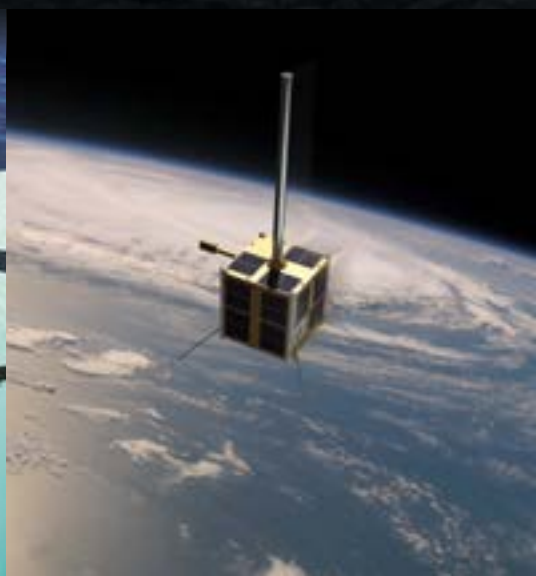


INTSOK

Norwegian Oil and Gas
Partners

ARCTIC CATALOGUE

March 2015



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INTRODUCTION

The purpose of this catalogue is to identify and highlight INTSOK partner companies that deliver technology and services representing potential contributions to oil and gas operations in the Arctic, and the relation between different types of contributions. The catalogue presents INTSOK partner companies and their capability to deliver technological solutions within the following Arctic focus areas:

- Design and construction of vessels and platforms
- Drilling operations and well control
- Environmental protection, monitoring systems and oil spill contingency
- Subsea installations and pipelines
- Marine operations
- Property and Personnel protection, Maritime training
- Weather forecasting, surveillance and communication

The descriptions of challenges and technologies presented in this catalogue are, to a substantial degree, based on the knowledge and insight generated through the Russian-Norwegian Oil and Gas Industry Cooperation in the High North Project (RU-NO Barents Project).¹

Currently, approximately 65 large oil and gas fields have been discovered within the Arctic Circle in Russia, United States (Alaska), Canada, Denmark (Greenland) and Norway. Furthermore, a great deal of the attention has been paid to Arctic resources that stem from the potential of undiscovered oil and gas resources. Undiscovered resources refer to oil and gas that, of a given date, is thought to be recoverable from undiscovered accumulations in future development projects. According to the United States Geological Survey (USGS) the Arctic is supposed to contain 13 % of the world's undiscovered oil reserves and 30 % of the world's undiscovered natural gas reserves. Russia is estimated to hold more than half of the total Arctic resources. Russia also holds the largest amount of natural gas resources, while the largest oil resources are in the United States (Alaska).

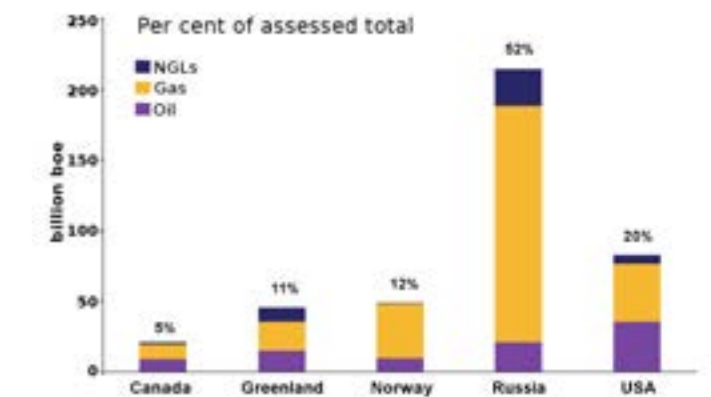


Figure: Potential Arctic oil and gas resources (total assessed resources = 412 billion boe) Source: USGS

POTENTIAL

The Arctic areas of the world have proven to be rich in oil and gas resources. The Arctic has already been producers of significant quantities of oil and gas resources for almost forty years. INTSOK companies have, through an extensive record of onerous offshore operations, demonstrated the capability to develop and to apply innovative and sustainable technologies for operations in the Arctic.

THE ARCTIC – THE NEW FRONTIER

Metrological and oceanographic conditions in the Arctic make offshore oil and gas operations in these areas particularly challenging. In some areas, the presence of sea ice is likely to limit the operating season emphasizing the importance of operational efficiency. The presence of sea ice also requires that vessels, installations and equipment are designed to withstand increased pressure and impacts from drifting ice.

¹ The RU-NO Barents Project was carried out in the period 2012-2015 with the aim to increase Russian and Norwegian industry participation in future oil and gas operations in the High North. The material from the Russian-Norwegian Barents Project is available at: www.intsok.ru

Main image on front cover: Source DNV GL.

Small images from left to right: Source DNV GL, Kvaerner, Kongsberg Maritime AS

Image back cover: Source Norwegian Coastal Administration



Low air, icing temperatures, reduced visibility, polar lows, heavy snowfall and darkness could cause cancellations or delayed operations, as installations and equipment need to be protected and personnel are being prohibited from operating outdoor for longer periods. Such weather conditions may also lead to icing on vessels and installations as well as higher risk during search and rescue operations.

Development of oil and gas in the Arctic will be conducted in areas located in vast distance from existing infrastructure. This increases time of travel in and out of operating areas, while also leading to higher costs. Combined with insufficient access to critical transport infrastructure, a lack of reliable weather forecasts, degradation of data quality induced by the high latitude and inadequate satellite coverage, these represent sources of uncertainty and rising costs, which may delay, halt or even avert operations.

Confronted with the physical and operational challenges in the Arctic, safe and cost effective operations demand significant improvements in technology to achieve feasible and cost effective solutions. INTSOK partners are in the forefront of developing the technology necessary to allow operations in the Arctic to be carried out in a safe and cost effective manner. This includes, among other things, improved hull and ship design, satellite technology and more reliable weather forecast models and well control systems.



Hammerfest (Source: Aibel, Foto Øyvind Sætre)

DESIGN AND CONSTRUCTION OF VESSELS AND PLATFORMS

Arctic offshore oil and gas operations are regularly carried out in ice-covered waters. Combined with water depths reaching from only some 20-30 meters down to several thousand meters and soil conditions changing from solid permafrost to soft muddy sediments, it is imperative to design and to construct vessels and platforms that meet the highest technical standards and which are capable to operate efficiently and safely in the harsh operating conditions in the Arctic.

Placed against the potential impact of one-year ice up to 2,5 meters thick, drifting icebergs and ice ridges (stamukhi) - in designing and constructing vessels and platforms for arctic operations - it is critical to determine how ice loads affect the strength and fatigue resistance of hulls and platform foundations, both global and local. Furthermore, soil conditions and soil movement effects on gravitation base or piles must be accounted for when designing and constructing fixed installations for use in the Arctic.

During operations in the Arctic, low temperatures and sea spray may lead to icing of topside installations and equipment. To assure safe and efficient operations, winterization of topside installations and equipment, such as derricks and hoisting systems, are critical.

The ability of a mobile drilling unit (MODU) to operate in water depths of around 100 to 350 meters would typically require a moored system for keeping station within the needed watch circle to maintain an allowable riser angle. For deeper waters, either mooring or a dynamically positioning system may be used. For operations in ice-covered waters, the mooring system should allow efficiently executed planned as well as emergency disconnect and reconnect from the moorings. Currently, a turret based system is believed to be the most viable alternative.

In designing and constructing vessels and platforms for arctic operations, INTSOK partners deliver market leading products and service within the following areas:

- Ice load modelling
- Vessel and platform design and construction
- Topside and offloading installations and systems
- Mooring, anchoring and positioning systems
- Maintenance and installation services



Cylindrical hull concept – Arctic Ice hull (Source: Sevan Marine)



INTSOK PARTNER DELIVERABLES

ICE LOAD MODELLING

- **Inocean:** Operations in ice, Ice loads modelling, Ice resistance, Model testing in ice
- **MARINTEK:** Wave and slamming impact loads simulation, hull and propulsion optimization, hydroelastic modelling and testing and oblique flow simulations
- **Moss Maritime:** Global Dynamic Numerical Ice Impact analysis. Full Dynamic Numerical Ice induced Vibration analysis. Ice Model tests specifications and follow up
- **Multiconsult:** Numerical ice load simulations and modeling (hull and mooring systems)
- **NTNU:** Numerical ice load modeling (probabilistic and stochastic)
- **REINERTSEN:** Concept optimization with the aim of reduced ice actions. REINERTSEN's in-house developed models can predict the probability and quantity of ice infested load scenarios on bottom fixed and floating structures
- **Scan Tech:** StressAlert Hull Stress monitoring

VESSEL AND PLATFORM DESIGN AND CONSTRUCTION

- **Aibel:** Submersible hull design for shallow waters
- **Aker Solutions:** Floater designs (semi-submersible platforms and drilling rigs, FPSOs and TLP)
- **DNV GL:** Strength assessment and classification of ships, machinery software, waveship software, cutres software, 3D beam modelling software, platform classification and design approval
- **DWellop:** MODU design
- **Inocean:** MODU design (Statoil Cat I Arctic Drillship, INO 80 Drillship, Marotec semi design), INO 240 000 FPSO, Winterization and Compliance documentation
- **Kvaerner:** Floating designs (SEMI, TLP and concrete) and



Arctic Mobile Offshore Drilling Unit (MODU) (Source: Kvaerner)

- EPCI delivery. Fixed solutions (Concrete and steel) designs and EPCI delivery. Topsides and substructures for production and exploration (incl. MODU design). Nearshore LNG production and regas
- **LMG Marin:** Offshore support vessels, seismic vessels, construction vessels, deep water drill ships, LNG powered ships and engineering services
- **Moss Maritime:** Icebreaking Supply and service vessels (AHTS, PSV and oceanographic research). Icebreaking LNG Carriers, icebreaking turret moored drillship, icebreaking turret moored FPSO. Arctic catamaran semi-submersibles design (Moss CS-series), Arctic axisymmetric drilling and production units (Moss octopus). Moss Maritime is introducing green technologies for next generation floater designs: Moss Eco Drive™ - Hybrid power system with energy storage. Moss Eco LNG™ - Dual fuel power generation with reduced emissions. Moss Eco Green™ - 'Zero discharges' and waste heat recovery. State of the art engineering services i.e. non Linear FEA collision simulations and fracture modelling



Arctic Drillship II (Source: Moss Maritime)

- **Multiconsult:** Structural engineering services, hull design and CTD analysis (spray ice)
- **Odfjell Drilling:** Drillships and semi-submersibles design
- **REINERTSEN:** REINERTSEN is well familiar with the current design codes applicable for structures located in arctic conditions
- **Rolls Royce Marine:** Hull form design, propulsion systems, maneuvering and thrusters systems, deck design and machinery, anchor handling systems, multipurpose service vessels (MPSV) design and engines (gas and diesel)
- **Scan Tech:** Structural monitoring
- **Sevan Marine:** Cylindrical hull design with dynamic structure (vertical and slope) for FPSO and MODU, and topside process systems
- **SINTEF:** Vessel design and construction modelling
- **Technip:** Design of MODU, spars, tensioned leg platforms (TLP) and FPSO, design of conventional platforms, gravity based structures (GBS) and arctic spars, self-installing platforms and artificial islands



Icebreaking Support Vessel VARD 9 07 (Source: VARD)

- **Ulstein International:** X-Bow design, offshore support vessels, heavy offshore vessels, mission/interface equipment, and power and control systems, supply & service vessels, anchor handling tug supply vessels and specialised/multifunctional vessels (with ice class notation)
- **VARD:** Design concepts and R&D, platform supply vessels, offshore subsea construction vessels, anchor handling tug supply vessels and specialized vessels (all compatible with ice class notation)
- **Wood Group Mustang Norway:** Design of MODUs, e.g. Drilling semis and drill ships, design of floating production units such as production semis and FPSOs. Multidiscipline engineering services. From early concept studies to detail engineering
- **Apply Leirvik:** Living quarters and helidecks design and construction, topside drilling and processing system design and construction and automation systems
- **DNV GL:** Offloading installation design
- **DWellop:** Jacking and tension frames and weather deck hoists
- **Euro Offshore:** Topside modules
- **GE Oil and Gas:** Turbines, control systems, pumps and compressors
- **Glamox:** Lightning systems (e.g. search lights, navigation lights, explosion and proof lights, emergency lights and helideck lights)
- **Eaton (HERNIS CCTV Solutions):** Systems house offering full CCTV project management, design expertise, commissioning, after sales service, and system lifecycle support. Surveillance solutions for projects of any size and complexity. Inter-connected systems and remote surveillance solutions
- **Inocean:** Topside equipment design and construction, side by side LNG offloading systems and equipment stern condensate offloading systems
- **IK-Norway:** Isolation, pressure testing, hot taping, pipe intervention in connection with pipe upgrading and modifications
- **Kongsberg Maritime:** Thruster control systems, marine switchboard, engine room and automation systems, propulsion control systems, camera and bridge systems and sensors and transmitters

TOPSIDE AND OFFLOADING INSTALLATIONS AND SYSTEMS

- **ABB:** Topside equipment design and construction (motors, generators and electric equipment), control and instrumentation systems, control room equipment, telecommunication and power system components
- **Aibel:** Topside platforms and onshore oil and gas facilities covering; front end studies and EPC delivery, major upgrades and new-builds
- **Aker Solutions:** Compensators, tensioners, control rooms and operator cabins, drillfloor equipment (e.g. hydraulic roughnecks, winches, mud buckets, manipulator arms), operator equipment, handling tools, hoisting systems and design (e.g. derricks and line drums), hydraulic power units and mud pumps



- **Kvaerner:** Jackets and topside installations and equipment
- **Lloyd's Register Consulting:** Risk assessments/ optimization studies for layout/ventilation – CFD fire & explosion simulations. Tech safety system assessments. Human factors engineering
- **Moss Maritime:** Winterization of floaters including topside and systems in compliance with NMA, NORSOK and Class Notation requirements
- **Multiconsult:** Winterization design services and HVAC
- **Nymo:** Drilling modules and packages
- **Rapp Bomek:** Fire doors and protection equipment
- **REINERTSEN:** Offloading installation design
- **Safety Tools Allmet:** High quality air tools and unique design rotating files. The tools from Safety Tools are EX certified and perfect for maintenance and surface protection in Arctic areas.
- **Scana Group:** Hose reels, hawser winch and hose end coupling equipment, repair, maintenance and inspections, handling tools, crown blocks
- **Scan Tech:** Delivers load monitoring, Cleaning systems, ATEX Compressors and Air Lift Systems
- **Sevan Marine (Kanfa):** Gas scrubbing, inter-cooling, dehydration, sweetening and liquefaction systems, topside processing systems (compression, injection and separation) and topside power systems and equipment
- **SINTEF/MARINTEK:** Offloading installation design
- **Subsea 7:** Offloading systems for FPSOs
- **Technip:** Loading/offloading buoy installations

- **Wood Group Mustang Norway:** Topsides engineering, procurement and construction support for MODUs, floating production units and fixed platforms. From early concept studies to detail engineering. Hook-up and commissioning support

MOORING, STATION KEEPING AND POSITIONING SYSTEMS AND EQUIPMENT

- **Aker Solutions:** Mooring system design
- **Control Cutter:** Emergency release and disconnect systems during arctic conditions by cutting anchor chains instantly
- **Deep Sea Mooring:** Mooring positioning systems (ADAPS™), hydroacoustic release hook, ultra high holding power anchors, chains, buoys and fibre ropes, swivels, wires, mooring connectors and hooks and pre-lay mooring services
- **DNV GL:** Mooring system design and dynamic positioning system design
- **IKM Group:** Mooring spreads
- **Inocean:** Mooring and DP analysis, Anchor design
- **IOS Intermoor:** Quasi-static and dynamic mooring analysis, anchor design (SEPLA and torpedo) catenary installations and taut-leg preset systems, anchor pendant buoyancy, mooring chains, ropes and spooling systems and foundations
- **Kongsberg Maritime:** Anchor bolster monitoring TV system, dynamic positioning systems (compact, single, dual and triple redundant), position mooring systems, thruster control systems (side, azimuth, propulsion, rudders)
- **Kvaerner:** Mooring system design and EPC delivery
- **Moss Maritime:** Mooring analysis, Dynamic Position analysis. Mooring installation and disconnection philosophies and procedures. Design of anchor handling/tug/supply vessels (with ice class notation)



Arctic FPSO for Shtokman (Source: Moss Maritime)

- **Multiconsult:** Mooring and anchor design and response of moored structures
- **NTNU:** Modeling and control of mobile, interconnected aquastructures for harsh conditions, modeling of station-keeping and maneuvering of ships in waves and estimation and control of parametric roll for ships
- **Scana Group:** Mooring winches fabrication
- **Scan Tech:** Mooring monitoring, Hydraulic winches from 2.5 to 250T, Excursion monitoring, RLM (Running Line Monitoring), Chain tension, Position monitoring



SEPLA anchor system (Source: IOS Intermoor)

MAINTENANCE AND INSTALLATION SERVICES



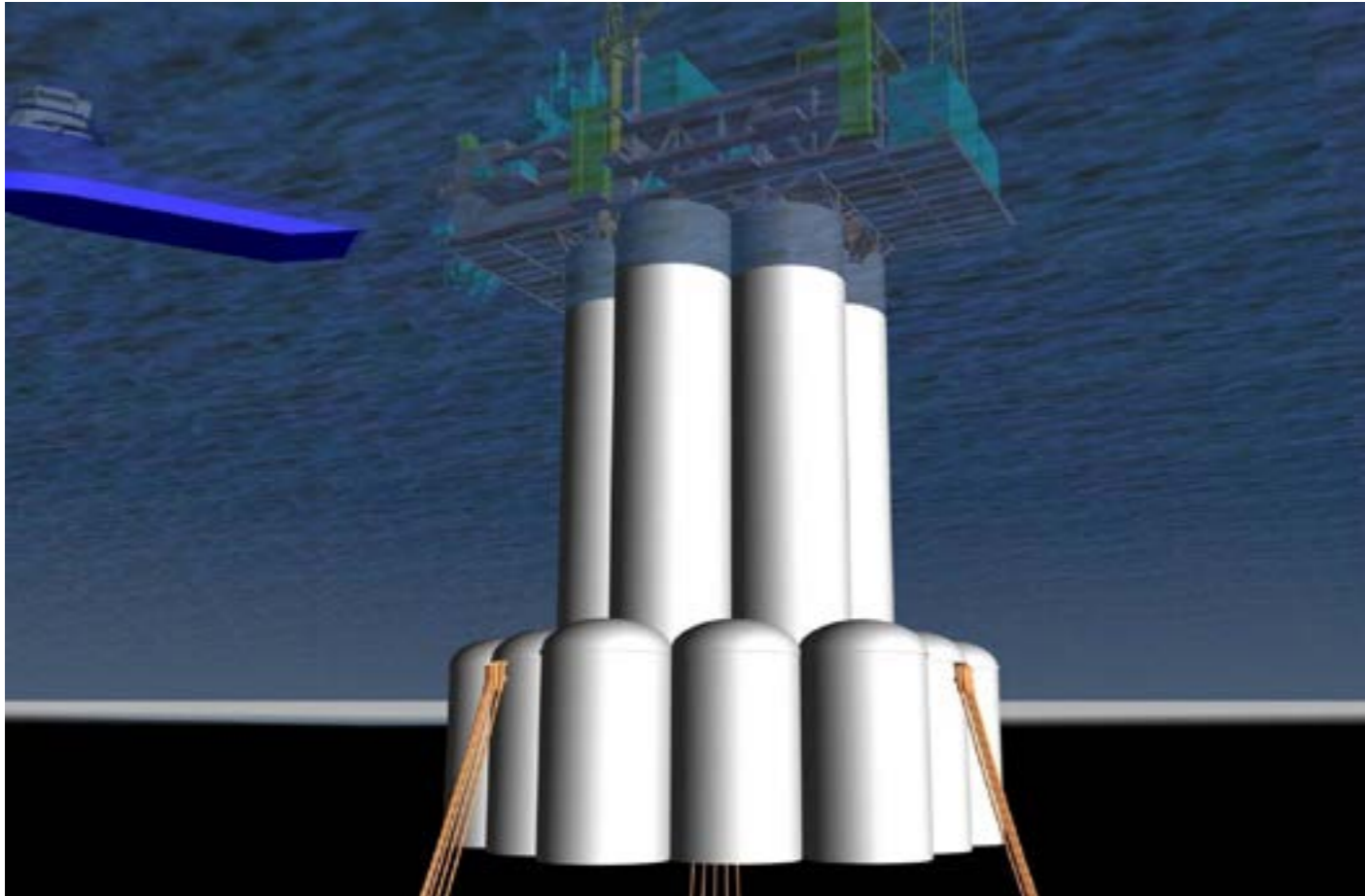
ControlCutter Unit (Source: ControlCutter)

- **ABB:** Topside maintenance engineering, condition monitoring of motors and generators, life expectancy analyses, extension, upgrade and retrofit
- **Aibel:** Front end studies, topside; maintenance, operations support, repair and major upgrades
- **Aker Solutions:** Front end studies, life of field technology, asset integrity management systems and MMO modification
- **Apply Leirvik:** Topside (living quarters) maintenance and repair, topside drilling and processing system installation
- **DNV GL:** In-service surveying, vessel towing and installation programmes, engineering service and risk assessments
- **IKM Group:** Offshore field calibration, condition monitoring, maintenance management, planning and analyses and operational modifications
- **IK-Norway:** Bolt tensioning services, bolt replacement operations by use of hot bolting. Corrective maintenance on live systems, pipe repair and valve replacement
- **Inocean:** Topside installation engineering services and design
- **Lloyd's Register Consulting:** Risk assessments. Marine installation Safe Operations Analysis
- **REINERTSEN:** Studies, FEEDS, and EPCI of Modification and Maintenance. Topside substructure and subsea infrastructure
- **Scan Tech:** Sales and rental of a wide range of products and equipment such as Crane and Lifting equipment, Air Compressors, Breathing Air Compressors, Driers, Hot Air Fans, Dehumidifier, Reelers and Chain Hoists
- **Subsea 7:** Life of field services

- **Sevan Marine:** Mooring system design (anchor-chain-polyester-chain)
- **Stinger Technology:** Real-time anchor chain monitoring system for vessels and floating facilities
- **Subsea 7:** Mooring system design
- **Technip:** Taut leg catenary moorings, polyester mooring systems, suction pile and suction embedded plate anchors (SEPLA) and mooring system installation
- **4 Subsea:** Mooring system design



- **Technip:** Technological upgrading and operational support and modifications, ROVs and ROV training simulators and floatover operation
- **Wood Group Mustang Norway:** Maintenance and modification engineering, front end studies, full range of EPCIC services, subsea tie-in projects, topside process modifications, pre-compression, modifications and maintenance on electrical, instruments, control systems, safety and automation systems and telecom



Concrete deep floater production designed to stay in ice infested waters (Source: Kvaerner)

DRILLING OPERATIONS AND WELL CONTROL

The physical characteristics and natural conditions will, to a large extent, dictate the nature of drilling and well operations in the Arctic. Arctic drilling is also dependent on location. Location specific factors include distance from pre-staged emergency response equipment, logistical support to receive and deploy emergency response equipment, proximity of rigs capable of drilling relief wells, open water season length, ice conditions, and ability of marshalled equipment to operate in ice.

The number one focus of drilling and well operations is prevention of incidents leading to loss of well control. This is accomplished through proper well and riser design, material and equipment selection, review and assurance, monitoring, procedures, standards, training, and people capability.

While focus is on preventing incidents, capability for emergency response must be in place or quickly deployable to respond to the loss of well control. Typical controls include the blow out preventer (BOP), relief well drilling, well capping, containment, subsea dispersant application and Oil Spill Response (OSR).

INTSOK partners are in the forefront of developing technologies and solutions leading to safer and more efficient drilling and well operations in the Arctic. Deliveries include:

- Well control, well capping and containment systems and equipment
- Wellhead solutions, protection systems and well design
- Waste, cuttings and discharge
- Drilling services

INTSOK PARTNER DELIVERABLES

WELL CONTROL, WELL CAPPING AND CONTAINMENT SYSTEMS AND EQUIPMENT

- **Ace Oil Tools:** Ratchet collars and clamps
- **Add Energy:** Well control & blowout support (contingency planning, well control incident response, dynamic multiphase flow simulations, transient multiphase flow analyses, well flow assurance & control)
- **Aker Solutions:** Riserless light well intervention (RLWI) and well intervention academy
- **Control Cutter:** Light and efficient subsea cutters for riser cutting, debris clearance and general Oil Spill Response
- **Enhanced Drilling:** Managed pressure drilling system, dual gradient drilling systems/riserless mud recovery systems, managed pressure cementing systems
- **Inocean:** Plug & Abandonment vessels, well intervention vessels
- **Kongsberg Oil & Gas Technologies:** Well management and well planning systems
- **Lloyd's Register Consulting:** BOP risk model – monitoring BOP performance on-line
- **Multiconsult:** Drilling floor design and fire and fatigue analysis
- **Nymo:** Drilling modules and packages
- **Petroleum Technology Company (PTC):** Well integrity assurance, chemical and gas lift injection systems, wellhead valve removal solutions, injection equipment, wellhead safety valves, jet pumps, circulation valves
- **Scan Tech:** Compressors for Mud Handling, HP washers for clean-up



WELLHEAD SOLUTIONS, PROTECTION SYSTEMS AND WELL DESIGN

- **Add Energy:** Reservoir development (e.g. well performance modeling, production optimization, well design concept studies, well examination / peer / partner reviews and audits and time and cost analysis)
- **Aker Solutions:** Well engineering
- **DNV GL:** Verification and condition assessment of drilling and well systems, well integrity management, risk management of drilling and well operations, technical advisory and consultancy
- **Enhanced Drilling:** Managed pressure drilling system (EC-Drill) and zonal isolation technology
- **Fishbones:** Open hole liner completion systems (Acid jetting and Dreamliner drilling)
- **Kongsberg Oil & Gas Technologies:** Well management and well planning systems
- **Lloyd's Register Consulting:** Risk management/Risk analysis
- **Moss Maritime:** Riser Ice-Protection solutions. Design of Well service platforms, Well intervention vessels (with ice class notation)



Riserless Mud Recovery System (Source: Enhanced Drilling)

- **Petroleum Technology Company (PTC):** Well integrity assurance, chemical and gas lift injection systems, wellhead valve removal solutions, injection equipment, wellhead safety valves, jet pumps, circulation valves
- **Scan Tech:** Weak Link Bails
- **SINTEF Petroleum Research:** Well integrity research (e.g. material integrity, thermal cycling, well barriers materials), drilling software and training simulators
- **Subsea Services:** HPE Swivel, Gooseneck system, LMRP system, engineering, inspections, maintenance and repair and modifications and upgrades

WASTE, CUTTINGS AND DISCHARGE SOLUTIONS

- **Deep C Solutions:** Drill cut transportation, Excavation
- **Ellingsen Nor Instruments:** Mud skids
- **Enhanced Drilling:** Riserless mud recovery and cuttings removal and transportation systems
- **Gann Mekaniske:** Mud treatment systems (e.g. shale shakers, degassers, centrifuges, mud sharing systems, spreader boxes, dump valves, mud guns, conveyors), mud treatment systems design, production, testing, maintenance and spare parts
- **StormGeo:** StormGeo Coral Watch system, monitoring drilling cuttings and produced water discharge to contain impacts, based on direction of ocean currents
- **Scan Tech:** Rental of Air Compressors, Air Coolers, Air Hoses
- **Subsea Services:** Mud recovery systems
- **Thermtech:** Thermomechanical cuttings cleaning systems



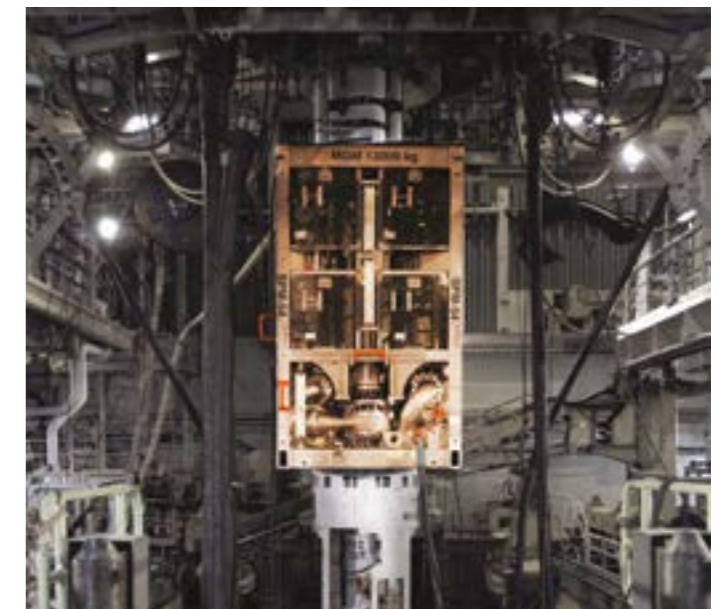
CS50 Arctic (Source: Moss Maritime)

- **NTNU:** Drilling engineering (horizontal drilling, electric pulse drilling, improved drilling fluid properties and managed pressure drilling)
- **Odfjell Drilling:** Well intervention systems and products (e.g. casing equipment and wellbore cleaning equipment), downhole equipment (e.g. drillstem valves, drillcollars and pulp joints), tubular handling equipment (e.g. elevators and lifts, safety clamps, sliding spider and rig tongs), tubular services, rental services and well intervention services

DRILLING SERVICES

- **ABB:** Integrated automation and electrical products and systems, engineering, procurement and construction services
- **Add Energy:** Drilling project management, drilling rig and drilling equipment assessment
- **eDrilling Solutions:** Dynamic drilling models and diagnosis technology, pre-drill simulations, integrated manage pressure drilling systems, drilling training simulators
- **Emerson Process Management:** Reservoir management, downhole monitoring systems, pressure and temperature monitoring, injection valves
- **Exprosoft:** Operation benchmarking systems (Wellmaster)
- **Eaton (HERNIS CCTV Solutions):** Process surveillance solutions for all drilling segments, onshore and offshore. Stand-alone CCTV systems and Original Equipment Manufacturer (OEM) integrated solutions (all major drilling equipment contractors)
- **GMC Electro:** Winterization solutions for drilling rigs or vessels. Anti-icing of escape routes. De-icing of equipment, drilling deck or storage rooms. Power management
- **Inocean:** Drilling equipment arrangements and integration, Site specific approval documentation
- **Lloyd's Register Consulting:** Consulting/risk assessments related to drilling rigs/Winterization. FMEA/HAZOP of systems/equipment. Wind chill studies. Human engineering
- **Moss Maritime:** Icebreaking Supply and service vessels (AHTS, PSV)
- **Norshore:** Drilling vessels, top hole drilling (riserless drilling) systems, slender well drilling systems, well intervention systems, sub-sea construction and riserless plug & abandonment
- **NTNU:** Geophysics modelling and analysis, reservoir engineering
- **Odfjell Drilling:** Drilling modules design and construction, integrated drilling & technical maintenance and Onshore Operations Centres
- **Resman:** Wireless reservoir and well monitoring
- **Safety Tools Allmet:** High quality air tools and unique design rotation abrasive files. The tools from Safety Tools are EX certified and can be used without the need for "Hotwork Permit"
- **Scana Group:** BOPs, handling tools, marine/drilling risers, riser tensioners, guideline tensioners, long piston rods, gate valves (API) and chokes, flex loop and coflexip hoses, mud pumps, crown blocks, gear boxes, welding, mechanical and other specialist functions offshore

- **Scan Tech:** Offers sales and rental of a wide range of products and equipment such as Crane and Lifting equipment, Air Compressors, Breathing Air Compressors, Steam generators, Diesel and Electric Compressors, Driers, Hot Air Fans, Dehumidifier, Reelers and Chain Hoists
- **Sekal:** Drilling monitoring, diagnostics and control systems
- **Sevan Marine:** Cylindrical hull design with dynamic structure (vertical and slope) for FPSO and MODU, and topside process systems
- **SINTEF Petroleum Research:** Managed Pressure Drilling (MPD) and pre-drill simulation
- **Tenaris Global Services:** Pipes, casings, connections and tubings. Products with proven track records in horizontal and extended-reach drilling operations. Dry multifunctional coating, Dopeless@ technology, making thread compounds obsolete. Wedge™ Series connections providing superior compression and bending resistance. Low Temperature proprietary steel grades
- **Verdande Technology:** Drilling optimization software
- **Wood Group Mustang Norway:** Design and engineering of drilling and well intervention vessels. From concept through to FEED studies and detail engineering, project and integrity management services and equipment qualification



Easy Drill Pump Module mounted on the modified riser joint of the drilling riser (Source: Enhanced Drilling)



ENVIRONMENTAL PROTECTION, MONITORING SYSTEMS AND OIL SPILL CONTINGENCY

Environmental risk related to oil spills is a major concern for operators, regulators and the public in general. With long distances to established infrastructure and physical conditions such as sea ice, darkness and low temperatures, it is critical to develop technologies and solutions that promote environmentally sustainable operations in the Arctic.

Environmental risk assessments (ERA) and oil spill contingency analysis (OSCA) are important tools for decision-making in planning and in permitting processes for oil and gas operations.

Oil spill detection (OSD) and monitoring must be in place in order to provide an effective oil spill contingency for oil and gas exploration and production activities. In the Arctic, detection and monitoring is particularly challenging due to polar night, fog and snow, low cloud ceilings and sea ice.

Methods currently being used to respond to an oil spill include mechanical recovery, use of dispersants and in situ burning. These methods are all applicable in Arctic conditions, but efforts to enhance the effectiveness of these methods in Arctic conditions are still required.

Through a combination of field operations and R&D initiatives, INTSOK partners are developing technologies enabling more accurate modelling of oil spills, early detection and monitoring and more effective oil response methods for use in arctic conditions. Focus areas are:

- Natural resource data
- Environmental risk assessment and oil spill contingency support
- Oil spill monitoring and detection
- Oil spill response
- Monitoring Systems

INTSOK PARTNER DELIVERABLES

NATURAL RESOURCE DATA

- **Akvaplan-Niva:** Ecotoxicology, climate and ecosystems data, biodiversity and physical oceanography
- **DNV GL:** Habitat studies (visual screening and investigation with ROV), sampling and analyses of benthic macro fauna
- **IRIS:** Ecotoxicology, ecosystems services and environmental monitoring and biosensors
- **Multiconsult:** Environmental geology services (seabed pollution) and met ocean data
- **Norconsult:** Environment monitoring systems and support
- **SINTEF Materials and Chemistry:** Environment monitoring and biosensors and ecotoxicology

- **StormGeo:** Environmental Monitoring and metocean reports and analysis

ENVIRONMENT RISK ASSESSMENTS AND OIL SPILL CONTINGENCY SUPPORT

- **Akvaplan-Niva:** Blow out simulations, oil spill trajectory modelling, operational decision support, environmental screening analysis and oil spill contingency support
- **DNV GL:** Coral risk assessment, quantitative or qualitative analysis of environmental risk, statistical or single scenario analysis of oil spill contingency (based on OSCAR), oil spill preparedness plans on company or activity specific level and training
- **Inocean:** Gap analysis, BAT analysis, Compliance documentation, Risk assessments

- **IRIS:** Ecotoxicology, ecosystems services and environmental monitoring and biosensors
- **Lloyd's Register Consulting:** QRA/Risk assessments. Oil spill modeling (OSCAR)
- **Norconsult:** Environmental risk assessment and oil spill contingency analysis support and oil spill trajectory modelling
- **SINTEF Materials and Chemistry:** Environmental monitoring and biosensors and ecotoxicology, fluid and surface chemistry, 3D dynamic oil spill modelling (OSCAR), 3D modelling of consequences of planned releases (DREAM/Partrack™) and training courses
- **StormGeo:** Spill Watch simulation tools and sensors to track and predict the dispersion and effect of accidental oil spill based on OSCAR model and real time monitoring of ocean currents. Oil spill simulation and training

- **Scan Tech:** Pyrocentry, Heatcentry
- **Stinger Technology:** Subsea leak detection and monitoring systems

OIL SPILL RESPONSE

- **Egersund Group:** Oil spill lenses (MOS Sweeper)
- **Frank Mohn:** Emergency offloading equipment, arctic skimmer (Polaris), remote offloading of sunken vessels (ROLS), and parts and services
- **Markleen Ltd.:** Arctic skimmers and booms (Uniboom), peristaltic pumps, oilbags and tanks, dispersant spray systems and equipment, sorbents, boom reels, silt curtains and workboats
- **Norlense:** Arctic skimmers and booms, absorbents, boom anchoring systems, beach cleaning equipment and silt curtains



Oil Spill Detection System (Source: Miros)

OIL SPILL MONITORING AND DETECTION

- **Aptomar:** High sensitive IR camera (SECurus™) with GPS pixels
- **Kongsberg Maritime:** Satellite based OSD systems (Synthetic Aperture Radar sensor)
- **Kongsberg Satellite Service:** Oil spill detection service
- **Miros:** Oil spill detection radar and thermal imaging systems (marine X-band radar, integrated video digitizer units, gyros, GPS, wind and AIS sensor interfaces, flat-screen monitor, IR cameras)
- **Norbit Subsea:** Subsea oil spill monitoring systems and sonars (compact Automatic Leakage Detection system – cALD™)
- **Norconsult:** Oil spill monitoring systems and support
- **Ocean Visuals:** Real-time sensor data management software and HLIF LiDAR sensors in top-sea and airborne applications for detecting oil spills and submerged oil in open and icy waters
- **Octio:** Reservoir monitoring (REM) systems



Arctic Oil Spill Boom (Source: Norlense)

- **Parat Halvorsen:** Tank heating solutions and equipment for oil spill response vessels
- **TESS:** Container based emergency storage system for oil spill, coastal cleaning equipment (moss, minibooms, berms, absorbents, blasters, high pressure cleaners) and personnel protection equipment

MONITORING SYSTEMS

- **Autronica Fire and Security:** Integrated Fire and Gas Detection Systems, TUV IEC 61508 SIL 2 certified. Flame and gas detectors, high sensitive smoke detection (HSSD), gas sampling, alarm management and control systems. Heated optics and detector solutions
- **Eaton (HERNIS CCTV Solutions):** Advanced surveillance solutions for harsh and hazardous environments, including remote monitoring, video motion detection and thermal imaging. Capable of integration with 3rd. party Original Equipment Manufacturers (OEM). Sophisticated solutions detecting, preventing and reducing environmental impact



SUBSEA INSTALLATIONS AND PIPELINES

Since the early 1990s, vast quantities of oil and gas have been produced using subsea production systems. With new smart-wells and cost effective intervention methods, the gap between traditional and subsea production is narrowing. Although most subsea production systems are developed for waters outside the Arctic, technologies and methods currently used in subsea operations are representing a solid foundation for arctic subsea operations.

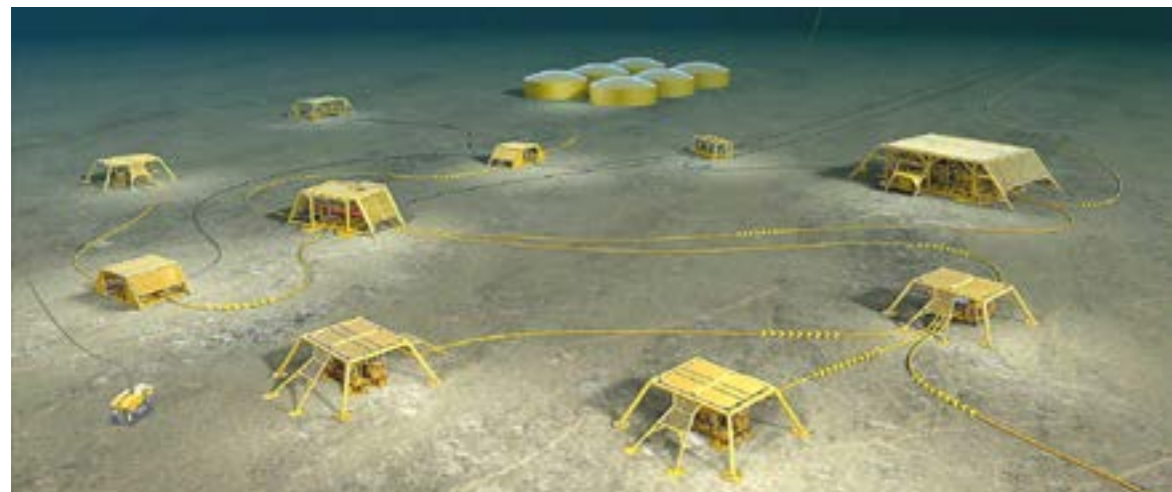
Changing soil conditions are, due to presence of relict seabed ice and gas hydrates, among the most important challenges when designing and constructing manifold, templates and x-mas trees for Arctic operations. Low temperatures and the presence of sea ice transport make deployment and storage of subsea installations and pressure drops of electric signals and flows of fluids through umbilicals more challenging.

Subsea processing technologies can enhance the economic viability of Arctic oil and gas production by increasing production rates, addressing flow assurance challenges and by reducing topside constraints. It may also reduce the environmental footprint and development costs. In some cases, subsea processing technologies can enable development of otherwise inaccessible resources by allowing year-around subsea production under ice.

Subsea Production System (SPS) power supply with the required level of reliability while ensuring acceptable initial expenses and operational costs, is a key issue for field development. While electrical equipment and power transmission technologies currently applied in international operations do not comply with the requirements for operations in the remotest part of the Arctic, technologies, such as high voltage direct current (HVDC) and fuel cell technologies, are now being developed.

Being already firmly established as market leaders within their respective segments, INTSOK partners are delivering subsea technologies and solutions, which will constitute the backbone of future subsea operations in the Arctic.

- Manifolds, template and X-mas trees
- Umbilicals and risers
- Subsea control, intervention and workover systems
- Subsea processing and flow assurance
- Power supply systems
- Pipeline design and installation



Subsea Factory
(Source: Statoil)

INTSOK PARTNER DELIVERABLES

MANIFOLDS, TEMPLATES AND X-MAS TREES

- **Aibel:** PLEM, PLET, Manifold, and template construction
- **Aker Solutions:** Overtrawable templates and manifolds, deepwater cluster manifolds, satellite protection structures, moonpool installable structures, pipeline-end manifolds and terminations, flow and riser bases, wellhead tooling (slimline rigid lockdown wellhead, single trip multi-purpose tool) and horizontal and vertical X-mas trees



RapidSolution subsea tree (Source: Aker Solutions)

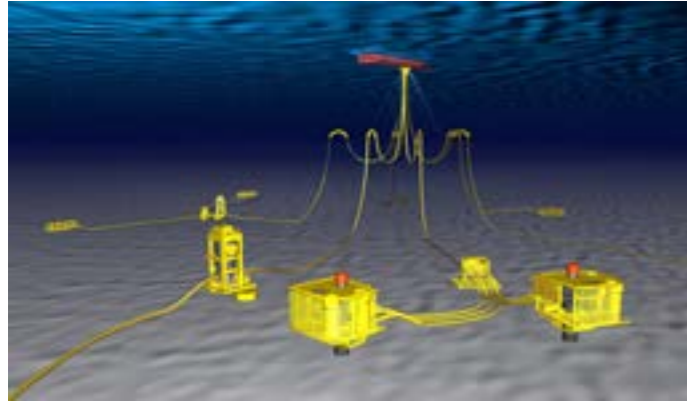
- **DNV GL:** Subsea installations design (loads, soil condition investigation, geotechnical design and verification, manifold and template surveillance)
- **FMC Technologies:** Horizontal and vertical X-mas trees, wellhead systems (UWD) and slimbore, manifolds and manifold pipeline systems
- **GE Oil and Gas:** Manifolds (cluster, HIPPS and template, tie-in), drilling templates and vertical X-mas trees
- **IKM Group:** Pipeline manifold and X-mas trees design
- **IK-Norway:** Repair claps for flanges, hubs and piping
- **Kongsberg Oil & Gas Technologies:** Manifold (production, pipeline end and termination) and protection structure design

- **Multiconsult:** Subsea structure foundation design, geo-technical assessments and soil investigation planning (including scouring ice berg impact assessments)
- **Nymo:** Manifold construction
- **OneSubsea:** Vertical and horizontal X-mas trees, manifolds, wellhead design and systems (STM-15 E/DW5)
- **REINERTSEN:** Supplier neutral feasibility studies, Concept development, FEED and pre-engineering of Subsea Production Systems in a well to host perspective

UMBILICALS AND RISERS

- **Aker Solutions:** Integrated power umbilicals (IPU) with skin effect heat tracing systems, steel tube umbilicals, composite technology and electric power cables, riser systems design and installation (e.g. riser spider, telescopic joint, tensioner rings, termination adapter and joint, wedge clip connectors, spacer and hang-off joints), deepwater riser design, integrated platform/riser/mooring design and analysis
- **Aquamarine Subsea Solutions:** Riser repair
- **Control Cutters:** Subsea cutting of umbilicals, risers (flexible and rigid) and flowlines
- **DeepOcean:** Subsea umbilicals, risers and flowline installation (SURF)
- **DNV GL:** Riser designs and systems
- **DOF Subsea:** Subsea umbilicals, risers and flowline installation (SURF)
- **EMAS AMC:** Subsea umbilicals, risers and flowline installation (SURF)
- **FMC Technologies:** Completion workover riser system
- **GE Oil and Gas:** Umbilical termination assembly, umbilical monitoring device (VectoGray)
- **IK-Norway:** Cutting tools, recovery tools, hang off tools and hold back tools
- **Inocean:** Umbilical and riser analysis, EPC deliveries of Mid Water Arches, including tether and anchor systems
- **Kongsberg Oil & Gas Technologies:** Riser base design, subsea riser and umbilical engineering (flexible and rigid risers), riser management and position reference systems and flexible riser engineering
- **MARINTEK:** Measurement and dynamic testing of loads and motions of risers and umbilicals, stress, fatigue and reliability analysis of complex cross sections, flexible risers, umbilicals and power cables, model testing and numerical analysis of vortex-induced vibrations (VIV) on deepwater risers and flowlines



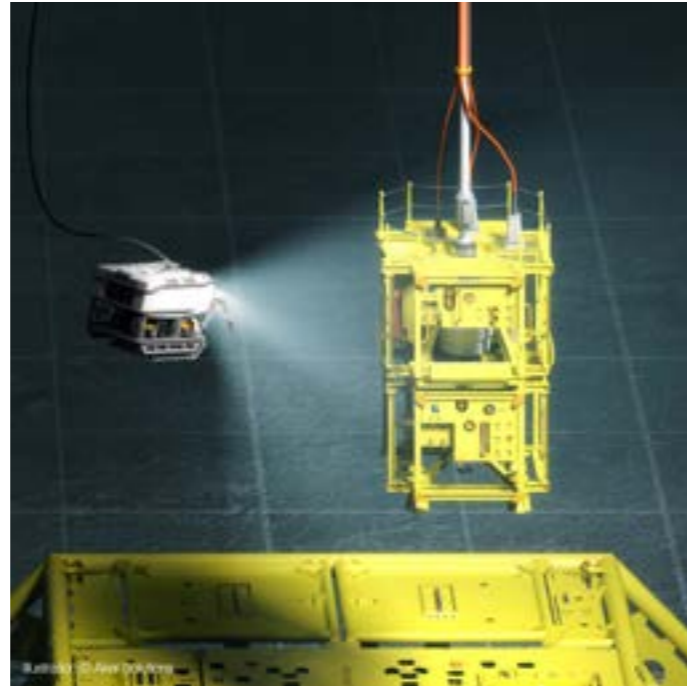


Subsea Umbilical System (Source: Nexans)

- **Nexans:** Direct electrical heating (DEH) riser cables, feeder cables and umbilicals (ROV)
- **Nymo:** Risers construction
- **OneSubsea:** Umbilicals
- **REINERTSEN:** Riser and umbilical system engineering
- **Scana Group:** Drilling risers, riser tensioners and piston rods
- **Scan Tech:** Riser and pull-in systems, ROV Tools, Riser monitoring, Grit Blasting system, Riser reels, Subsea Winches
- **Sevan Marine (Kanfa):** Riser design and systems
- **SINTEF:** Coating and fatigue modelling
- **Sub Sea Services:** Riser running tool and pin end for riser line, remotely operated pull-in systems (ROPS), choke/kill, booster & hydraulic lines male stab, riser running tool, maintenance, repair, modifications and inspections
- **Subsea 7:** Subsea umbilicals, risers and flowline installation (SURF), coupled risers (steel catenary risers, weight-distributed SCRs, steel lazy-wave risers, flexible riser systems) and un-coupled risers (single hybrid riser, grouped SLOR, hybrid riser tower, buoyancy-supported risers, tethered catenary riser and catenary offset buoyant riser assembly)
- **Technip:** Riser design and systems
- **Trelleborg Offshore:** Pipeline buoyancy equipment
- **4 Subsea:** Rigid and soft flexible riser repair clamps

SUBSEA CONTROL, INTERVENTION AND WORKOVER SYSTEMS

- **ABB:** Subsea automation systems and control systems (SCADA Advantage™)
- **Aker Solutions:** Intervention tooling (torque tools system, seal replacement and cleaning tools), workover systems (multi-WOCS™), LARS systems, jack-up rig systems, landing string systems and riserless systems, flow measurement systems, subsea control modules (iCon™), pressure measurement systems



Well Control System. (Source: Aker Solutions)

- **Aquamarine Subsea Solutions:** Advanced welding services (clad welding and heat treatment) and multiple fabrication, repair and maintenance services
- **Control Cutter:** Subsea cutting of umbilicals, risers (flexible and rigid), flowlines, wires, chains, structures etc.
- **Cre8:** Intervention workover control system, workover control system, wellhead control panel, test & flushing HPU, hydraulic distribution and termination panels, X-mas tree instrumentation, umbilicals connection plate and hydraulic accumulation unit
- **Deep C Solutions:** Seabed Intervention Services (dredging/excavation, trenching, free-span correction, boulder removal), Bespoke subsea tooling



SUV Goliat. Deep C SUV at 61° north, 350 meters water depth (Source: Deep C Solutions)

- **DeepOcean:** Seabed mapping and surveying, inspections (pipeline and structure), seabed intervention (jet trenching, mechanical cutting, ploughing, cable lay and geotechnical services) and multiple IMR operations, IMR vessels and ROVs, trenchers and ploughs and geotechnical drilling rig
- **DOF Subsea:** Seabed mapping and subsea positioning, subsea service vessels, ROVs and AUVs, multiple subsea services (inspections, water jetting, cuttings operations, leak detection, tie-in operations)
- **Ellingsen Nor Instruments:** Valves and control systems
- **EMAS AMC:** Subsea Construction and IMR
- **Emerson Process Management:** Subsea automation systems, remote operations controller (SCADA)
- **FMC Technologies:** Topside control systems, tree control systems and subsea distribution systems (flying leads, heads and installation and workover control systems), riserless light well intervention systems (RLWI), completion workover riser system and landing string systems
- **Force Technology:** Subsea ROV tools
- **Freudenberg:** ROV connectors (Optima), pig launcher receivers, actuation equipment and systems and seals and plugs
- **GE Oil and Gas:** Connection modules and systems (VH, HCCS, Icarus, ROV stab, vertical clamp), jumpers, subsea control (VectoGray ModPod) and distribution modules and equipment
- **Hitec Products Group:** Workover control systems (modular IWOCSS, remote control systems, rig interface equipment, panels, power units), control room systems and equipment and hydraulic power subsea control units
- **IKM Group:** ROVs
- **Institute for Energy Technology:** Process monitoring and simulation models
- **Kongsberg Oil & Gas Technologies:** ROV tools, subsea storage systems and clamps
- **Norbit Subsea:** Bathymetric sonars (MultiBeam Echo Sounder, Wideband MultiBeam) and leakage detection systems
- **OneSubsea:** Electrohydraulic control and monitoring systems and modules, broadband communication systems, all electric actuated process valve
- **Parker Maritime:** Seabed mapping and surveying systems and services and subsea metrology
- **RAE Energy:** Welding and inspection services
- **READ:** Subsea installation monitoring systems and seismic profiling and monitoring systems (SPRINT™)
- **REINERTSEN:** Product/supplier neutral feasibility studies, evaluations, FEED and Engineering Services

- **Scan Tech:** Underwater excavation systems (HydroDigger) and Subsea Material Handling system



HydroDigger excavation system (Source: Scan Tech)

- **Siemens:** Subsea sensors (pressure, temperature, flow measurement and vibration), subsea connectors (DigiTron and SpecTron) and surveillance systems
- **Stinger Technology:** Subsea leak detection systems and units (ROVs, LeakPod, LeakSlim) soil investigation systems and modules, ROV structure inspections and control systems
- **Sub Sea Services:** Stab connector, gooseneck system, cross over male sub, high pressure equalized swivel and IMR services
- **Subsea 7:** ROV and remote intervention, welding, IMR services
- **Technip Norge:** IMR services, manned and ROV subsea operations, underwater contracting and project management
- **Techno Dive:** IMR services, subsea welding and cofferdams
- **Trelleborg Offshore:** Flowline buoyancy solutions, ROV and umbilical buoyancy solutions (Linksyn™), subsea modular buoys, subsea arch systems and transponder floats
- **Wirescan:** Subsea monitoring systems (LIRA)
- **Wood Group Mustang Norway:** Design and engineering of drilling and well intervention vessels. From concept through to FEED studies and detail engineering, project and integrity management services and equipment qualification

POWER SUPPLY SYSTEMS

- **ABB:** Subsea power transformers and transmitters, Gigh voltage cables and engineering services, remote monitoring systems and controllers
- **Aker Solutions:** Subsea power distribution (circuit breakers and VSD systems) and monitoring systems
- **EMAS AMC:** Power cable installation





Testing of an ABB subsea trafo in Vaasa, Finland
(Source: ABB, Foto Johannes Tervo)

- **IKM Group:** Subsea electric motor and transformers
- **Nexans:** High voltage subsea power cables
- **REINERTSEN:** Product/supplier neutral feasibility studies, Concept development, equipment evaluation, cost optimization, FEED and Engineering services for Power Systems - from surface supply to Subsea consumer
- **Scan Tech:** Power cable reels
- **Siemens:** Instrumentation feedthrough connectors (Electron), fiber optic connectors and systems (FoeTron), subsea power distribution and high power changeover systems (Anguila)

SUBSEA PROCESSING AND FLOW ASSURANCE

- **ABB:** Compression and pumping systems and electrical motors, multiphase flowmeters and flow monitoring and measurement systems and equipment
- **Abbon:** Multiphase flowmeters
- **Aker Solutions:** Retrievable gas-liquid separators (compact cyclonic degasser) and retrievable liquid pump module (LiquidBooster™), degassing and scrubbing systems, electrostatic coalescer (FlexSep™), compact separators (GasBooster™), subsea pumps and pumping systems, multiphase boosting solutions (HybridBooster™, Multi-booster™), vertical and horizontal connection systems and remote tie-in systems (RTS)
- **ClampOn:** Pig detectors and monitors (sand/particle, leak, condition, vibration, corrosion-erosion), retrofit solutions and support and service
- **Delta-P:** Centrifugal pump
- **DNV GL:** Flow assurance services (sand management, flowline surveillance) and verification
- **DOF Subsea:** Commissioning services
- **Ellingsen Nor Instruments:** Pump systems, injection packages and separation systems (Hydrovac Oil Purifier)

- **Emerson Process Management:** Reservoir and pump management systems, subsea corrosion monitoring and flow metering systems
- **FMC Technologies:** Helico-axial pump, InLine separation systems (gas-liquid, liquid-liquid, solids and sand removal and cyclone scrubber), horizontal and vertical tie-in systems, modules and structures, jumper spools, connectors and collets, subsea chokes (retrievable and non-retrievable) and flow modules
- **Fuglesangs Subsea:** Pumps (centrifugal, positive displacement), hydraulic motors drivers and cylinders and seals
- **GE Oil and Gas:** Subsea chokes and actuators (VectoGray), flowline products



Installation of a OneSubsea Dual Pump Station
(Source: OneSubsea)

- **Institute for Energy Technology:** Multiphase flow models, hydrate and wax particle prediction models, sand modelling and corrosion control methods, geochemistry, reservoir and tracer technology development
- **Kongsberg Oil & Gas Technologies:** Flow assurance software systems
- **Lloyd's Register Consulting:** Flow simulations – OLGA. Hydrate control studies
- **Nexans:** Cables for monitoring and detection systems
- **NLI Solutions:** Pressure caps, subsea valves, stabs and receptacles and subsea jumpers
- **NTNU:** Multiphase flow in wells and pipelines, pumping and artificial lift, flow assurance and condition monitoring, hydrate for transport of natural gas and processing of oil and gas
- **Nymo:** Seabed compression and separation unit construction, injection wellhead frames and satellite production wellhead frames
- **OneSubsea:** Pumps (multiphase, single-phase and hybrid) and pump stations, multiphase compressors and meters, separators (NATCO® and PETRECO®), subsea loading systems and swivel stack systems

- **PG Marine Group:** Subsea pumps (multiphase and single-phase) for boosting, cuttings and injections
- **REINERTSEN:** Product/supplier neutral "mix&match" Concept developments and feasibility studies, equipment assessment, TRL & TQP evaluations, FEED and Engineering of Subsea Processing Systems, including flow assurance - in a wellhead to host perspective
- **Seabox:** SWIT treatment process systems and services
- **Wood Group Mustang Norway:** Flow assurance analysis

PIPELINE DESIGN AND INSTALLATION

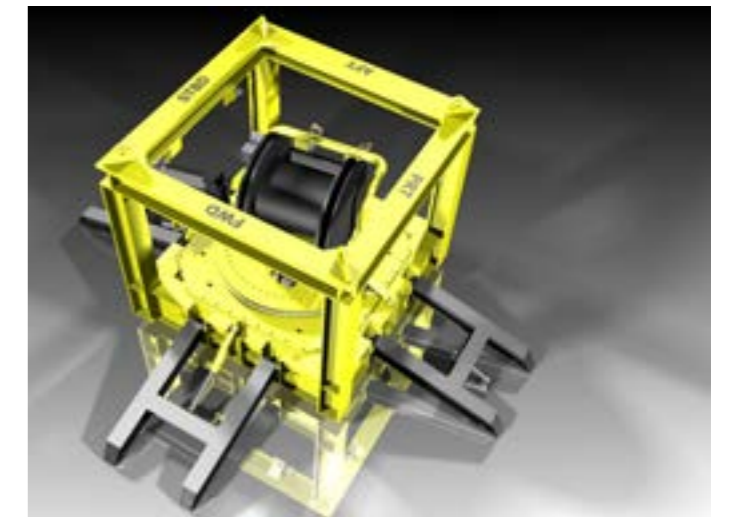
- **Bredero Shaw:** Pipe coating solutions (anti-corrosion, protective and weight, flow assurance and internal)



Goliat Platform (Source: Bredero Shaw)

- **ComputIT:** Process/pipeline technology (numerical simulations)
- **Control Cutter:** Subsea cutting of pipelines
- **DOF Subsea:** Pipeline design
- **EMAS AMC:** Pipelaying vessels
- **IKM Group:** Pipeline design (hydraulics and sizing, weight coating, wall thickness and steel grade, fatigue)
- **IK-Norway:** Connector bolts, epoxy injection, grouting tools and operations, mechanical connector and flanges, pipeline clamps and recovery tools, plugs, ROV tools and equipment (drilling, cleaning, cutting and milling), special designs (lifting tools, peg equipment and protections structures) and pipeline monitoring and data logging
- **Institute for Energy Technology:** Corrosion inhibitor technology development
- **Kongsberg Oil & Gas Technologies:** Pipeline support and spools

- **MARINTEK:** Static and dynamic analysis of pipeline, simulation of pipe laying, free span assessment and upheaval buckling and snaking, reliability tests
- **Multiconsult:** Pipeline foundation design rock cover design
- **NLI Solutions:** Pipeline reels
- **Nymo:** Platform tie-in pipeline and seabed pipe branch connectors
- **RAE Energy:** Coating services
- **REINERTSEN:** Pipelaying engineering and planning
- **Tenaris Global Services:** Dry multifunctional coating, Dopeless® technology, making thread compounds obsolete. Low Temperature proprietary steel grades
- **Wood Group Mustang Norway:** Route selection, pipeline engineering, design verification and size optimization, materials engineering and corrosion and integrity management



Subsea winch (Source: Scan Tech)



MARINE OPERATIONS

A large part of future offshore platforms will be constructed at a yard outside the Arctic prior to being transported and installed/ assembled at site. Vessels used in transportation (towing) and installation of fixed and floating structures will therefore have to be designed and constructed to operate in ice affected waters and low temperatures. This includes ice-strengthened hulls, winterization of topside equipment and mooring systems of installation vessels. In some areas, preparation of the seabed using dredgers and rock dumping dredgers are required.

With the presence of sea and icebergs, an effective Ice Management system is critical during oil and gas operations in the Arctic. While ice detection, tracking and forecasting must be capable of identifying, tracking and predicting the drift of all kinds of potentially hazardous ice features or ice situations, physical Ice Management must provide a demonstrated and adequate level of effectiveness and be consistent with the reliability requirements of the overall Ice Management system. They must also be available on a fit-for-service basis when required and be designed to operate under the anticipated range of physical environmental conditions.

INTSOK partners are among the key suppliers of technologies and solutions relevant to arctic marine operations, including installation and towing services and ice management.

INTSOK PARTNER DELIVERABLES

INSTALLATION AND TOWING SERVICES

- **Aker Solutions:** Installation and towing of semi submersibles and topside float-over operations services
- **Deep C Solutions:** Subsea Utility Vehicle (tracked seabed vehicle for dredging and intervention operations), Subsea high pressure jetting and cutting
- **Deep Ocean:** Subsea installation and module replacement
- **Deep Sea Mooring:** Rig and platform move services and pre-lay mooring
- **DNV GL:** Risk assessments and verification
- **DOF Subsea:** Subsea installation, FPSO, mooring buoy and mooring system installation, precommissioning and commissioning, installation engineering, and supply and construction support vessel services
- **EMAS AMC:** Float-over and pre-mooring services
- **IKM Group:** Subsea installation services and topside float-over services
- **IK-Norway:** Lifting and handling tools
- **Inocean:** Installation engineering, Method statements, Step drawings, Dynamic analysis

- **Kvaerner:** GBS, FPSO and Arctic Marine Operations. GBS marine ops: Out of dock preparations, tow out of dock, installation and hook up, deck float over, ballasting, solid and liquid, final positioning and grouting scour protection installation FPSO marine ops: Design of anchors and mooring system, including geotechnical assessment, structural design and mooring line composition, mooring, installation using AHV's, tow to field, hook up to mooring. Arctic marine ops: Design of marine operation systems for working in the Ice, Ice Management planning and execution for installation, tow to site, route planning and tow force vs. ice concentration planning
- **Moss Maritime:** Analysis and simulation of marine installation operations and towing operations
- **StormGeo:** Weather window analysis, way points weather forecasting, on-site meteorologist
- **Subsea 7:** Hook up services, and supply and construction support vessel services
- **Technip:** Tow-out and float-over services

ICE MANAGEMENT

- **DNV GL:** Risk assessment models and analysis and system verification
- **Egersund Group:** Ice berg trawling equipment

- **Eaton (HERNIS CCTV Solutions):** Advanced surveillance solutions for harsh and hazardous environments. Interface compatibility with Vessel Traffic Management Systems (VTMS) and Automatic Identification Systems (AIS). Radar Tracking CCTV solution providing video of up to 10 radar targets in a 360 degree radius on a 24h basis. Thermal imaging, Video Motion Detection
- **Kongsberg Maritime:** Ice detection and tracking systems and equipment
- **Moss Maritime:** Ice and Iceberg Management philosophy and procedures. Icebreaker vessels and ice-strengthened service vessels for iceberg towing
- **Multiconsult:** Ice drift modelling
- **StormGeo:** Ice Watch including; sea ice analysis and prediction, iceberg tracking, seasonal ice freeze-up and break up prediction



GBS installation at field (Source: Kvaerner)



Skandi Arctic (Source: Technip)



PROPERTY AND PERSONNEL PROTECTION, MARITIME TRAINING

Protection and lifesaving equipment able to sustain the bleak operating conditions in the Arctic are essential to property and personnel safety during offshore oil and gas operations.

Human skills are immensely important when operating in the Arctic. Training simulators have a significant role to play to ensure and secure the safety of the working environment for navigators and personnel operating in Arctic conditions.

Escape, Evacuation and Rescue (EER) is seen as one of the most important challenges for arctic marine operations. In the Arctic, installations will be often be located a long way from land and far outside the point of no return of helicopters, which currently serves the as the primary means of evacuation can. For areas where lifeboats could be used there is a need to develop technology to prevent icing on the lifeboats, prevent damage to the lifeboat propulsion equipment when navigating in ice infested waters and to improve manoeuvrability of the lifeboat in close pack ice. Possible new ways of launching free fall boats in Arctic waters also need to be considered.

INTSOK partners are delivering technologies and solutions frequently used during operations and at training facilities across the globe. Areas of expertise include:

- Fire prevention and suppression
- Training software and hardware platforms tailor made for the realistic visualization of real-time simulation for arctic conditions
- Escape, evacuation and rescue
- Clothing and textile
- Risk assessments
- Maritime training systems and equipment

INTSOK PARTNER DELIVERABLES

FIRE PREVENTION AND SUPPRESSION

- **Aptomar:** IR cameras
- **Autronica Fire and Security:** FEED/Study support, system design and engineering, project management, installation and commissioning, after sales service and training for Fire and Gas detection systems
- **Eureka Pumps:** Fire water pump systems
- **Firenor:** Deluge and sprinkler systems, fire suppression systems (water mist, foam and gaseous), hose reels, extinguishers, flame monitors and automatic DIFFS
- **Fire Protection Engineering:** Foam skids, deluge and sprinkler systems, hose and hose reels and fire detection systems
- **Eaton (HERNIS CCTV Solutions):** Video surveillance solu-

tions enhancing safety and security on oil & gas installations and marine vessels. Crane TV systems mitigating risk during crane/deck operations. Video motion detection enabling early warning of potential threats like oil and gas leaks or intrusion in guard zones. Integration compatibility with Fire/Alarm systems. Remote surveillance for improved protection and risk assessment on oil & gas installations

- **Novenco:** Fire dampers, air handling systems and filters



Fire Doors for Offshore Oil and Gas Installations (Source: Rapp Bomek)

- **Rapp Bomek:** Fire doors and HSE services
- **Scan Tech:** Pyrocentry, Heatcentry
- **Solberg Scandinavian AS:** Foam production

ESCAPE, EVACUATION AND RESCUE

- **DNV GL:** Risk assessment and system verifications
- **Eureka Pumps:** Emergency generator systems
- **Fedem Technology:** Life boat design
- **Harding Safety:** Life and rescue boats and davits
- **Inocean:** Evacuation analysis, Rescue evaluations, Escape-ways arrangements, Compliance documentation
- **Lloyd's Register Consulting:** Escape and evacuation analysis, emergency preparedness studies
- **MARINTEK:** Numerical life boat launching simulations with Computational Fluid Dynamic
- **SINTEF:** Life boat models and simulations, risk assessment models (MarSafe and SARINOR)

CLOTHING AND TEXTILE

- **SINTEF:** ColdWear (integrated electric sensor systems and advanced materials)

RISK ASSESSMENTS

- **DNV GL:** Safety culture assessments, crew resource management, human reliability assessments, cold climate operations Hazard Identification (HAZID)

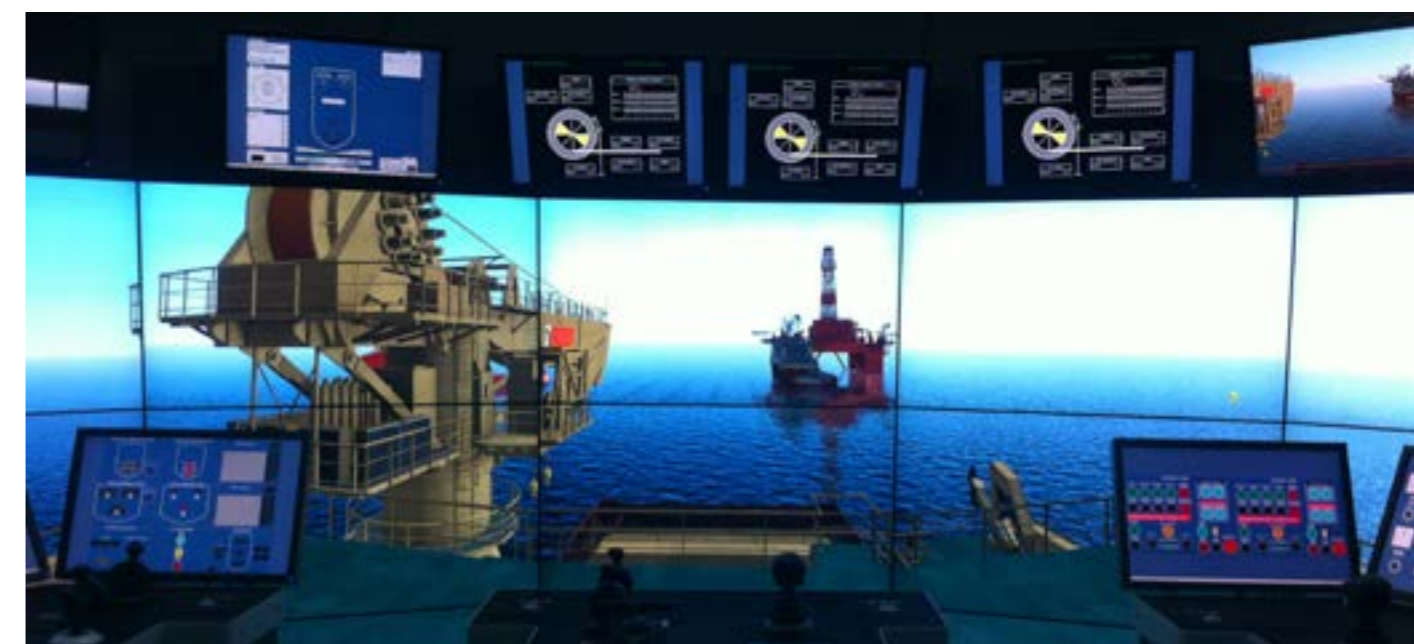


Arctic Rescue Operation (Source: SINTEF/Courtesy of 330 Squadron)

- **Lloyd's Register Consulting:** Human engineering/working environment assessments. Winterization studies, Risk assessments/HAZID/QRA. CFD Fire/explosion studies. Wind chill studies

MARITIME TRAINING SYSTEMS AND EQUIPMENT

- **DNV GL:** Development of standards and certification of training courses for Arctic operations
- **Kongsberg Maritime:** Simulator equipment including software features, training applications and hardware components. Dynamic Positioning (DP) simulators / K-Sim DP, Offshore Vessel Simulator, Ships bridge simulator, Crane simulators, E-Learning system for maritime training, Engine room simulator. Simulation technology customized for various Arctic conditions (e.g. ice navigation, ice breaking, towing in ice and icing), Polaris Communication (GMDSS), Radar and SAR simulator. Vessel traffic services (VTS) simulator
- **MARINTEK:** Ice tank trials



Arctic Maritime Training System (Source: Kongsberg Maritime)



WEATHER FORECASTING, SURVEILLANCE AND COMMUNICATION

Weather phenomena such as low temperatures, icing, polar lows and sea ice render Arctic oil and gas operations particularly challenging. To execute offshore oil and gas operations in a safe and sustainable manner, it is therefore essential to continue to improve weather forecast models. It is also important to develop communication systems capable of providing reliable and accurate information, even as oil and gas operation are expanded further north.

Today, communication and search and rescue (SAR) operations in the Arctic are restricted by insufficient ground infrastructure and limited geostationary satellite (GEO) coverage at latitudes above 72° N. At latitudes above 75°N, satellite coverage is, for all practical purposes, non-existing.

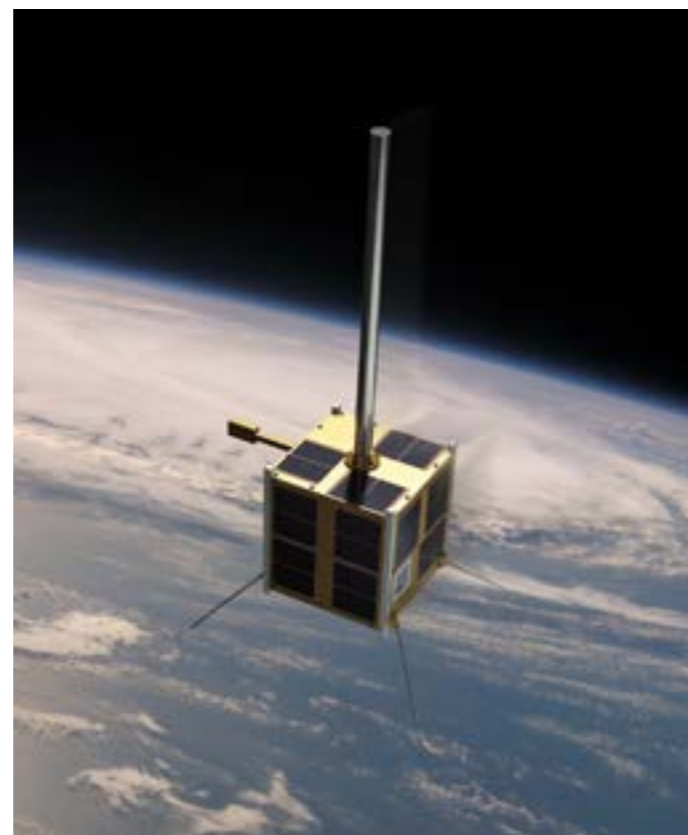
INTSOK partners play a key role in developing the next generation of communication and surveillance systems, which will lead to improved satellite coverage and more effective SAR operations at high latitudes. Areas of expertise include:

- Communication and Surveillance
- Navigation and tracking
- Wave, wind and current monitoring
- Weather forecasting

INTSOK PARTNER DELIVERABLES

COMMUNICATION AND SURVEILLANCE

- **Aptomar:** IR and long range video cameras
- **Eaton (HERNIS CCTV Solutions):** Real-time surveillance solutions on-site and remote for weather forecasting and monitoring of oil & gas installations and marine vessels. High Definition (HD) or Standard Definition (SD) video. Stand-alone CCTV systems or integrated in the overall security scheme
- **Kongsberg Norcontrol IT:** Vessel Surveillance Systems (C Scope), Port Management Information Systems (PMIS), Vessel Traffic Services (VTS), Offshore Surveillance Systems and River Information Systems
- **Kongsberg Maritime (Seatex):** Automatic Identification System (AIS)



Automatic Identification System Satellite
(Source: Kongsberg Maritime (Seatex))

- **MARINTEK:** MARENOR project (with SINTEF), ASK project (with Telenor)

NAVIGATION AND TRACKING

- **DNV GL:** Port navigation systems, HSSEQ navigation, vessel monitoring systems and voyage planning
- **Kongsberg Maritime:** Automatic Radar Plotting Aid (ARPA), Electronic Chart Display Systems (ECDIS), Global Position Systems (GPS), Differential Global Positioning System (DGPS)
- **Kongsberg Satellite Services:** Ground network services (telemetry, tracking & command, data acquisition, hosting services, LEOP & launch support, sounding rocket support and data handling)
- **Scan Tech:** GPS monitoring system, DGPS
- **StormGeo:** Vessel monitoring system and motion prediction, operational window planning, voyage planning, route optimization

WAVE, WIND AND CURRENT MONITORING

- **Miros:** Directional and Non-Directional Wave Data (Wavex and Wavefinder), Wave Radar and Remote Sensing (SM-050), Water Level and Subsea Sensors and Helideck Monitoring Systems
- **Scan Tech:** Environmental monitoring, MetOcean, ADCP
- **SINTEF (ICT):** Rain Intensity Models (Weather disrupt satellite signals at high latitudes), Turbulence and Air Flow Models (SIMRA)

WEATHER FORECASTING

- **StormGeo:** Metocean forecasts, Offshore Consultancy, Environmental Monitoring and Ocean Current Control, Seaware Routing and Sloshing Systems, Offshore Aviation Criteria Forecasting and Weather Modelling and Statistic





Iceberg off Greenland (Source: Egersund Group)



KV Nordkapp in ice (Source: Norwegian Coast Guard)



Iceberg towing off Greenland (Source: Egersund Group)



Oil in ice in-field research (Source: Norwegian Coast Guard)



PROMOTING NORWEGIAN OIL AND GAS CAPABILITIES IN INTERNATIONAL MARKETS

INTSOK, Oslo

Hoffsveien 23, 2nd floor
P.O. Box 631 Skøyen
NO-0214 Oslo
Norway
Phone: +47 22 06 14 80

INTSOK, Stavanger

Prof. Olav Hanssensvei 7a
P.O. Box 8034
NO-4068 Stavanger
Norway
Phone: +47 51 87 48 80

INTSOK, Bergen

Visiting Address:
Sandslimarka 55
N-5020 Bergen
Norway
Phone: +47 90 56 03 35

INTSOK@INTSOK.COM
WWW.INTSOK.COM

INTSOK
Norwegian Oil and Gas
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