

# Estimating Manoeuvres Safety Level of the Unity Line m/f "Polonia" Ferry at the Port of Ystad

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**ABSTRACT:** Briefly characteristic of m/f „Polonia” ferry has been presented. For the port of Ystad, topographical, hydro and meteorological conditions have been described. Moorings of the “Polonia” ferry at the port of Ystad have been discussed. Researches based on experts’ questionnaire and statistical methods of analyses have been exemplified. Finally there are some conclusions concerning improvements of ferries manoeuvres safety.

## 1 INTRODUCTION

Estimating moorings manoeuvres safety level is a basic problem undertaken in the procedure of manoeuvre planning. Captain or Pilot manoeuvring the vessel needs to take into consideration the vertical and horizontal restrictions of the navigating area. During vessel manoeuvre process it is necessary to take also into consideration other important factors such as hydro meteorological conditions, equipment and standard of technical maintenance of the vessel, deck and engine crew qualifications, the condition of navigational aids of the navigational area, the intensity of vessel traffic and the quality of local Vessel Traffic Service.



Figure 1. View of m/f “Polonia”.

Researches evaluating the level of safety moorings manoeuvres of the m/f “Polonia” ferry at the port of Ystad based on experts’ questionnaire have been carried out. Researches of manoeuvres only one vessel, verified during more than 10 years of experience, at only one port give the chance to reject influence of factors others than selected in hypothetical questionnaire. Researches were conducted for the following variables: force and direction of wind, visibility, day and night manoeuvres. Additional var-

iable has been introduced: manoeuvres done with or without Ferry Nautical Anti-collision System (FNAS) – specialized equipment type of Electronic Nautical Chart. Experts asked in questionnaire were captains with manoeuvring experience of m/f “Polonia”. Every one of them was a holder of suitable pilot exemption certificate. 16 experts completed and returned the questionnaire.

## 2 OBJECT AND PLACE OF RESEARCHES

Unity Line m/f “Polonia” ferry was built in 1995 at Norwegian Shipyard Langsten Slip & Batbyggeri A/S in Tomfjord. She is modern passenger rail car ferry, especially designed for Świnoujście - Ystad service. The ferry is berthed at Ystad’s rail ferry Stand no 4. Below are some technical and manoeuvre data of m/f “Polonia”:

over all length 169,9 m, breadth 28 m, GRT 29875;

4 main engines Stork-Wartsila type each 3960, kW clutched in twos, each pair drive one of two controllable pitch propeller;

behind each of propeller double, Becker type flap rudder is situated;

3 bow thrusters, 1 stern thruster, each 1600 kW Brunvoll SPA-VP type;

summer draft 6,2 m corresponding to wind pressure area 3250 m<sup>2</sup>;

4 navigational radars, first radar aerial is situated on the bow, second on stern, last two are on radar mast above wheelhouse.

M/f "Polonia" is equipped with Ferry Nautical Anti-collision System (FNAS). FNAS is a kind of Electronic Nautical Chart (ENC) with some function specially designed for pilot's passages and manoeuvres.



Figure 2. View of m/f "Polonia" manoeuvring controls on port side wing.

On the bridge in a centre, main ferry controls are located. M/f "Polonia" always berths port side for this reason on bridge port wing additional ferry steering and manoeuvring control equipment are located. Main controls are joysticks of both controllable pitch propellers, coupled in one joystick which control three bow thrusters, another one for stern thruster, hand wheels for each main rudders with possibility of synchronized operation. On steering console FNAS LCD monitor is mounted. Above it is the monitor of ship's internal TV system with a selected view of ferry area.

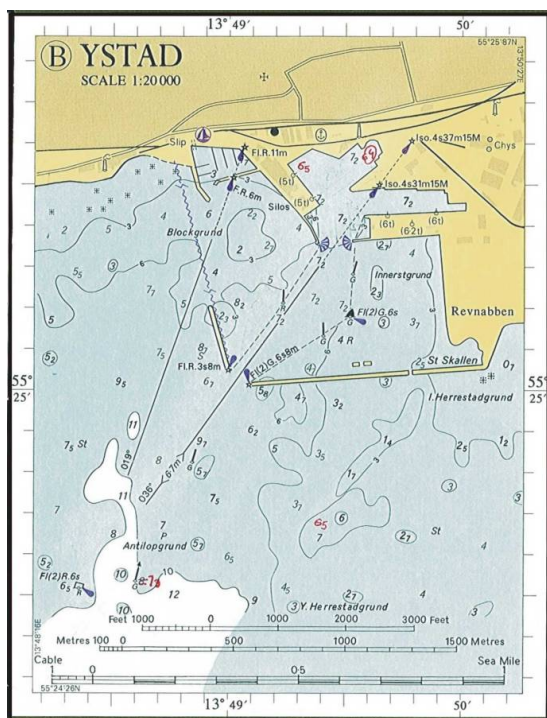


Figure 3. Nautical chart of Ystad and approaches. [BA Chart, UKHO]

Port of Ystad is located on the southern Baltic coast of Sweden. Due to its location the port is well sheltered from northerly winds, but is fully exposed to winds from southern directions. Force of easterly winds is only a little reduced due to port location on south-eastern cape. Ystad port is relatively well secured from westerly winds. The inner port area has additional protection from west by high grain silos and port's buildings along the western quay - Vastra Kajen.

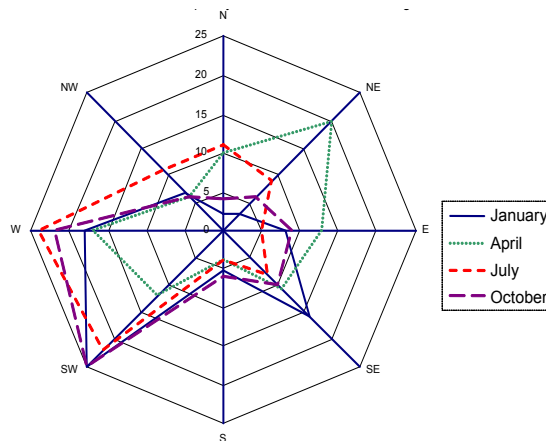


Figure 4. Mean values of wind occurrence form given directions for each quarter of year. [data UKHO, BSH]

M/f "Polonia" was designed as maximum size ferry for berthing at rail stand no 4. Then for summer draft 6,2 m, the ferry has only 0,5 m draft reserve. At the port water level is changing according to the same rules as all south-western Baltic. When strong wind is blowing from southern and south-western directions, water level is rapidly falling down to 1 meter below mean water level. In this hydro and meteorological conditions during powerful manoeuvres of own propellers and thrusters the shallow water effect is of great importance.

### 3 MANOEUVRING OF THE FERRY M/F "POLONIA" IN YSTAD

During multi year operation of the ferry, methods of manoeuvres were standardized and optimized. Since the ferry was properly designed for the Świnoujście – Ystad line, for the changed hydro and meteorological conditions manoeuvring strategy will not be changed. Only some adjustments of settings for propellers and thrusters will be necessary.

Based on captain's experience, some stages of manoeuvres of m/f "Polonia" at Ystad were separated. Criteria of manoeuvres division was the goal done on each separate stage. 8 stages for entry manoeuvres and 5 for departure were obtained. The table on figures 5.1 and 5.2 show manoeuvres division

placed at expert's questionnaire including events discriminating the stages.

Scale of difficulty and complication of manoeuvres can easily estimate based on the ferry speed on each stage of mooring. When passing the outer heads (110 m distance between heads) speed is about 10,5 kts, in the inner heads about 7 kts. At the beginning of slow down at the moment of reversing the engine speed is about 5,5 kts and at this speed on a distance of 130 m, the ferry stops and continues left side turning. In very good hydro meteorological conditions at wind force 0 m/s, the ferry passes concrete elements of ports infrastructure on the distance of 20 – 25 m. The distances to piers and breakwaters are reduced rapidly simultaneously with the deterioration of hydro meteorological conditions.

#### 4 EXPERT RESEARCHES OF MOORING SAFETY

Researches were based on anonymous questionnaire reverred directly to respondents. Every respondent received 12 sheets with relevant questions. Each questionnaire consists of entering or departure manoeuvres tables, same as on figures 5.1 and 5.2 with place for individual answer for every stage of manoeuvres and for changeable conditions of manoeuvres.

No	Consecutive stages of ferry entering manoeuvres	Events discriminating the stages
		Sea buoy Ystad
1	Approaches to the port	Stabilized in the line of leading lights
2	Outer port entry after passing heads.	Red pole beam
3	Deviation on the left side of leading lights.	Left inner head on fore beam
4	Turning to the left	Quay corner left beam
5	Continuation of turning, commencing of stopping the forward run	Longitudinal run stopped, stern passed quay IV corner
6	Continuation of turning, commencing of astern run	Completing of astern run
7	Approaching to the quay	Ferry contact with fender at the Quay
8	Astern run alongside	Ferry alongside at the train stand

Figure 5.1 Examples of expert's entering questionnaire.

No	Consecutive stages of ferry departure manoeuvres	Events discriminating the stages
		Ferry alongside at the train stand
1	Unberthing, commencing the run forward	Abeam quay corner I/IV
2	Turning to the port	Turning stopped
3	Turning to starboard	Ferry in the line of leading lights
4	Inner port passage	Ferry passed breakwater heads
5	Departure the harbour	Sea buoy

Figure 5.2 Examples of expert's departure questionnaire.

Scale of opinion was integer number started from 1 for very easy manoeuvre to 10 for very risky manoeuvre but still feasible with acceptable level of risk. If the level of risk exceeded acceptable level experts were asked to use mark "X" instead of integer number. Initial conditions were: day, no wind, good visibility and manoeuvres done without support of FNAS. Next the opinion concerning the following conditions was estimated:

night manoeuvres;

visibility 0,2 Nm and 50m;

wind E 5 m/s, E 15 m/s, E 25 m/s;

wind W 5 m/s, W 15 m/s, W 25 m/s;

wind S 5 m/s, S 15 m/s, S 25 m/s;

manoeuvres done with support of FNAS.

Minimized to 3 levels only the wind and visibility variable were taken into consideration. Recognized that additional levels will generate non-sharp and subjective component to opinions. 4 Nm suggest good visibility. 0,2 Nm mean bad visibility – only the nearest area around the ferry is visible, navigational marks and aids are not visible. Very bad visibility 50 m – possible only a view of the water below conning position. Stern and amidships are not visible. Earlier researches reveal that critical force of the wind for m/f "Polonia" ferry is 27 m/s. For this reason the following has been assumed: weak wind force as 5 m/s, strong wind 15 m/s and very strong wind force 25 m/s. 3 directions of the wind has been selected: W, S, E. Choice of this direction respects not only the occurrence of the wind according to fig 4 but also exposed the port area for winds from the selected directions.

## 5 ANALYSIS OF SELECTED RESULTS OF RESEARCHES

For all conditions covered by 12 questionnaires, as anticipated, no expert estimated any stage of the manoeuvre “as risk that’ will exceed acceptable level”. Once again well-calculated critical force of the wind for m/f “Polonia” ferry – 27 m/s was confirmed.

Selected results of researches are shown on figures 6, 7, 8. For each result was calculated range of mean safety level with 0,95 probability and passed test of normality distribution. For each stage of manoeuvres and for each variable difference of average estimate of safety level was tested by t-test pre-test – post-test for a standard significant level 0,05. Acceptance of zero hypothesis means no changes in safety level opinions despite changes of visibility, force and direction of wind, night and daytime, usage of FNAS. Rejection of zero hypothesis means changes in experts’ opinion.

### 5.1 Entering and departure daytime manoeuvres with restricted visibility. No wind.

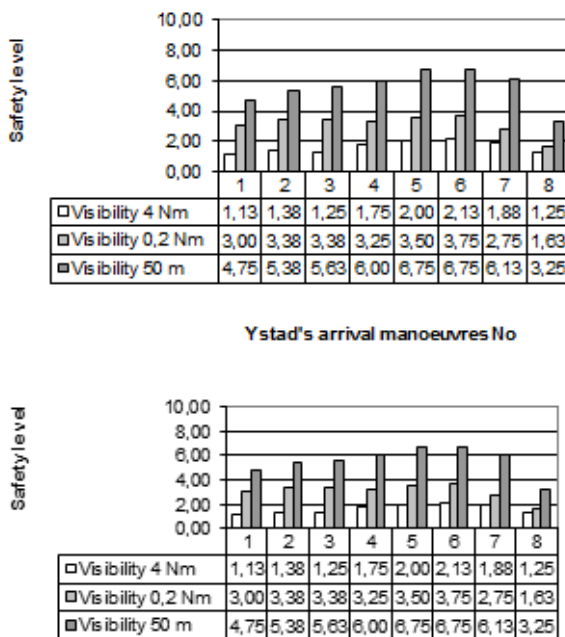
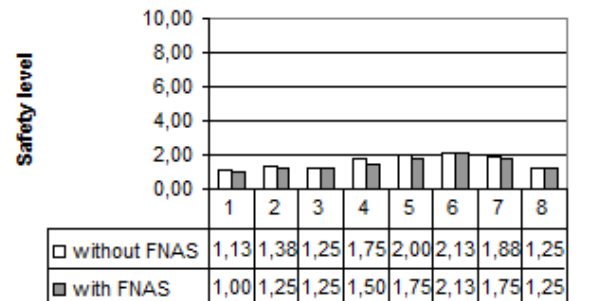


Figure 6. Results of experts’ opinions for manoeuvres during restricted visibility without the use of FNAS.

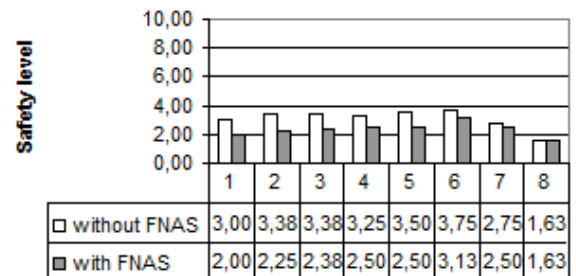
For daytime, at no wind conditions, on each stage of manoeuvres with variable described as visibility for every stage, zero hypothesis was rejected. For each stage of manoeuvres, along with decreasing of visibility deterioration of experts’ opinions concerning safety level was observed. Approaching manoeuvres were estimated as less safe than departure from Ystad. Regardless of the kind of manoeuvres at

visibility reduced from 4 Nm to 50 m, 3-4 time reduction of estimated safety level was observed. That’ means strong influence of restricted visibility on manoeuvres safety.

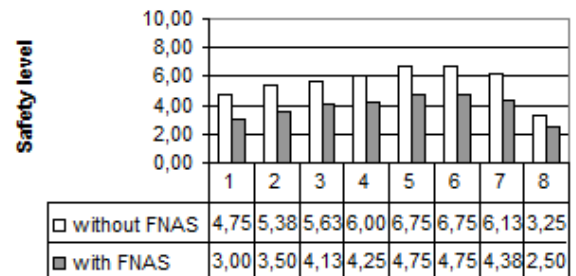
### 5.2 Entering and departure daytime manoeuvres with restricted visibility with FNAS in use. No wind.



Ystad's arrival manoeuvres visibility 4 Nm



Ystad's arrival manoeuvres visibility 0,2 Nm

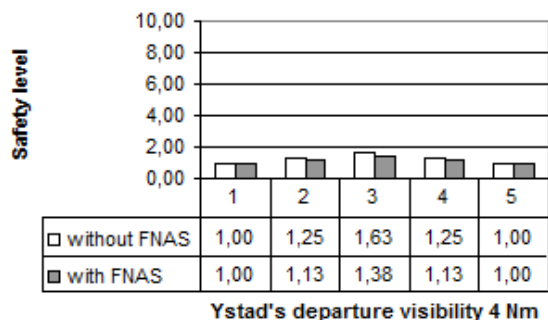


Ystad's arrival manoeuvres visibility 50 m

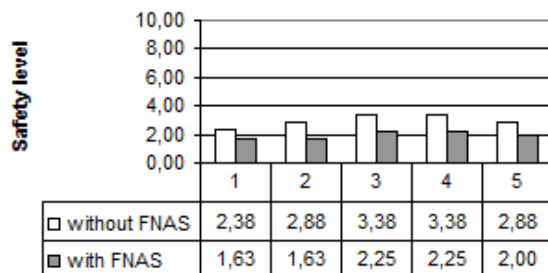
Figure 7.1. Results of experts’ opinions on entering manoeuvres in restricted visibility without FNAS compared to manoeuvres with FNAS.

At good visibility of 4 Nm, the average estimate of safety level varies from 1 to 2. Except for entry manoeuvres no 4 and 5, the zero hypothesis was not rejected. For 4th and 5th manoeuvres at these conditions a dozen or so improvement of safety was observed when FNAS was in use. This manoeuvres was estimated as a most difficult. For the best possible hydro meteorological conditions, usage of FNAS can also improve safety of manoeuvres.

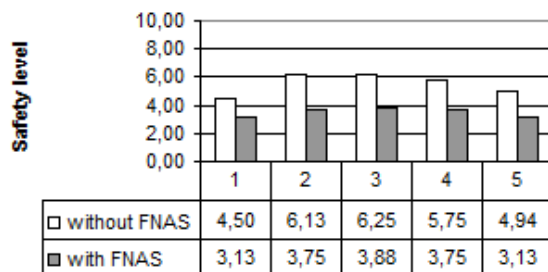




Ystad's departure visibility 4 Nm



Ystad's departure visibility 0,2 Nm



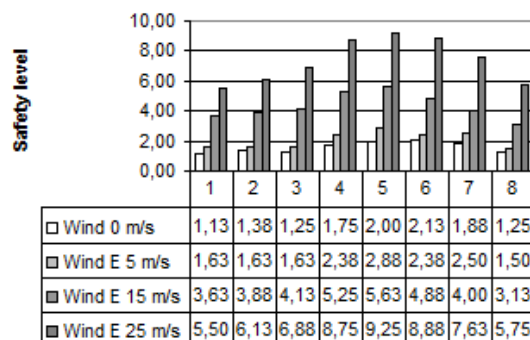
Ystad's departure visibility 50 m

Figure 7.2. Results of experts' opinions on departure manoeuvres in restricted visibility without FNAS compared to manoeuvres with FNAS.

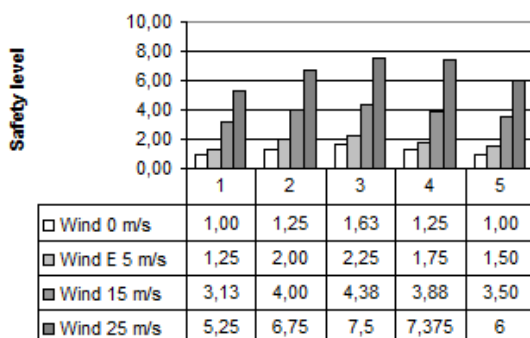
For bad visibility of 0,2 Nm for manoeuvres without FNAS, average experts' opinions do not exceed "4". When FNAS was in use at the same visibility conditions, 50 percent in crease in safety was observed. That was observed for all kinds of manoeuvres except entry no 7 and 8 where ferry directly approaches to the quay and keeps contact with fender moves along stand no 4. For these stages sight distance of 0,2 Nm enables sufficient level of visibility for execution of safety manoeuvres.

At very bad visibility up to 50 m, the most difficult stages were estimated up to "7". For all kinds of entering and departure manoeuvres the average safety level was improved about 50 percent when FNAS was in use. In this circumstances average safety level does not exceed "5".

### 5.3 Daytime manoeuvres. Easterly wind. Good visibility.



Ystad's arrival easterly winds



Ystad's departure easterly winds

Figure 8. Results of experts' opinions on maneuvers during easterly winds.

Average experts safety opinions for easterly wind force 0 m/s – 5 m/s, 5 m/s – 15 m/s, 15 m/s – 25 m/s were compared. For every stage zero hypotheses was rejected except entering manoeuvres no 6 and 8 when compared easterly wind 0 m/s – 5 m/s. During stage no 6 weak easterly wind not disturb manoeuvre. For stage 8 when ferry keeps contact with fenders on quay and moves along stand no 4, the weak opposite wind never disturbs the progress. For all estimated, manoeuvres at easterly wind were described as the least safe. For the most difficult entry stages no 4, 5, 6, 7 sometimes levels "10" appear the last acceptable safety level. But taken this into consideration only for entry manoeuvres stage no 5 average level exceeds "9" at the easterly wind 25 m/s.

## 6 CONCLUSIONS

The paper presents selected results of experts' researches based on questionnaire.

By the experts' researches, it is possible to estimate of the mooring manoeuvres safety level. The difference average of safety levels for consecutive manoeuvres confirm the correct division entry manoeuvres for 8 stages, and departure manoeuvres for 5 stages. According to results of researches, the most dangerous manoeuvring conditions are during the 25

m/s wind when safety level appears “10” the last acceptable safety level. For strong winds 15 m/s and during 50 m restricted visibility, experts’ opinions are situated at the center of safety scale.

During any kind of restricted visibility when Ferry Nautical Anti-collision System (FNAS) was in use, improvement on safety about 50 percent was observed. Manoeuvres done with support of FNAS always improve safety level. Researches were conducted on the ferries, where persons manoeuvring the vessel have excellent theoretical and practical knowledge about sailing areas. Presumably, when the vessel is manoeuvring on the less known areas, improvement of the safety level should be more effective.

Carrying out the experts’ questionnaire researches, it is possible to establish objectively hydro mete-

orological conditions for selected and satisfied manoeuvres safety level. Researches may be used for risk management at shipping companies. Additionally results of researches may be used for planning ship’s operations during extreme hydro and meteorological conditions.

## REFERENCES

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