Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 42 (1983)

Artikel: Platform collision risk on the Norwegian continental shelf

Autor: Kristiansen, Svein

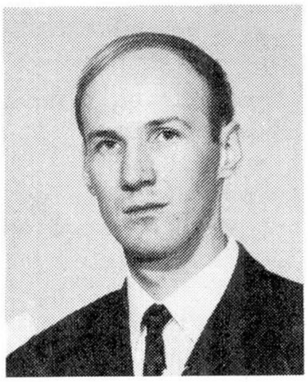
DOI: https://doi.org/10.5169/seals-32415

Platform Collision Risk on the Norwegian Continental Shelf

Probabilité d'une collision de plate-forme en Mer du Nord

Kollisionsrisiko mit »Offshore«-Bauten in der norwegischen Nordsee

Svein KRISTIANSEN
Assoc. Professor
Norwegian Inst. of Technology
Trondheim, Norway



Svein Kristiansen, born 1942, got his Masters degree in Naval Architecture and Marine Engineering from the Norwegian Institute of Technology in 1966. Dr.ing. thesis from 1980 had the title: "Safety in Ship Control – An investigation of ship casualty data".

SUMMARY
This paper suggests a model for the estimation of the ship-platform collision probability. The model is applicable in the risk-assesment phase of the planning and design of offshore installations. An analogy with ship accidents is utilized in the model. The findings from a survey of the marine traffic in the Norwegian part of the North Sea are summarized. The collision probabilities have been estimated for the Statfjord and Ekofisk fields.

RÉSUMÉ
Cette publication présente un modèle de probabilité d'une collision entre un navire et une plate-forme. Ce modèle peut servir pendant la phase d'évaluation de risques de constructions en mer. Ce modèle fait l'analogie avec des accidents de navire et présente le résumé des résultats des observations de la circulation dans la part norvégienne de la Mer du Nord. Les probabilités de collision ont été estimées pour les gisements de Statfjord et de Ekofisk.

ZUSAMMENFASSUNG
Diese Arbeit schlägt ein Modell für die Berechnung der Kollisionswahrscheinlichkeit Schiff-Plattform vor. Das Modell ist für Planung und Entwurf von Offshore-Bauten der Risikoanalyse angepaßt. Das Modell setzt eine Analogie mit Schiffsunfällen voraus. Die Ergebnisse einer Studie des Seeverkehrs in den norwegischen Nordseegebieten werden erläutert. Die Kollisionswahrscheinlichkeiten auf Statfjord und Ekofisk sind näher untersucht worden.

1. INTRODUCTION

Platform installations in the North Sea are exposed to a number of risk phenomena. One of these is the collision with a vessel or other mobile unit. The marine traffic is usually structured as follows: Visiting vessels, nearby traffic and passing ships. This paper is confined to the probability of collision between a passing vessel and a platform. Because of speed and displacement the collision with a passing vessel represents one of the greatest accidental loads to the platform. So far, only one collision of this type has been reported [1].

National Maritime Institute in Great Britain have done pioneering work in the field of platform collision risk estimation. It is referred to reports by Anonymous [2], Batchelor, Chalk and Lewison [3] and Barratt [4]. The models for collision probability is largely based on analogies with the ship-ship collision scenario. The traffic exposure have been studied through various forms of surveys. Similar models have been suggested by Goodwin and Kemp [5].

Accident phenomena as ship-ship collision, grounding and stranding are better known than the ship-platform collision. This is both in terms of models and empirical data. We shall only briefly list some of the contributions in the field of marine traffic research: Oshima and Fujii [6], Fujii and Shiobara [7], Fujii and Tanaka [8], Fujii, Yamanouchi and Mizuki [9], Lewison [10], Dare and Lewison [11], Lewison [12], Macduff [13], Van der Tak and Spaans [14], Kwik and Stecher [15], Kwik [16], Kwik [17], Krappinger [18], Krappinger [19], Chen [20].

The analysis and understanding of the failure processes that may lead to platform collisions are by no means complete. One reason for this is the simple fact that these collisions are very rare events. We have for instance not been witness to collisions between merchant ships and platforms in the North Sea to this day.

Experience from groundings and ship-ship collisions further indicate that this type of casualty has a rather complex nature. The main components of the collision-process are following phases: Exposure, initiation, causation, structural and system damage and development of consequences. The actual casualty may take one of a number of potential patterns or sequences.

It is further a situation or scenario for a collision. This is the set of passive factors such as the fairway and the platform located in the fairway. The situation is further characterized by its exposure to weather and sea.

The initiating element is the traffic near the platform. Under normal conditions this traffic will pass without any incidents. The degree of risk or probability that this traffic can lead to collisions may be related to factors as traffic density, ship characteristics and symptoms like the number of infringements of regulations applying to the traffic.

The most complex and less understood component is the causation process. This is so because the accident often develops as an interaction between organizational, human, technical and ergonomic factors. The interaction process is both timedependent, multidimensional, dynamic and stochastic in its nature. The MORT system Johnson and Lowman [21] was developed as framework for the analysis of such accident phenomena. The author of this paper has studied the causal factors of groundings and ship-ship collisions. See the report by Karlsen and Krisitansen [22]. Another interesting approach is the socalled Task Analysis. See Smith et al [26].

The rest of this paper will be devoted to the estimation of platform-collision probability. The model that is suggested is based on concepts familiar in traditional marin traffic research. It is hoped that the model will contribute to a more unified analysis of casualties of the impact-type.

2. ACCIDENT PROBABILITY

2.1 Model concept

The model that will be presented in this paper is applicable both to ship accidents and ship-platform collisions. The model scenario is as follows. A limited fairway-section is given. This fairway may have obstructions like coastlines, shoals, offshore platforms and ship traffic. A vessel enters the fairway section and may loose control during the passage due to navigation error, mismanouvre or system failure. Loss of control is assumed to give the ship a linear course with random heading. The ship may then hit one of the obstructions in the fairway. The probability of such an impact is a function of the fairway-geometry and ship-kinematics.

Assuming that a fairway segment is exposed to N ship passages, the expected number of accidents of a certain kind is given by:

$$C = N \cdot P \cdot I \cdot K \qquad (1)$$

where the probability of loss of control is taken as a function of distance sailed, D, and the failure intensity, μ:

$$P = \mu \cdot D \qquad (2)$$

The expected number of impacts per passage assuming non-control, I, is a function of the accident scenario. The most common scenarios will be described in the following paragraphs.

The visibility is viewed as the most dominating external parameter. The model takes account for visibility by means of the factor K.

2.2 Grounding, stranding

The situation where a ship may ground in a straight fairway is depicted in figure 1. It is easy to show that the expected number of groundings per passage given a random course is given by:

$$I_G = \frac{B+C}{W} \qquad (3)$$

The numerator expresses the sum of ship breath and effective cross-section of the shoal. Studies by Fujii, Yamanouchi and Mizuki [9] indicates a probability of loss of control in the range of:

$$P_G = 2 \cdot 10^{-4} \qquad (4)$$

The stranding scenario is also shown in figure 1. Assuming a random course ahead we get as follows:

$$I_S = \frac{\alpha}{\pi/2}$$

This expression is based on the average position during the passage of the fairway distance D. Using a series-approximation we get the expression:

$$I_S = 1 - \frac{2 \cdot W}{\pi \cdot D} \quad (5)$$

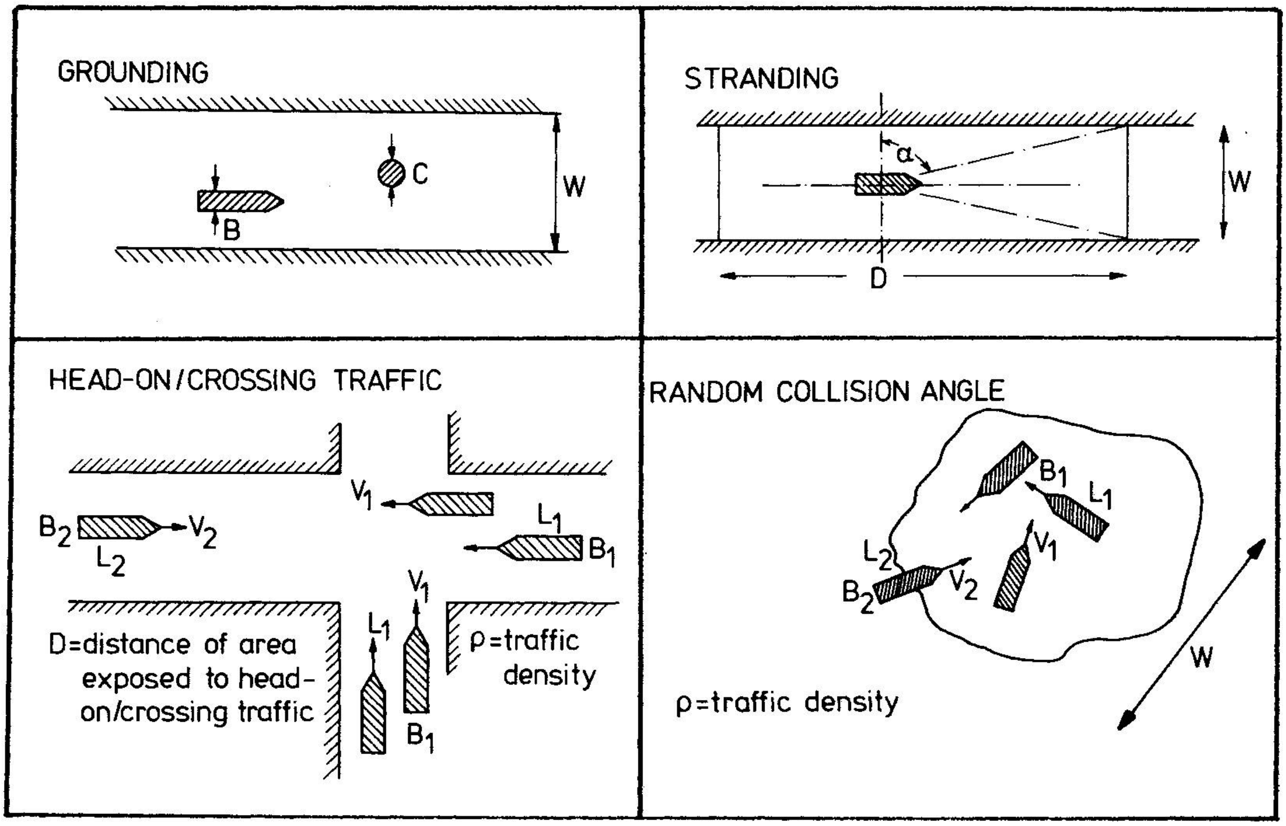


Figure 1. Ship accident scenarios

Fujii, Yamanouchi and Mizuki [9] has also estimated the loss-of-control intensity for strandings:

$$\mu_S = 2 \cdot 10^{-5} \text{ failures/n.mile} \quad (6)$$

2.3 Ship-ship collisions

Figure 1 describes the most typical collision scenarious: Head-on, crossing and random traffic. We assume that own ship (indexed 2) is exposed to the traffic in a fairway (indexed 1). The fact that both ships may contribute to a collision gives following modification of the basic model (equation 1):

$$C = 2 \cdot N \cdot P \cdot I \cdot K \quad (7)$$

Assuming straight traffic flows it is a rather simple task to develop expressions for the expected number of collisions per passage for own ship:

Head-on : $I_{CH} = (B_1+B_2)(V_1+V_2)\ \frac{D}{V_2}\cdot\rho$ (8)

Crossing: $I_{CC} = ((L_2+B_1)V_1 + (L_1+B_2)V_2)\ \frac{D}{V_2}\cdot\rho$ (9)

Length and breadth of ship are expressed by L and B, and speed by V. The models are also functions of distance, D, and traffic density, ρ.

Chen [20] has suggested a model for a random traffic pattern. Assuming average values for main ship dimensions and speed Kristiansen [23] has suggested:

$$I_{CR} = (\frac{4}{\pi}\cdot L + 2\cdot B)\ W\cdot\rho \quad (10)$$

Analysis of studies by Chen [20] and Lewison [12] indicates loss-of-control failure intensities in the following range:

Situation	μ(failures/n.mile)
Head-on	$3{,}0\cdot10^{-5}$
Overtaking	$1{,}5\cdot10^{-5}$
Crossing	$1{,}5\cdot10^{-5}$
Random crossing	$2{,}0\cdot10^{-5}$

2.4 Reduced visibility

The values for loss-of-control intensity, μ, quoted in the preceeding paragraphs is based on the visibility conditions prevailing in Dover. The visibility may be described with following parameter:

$$VR = 330\cdot t_1 + 20\cdot t_2 + t_3 \quad (12)$$

where t_i expresses the relative occurence of visibility code i. Following values have been estimated by Lewison [10] for Dover:

Code:	i	1	2	3
Range		<200 m	200m-4km	4 km<
Occurence:	t_i(%)	0,76	4,96	94,28

The correction factor for Dover can then be computed:

$$VR_D = 4{,}44$$

This means that the expected number of accidents in Dover is more than four times as high as clear weather conditions would suggest.

We are now able to take account for the visibility, expressed by VR, in other waters:

$$K = VR/VR_D \quad (13)$$

The model is in general also confirmed by Fujii and Yamanouchi [24].

2.5 Ship-platform collisions

As already pointed out the probability of collision between ship and platform can not be based on empirical data. We will now propose a model which is the analogue to the ship-accident scenarios presented in the preceeding paragraphs.

Figure 2 describes a situation where a platform is exposed to a colinear traffic flow of ships. This is identical to the situation where the platform "moves" with the same speed, V, relative to the "stationary" ships. During a time period, T, following area is exposed to collisions:

$$A = (B+E)\cdot V\cdot T \qquad (14)$$

Assuming a traffic density, ρ, we get following expression for the expected number of ship-platform collisions:

$$C = T\cdot P_{PC}\cdot(B+E)\cdot V\cdot\rho\cdot K \qquad (15)$$

In the absence of any estimate for the probability of loss of control in the vicinity of a platform, following average value for ship accidents is suggested:

$$P_{PC} = 2\cdot 10^{-4}$$

The interval of uncertainty should at this stage of knowledge at least be: $1\cdot 10^{-4}$ to $3\cdot 10^{-4}$.

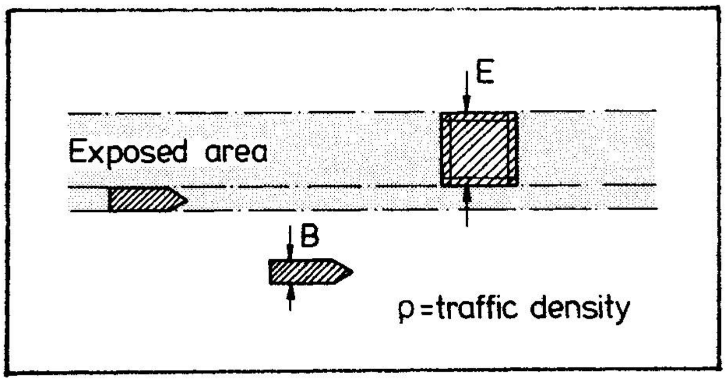


Figure 2. Ship-platform scenario

3. EXPOSURE TO PASSING TRAFFIC

3.1 Coast Guard Data

The marine traffic in the Norwegian economic zone is observed on a near continous basis by Coast Guard vessels and airplanes. Coast Guard observation data have been analysed by Laheld [25] and Gunnersen [26]. These data are the basis for the collision probability estimates in this paper. Figure 3 shows the average merchant ship traffic density (ships per 1000 nm^2) for the period 10.09.1981 - 21.07.1982.

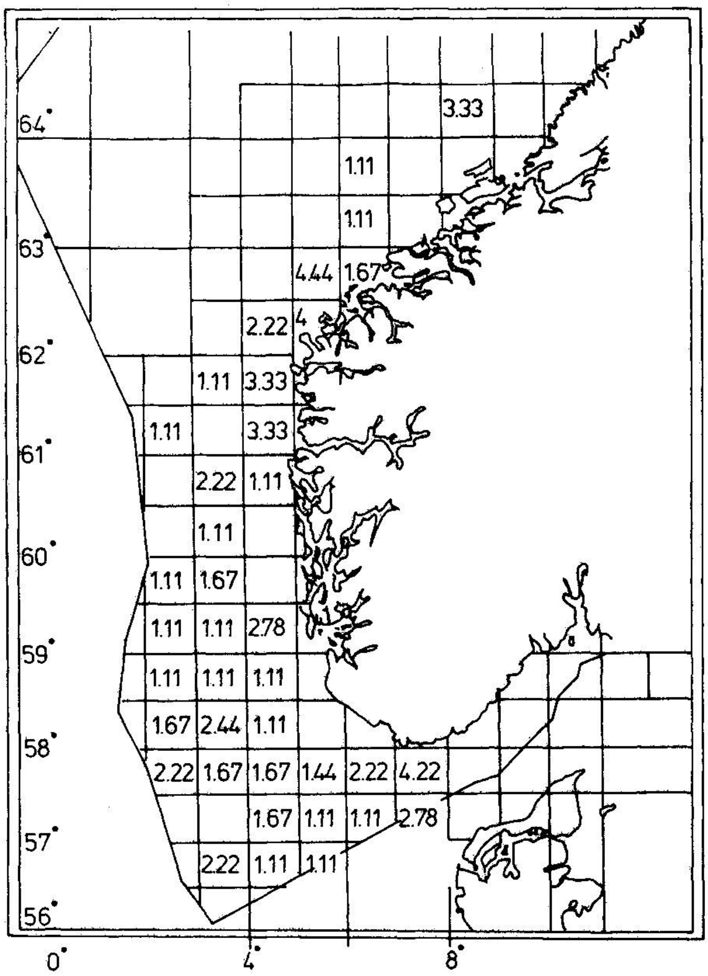


Figure 3. Merchant ship traffic density.
(Ships/1000 nm^2). 10.09.81-21.07.82.
Monthly air patrol observations.

3.2 Traffic desity

The traffic density of merchant and fishing vessels have been estimated for the Norwegian economic zone south of 62°N. These estimates were based on monthly air observations in the period January 1981 - July 1982. A rate of detection of 70% was assumed [2]. The average traffic density is $2{,}08 \cdot 10^{-3}$ ships/km^2 which compares well with $1{,}95 \cdot 10^{-3}$ based on NMI-data [2]. Estimates for Statfjord and Ekofisk are shown in table 1.

Table 1. Traffic density in the Norwegian economic zone (ships/1000 km^2)

Area	Fishing vessels	Merchant ships	Total
South of 62°N	1,46	0,62	2,08
Statfjord	0,77	0,40	1,18
Ekofisk	0,56	0,80	1,36

At Statfjord merchant ships represent 34% of the traffic whereas it comes to 59% at Ekofisk.

3.3 Traffic near installations

The traffic density estimates are based on observations in localities of 900 nm^2. It has been shown in a number of studies that a considerable part of the marine traffic will avoid potential hazards in the fairway. This means that the traffic density in the vicinity of an installation is lower than the density for the corresponding locality. Based on local surveys for Forties and Statfjord [3] and [27] the reduction factor for traffic inside a 12 nm annulus is conservatively estimated to 30%. This gives following merchant ship density near installations:

- Statfjord field: $0{,}12 \cdot 10^{-3}$ ships/km^2
- Ekofisk field: $0{,}24 \cdot 10^{-3}$ "

4. COLLISION PROBABILITY

4.1 Expected number of collisions with merchant ships

In order to estimate the number of collisions in a period platform dimensions, traffic speed and visibility must be established. The assumed characteristics for Statfjord and Ekofisk are summarized in table 2. Both a single platform and the whole field are studied.

Table 2. Model paramtres

Field		Statfjord	Ekofisk
Collision diameter B+E (km)	Platform	0,090 1)	0,203 2)
	Field	0,326	1,857
Visibility: K		0,88	1,25
Ship speed (m/sec)		5,2	5,2

1) Condeep-platform 2) Albuskjell 2/4 F-PDQ

The expected number of collisions with merchant ships in one year has been computed by means of formula (15). The results are shown in the first line of table 3. It appears that the expected number of collisions for the Albuskjell 2/4 F is more than 6 times as high as for a Condeep platform at Statfjord. Further, the estimates indicate that the expectancy of collision at Ekofisk is more than 16 times as high as for Statfjord.

4.2 Collision probability

By assuming that collisions can be described by a Poisson-distribution, we are able to estimate the probability that a collision will happen in the course of the field-life. From table 3 it appears that the probability of a collision at Statfjord in 30 years is 28%. This must be viewed as an alarming high figure. The implication of the model is further that a collision at Ekofisk in the course of 15 years is almost sure to happen (94% probability).

Table 3. Expected number and probability of collision

Platform or field	Condeep	Statfjord	Albuskjell	Ekofisk
Collisions per year: C	$3{,}1 \cdot 10^{-3}$	$1{,}1 \cdot 10^{-2}$	$20{,}0 \cdot 10^{-3}$	$18{,}3 \cdot 10^{-2}$
Production period (years)	30	30	15	15
Probability of at least one collision	0,088	0,28	0,26	0,94
Operation period (years)	5		10	
Probability of no collision	0,98		0,82	

The above given conclusions may perhaps be viewed as contradicted by our experience so far, looking to the fact that no collision has happened to this day. A closer look, however, shows that this argument should be rejected. The probability of not having a collision in say 5-10 years has been computed by means of the model. A collision with a Condeep-platform in 5 years is not a likely event (98%). Even a collision with an Albuskjell platform type in 10 years is not very probable.

5 CONCLUSIONS

The model presented in this paper indicates that a collision with a platform in the Norwegian zone is much likely to happen in the course of a field's life. The conclusion is, however, based on experience from ship accidents and limited traffic data.

It is recommended further research on the modelling of platform collisions and more extensive traffic surveys. This will enable us to give better estimates of the collision probability.

REFERENCES

1. NATIONAL TRANSPORTATION SAFETY BOARD, U.S. Tankship SS TEXACO NORTH DAKOTA and Artificial Island EI-361-A Collision and Fire, Gulf of Mexico; 21 August 1980, NTSB-MAR-81-4.
2. ANONYMOUS, The Risk of Ship/Platform Encounters in UK Waters. Feltham: National Maritime Institute, NMI Report R39, 1978.
3. BATCHELOR, K.S., CHALK, R.F., LEWINSON, G.R.G., Survey of Shipping in the Forties Field 1978. Feltham: National Maritime Institute, NMI Report R52, 1979.
4. BARRAT, M.J., Collision Risk Estimates in the English Channel and Western Approaches. Feltham: National Maritime Institute, NMI Report R115, 1981.
5. GOODWIN, E.M., and KEMP, J.F., Collision Risks for Off-shore Structures. Journal of Navigation, vol. 33 no. 3, p.351, 1981.
6. OSHIMA, R. and FUJII, Y., The Diameter of evasion for crossing encounters. Journal of Navigation, vol. 27 (1974), no. 2 April, p. 235.
7. FUJII, Y., and SHIOBARA, R., The analysis of Traffic Accidents. Journal of Navigation, vol. 24 (1971), no 4, p. 534.
8. FUJII, Y., and TANAKA, K., Traffic Capacity. Journal of Navigation, vol. 24 (1971), no. 4, p. 544.
9. FUJII, Y., YAMANOUCHI, H., and MIZUKI, N., The Probability of Stranding. Journal of Navigation, vol. 27 (1974), no. 2, p. 239.
10. LEWINSON, G.R.G., The Risk of a Ship Encounter Leading to a Collision. Journal of Navigation, vol. 31 (1978), no. 3, p. 384.
11. DARE, S.C., and LEWINSON, G.R.G., The Recent Casualty Record in the Dover Strait. Journal of Navigation, vol. 33 (1980), no. 1, p. 192.
12. LEWINSON; G.R.G., The Estimation of Collision Risk for Marine Traffic in UK Waters. Journal of Navigation, vol. 33 (1980), no. 3, p. 317.
13. MACDUFF, T., The probability of vessel collisions. Ocean Industry, 1974, September, p.144.

14. VAN DER TAK, C., and SPAANS, J.A., Model to Calculate A Maritime Risk Criterium Number. Navigation, vol. 23 (Winter 1976-77), no. 4, p. 343.

15. KWIK, K.H., and STECHER, W., Erfassung von Kenndaten für die Sicherheit von Schiffen im Seeverkehr. Institut für Schiffbau der Universität Hamburg, Bericht Nr. 359.

16. KWIK, K.H., Evaluation of the Safety of Ships in Traffic. Institut für Schiffbau der Universität Hamburg, Bericht Nr. 370. Januar 1979.

17. KWIK, K.H., Kinematik der Begegnung von Schiffen und Kollisionverhütung mit einer Betrachtung der Fahrregeln. Institut für Schiffbau der Universität Hamburg, Bericht Nr. 294, September 1973.

18. KRAPPINGER, O., Ansätze zur Bestimmung der Kollisionsrate. Institut für Schiffbau der Universität Hamburg, Bericht Nr. 295, Oktober 1973.

19. KRAPPINGER, O., Safety Calculations applied in ship systems. Paper at One-day seminar held April 5th 1978 at the Norwegian Institute of Technology, University of Trondheim.

20. CHEN, E., Analysis of Ship Collision Probabilities. Paper presented at the Fouth International Symposium on Transport of Hazardous Cargoes by Sea & Inland Waterways, Jacksonville, USA, 26-30 October 1975.

21. JOHNSON, W.G., and LOWMAN, G., The Management Oversight & Risk Tree - MORT. Washington D.C.: U.S. Government Printing Office. Reprinted by Energy Research & Development Administration, report no. SAN 821-2.

22. KARLSEN, J.E., and KRISTIANSEN, S., Analysis of Causal factors and situation depentent factors. Det norske VERITAS, report no. 80-1144, December 1980.

23. KRISTIANSEN, S., Probability of ship collision (in Norwegian). Division of marine system design, Norwegian Institute of Technology, lecture notes in Marine Traffic Engineering, Trondheim October 15th 1982.

24. FUJII, Y., and YAMANOUCHI, H., Visual Range and the Degree of Risk. Journal of Navigation, vol. 27 (1974), no. 2, p. 248.

25. LAHELD, B.C.H., Ship traffic on the Norwegian Continental Shelf south of 65^{o}N Latitude. Det norske VERITAS, note no. FDIV/20-82-014, July 15th 1982.

26. SMITH, J., et al., Task Analysis Report Relative to Vessel Collisions, Rammings and Groundings. Operations Research Inc., Maryland. CG-D-1-77, 1976.

27. GUNNERSEN, N.G., Traffic density near installations in the North Sea. (In Norwegian). Masters Thesis. Division of marine system design, Norwegian Institute of Technology, Trondheim, 1981.