Subsea Developments in Statoil
The Future is now

Statoil

Presented by Ole Jørgen Johansen, Project Manager Statoil

Åsgard Subsea Compression - A Success Story


ÅRETS INGENIØRBRAGD 2012

Dette er årets ingeniørbragd

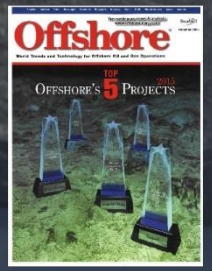
Ingeniørene starten på et nytt eventyr i norsk oljeindustri.


Skriver teknologihistorie

STOLT: Prosjektleder i Statoil, Ole Jørgen Johansen er stolt over å lede prosjektet som mottok prisen for årets ingeniørbragd. FOTO:


Åsgard subsea gas compression receives ONS innovation award

August 29 2012



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The Åsgard Fie

Åsgard transport

Åsgard C

Smørbukk

Midgard

Midgard

Midgard

Smørbukk sør

Kristin

Tyrihans

Åsgard transport to Kårstø

Hammerfest

Harstad

Russia

Finland

Sweden

Stjørdal

Tron heim

Mikkel

Norway

Bergen

Oslo

Stavanger

Porsgrunn

Denmark

Statoil office

Partners	
Statoil ASA (operator)	34,57 %
Eni Norge AS	14,82 %
Exxon Mobil E&P Norway AS	7,24 %
Petoro AS	35,69 %
Total E&P Norge AS	7,68 %

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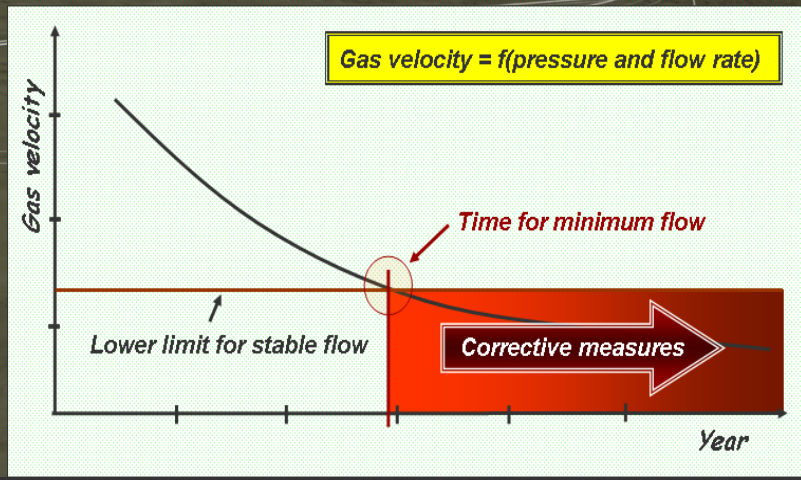
The Minimum Flow Challenge

A minimum gas rate is required to:

- Avoid dynamical instabilities in flow lines
- Ensure surge waves not exceed liquid handling capacity
- Maintain continuous MEG production
- Avoid hydrate incidents



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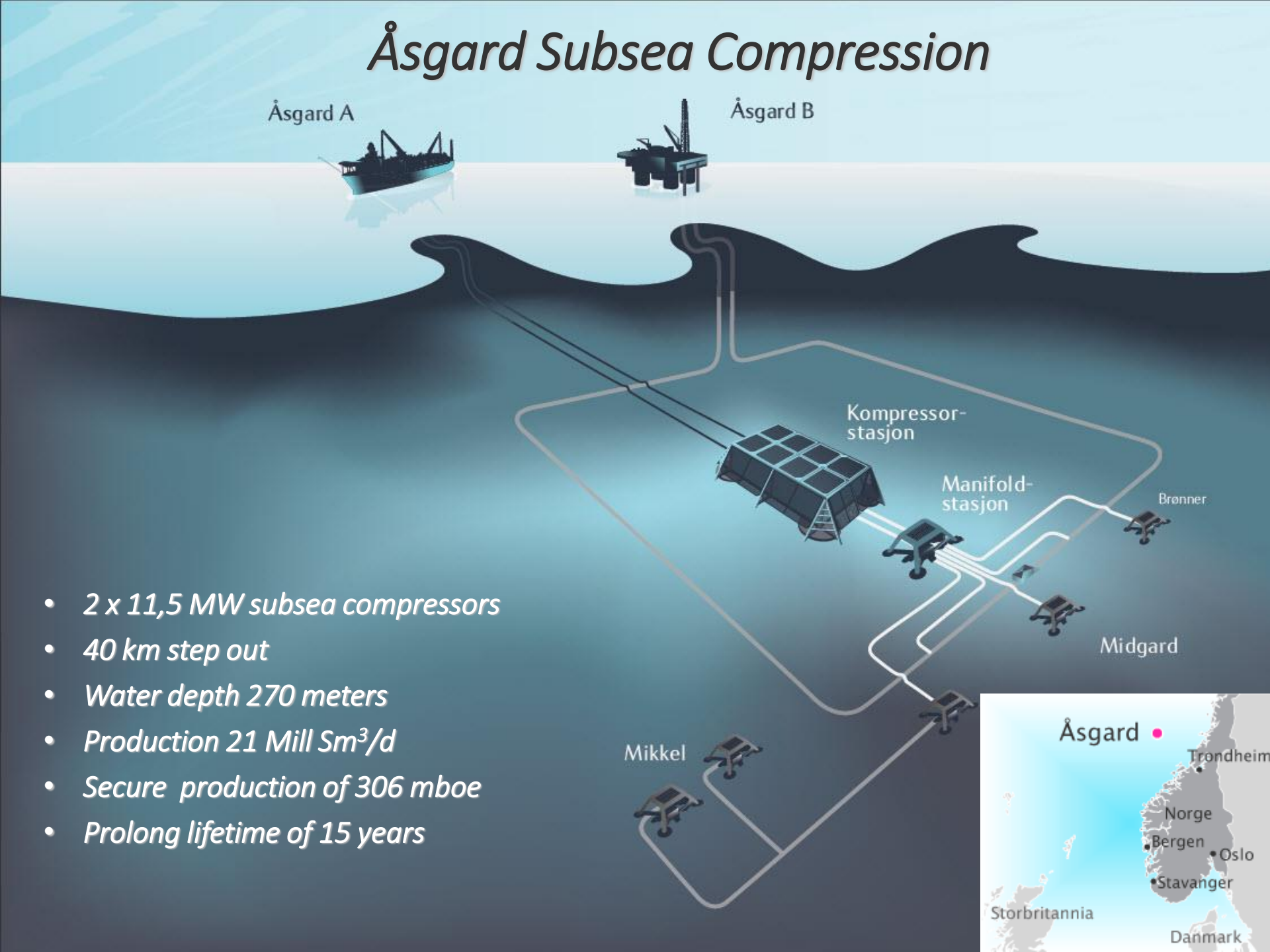
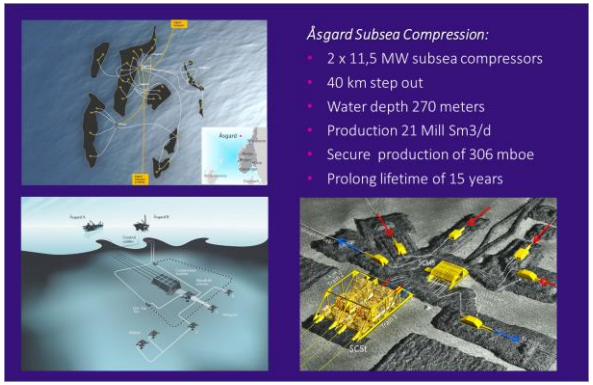
Åsgard Subsea Compression



- *2 x 11,5 MW subsea compressors*
- *40 km step out*
- *Water depth 270 meters*
- *Production 21 Mill Sm^3/d*
- *Secure production of 306 mboe*
- *Prolong lifetime of 15 years*

Åsgard Subsea Compression Overview



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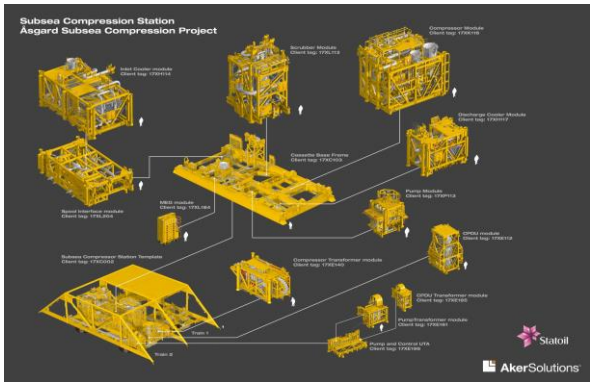
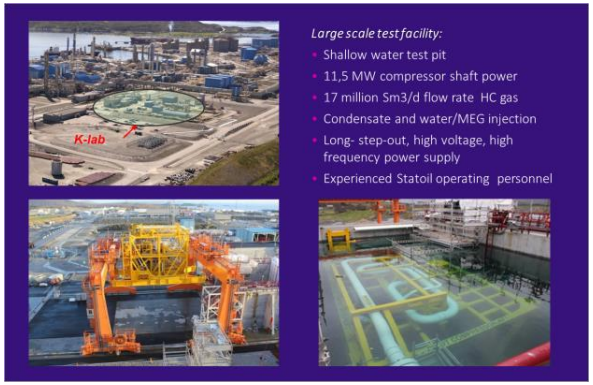


North Sea Giant:

- Accommodation 120 person
- Main Deck area 2900m2
- WROV x2, Triton XLX and XLR
- SHS for large modules in fabrication
- Capacity 388 tons, 15x12x12 m, Hs 4.5m
- Moonpool Handling System 70 tons, 7.2x7.2m
- Subsea Process Intervention System

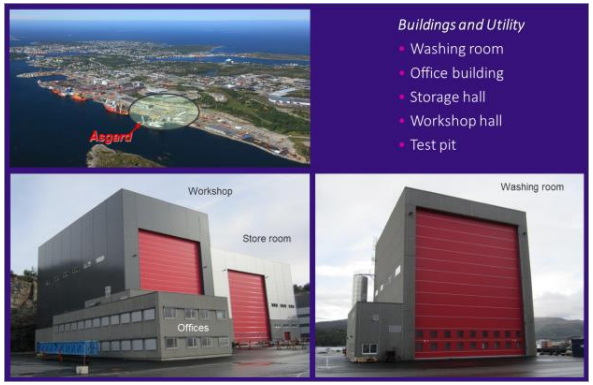


Large scale test facility:

- Shallow water test pit
- 11,5 MW compressor shaft power
- 17 million Sm3/d flow rate HC gas
- Condensate and water/MEG injection
- Long- step-out, high voltage, high frequency power supply
- Experienced Statoil operating personnel

Åsgard SURF and Marine scope:

- ~1600 vessel days, 14 vessels
- 6 pipelines, total 63 km
- Hot-tap on unprepared pipeline
- 12 PLEMs, 18 spools
- 139 tie-ins
- Decommission of pipelines



Buildings and Utility

- Washing room
- Office building
- Storage hall
- Workshop hall
- Test pit

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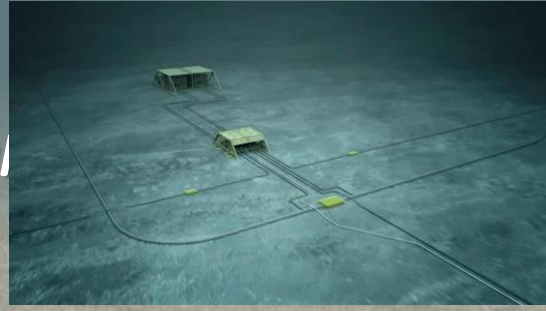
sgard Subsea Compressio
Subsea Modules



To Åsgard B

From Midgard X

Compression Station
Weight: 4752 tons
Size: 74x45x26 m

Manifold station
Weight: 865 tons
Size: 34x27x15 m

To Hot-Tap on Y-101

From Midgard Y

From Midgard Z
& Mikkel A & B

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Subsea Compressor Station Modules

Scrubber
210 tons
8x8x12m

Compressor
289 tons
11x9x10m

Pump
45 tons
5x5x6m

Inlet/antisurge
cooler
235 tons
15x10x7m

Outlet cooler
107 tons
9x7x5m

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Technology Qualification Program

Cooler

All Electric Subsea Control System

Active Magnetic Bearing Control

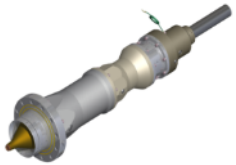
Scrubber

Initiated 2007

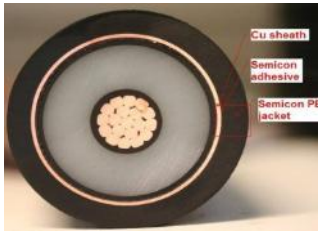
Comprehensive Scope

Maturing Competitive Vendors

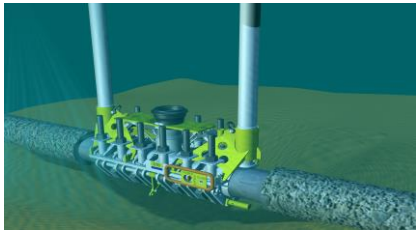
Subsea Transformer



HV Connectors and Penetrators



Power Cable



Hot-Tap

Pump

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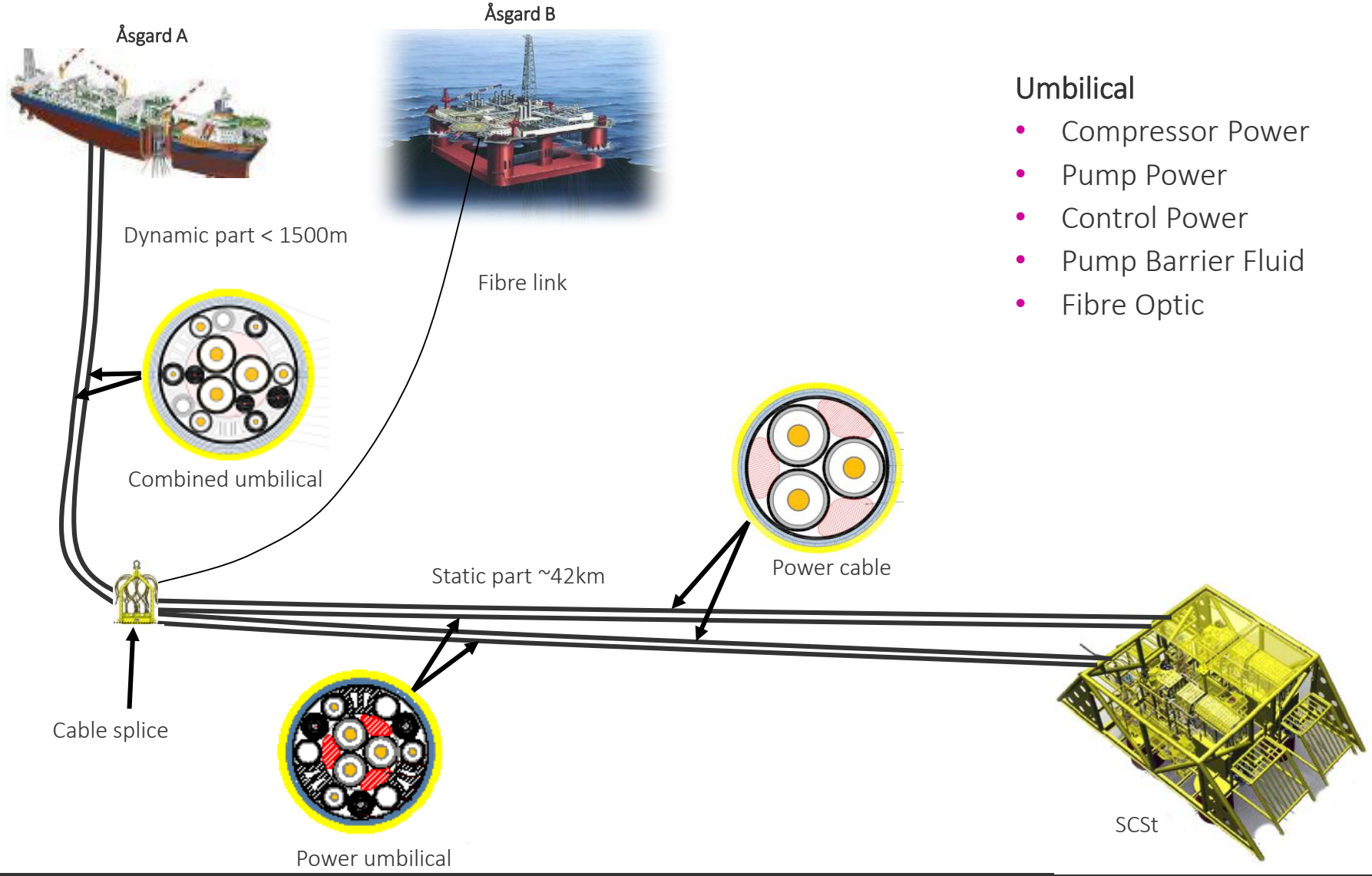
Power and Control Umbilical



Umbilical

- Compressor Power
- Pump Power
- Control Power
- Pump Barrier Fluid
- Fibre Optic

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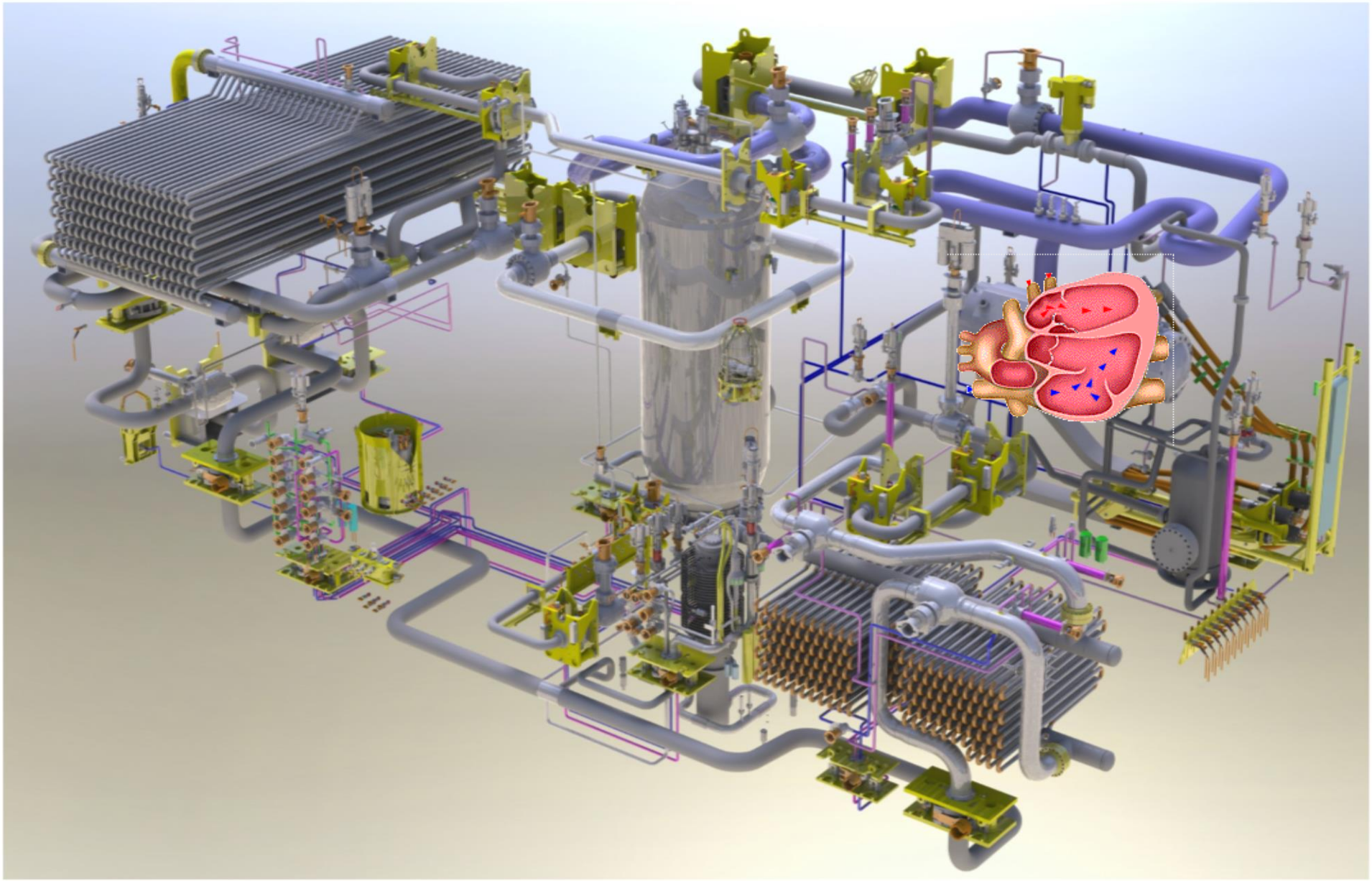

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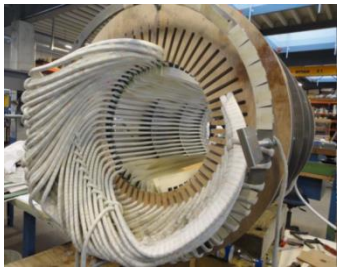
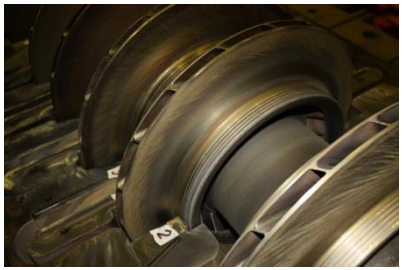
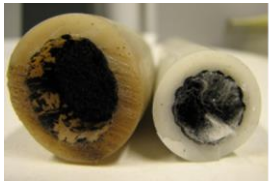
Compressor TQP

Challenges

- Corrosion
- Particle erosion
- Droplet erosion
- Erosion-corrosion
- Heat transfer
- Vibrations
- AMB winding insulation
- Motor stator cable insulation
- Compatibility







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K-lab Test Facility

- World's first large scale test loop for subsea compressors built 2007-2008
- Large upgrade 2011-2013
- Shallow water test pit
- 11.5 MW compressor shaft power
- 1-7 million Sm^3/d flow rate hydrocarbon gas
- Condensate and water/MEG injection
- Long step-out, high voltage, high frequency power supply
- Experienced Statoil operating personnel

K-lab

K-lab

Egersund Site

- Fabrication and FAT
- Mechanical Completion
- Mechanical SIT
- Controls SIT
- Commissioning FFAT

Åsgard: Old Field Layout

Significant marine operations and topside modifications at Åsgard

From Yttergryta

X

Y

In-line Tee

In-line Tee

Y-102

Y-101

Z

Y-101

From Mikkel

IMPORT to SCSt/SCMS
EXPORT to Åsgard B
POWER/ UMBILICAL
MEG
PLEM/PLET
CABLE SPLICE BOX
NOT STARTED
DEAD LEG

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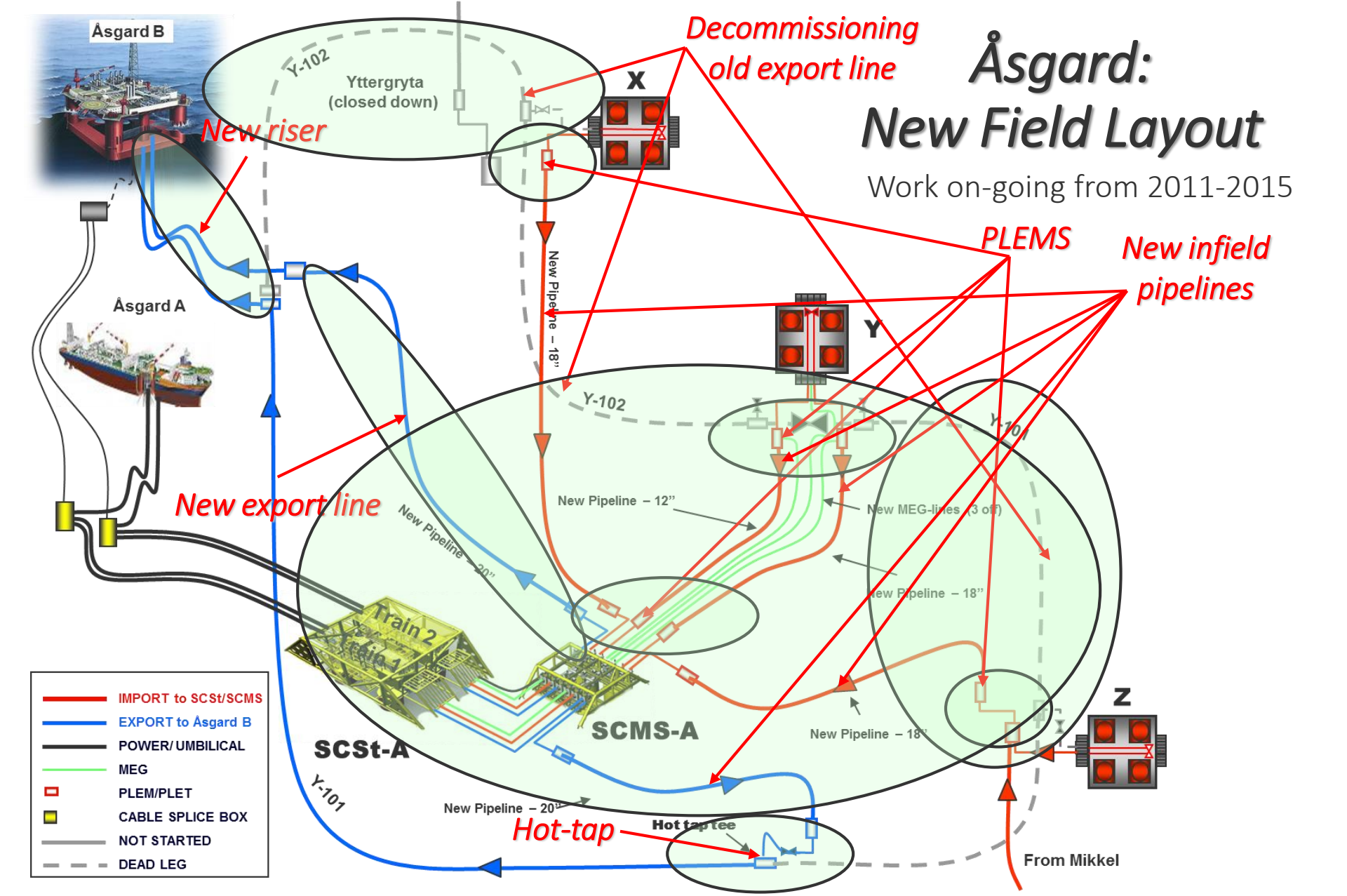
Åsgard: New Field Layout

Work on-going from 2011-2015



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Åsgard Marine Operations

Vessel days	
2013	706
2014	547
2015	383

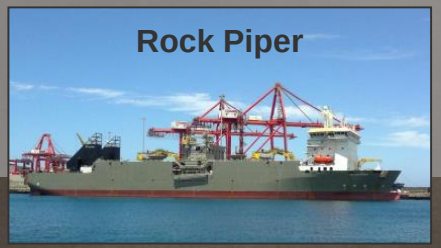
Activities

Survey
Rock/cover removal
Rock dumping
Trenching
Pipeline/PLEM installation
Hot-tap
Spool installation and tie-in
Riser base installation
Spool installation and tie-in
Heavy lift
Module installation

Connections on compressor modules:

12 HV connections
208 signal/controls connections
44 Process piping connections

Total 14 vessel used



June 2013 – HLV «S-7000» Installation Campaign

Weight 4.800t
(With all Modules)

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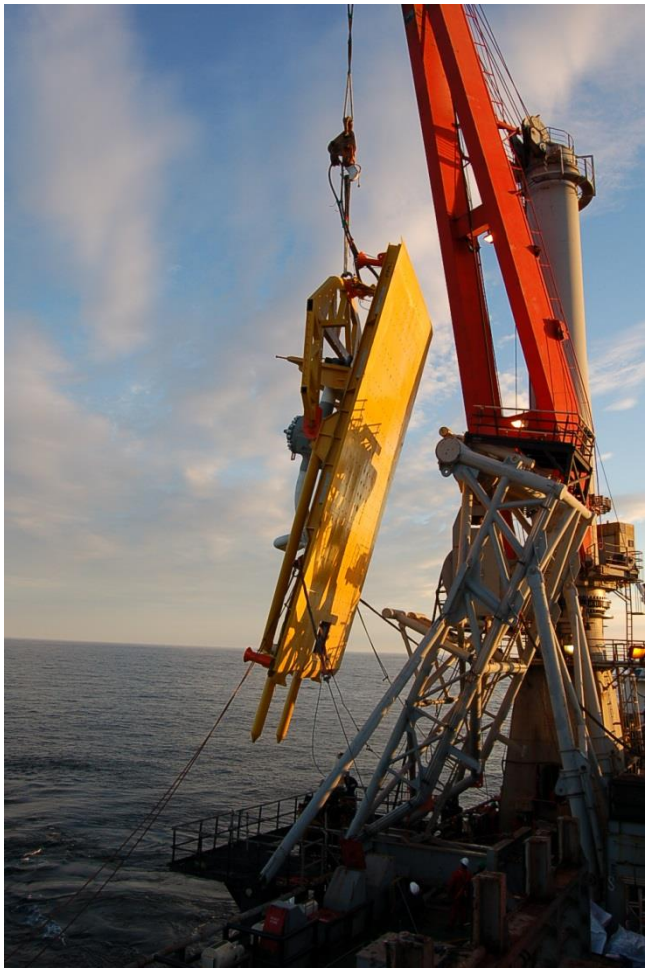
Summer 2013 Allseas «Lorelay»

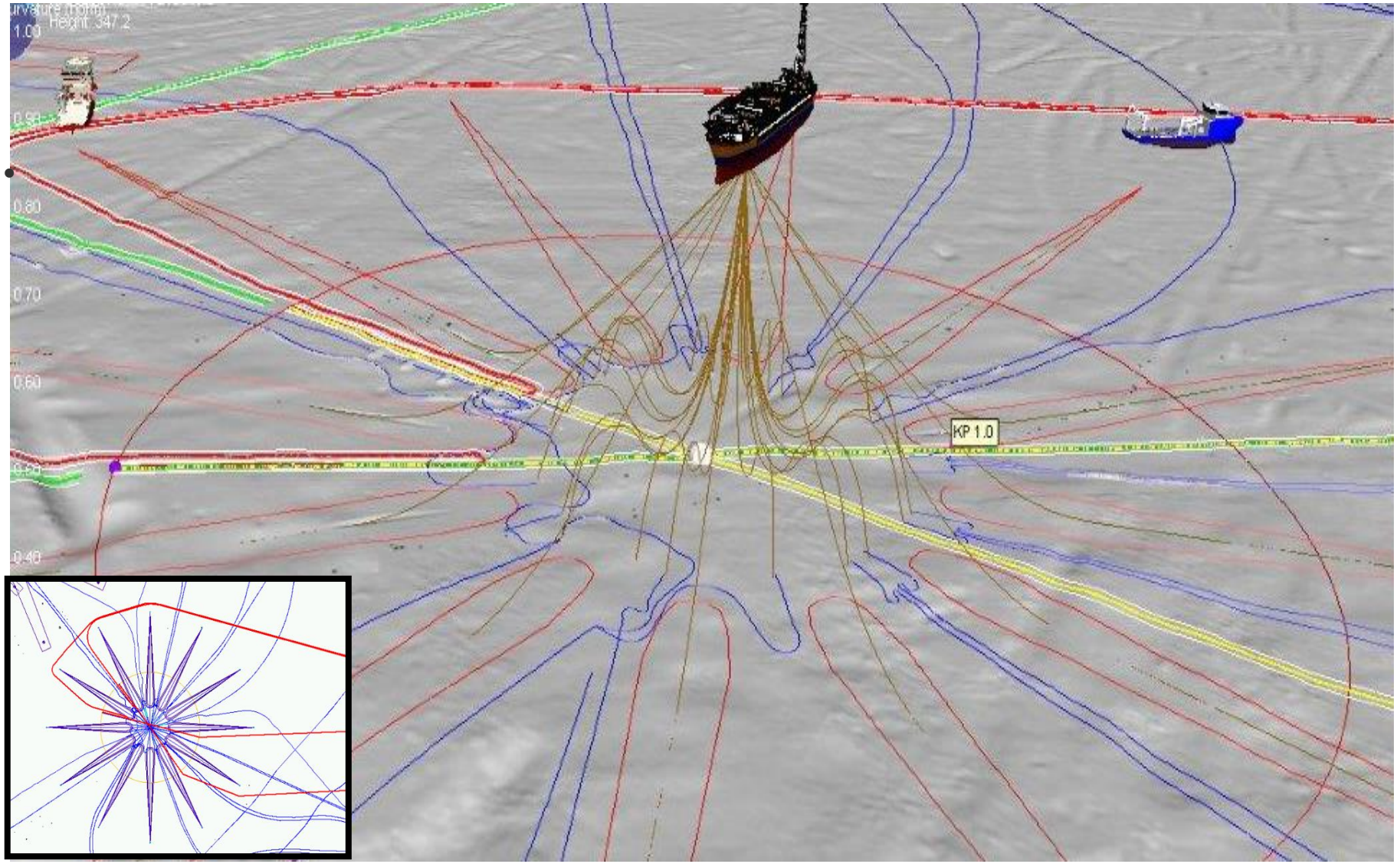


8 Pipelines – total 63km

11 PLEMs, each weighing 60-107t

APRIL – MAY - JUNE
Install 4x 40km
Static Cables

New Layout, called the subsea X – Games



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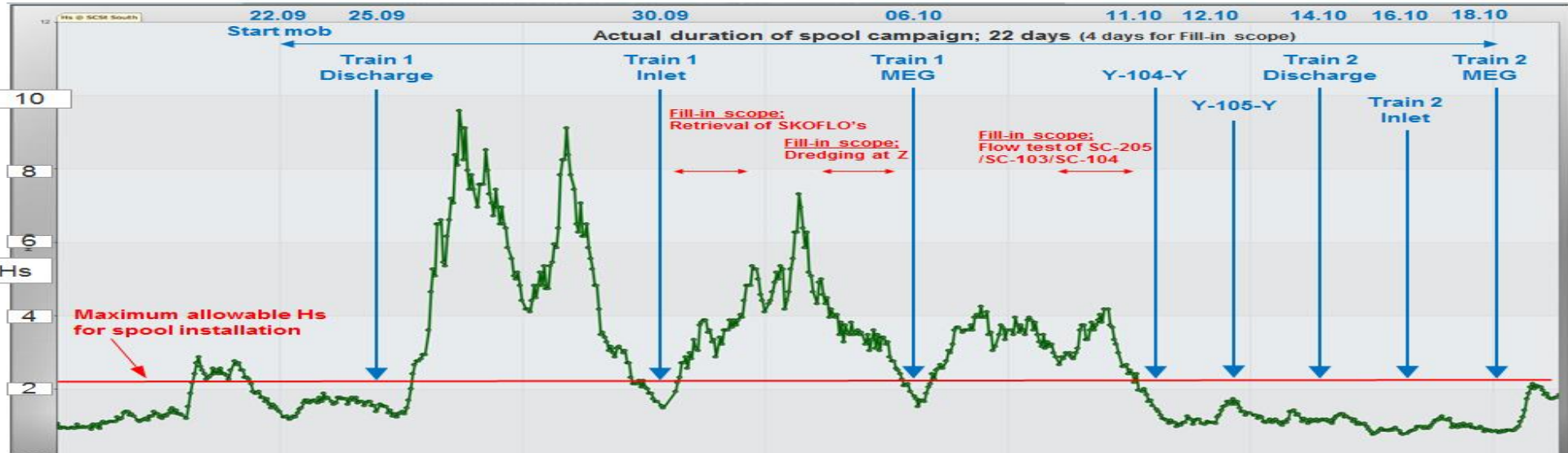
OCTOBER Install 8 Spools, SCSt & Y



North Sea Giant – "This boat can do anything"

160m long / 30m wide & Voith Schneider
3.000 m² free deck, 2.000m² with MHS & SHS
+/- 30 cm Lateral movement, Hs 4.5m Head Sea

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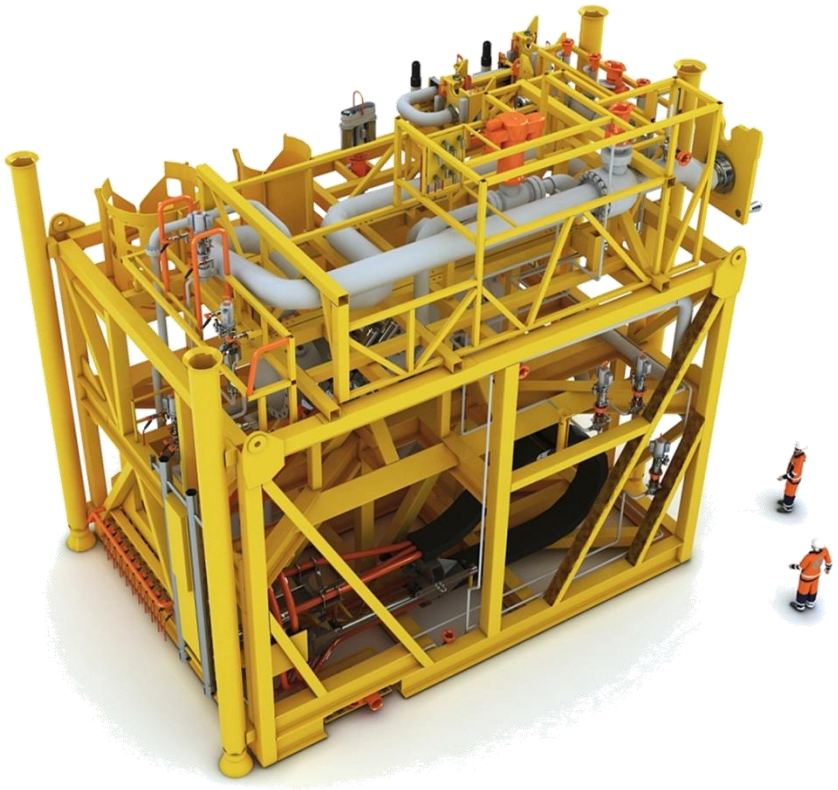
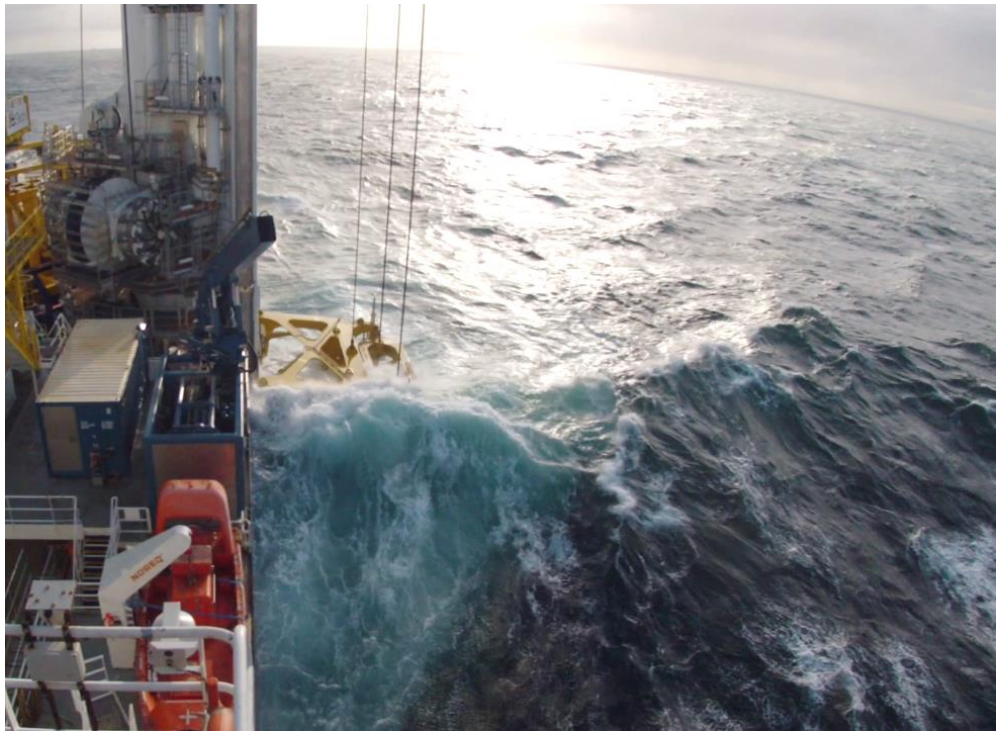
Availability Requirements (Business Case)

- Availability is MTBF (Mean Time Before Failure) & Repair Time
- For Åsgard, **availability is set to ~96%** uptime of subsea plant
- Means; REPAIR TIME = 5 days response time + 10 days replacement / year
- Means; COMPRESSOR MODULE REPAIR IN Hs = **4.5m**





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Åsgard Opening Ceremony

ÅSC started up September 16th 2015

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Vestbase Storage and Maintenance Facility

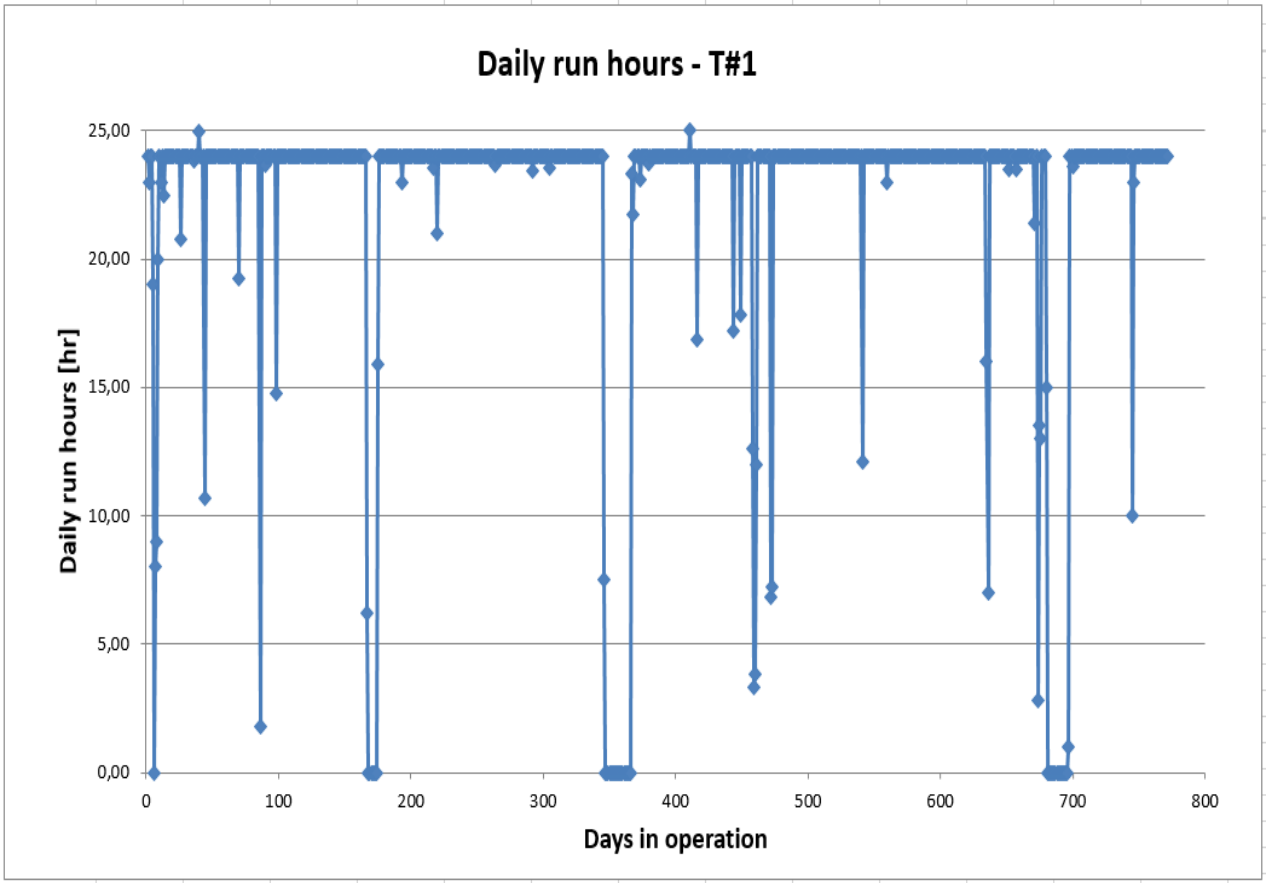
Buildings and Utility

- Washing room
- Office building
- Storage hall
- Workshop hall
- Test pit

Åsgard

Daily run hours – T#1 since start-up

- T#1 start-up 16.09.15
- T#2 start-up 28.02.16
- Increased production by approx ~8 MSm3/d!!
- Most production shut-downs caused by loss of power from Åsgard A
- Only minor technical issues prior to breakdown of T1 pump in July 2017
- Producing above design rates since start-up

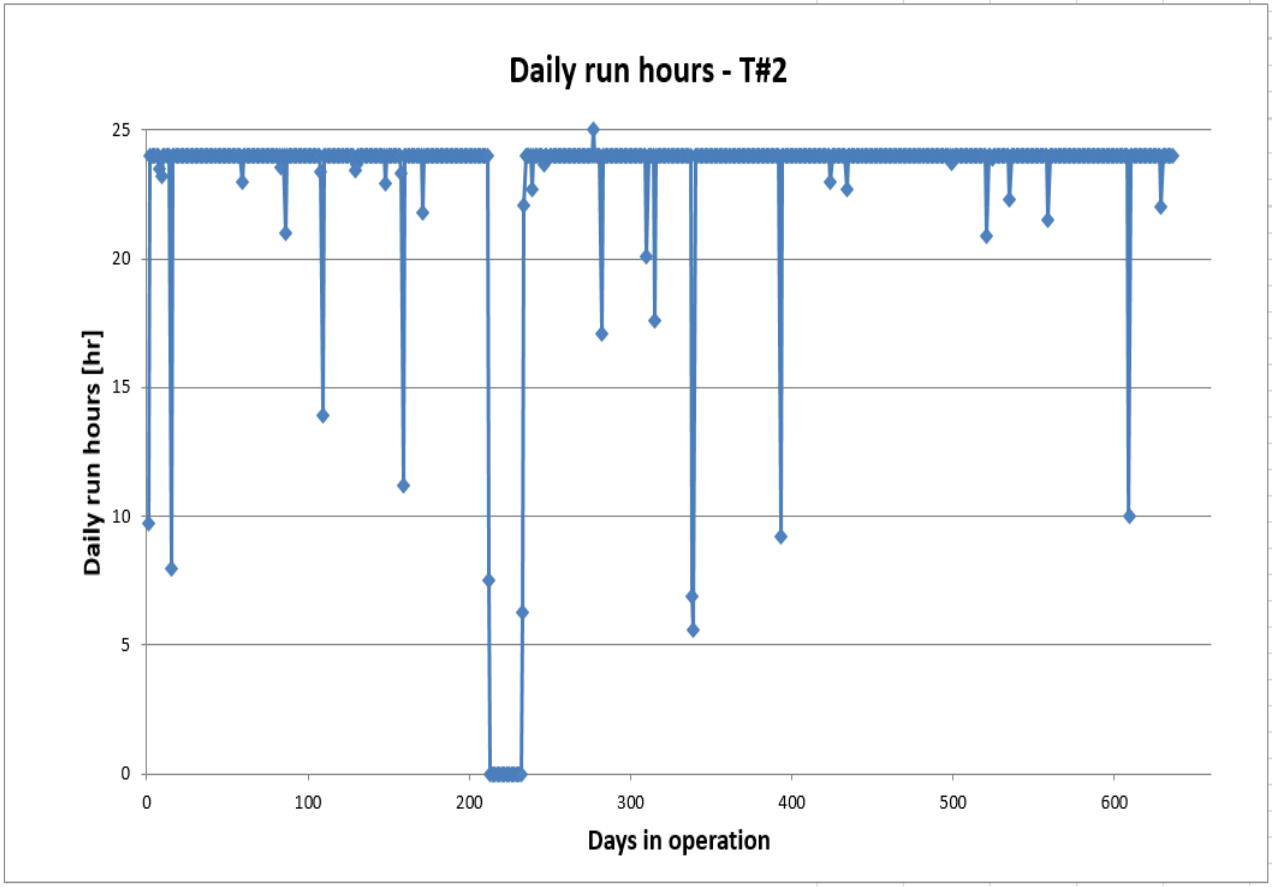


Updated 25.10.17

Statoil

Daily run hours – T#2 since start-up

- T#1 start-up 16.09.15
- T#2 start-up 28.02.16
- Increased production by approx ~8 MSm3/d!!
- Most production shut-downs caused by loss of power from Åsgard A
- Only minor technical issues prior to breakdown of T1 pump in July 2017
- Producing above design rates since start-up



Updated 25.10.17

Statoil

Operational experience

- T#1 start-up 16.09.15
- T#2 start-up 28.02.16
- Increased production by approx ~8 MSm3/d!!
- Most production shut-downs caused by loss of power from Åsgard A
- Only minor technical issues prior to breakdown of T1 pump in July 2017
- Producing above design rates since start-up

Year / Cat	Entire system incl power generation ÅsgA		System 17 (subsea + topside)		Subsea Station	
	PE loss (%)	Total PE (%)	PE loss (%)	Total PE (%)	PE loss (%)	Total PE (%)
2015	2,78	97,22	0,73	99,27	0,73	99,27
2016	2,70	97,30	2,05	97,95	0,01	99,99

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Operational challenges and interventions prior to July 2017

- **Only minor technical issues !**
  - Pump regulation
    - Improved in March 2016
  - Loss of some redundancy in control system
  - Two minor interventions performed:
    - Valve operation @ T1 pump module
    - NLD replacement scrubber module T#2

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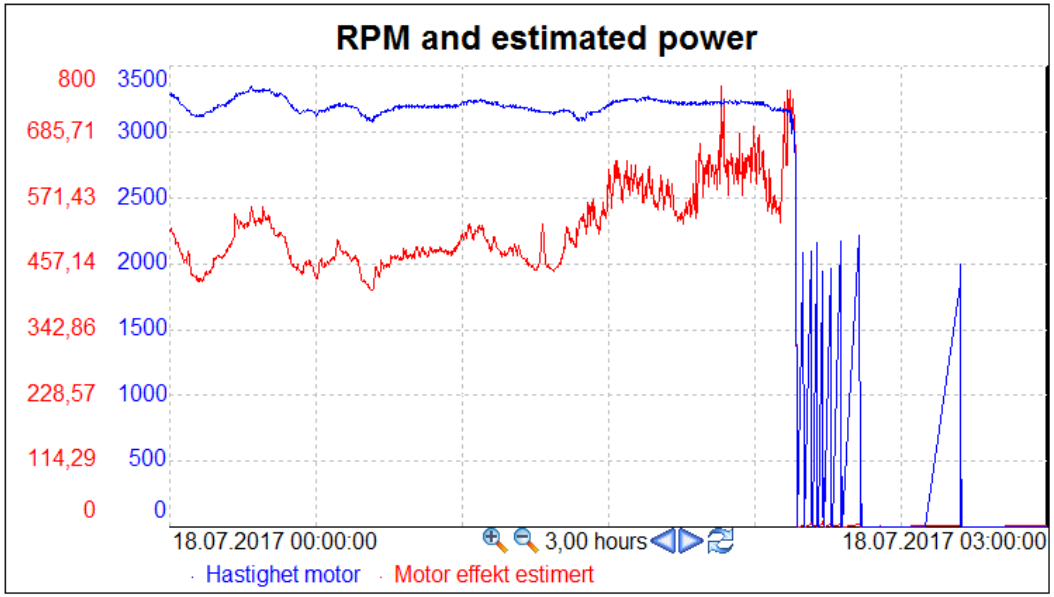
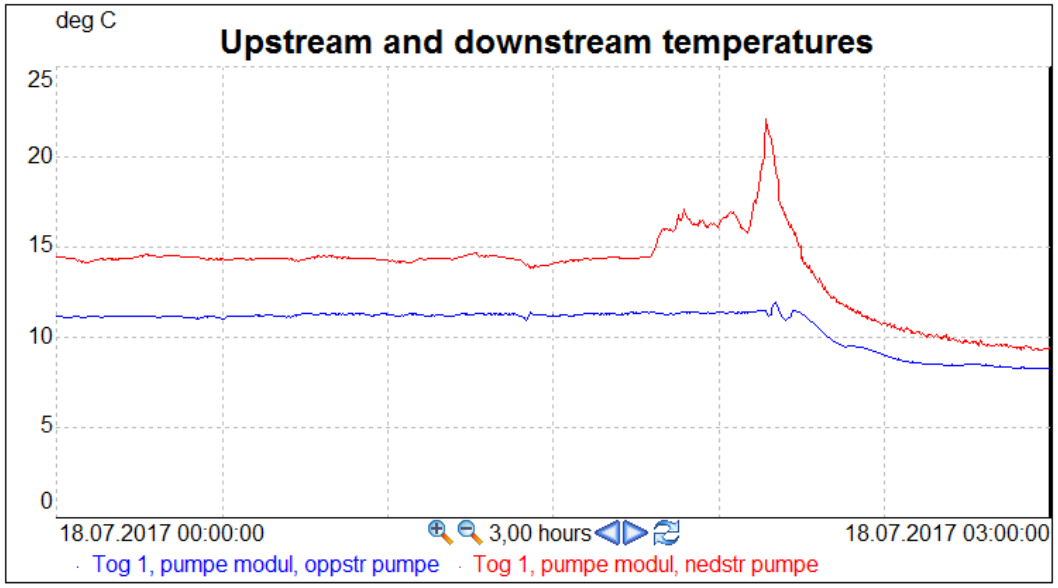
July 2017 - T1 pump breakdown

- Occured 18.07.17 02:09
- Cause of trip: LL on flow
- Locked rotor when trying to restart – not able to spin pump
- Faultfinding located the problem to the pump module, not electrical system / umbilical





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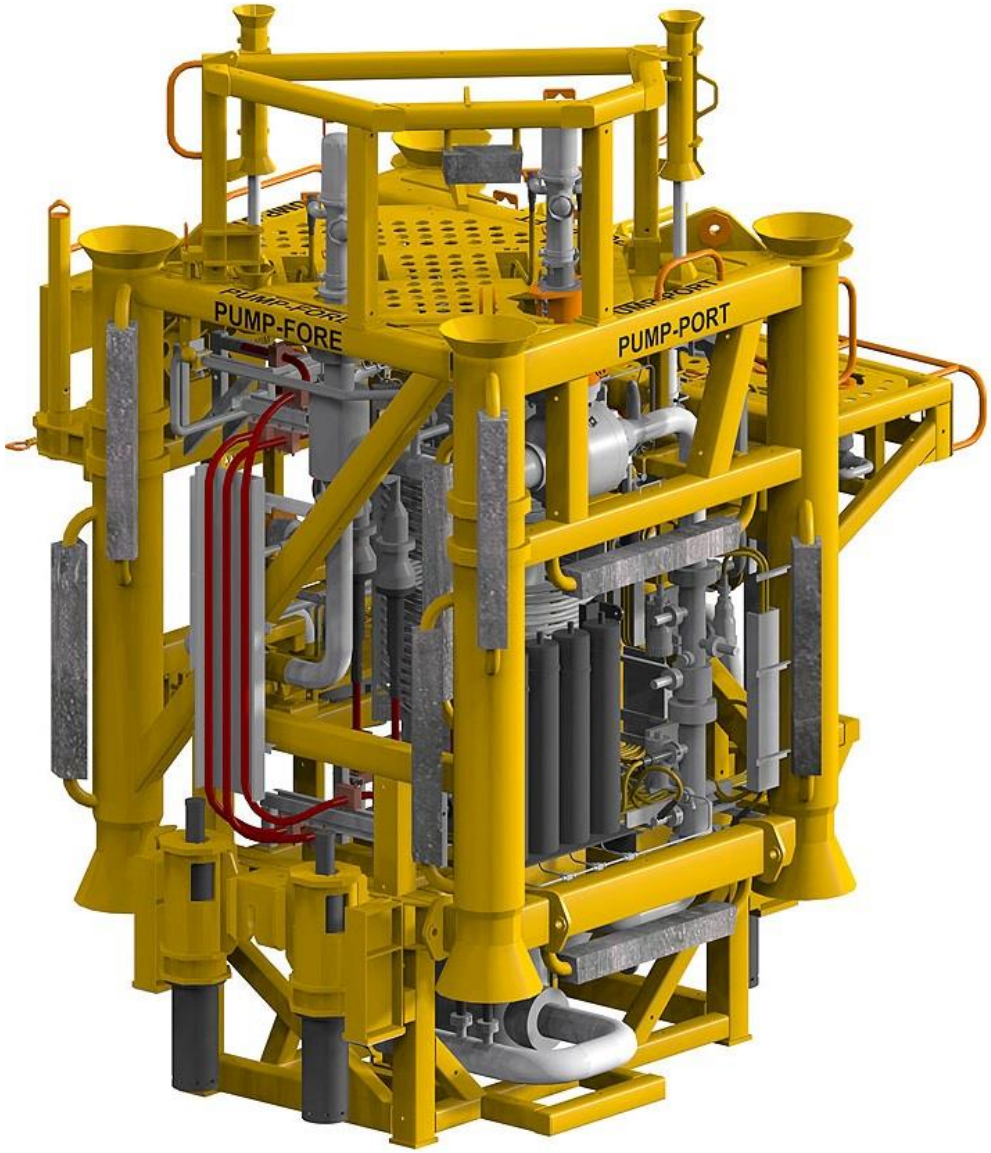
ÅSC Pump Module

- Main purpose:
  - Control level in scrubber
  - Recycle a continuous flow rate for sand
  - Supply liquid for compressor washing
- Weigth in air: 57 T
- Retrieval weight (water filled structure): 64 T
- Dimensions, incl. lift rigging: 5621x4640x7865
- Intervention by use of NSG MHS



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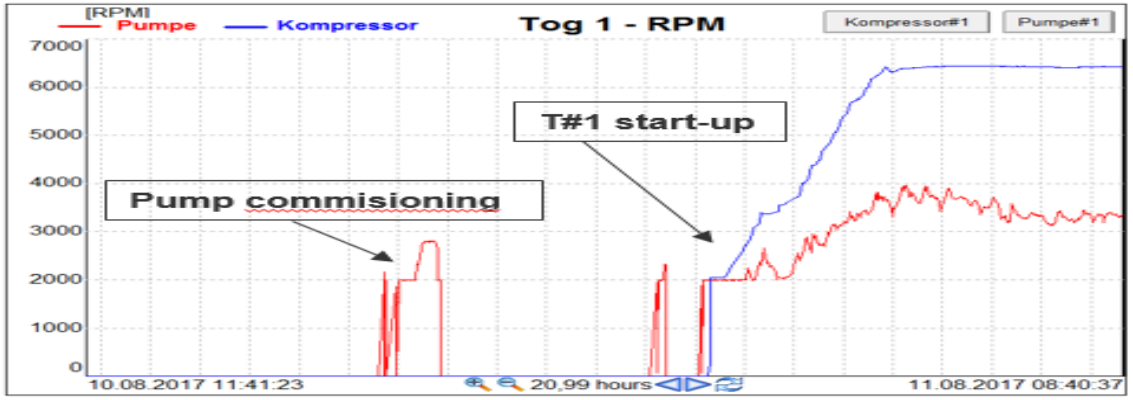
ÅSC T1 Pump replacement

- North Sea Giant in KSU 01.08.17 to start mobilize for pump replacement
  - Pump replacement finished by 10.08.17
  - Commisioning 09.08.17 -10.08.17
  - Train #1 start-up 11.08.17 00:20
  - Pump #1 and T#1 in operation since
  - Very rapid operation without major issues



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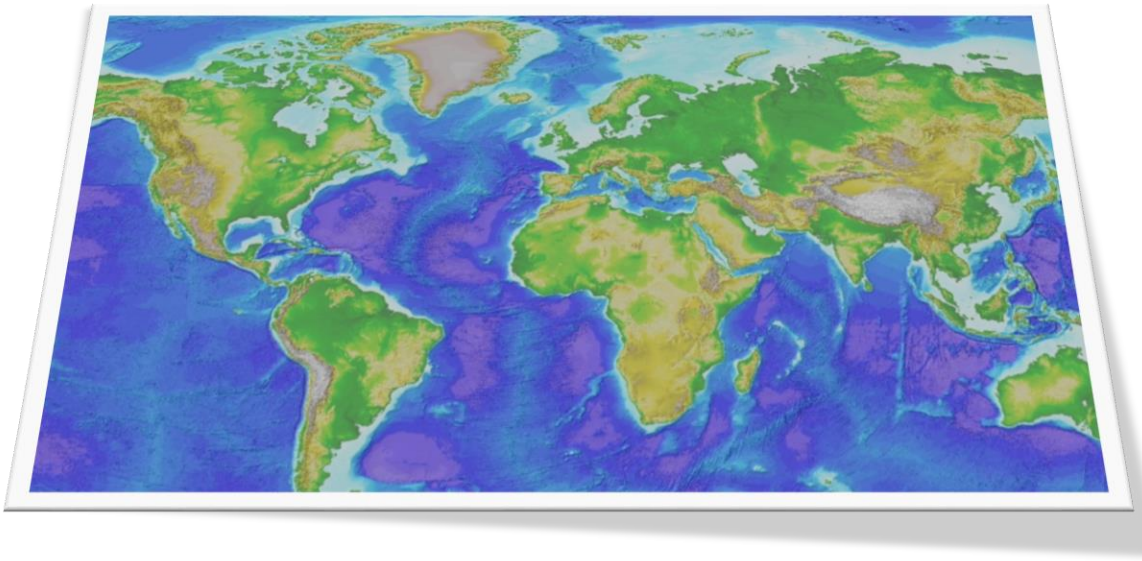
Summary

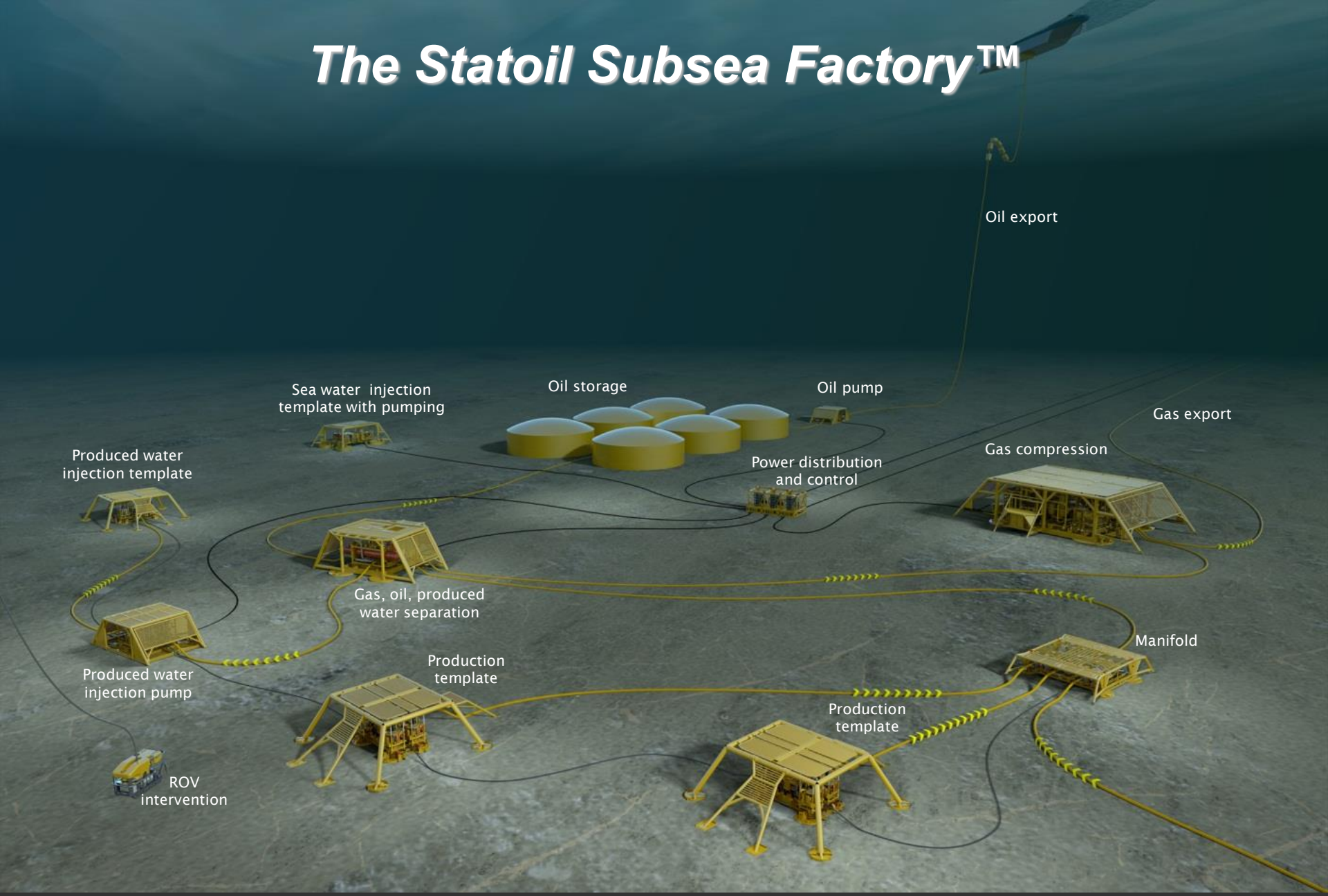
- World's first subsea compression system realised at the Åsgard field
- Secure production of 306 mboe and 15 years prolonged operation
- Nearly 50 technology qualification activities carried out 2007-2015:
  - Strict qualification process applied
  - Process modules, Power system, and Control system
- Testing and installation of subsea modules 2014-2015
- Successfully started-up September 2015
- Operated successfully for more than two year
- Regularity over 99 % for the Subsea Station
- A money making Machine for Statoil and Partners

Future possibilities in Statoil portfolio

- Norwegian Continental Shelf (NCS):
  - Tail end production – lower pressure and higher water cut
  - Existing infrastructure with space, weight and time limitations
  - Smaller discoveries
- Gulf of Mexico
  - Tight reservoir
  - High shut-in pressure
  - Deep water
- Brazil/West Africa
  - Deep water
  - Heavy oil
  - Lack of infrastructure for gas
- East Africa
  - Deep water, limited infrastructure
- Remote areas
  - Lack of existing infrastructure
  - Likely to be long tie-backs
  - Possibly harsh environment



The Statoil Subsea Factory™



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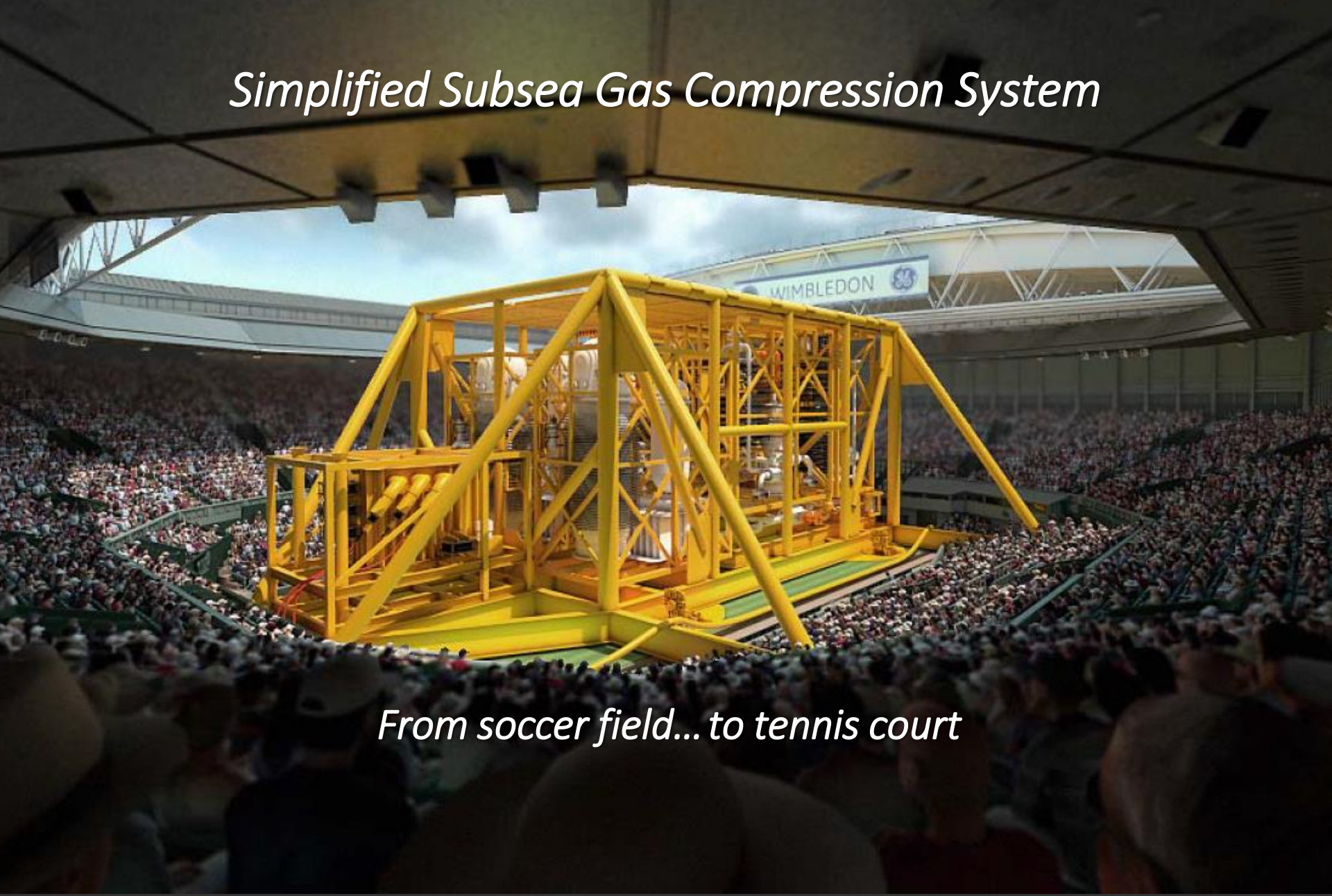
Simplified Subsea Gas Compression System



From soccer field… to tennis court

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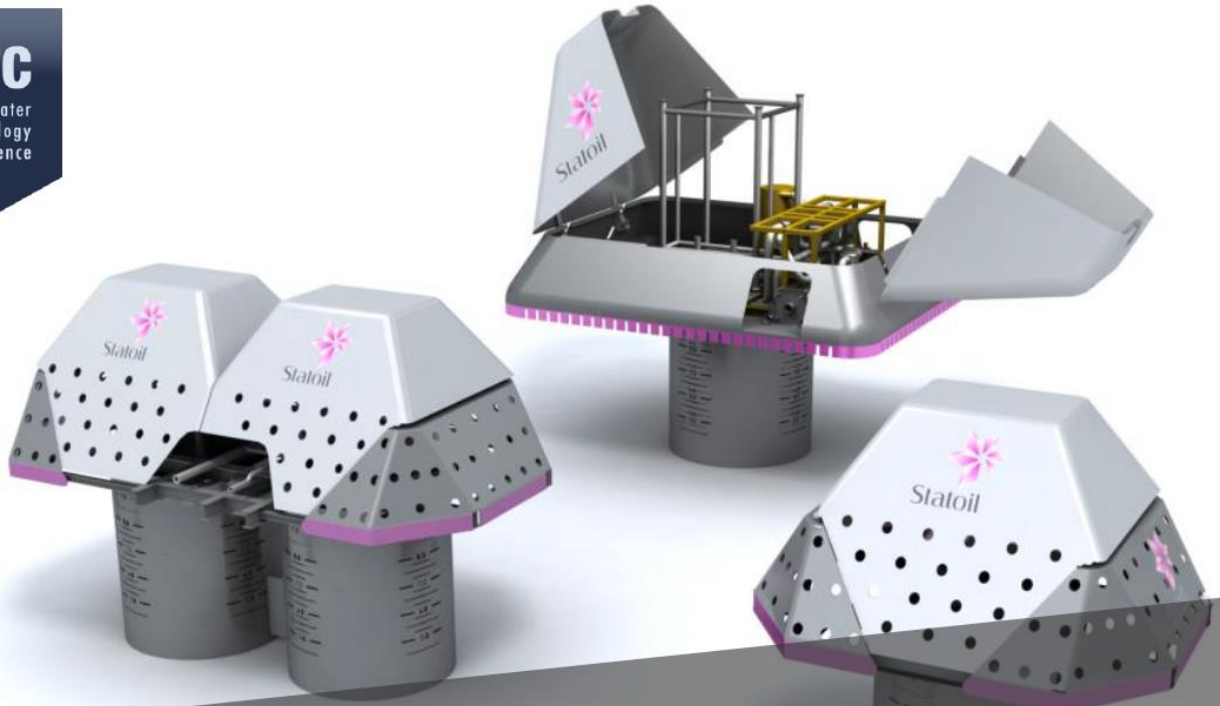
UTC
Underwater
Technology
Conference



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The Statoil CAP-X ™ Solution
Next generation subsea

0

Cap-X™ is shaping the future

Conventional satellite

Single slot satellite with large footprint

Approx 22 x 22 m

Statoil Cap-X™

New solution enabling subsea standardisation

Footprint reduced to 1/4 of regular satellites

10 x 10 m

UTC Underwater Technology Conference

Statoil

Strategic fit

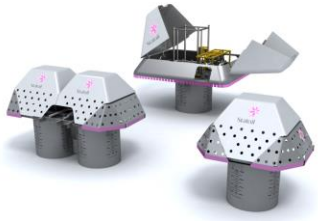
Taking driver's seat in system design

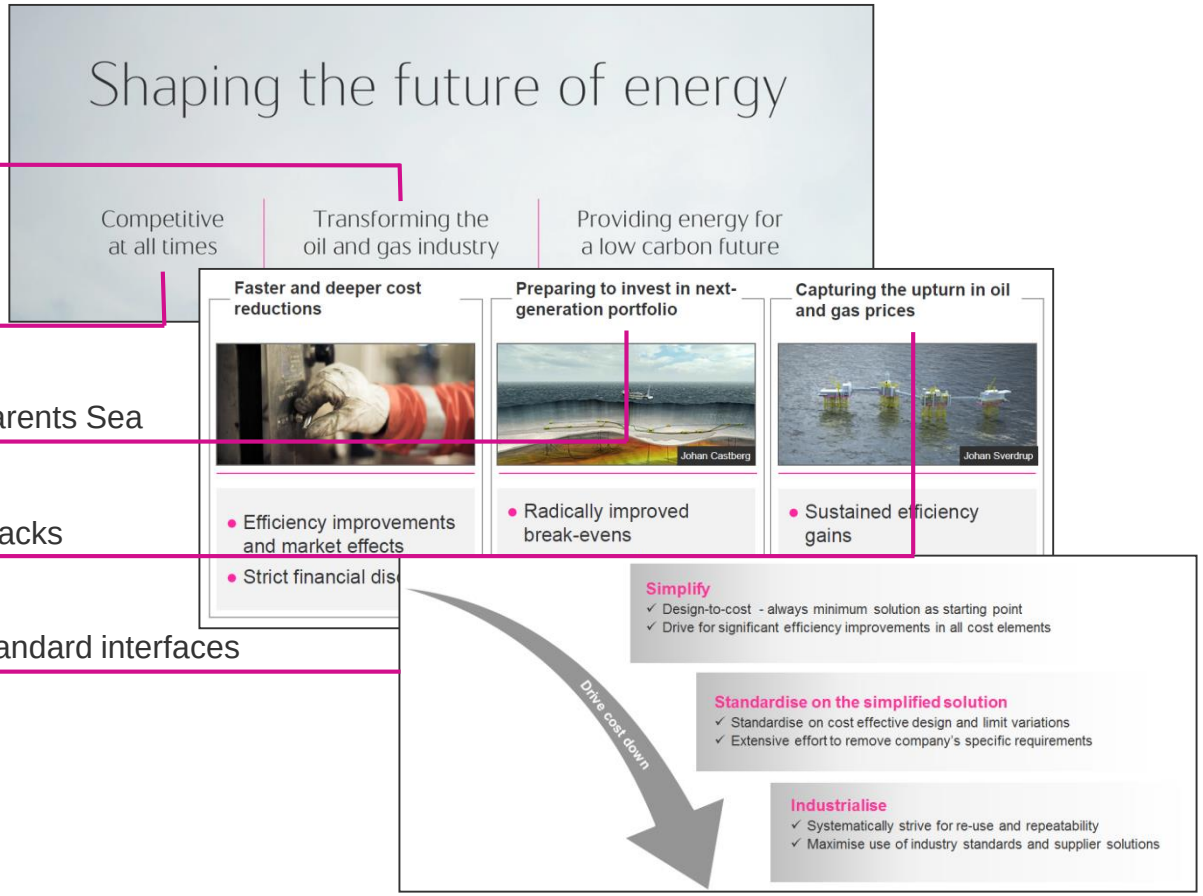
Wider competition also in heated market

Enabling shallow reservoir development in Barents Sea

Enabling project economy in small tie-backs

Accelerating simplification, creating new standard interfaces





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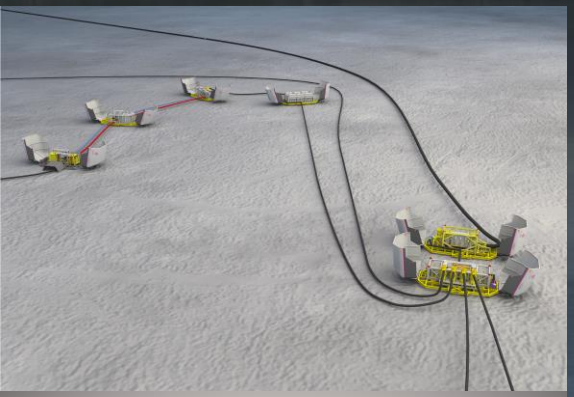
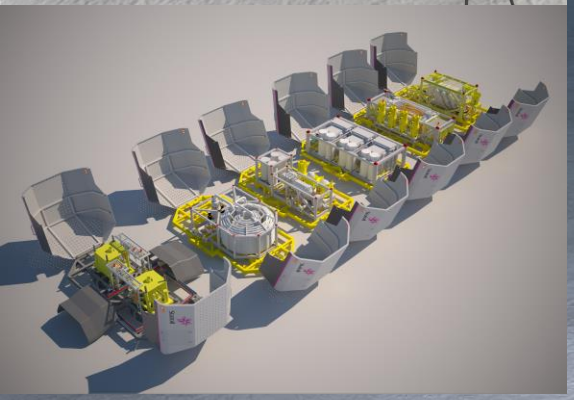
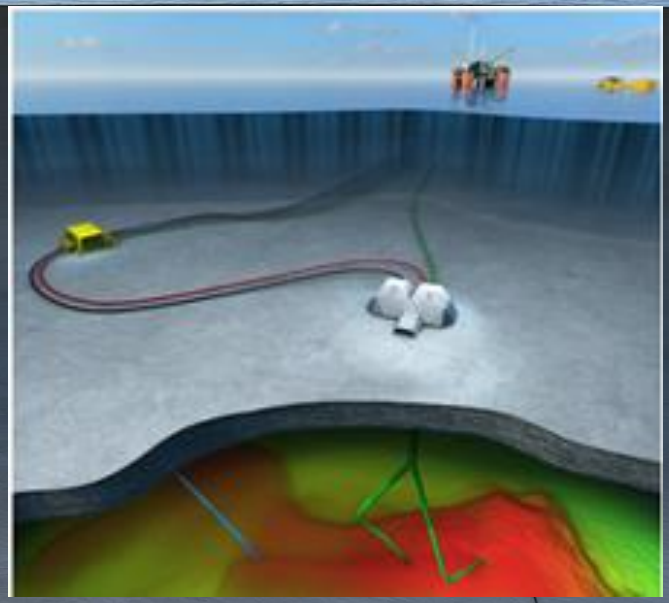
Utilise CAP-X



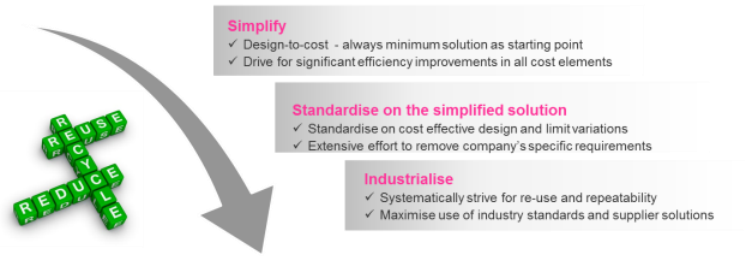


- Standardised modules
- Open Interface
- Reduced development cost
- More flexible contract strategy
- Bauge first user
  - Installation in 2019
  - Production startup in 2020



Statoil

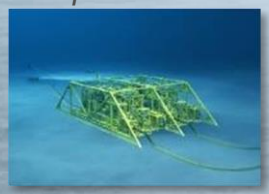
Industrialise



- Reuse qualified and proven technology
  - First time implementation will normally be more costly than the next
- Realise synergies through projects and align execution
- Collaboration between operators
  - Establish common spare parts pool
  - Vessel availability
- Utilise existing vendor production lines and experiences

Statoil Remotely Operated Factory (ROF™)
Development roadmap

Åsgard
In operation

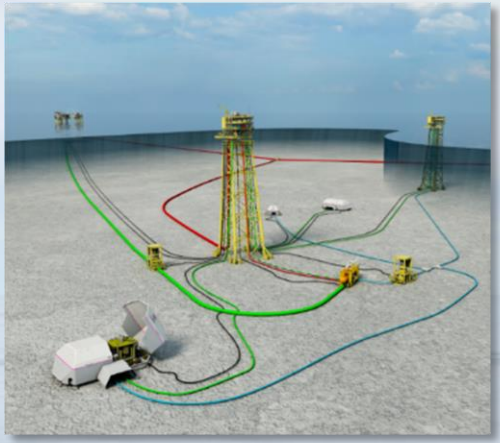


Subsea Compression

Oseberg Vestflanken 2
Ongoing

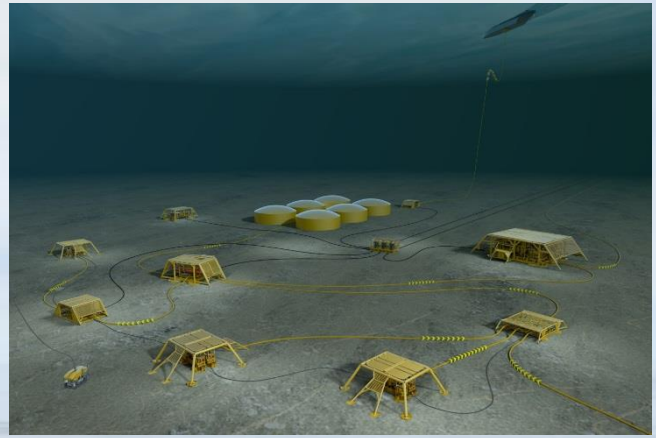
Unmanned Wellhead Platform (UWP™)

Early phase projects



Unmanned Production Platform (UPP™) supported by host

Future projects



Remotely operated factory – all subsea

Statoil Subsea Technology

Summary

- Subsea Developments has a bright future
  - Technology is well advanced
  - Subsea development minimises the envrionmental footprint
  - Large potential for subsea technology within future ocean development
- Simplify, Standardize,Industrialize, Collaborate and LEAN are Key words
  - Main Subsea Factory technology elements ready for deployment
  - Significantly reduced size and simplified layout for next generation
  - On-going work to standardise modules and interfaces
  - Several potential industrialisation candidates for subsea processing
  - Collaboration across Projects boarders reduces cost
  - Use of LEAN actively in all work processes
- CAP-X will allow development of marginal fields
  - LEAN approach required to capitalize on opportunities

Thank you