to AC to allow for the step-down in voltage to feed the local AC consumers. Switching off high voltage DC power in switchgear is also very challenging because the voltage does not go through zero as it does with AC (this is required to stop an arc of electric current between the contact points in a switch). This makes high-voltage, high-power DC transmission of power to a subsea tie-back technically unachievable in the near term.

For DC power transmission, only an intermediate solution involving some form of topside structure that contains the DC/AC conversion equipment can be considered as a viable option when evaluating options for power transmission over long distances. However, DC power transmission systems for the long-distance operation of low-power subsea equipment such as control modules and smaller valves are already available on the market, although not yet for high-power consumers.

AC subsea power transmission becomes very challenging for typical long-distance tie-back lengths of 150km and beyond. The HVAC cable for Total's Martin Linge Project installed by Subsea 7 in 2015 was 163km with 55MW power supply.

As cables become longer, their capacity increases the phase angle between current and voltage, leading to significant losses (reactive power). AC normally operates at 50Hz, but power losses can be decreased by introducing subsea phase compensation equipment and/or reducing the frequency. Major power system providers are now looking at the transmission of AC power for distances up to 600km. Because of their high development and operation costs, complex power transmission and distributions systems require early incorporation into the conceptual design to establish project feasibility. The selection of the electrical power distribution system may well also drive the concept for the subsea processing and control system.

Local power generation/energy harvesting may yet have an influential part to play in providing offshore electrical power.

MEETING FUTURE DEMAND

There are a number of reasons why the efficient electrification of subsea oil and gas fields is critical. The demand for electrical power is growing due to:

- The increased deployment of boosting and separation equipment in subsea processing
- Greater flexibility and agility in electrical controls and monitoring compared to hydraulic
- Longer tie-back distances from the host which exceed hydraulic limits
- Environmental drive towards renewable energy as part of the mix for powering subsea oil and gas fields
- Reducing the risk of environmental spillage from hydraulic systems

Subsea 7 is working in partnership with a number of technology providers within offshore energy harvesting to develop future systems that will eliminate the need for providing power from shore or offshore facilities to power subsea consumers. These partners include Flumill and GEPS Techno who are at advanced stages of development for current and wave energy harvesting technologies.

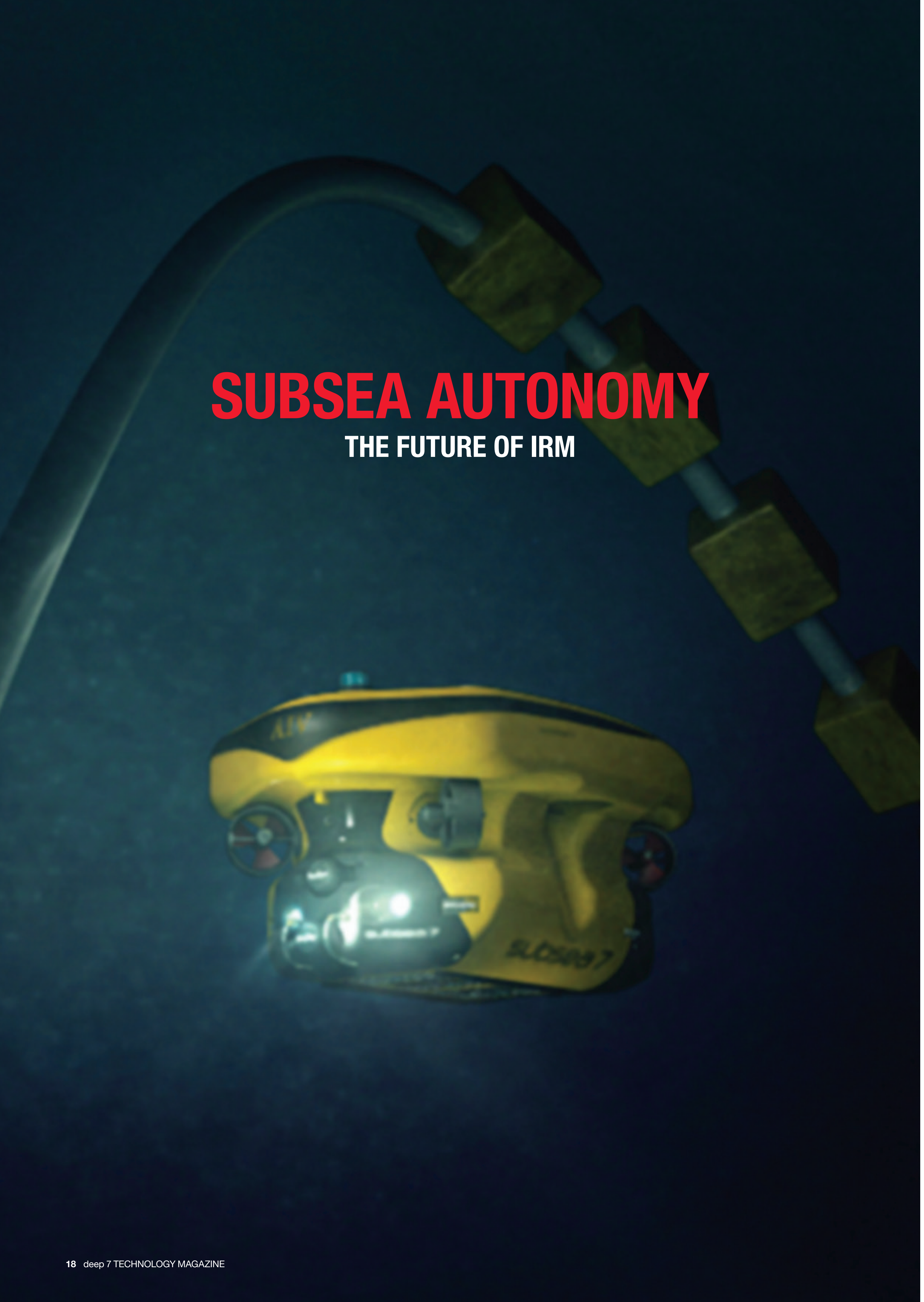
These developments have the additional benefits of providing alternatives for umbilical replacement, de-bottlenecking topside power capabilities and providing cost-effective power supplies for monitoring depleted or remote wells and acting as a recharging station for ROVs/AIVs.

Despite the emergence of new hardware for subsea electrical power distribution there will not be a 'one-fits-all' solution. Long tie-backs will continue using current hardware for many years simply because it combines well-proven technology with a competitive and well-understood cost base.

However, the increase in subsea power consumers will create demand for more advanced subsea power distribution. The drive towards more environmentally sustainable solutions will require local energy harvesting and subsea energy storage. Subsea 7 is actively leading the way in both of these areas as part of our technology investment programme.

DEVELOPING A SUBSEA ELECTRICAL POWER DISTRIBUTION UNIT AND PARTNERING WITH ENERGY HARVESTING TECHNOLOGY COMPANIES TO DEVELOP OFF-GRID SOLUTIONS.

ROV operations enable safe and fast connection and disconnection of modules inside the Submerged Production Unit (SPU).



SUBSEA AUTONOMY
THE FUTURE OF IRM

THE INDUSTRY CHALLENGE: Utilise digital and robotic technologies adopted from other industries to deliver smart IRM services that transform the integrity of subsea infrastructure.

BENEFITS: Major cost reductions in IRM campaigns, efficiencies through automation of repetitive activities, increased reliability and reduced risks to the environment.

JIM JAMIESON
Strategy & Technology Development Manager.
i-Tech Services.

Technological innovation is transforming the way we manage subsea inspection, repair and maintenance activities. In this article, we look ahead to electrically-powered seabed-resident vehicles being remotely controlled from beach-based command centres.

During the next five years, the subsea sector will experience a significant and disruptive technology phase through advances in the remote piloting of ROVs, subsea hosting of vehicles, autonomous surface vessels and digitalisation.

These technologies will challenge the way we execute inspection and maintenance work scopes under the traditional vessel-based IRM business model. This technological shift is potentially as significant as the introduction of ROVs 30 years ago.

The recent prolonged industry downturn has brought strong client pressure to reduce operating costs. The adoption and implementation of disruptive new technology is offering i-Tech Services an opportunity to lead the market change.

Experience has shown that, as a rule, inspection can account for 20%, repair 50% and maintenance 30% of a standard IRM long-term vessel-based campaign. We now see technological innovation influencing clients' buying behaviour and the way we manage inspection and maintenance activities, freeing up vessels for more repair-orientated work scopes. Typically, repair tasks which include heavy intervention, lifting or high-power tasks are most suited for delivery by field support vessels.

Our Electric Work Class 'eROV', Autonomy and Asset Integrity Management programmes, underpinned by our work on digitalisation with Leidos and autonomy development with SeeByte Ltd, are designed to address this technology-led change in the subsea inspection and maintenance markets.

The future is a suite of vehicles, which combine a move from hydraulic to electric propulsion and operate either fully autonomously or under supervised autonomy control.

The introduction of electrically-powered propulsion enables long-term subsea hosting of vehicles and therefore reduces the environmental footprint (CO_2) of the service by minimising support vessel time. In addition, electric vehicles have fewer drive train components, leading to increasing reliability over current hydraulic technology, and pose fewer risks to the environment.

The introduction of autonomy, whether full or supervised, enables the control of vehicles deployed offshore by operators located in an Onshore Control Centre (OCC). Autonomous control is focused on inspection, survey and light intervention tasks, while heavy intervention and repair are delivered by targeted vessel campaigns.

i-Tech Services has many years' experience of working closely with ROV designers and manufacturers to lead the development of bespoke, fit-for-purpose vehicles based on the successful integration of new technologies.

The first technology step to be commercialised will be to achieve remote control from beach-based OCCs, and we are currently in the final stages of commissioning OCCs in our Aberdeen and Stavanger facilities.

The expected increased deployment of autonomy will deliver significant efficiencies and cost savings.

i-Tech Services is developing a suite of AIV/AUV vehicles, which combine a move from hydraulic to electric propulsion, autonomous control and supervised autonomy.

REMOTE OPERATIONS: THE FIRST STEP TOWARDS FULL SUBSEA AUTONOMY

i-Tech Services' Autonomous Inspection Vehicle (AIV) is the most advanced, fully autonomous, hovering vehicle in the subsea market. The AIV is capable of unmanned inspection of pipelines, umbilicals, risers and subsea structures.

We continue to trial and qualify our AIV technology with clients, gaining valuable experience which increasingly strengthens the business case to commercialise the technology for deployment in its current form.

Confirming industry interest in this key area of subsea technology, we recently delivered a study report to a major Norwegian operator to assess the potential of Seabed-Hosted Vehicles (SHVs) and their deployment as part of a future North Sea field development.

Based on our record of accomplishment in supplying ROV and intervention services and our knowledge of autonomy within subsea vehicles, we worked closely with the client to identify the technology gaps and the approach required to deliver an IRM field-wide service.

The client is utilising the outputs of the report to progress plans towards the introduction of SHVs, permanently deployed subsea to provide inspection and light intervention services across the field. The implementation model is designed to be replicated as a regional service.

Autonomous systems allow the industry to execute work safely and efficiently while reducing operational and environmental costs.

These technical and capability advances are now closely tracking global trends towards the acceptance of autonomous systems in everyday life.

In our industry, there has recently been significant progress in the understanding and acceptance of autonomous equipment and vehicles to transform offshore oil and gas operations. Surface robots now execute routine, repetitive tasks and navigate around complex structures on onshore facilities, allowing personnel to focus on supervisory activities and limiting their exposure to potential hazards.

A pilot study of this kind, initiated by a major operator, confirms that the industry recognises the potential of autonomous systems to deliver safer, sustainable and profitable subsea operations.

RATIONALE FOR AUTONOMY: IMPACT ON VESSEL DEPENDENCY

A move to autonomy and semi-autonomy can significantly lower operating costs, improve operations, reduce the risk to offshore workers and enhance safety by reducing the human error factor.

	TODAY Vessel-dependent	TOMORROW Hosted	Vessel
Inspection	20% ROV-based inspection	20%	0%
Maintenance	30% Light intervention	20%	10%
Repair	50% Lifting and high-power	0%	50%

With a seabed-resident vehicle for 365 days per annum, we estimate a 40% reduction in vessel days.

AUTONOMOUS OR SUPERVISED AUTONOMY 'PILOT-IN-THE-LOOP' VEHICLES WILL IN THE NEAR FUTURE BE THE RESIDENT EYES AND EARS ON THE SEABED, REDUCING THE NEED FOR A FIELD SUPPORT VESSEL TO EXECUTE ALL IRM ACTIVITIES.

AIV

i-Tech Services' AIV is at the forefront of fully autonomous, hovering vehicle technology for subsea inspections.

20% REDUCTION IN INSPECTION COSTS

4 OFFSHORE TRIALS COMPLETED (TRL 5)

24 HOUR ENDURANCE, 40KM ROUND TRIP

3,000m RATED HOVER CAPABLE INFIELD INSPECTION VEHICLE

96 INSPECTIONS CARRIED OUT WITHIN A SINGLE 18 HOUR PERIOD

DIGITALISATION

THE TRANSFORMATIVE TECHNOLOGY

THE INDUSTRY CHALLENGE: To become a knowledge industry collaborating on shared data to transform performance through the energy lifecycle.

BENEFITS: Significant cost savings from fresh insights into design and operating environments, superior decision-making in addressing perceived risk or life-extension assessments.

HUGH FERGUSON
Strategic Development Director.
i-Tech Services.

Digitalisation represents the single biggest transformative step-change in the way many industries work. Collecting and analysing multiple data sets can provide insights into design and operating environments which deliver significant cost savings.

The oil and gas industry has been very good at utilising data to model, analyse and predict reservoir characteristics using seismic and exploration drilling data, but we have struggled to exploit data through the energy lifecycle.

In an already cyclical industry that is currently experiencing ‘the great crew change’, we are at risk of losing significant experience, history and proficiency.

In addition, the use of manual-intensive serial-type workflows means that our highly experienced and knowledgeable resources are wasted on repetitive industrial processing tasks. Digitalisation of the oil industry is not so much about technology development but more about becoming a knowledge industry that uses data to transform our ways of working.

i-Tech Services has a proven track record in delivering data solutions and has been collecting, processing and providing high-quality data insight to clients for 40 years.

Supported by a dedicated team of data science specialists, we provide end-to-end data solutions throughout the field life, concentrating on data management, data science and the application of integrated digital technologies.

APPLICATION OF DIGITALISATION

Initially we were focused on standardising the collection of data and ensuring a common architecture was used to allow the fast sorting and retrieval of data.

Today, we are proving data automation techniques such as automating cathodic protection inspections or using visual recognition systems to identify features on a pipeline and automate the engineering analysis of potential problems such as freespans or loss of a strake.

In particular, we are pioneering on-demand inspection and intervention services using subsea drones. This development is based on several key components: ROVs or drones that ‘live’ in the field, effective communication protocols to ensure safe, reliable control of these systems and automated data systems to maximise efficiency.

These on-demand services reduce or eliminate the cost of support vessels, the health, safety and environmental exposure and the logistics burden of supporting IRM operations.

Building on technology developed in our Autonomous Inspection Vehicle (AIV) programme, we are extending the worksite though remote piloting and control. These systems automate key tasks and put expert users in control of multiple units.

Using visual recognition systems, the efficiency of autonomous systems is greatly improved and realises the optimum cost savings of eliminating a support vessel.

By sharing this data and visual representation of the field as a living system, any robotic platform can be made aware of hazards, features and the latest field information.

DIGITALISATION PROGRAMME

i-Tech Services is focused on developing products and services that lower clients' total expenditure on Inspection, Repair and Maintenance-related activities, reduce dependence on expensive support vessels for offshore operations and lower QHSE exposure.

Managing risk (as opposed to accepting a higher risk profile) in continued operations and ensuring supply and flow of the product depend on collecting large volumes of high-quality data. This drives how assets are managed and underpins decision-making in addressing perceived risk or life-extension assessments.

To achieve this, we are investing in a digitalisation programme covering all aspects of work to enhance our service delivery to our customers. We chose a technology partner with multi-sector experience who could apply its cross-industry knowledge to the subsea market.

Earlier this year, i-Tech Services signed an exclusive partnership with Leidos to realise the many future benefits of digitalisation throughout the life of the field. Both companies share similar strengths, values and ambitions, underpinning a strong partnership to fast-track our digitalisation offering.

Our joint development programme increases the efficiency and responsiveness of several key activities:

- Collecting data
- Processing data
- Providing critical insights

COLLECTING DATA

We are focused on two main goals in data collection. The first is making data more available through the development of sensors and condition monitoring; the second is lowering the cost of collecting data through enhancing our underwater vehicles, decoupled from the vessel, which are used as repeat data-harvesting devices to combat the difficulties of through-water communications.

This digitalisation programme is not a linear process. The outputs of the new digital workflows will inform the optimum inspection requirements, enabling more targeted data collection and leading to valuable reductions in the duration and costs of IRM campaigns.

PROCESSING DATA

The automated processing of data, ensuring high-quality collection and availability in standardised formats, is the key to efficient analytics. This is achieved through a number of technological developments.

Common data architecture standardises the approach to data management from acquisition through to delivery. This allows for workflow optimisation based on established industry software packages, with targeted apps to reduce time and effort in routine processes.

We have carried out successful early development tests in machine vision image recognition, based on automatic review of video footage to identify specific anomalies, working towards the identification of subsea-specific anomalies. This will accelerate the processing of data remotely and locally, including edge computing on autonomous vehicles. The machine vision outputs will be combined with Deep Learning to assist automatic classification.

Advances in visualisation are delivering efficiencies in interpretation. 2D image mosaics provide an instantly accessible view of data from inspections, and can be visualised alongside MultiBeam EchoSounder, Laser Profiler and Side Scan Sonar data.

Creating a World Map or 3D field image allows the rapid access of data and the navigation of systems through the field based on high-quality visualisation platforms.

The workflow optimisation, image recognition and visualisation advances which are described here are currently being efficiently adopted from adjacent industries. This allows us to select the optimum technologies for capability and pro-actively collaborate on their next-stage development.

PROVIDING CRITICAL INSIGHTS

Based on these technologies, we are developing predictive and prescriptive analytics to monitor changes, identify events and predict the health of assets. Although all data collected is made available to the client, we concentrate on providing exception reporting that enables facilities/inspection engineers to directly address pre-identified issues without having to sort through large volumes of data.

Using advanced digitalisation techniques adopted from other sectors and industries to enable data automation, aggregation of multiple data sets, processes and analysis to create high-value insights.

We are developing a series of apps and customisable dashboards that allow various levels of users to interrogate data for a variety of purposes:

- To understand the risk in overall operation
- To check the health of assets
- To predict when failures could happen
- To optimise maintenance activities, the ordering of spares and manage vessel campaigns

Initially focused on greenfield sites, we are developing a digital 'twin' that will allow pipeline movement, support, corrosion and flow to be monitored, eliminating pipeline pigging while tracking the degradation of flow and integrity, if used in conjunction with production flow and composition monitoring.

The advanced application of Deep Learning, using all available data including historical, maximises the potential value of the insights.

The 'twin' is a virtual 3D model of the field riser, pipeline or mooring system which, through continuous sensor monitoring, allows the loading on the system to give a more accurate understanding of its condition and life expectancy. It is essentially a digital replica of the field that experiences the same conditions as its physical entity.

These streamlined activities and integrity insights allow faster decision-making, the ability to monitor rather than repair and the performance of real-time life extensions based on actual equipment usage, rather than historical trends and statistics or the use of safety factors.

DELIVERING GREATER CLIENT VALUE

By automating previously manual processes we radically speed up the analysis of data, improving efficiency and enabling more accurate decisions to be made. Automation reduces delivery timescales from months to days.

Digitalisation also makes survey or inspection campaigns significantly more efficient and cost-effective, while reducing risk to both i-Tech Services and our clients.

By bringing data and information to life we are opening up new insights. Using data from both the past and the present, in conjunction with advanced AI techniques, as indicators of the future to predict outcomes is providing clients with significantly higher quality data.

LOOKING TO THE FUTURE

i-Tech Services is using advanced digitalisation techniques adopted from other sectors and industries, including Deep Learning and Machine Vision, to enable data automation, aggregation of multiple data sets, processes and analysis to create high-value insights – and greater value – for our clients.

Our long-term vision is to continually develop a fully automated scalable portfolio of digital solutions to increase speed, quality and value for current and future client data requirements. Our platform and architecture are designed to integrate with any potential client system and accommodate existing and developing technology.

We will achieve our goal by using an agile development methodology which enables us to adapt to changing technology environments and continue to deliver best-in-class solutions.

i-Tech Services Aberdeen – Remote Onshore Control Room

Q&A

YOUR QUESTIONS ANSWERED

deep 7

Subsea 7's track record is based on our extensive in-house technology expertise, acquired over decades of executing challenging offshore construction and engineering projects on a global basis.

As the scope of subsea technologies widens, however, we have also invested in specialist hi-tech companies and groups who are operating at the cutting edge of development.

To complement the main articles elsewhere in *deep 7*, we invited experts from four of these specialist organisations to field wide-ranging questions on their particular transformative technologies.

Our thanks to the following technologists for their personal insights:

- Henk de Boer, Airborne Oil & Gas* – Thermoplastic Composite Pipe (TCP)
- Dr Richard Jones, Subsea 7 Pipeline Production Team – Friction Stir Welding
- Liam Macintyre, Swagelining (a Subsea 7 company) – Corrosion-resistant pipelines
- Philippe Magaldi, GEPS Techno* – off-grid renewable energy

** Subsea 7 is a minority shareholder in Airborne and GEPS Techno*

THERMOPLASTIC COMPOSITE PIPE (TCP)

Henk de Boer
CTO, Airborne Oil & Gas

Henk de Boer has worked in composite structural design for 20 years, and, before taking up his current post, was Team Lead Structural Design and Engineering Manager with Airborne Oil & Gas.

Q: How have you introduced the concept of TCP to the oil and gas market?

A: The really important element about TCP is its simplicity. This is a single-layer, fully-bonded pipe with no complicated interactions between layers; it is strong, lightweight and corrosion-resistant; it is completely spoolable and connects with simple end-fittings.

Based on the application, we select the right fibre, carbon or glass, and the right polymer, to ensure that we have the best fit-for-purpose solution. We have been highly strategic in approaching the subsea market with what is, for oil and gas, a radically new technology.

Our staircase into this market therefore started with temporary applications like TCP downlines and jumpers (essentially temporary risers) for subsea well intervention before moving into permanent installations in the SURF market, starting with well jumpers and static flowlines before moving on to deepwater TCP dynamic risers.

We are particularly proud of our achievement of the world's first TCP flowline in full hydrocarbon service.

Q&A

Q: What have been the main challenges in the technology journey so far?

A: As with many new technologies, market acceptance is essentially a trade-off between perceived benefits and risks. As we knew it would be, our development route has been a long journey and it now benefits greatly from the synergy between ourselves and Subsea 7, which has been a shareholder in our company since 2017. Drawing on Subsea 7's global market experience and know-how helps us to define the 'sweet spot' for TCP – where it really adds the greatest value for clients.

Q: What sectors of the subsea market have the greatest potential for TCP?

A: We have a strong business case for well jumpers, based on the fact that we do not require any metrology, the TCP being flexible and lightweight, and our short delivery times.

At OTC in 2017, the Libra Joint Project Team presented a detailed business case for free-hanging TCP catenary risers in deepwater riser developments with no external buoyancy and significant reductions in topside tension. For full deployment of TCP in FPSO risers, cost reductions could be as great as $200 million.

Q: What is your vision of the future for TCP?

A: Long-term maintenance costs with TCP are going to be significantly lower, but it is too early to build a solid quantifiable case on a total cost of ownership basis.

Similarly, lighter TCP pipes will give significantly lower loads on subsea connections, so the complexity and size of floaters, turrets and subsea structures can be simplified and reduced.

The greatest benefits of TCP will be realised when field layouts are designed around this technology, rather than viewing it as a replacement technology for steel pipeline.

I look forward to the day when the Subsea 7 fleet includes specialist vessels designed specifically for the installation of TCP flowlines.

FRICTION STIR WELDING OF PIPELINES

Dr Richard Jones
Pipeline Production Team
Technology Manager, Subsea 7
Richard Jones manages Subsea 7's strategic development programmes for materials, welding, NDT and FJC for pipeline fabrication. He previously worked on technology development with The Welding Institute for 30 years.

Q: What do you see as the next major technological development in subsea pipeline welding?

A: Welding processes currently used for pipeline fabrication have remained largely unchanged and based on arc welding for around 50 years. Although advances in technology and equipment have led to improvements in fabrication efficiency and weld quality during this time, the basic process characteristic of arc welding makes it difficult to achieve step-changes in production performance.

For this reason, Subsea 7 is constantly looking at alternative joining technologies to address the increasing market demand for more cost-effective pipeline fabrication. Friction Stir Welding (FSW) has been identified as a potential disruptive technology capable of advancing the automation of pipeline fabrication and improving weld quality. FSW is a solid-state one-shot joining process which offers rapid joint completion rates with minimal personnel requirements.

Q: How does FSW technology work?

A: The process uses a rotating tool to generate frictional heat at the interface between the parts to be welded. The substrate is softened and consolidated into a weld while contained between the tool and a backing support.

FSW is well established for the welding of aluminium in other industries, but the welding of steel pipelines presents some unique technical challenges due to the high temperature strength of the steel material.

Working closely with industry-leading exponents of FSW, Subsea 7's current development programme is focused on optimising the FSW tool design and material in combination with more effective procedures and equipment to control the thermal cycle of the joining process.

We expect to progress in the near-term to the construction of a prototype FSW machine which will enable the full potential of this exciting new joining process to be assessed.

Q: What other material technologies are under development by the Subsea 7 Pipeline Production Team?

A: We have a world-class pipeline R&D facility here in Scotland at Napier House, our new centre outside Glasgow. We are constantly assessing more cost-efficient pipeline material solutions and associated fabrication technologies which can transform the economic feasibility of field developments.

For high-pressure deepwater installations, we have performed qualification programmes for such high-strength steels as X80 pipe, delivering a reduced pipeline wall thickness to support the design of offshore risers and flowlines. Our current focus is on the development of even higher-strength steels, bringing the prospect of further pipeline weight reductions.

Working with Butting, our long-term manufacturing partner for CRA mechanically lined pipe, we are currently qualifying a new line pipe product called GluBi®. This is an adhesively bonded lined pipe which avoids the need for internal pressurisation to prevent liner damage during reeling. GluBi® will greatly simplify spooling and installation procedures compared with BuBi® pipe.

We are also working with pipe suppliers on extending the range of High-Frequency Welded Pipe (HFW), which delivers significant cost savings over seamless pipe and submerged arc welding pipe.

SWAGELINING®: CORROSION-RESISTANT PIPELINES TO ENHANCE SUSTAINABILITY

Liam Macintyre
Managing Director, Swagelining (a Subsea 7 company)
Liam Macintyre is an Incorporated Mechanical Engineer with the IMechE and holds extensive experience in subsea construction, project management, business development and integrity management of flexible pipe systems.

Q: How does Swagelining fit into the Subsea 7 technology development strategy?

A: In recent years Subsea 7 has grown its capability in the fabrication of corrosion-resistant pipelines to become a recognised industry leader in this subsea market. These innovative technologies include polymer-lined pipeline systems developed by in-house specialist manufacturer Swagelining, which was acquired by Subsea 7 in 2016.

The Swagelining technology is based on a simple yet ingenious composite pipe fabricated of steel and polymer layers which has a successful 25-year track record of subsea service.

With its 50-year qualified design life, reduced weight and improved flow assurance, the Swagelining product offers clients long-term pipeline integrity and cost advantages over CRA alternatives such as clad and mechanically lined pipe for a growing range of service conditions.

The Subsea 7 vision is to globalise this corrosion-resistant technology and develop it for all subsea pipeline applications.

Q: What are the most significant steps in this journey?

A: The first big game-changer is our LinerBridge® technology, the world's first all-polymer connector for polymer-lined pipelines. This electro-fused connector is the enabler for expanding the application of Swagelining's corrosion-resistant pipeline technology, simplifying offshore pipeline fabrication processes and allowing a 35% EPCI cost reduction when compared to CRA alternatives.

The LinerBridge® technology also enables Swagelining deployment for the first time in deepwater dynamic riser applications, high-temperature field-joint coating applications and alternative pipeline installation methods such as S-lay and J-lay. The connector has recently completed DNV GL technology certification, has been approved for use in water injection applications worldwide by Equinor and is a key component in three awarded North Sea projects using Swagelining's composite pipe system during 2018/19.

This new development has our LinerVent™ technology at its core which ensures pressure equalisation across the polymer liner and prevents liner collapse due to gas diffusion through semi-permeable liner materials.

Q: How do you assess industry demand for polymer lining pipeline?

A: In recent years, the cost to the industry of internal pipeline corrosion is being increasingly quantified, driving strong demand for a cost-effective, long-life corrosion barrier – and our all-polymer systems meet that need.

In addition, as the industry seeks improved oil recovery efficiencies, the Swagelining product supports this goal by delivering ensured water cleanliness to support both secondary recovery (water injection) and tertiary recovery (Enhanced Oil Recovery (EOR)) processes.

Q: What is the ultimate technological vision for Swagelining?

A: We believe in making subsea pipeline fluid transport systems more sustainable by offering a cost-efficient corrosion-resistant polymer lining solution for all types of subsea rigid pipeline systems on a global basis.

The ultimate challenge is developing a technology which allows the realisation of all the benefits of polymer lining for high-pressure hydrocarbon service. We have a new product under qualification for multi-phase hydrocarbon service and are actively discussing this with key global oil companies.

Q&A

GEPS TECHNO

Philippe Magaldi
Technical Director, GEPS Techno

Philippe Magaldi is a hydrodynamics engineer and naval architect who specialises in marine energy. Prior to co-founding GEPS Techno, his varied maritime career included project-managing the construction of RMS Queen Mary 2, the flagship of the Cunard Line.

Q: Can you describe the innovative technologies which you are developing?

A: We are concentrating on new concepts in off-grid renewable energy which can power marine equipment operating in remote sites. To ensure simplicity, reliability and ecosystem compliance, our technology is based on harvesting multiple sources of energy – solar and wave, for example.

Our goal is clear: to produce efficient new power generation products with reduced storage needs which are not reliant on intermittent, single-source energy sources. Our marine generators conform to a simple design based on internal water flow through a floating turbine, which can be platform-mounted on either a buoy or a vessel as a passive stabiliser.

With three prototypes tested at sea since 2015, we believe we already have a lead in terms of market-readiness.

Q: How does GEPS Techno fit into the Subsea 7 world?

A: Our technology is scalable and we identified strong potential in the offshore oil and gas market – but we need to collaborate with a large global company to help us to identify low-power needs in the subsea market.

Subsea 7 was looking for alternative power sources for umbilical connection to subsea equipment and gave us a thorough audit before taking a minority shareholding in our company and drawing up an agreement to work with us.

We have several specific objectives: to power remote applications, eventually including long-distance tie-backs; to use green technology design to improve the efficiency of specific offshore oil and gas processes; and to achieve carbon footprint reduction goals.

We will also rely on Subsea 7's expertise in offshore installation and mooring for our power generation plants, and, in the Life of Field market, our autonomous power generation proposition is highly compatible with the AIV/AUV concepts being developed by i-Tech Services.

Q: What are the main industry challenges in getting this technology to market?

A: We are confident that our technology can be developed to meet more power-hungry applications. We currently have a 150kW demonstrator ready for sea trials early next year, and a 300kW platform is proposed for operation in 2020.

There are, however, two significant cultural challenges with renewable energy. The first is the higher CAPEX which comes with renewable generating equipment. This is offset by the elimination of OPEX costs (no variable fuel costs) and makes the TOTEX an attractive proposition, but it does require a willingness to invest.

Secondly, renewables require a change in mindset about power consumption. Our products harvest all available energy sources, but, even so, power supply may be intermittent. As with all renewable generator developers, we are working towards making power supply continuous, but it does require consumers to consider adapting specific processes to meet irregular power availability. Technological advances in energy storage can match the supply and demand characteristics.

These are significant challenges – but the rewards justify the efforts made to overcome them.

SUBSEA 7 CAPABILITIES ACROSS THE ENERGY LIFECYCLE

SOLUTIONS THAT DELIVER VALUE TO CLIENTS

Early engagement through global alliances and client partnerships optimises the solutions Subsea 7 can provide.

EXECUTING PROJECTS AND SERVICES THAT MEET CLIENT EXPECTATIONS

An extensive track record of safely executed projects worldwide makes Subsea 7 a market-leading provider.

EARLY ENGAGEMENT
Creating value for clients in the earliest stages of project planning, lowering costs and streaming schedules.

CONCEPT
Input at concept allows for optimisation of later cycle stages.

DESIGN
Robust FEED ensuring minimal change and accurate forecasting during design.

ENGINEER
Detailed engineering by experienced personnel to deliver the best solution.

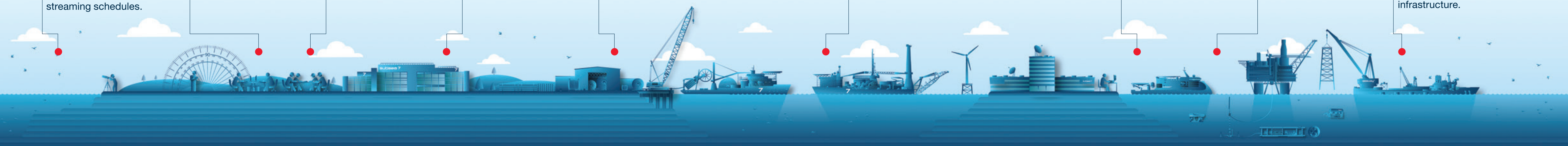
PROCURE & FABRICATE
Efficient procurement and high quality fabrication delivered on time.

INSTALL & COMMISSION
Safe, on-schedule and cost-efficient installations by world-class vessels.

MAINTAIN
Effective and responsive maintenance reducing cost of ownership.

EXTEND
Maximised return on investment by utilising new technologies and tie-back solutions.

DECOMMISSION
Facilitated abandonment and decommissioning with heavy lift vessels and re-use of infrastructure.



OUR DIFFERENTIATORS

Culture	Global team with expertise, passion and commitment to deliver.
Creativity	Ability to innovate through technology, processes and partnerships.
Relationships	Working and learning together to achieve success for all.
Reliability	Trusted partner in delivering projects.
Solutions	Client-focused mindset to create the right solution.

deep7

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