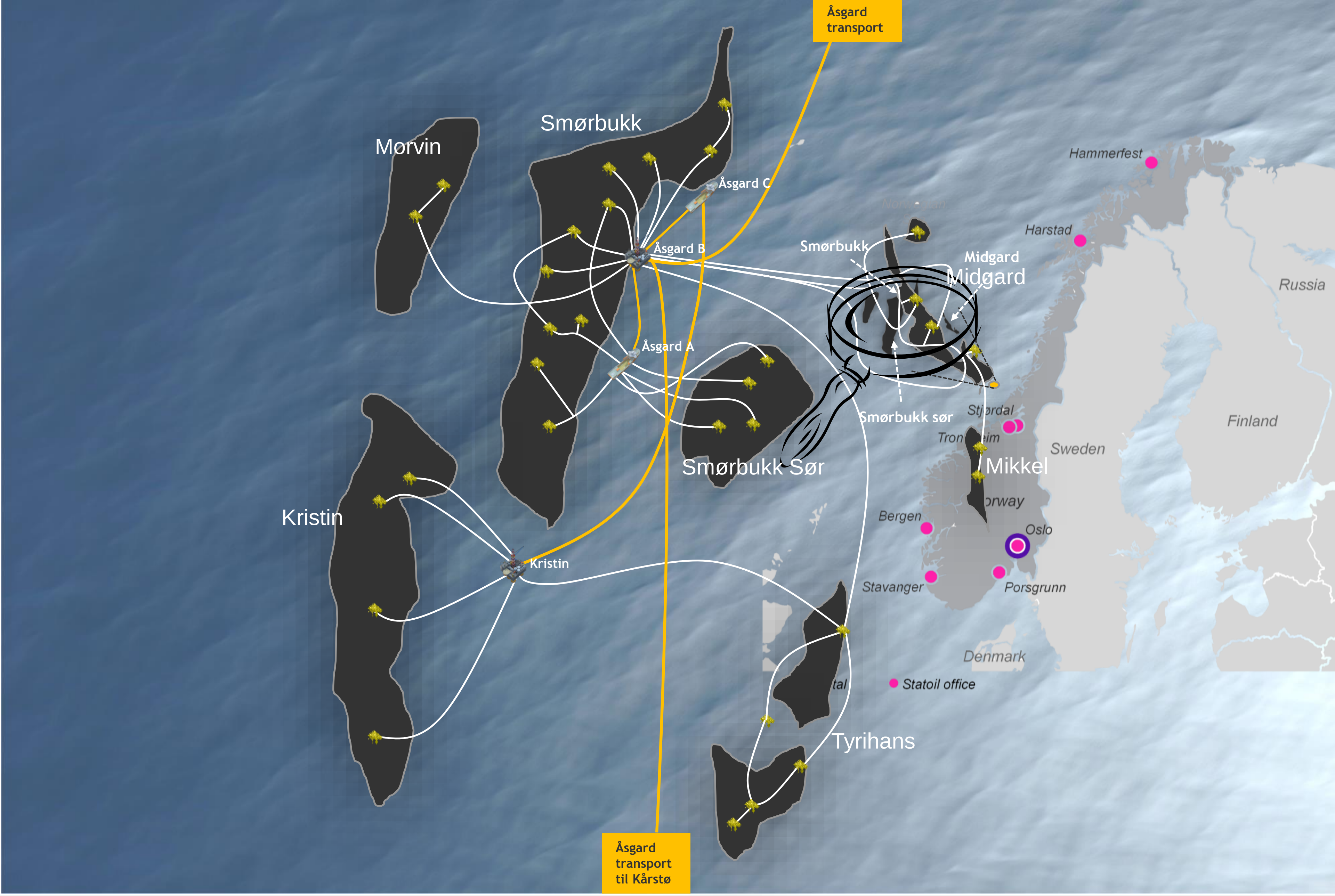
Statoil

ÅSC – Operational experience

NTNU 140218 – Petter Harstad


Åsgard transport
Smørbukk
Morvin
Åsgard C
Åsgard B
Hammerfest
Harstad
Smørbukk
Midgard
Midgard
Russia
Åsgard A
Smørbukk sør
Stjørdal
Finland
Sweden
Mikkel
Smørbukk Sør
Kristin
Bergen
Oslo
Kristin
Stavanger
Porsgrunn
Denmark
Statoil office
Tyrihans
Åsgard transport til Kårstø

Midgard and Mikkel

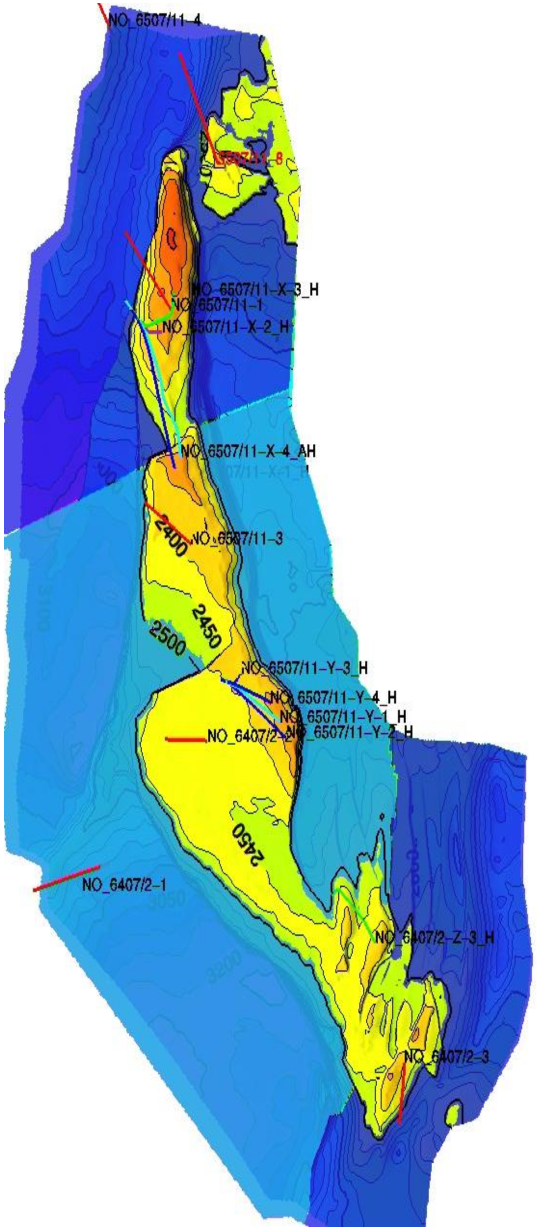
Midgard;

- Production start up 01.10.2000
- 3 templates
- 10 wells

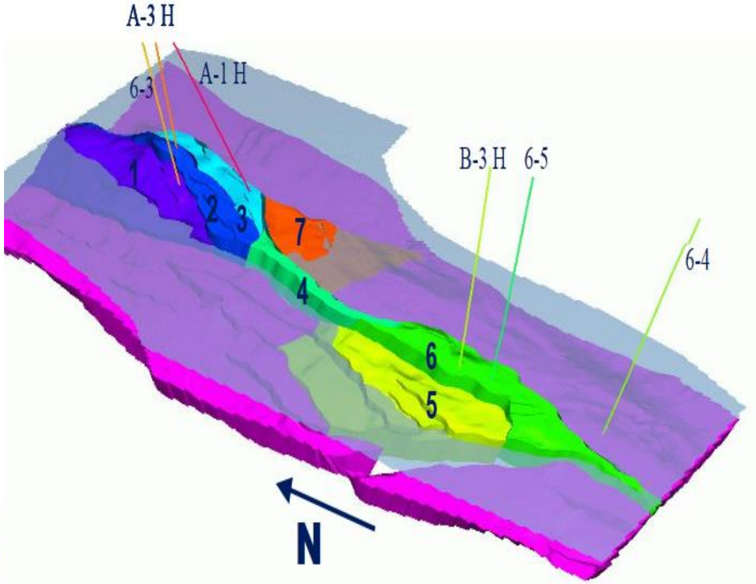
Mikkel;

- Production start up 01.08.2003
- 2 templates
- 3 wells
- Tie in Field to Åsgard

- Both Migard and Mikkel have very good reservoir properties, and are produced by pressure depletion
- Well completions:
  - Gravel pack with screens
  - Stand alone screens (SAS)

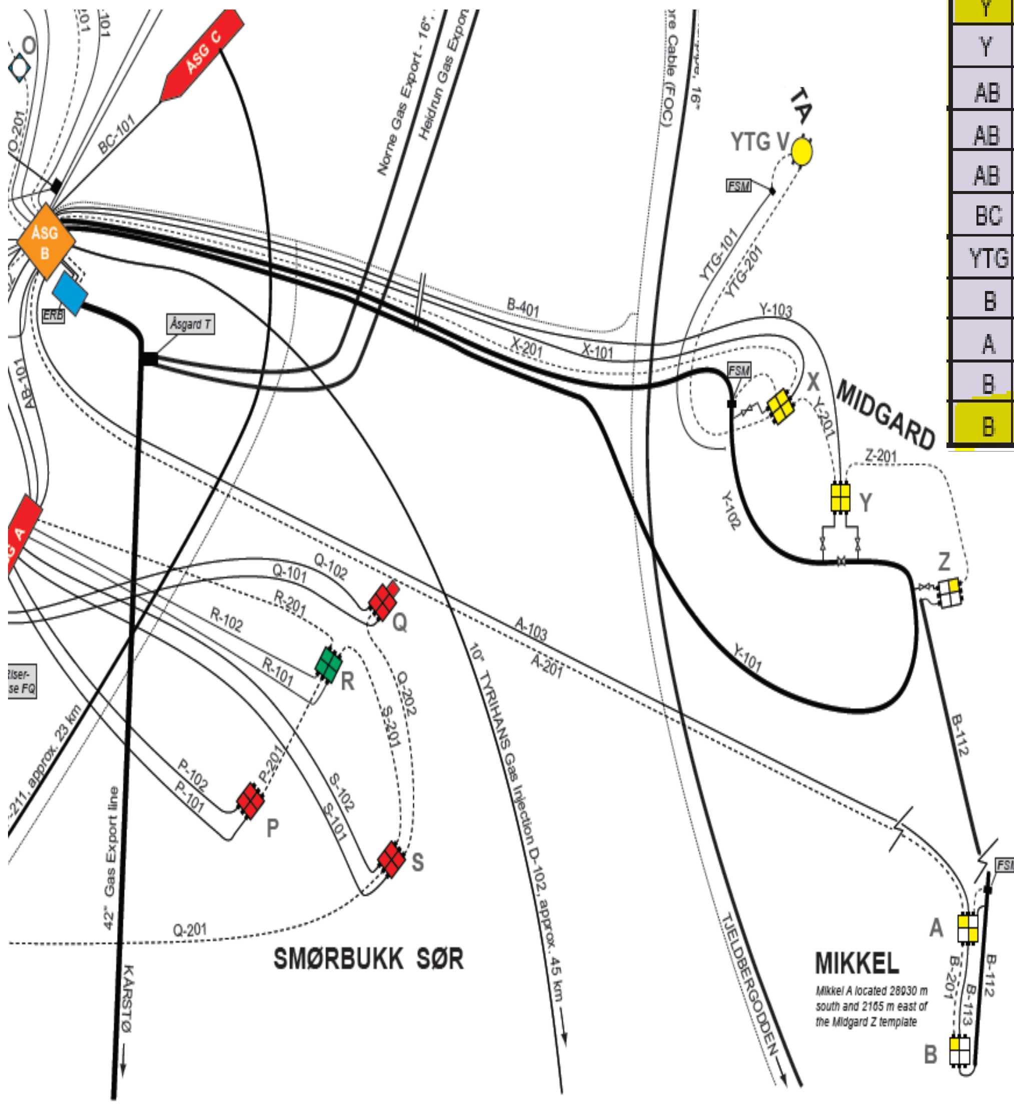


Partners	Åsgard	Mikkel
Statoil ASA (operator)	34,57 %	43,97 %
Eni Norge AS	14,82 %	14,90 %
Exxon Mobil E&P Norway AS	7,24 %	33,48 %
Petoro AS	35,69 %	0 %
Total E&P Norge AS	7,68 %	7.65 %



Old Midgard and Mikkel Production System

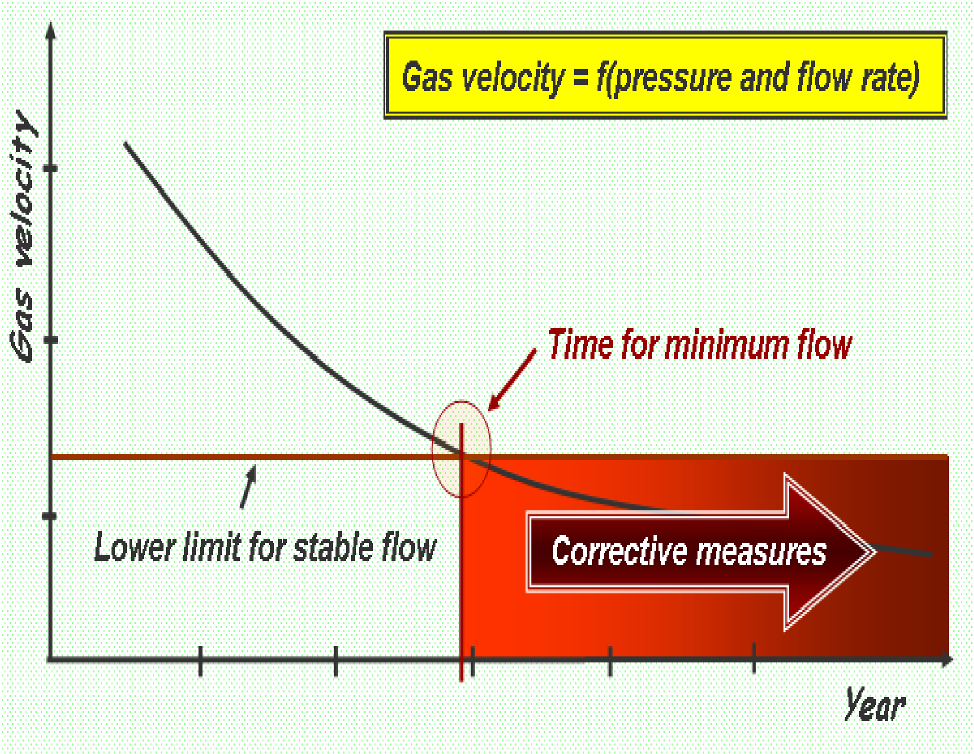
- Long flowlines with large dimension (ID ~ 20'')
- Continous MEG injection at wellheads to prevent hydrates in the flowlines
- At Åsgard B the produced MEG is regenerated and the MEG is then injected at the wells again
- A certain concentration of MEG is needed to keep the flowlines protected from hydrates



Y	101	20	53.4
Y	102	20	44.7
Y	103	3,5	MEG 45.4
AB	101	12	5.8
AB	102	12	5.4
AB	103	12	5.4
BC	101	12	3.7
YTG	101	10	5.2
B	105	10.5	20.3
A	103	3.5	MEG 64
B	113	3.5	MEG 7.8
B	112	18	36.9

Minimum Flow Challenge

- A certain gas velocity is needed to be able to transport the injected MEG together with condensed water to Åsgard B
- With time the gas velocity becomes too low to maintain stable production
- MEG accumulates in the flowlines and will be produced to Åsgard B in slugs.
- **Minimum flow rate**; rate at which the largest liquid slug Åsgard B can handle occurs

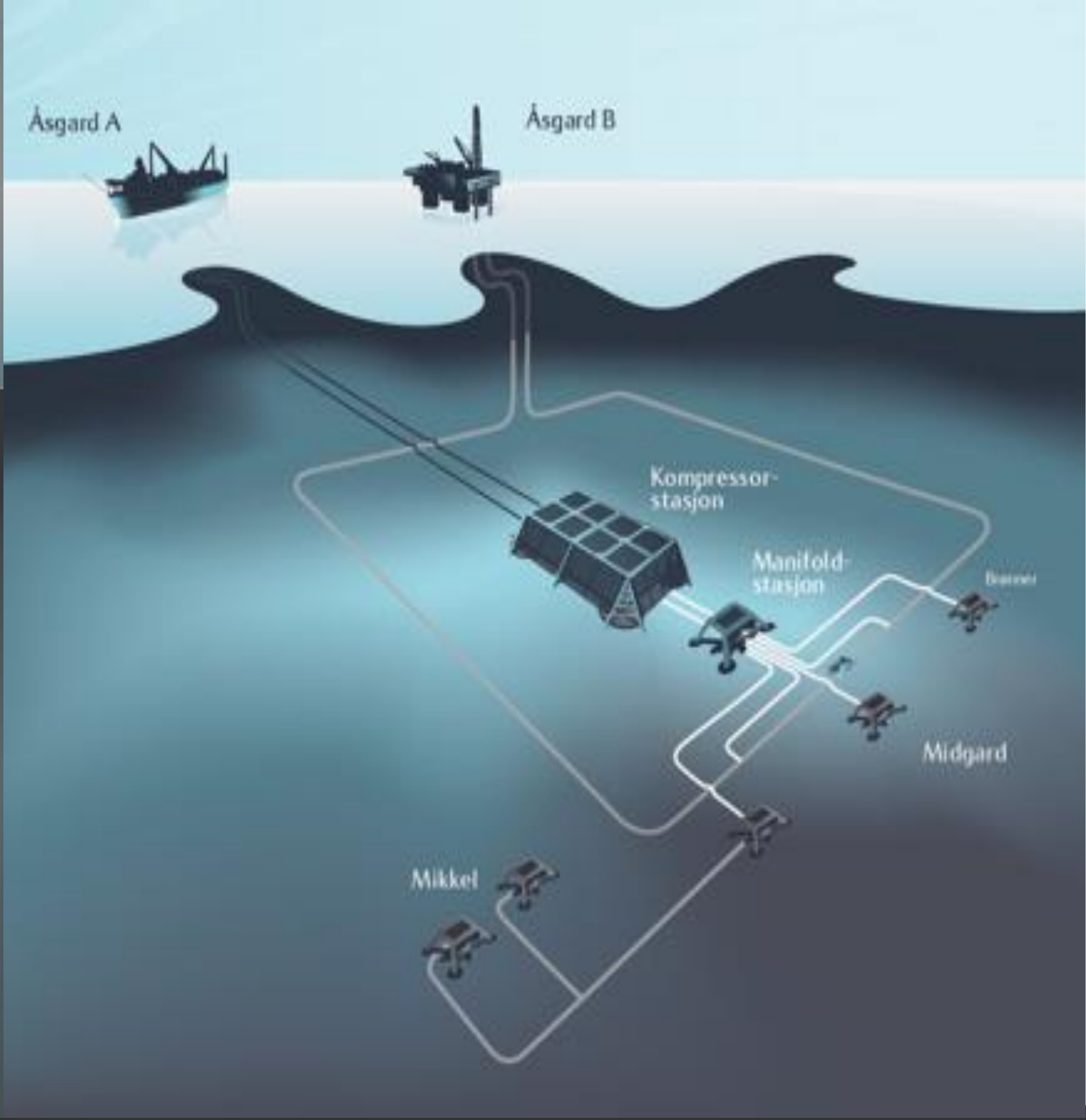


The SOLUTION:

Åsgard Subsea Compression

- Design gas flow rate: **21 MSm3/d**
- Pressure boost: **52 bar**
- Power: 2 x 11,5 MW centrifugal compressors
- 40 km step out
- Water depth 265 meters

- Additional reserves:
  - **306 Mboe**

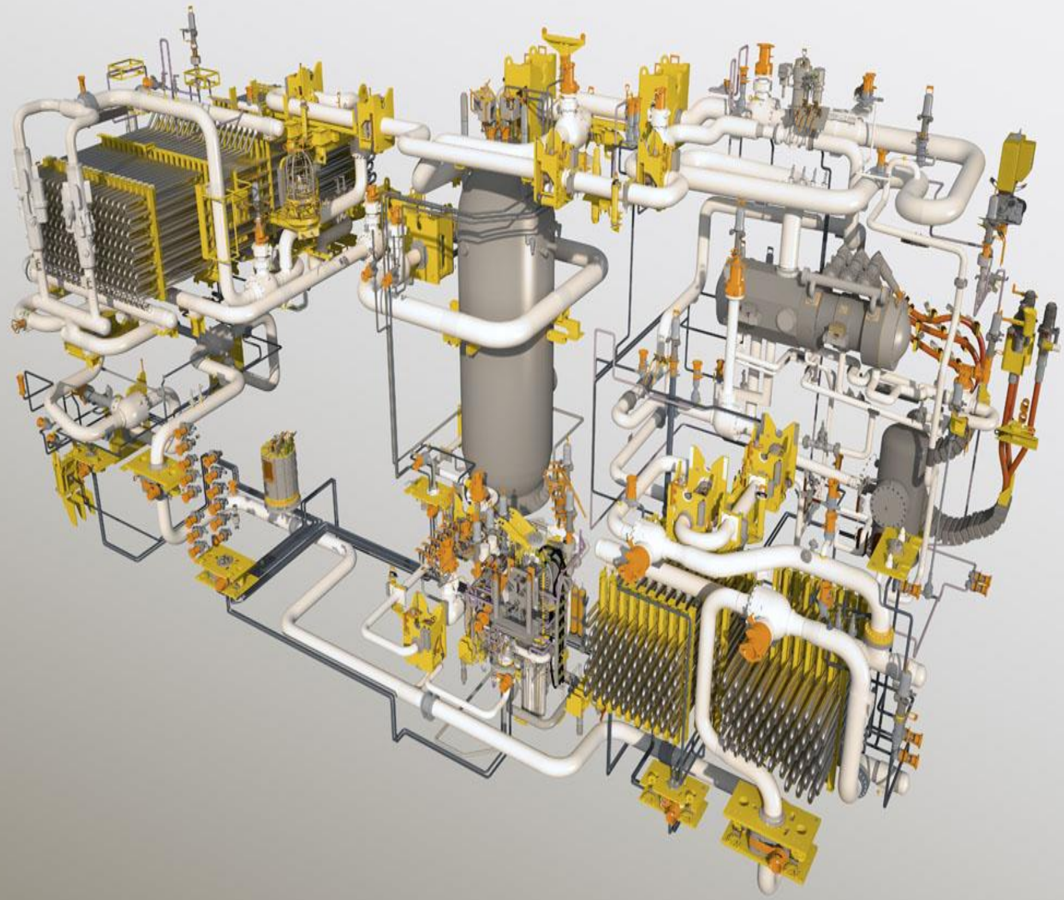


System overview

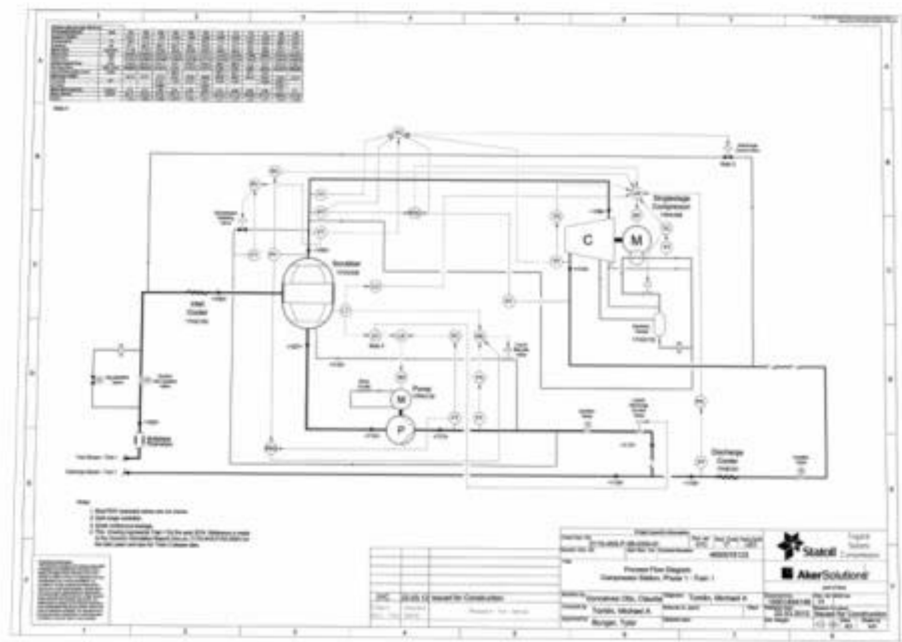
Åsgard Subsea Compression Station

Process Flow Diagram

Main components:
- Inlet cooler
- Scrubber
- Liquid pump
- Wet gas compressor
- Outlet cooler



The Gas Compression Process

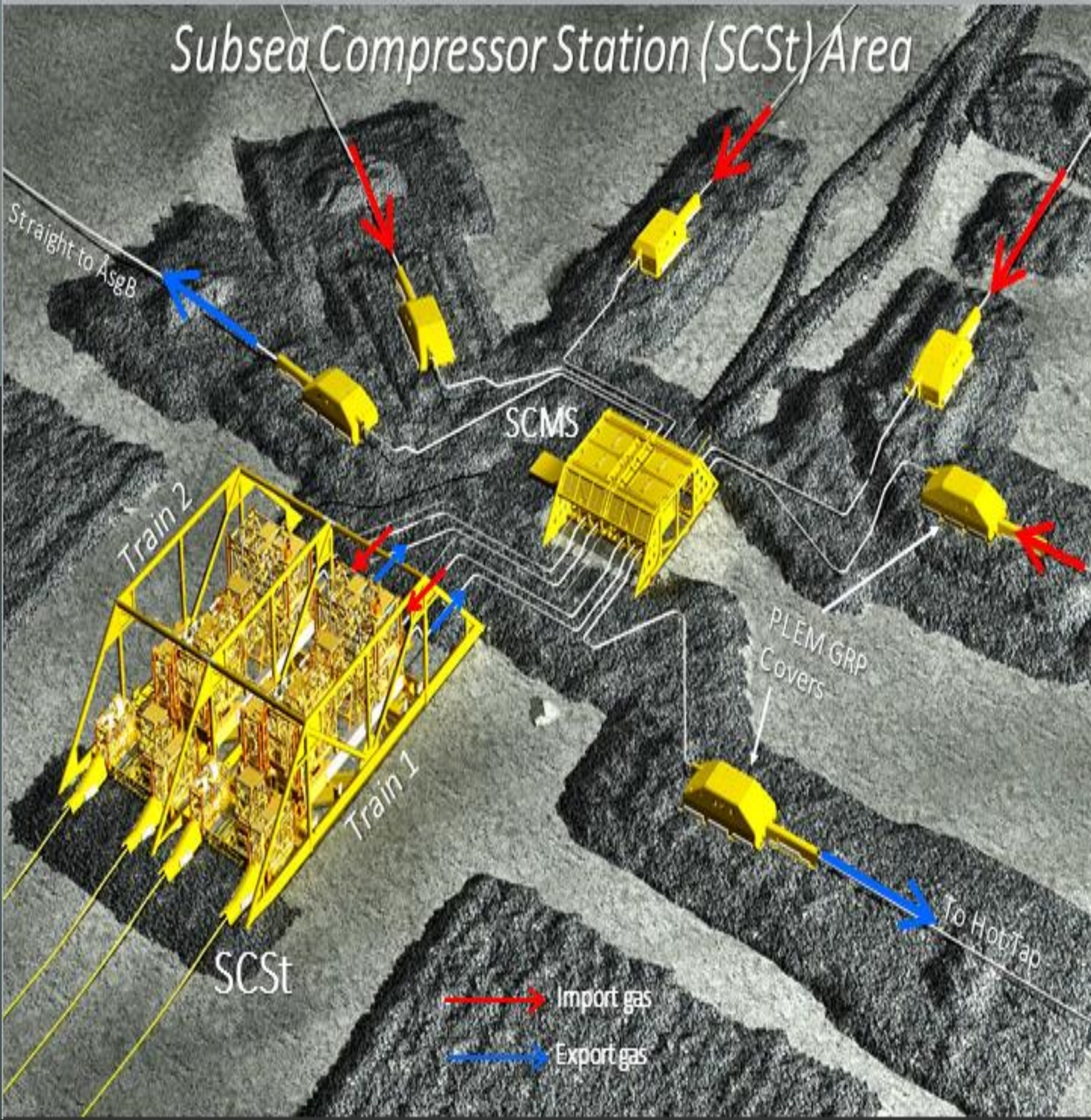


New Field Layout

ÅSC Pipeline scope:

- Hot Tap into Y-101
- 60 km of new pipelines
- 12 PLEMS
- 2x dynamic integrated power/umilical risers
- 4x40km power cables and umbilicals
- 18 spools
- ++

- Last part of pipeline scope finished in August 2015



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Discovery Channel – Mighty Ships

- Discovery Channel followed the installation of the last compressor module and made a program for their series «Mighty Ships» ! :
- Season 9, episode 1 ! ☺
- https://www.youtube.com/watch?v=WMNz7jE4yBQ

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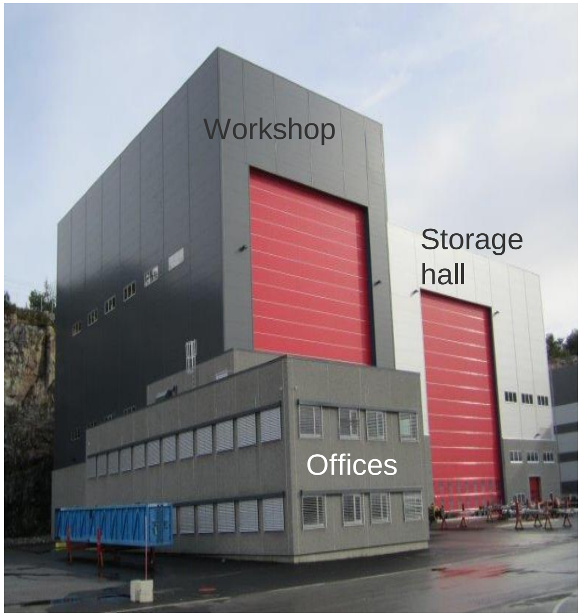
Operational experience

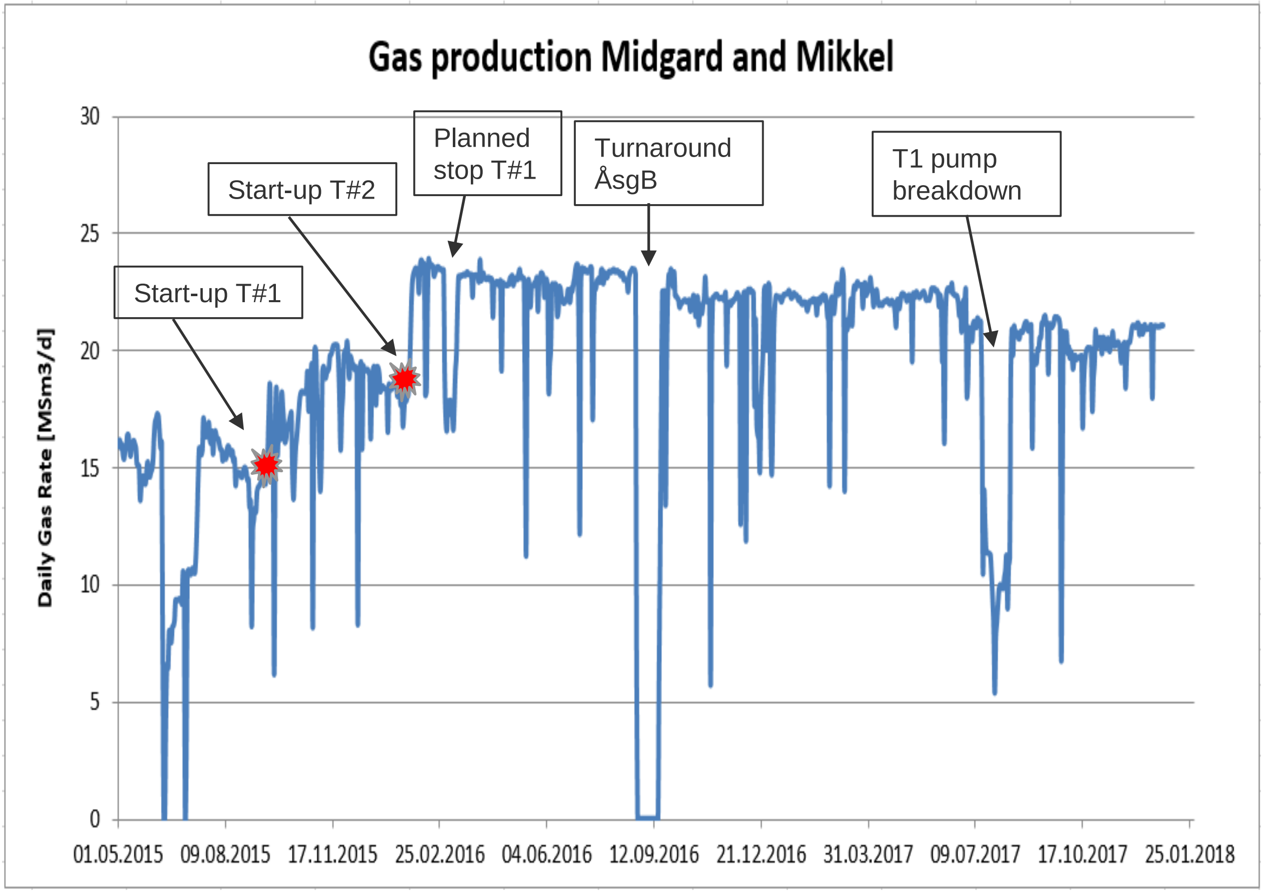
ÅSC operation support group

- ÅSC operation support is run from Statoil office in Stjørdal
  - Day-to-day follow up of ÅSC related tasks and production optimization
- Spare train stored @ Vestbase:
  - Storage hall
  - Workshop hall
  - Washing hall
  - Test pit
  - Office building



Operational experience - MID/MIK gas production

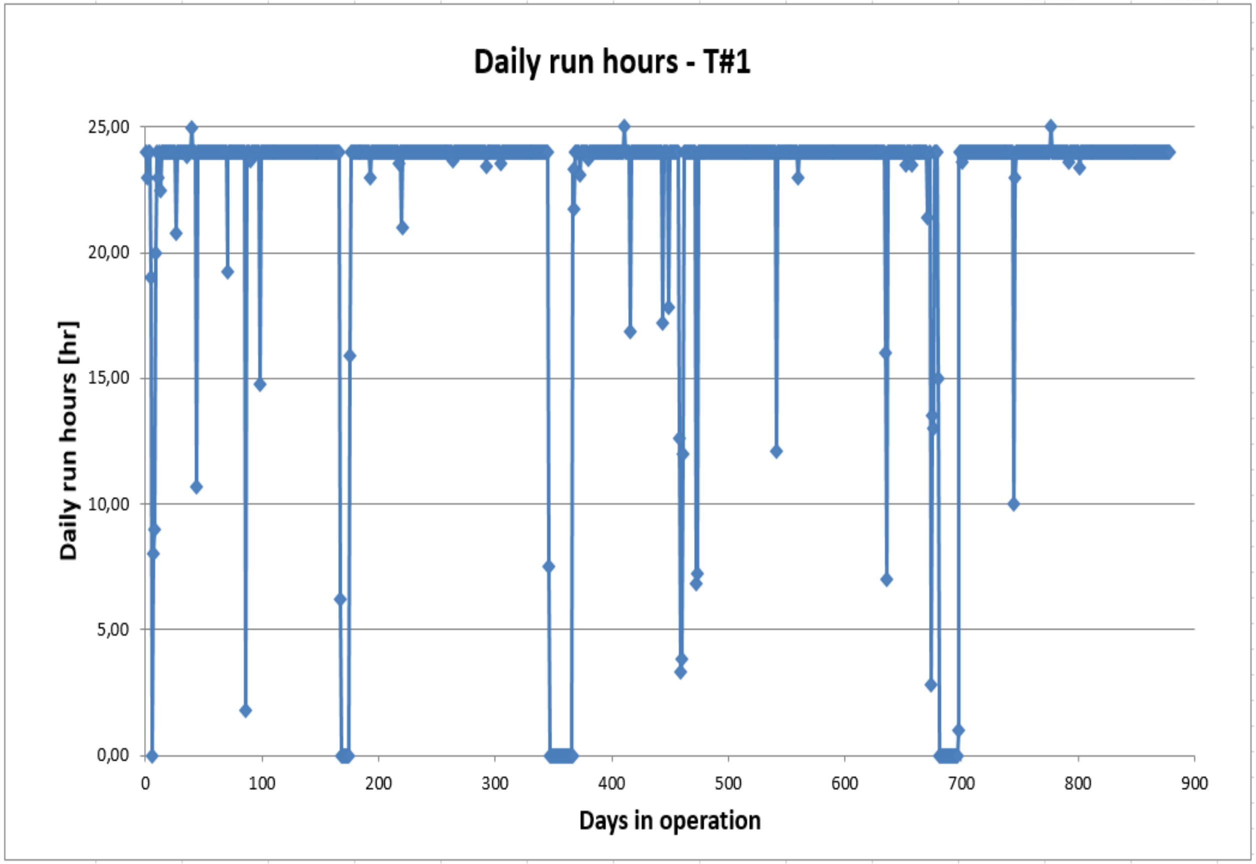
- T#1 start-up 16.09.15
- T#2 start-up 28.02.16
- Increased production by approx ~8 MSm3/d
- Producing above design rates since start-up
- Most production shut-downs caused by loss of power from Åsgard A
- Only minor technical issues prior to breakdown of T1 pump in July 2017



Updated 08.02.18

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
- Producing above design rates since start-up
- 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

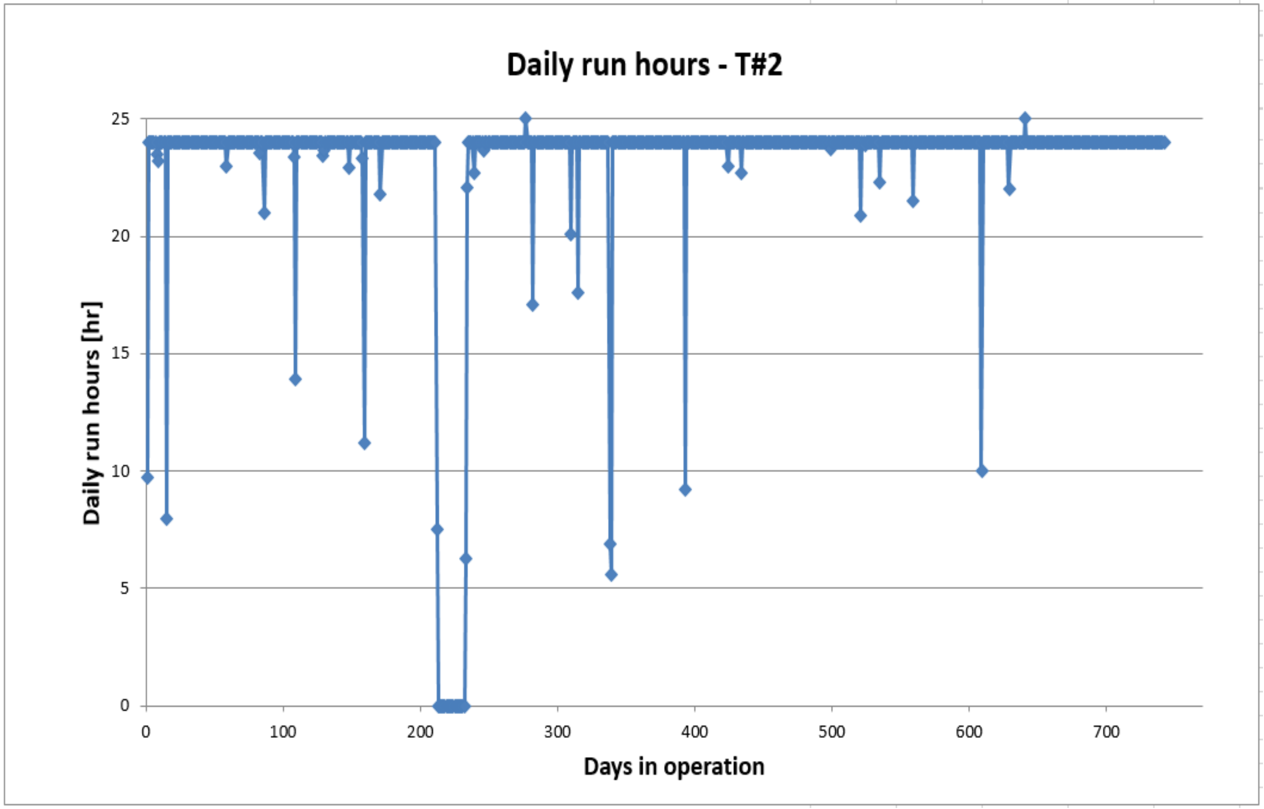


Updated 08.02.18

  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
- Producing above design rates since start-up
- 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



Updated 08.02.18

Operational experience – Production Efficiency

- Project system target / design: 96%
- Most production shut-downs caused by loss of power from Åsgard A
  - Increased robustness from 2017
- Very few unplanned losses related to subsea system:
  - Most of them related to pump regulation issues
  - Compressor: 100% PE
- Loss of redundancy not captured in PE

Year / Cat	Entire system incl power generation Åsgard A		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	0,001	99,99
2017	3,08	96,92	2,78	97,22	2,66	97,34

Crucial factors for success

- **Testing, testing, testing!**
- Comprehensive onshore test program:
  - **K-lab**: Functional testing of compressor
  - **Tranby**: Functional testing of pump
  - **Egersund:** Site integration testing (SIT)
  - **Aberdeen:** Control system testing

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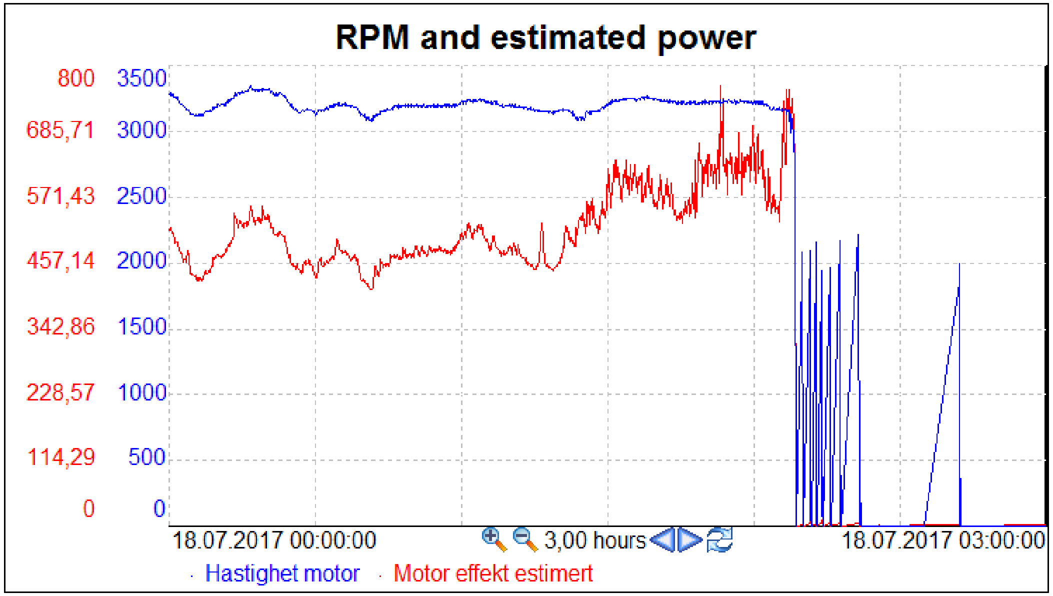
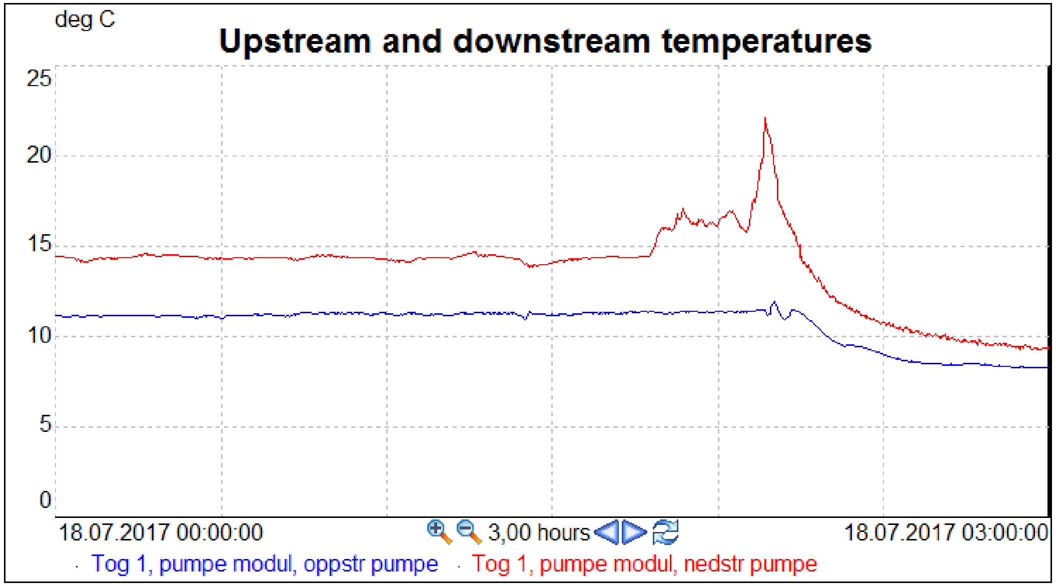
Pump breakdown July 2017

July 2017 - T1 pump breakdown

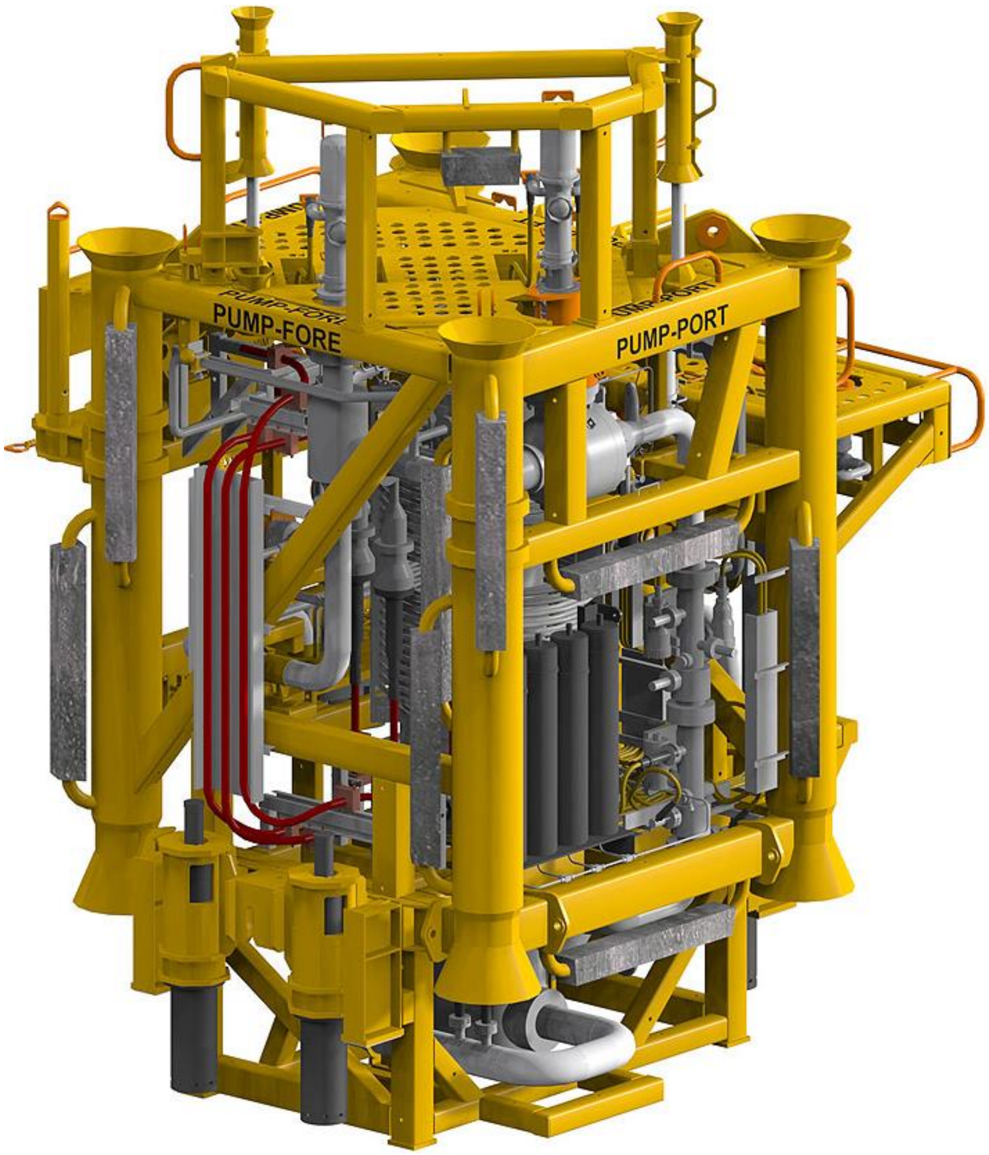
- Occured 18.07.17 02:09
- Increasing power consumption @ fixed speed prior to trip
- Indications of locked rotor when trying to restart – not able to spin pump





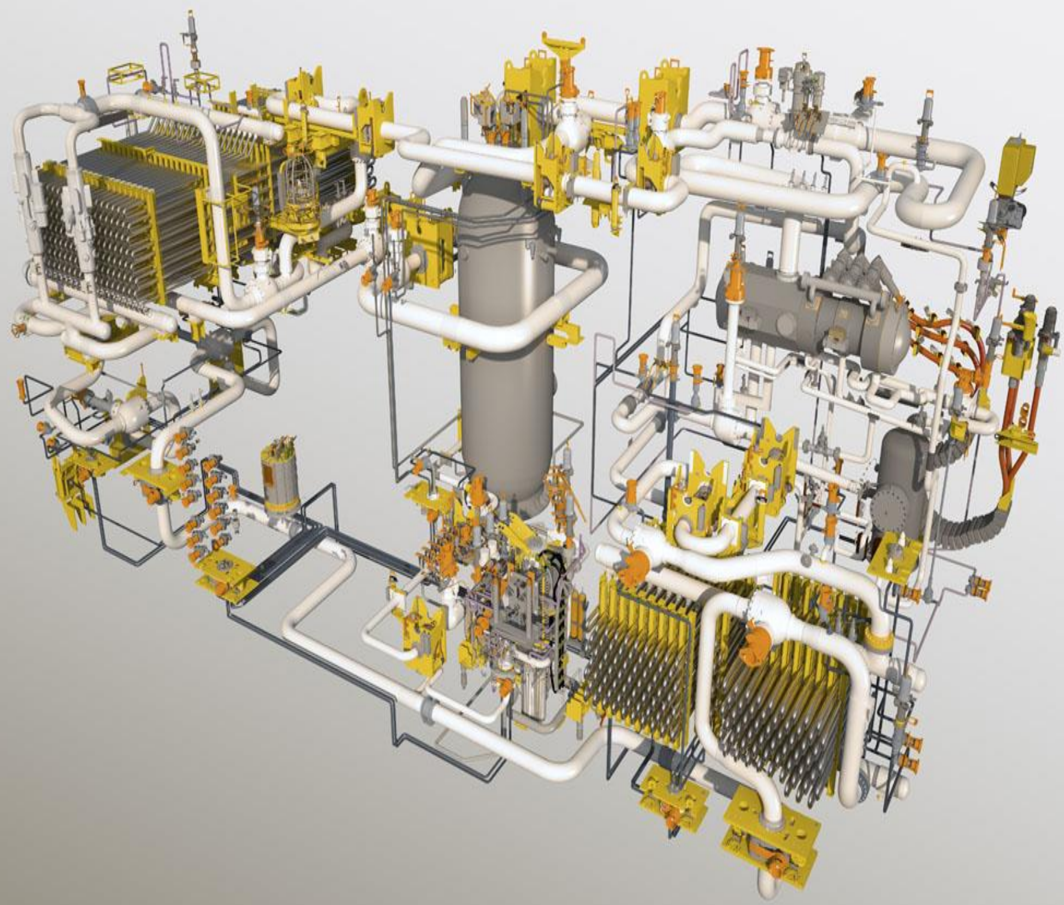
ÅSC Pump Module

- 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



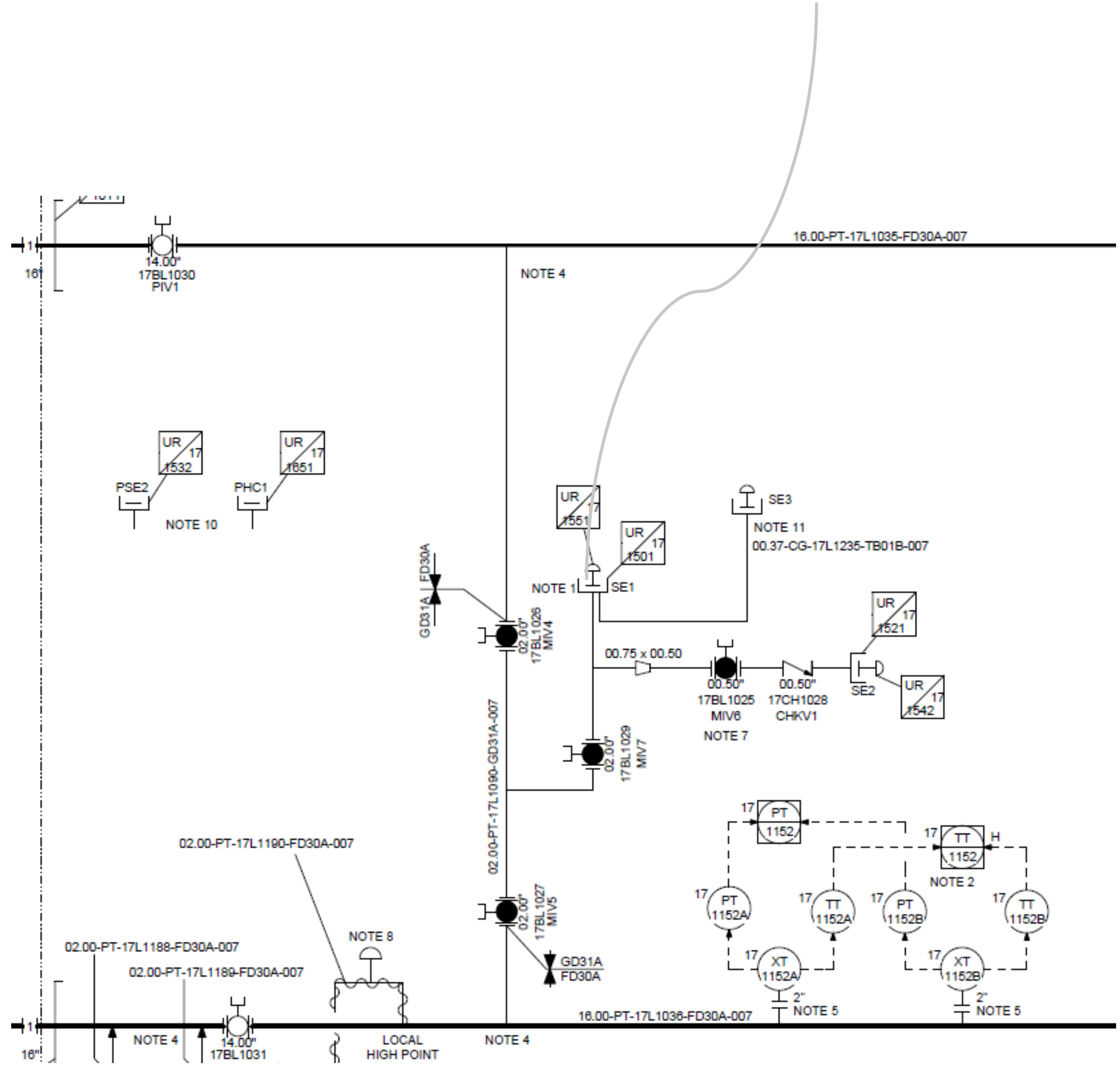
ÅSC Intervention challenge

- Requirement for year round intervention (Hs 4.5)
    - 400T modules
- Large volumes of HC
- Challenging pipe geometry
    - MEG and N2 needed to displace HC
- Complex single barriers
    - Difficult to do fault finding



Subsea Process Intervention System (SPIS)

- Allow safe and effective recovery and installation of ÅSC modules:
  - HC displacement
    - MEG
    - N2
  - Pressurization and depressurization
  - Leak testing
  - Seawater displacement
- Service hub in every module

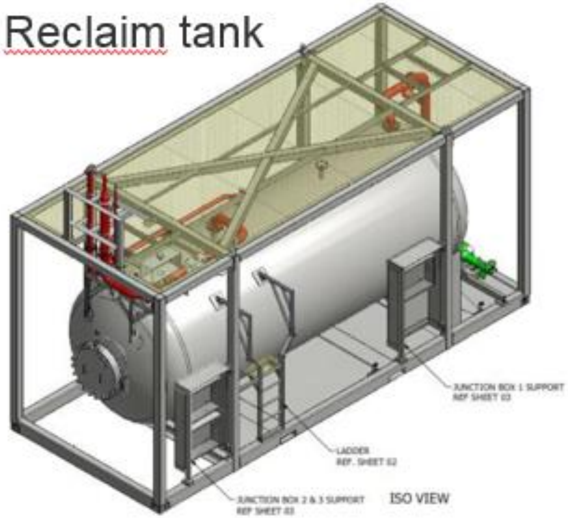


 Classification: Internal 8 februar 2018

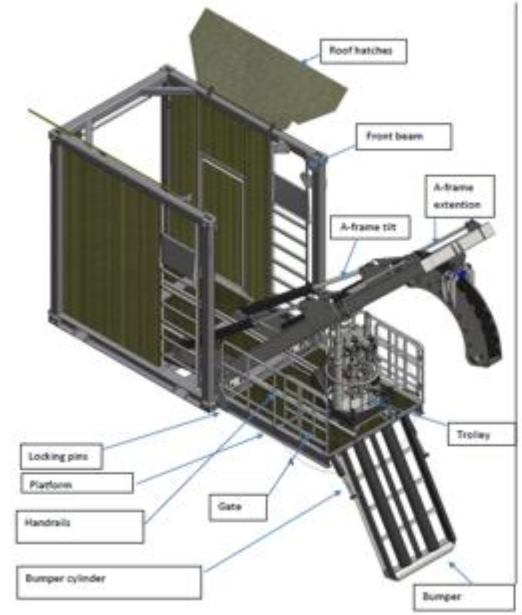
Subsea Process Intervention System (SPIS)

- Allow safe and effective recovery and installation of ÅSC modules:
    - HC displacement
        - MEG
        - N2
    - Pressurization and depressurization
    - Leak testing
    - Seawater displacement
- Service hub in every module

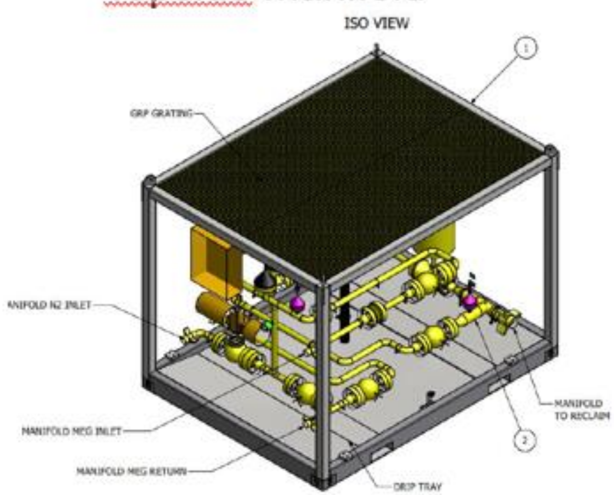
Reclaim tank



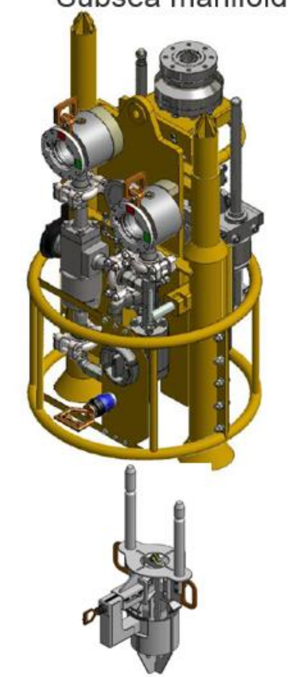
LARS



Topside manifold



Subsea manifold

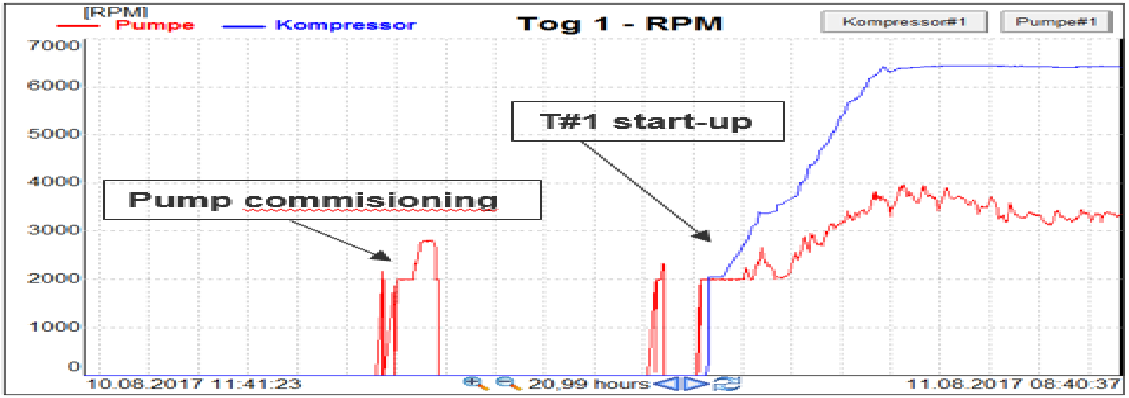


Subsea Process Intervention System (SPIS)

- Allow safe and effective recovery and installation of ÅSC modules:
  - HC displacement
    - MEG
    - N2
  - Pressurization and depressurization
  - Leak testing
  - Seawater displacement
- Service hub in every module

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
    - 24 days from trip
  - Pump #1 and T#1 in operation since
  - Very rapid operation without major issues



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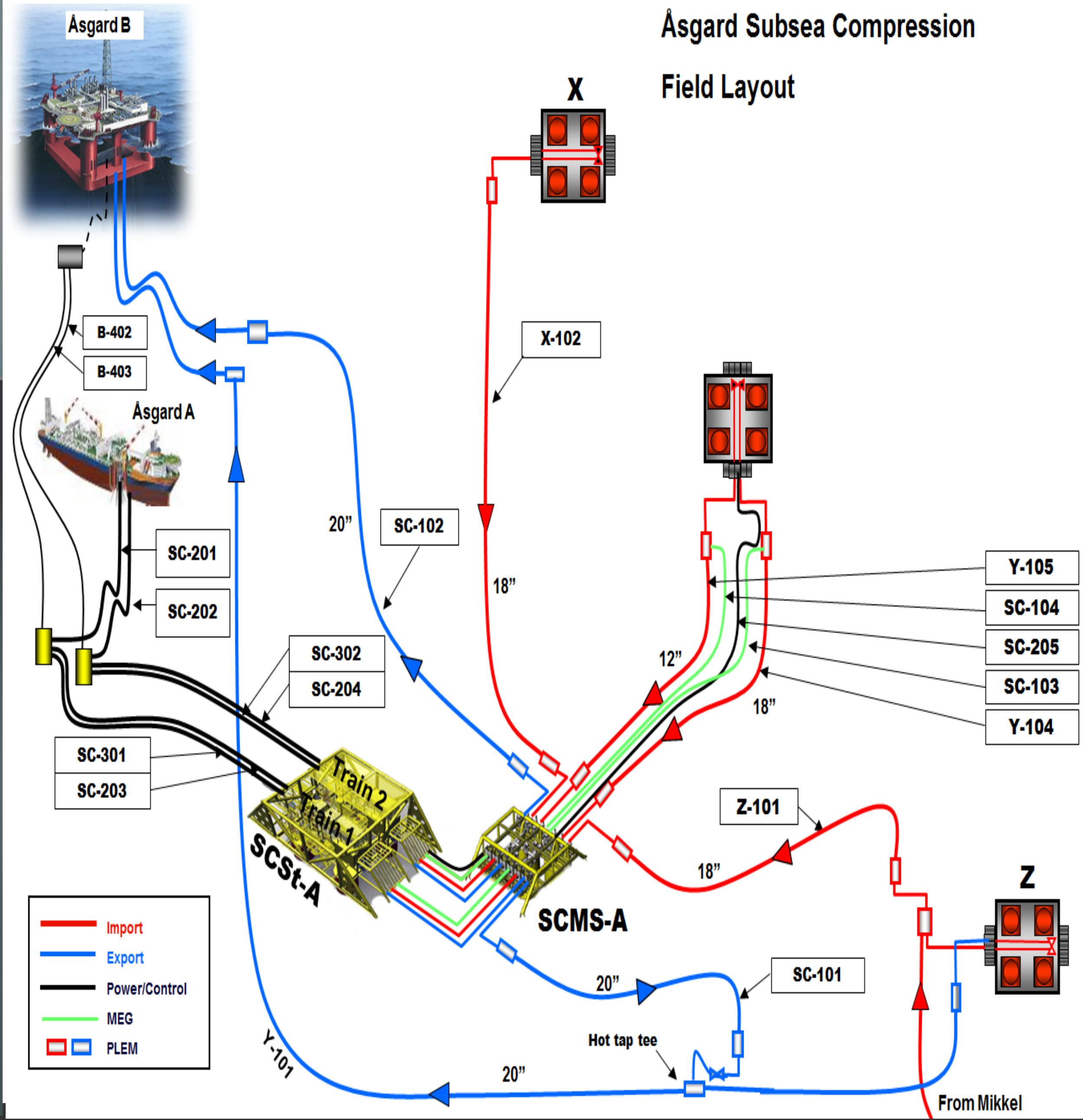
The future

ÅSC – Beyond 306 Mboe

- ÅSC enables future IOR possibilities in the Midgard / Mikkel area
- Infill wells
- Tie-in fields
- Built-in flexibility in current design
- Desired outcome:
  - Increase recovery!

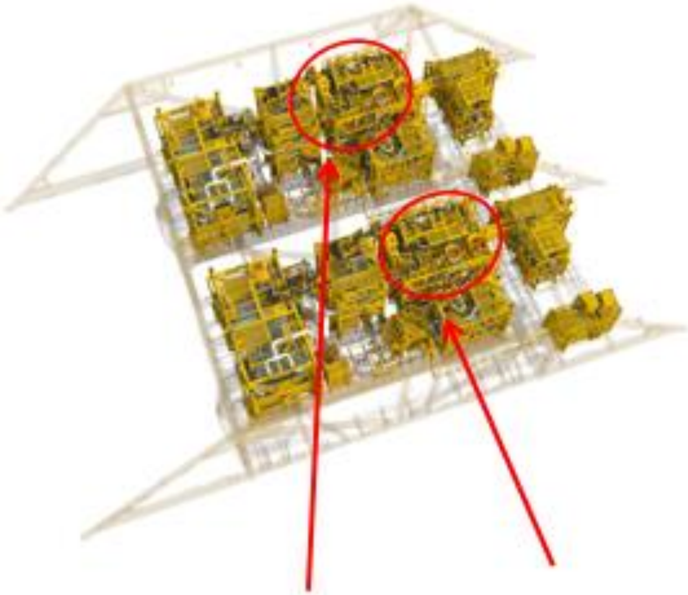


ÅSC – Phase II project

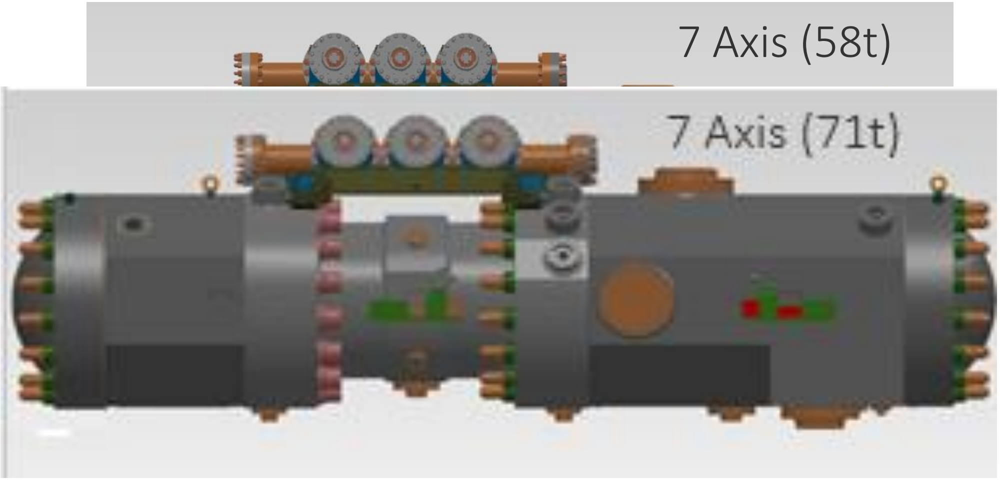
- Ongoing project
  - DG2 2018

- Qualify and modify existing compressor system for extended operational envelope
  - Increased speed
  - Wet gas compression

- Qualify new compressor solution for increased pressure ratio

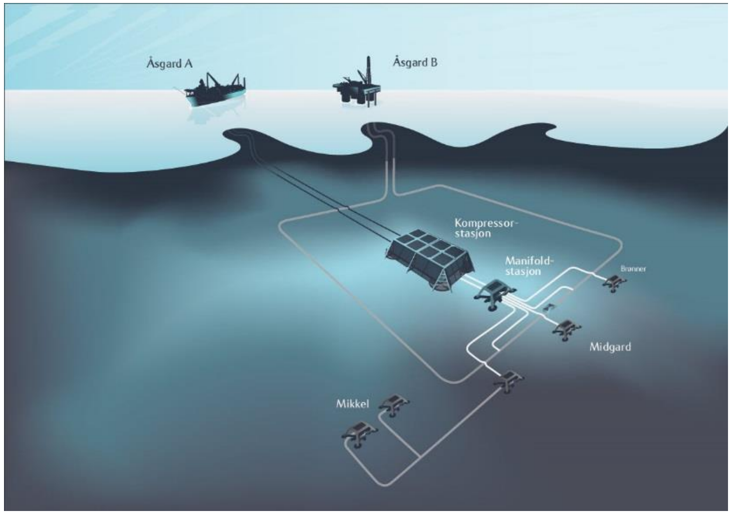


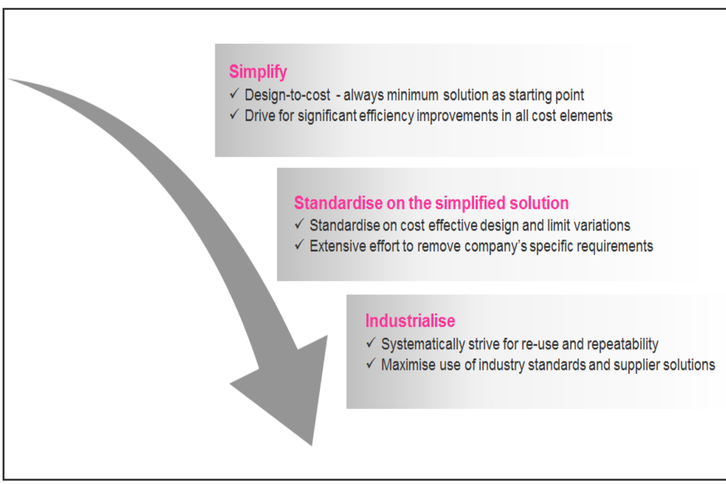
Affected part of existing facility



Simplify, Standardize, and Industrialize (SSI)

Where are we after ÅSC?





- ÅSC was first of it's kind and through ÅSC we have a unique opportunity towards the future:
  - Comprehensive technology tool-box available for reuse
  - Reuse of test and service facilities
  - Reuse of intervention system and tools
- From the different project stages and over two years in production a significant amount of learning's have been accumulated
- Ensure that further cost reductions are captured:
  - Simplification
  - Standardization on the simplified solution
  - Industrialization by repeating and re-use

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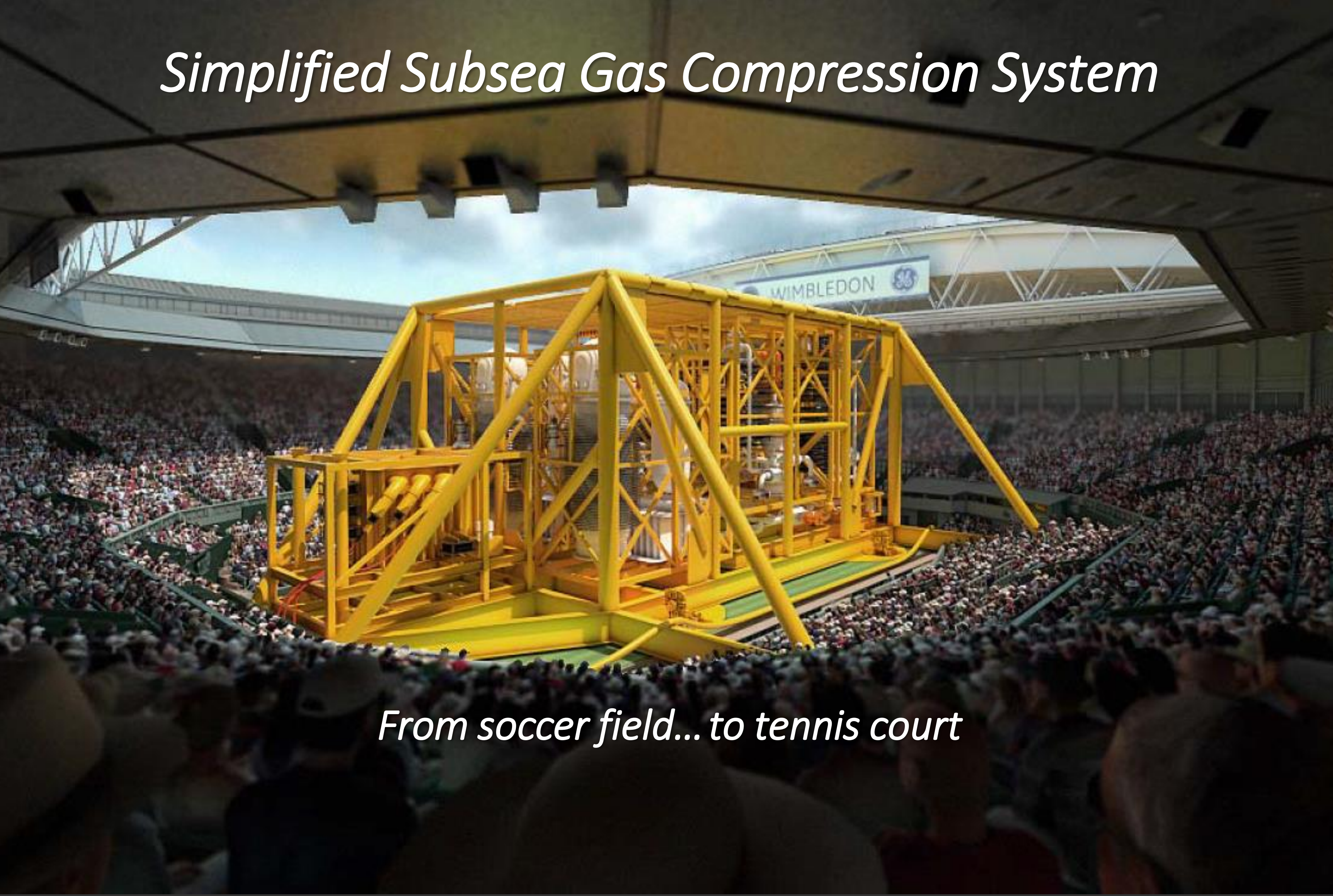
Simplified Subsea Gas Compression System



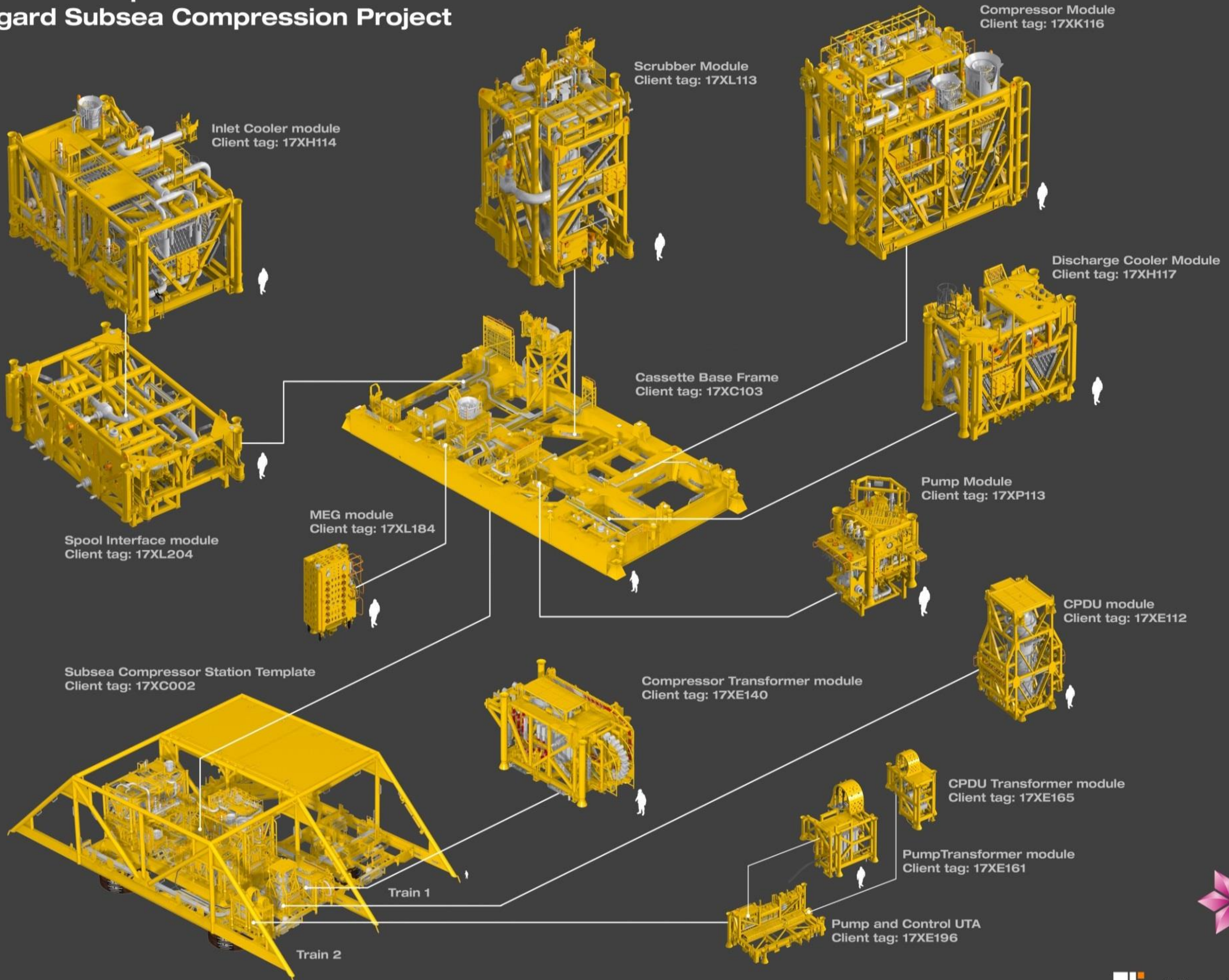
From soccer field… to tennis court

Back-up

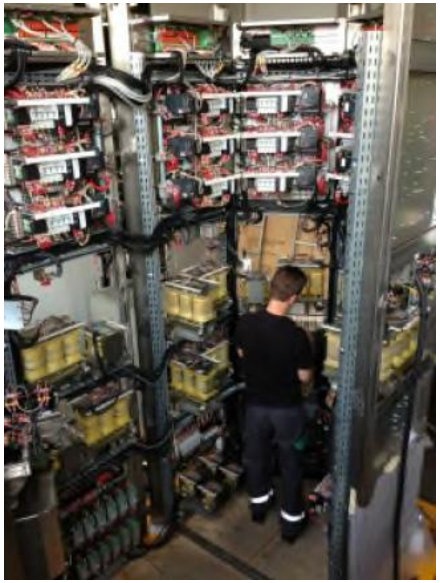
Installation and Intervention

- North Sea Giant
    - DP Class III
    - Size 161x30m
    - Accommodation 120 person
    - Main Deck area 2900m^2
    - WROV x2, Triton XLX and XLR
- SHS for large modules in fabrication
    - Total weight of structure ~1000Te, height 30m
    - Capacity 388 tons, 15x12x12 m, Hs 4.5m
- Moonpool Handling System 70 tons, 7.2x7.2m
- Subsea Process Intervention System
    - Handle residual hydrocarbons in modules
    - MEG displacement of modules
    - Nitrogen flushing

Subsea Compression Station
Åsgard Subsea Compression Project

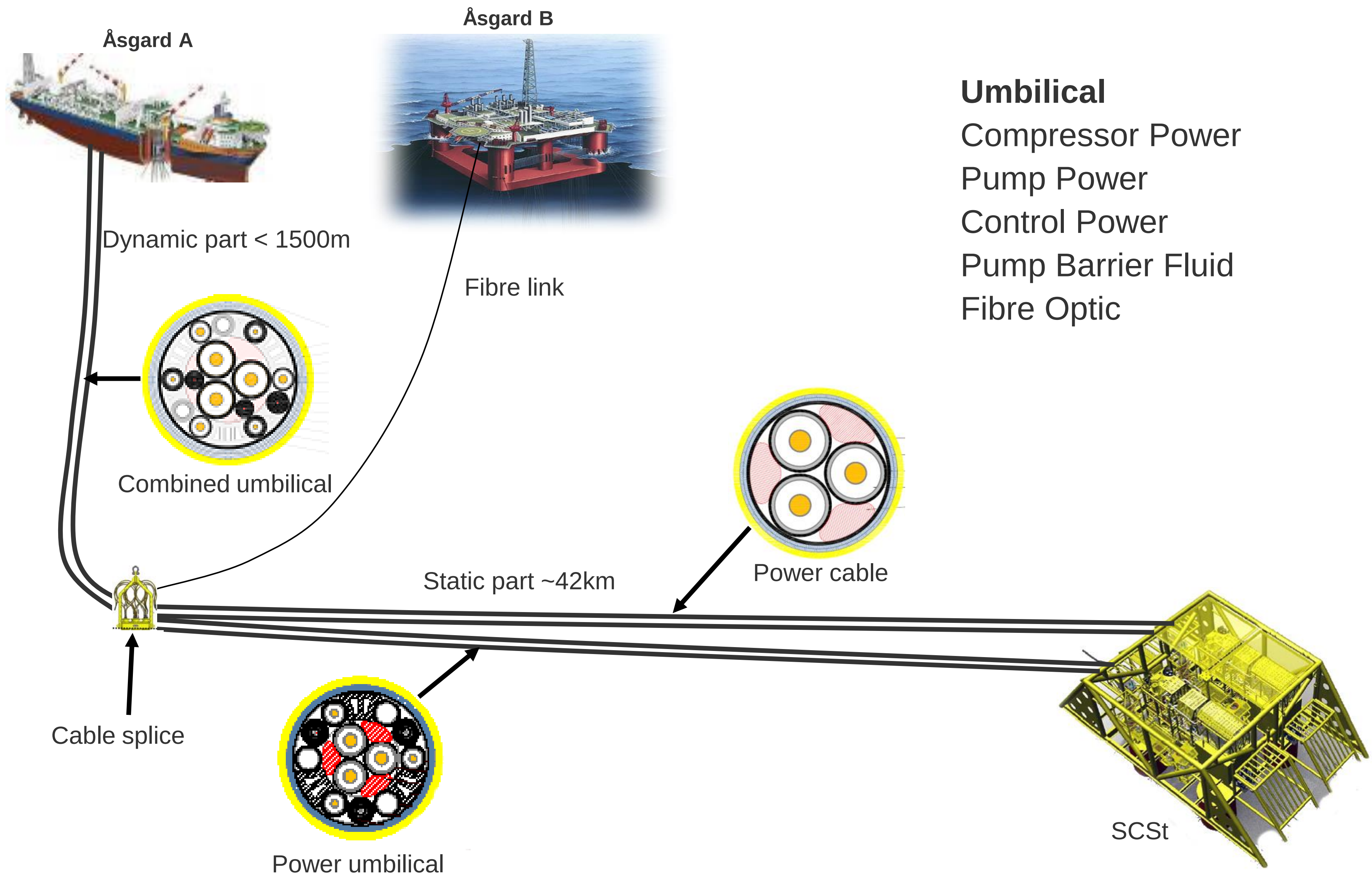


Control System



- All controls functionality integrated in SAS
- Power Supply
  - Topside UPS
  - Subsea Control Power Distribution Unit (CPDU)
- All electric system
- 3 segregated redundant systems
  - Process Control System (PCS)
  - Process Shutdown System (PSD)
  - Condition Monitoring System (CM)
- Subsea closed loop functionality
  - Active Magnetic Bearing System (AMB)
  - Anti Surge
- 100 Mb TCP/IP (Modbus/ModSafe) on separate fibers
- Subsea Control Modules:
  - 2 SCM per compressor train
  - 1 SCM on manifold station
- Hydrocarbon leak detection system

Umbilical System



Umbilical

Compressor Power

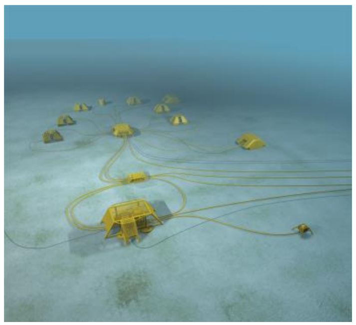
Pump Power

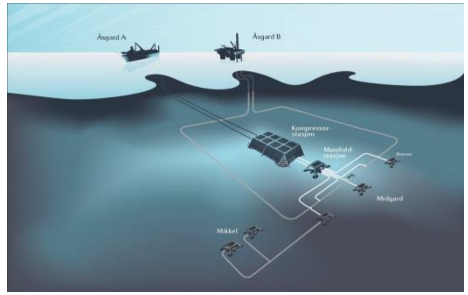
Control Power

Pump Barrier Fluid

Fibre Optic

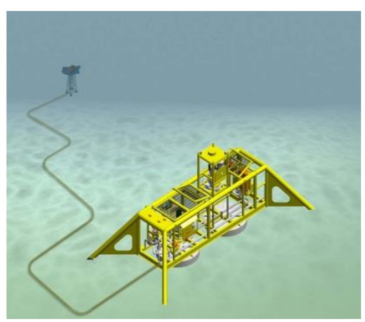
Subsea Processing





Lufeng: 1997
Subsea pump
5 x 0,4 MW
1 km

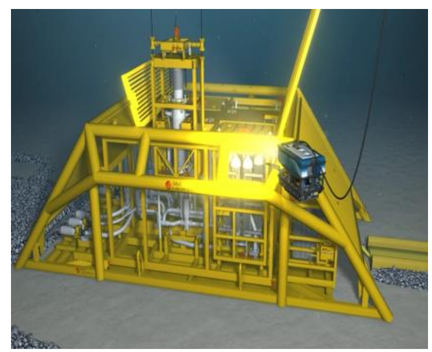
Troll: 2001
Subsea sep.
1 x 1,6 MW
4 km



Tordis: 2007
Subsea sep.
Sand handling
2 x 2,5 MW
12 km

Tyrihans: 2009
Subsea raw seawater injection
2 x 2,5 MW
43 km

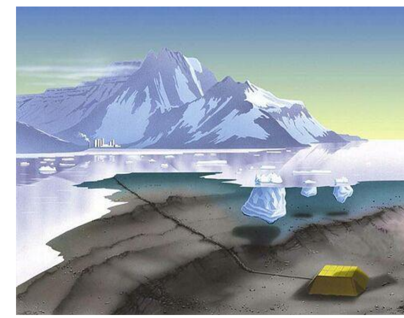
Åsgard: 2015
Subsea compression
2x11,5 MW
50 km



Gullfaks: 2015
Subsea compression
2x5 MW
17 km

Snøhvit: 2017-2020 ?
Subsea compression
140 km

Arctic: 2020+ ?
Subsea processing
Large step-out, large duty



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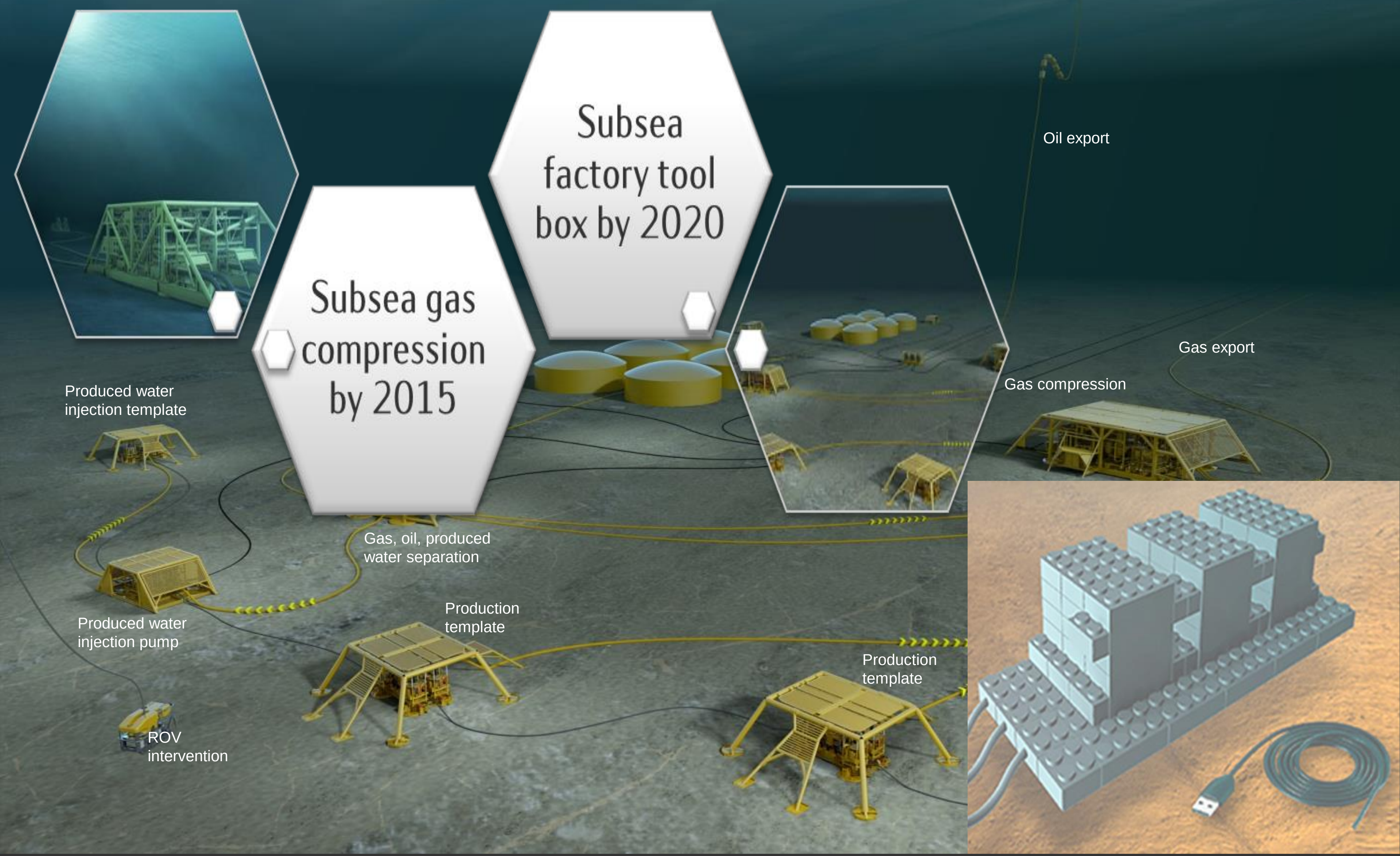
The Statoil Subsea Factory™



Main Subsea Factory technology elements ready for deployment

Large potential for reuse of technology and utility systems in new projects

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Subsea compression importance for future

Subsea compression can be enabling technology to gain:

1. Profitable tie back of gas fields by
   - Accelerated production & Inceased recovery
2. Operational flexibility compared to topside
   - To reduce impact on weight, space, HSE
   - Energy efficient & robust flow assurance
   - Act as hub for new tie backs, avoid new platform
3. Access deep water, environmentally sensitive locations