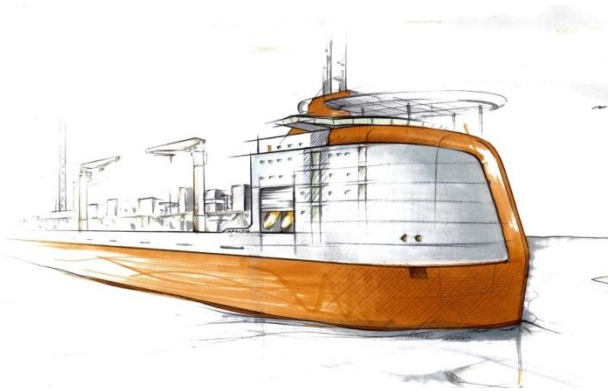
IBC 3rd Annual Drillships

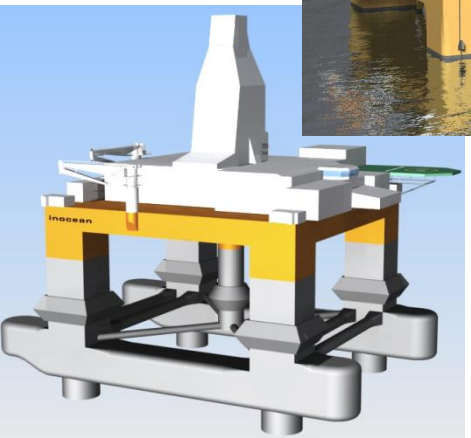
Design & Engineering Innovation of Statoil's CAT I Arctic Drillship

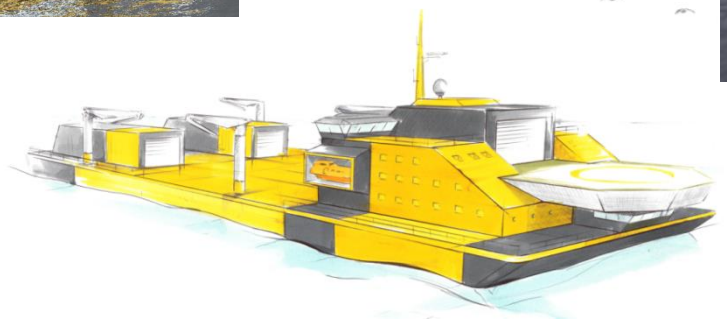
11th November 2014

Jørgen Jorde, VP MODU; SURF & Renew

Background: Solutions developed with clients …







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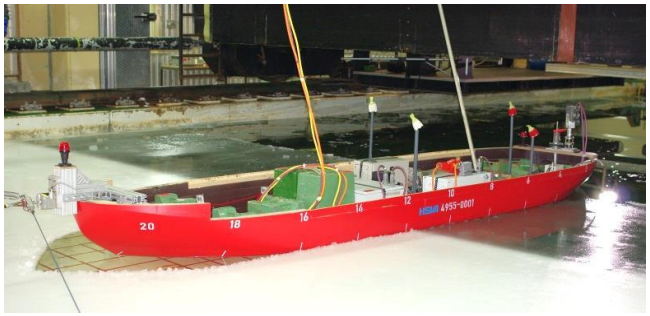
Inocean scope of services

Inocean is a ship design company, and also offers:

- **Development of operating philosophies**
  - ➢Support the team in developing the key philosophies

- **Winterization Reviews**
  - ➢ Identification of relevant equipment
  - ➢ Evaluate anti-icing/de-icing solutions and capacity requirements
  - ➢ Efficient material handling and logistics

- **Ice strengthening, stability & DP/mooring analysis**



- **Model Testing / ice resistance evaluations**

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- **Regulatory studies & GAP analysis**

- **HSE & Work Environment**
  - ➢ Environment / emission. Reuse of energy to reduce the environmental footprint.
  - ➢ Risk analysis related to heat and explosion loads
  - ➢ Evacuation in remote and dark areas and with a risk of icy waters
  - ➢ Review HSE procedures and monitor compliance

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Presentation overview

Contents:

- Background
- General/ arrangement/ class
- Hull & Design
- Motions & Operability
- Mooring
- Performance in ice
- HSE & Compliance

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Background

The larger perspective – is it worth it?

The Petro Foresight report made by Rystad Energy indicates a break-even rate for developments in the Barents sea of 58-70 USD/ bbl (16% more expensive than for eq fields in NCS)

This is believed to be competitive in a global perspective

Source: http://www.petro.no/nyheter/politikk/spar-barentshav-utbygginger-til-58-70-usd/fat/7d72946c-8c3c-4567-b470-b89f087d5802 (acessed 7 Nov 2014, in Norwegian)

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Inocean Marotec Giant 10k Winterization

Winterized MODU

- Client: Transocean
- 5th generation MODU
- Class: DNV ✠ 1A1
- Zero discharge
- Min design temp - 30°C
- Fully winterized, including full cover
- VDL 10.000t

Based on Marotec design for Ross Rig/ Transocean Arctic

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Eirik Raude, Winterized MODU

Eirik Raude, Ocean Rig

Winterized MODU

- Client: Ocean Rig
- 5th generation MODU
- Class: DNV ✠ 1A1
- Min design temp - 20°C
- Fully winterized
- Successful operation in Barents Sea and Canada since 2003
- VDL 7.000t

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INARCTIC™ FPSO

The Inocean INARCTIC™ FPSO is a flexible, ship shaped FPSO design intended for operation close to the arctic and polar ice front.

- Double side/bottom
- Ice strengthened hull
- Ice breaking capabilities
- Extended freeboard to reduce green sea/icing from sea spray
- Fully winterized, year around
- Safety & Environment focus
  - Min discharge philosophy
  - Working environment
  - Extended storage tanks for waste liquids etc.

MAIN PARTICULARS (approximately numbers):

Length over all, L_{oa}	260.00m
Breadth moulded, B	52.00m
Depth moulded, D	26.00m
Design draught, T_s	18.00m
Displacement at T_s	220.000 mt
Oil storage:	0.9 – 1 mill bbls
Production:	100-150 000 bopd
Topside weight:	25 000 t
Living quarter capacity	120-140 persons
Design temperature:	-20 deg C

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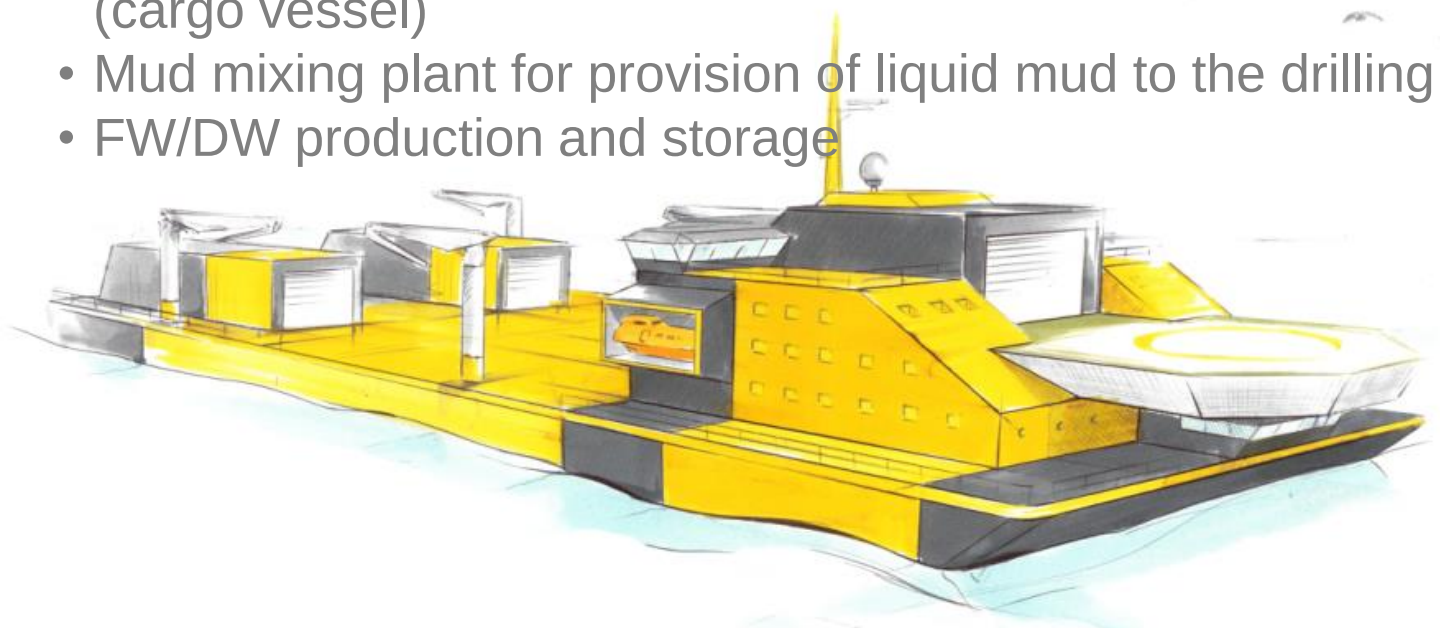
Floating shore base

- Receive, store and discharge drilling equipment and consumables from/ to Supply Vessels
- Bunker station for Supply Vessels
- Offshore heli-port
- Accommodate offshore crew change
- Maintainance/ repair workshop
- Oil recovery system onboard
- Stand-by vessel
- 2 offshore cranes: 85t and 25t capacity
- Mud mixing plant for provision of liquid mud to drilling units

Floating Shore Base

Arctic FSB Barge

- Receive, store and discharge drilling equipment and consumable from/to supply vessels
- Bunker station for supply vessels
- Offshore heli-port & Accommodation unit
- First aid room/ medical room for medical services
- Oil recovery; Emergency Operation Centre (EOC)
- Receive cuttings from drilling operations, store, handling and shipment (cargo vessel)
- Mud mixing plant for provision of liquid mud to the drilling units.
- FW/DW production and storage



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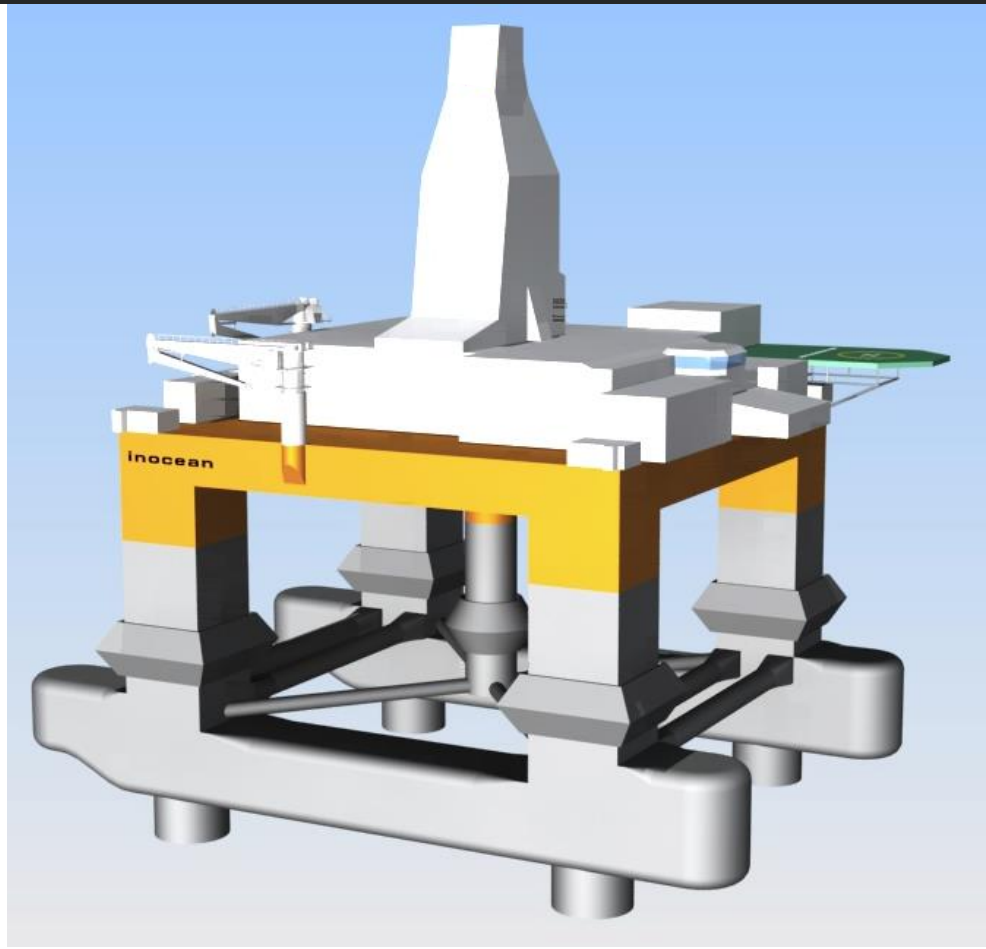
GBS Semi ADU – bottom founded

Gravity Based Semi for ice

- 30-50m water depth
- 1-2m thick ice (w/ IM)
- Design temp: -45^{o}C
- Center column for drilling
- Anchor caissons
- Ice deflection cans
- Ice strengthening
- Sheltered work areas
- Helideck + Hangar



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Inocean: Cat I – for Statoil

Arctic MODU

- Client: Statoil
- DP and Turret moored MODU
- Icebreaking 1.2m level ice
- Class: DNV ✠ 1A1 ICE10
- Min design temp - 30°C
- Fully winterized/ enclosed drilling areas
- VDL 16.000t / Payload 22,400 t

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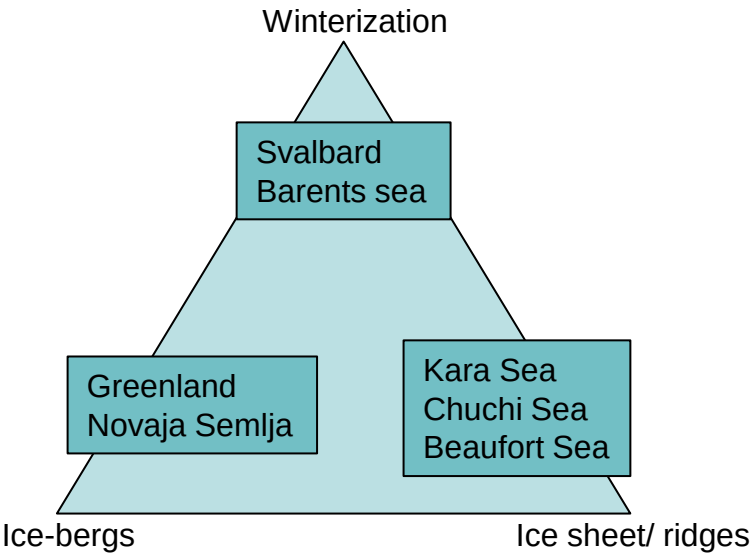
Arctic areas – very different localities



Water depths – from shallow to deep
HSE challenges
Sensitive environment
Rescue concepts
Streched logistics
Limited – extended season

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Ill: Nordpil.com

Ice management principles (1)

Challenges:
- Ice bergs
- Large ice floes
- Level ice
- Ice ridges

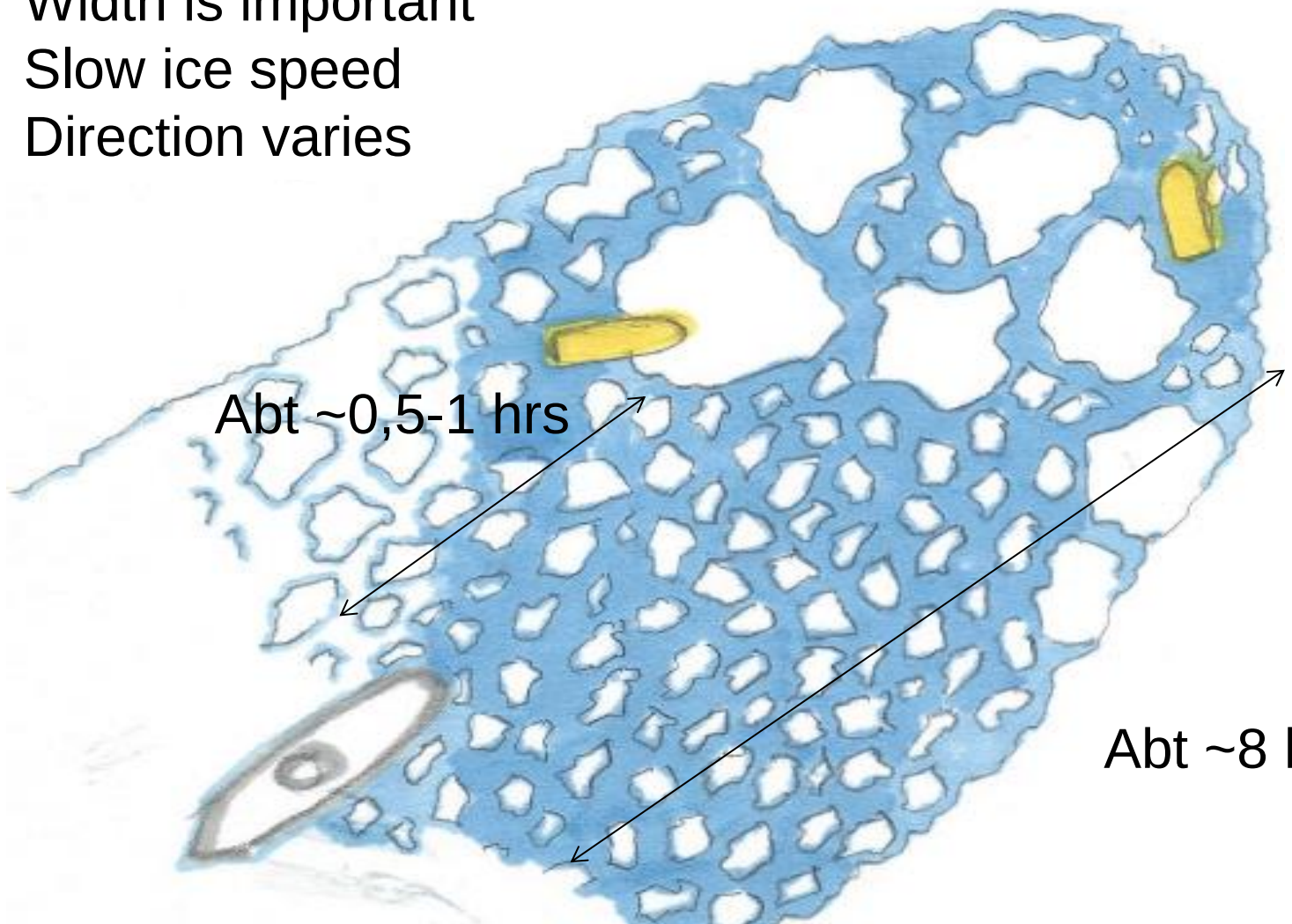
Methods:
- Towing
- Ice breaking
- Ice breaking
- Dispersal

And:
- Surveillance
- Warning

The time factor is important:
- Time to manage the environment …
- Time to plan and execute mtigative actions

Ice management principles (2)

Width is important
Slow ice speed
Direction varies



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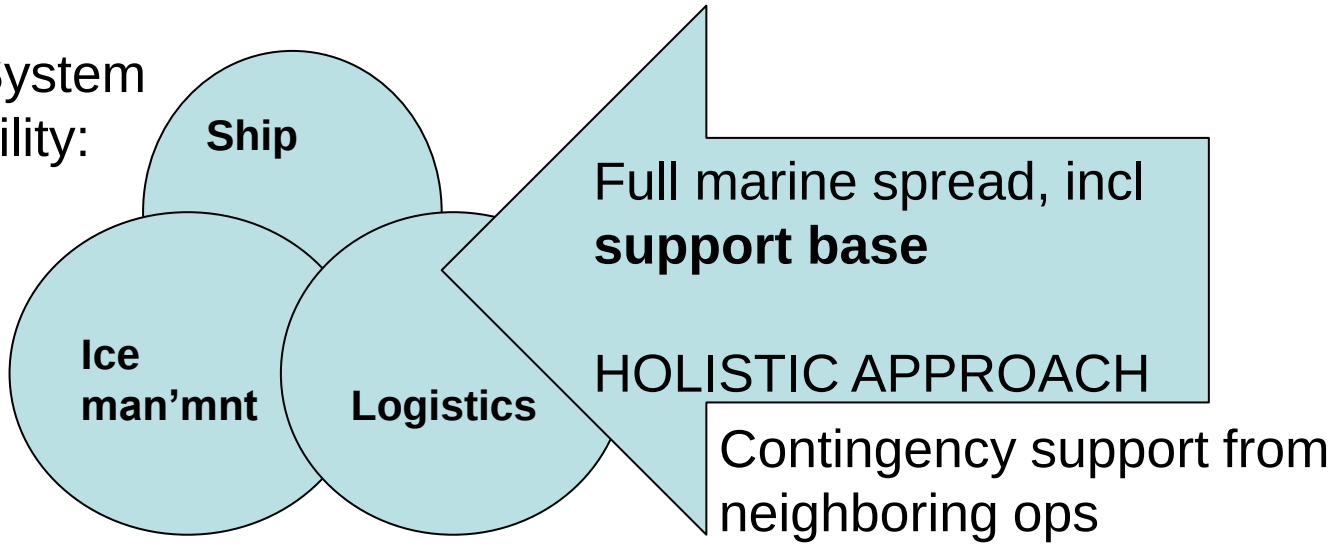
Rules and regulations framework

Maturity of framework is variable - not a lot of experience backing it up:

- Some requirements are too slack
- Some requirements are too tough
- Some requirements are poorly defined

Experience is needed – stepwise approach advised

Total System Capability:



Arctic Rescue and Evacuation concepts – not a review!

Many concepts – none cover all scenarioes/ conditions – neither do traditional concepts

More will come …

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Arctic Rescue and Evacuation concepts – holistic approach

Why use the above – when you can be cozy here?

Challenge: Bad weather and some ice …

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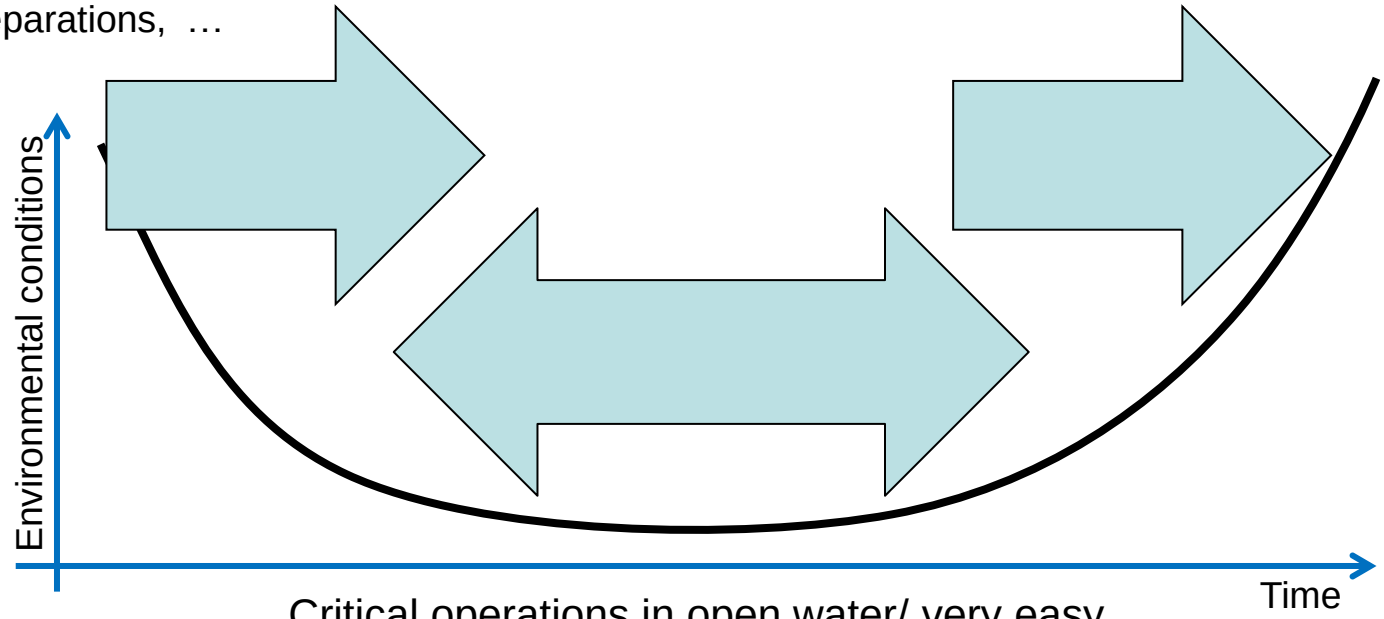
Arctic Drilling Operational Capabilities

Early entry: Transit in ice, DP operations, Hook-up, Preparations, …

Late Exit: DP operations, Disconnect, Clean-up, Transit in ice, …



Critical operations in open water/ very easy ice conditions only, moored condition

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CAT I Arctic Drilling Unit

General

Cat-I Presentation - general

The following areas have been focused upon:

- Economically attractive concept, with an arrangement for efficient drilling operations.
- HSE; in order to satisfy NCS requirements and Statoil's strong focus on HSE
- A robust and efficient turret solution with a proper interface for the riser and BOP operations
- High degree of operability in open water and in ice, within the given operational envelope
- Winterization of the unit

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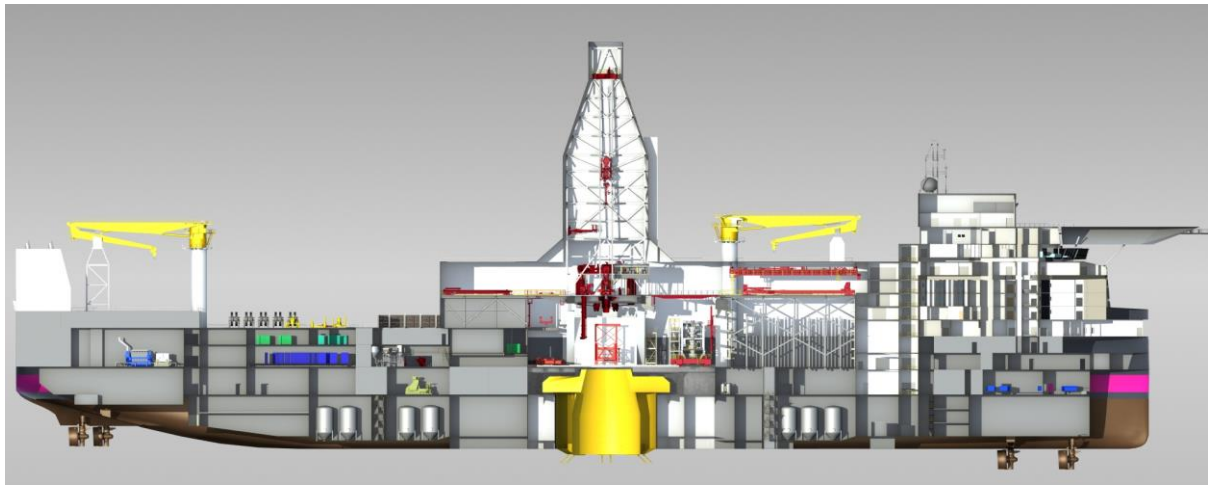
Cat-I Presentation - general

The main philosophy has been:

- The drillship is designed with similar safety level as on conventional drillships
- Minimal Environmental footprint, mainly to be achieved with low fuel consumption
- Enclose drilling areas to utilise proven drilling technology and limit harsh environment exposure.
- The enclosed area is designed as “outdoor areas” to limit cost impacts
- Design a hull that is optimized for forward operation in open seas with a conventional bow – and for aft wards operation in ice with an ice optimized stern
- Locate the turret amidship will improve drilling operability in open and harsh environment



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Cat-I Presentation

The Arctic Drilling Unit is designed for:

- moored condition in the defined managed ice conditions from 100 m to 500 m water depth, with a well depth up to 5000m measured depth.
- moored condition in the defined open water conditions from 100m to 500m water depth, and DP from 400-1500m, with a well depth up to 8500m.

The above also includes possibilities for easy implementation of:

- Well Test including burner booms
- RMR & Cuttings Transportation System (CTS)
- TTRD

Operations	**Comments/ restrictions**
Exploration and relief well drilling operations	Special focus kept towards self-supplied arctic drilling operations up to 5000m well depth.
HPHT operations.	Part of drilling package
Completion of sub-sea wells including handling of subsea production trees and running equipment.	Space for XMAS-trees and 2x BOPs are included. Running, handling and guiding equipment included
Intervention and maintenance of sub-sea wells and templates	ROVs and wire lines included
Wire line operations including down-hole tractor operations	Wire line container is located on drill floor.
Well testing and clean-up operations.	Area is allocated for. Available tank capacity and offloading capacity for clean-up operations.

Cat-I Presentation

Main parametres	
Length / Beam over all / Depth	232,0 m / 40,0 m / 19,0 m
Displacement Operation / Transit	90 000 / 78 000MT
VDL / Payload	16 000 / 22 400 MT
Thrusters / Transit speed	6 x 6 MW PC-4 Azi ducted/ 13+ knots
Fuel / Water ballast capacity	9 470 / 37 000 m^3
Mooring system – turret	12 lines, 92mm R5 chain
Drilling moonpool / ROV moonpools	Ø10/15 m (top/btm) / 2 off 5,0 x 5,1 m
Helideck / Accommodation	Ø28.5m x 17t for AW101 / 150 POB
Drilling depth in open w / icewaters	8500 m / 5000 m
Hook load / Drawworks power (HC)	680 t / 6000 HP
Mud pumps	4 x 2200 HP
Cranes	3 x 85 MT knuckle-booms

Cat-I Presentation - general

Operational capabilities		
Open water	Beaufort 9	13+ knots transit speed Moored 100-500 m water depth DP 400-1500 m water depth*
Managed ice	1.2 m 7/10 IC, managed ice	Moored 80-500 m water depth within 6,5º LFJA limit
Unmanaged ice	1.2 m level ice	3-4 knots 8+ m ice ridge in mooring condition

Operability (wrt motions) – all year		
Case	Åsgard	Johan Castberg
Max drilling	96,21 %	97,78 %
Riser disconnect	99,24 %	99,58 %

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Cat-I Presentation – class notation

+1A1 SHIP SHAPED DRILLING UNIT, WINTERIZED POLAR (-30°C), PC4, ICE 10, DAT(-25°C), DEICE, DRILL (N), CRANE (N), HELDK-SH(N), F-AM, E0, ECO, CLEAN DESIGN, BIS, COMF-C(1)V(1), DP Class 3 (DYNPOS AUTRO, DYNPOS ER, POSMOOR ATA)
(material selection up to now has been based on Dat -40)

DNV AiP (Approval in Principle) with respect to DNV-OSS-101 Rules for Classification of Offshore Drilling and Support Units, including applicable Classification Notes, Recommended Practices and Standards as well as MODU Code, MARPOL, SOLAS, LSA etc.

DNV·GL

Inocean Engineering AS
Att: Jonas Rekstad
Bryggegt. 3
0250 OSLO

DNV GL AS OC Approval
Floating Offshore Structures
P.O.Box 300
1322 Høvik
Norway
Tel: +47 67 57 99 00
Fax:
Org. No: NO 945 748 931 MVA

Date: 2014-04-01
Our reference: MOANO879/RUNE/P18398-J-175

Approval in Principle

Design: Statoil Cat I – Artic Ship-Shaped Drilling Unit.

Designer: Inocean Engineering AS

On request by Inocean Engineering AS, DNV GL has carried out a review of preliminary design documentation to assess the design principles of the "Statoil Cat I Artic Ship-Shaped Drilling Unit", in accordance with the specified rules and with the conditions and assumptions as given below. The intension with the Approval in Principle is to assess the feasibility of the concept and to identify potential challenges which may arise during design and construction of the unit.

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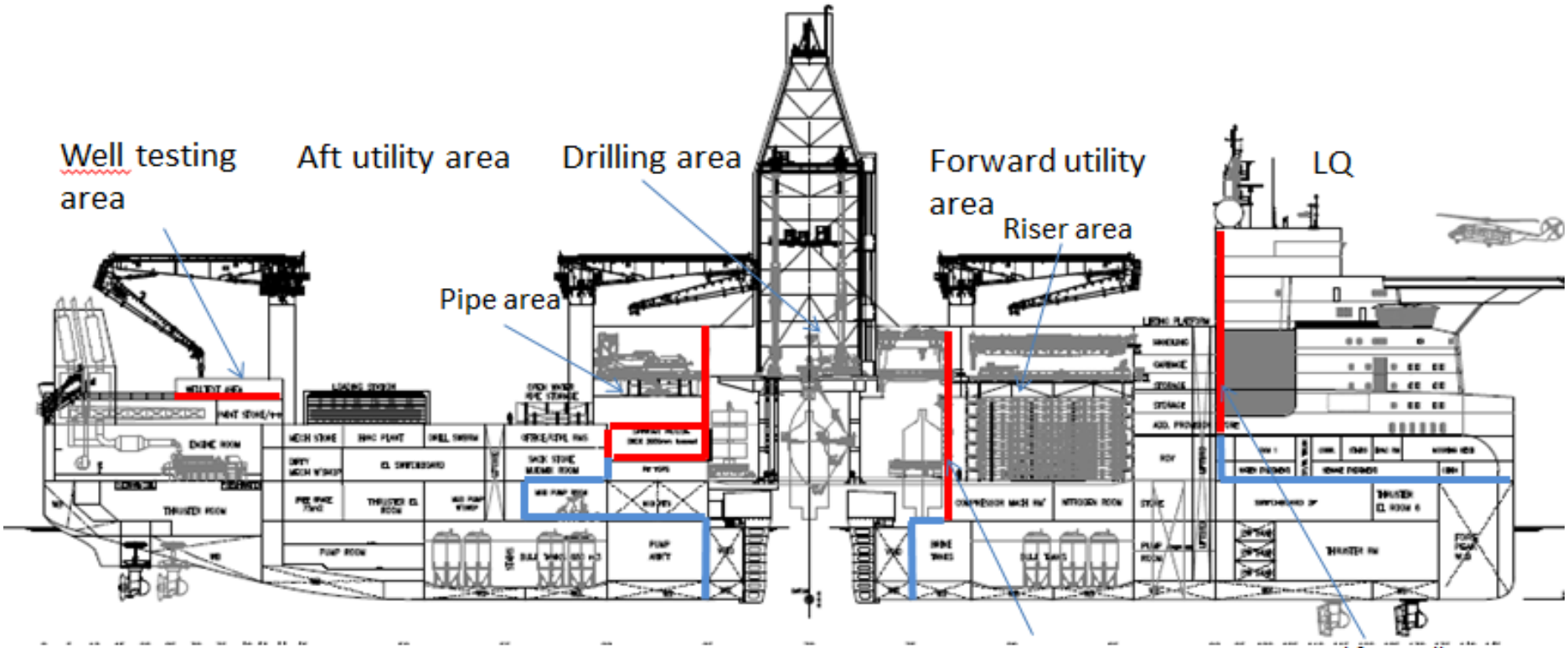
Cat-I Presentation - layout



Red lines denotes fire walls
Blue lines denotes analytical area division

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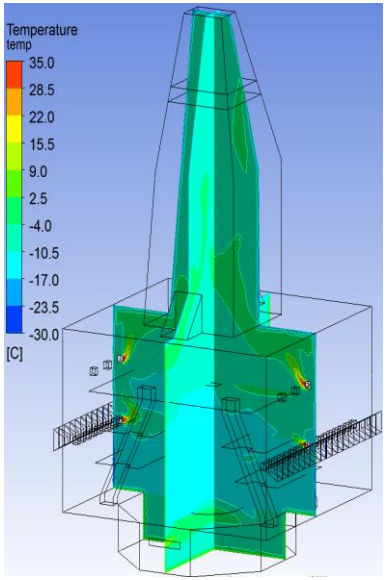
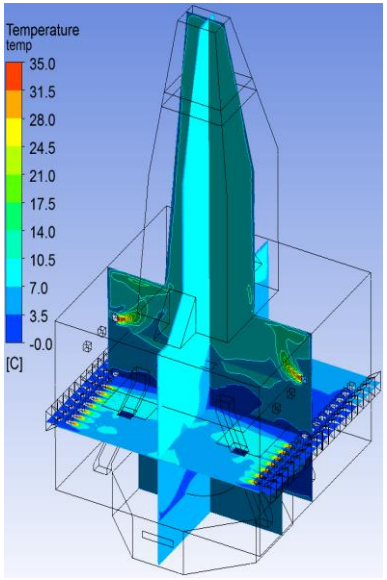
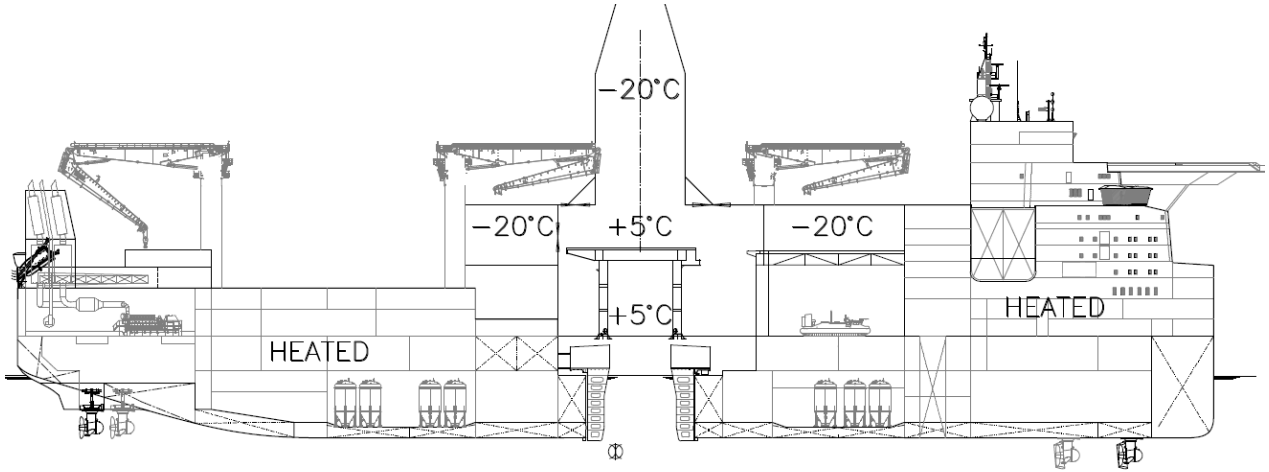
Cat-I Presentation – HVAC





Temperature profiles in the drilling area for -30 and 0 °C respectively



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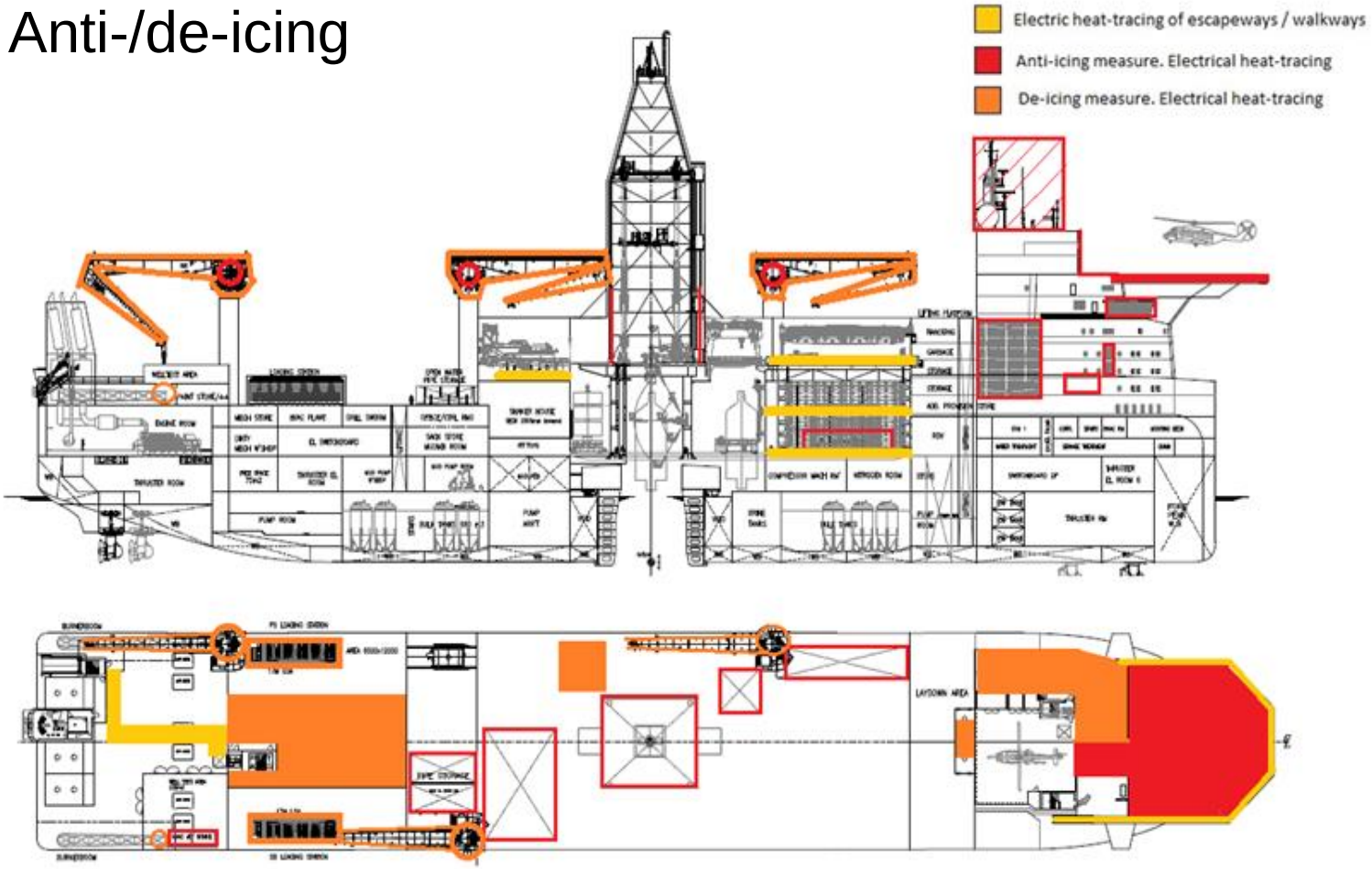
Cat-I Presentation

Anti-/de-icing



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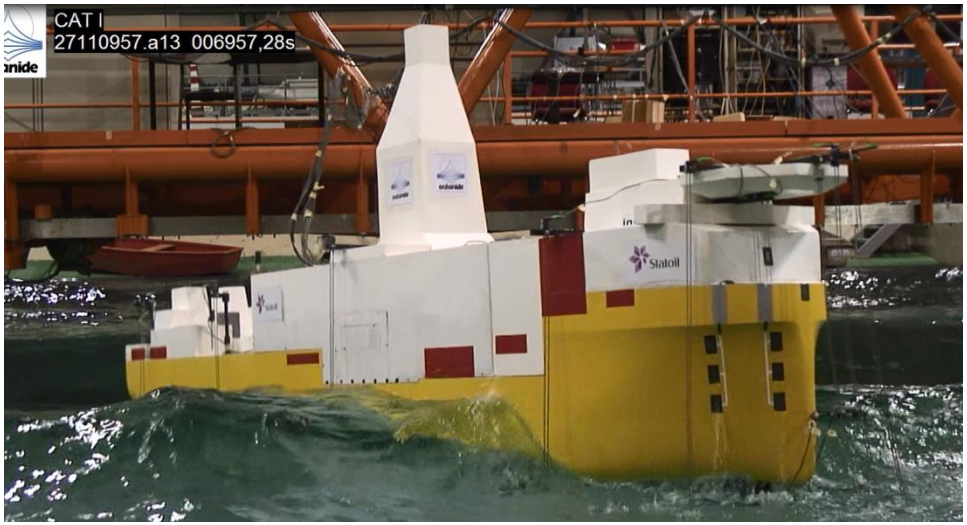
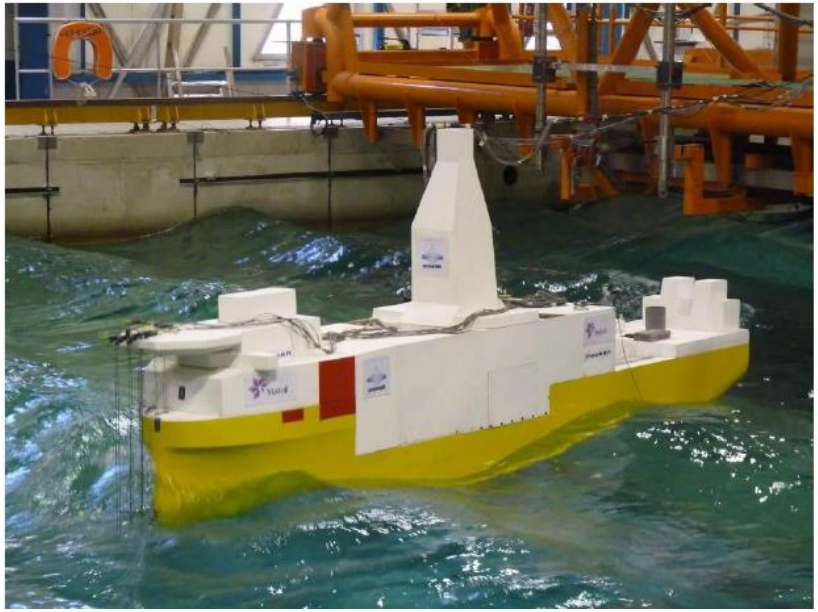
What has been done

- Testing of two pair of bilge keels ---------->
- Regular wave tests for 0° to 90° heading
  - To verify RAOs and drift forces
- Irregular ALS tests (10 000 year) for 0° and 30° heading
  - To obtain slamming values and assess green sea
- Transit tests
  - To obtain vessel resistance





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The all year operability for Åsgard and Skrugard is presented below:

Table 8-2: Total operability (all year) at Åsgard and Skrugard for 180°, 195° and 210° main wave direction.

Cat-I Presentation – Operability

	Total operability - All Year [%]					
Location	Åsgard			Skrugard		
Main wave direction	180°	195°	210°	180°	195°	210°
A: Running of riser and pipes from deck to RKB	89.21	87.10	81.27	93.24	91.78	87.49
B: Fishing operations	89.21	87.10	81.27	93.24	91.78	87.49
C: Tripping / running drill pipes in derrick	97.21	96.19	94.02	98.38	97.77	96.38
D: Handling drillpipe on pipe deck	97.21	96.19	94.02	98.38	97.77	96.38
E: Running casing	93.34	92.40	87.63	95.98	95.34	92.04
F: Electric logging operations	93.34	92.40	87.63	95.98	95.34	92.04
G: BOP and XMT handling/handling and installation of stack components	64.05	59.35	51.10	74.49	70.67	62.32
H: Drilling	96.21	95.07	92.41	97.78	97.07	95.34
I: Disconnection of riser.	99.24	98.94	98.15	99.58	99.41	98.95
J: Daylight helicopter operations	56.51	51.17	51.11	67.27	62.36	62.33
K: Launch and retrieval of ROV	84.17	84.17	81.30	89.65	89.65	87.51

Operability criteria are given as Roll, Pitch, Heave and Heave rate limits, but heave motions have been found to be the decisive criterion, probably due to excellent roll behaviour of the ship

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Cat-I Presentation – DP Operability

All year operability w.r.t. station keeping at Åsgard and Skrugard						
Direction [deg]	180		195		210	
Current [kn]	1	2	1	2	1	2
1min wind [kn]	73.79	70.12	54.58	51.24	31.64	26.73
1h wind [m/s]	30.8	29.4	23.4	22.0	14.0	11.9
All Year, Åsgard	100.00 %	99.99 %	99.70 %	99.44 %	87.81 %	78.22 %
All Year, Skrugard	100.00 %	100.00 %	99.86 %	99.71 %	89.54 %	80.02 %

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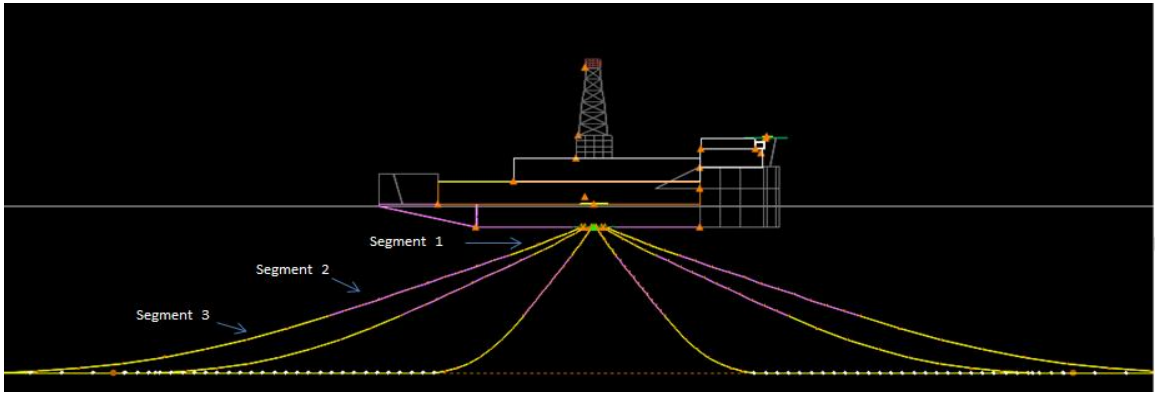
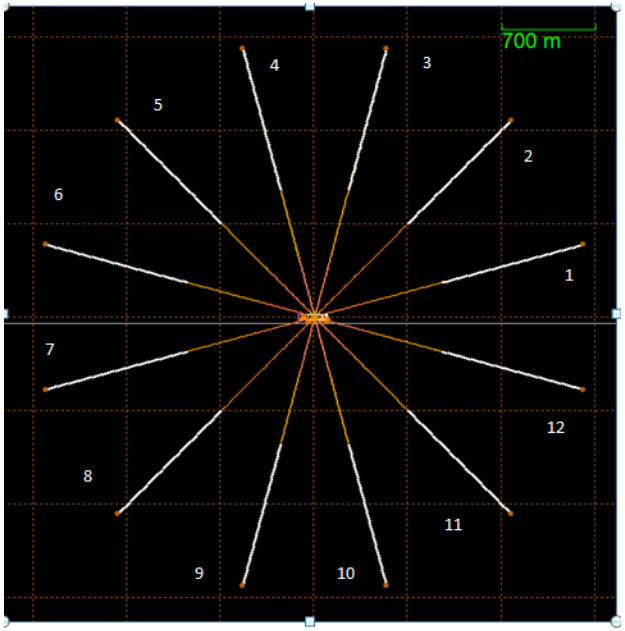
Mooring

Mooring line configuration:

Chain (92mm R5) – Polyester - Chain





	Open water		Ice	
Water depth	100 m	500 m	100 m	500 m
Line lengths	1050 m	2195 m	1065 m	2400 m
Pre tension	1040 kN	1800 kN	1175 kN	2200 kN
Thrust assist	200 T	200 T	-	-

RAR & disconnect ….

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Model testing at HSVA

4 ice sheets moored
2 ice sheets DP

Cat-I Presentation – Ice performance

Case	Achieved performance
DP operations in managed ice	1,2m ice, 7/10ths concentration, 50m ice floe, all headings
Mooring ULS capacity	Unmanaged 8+ m ice ridge straight astern
Under hull transportation of ice	Hull is shaped in order to avoid this during drilling operations, no such ice transport was observed during the testing in the moored condition
Transit in level ice	3-4 knots in 1,2m level ice

DP in ice: DP control system strategy is important

DP: 16m ice ridge resistance appx 6 MN/
Moored: 8m keel depth 12 MN total turret forces

- 1.2m managed ice (7/10): With yaw angle within +/- 20^{o} ice forces are within 5 MN
- 1.2m managed ice (9/10): With yaw angle within +/- 10^{o} ice forces are within 9 MN

Transverse forces dominate – small ice floes/ wide channel is helpful – ice management issue

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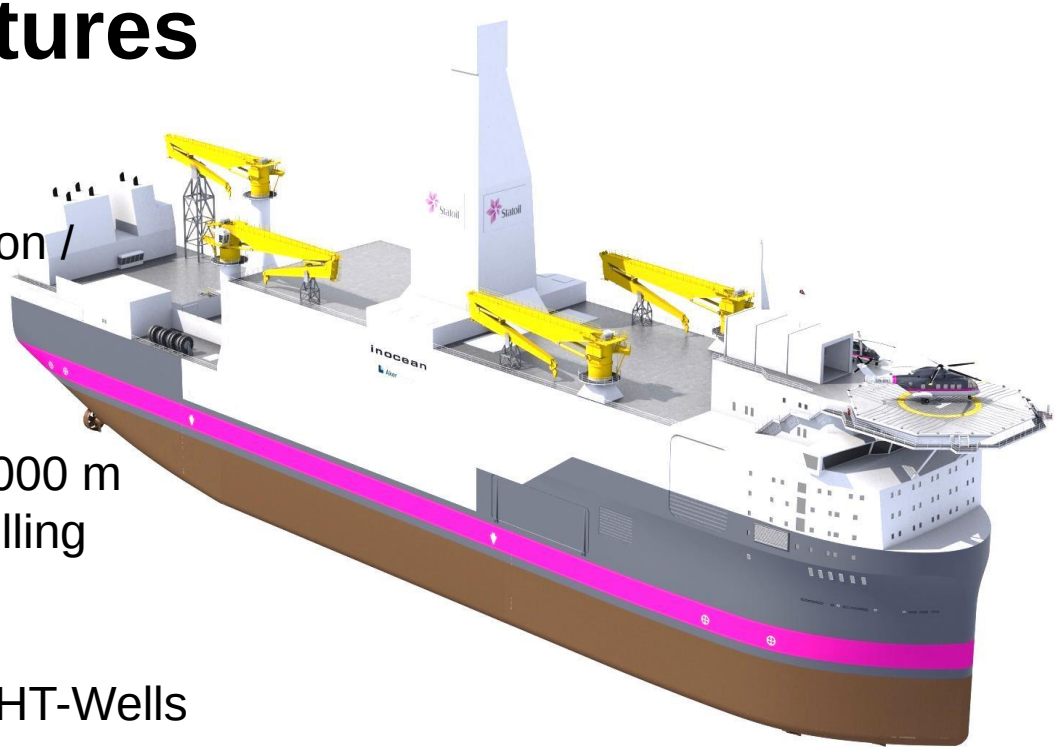
CAT I – Drilling features

Main Drilling Features

- Drilling / Completion / Intervention / Wireline / Well testing
- Water depths 100 - 1500 m

- Arctic drilling well depth up to 5000 m
- 120 days self supported with drilling consumables for one entire well
- Open water up to 8500 m
- Exploration- / Production- & HPHT-Wells



Hull arranged with two different topside concepts; NOV & Aker MH

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A NAUTICAL MILE AHEAD

1996 - 2011

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Commercial in Confidence