Arctique,
Défis et Contraintes liés à l'extraction des hydrocarbures

Paris
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Bureau VERITAS

Move Forward with Confidence

Plan

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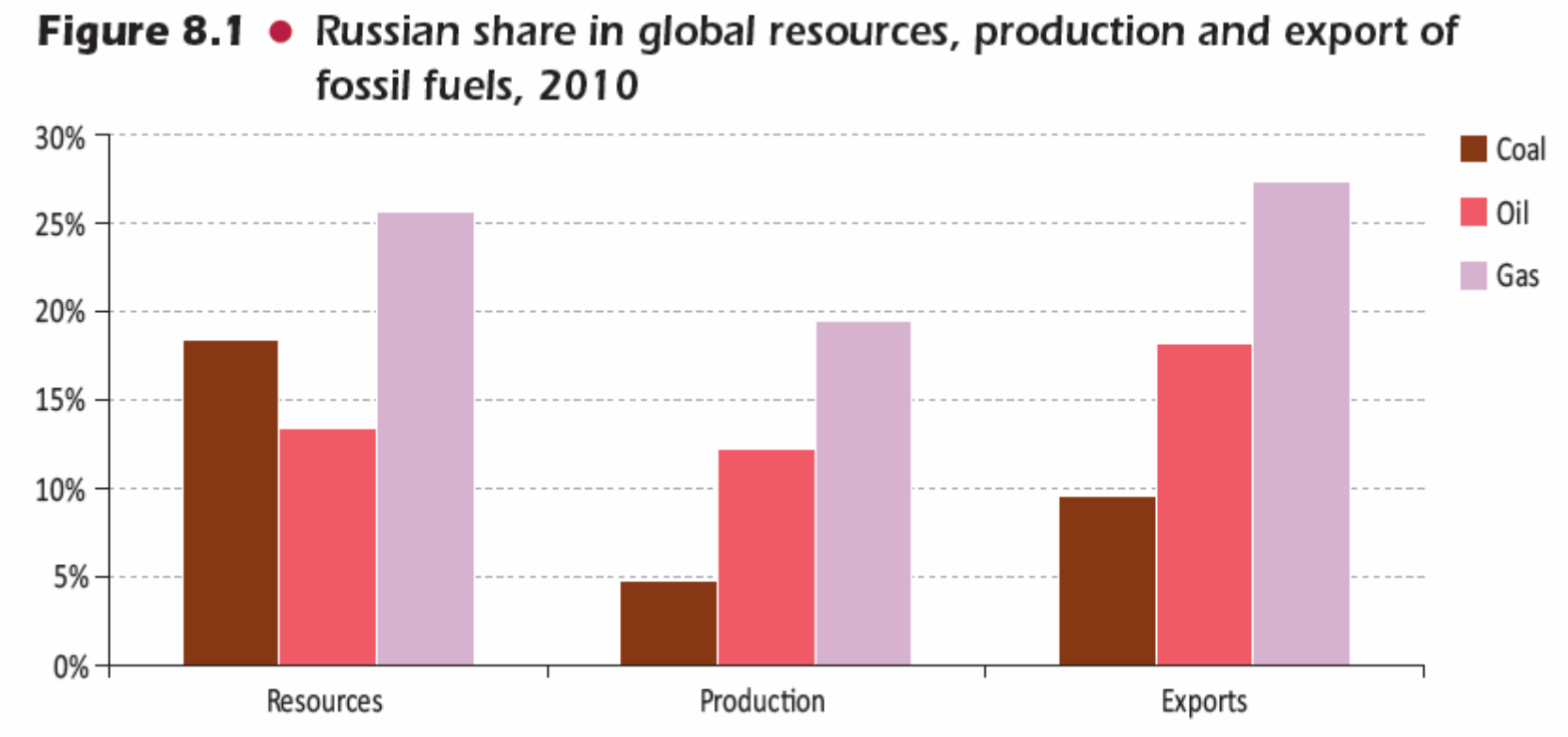
Pourquoi la Russie?



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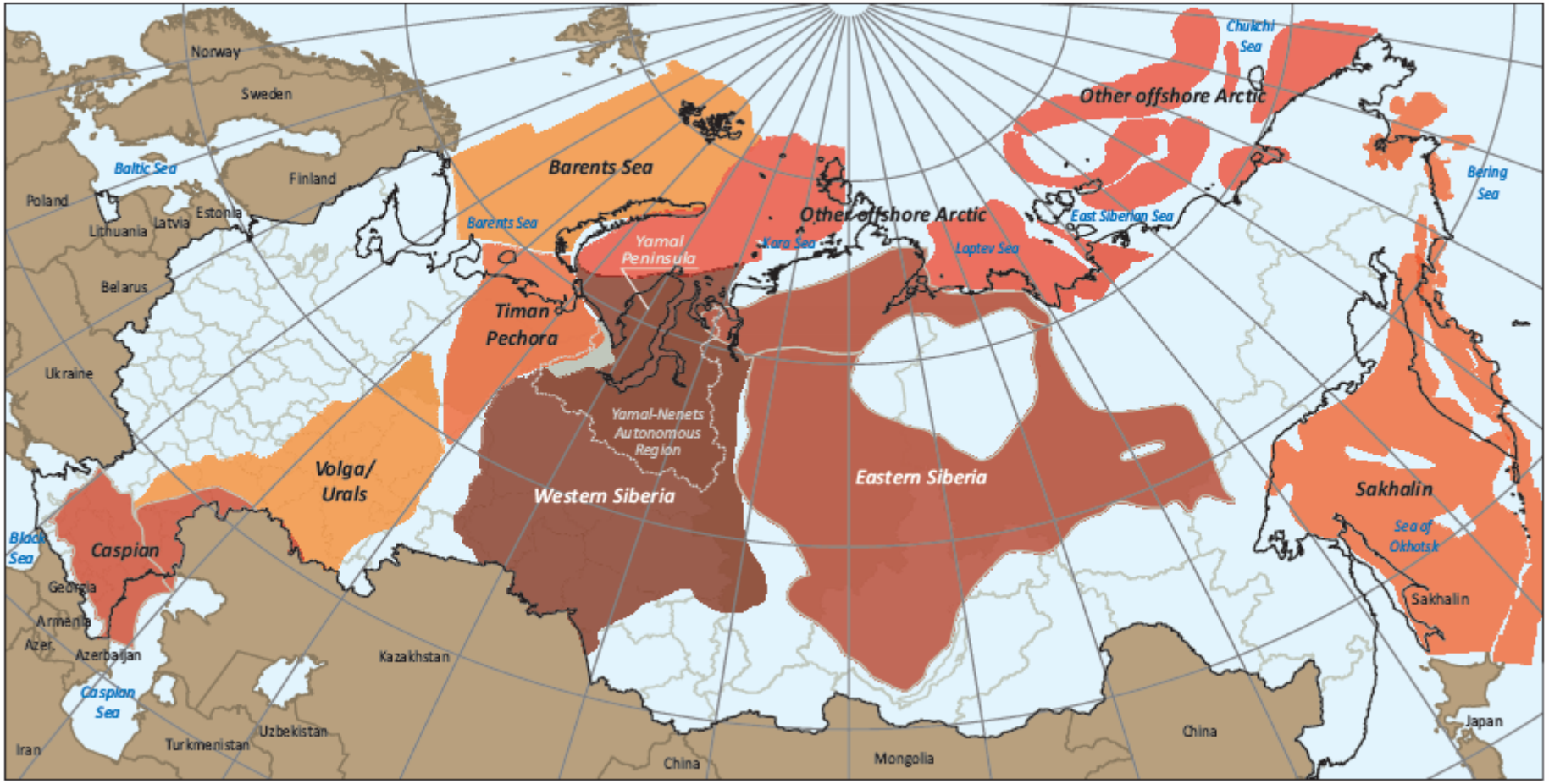
Pourquoi l'Arctique Russe?

Figure 8.7 • Oil and gas basins in Russia



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Le Gaz Russe!

Table 8.4 • Conventional gas resources in various Russian regions, end-2010 (tcm)

	Proven reserves*	Ultimately recoverable resources	Cumulative production	Remaining recoverable resources		
				Total	Share	Share per ABCD**
Western Siberia	22	59	18	41	39%	53%
Volga Urals	1	5	1	4	3%	1%
Timan Pechora	1	3	1	2	2%	2%
Eastern Siberia	1	7	0	7	7%	18%
Sakhalin	1	3	0	3	3%	3%
Caspian	1	7	1	6	6%	7%
Barents Sea	0	23	0	23	21%	7%
Other offshore Arctic	0	20	0	20	19%	9%
Others	0	1	0	1	1%	0%
Total Russia	**26**	**127**	**21**	**106**	**100%**	**100%**

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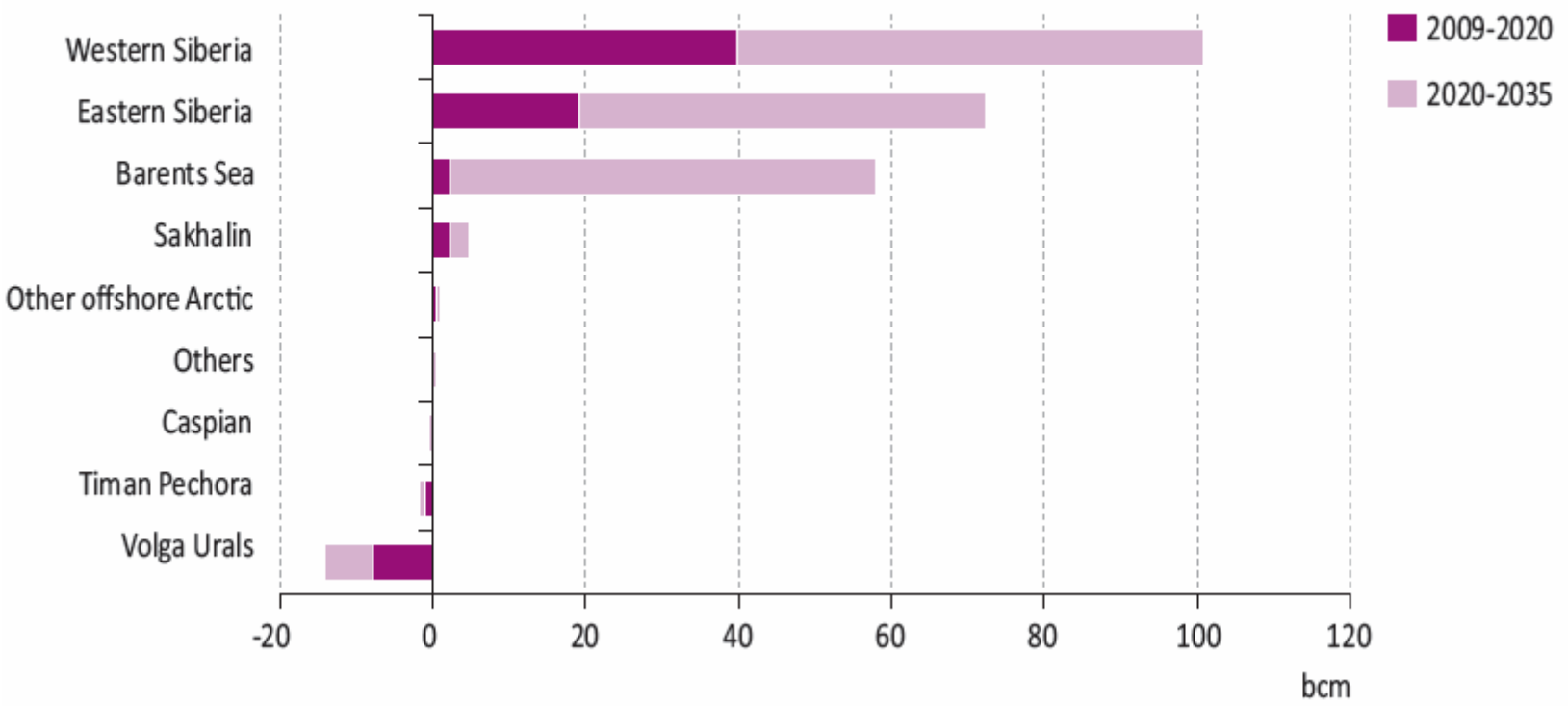
1 tcm LNG = 6.66 BBoe

Le Gaz Russe – Perspectives!

Figure 8.13 ● *Changes in Russian natural gas production by region in the New Policies Scenario*



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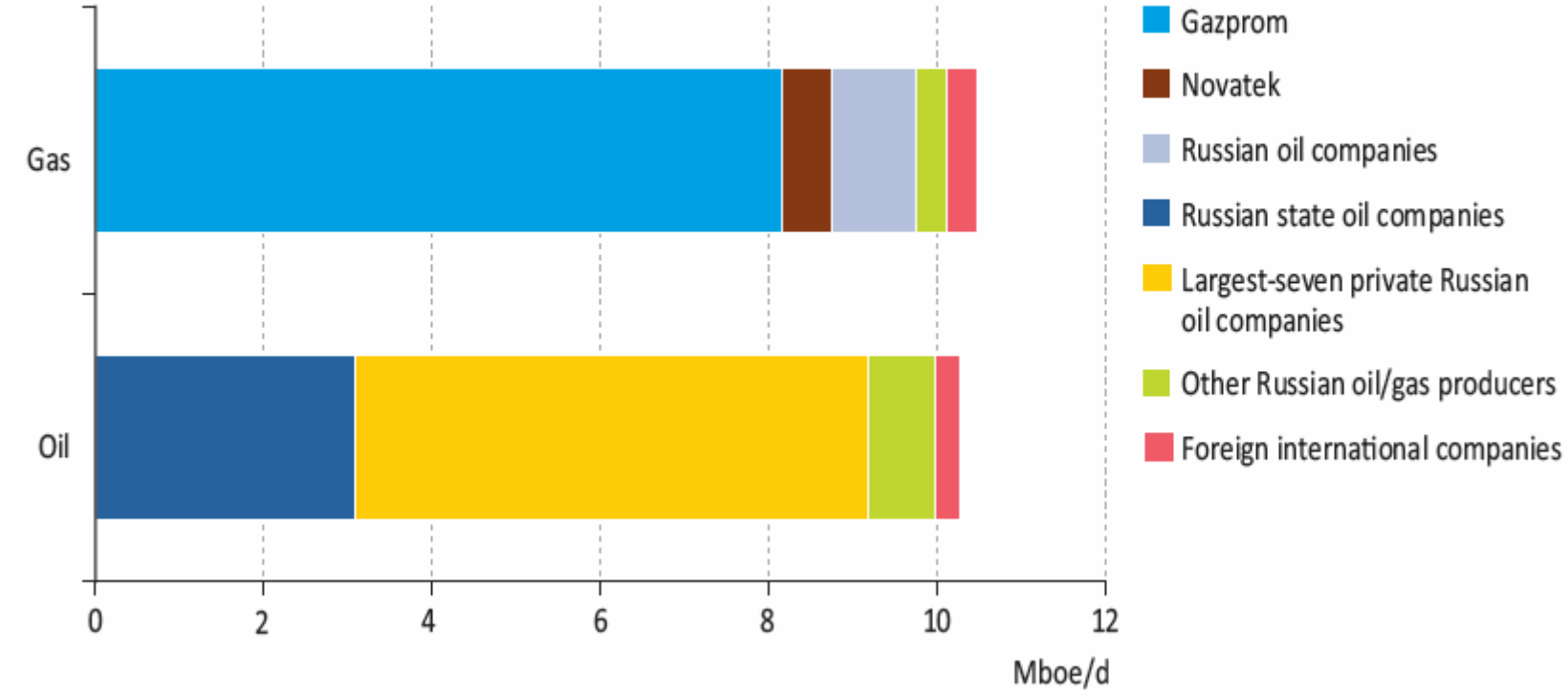
Gazprom Incontournable!

Figure 8.6 ● Estimated Russian oil and gas production by type of company, 2010



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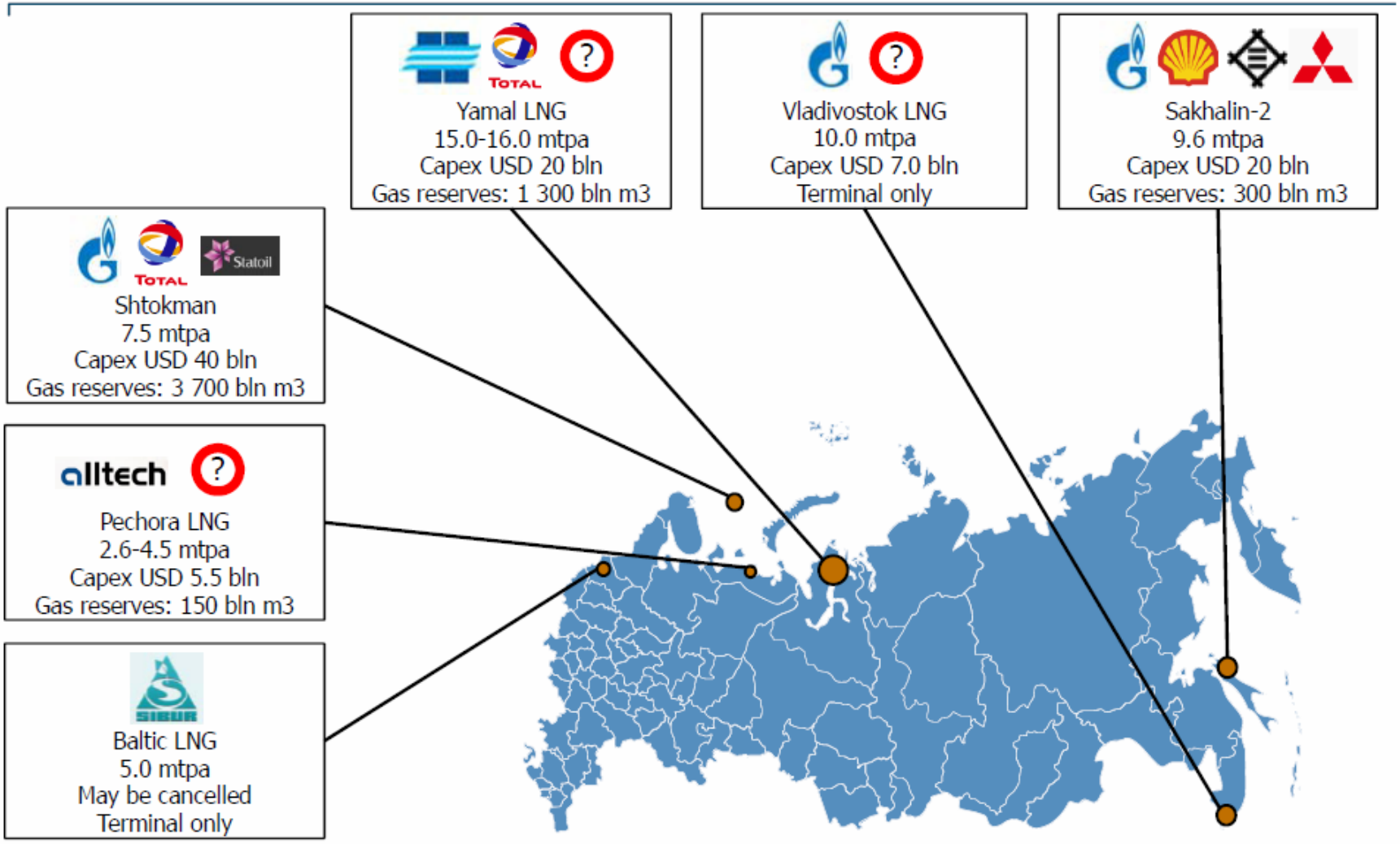
Gaz Russe – Les Projets

Russian LNG Projects



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Routes Maritimes dans l'océan Arctique

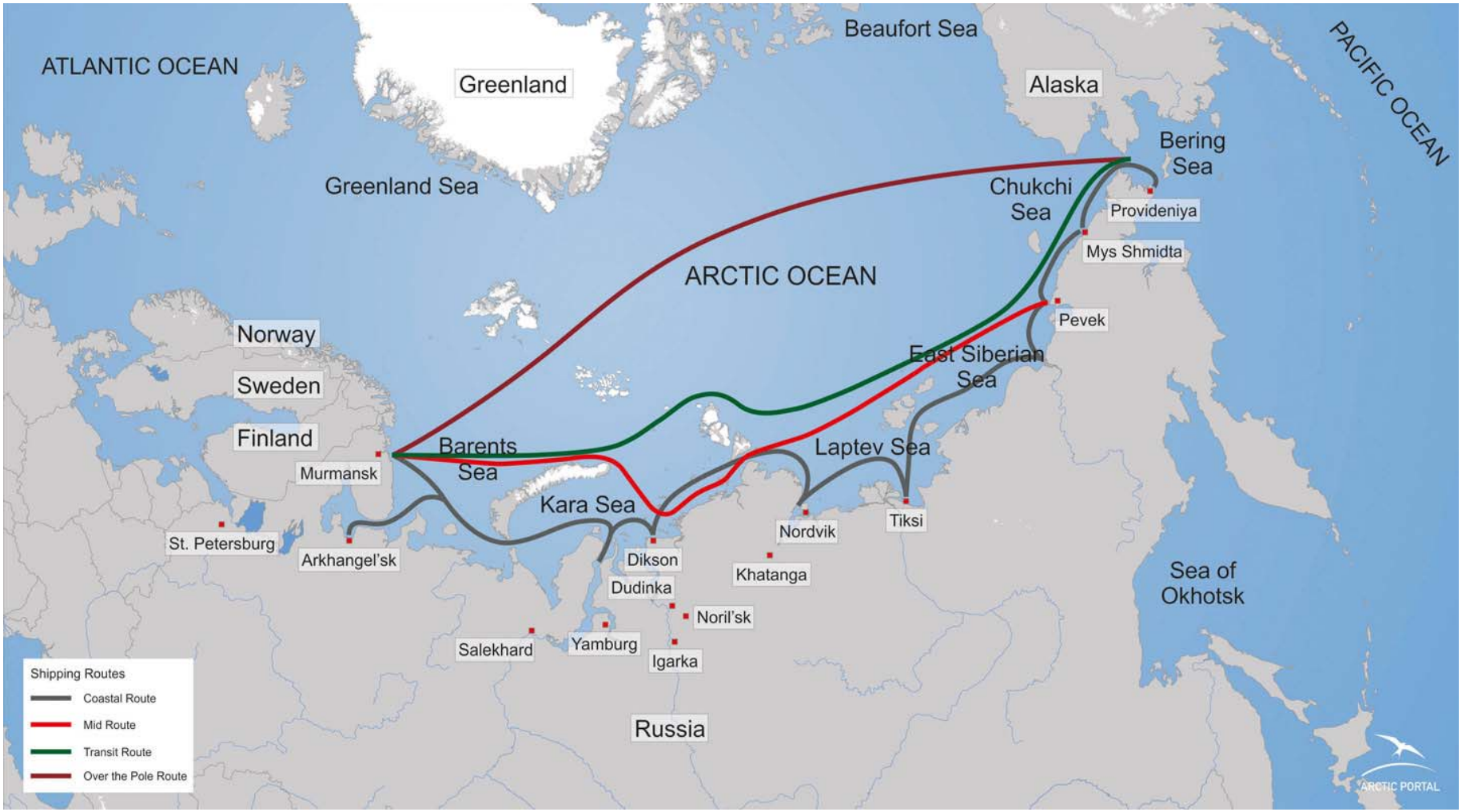
- Routes réduites pour le commerce international (Route du Nord et Passage du Nord est), mais imposant de pouvoir operer dans un environnement sévère avec de la glace et un froid extrême.

[masterresource.org]

- Rotterdam – San Francisco
  - 6700 miles vs. 7300 miles
- Rotterdam – Yokohama
  - 7350 miles vs. 11250 miles

Route du Nord

- Route du Nord



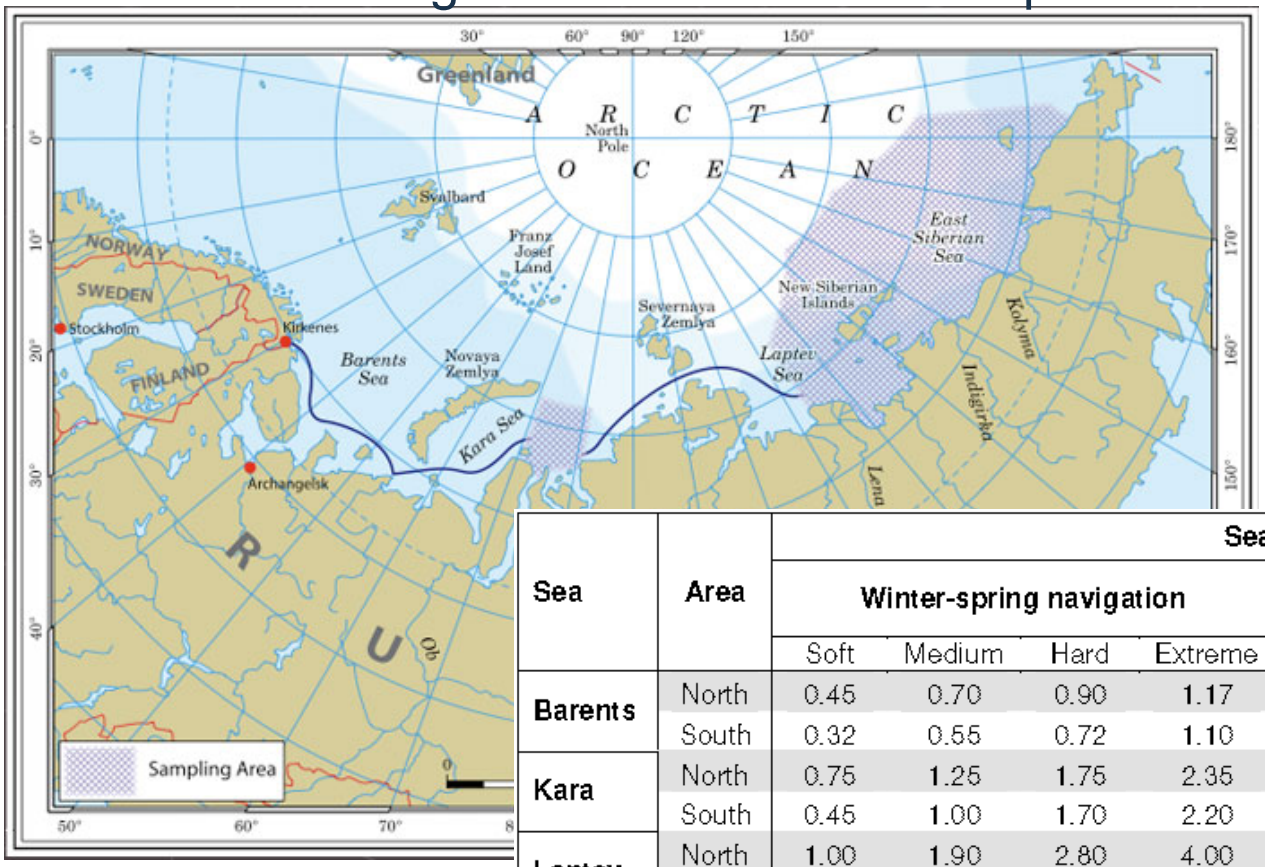
[http://arcticportal.org/shipping-routes/northeast-passage]

Challenges In Extreme Climate

- Low temperatures
  - Hard working conditions
  - Materials
  - Equipment
- Ice
  - Ice loads and ice management
  - Icing
- Specific natural conditions
  - Navigation
  - Rescue
- Vulnerable ecosystem
  - Emission to air
  - Discharge to water

Navigation in the Russian Arctic

- conditions de glace dans l'Océan Arctique Russe



Sea	Area	Season							
		Winter-spring navigation				Summer-autumn navigation			
		Soft	Medium	Hard	Extreme	Soft	Medium	Hard	Extreme
Barents	North	0.45	0.70	0.90	1.17	0.23	0.35	0.45	0.59
	South	0.32	0.55	0.72	1.10	–	–	–	–
Kara	North	0.75	1.25	1.75	2.35	0.38	0.63	0.88	1.18
	South	0.45	1.00	1.70	2.20	0.23	0.50	0.85	1.10
Laptev	North	1.00	1.90	2.80	4.00	0.50	0.95	1.40	2.00
	South	0.65	1.50	2.25	3.70	0.33	0.75	1.15	1.85
East Siberian	North	1.00	1.70	2.40	3.20	0.50	0.35	1.20	1.60
	South	0.60	1.34	1.90	2.95	0.30	0.67	0.95	1.50
Chukchi	North	0.85	1.50	2.50	3.75	0.43	0.75	1.25	1.88
	South	0.50	1.18	2.00	3.45	0.25	0.60	1.00	1.73

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Reglementations

- Internationales
  - Polar code…
- Réglementations locales
  - Route du Nord (NSR Russie)
  - Canadian Arctic Shipping Pollution Prevention Regulations…
- Règles des Sociétés de classification
  - IACS: mentions Polar Class
  - RMRS: mentions ARC
  - FMA
  - BV: mentions Polar Class (basées on IACS)
  - BV: Mention Cold …

Règlementation de la Route du Nord

- Les documents de référence pour la Route du Nord:
  - “Guide to Navigation through the Northern Sea Route”, 1996
  - “Regulations for Navigation on the Seaways of the Northern Sea Route”, 1991
  - “Regulations for Icebreaker-Assisted Pilotage of Vessels on the NSR”, 1996
  - “Requirements for Design, Equipment, and Supply of Vessels Navigating the NSR”,1996
  - Le “Ice Passport”, ou “Ice Certificate”, émis par l’Arctic and Antarctic Research Institute (AARI) ou le Central Marine Research & Design Institute (CNIIMF), qui est requis pour la navigation sur la route du nord.

Navigation dans l’ Arctique Russe

- Marque glace Russe pour la navigation dans l’ Arctic Russe

Ice Category	Operation Mode	Winter – Spring navigation in seas															
		Barents				Kara				Laptev				East-Siberian				Chukchi			
		E	H	M	Ea	E	H	M	Ea	E	H	M	Ea	E	H	M	Ea	E	H	M	Ea
Arc 4	IIN	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	IEN	–	*	+	+	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	*
Arc 5	IIN	–	–	+	+	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–
	IEN	*	+	+	+	–	–	*	+	–	–	–	+	–	–	–	+	–	–	*	+
Arc 6	IIN	*	+	+	+	–	–	–	+	–	–	–	+	–	–	–	+	–	–	–	+
	IEN	*	+	+	+	–	–	–	+	–	*	*	+	–	*	*	+	–	*	+	+
Arc 7	IIN	+	+	+	+	–	–	+	+	–	–	–	+	–	–	–	+	–	–	+	+
	IEN	+	+	+	+	+	+	+	+	*	+	+	+	*	+	+	+	*	+	+	+
Arc 8	IIN	+	+	+	+	+	+	+	+	–	*	+	+	*	+	+	+	*	+	+	+
	IEN	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Arc 9	IIN	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	IEN	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Extrait des “*Rules for the Classification and Construction of sea-going ships” du* Russian Maritime Register of Shipping.

Several operational modes are considered

Classification societies

IACS

Role des Societés de Classification

- Rules for assessment of key safety parameters and protection of the environment for vessels operating in ice and cold weather areas (hull structure resistance, propulsion, stability, safety of the crew, prevention of pollution, etc.)
- Refinement of requirements in accordance with prevailing ice and weather conditions and requirements of flag states and authorities
  - Ice Class (Baltic)
  - IACS Polar Class (Arctic)
  - COLD notation (winterization)
- Optional class notations to recognize specific features implemented by the ship owner
  - Improve level of comfort for people on board (noise, vibrations, protection against effects of cold weather)
  - Improve level of environmental protection, especially in sensitive areas

Polar Class de l' IACS

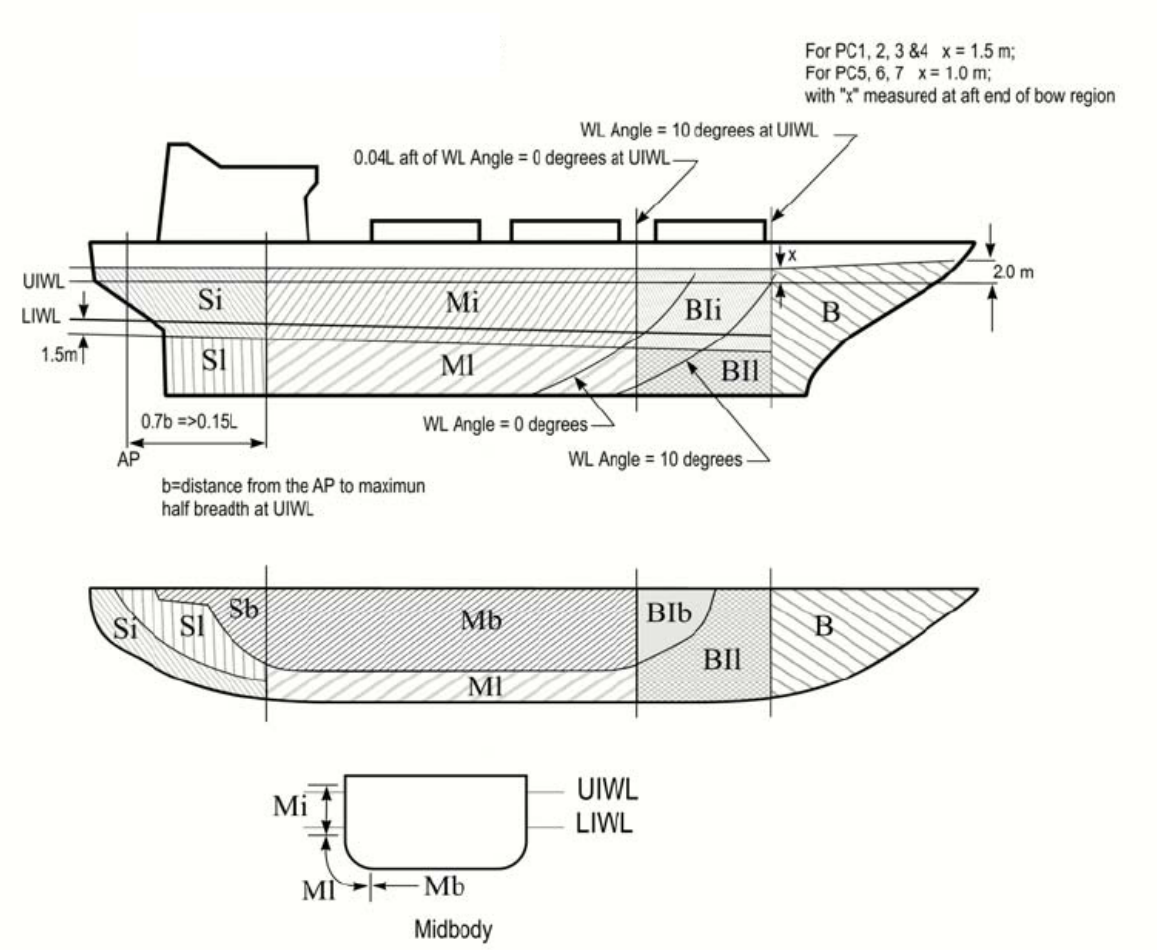
Additional class notation	Ice description (based on WMO Sea Ice Nomenclature) (1)
POLAR CLASS 1	Year-round operations in all polar waters
POLAR CLASS 2	Year-round operations in moderate multi-year ice conditions
POLAR CLASS 3	Year-round operations in second-year ice which may include multi-year ice inclusions
POLAR CLASS 4	Year-round operations in thick first-year ice which may include old ice inclusions
POLAR CLASS 5	Year-round operations in medium first-year ice which may include old ice inclusions
POLAR CLASS 6	Summer/autumn operations in medium first-year ice which may include old ice inclusions
POLAR CLASS 7	Summer/autumn operations in thin first-year ice which may include old ice inclusions
(1) WMO: World Meteorological Organization	

WMO Sea Ice Nomenclature terms

First-year ice	Thickness 30 cm - 2 m
Thin first-year ice / white ice	*First-year ice* 30-70 cm thick.
Thin first-year ice / white ice first stage	30-50 cm thick.
Thin first-year ice / white ice second stage	50-70 cm thick.
Medium first-year ice	*First-year ice* 70-120 cm thick.
Thick first-year ice	*First-year ice* over 120 cm thick.
Second-year ice	Typical thickness up to 2.5 m and sometimes more
Multi-year ice	*Old ice* up to 3 m or more thick

Polar Class de l'IACS

For the reinforcement of vessel's hull structure the different regions are defined in Polar Class rules.



Societies de Classification: exemple du BV

Ice Class Rules incorporate both theoretical derivations of requirements as well as experiences from ships in service.

The very first Russian ocean going icebreaker ERMAK built to BV Class in 1898

BV Rules for objects in service in Arctic region.

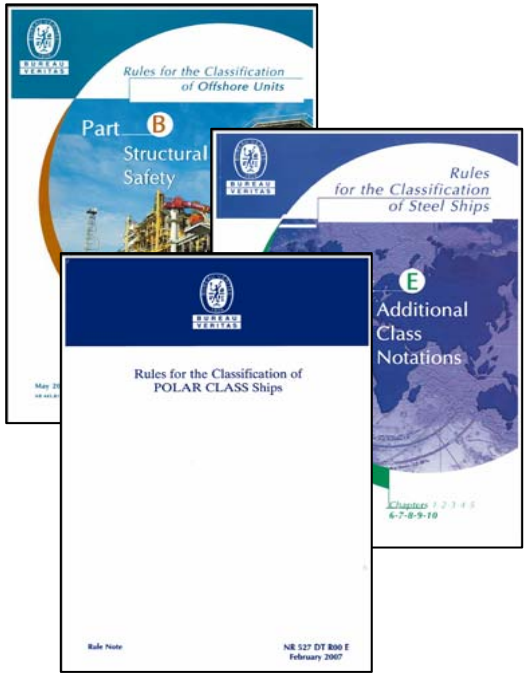
<u>Steel ships</u>

NR 467 "Rules for the Classification and Construction of Steel Ships"

NR 527 "Rules for the Classification of Polar Class Ships"
Feb 2007

NI 543 "Ice Reinforcement Selection in Different World Navigation Areas" Jan 2009

NI 565 "Ice Characteristics and Ice/Structure Interactions" Sept 2010



Différentes Mentions de Glace

Equivalency table of different Ice Class Notations

Ice Type	Typical ice thickness	Ice Class Ships (BV) [1]	Polar Class Ships (BV) [2]	Canada 1972 (ASPPR) [6]	Canada 1995 (ASPPR) [7]	Ice going ships (RMRS) [8]	Ice Class Ships (FMA) [9]
Year-round operation in all polar waters	> 3.0 m	–	PC 1	**Arctic Class 10**	**CAC 1**	Arc 9	–
Year-round operation in moderate multi-year ice conditions	3.0 m	–	PC 2	**Arctic Class 8**	**CAC 2**	Arc 8	–
Year-round operation in second- year ice with old ice inclusions	2.5 m	–	PC 3	**Arctic Class 6**	**CAC 3**	Arc 7	–
Year-round operation in thick first-year ice which may contain old ice inclusions	> 1.2 m	–	PC 4	**Arctic Class 3**	**CAC 4**	Arc 6	–
Year-round operation in medium first-year ice with old ice inclusions	1.2 m - 0.7 m	**IAS**	PC 5 PC 6	**Type A**	**Type A**	Arc 5	**IAS**
Summer / autumn operation in thin first-year ice with old ice inclusions	0.7 m	**IA**	PC 7	**Type B**	**Type B**	Arc 4	**IA**
First-year ice	0.5 m	**IB**	–	**Type C**	**Type C**	Ice 3	**IB**
First-year ice	0.4 m	**IC**	–	**Type D**	**Type D**	Ice 2	**IC**
Open sea with ice floes	–	ID	–	Type E	Type E	Ice 1	II

Winterisation

Protection contre le froid

- The operation in low ambient temperatures lays additional claims to:
  - Material class and grade selection for low air temperatures
  - Decks and superstructures
  - Stability
  - Propulsion and other essential services
  - Electricity production
  - Navigation
  - Crew protection and elimination of ice where necessary for safe access

Protection contre le froid

- Anti-icing of open decks:
  - Covers for open deck equipment and cargo systems (valves, P/V, …)
  - De-icing equipment (steam, electrical,…)
  - Special anti-slippery deck paint
- Machinery
  - Heating coils to fuel and fresh water tanks exposed to cold
  - Unused coils to be drained. Draining system.
  - Low suction of cooling water. Monitoring system + alarm of pressure and temperature at intakes of cooling water at all time when in ice.
  - Procedure for clearing ice from sea chest in event of blockage (back flow).
  - Ballast water heated in engine cooling system.
  - Extra fuel and fresh water storage (delays / manoeuvring)
  - Heated screen of cooling water intake
- Accommodation / bridge
  - Heating throughout the accommodation. Humidity control and monitoring device.
  - Clear view screens

Protection contre le froid

- Deballasting
  - Efficient bubbling system in water ballast tanks to prevent formation of an ice layer.
  - Suction pressure monitoring device + alarm / tripping down of ballast pump.
  - Covers / lid / heavy tarpaulin for water / ballast tank air pipes.
- Miscellaneous
  - High powered search lights (min. 6M Candella): 3 forward search lights to illuminate at more than a mile ahead + 2 search lights on bridge wings.
  - Heating of (forward) emergency fire pump
  - Heating of life boat engines
  - Heating of whistles
  - Space heaters as necessary (paint store etc..)
  - Hydraulic equipment kept running
  - Salt / snow shovels /scrappers
  - Safety lines on deck
  - Efficient draining system for fire line / bridge window washing line / fresh water line / steam line.

Equipements

Afin de naviguer en sécurité, il est nécessaire que tous les équipements et tous les auxiliaires du navire restent opérationnels en permanence dans les zones froides. On doit donc prévoir des dispositifs antigel et dégivrants adéquats pour les équipements exposés.

Ces dispositifs ne sont pas couverts par les notations de classe Glace.

Des recommandations on été éditées par certaines autorités

(ex. *Navigation dans les glaces en eaux canadiennes* publié par la Garde côtière canadienne)

Des notations de classe spécifiques ont également été développées par les sociétés de classification pour tenir compte de ces exigences (« COLD » pour le BV, « DEICE » pour le DNV, …)

Vue de la plage avant

A Bord

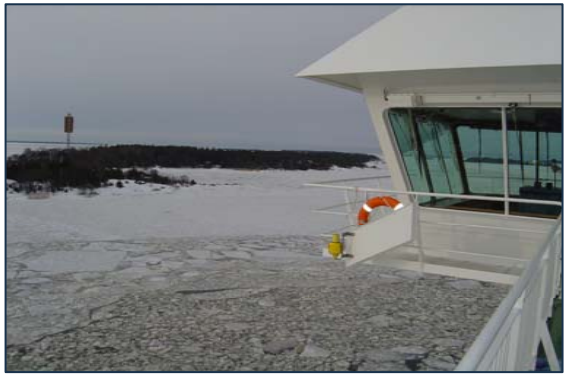
A bord

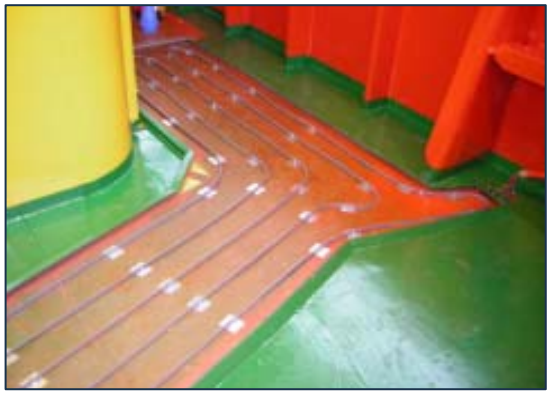
Cargo Installation & Safety Systems

- Protection of safety valves for cargo tanks and cargo containment, vent masts and risers
- Protection of cargo manifold, cargo lines and expansion arrangements
- Protection of gas compressors and GCU if fitted
- Protection of float level gauges, local instrumentation and valve actuators, ESD system
- Protection of safety systems, such as deck sprinkler, dry powder and water curtain

Solutions

- Trace Heating – Steam or Electric
- Ice Removal Equipment – Shovels, scrapers, salt/sand etc.
- Protective Covers – stainless steel or heavy duty layered fabric
- Heaters – Steam or Electric
- Steam Blowing
- Enclosed Spaces
- Correct selection and circulation of lubricants, oils, greases etc.





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Aides à la navigation

- Il existe un très vaste dispositif destiné à aider à des degrés divers les navires qui se déplacent dans des eaux couvertes de glaces.
- Les services ainsi assurés par les bureaux des glaces des états côtiers vont de la transmission de renseignements généraux et de prévisions à jour sur l'état des glaces à la diffusion d'avis détaillés sur les routes à suivre pour les navires faisant route sans escorte en passant par tout ce qui est escorte navale au moyen de brise-glace, et ce, selon les disponibilités et les besoins.

Navigation assistée par remorqueur brise-glace

Navigation derrière un brise glace

Navigation en convoi

Navigation

- La navigation dans la glace demande des équipages ayant subi une formation particulière et expérimentés, ainsi que des procédures spécifiques de navigation détaillées, qui doivent être suivies à la lettre.

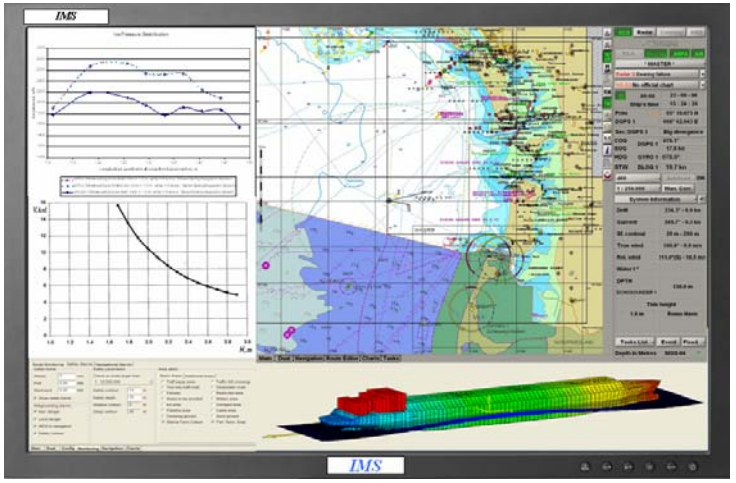
- L'expérience renseigne que trois règles fondamentales de manœuvre dans les glaces sont de mise.

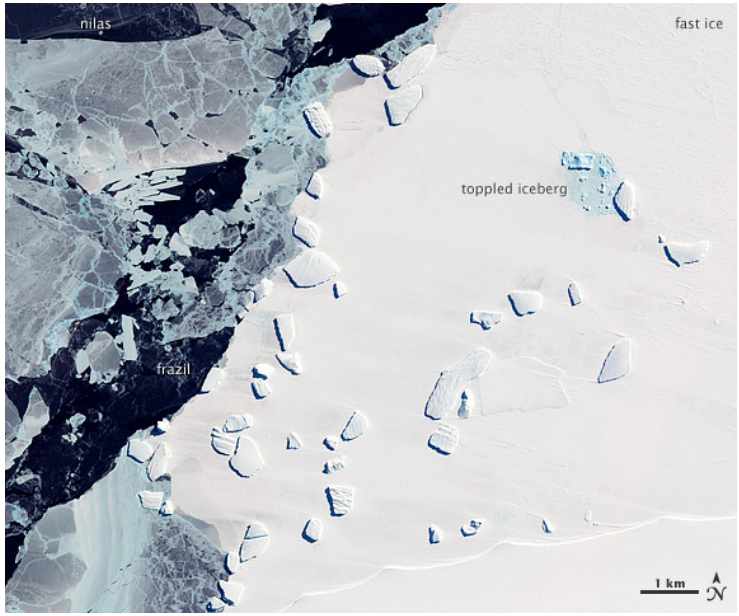
  - Le navire doit constamment maintenir son erre, même en mouvement très lent;
  - Le mouvement du navire doit épouser celui des glaces et non pas s'opérer au rebours; et
  - Une vitesse excessive est synonyme de dégâts par les glaces.

Simulateur IceNav

Gestion de la glace

- Ice management
  - Detection and classification of ice threats
  - Forecasting and monitoring of ice formation
  - Support of ice navigation with icebreakers
  - Assessment of risk and its mitigation





[http://www.spaceref.com/news/viewsr.html?pid=38866]

Gestion de la glace

- Crewing Requirements
  - Sufficient number of crew members and training to handle challenges
  - Safety and rescue in low temperatures and ice conditions
  - Sufficient equipment and clothe for working in cold conditions
  - Noise, vibration and cold resistance

[http://www.tc.gc.ca/eng/marinesafety/debs-arctic-shipping-operations-crewing-1340.htm]

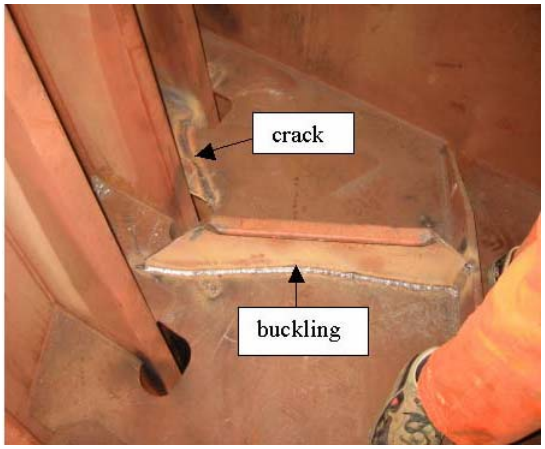
Workers remove ice blocks from under a vessel to release its propeller on the Khatanga River in Russia
[http://www.guardian.co.uk/world/picture/2010/apr/18/russia]

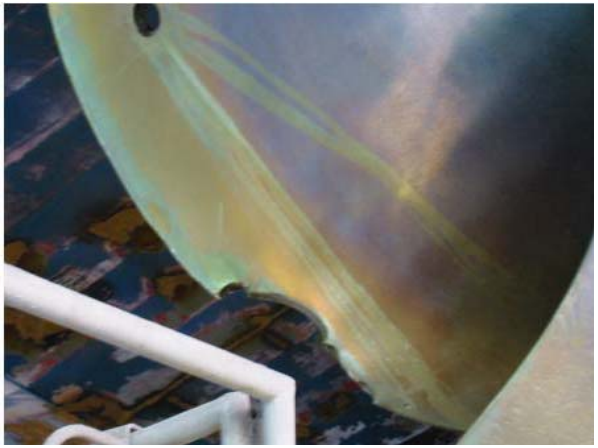
Avaries

AVARIES

- Un examen des accidents survenus en mer Baltique lors de la saison de glace de l'hiver 2002-2003 donne un bon aperçu de la diversité et de la sévérité de ces contraintes.
- **Statistiques d'accidents**

  - Enfoncements et cassures dues au contact avec la glace (30)
  - Collisions dues à la glace (23)
  - Echouements dues aux mauvaises conditions de navigation (3)
  - Avarie d'hélice (36)
  - Avarie de gouvernail (7)
  - Avarie machine (3)
  - Renforts glace insuffisants (5)





Exemple d’avarie due à la glace (2)

Exemple d’avarie due à la glace (3)

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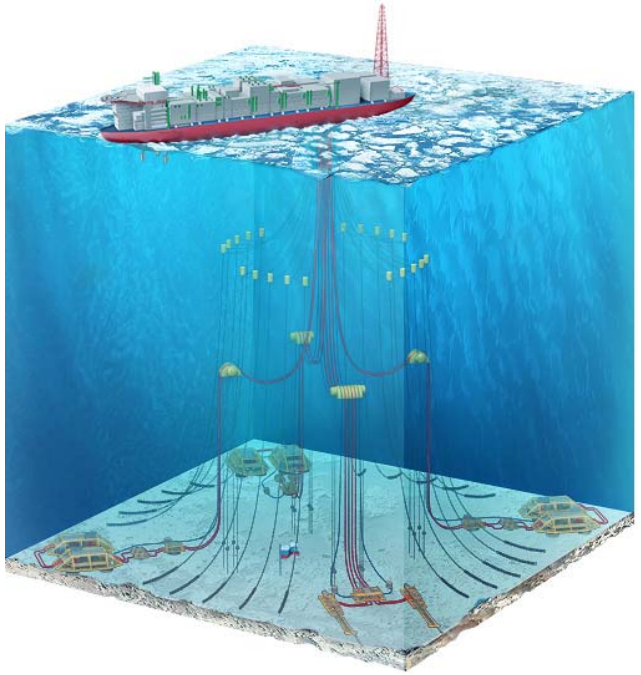
Nouveaux défis

- Demands for arctic trade sea routes, new types of offshore units and large tonnage oil tankers and LNG carriers require additional investigations to withstand ice loads;



- R&D program has two main objectives :

  - Improvement and further develop guidance and rules for navigation of ships and operation of offshore units in arctic conditions

  - Development numerical tool for the direct analysis of ships and offshore units in arctic conditions – *"IceSTAR"*

Co-operations

- R&D activities are in co-operation or close contact with research institutes, design offices, maritime administrations, owners etc. :
  - Russian Register of Shipping
  - St Petersburg State Maritime University
  - Aker Arctic
  - Acer Yards
  - Krylov Institute
  - Severnoye Design Bureau
  - FMA
  - Shipyards
  - IACS

Propulsion par POD

- Rule requirements to be based on realistic formulation of ice loads
- Severity of ice load scenarios depends on a number of factors
  - Ice types found in the geographical areas of operation
  - Operational strategy and safety culture of the operator
  - Available technical means on board for detecting ice formations during poor visibility and receiving ice charts and information on ice conditions
- Maximum speed and practical speed limit for every ice type
  - Prudent navigation
  - Experience from full scale tests
- Ice load scenarios for pods
  - Ahead and astern operations
  - Longitudinal and transverse load cases

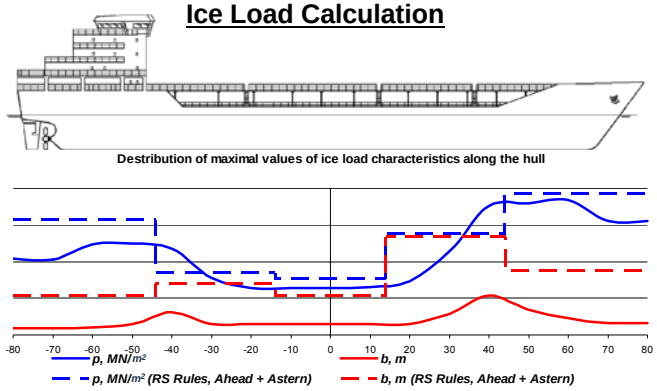
- **Dimensionnement des navires: Etudes directes**

- L'expérience déjà acquise sur la navigation dans la glace et l'arrivée de nouveaux projets dans l'océan Arctique conduisent actuellement à la révision de certains outils, comme la création de bassin à glace pour mieux déterminer la puissance propulsive (parfois excessive si l'on applique le calcul du règlement), ou la mise en place de calculs éléments finis pour calculer l'hélice en prenant en compte les interactions héliceglace.

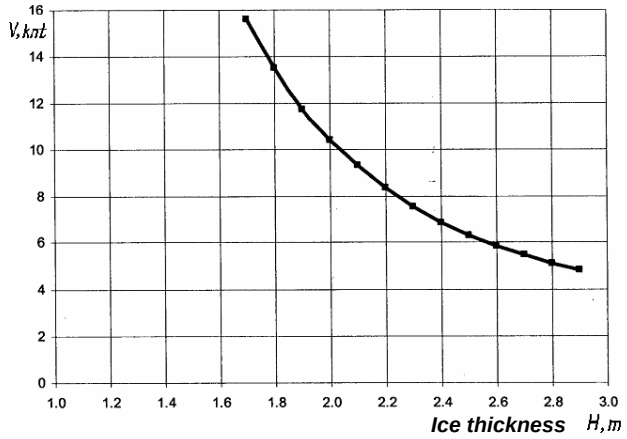
IceSTAR

- IceSTAR software is considered as an additional tool intended for:
  - Direct calculation of ice load exerted on ship hull by ice objects;
  - Determination of safe ice navigation regimes.

Ice Load Calculation



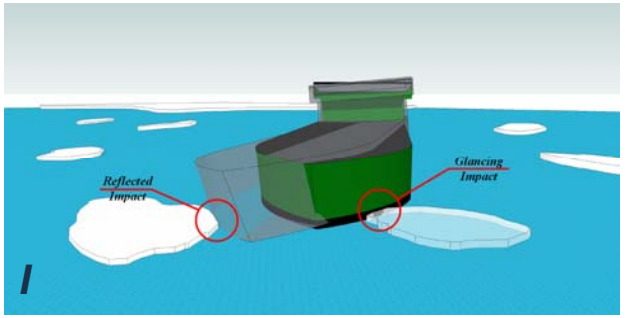
Safe navigation regime

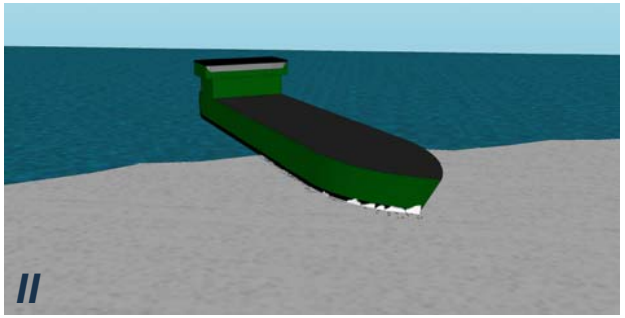


- The main benefits of the software:
  - Individual approach to every vessel;
  - Direct calculation of ice load in any point of a hull;
  - Consideration of various interaction scenarios;
  - Application of real environmental conditions.

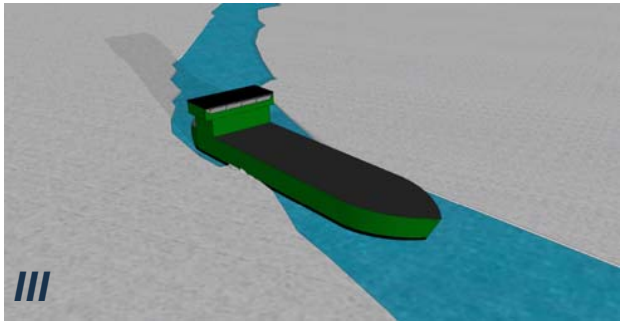
Glace structure – Scenarios d'Interaction

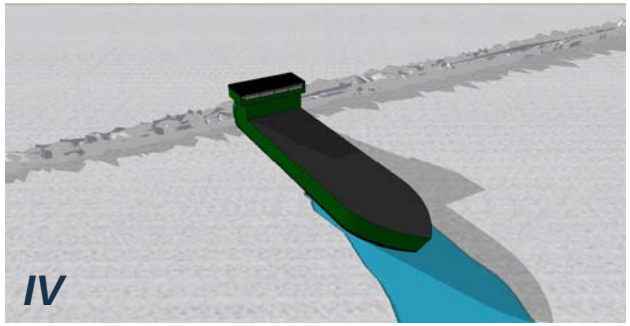
- Design scenarios of ship & ice interaction define the selection of appropriate ice failure model



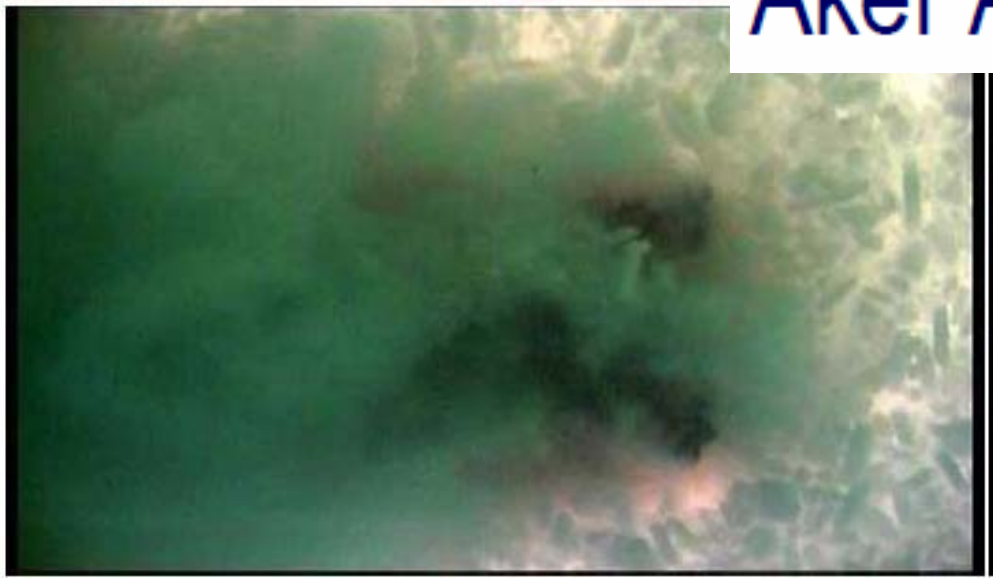


Scenario	Contact region	Navigation mode
I. Glancing impact	Bow, Shoulder, Stern (***DAS***)	Ahead and astern navigation in broken ice of different concentration
I. Reflected impact	Bow, Shoulder, Stern (***DAS***)	Ahead and astern navigation in broken ice of different concentration
II. Icebreaking	Bow, Shoulder, Stern (***DAS***)	Ahead and astern navigation in ice field
III. Maneuvering	Bow, Shoulder, Midbody, Stern (***DAS***)	Gyration in ice, maneuvering in channel
IV. Ice Ridge	Stern	Navigation in heavy ice conditions
V. Iceberg Collision	Bow, Shoulder, Midbody, Stern (***DAS***)	Low visibility





Aker Arctic



Conclusion

CONCLUSION

- Growth possibilities for shipping and offshore activities in the arctic
- Protection of crews, ships, cargo and sensitive arctic marine environment is key
  - Ice reinforcement of the hull structure
  - Ship hull form and engine power
  - Robustness of propulsion machinery
  - Winterization of ship borne equipment
  - Good knowledge and experience of crews navigating in ice

- Wide variety of class and national rules and regulations available
  - Bureau Veritas provides guidance to ship owners and designers top select appropriate requirements
  - Bureau Veritas is actively participating in working groups concerning rule development (IACS, FMA)

CONCLUSION

- Bureau Veritas R&D program for further development of rules to take into account industry developments (new ship types, larger ships)
- Methodology and calculation tool IceSTAR for a first principle based assessment of ice loads on the ship's structure
  - Rational and detailed assessment of loads to be expected in ice conditions
  - Calculation of safe speed in given ice conditions
  - Results can be used in FEM analysis for verification of the hull structure
- Re-assessment and updating of COLD notation for application to extreme arctic conditions
- Development of ice loading scenarios for pod propulsors for derivation of associated loads and strength requirements
- Bureau Veritas actively contributes to reducing risks associated with ship operations in arctic conditions: enhanced safety and environmental protection

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