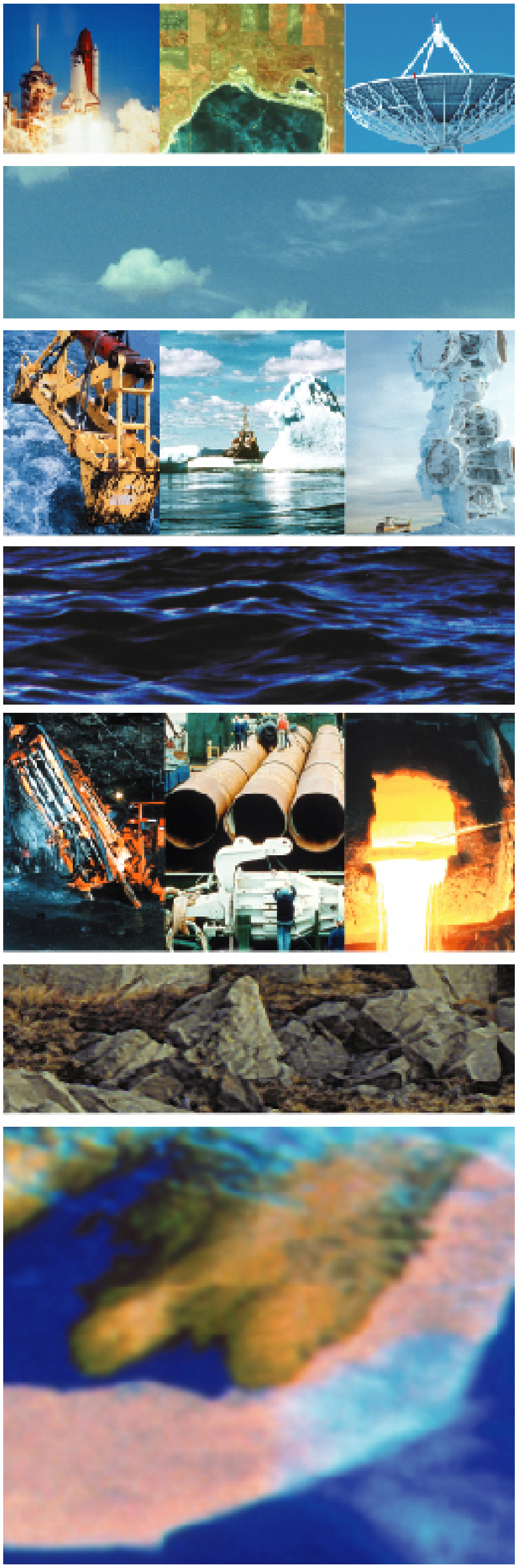

CHARACTERIZATION OF ICE-FREE SEASON FOR OFFSHORE NEWFOUNDLAND

ADDENDUM: CALCULATION OF ICEBERG COLLISION RISK DURING ICE-FREE SEASON

May 2005
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Version 2

ADDENDUM: CALCULATION OF ICEBERG COLLISION RISK DURING ICE-FREE SEASON

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C-NOPB

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Foreword

This report has been prepared by C-CORE for the Canada-Newfoundland Offshore Petroleum Board (C-NOPB). The primary purpose of the report is to assist the C-NOPB in assessing the feasibility of allowing certain types of drilling installations (in particular, jack-ups) to operate in the Newfoundland offshore area on a seasonal basis.

It should be understood by all users of this report that the information in this report is **not** to be interpreted as the approved operating season for jack-up drilling installations.

Due to the high variability of ice conditions offshore Newfoundland, the C-NOPB has determined that the acceptable operating periods for jack-ups will be made on a season-by-season basis, based on actual ice conditions (and other factors) and not necessarily on historical ice data information. The determination of a suitable window of operations for jack-ups will be based on the proposed geographical area of operations and the results from the ice surveillance program for that particular year, taking into account actual (observed) as well as forecasted pack ice and iceberg conditions, as well as weather conditions.

Nevertheless, the results of this report may be very helpful for general planning purposes and in gaining a better understanding of pack ice and iceberg conditions in the Newfoundland offshore area.

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1 INTRODUCTION

1.1 Background

While icebergs and pack ice are important considerations for exploration and development activities for offshore Newfoundland, they do not occur on a year-round basis, or even on an annual basis. Routine activities are generally conducted on a year-round basis, with ice-related risks mitigated using conventional surveillance and ice management techniques. However, it may be desirable to perform certain operations during ice-free periods. C-CORE has been contracted by the Canada-Newfoundland Offshore Petroleum Board (CNOPB) to perform an analysis to determine when the Newfoundland offshore can be considered free of ice.

This report was not intended to be a probability-based analysis of iceberg or pack ice impact frequencies or loads. Rather, it is a general guide documenting the months when the influence of ice on offshore operations are negligible. For specific operations within a given year, the decision whether an ice-sensitive operation proceeds at a given time resides with the CNOPB. These decisions would not be constrained in any way by the contents of this report.

1.2 Objectives

This addendum serves two purposes:

- to demonstrate the probabilistic procedure used to evaluate iceberg contact frequency for a structure, and
- to demonstrate in particular the very small probability of iceberg collision with a facility or structure during an operation with limited duration during a period with low iceberg occurrence rate.

2 PROBABILISTIC EVALUATION OF "ICE-FREE" CRITERION

The contact frequency, n_i, for icebergs with a structure is given by:

$$n_i = \rho_i(L_i + D_s)v_i$$

where ρ is the average areal density of icebergs, L is the mean iceberg waterline length, D is the effective diameter of the structure, v is the mean iceberg drift speed.

The average iceberg waterline length in the vicinity of the Grand Banks is 59 m (Jordaan et al., 1995). A representative iceberg drift speed in the vicinity of the northeast Grand Banks is 0.34 m/s (King, 2002). An effective (or mean) structure diameter of 50 m will be assumed.

The criterion used in this report for defining a month in a specified degree square that is typically "iceberg free" is when icebergs are sighted in that degree square with an average frequency of less than once every five years. The degree square considered here will be centered on 46°30′ N and 48°30′ W (the degree square containing Hibernia, Terra Nova and White Rose). The area covered by this degree square is approximately 8500 km^2. Based on an analysis of iceberg trajectory data, the average time for an iceberg to pass through this degree square (resident time) is approximately 7.1 days (Jordaan et al., 1999). If it is assumed that 1 iceberg was observed in a given degree square in a five year period, the corresponding iceberg density, $\rho_{i,}$ for that month (assuming a 31 day month) during that 5 year period would be:

$$\rho_i = (7.1\ days / (5 \times 31 days)) / 8500\ km^2 = 5.4\times10^{-6}\ km^{-2} = 5.4\times10^{-12}\ m^{-2}$$

The corresponding contact frequency is:

$$n_i = 5.4\times10^{-12}\ m^{-2} \times (59\ m + 50\ m) \times 0.34\ m/s = 2.0 \times10^{-10}\ s^{-1}$$

If it is assumed that an ice-sensitive operation requires 1 month (2.7×10^6 seconds), then the probability of iceberg contact during the operation is:

$$P_i = 2.0 \times10^{-10}\ s^{-1} \times 2.7\times10^{6}\ s = 5.4\times10^{-4}$$

or roughly 1 in 2,000. Ice management has been shown to reduce iceberg risk by approximately 83% (PAL, 2004). Thus, with iceberg management, the probability of iceberg contact during the operation would be:

$$P_i = 5.4\times10^{-4} \times (1\text{-}0.83) = 9.2\times10^{-5}$$

or approximately 1 in 11,000. This final contact probability is a function of several variables, and sensitivity of this probability to reasonable variations of these values, as well as the uncertainty associated with these values, follows.

The 59 m average iceberg waterline length is a reliable parameter. Even with the appearance of ice islands in the 2002-2004 ice seasons, this value has not varied significantly. Since the relatively shallow water depths in the degree square centered on 46°30′ N and 48°30′ W restricts some of the larger icebergs from entering, the average waterline length within is actually less than 59 m, thus this value is reasonably conservative.

The 7.1 day resident time for icebergs to pass through the degree square is based on an analysis of iceberg trajectory data from the 1980's (Jordaan et al., 1999). This analysis has not been repeated using more recent data, however it has been suggested that the resident time for the degree square centered on 46°30′ N and 48°30′ W is probably closer to 5 days. Thus, this value can be considered reasonably conservative. Detailed analysis of recent trajectory data would be required to better define this value.

The contact risk increases with the size of the structure considered. If the mean projected structure diameter is increased from 50 m to 100 m the probability of iceberg contact increases by 46%, or 1.3×10^{-4} for an operation with a duration of 1 month.

Increasing the duration of the operation will also increase the probability of iceberg contact. While it may be assumed that increasing the operation duration to two or three months will increase the iceberg contact probability proportionally (by a factor of two or three), this is actually a conservative assumption. The probability of an iceberg occurring in the ice-free season is highest at the beginning and end of the ice-free season (just after and before the ice season) and lowest midway through the ice-free season. Thus, if it is assumed that an operation is started in the first month of the "ice-free" season (based on the 1 in 5 year criterion), the probability of an iceberg appearing would be expected to be less in the second or third months. The conservative approach was used to generate estimates of contact probabilities for various structure sizes and operation durations.

An ice management effectiveness of 83% is reasonable, and is likely to become higher with the introduction of new ice management technology, such as the iceberg net. Higher management effectiveness would reduce iceberg contact probabilities.

Table 2-1 Contact probabilities for structure during "ice-free" season as a function of structure diameter and duration of operation (with ice management)

	Duration of Operation (months)		
Structure Diameter (m)	1	2	3
50	9.2×10^{-5}	1.8×10^{-4}	2.8×10^{-4}
100	1.3×10^{-4}	2.7×10^{-4}	4.0×10^{-4}

3 CONCLUSIONS

The contact risks calculated here are upper bounds for the cases considered, for a number of reasons. The iceberg occurrence rate used to define the "iceberg free" season for a degree square was *less than* 1 in 5 years for a given month (not 1 in 5, and the rate is often substantially less than 1 in 5). The mean iceberg drift speed of 0.34 m/s ignores occasions when icebergs are grounded, which would result in a lower drift speed, as thus lower contact probability. The development of new iceberg towing technologies, such as the iceberg towing net, holds the promise of higher towing success rates. It was assumed that no long-range surveillance was used to assess the presence of icebergs upstream, as well as using available iceberg drift forecasting capabilities (i.e. the CIS Iceberg Drift Model), to assess the probability of an iceberg drifting near the operation. It was also assumed that it was not possible to perform evasive maneuvers to avoid iceberg contact.

The risk levels calculated here are compatible with current CSA (2004) regulations. For a Safety Class 1 structure, there would be no requirement to consider any load for events below the 10^{-4} annual level. Any strategy, including surveillance and detection with subsequent evacuation, could reduce the requirements to a Safety Class 2 level, in which case there would be no requirements for design for events below the 10^{-2} level.

Based on the preceding calculations and discussion, it may be concluded that the criterion used to define "iceberg free" in this report is reasonable.

4 REFERENCES

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