BETTER SHIPS, BLUE OCEANS

Collision risk for platform F06-A

A SAMSON case study

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1 INTRODUCTION

One-Dyas has requested MARIN to perform a ship collision risk study for platform F06-A in the North Sea (Figure 1-1). It is planned to be built in the offshore windfarm ‘area 6/7’, which is scheduled for construction in the future.

Other windfarms are also planned to be built in the neighbourhood of the platforms. This is described in the partial revision of the North Sea [Ref 2.]. It should be noted that the plans presented in the partial revision are subject to change. The partial revision has changed already significantly in the last two years. Most notable changes are the removal of area 5 and 8 (Figure 1-2). It should be noted that platform F06-A lies close to the German border. It is currently uncertain how the configuration of the German windfarms will be in detail. Therefore, only the planned Dutch wind farms are taken into account.

As ships are not allowed to enter the boundaries of a windfarm, the presence of a windfarm has impact on the traffic around the platform. Therefore, two different scenarios are considered

1. The current situation, where ships should keep 500m distance from an offshore installation
2. The future situation, where the windfarm has been built.

This report describes the assumptions, approach and results of the collision risk assessment for the platform. A short description of the model is given in chapter 2. Chapter 3 contains the different input parameters and some traffic pictures. The results are presented in chapter 4 and the overall findings of this study are presented in chapter 5.

1.1 Objectives

The objective of this study is to determine the collision risk for platform F06-A for the two above described scenarios.

This is achieved by determining the collision frequencies for the offshore installation by passing ships based on AIS data. The collision frequencies are given for various energy classes, based on the characteristics of the colliding ships.

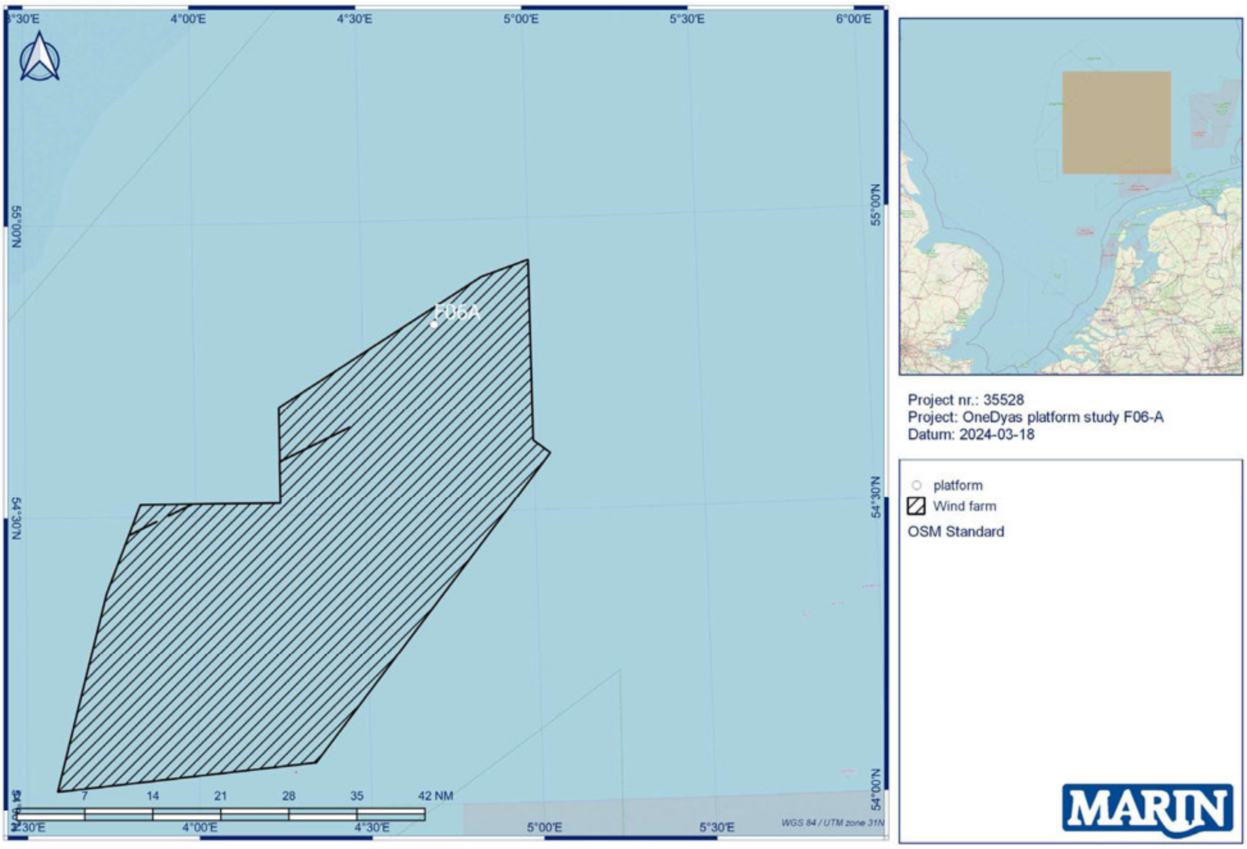

Figure 1-1 Location of the platform

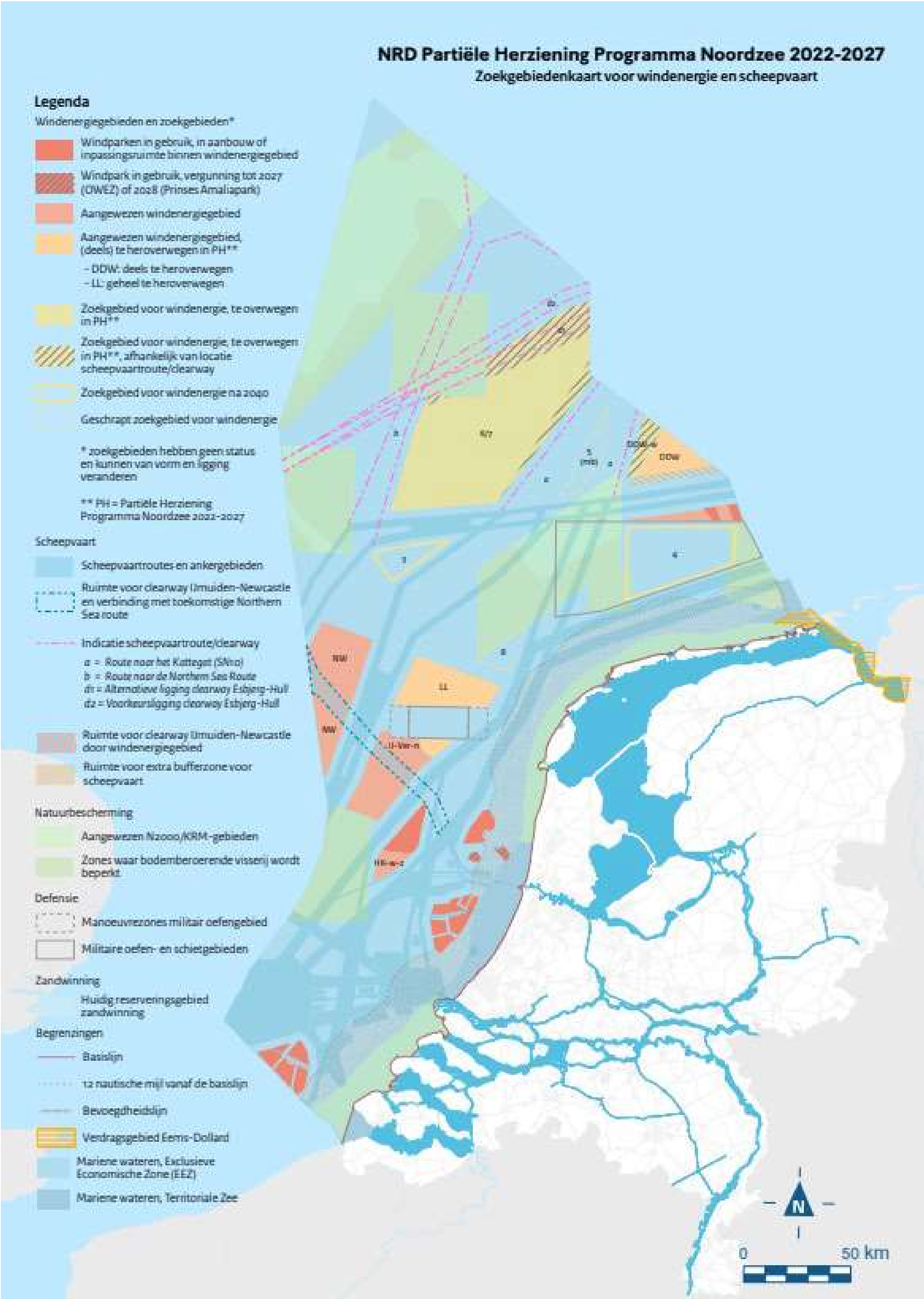

Figure 1-2 Partial revision North Sea

2 DESCRIPTION OF THE MODEL

This chapter gives a description of the model used to determine the collision risk. In the first section, the general outline of the model is presented. The second section describes the part of SAMSON, which is used to calculate frequencies and impacts of ship-platform collisions.

2.1 AIS-data

Since January 2005, it is mandatory for all merchant vessels over 300 Gross Tonnage (GT) to send out AIS-messages. These messages contain information about the ship, such as the Maritime Mobile Service Identity (MMSI)-number, ship type, ship size, and position of the vessel. The messages containing the GPS-position of the vessel are broadcasted every 2 to 10 seconds. This system is developed for collision avoidance, but it is also a valuable source of information on the behaviour of ships. The AIS-data is received by base stations of the Dutch Coastguard along the coast and on some offshore platforms and sent to the Coastguard Centre in Den Helder. MARIN is allowed to use the data for research applications, for example to improve and/or build up the traffic image of the whole North Sea. In addition, analyses of the data are performed to improve the knowledge about the behaviour of vessels at sea.

2.2 Traffic model

The AIS-data is combined with modules of the SAMSON-model: the Safety Assessment Model for Shipping and Offshore in the North Sea. This model was developed for the Dutch ministry of Transport, Public Works and Water Management and is used for the calculation of frequencies and consequences of all sorts of accidents at sea. An important input for SAMSON is the traffic database, consisting of waypoints and connecting links. For each link (line), the number of movements per year for certain ship types and sizes is defined in the traffic database.

2.3 Ship – Platform collision model

Within this study, the ship-platform collision model of SAMSON is used. This is one of the casualty models of SAMSON. Due to different causes, a ship can collide with a platform or drilling platform. In the SAMSON-model, two types of collisions with an object are distinguished: ramming and drifting collisions. Both are shortly described below:

- A ***ramming*** collision occurs when a ship, during normal operation, is on a collision course with a platform and then a navigational error occurs. This error is not detected until after the point of no return, and then the ship collides with the platform. The collision may be at high or low speed depending on the time lapse between the point of no return and the implementation of a corrective action after the detection of the error.
- A ***drifting*** collision occurs when a ship in the vicinity of a platform/rig experiences a failure in the propulsion engine or in the steering equipment. Since the ship slowly becomes uncontrollable as it loses speed, the combined effect of wind, waves and current may carry it towards the platform. If dropping anchor does not help or is not practical and the repair time exceeds the available time, the ship may collide against the platform/rig. This generally happens at a low speed.

A more theoretical description of the model is enclosed in APPENDIX 1.

2.3.1 Probability calculation

For both types of collisions, two probabilities are calculated:

- the probability on the initial event leading to the collision
- the probability that this event will in fact lead to a collision

The product of both probabilities is the probability of a collision. In this section, some explanation is given on the considerations in the determination of the probabilities.

For *ramming,* the initial event is a *navigational error* resulting in a situation in which the ship is on a collision course with the platform. Such an error can for instance occur in case the navigator has left the bridge, or a mistake is made in setting the course, e.g. through incorrect instruments or reading there-of. Heart attack, drunkenness and sleep deprivation are contributory factors to the navigational error. Other infrequent factors are criminal negligence of duty and suicidal behaviour. It is also known that vessels use the platform as a fixed waypoint for navigation: this means that a vessel is oriented towards the installation with the intent of changing navigating away from the collision course well before arriving at the location.

If the error happens at a large distance from the platform, there is a probability that the error can be corrected before the ship collides with the platform. For instance, when the navigator has left the bridge and finds his vessel on a collision course upon his return, he will try to avoid the collision by giving a “full astern” or by initiating an emergency turn. This might prevent the collision or at least reduce the impact.

For *drifting,* the initial event is an *engine failure* resulting in a situation in which the ship is on a drifting collision course with the platform. In this case, there is a probability that the engine is repaired in time and that as such a collision can be averted. Another possibility is that the vessel successfully drops its anchor before it hits the platform. However, dropping the anchor is not always possible due to the presence of cables and pipelines. In addition, the success rate of the action, dropping the anchor, depends strongly on the weather conditions. A number of other methods like ballasting, use of rudder and bow thrusters can be used to obtain a small change in the drifting direction of the ship.

2.3.2 Kinetic energy classes

The result of the calculations is the collision frequency per year, divided over a number of kinetic energy classes. As such, collisions with high and low impact energy can be distinguished. The kinetic energy for the ramming and drifting collision used in these calculations is the worst-case energy value as if the contact with the platform or rig takes place in the direction of the movement of the centre of gravity of the ship. This is certainly not always the case, because of the following reasons:

- for ramming, a platform/rig is not always hit frontally. As a result, a part of the energy may not have to be resisted by the platform;
- for drifting, the first contact point can be spread over the whole length of the ship. The impact energy only approaches the energy value from the calculations when the first contact point lies near the middle of the ship.

3 INPUT FOR THE COLLISION RISK CALCULATIONS

3.1 Platform characteristics

The location of the platform (Table 3-1) was provided by One-Dyas. The orientation of the platform is defined as the smallest angle between the geographical North and the direction of the longest side of the platform.

Table 3-1 Platform characteristics used in calculations

	Position [UTM]		Length (m)	Width (m)	Orientation
	x	y			
F06-A	610149	6076264	47	35	1.4°

Although the upper structure of the platform is high above the water surface, the length and widths are taken as the basis for the platform dimensions. This results in a higher collision frequency than when the legs are taken as the platform contours. The main reason to do this is that the ships, which are considered to actually threaten the platform integrity when colliding, do reach the upper structure. These are the larger vessels: only small vessels like fishing boats can sail below the upper structure without touching the upper structure. The result of this assumption is an overestimation of the collision frequency, but not an overestimation of the consequences, as the vessels that can sail below the structure do not threaten the platform integrity.

3.2 Traffic database

AIS data from 2023 from the Dutch coastguard was collected for a region around the platform. The ship data is split into route bound (RB) and non-route bound (NRB) traffic. Currently, RB traffic in the area where platform F06-A is located, does not need to adhere to a traffic separation schema. This results in many different ship trajectories. In Figure 3-1 all tracks from June 2023 of General Dry Cargo vessels in the neighborhood of the platform location are presented. Figure 3-2 shows the tracks of tankers.

RB traffic is used to create a route network with weighted links, where the weight corresponds to the number of ships that traverse that link on a yearly basis. A density map is created from the NRB traffic, using square cells with an area of 16 km^2 (4 x 4 km cells).
The route network created in the cumulative effects research [Ref 1.] has been used as a basis for the RB traffic database. Two different traffic databases were created, based on the two different scenarios.

- Scenario without windfarm: This traffic database reflects the current situation around the platform. (Figure 3-3)
- Scenario with windfarm: This traffic database represents the situation where the windfarm is present (Figure 3-4). In this case, RB and NRB traffic is not allowed inside the area of the windfarm. In order to reflect this in the traffic database, two changes are made:
  - NRB traffic within the windfarm is replaced to outside of the boundaries of the farm.
  - The links intersecting the windfarms are modified, such that they reflect the expected shipping route.

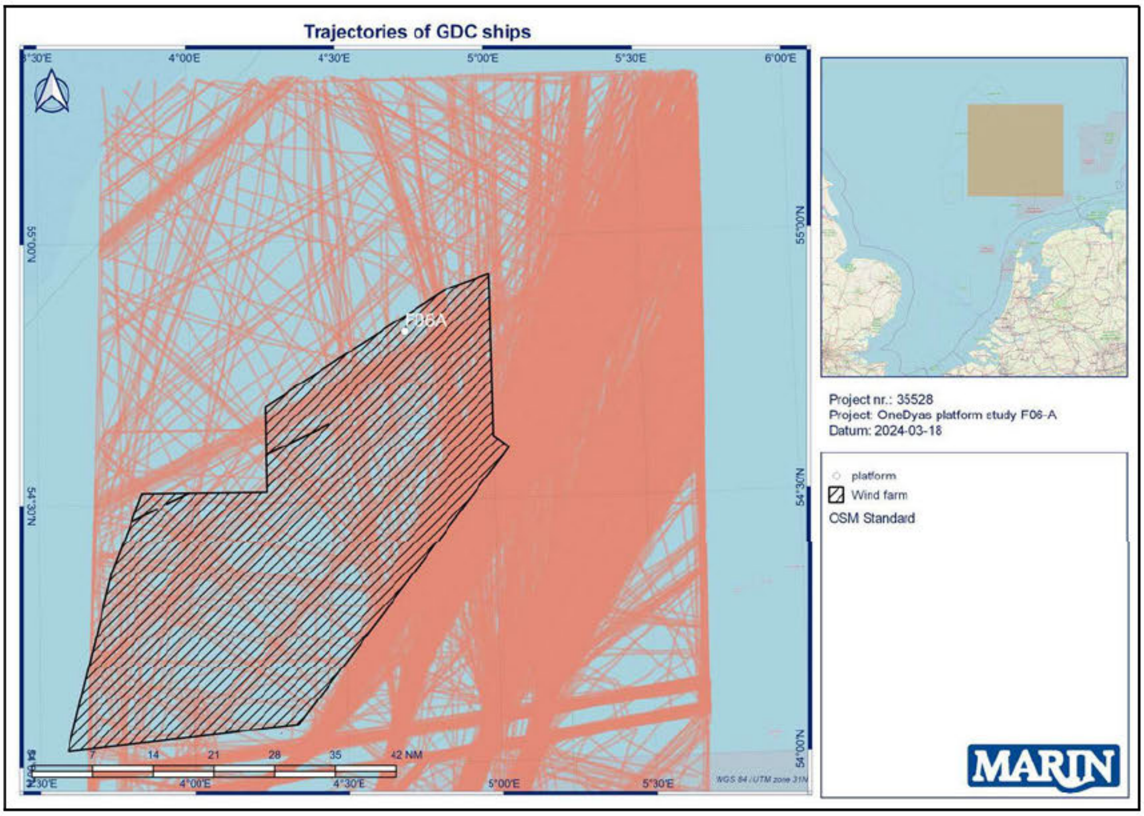

Figure 3-1 A sample of the trajectories of General Dry Cargo vessels in the neighbourhood of platform F06-A.

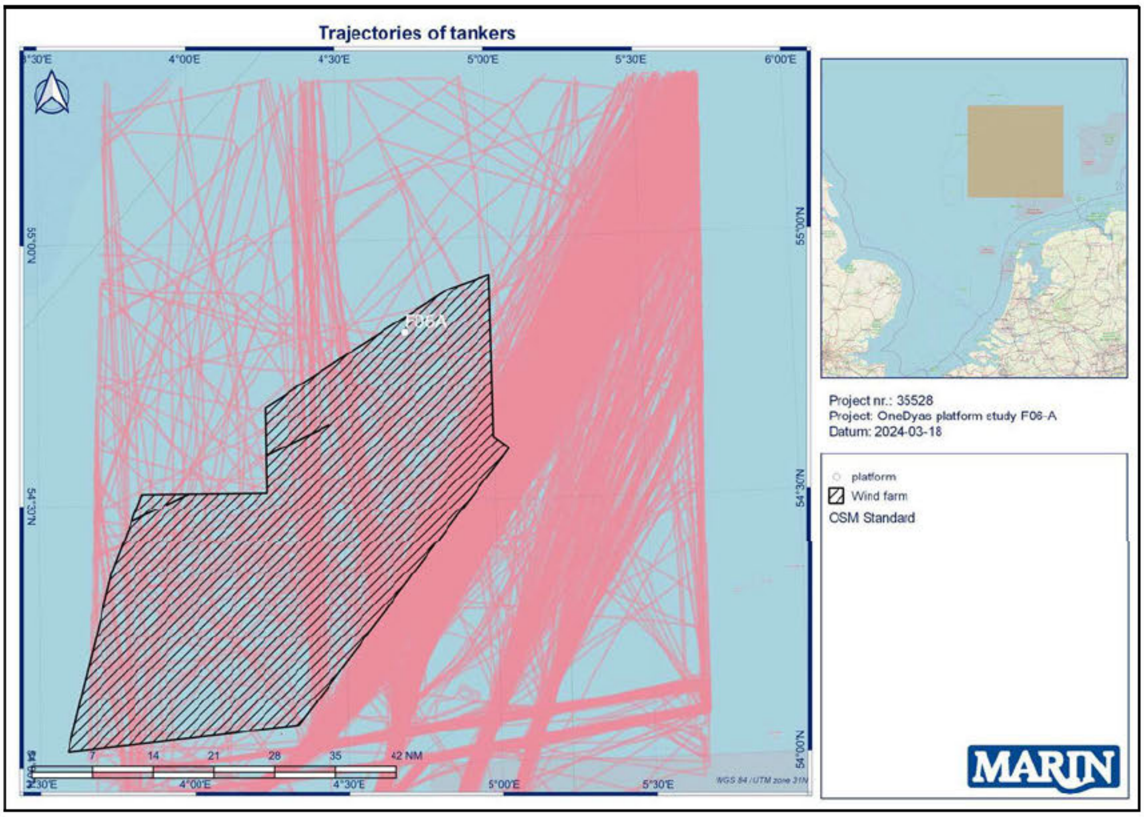

Figure 3-2 A sample of the trajectories of tankers in the neighbourhood of platform F06-A.

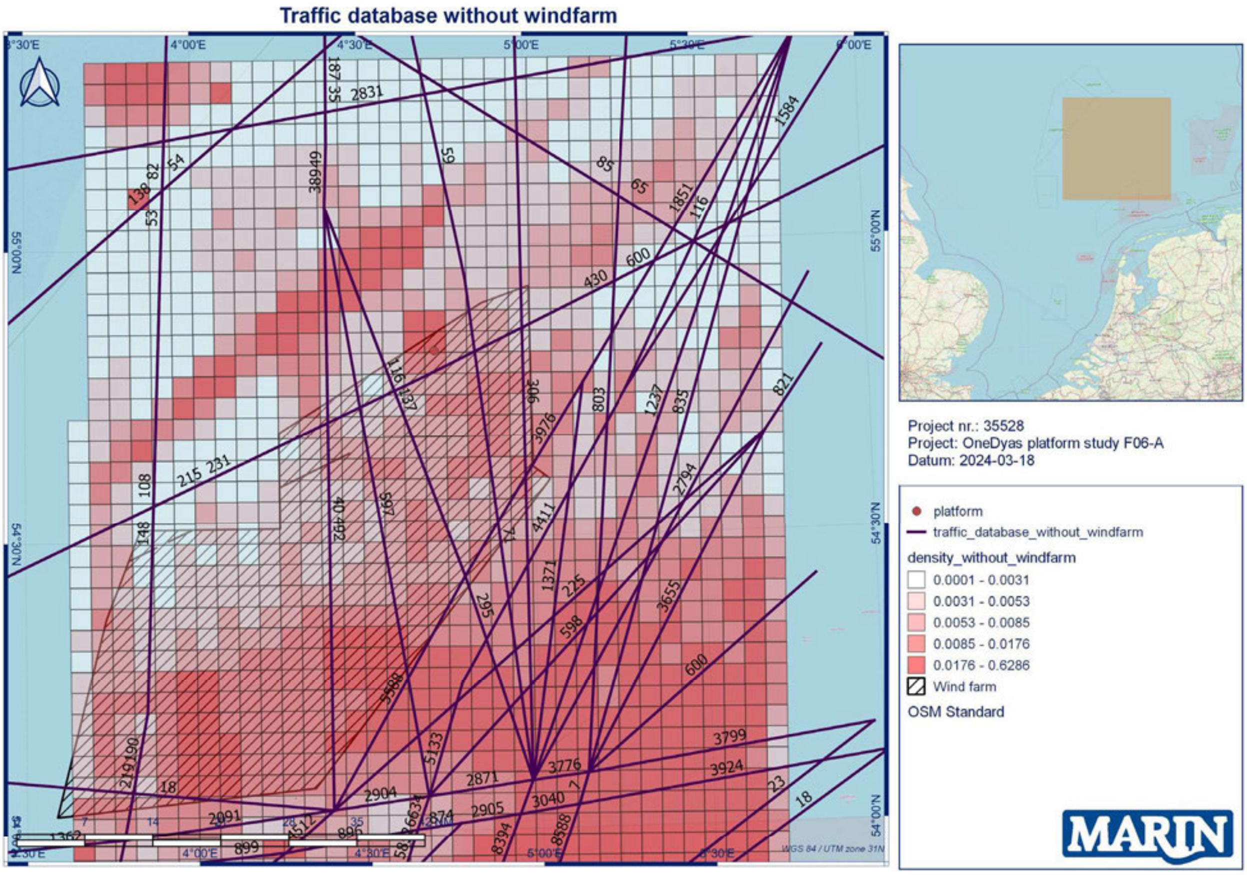

Figure 3-3 The traffic database for the scenario without windfarm. The lines represent the route network. The numbers on the lines are the number of ships that traverse the line in a year. Density_without_windfarm is the density map for NRB traffic, it corresponds to the average number of ships inside a grid cell during 2023.

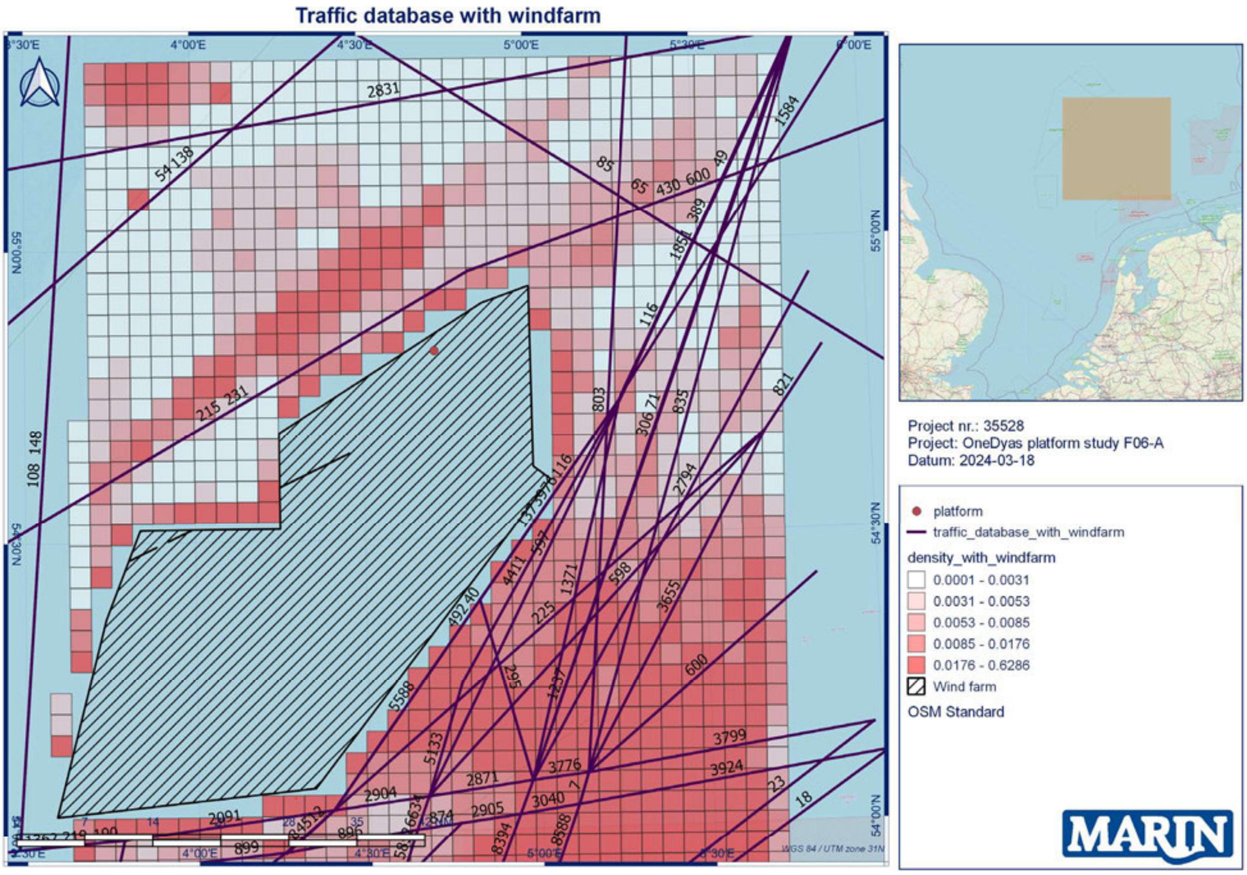

Figure 3-4 The traffic database for the scenario with windfarm. The lines represent the route network. The numbers on the lines are the number of ships that traverse the line in a year. Density_with_windfarm is the density map for NRB traffic, it corresponds to the average number of ships inside a grid cell during 2023.

4 RESULTS

The SAMSON model has been run for the different scenarios. Here, the results are described.
Collision risk decreases in the scenario with windfarm. In the presence of a windfarm, probability of a collision decreases with a factor three (Table 4-1). The largest change is observed in ramming probabilities for RB traffic in size class 6 (Figure 4-1, Figure 4-2, Table 4-4 and Table 4-2 for the definition of the size classes). This is the result of the fact that all RB traffic is modeled out of the area surrounding the windfarm. Collision risk by working vessels that have a destination inside the windfarm are not part of the model.
Similarly, the probability of a collision above a certain kinetic energy level decreases (Figure 4-3, Table 4-3).

Table 4-1 Summary of collision risk results for the platform.

Platform	Scenario	Non-route bound	Route bound	Total probability	Once every ... year
F06-A	With windfarm	3.68e-05	7.10e-06	4.39e-05	22774
	Without windfarm	5.14e-05	1.14e-04	1.65e-04	6062

Table 4-2 The different size classes for ships for RB and NRB traffic.

Size	Non-route bound (GT)	Route bound (GT)
1	0 - 50	0 - 1000
2	50 - 100	1000 - 1600
3	100 - 500	1600 - 5000
4	500 - 1000	5000 - 10000
5	1000 - 1600	10000 - 30000
6	1600 - 5000	30000 - 60000
7	5000 - 10000	60000 - 100000
8	10000 - 1000000	100000 - 1000000

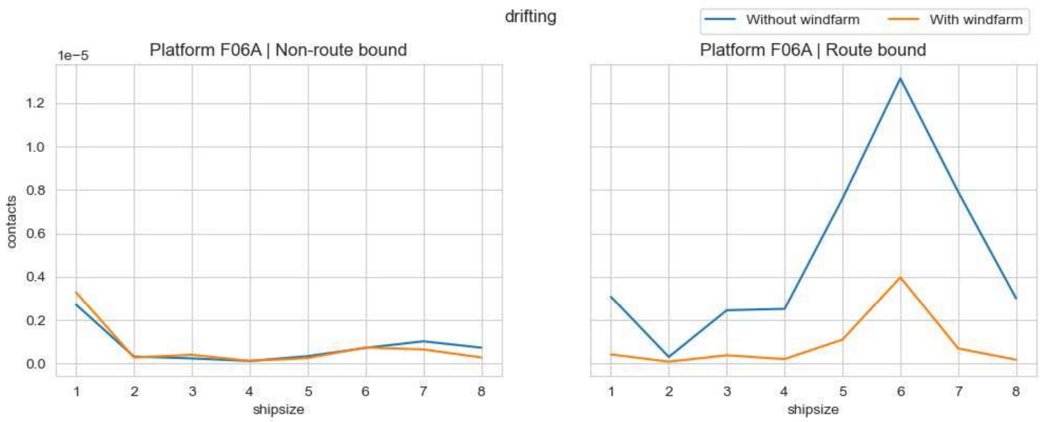

Figure 4-1 The probability of drifting collisions per ship size class.

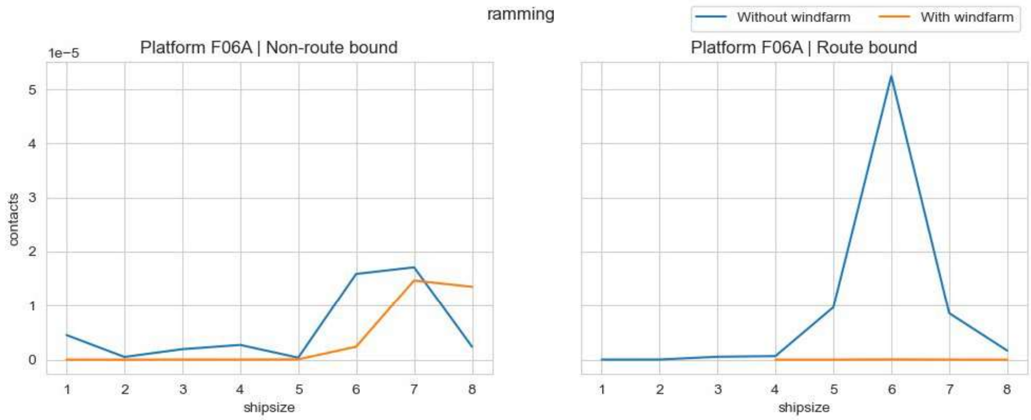

Figure 4-2 The probability of ramming collisions per size class.

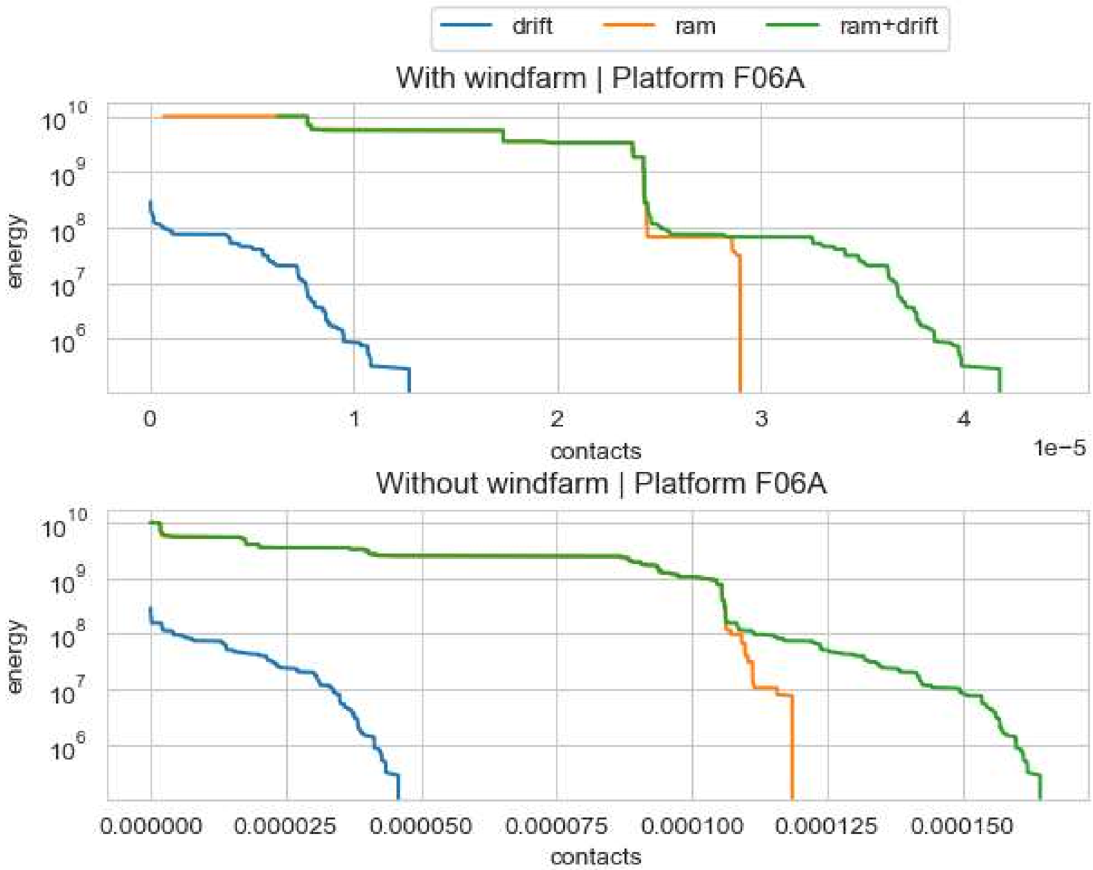

Figure 4-3 Frequency of ramming's / driftings / "rammings+driftings" per year above a certain kinetic energy value for both scenarios. Note that the x axes are different across the plots.

Table 4-3 Probability of collision for different energy classes

	Scenario	Without windfarm			With windfarm		
	Collision type	Drifting	Ramming	Total	Drifting	Ramming	Total
Platform	Energy (MJoules)						
F06-A	<1	4.68e-06	3.43e-07	5.02e-06	3.74e-06	1.61e-06	5.35e-06
	1-3	3.63e-06	0	3.63e-06	9.79e-07	1.89e-12	9.79e-07
	3-5	1.94e-06	0	1.94e-06	6.42e-07	0	6.42e-07
	5-10	2.08e-06	2.83e-06	4.91e-06	2.49e-07	1.31e-08	2.62e-07
	10-15	3.61e-06	4.52e-06	8.14e-06	4.37e-07	8.05e-09	4.45e-07
	15-50	1.46e-05	1.36e-06	1.60e-05	2.84e-06	3.87e-07	3.23e-06
	50-100	1.13e-05	2.66e-06	1.39e-05	3.73e-06	4.18e-06	7.91e-06
	100-200	4.13e-06	1.00e-06	5.13e-06	6.02e-07	1.65e-08	6.18e-07
	>200	7.82e-08	1.06e-04	1.06e-04	5.22e-08	2.44e-05	2.45e-05

Table 4-4 Probability of collision for different size classes

	Scenario	Without windfarm			With windfarm		
	Collision type	Drifting	Ramming	Total	Drifting	Ramming	Total
Platform	Ship size						
F06-A	1	6.36e-06	4.53e-06	1.09e-05	3.14e-06	4.93e-09	3.14e-06
	2	5.85e-07	5.10e-07	1.10e-06	4.11e-07	8.24e-10	4.12e-07
	3	2.86e-06	2.45e-06	5.31e-06	6.23e-07	1.33e-08	6.37e-07
	4	2.64e-06	3.36e-06	6.00e-06	3.29e-07	9.35e-09	3.39e-07
	5	7.86e-06	1.00e-05	1.79e-05	1.44e-06	4.91e-08	1.49e-06
	6	1.39e-05	6.83e-05	8.22e-05	4.70e-06	2.42e-06	7.12e-06
	7	8.57e-06	2.57e-05	3.42e-05	1.72e-06	1.47e-05	1.64e-05
	8	3.29e-06	4.06e-06	7.35e-06	9.11e-07	1.35e-05	1.44e-05

5 CONCLUSION AND DISCUSSION

In this study, collision risk was determined for platform F06-A and two scenarios, without and with windfarm respectively. The Dutch partial revision North Sea [Ref 2.] was used as a basis for this study. Windfarms from Germany were not taking into account, as their defined locations are as of yet unknown. It was determined that the collision risk decreases in the scenario with windfarm. This result was expected, given the fact that in the absence of a windfarm, ships are allowed closer to platforms.

In the present study, it is assumed that RB and NRB traffic remain constant through time. However, due to the vast area of windfarms that is going to be built in the future, the present NRB traffic is in fact expected to decrease vastly. This implies that for the scenario with windfarm, the NRB collision is probably smaller. On the other hand, RB traffic might increase, which would imply higher collision risk.

It should be noted that a platform as well as a windfarm also attracts ships, e.g. for maintenance of the windmills. These ships have to comply with strict safety regulations that differ vastly from regular NRB traffic. This renders it difficult to quantify collision probabilities for windfarm related traffic. On top of that, not much is known about accidents or near misses in windfarms. Nevertheless, possible accidents with these specialized vessels should be taken into account.

REFERENCES

[Ref 1.] 5.1.2.e

SAMSON-analyse Wind op Zee; versnellingsopgave 2030 met doorkijk naar 2040

MARIN, 31797-1-MO-rev.1.0, augustus 2022

[Ref 2.] Rijksoverheid

Concept NRD en Participatieplan | Programma Noordzee 2022 – 2027

(Concept NRD en Participatieplan | Programma Noordzee 2022 - 2027 | Platform Participatie)

ABBREVIATIONS

AIS	= Automatic Identification System
RB	= Route bound
NRB	= Non-route bound
SAMSON	= Safety Assessment Model for Shipping and Offshore on the North Sea

APPENDIX

APPENDIX 1 DESCRIPTION OF THE SHIP-OBJECT CONTACT MODEL SAMSON

Description of the ship-object contact model

Two causes of contact between a ship and an object are revealed during accident analyses:
- a contact as a result of a navigational error,
- a contact as a result of a mechanical failure of the engine or steering engine.

The first type is due to a human failure in the vicinity of an object that cannot be recovered or is first recovered after the point of no return. In some cases, the forces of nature are too large to be compensated for with the power on board. In these cases, the navigator made the mistake to be too close to an object and the vessel has insufficient means to deal with the situation.
The second type is the result of a power failure near an object.
Both accident types have a common characteristic: the vessels are close to an object.

Contact with an object as a result of a navigational error (ramming)

In Figure B-1 a vessel is shown at a distance x from the last waypoint. The vessel proceeds to the next waypoint where the vessel has to change course. For a given position of the vessel, 3 lines are drawn on either side of the vessel track with an interval of 10˚. The object near the vessel is defined as a selection of straight lines between different points. These straight lines are characterized by two geographic positions. In the figure, they are denoted as 1 and 2.

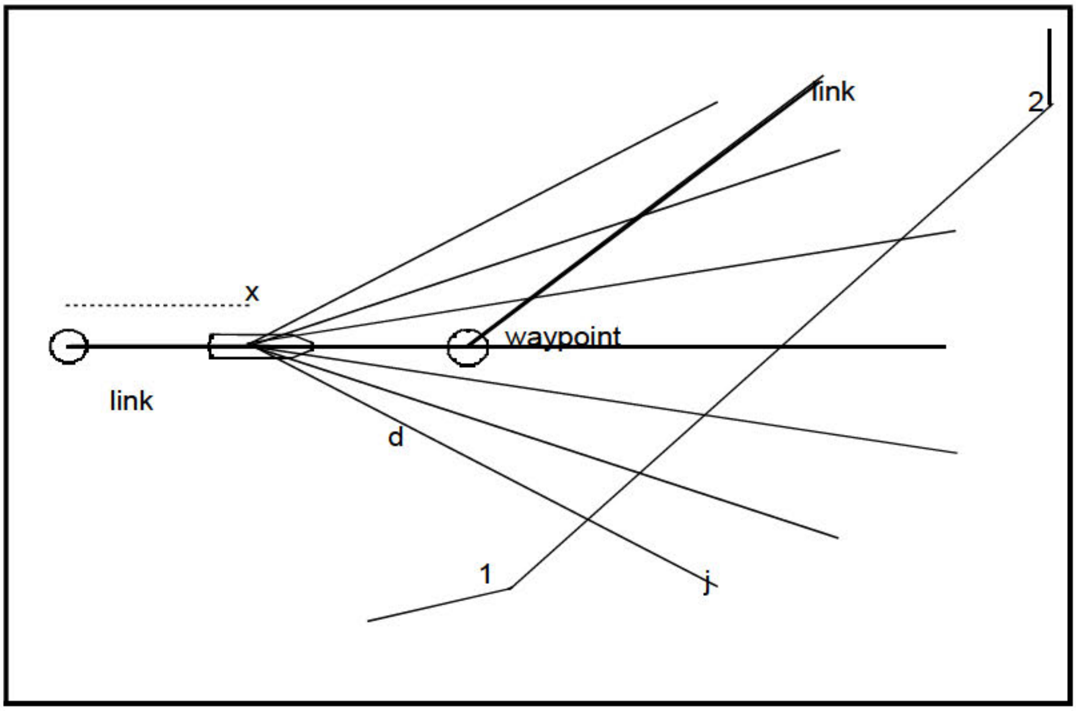

Figure A1-1 Definition of ramming opportunity

Contact with the object (ramming) due to a navigational error can start at every position. The speed at which the navigational error occurs is assumed to be equal to the service speed. The distance to the object, which is expressed by the number of ship lengths, is determined both for the initial course line and for the six new lines. The directions are weighed as follows: 0.05, 0.1, 0.2, 0.3, 0.2, 0.1, 0.05. The number of ship lengths that are available in each direction towards the object indicate the available time for the navigator to mitigate the consequences of his mistake. The probability of a navigational error is related to the distance as follows:

$$p_{nav} = \int_{x_1}^{x_2} e^{-a\frac{d_\psi(x)}{L_i}} dx \qquad (1)$$

with

a	= Danger measure
d_ψ	= Distance of the vessel on the link to the object in direction ψ
L_i	= Ship length of class i
x	= Position of the vessel on a link
p_{nav}	= probability of a navigational error

The best fit between the predicted number of accidents and observed number was found for a = 0.1. This means that the probability of a contact by a navigational error at 6 ship lengths is more than 4 times as large as the probability after a navigational error at 20 ship lengths away from the object.
The ramming opportunity is now given by the following expression.

$$RO_k = \sum_\psi \sum_i p_\psi N_{ij} \int_{x_1}^{x_2} e^{-a\frac{d_\psi(x)}{L_i}} dx \qquad (2)$$

with

N_{ij}	= Number of vessels using link j of vessel class i
p_ψ	= Probability of a course in direction ψ
RO_k	= Ramming opportunity for an object on link k

The number of contacts can be calculated when the ramming opportunity is known:

$$\#contacts_{NE} = CASRAT_{RO} \sum_k RO_k \qquad (3)$$

with

NE	= navigational error
$CASRAT_{RO}$	= matrix with contact rate for contacts due to a navigational error, $0.65 * 10^{-4}$ for each ship.

Contact as a result of an engine failure (drifting)

A contact with an object as a result of an engine failure can, in principle, be initiated at any position of the vessel. The vessel can drift in any direction indicated by the environmental conditions. The distance to the closest object line is a measure for the time available to repair the engine. In this model, the drifting speed is assumed to depend on the Beaufort class.

The probability of an engine failure with a given duration is determined according to the following information:

- a failure between 2 and 6 hours has a frequency of 3R
- a failure of more than 6 hours has a frequency of R

with
R = probability that a vessel has an engine failure of more than 6 hours (number /year)

The value of R is determined using the Lloyds casualty database by the assumption that all vessels with an engine failure of more than 6 hours are assisted by a tug. This number is known. The corresponding value of R equals 10^{-6} /year.

To determine whether drifting results in a contact with an object, two times should be compared:
1. the drifting time: the time between the initiation of the engine failure and the time that the vessels hits an object, and
2. the repair time: the duration of the engine failure.

In other words: a contact occurs when the engine repair time is longer than the drifting time.

We suppose that the engine failure rate can be described by a probability function as follows:

$$p(t) = ce^{-t/T} \tag{4}$$

with

p(t)	= probability of engine failure of a certain time (t)
c	= first engine failure parameter
t	= engine time failure
T	= second engine failure parameter

The parameters c and *T* are calculated using the number of failures with a duration of more than 6 hours and the number of failures between 2 and 6 hours.

$$c = 2.774R$$
$$T = 2.885$$

The probability that the duration of engine failure is larger than the drifting time is given as follows:

$$P(t > t_S) = \int_{t_S}^{\infty} 2.774 \mathrm{Re}^{-t/2.885} dt = 8 \mathrm{Re}^{-t_s/2.885} \tag{5}$$

with

t_s = drifting time

The number of vessels that will hit the object on the danger miles *DM* for a given link k for Beaufort scale b can be determined by the provision of the danger miles *DM*:

$$DM_{bk} = \sum_{n} \sum_{n\psi} \sum_{i} p_n p_{n\psi} N_{ik} \int_{x_1}^{x_2} P(t > d_{n\psi}(x) / v_{dbin}) dx \tag{6}$$

In this equation the following parameters are used:

b = Beaufort class
DM_{bk} = Danger miles for link k and Beaufort scale b
$d_{n\psi}$ = Distance of a point x on a link to the object
i = ship class
k = link
n = loading condition
N_{ik} = Number of vessels in vessel class *i* on link *k*
$p_{n\psi}$ = Probability of a wind direction
p_n = Probability of a loading condition
v_{dbin} = Resulting drifting speed of ship *i* in loading condition *n* at Beaufort scale number b
x = Integration limits are determined by the geographical constraints

The number of contacts is determined by a summation of all links multiplied by the engine failure rate as follows:

$$\#contacts_{EF} = CASRAT_{EF0-7} \sum_{k} \sum_{b=0}^{7} p_b DM_{bk} + CASRAT_{EF8up} \sum_{k} \sum_{b=8}^{11} p_b DM_{bk} \tag{7}$$

$CASRAT_{EF0-7}$ = Engine failure rate for 0-7 Beaufort
$CASRAT_{EF8up}$ = Engine failure rate for 8-11 Beaufort
p_b = Probability of Beaufort class *b*

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