School of Engineering

Department Offshore and Structural Mechanics

RISK ANALYSIS OF OPERATION OF MOBILE DRILLING UNITS IN THE KARA SEA ICE CONDITIONS

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MODU – Mobile offshore drilling unit

Timeliness of the topic

Oil and gas projects of exploration drilling in the Kara Sea are developing. Reserves in the Kara Sea are estimated at 4.9 billion tons of oil and 8.3 trillion cubic meters of gas

The development of oil and gas deposits in the shelf of the northern seas is greatly complicated by the presence of ice cover

Risks associated with the operating of MODUs must be analyzed and predicted in order to avoid emergency situations

State of knowledge

Foreign methods for risk assessment are more diverse and approved for the exploitation of oil and gas facilities on the shelf.

Organizations developed main foreign risk analysis standards recommended for MODU:

- ISO
- API (USA)
- DNV GL (Norway)
- NORSOK (Norway)
- IEC
- IMO

- Project Barents-2020 (Russia-Norway)

The question is still relevant due to the new technologies and new regions for offshore operations

Goal:

Improvement the of operation risk assessment of MODU in ice conditions

Tasks:

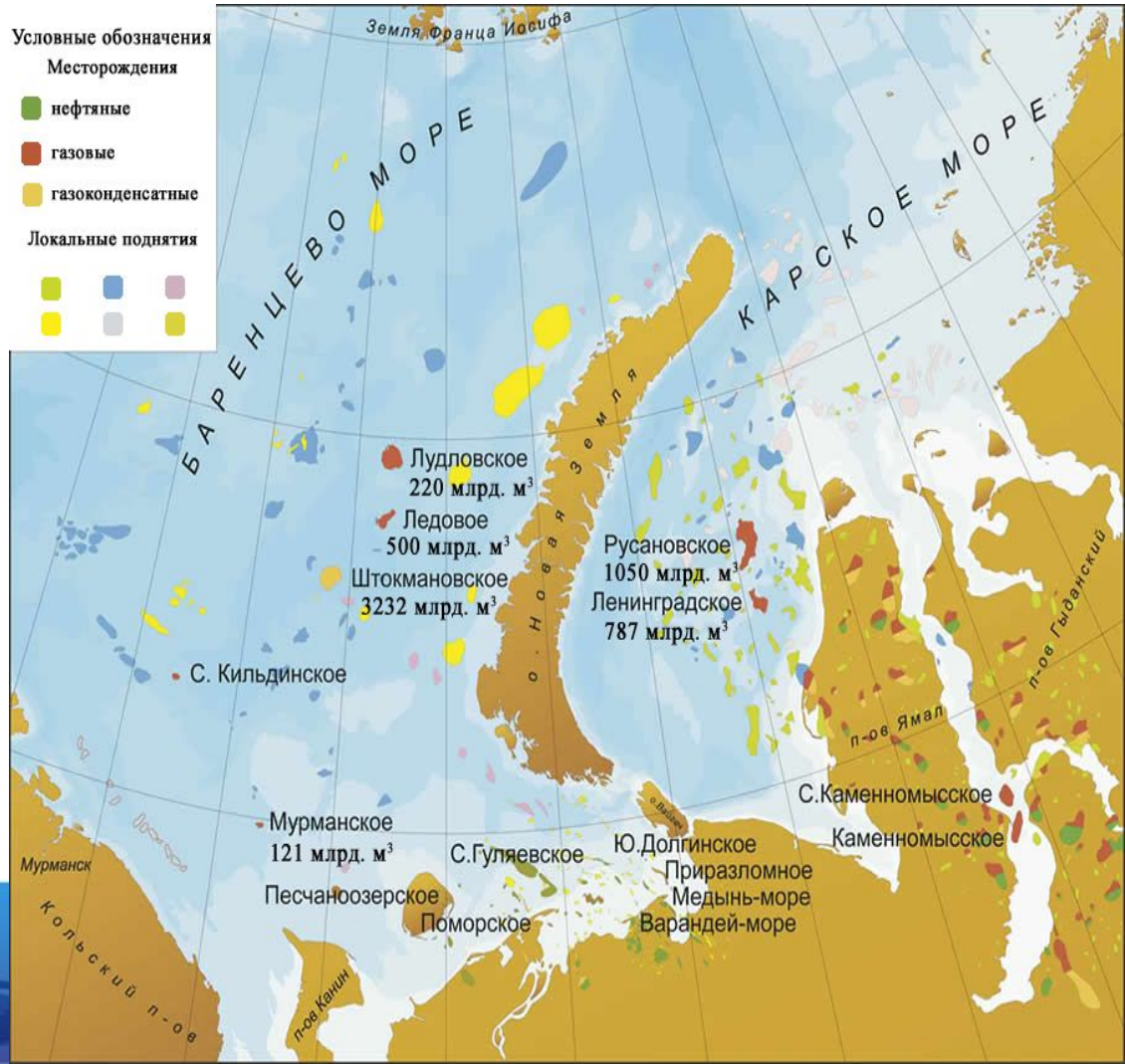
1. Conduct a review of risk assessment methods and studies;
2. Conduct an ice risk analysis for the MODU;
3. Identify measures to reduce risks for the MODU and its structural elements;
4. To give recommendations on conducting risk analysis and reducing the operation risks of MODUs.

The object of research is MODU. ***The subject*** is the ice risk analysis and safety problems of MODUs in ice conditions.

Oil and gas deposits of Kara sea

Russian shelf contains a quarter of Russian oil reserves and half of gas reserves.

Reserves in the Kara Sea are estimated at 4.9 billion tons of oil and 8.3 trillion cubic meters of gas.



Kara Sea metocean conditions analysis

Ice regime

	January	Fabruary	March	April	May	June	July	Aurust	Septemer	October	November	December
Kara sea	precence of ice		winter ice			precence of ice						
	- probability of icebergs											

Main hazards of Kara Sea:

- instant ice formation in the Kara Sea;
- an intensive removal of ice up to 3 m thickness in May-June ;
- the presence of negative temperatures down to -20 ° C at the end of ice-free months;
- silted-up bottom;
- presence in the bottom part of depth up to 100 m of permafrost;

Configurations of MODUs for ice conditions

Main factors for choosing the configuration:

- Depth of water
- External environment load (ice and waves)
- Soil conditions
- Weight of top side (and winter protection)
- Required capacity of the oil storage
- Storage capacity
- Cost
- Work schedule

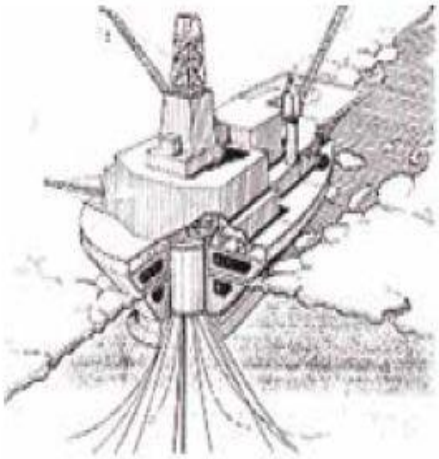
According to the method of installation Drilling Units at the well during the drilling are divided into:

Button-based

Floating during the drilling

Floating drilling units

Possible MODUs configurations for ice conditions



а

б

в

г

Main technological problems:

- Housing design
- Holding the unit at the drilling point
- Protection against ice of the riser system
- Depth restrictions

Types of drilling units for ice conditions:

а - egg-shaped;

б - installation with a body in the form of a body of revolution (KULLUK);

в – wedge-shaped (conception "Coral");

г - installation with a body in the form of a body of rotation («Sevan»).

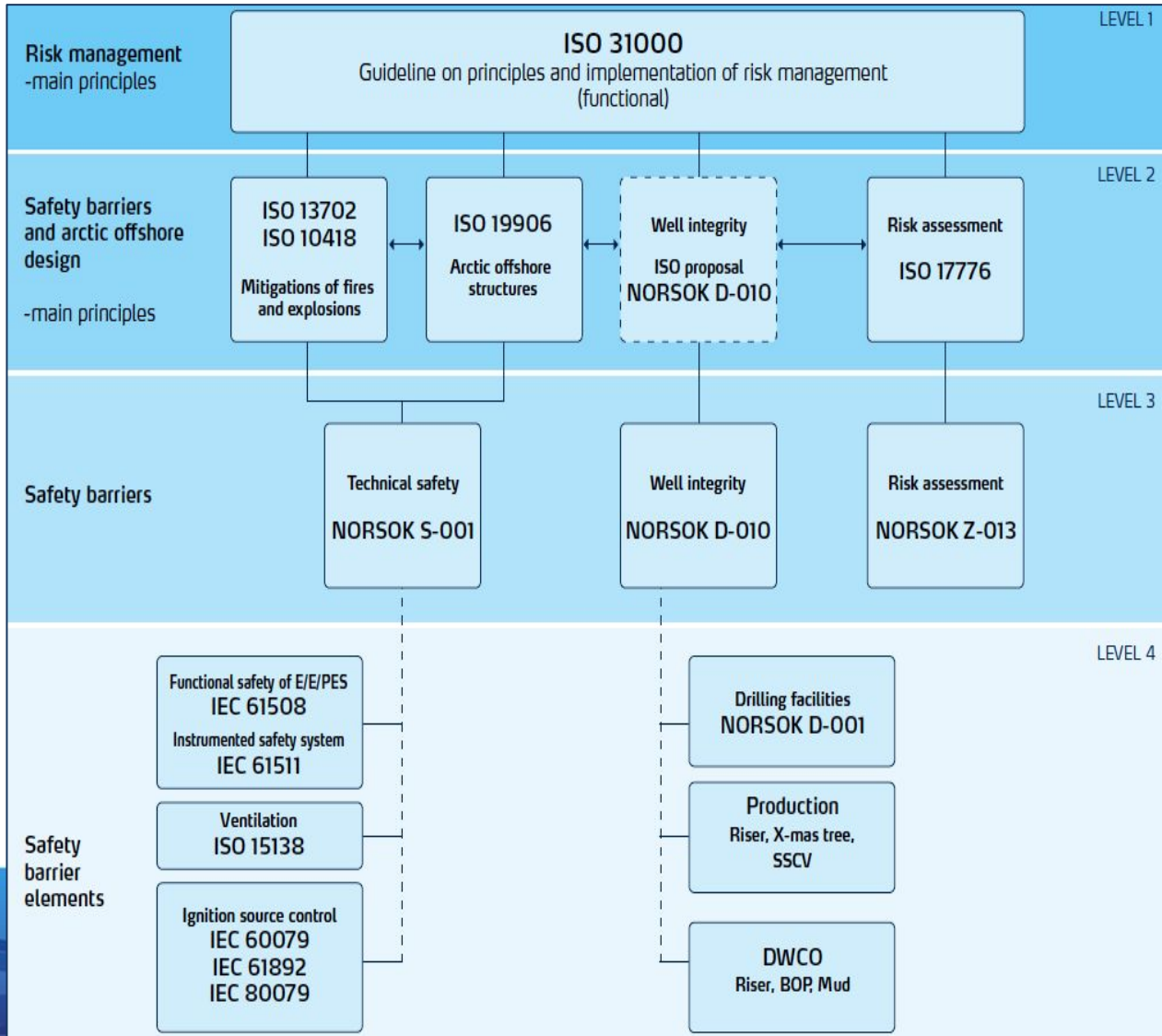
The main problems of safety in the operation of MODU

Construction safety of MODU is achieved by:

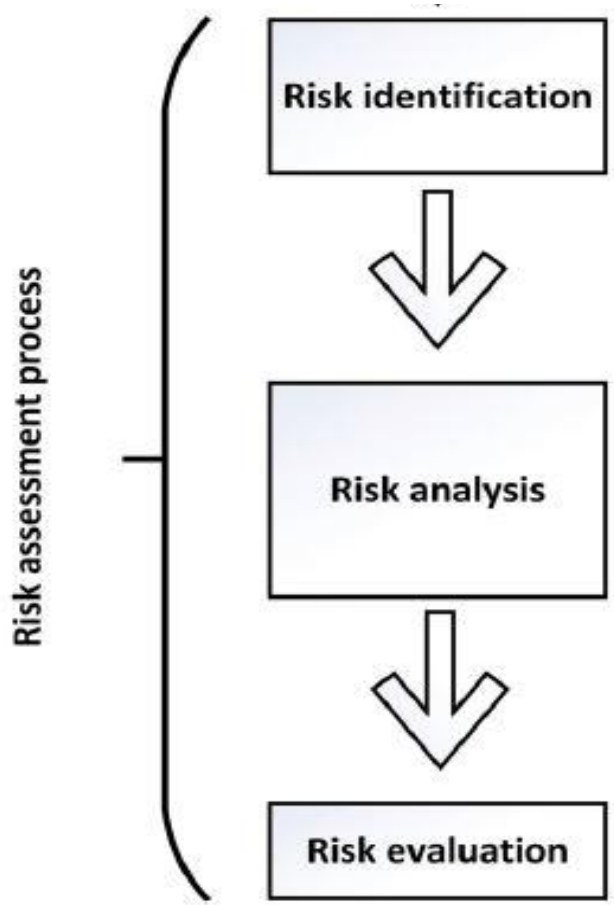
- constructive reliability
- safe configuration
- availability of special emergency response devices and systems
- constructive protection of critical areas

Recommended Standards for MODU

Management of each type of risk is associated with relevant laws, regulations, interstate and international agreements and other legal documents. It significantly expands and deepens the activities of the oil company and complicates the methods of risk assessment and decision-making mechanisms.



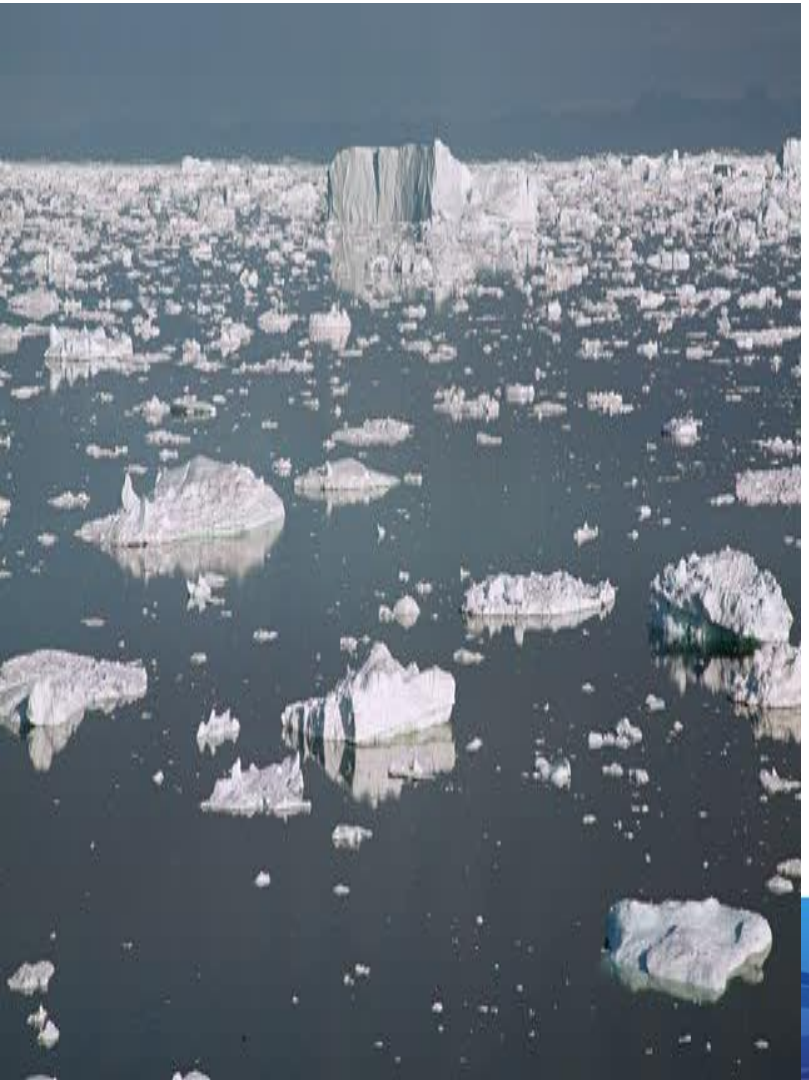
Methods of Risk Analysis



Risk analysis methodologies:

- Checklist
- “What If” Analysis
- Hazard and Operability (HAZOP)
- Failure Modes and Effects Analysis (FMEA)
- Fault Tree Analysis (FTA)
- Event tree analysis

Identification of hazards for MODU



The hazards associated with offshore structures:

- Equipment-related Hazards
- Process-related Hazards
- Well-related Hazards
- Environmental Hazards
- Material Handling

Consequences:

- Personnel injury
- Loss of life
- Impact on public
- Environmental impact
- Loss of facilities and equipment damage
- Loss of production
- Impact on associated operations

Identification of hazards for MODU

The hazards associated with offshore structures:

- Equipment-related Hazards
- Process-related Hazards
- Well-related Hazards
- **Environmental Hazards**
- Material Handling

Basic ice hazards:

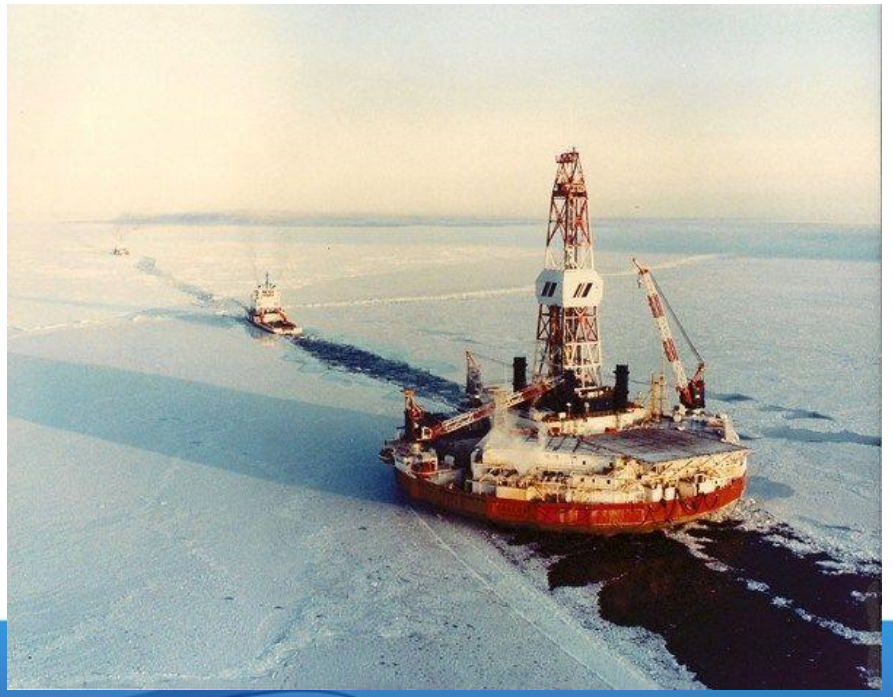
- the passage of ice under the MODU
- impact of ice on the risers;
- drilling pipe freezing into ice;
- vibration caused by ice;
- global loads, pack and glacier ice;
- local loads, pack and glacier ice;
- a dynamic reaction that combines all degrees of freedom;
- change the direction of ice.

Initial data for risk assessment

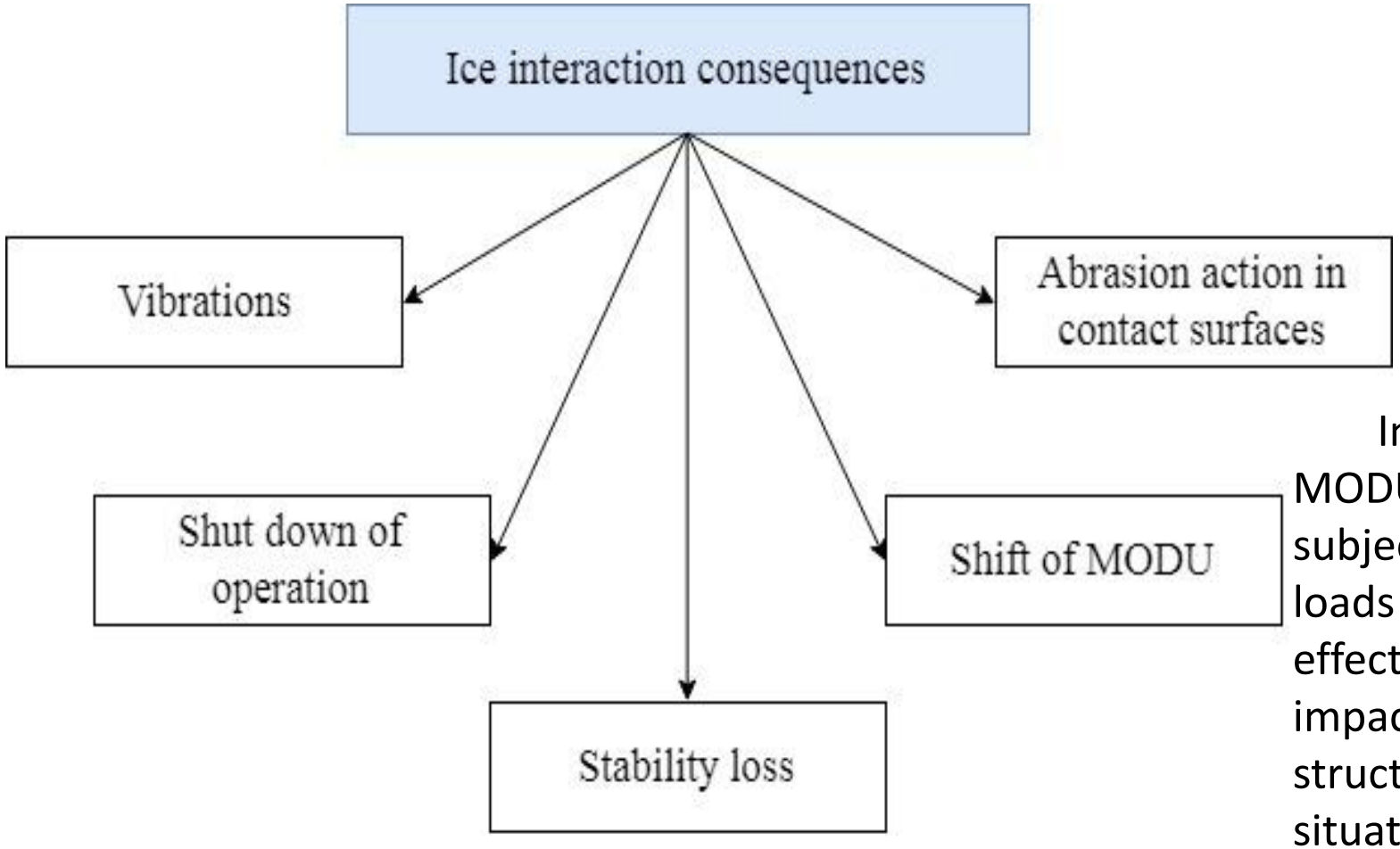
1)Meteorology
2) Hydrology
3) Characterization of sites and structures
4) Initiating event frequency, Information on resistance of plant and equipment to effects of physical events of an accident
5) Methods of risk analysis including methods of expected frequency and effect calculations for the hazards in question

Ice cover parameters:

- ice compaction
- ice thickness
- Ridging
- extent of ice destruction
- breaking-up of ice

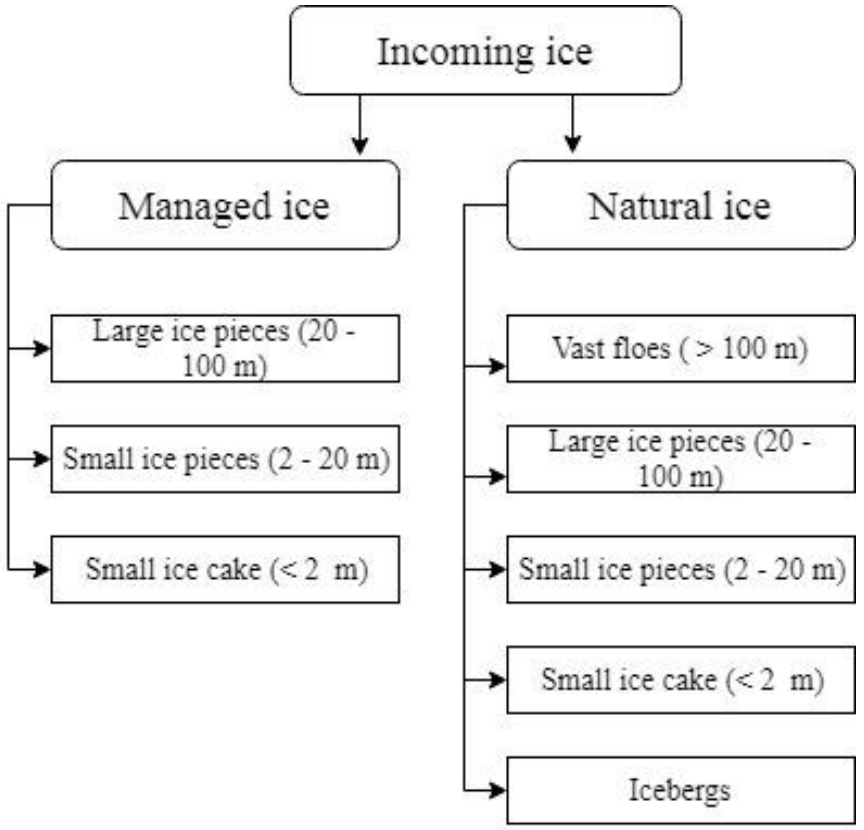


Ice impact on MODU

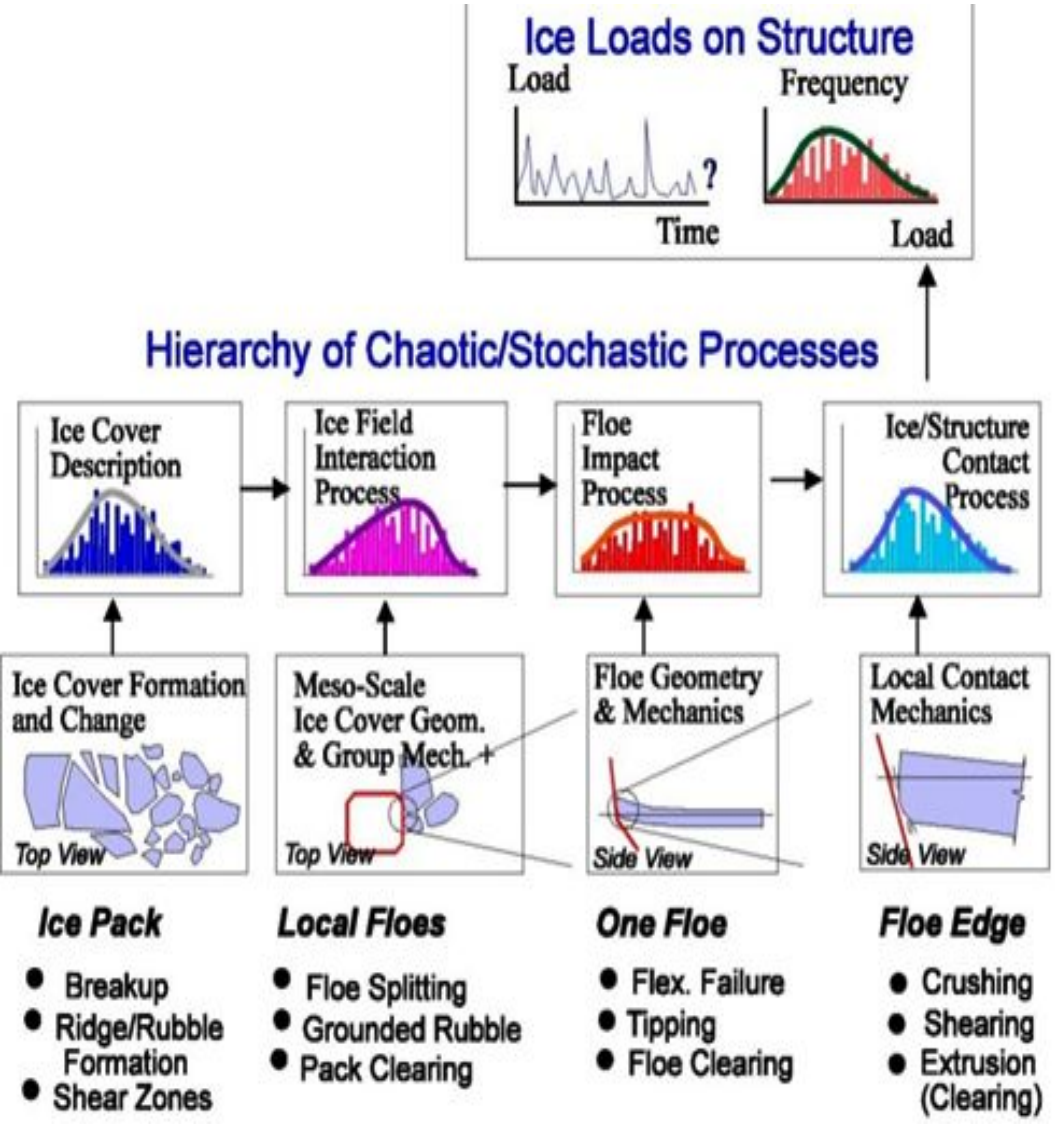


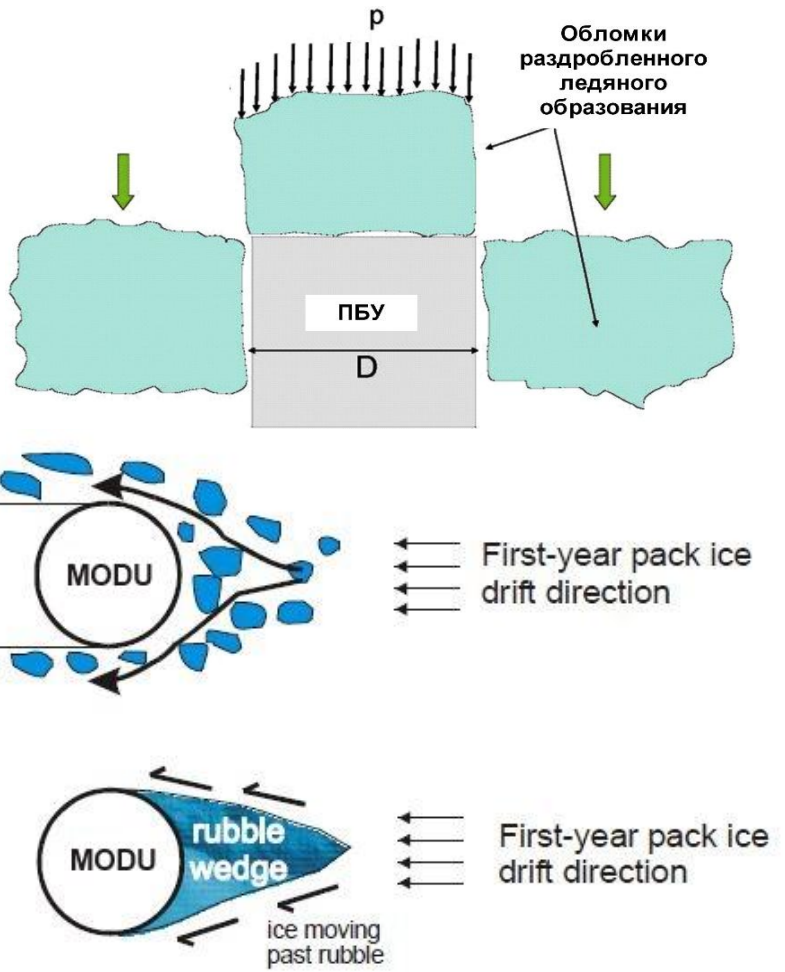
In the Arctic regions, MODU are often subjected to significant loads that arise from the effects of ice. Due to the impact of ice for a structure the dangerous situations exist.

Managed ice


Incoming ice
Managed ice
Natural ice
Large ice pieces (20 - 100 m)
Small ice pieces (2 - 20 m)
Small ice cake (< 2 m)
Vast floes (> 100 m)
Large ice pieces (20 - 100 m)
Small ice pieces (2 - 20 m)
Small ice cake (< 2 m)
Icebergs

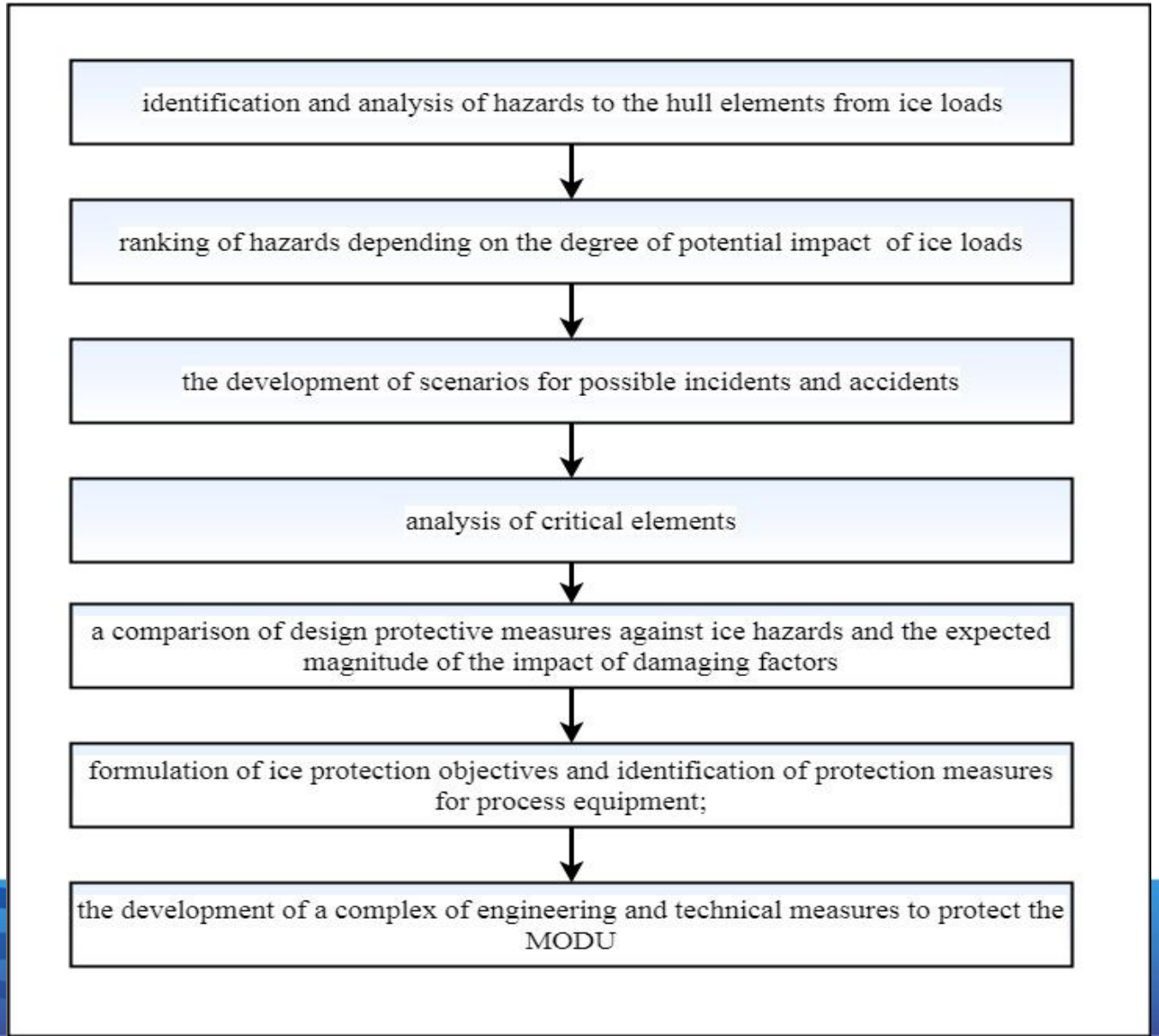
Ice features and scenarios





Modelling results used for risk analysis

Steps of Risk Analysis of ice hazards



Qualitative assessment of risk

Ranking of ice influence on MODU

Ice scenario	Consequences of the ice interaction						
	Full destruction of the support structure	Partial destruction of the support structure	The formation of cracks in the concrete of the above-water part of the base	Damage of tensioning ram and anchoring system	Shut down of operations	Vibrations	Sum
Large ice pieces (20-100m)	3	3	2	3	2	2	15
Small ice pieces (2–20 m)	2	1	1	2	2	2	10
Small ice cake (<2 m)	2	1	1	1	2	2	9
Sum	6	4	4	6	6	6	

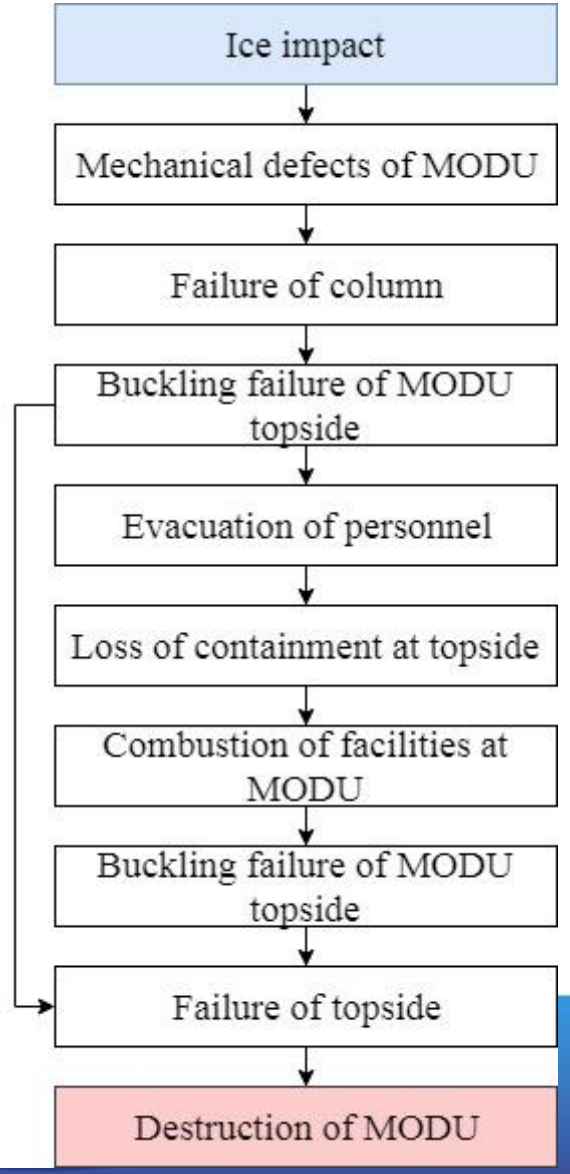
Extremely critical elements are:

- tensioning ram and anchoring system
- Hull of MODU

Qualitative assessment of risk

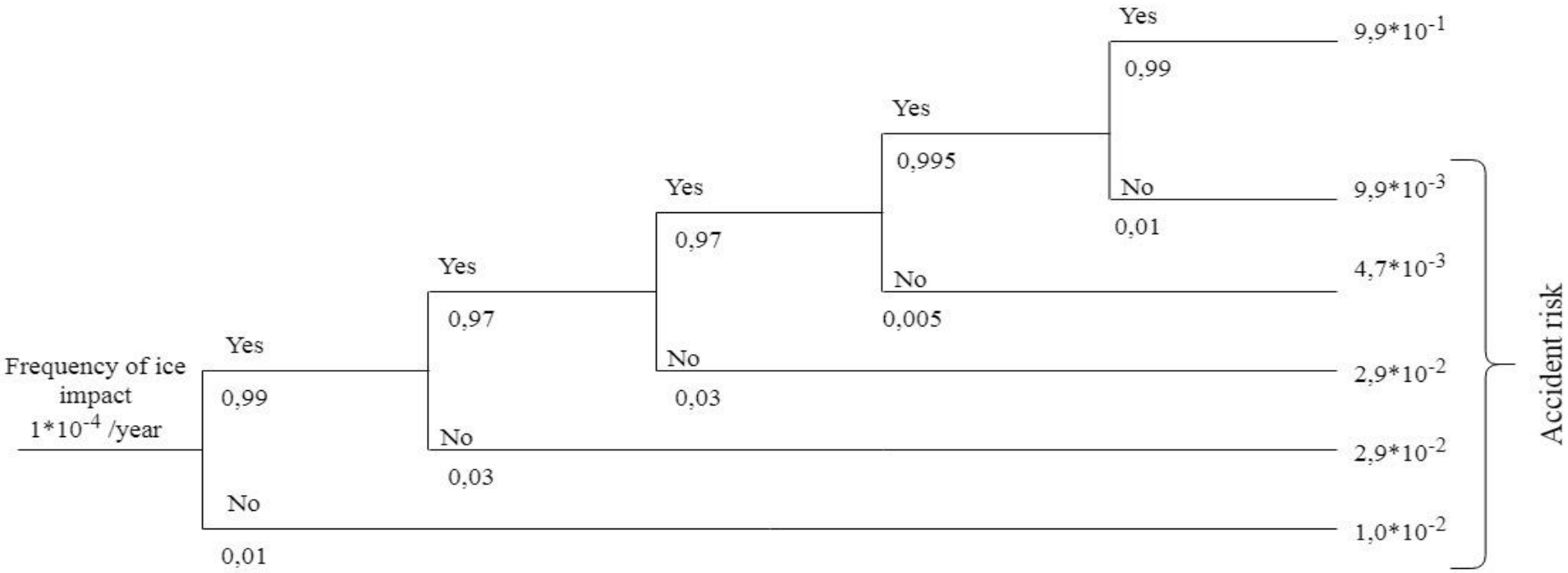
Matrix of qualitative expert ranking of accidents, possible on MODU

Likelihood of accident	Consequences of accident		
	Minor (1)	Moderate (2)	Major (3)
Improbable (1)	C	B	B
Possible (2)	C	B	A
Probabale (3)	B	A	A



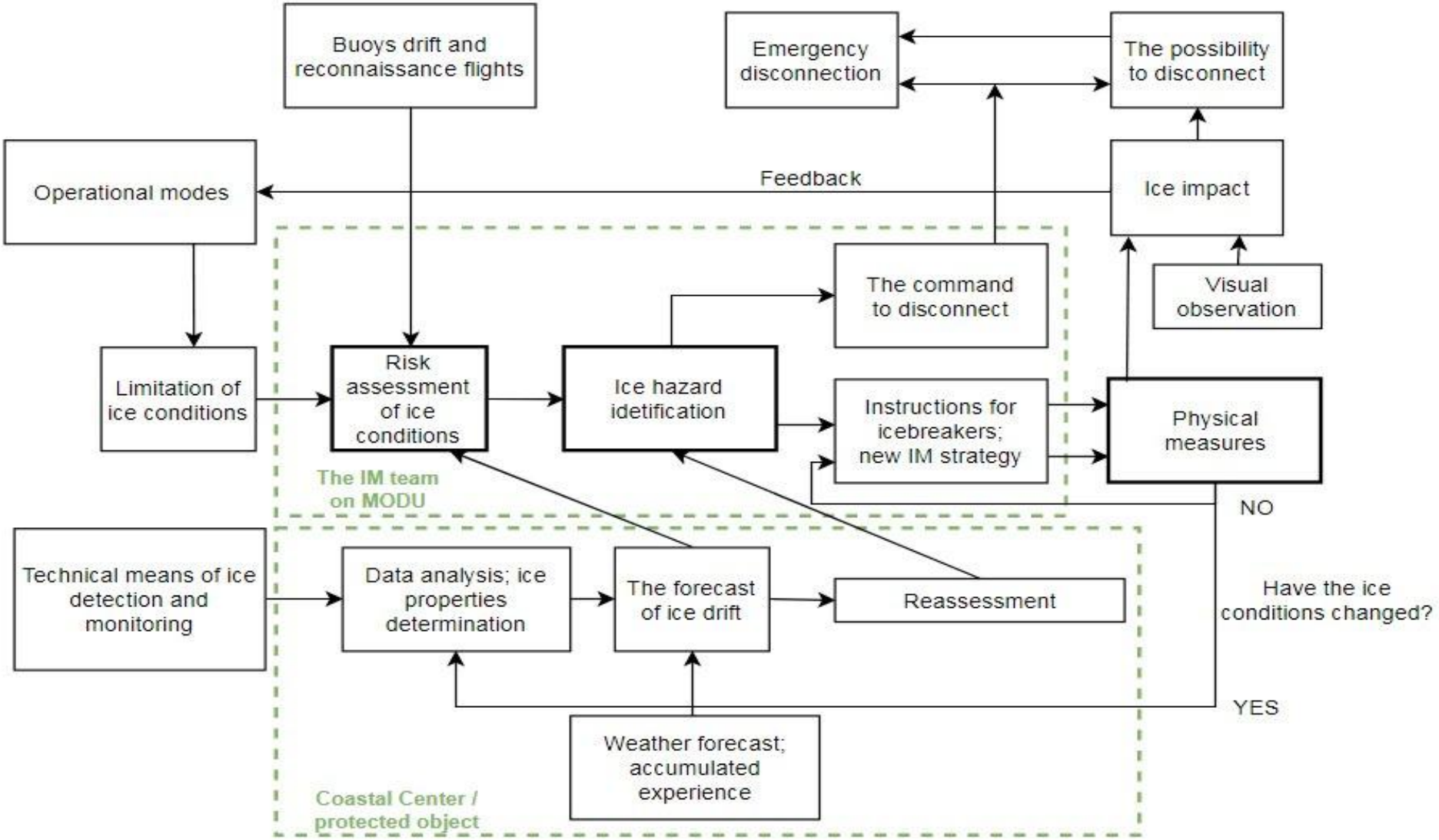
Event tree of incoming ice floes at MODU

Were operation conditions determined right?	Will the measures taken to prevent damage of MODU be effective?	Will the use of additional means for ice managment be needed?	Will be the ice load within the design limits?	Will the break of structure integrity exceed the design one?	Combined probability Yes=accident will not occur No=accident risk

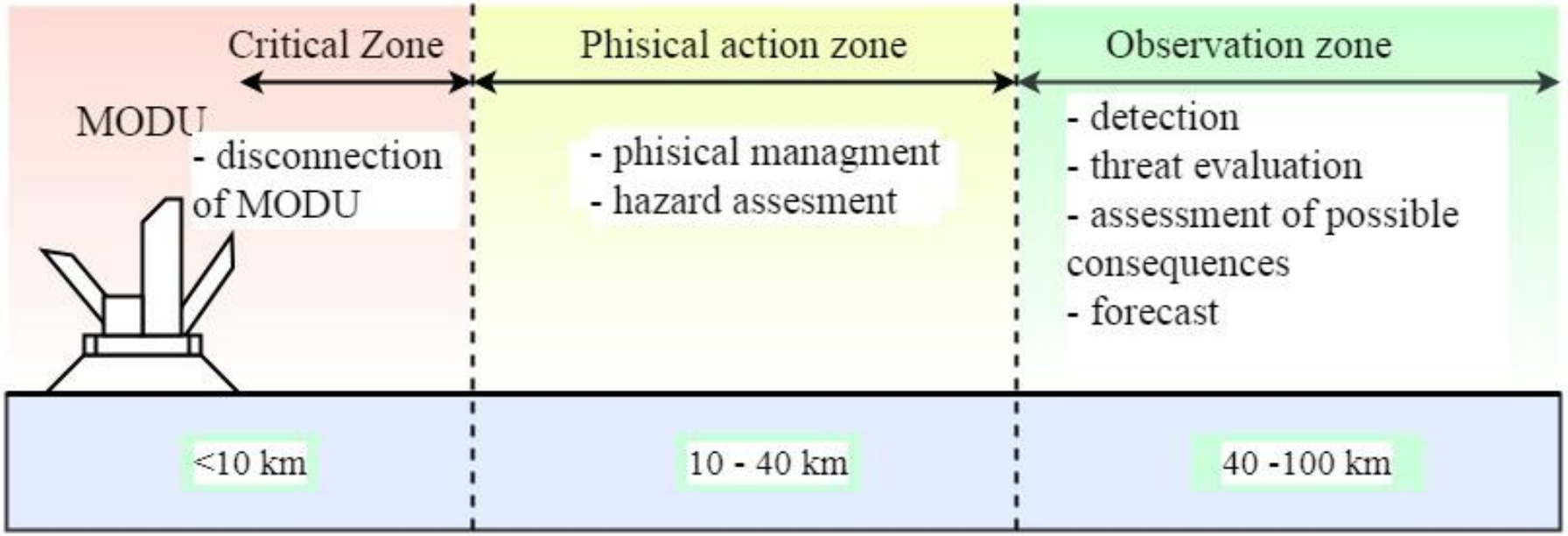


Risk Control

Flowchart of ice management



The recommendations on ice risks mitigation



The recommendations on ice risks mitigation

To ensure safe operation of MODUs, it is necessary to develop and implement the main tasks at the stage of exploratory drilling in open water conditions:

- To formulate requirements for ice monitoring system;
- To assess the frequency and reliability of ice reports and forecasts;
- To develop requirements for the location of ice-management management vessels;
- To maintain records and statistics to assess the frequency and intensity of hazardous ice conditions;
- To eliminate or minimize downtime of MODUs due to ice conditions through monitoring, forecasting and physical control;
- To avoid or minimize the number of emergency disconnections that can lead to serious problems in terms of well integrity and control;
- To create a database of ice and hydrological and meteorological parameters;
- To develop recommendations on the choice of the icebreaker fleet or the characteristics of ship hulls planned for ice management for a specific field under given ice conditions.

Conclusions

1. Risk assessment for the operation of the MODU in ice conditions depends on defining how ice loads affect the structures. Industrial companies have only limited access to metrological and oceanic data.
2. The requirements on risk assessment for MODU in ice conditions present methodologies for risk analysis, but the application of them will be individually analyzed for each MODU.
3. For risk analysis data base of ice, hydrological and meteorological parameters, technical information about the MODU are required. The absence of historical observations of most important metocean parameters at the site zone and a wide range of laboratory studies is main problem.
4. It is proposed to include in the standards an information listing the problems of arctic conditions that should be reflected in the risk assessments and a description of how the problems associated with the presence of ice affect various safety barriers.
5. The conduct of work in the Kara Sea corresponds to conditions that increase uncertainty. The risk assessment uses frequency databases, effects assessments and calculation procedures to take into account the effect of the cold climate on the outcome of the risk assessment, as well as the relationship between safety and winterization.
6. To reduce risks, additional requirements for technical barriers to safety are introduced into technical standards. Ice management systems have proven to be quite successful in many situations, with the actual ice related downtime levels providing a feel for their overall reliability.


Thank you for your attention!