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# ASSESSMENT OF INFLUENCE OF TRAFFIC INTENSITY INCREASE ON COLLISION PROBABILITY IN THE GULF OF TRIESTE

## ABSTRACT

The paper presents results of researches aimed at assessing of influence of traffic intensity increase on collision probability in the Gulf of Trieste. Stochastic, simulation model working in fast time was used in the researches. Ships traffic was modeled on the basis of real data obtained from AIS.

**Keywords:** Ships' Collision, Marine Traffic.

## INTRODUCTION

The aim of this analysis is to objectively assess the risk of collisions of ships maneuvering in Gulf of Trieste. Due to complexity of navigational situation and navigational routes the assessment has been conducted by means of navigation safety stochastic model developed in Maritime University of Szczecin [1].

The base model input is probabilistic characteristics of ships traffic (intensity and ship size) and routes (variability of routes in dependence to ship size) together with navigational situation and as an output the places of simulated collisions have been determined.

## ASSUMPTIONS

Following assumptions have been made:

- The ships traffic was divided into three size groups.
- The most important factor as probability of collision of ships in different situations was established on the basis of Baltic Sea statistical data. (This was

done due to lack of statistical data in Gulf of Trieste).

- Simulations were conducted in two scenarios:
  - with steady traffic on level existing today in Gulf of Trieste
  - with 20% increase of traffic during 5 years in Koper Port (100% of today traffic after 5 years).
- The simulations have been conducted within 5 years periods and repeated several times to obtain proper statistical significance of model results.

**Area**

Three ports exist near analyzed area:

- Port of Koper (Slovenia)
- Port of Trieste (Italy)
- Port of Monfalcone (Italy)

The ships traffic is regulated by complicated traffic separation scheme (Fig. 1).

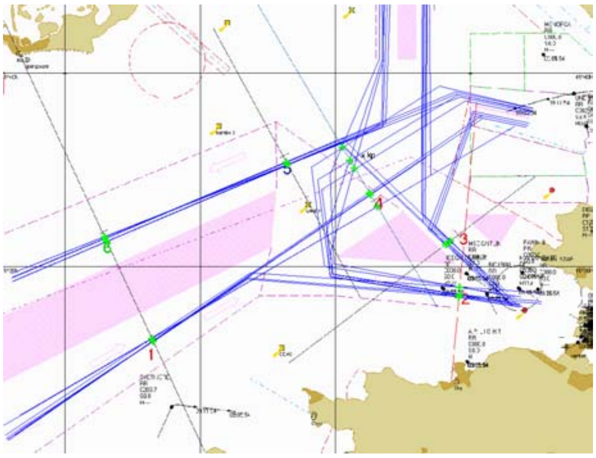

Fig. 1. Layout of analyzed area (TSS and AIS gates)

**Traffic**

Traffic has been analyzed on the basis of AIS records (01.02.2008-23.03.2008). Ships were divided into three classes according to GT:

- small ships of 0-10000 GT
- medium class ships of 10000-50000 GT
- large ships more than 50000 GT

The mean traffic in analyzed ports is presented in Tab.1. Total number of ships in analyzed area is around 9300 ships annually.

Table 1. Traffic [ships/year] in ports divided into size groups based on AIS data

| Ships group | Koper | Traffic increase after 5 years in Koper | Trieste | Monfalcone |
|---|---|---|---|---|
| Small | 2527 | 5054 | 2135 | 237 |
| Medium | 1362 | 2724 | 1939 | 215 |
| Large | 182 | 364 | 638 | 71 |
| Total | 4071 | 8142 | 4712 | 523 |

## TRAFFIC INCREASE

According to economic analysis it has been assumed that traffic in Port of Koper will increase of about 20% per year. The simulations have been conducted within 5 year period and on the end of this period traffic in Koper is assumed to be doubled according to existing one.

### AIS researches - AIS gates

Traffic in Golf of Trieste and Koper have been analyzed on the base of AIS researches. Vessel's passages are checked in 7 gates. Positions of AIS gates are presented in figure 1.

For each vessel course, speed and distance to check point at time of crossing rectangular line to direction of traffic flow have been measured.

### Routes and its variability

On the base of AIS measurements the routes of ships have been determined. After analysis due to different behavior of navigators on different size of ships routes have been analyzed for three different ships sizes separately.

The AIS researches enable to evaluate two probabilistic parameters of ships routes: mean and standard deviation of Way Points in given routes. Traffic on the routes has been modeled as with use of Poisson distribution and Way Points have been modeled by 2-dimensional normal distribution with mean and standard deviation assessed from AIS data (Fig.2).

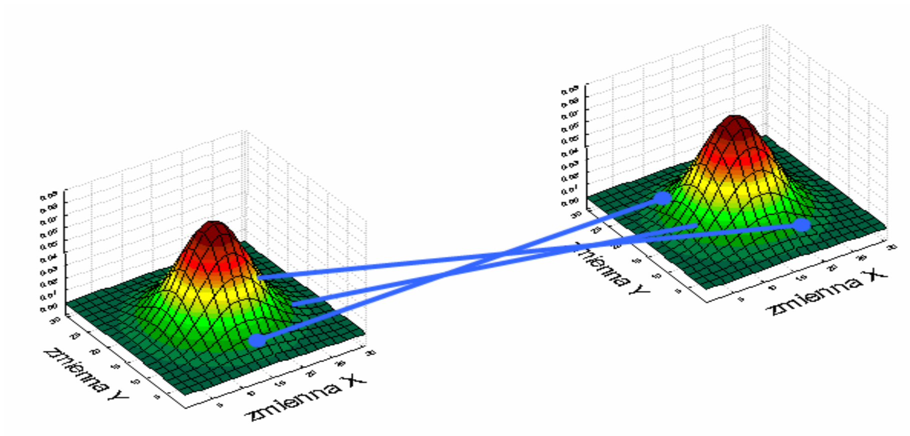


Fig. 2. Modeling ships traffic between Way Points

Total number of routes included in the model is equal 30. All routes are presented in figure 1.

## METHODOLOGY

### Stochastic model of ships accidents

One of the most appropriate approaches to assess the safety of complex marine traffic engineering systems is use of stochastic simulation models [2, 3]. The model presented in figure 3 could be used for almost all navigational accidents assessment like collisions, groundings, collision with fixed object [3], indirect accidents such as anchor accidents or accidents caused by ship generated waves [4]. This methodology was used already by several authors before with different effect [5, 6, 7].

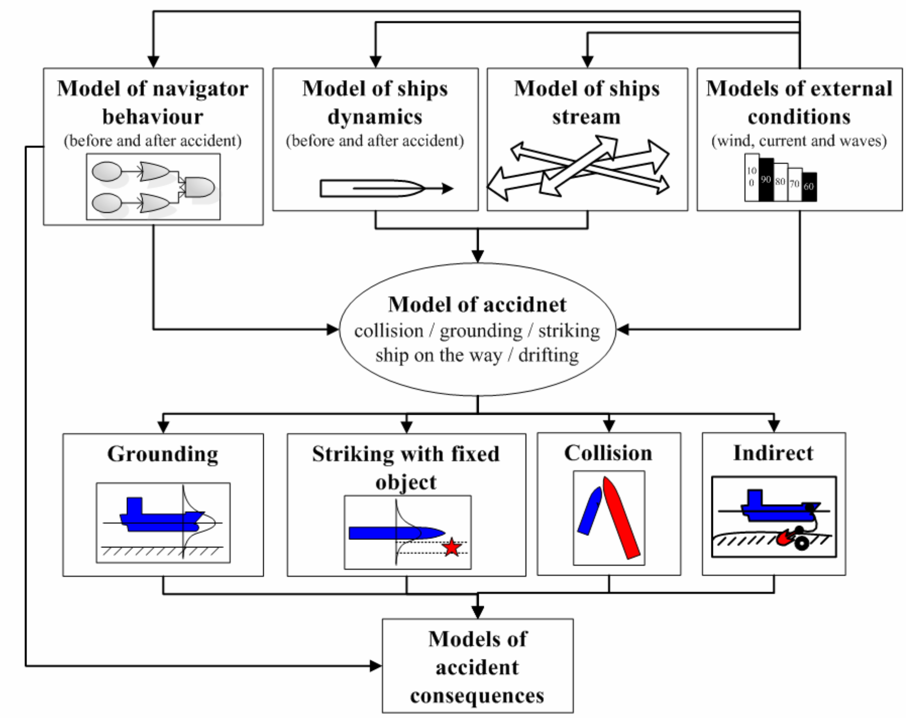


Fig. 3. Diagram of fully developed stochastic model of navigation safety assessment

**Collision accident models**

To model the collisions simplified statistical model is used. The model neglects several dependencies but because it is based on real statistical data the achieved results are very close to reality.

Due to lack of collision statistical data in Gulf of Trieste the most important factor as probability of collision of ships in different situations was established on the basis of Baltic Sea statistical data.

The most unknown parameter necessary for collision probability assessment on large sea areas is number of ships encounter situations. In complex systems with several traffic routes this number could be evaluated only by traffic streams simulation models such as the one presented in this study.

After collecting necessary input data the simulation experiment has been carried out and the expected number of encounter situation was calculated. The critical distance where navigators perform anti-collision manoeuvre was assumed on the base of expert opinion separate for head on (heading difference ±170°), crossing and overtaking situations (heading difference ±10°).

These distances called minimal distances of navigator's reaction were estimated by expert opinion and real time non-autonomous simulation experiment performed on ARPA simulator. The overall number of encounter situation estimated by simulation model is around 140000 per year where 30% of them are head on situations, 40% of crossing and 30% of overtaking.

Statistical data from southern part of the Baltic Sea accidents were used for evaluation of mean intensity of ship collision accidents in the Southern Baltic. The mean intensity of collision accidents equals 2.2 per year.

Calculated number of encounter situations and the evaluated mean intensity of collision have been used for estimating the probability of collision. To simplify the calculations it was assumed that probability of collision is equal in all considered situations. The existing databases of real accidents scenarios justify this assumption.

The calculated probabilities of collision in single encounter situation are presented in figure 4.

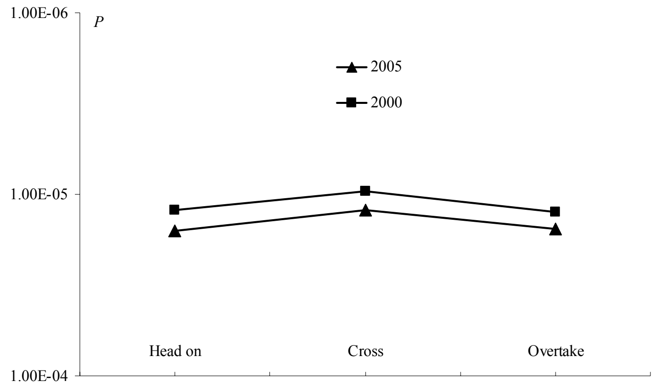


Fig. 4. Probability of collision accident (P) in different encounter situations in 2000 and 2005 on the Southern Baltic Sea

Estimated collision probability on the Baltic Sea (Fig 10) has been used in model of Gulf of Trieste navigational safety. Mean probability (2000 and 2005) have been applied in given collision situations.

## RESULTS

The simulations have been carried out in series each for 5 years as the period of interests during which the traffic increase could be predicted with relatively accurate precision. The results are presented in fig. 5, fig.6 and tab.2.

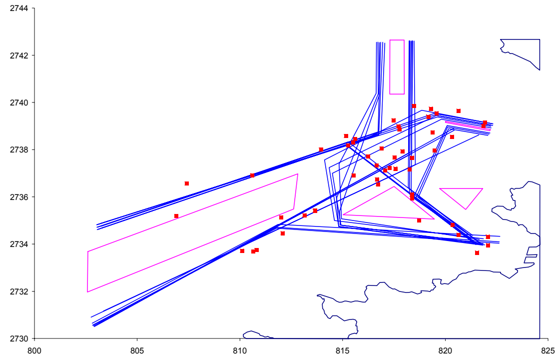


Fig. 5. Simulated places of collisions in scenario 1 (no increase of traffic) during 800x5 years period

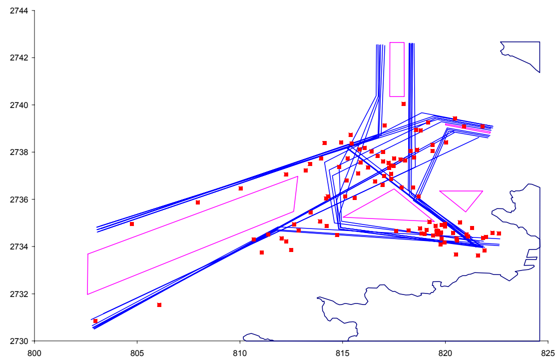


Fig. 6. Simulated places of collisions in scenario 1 (100% increase of traffic) during 800x5 years period

Table 2. Mean number of accidents, probability of accidents and mean time between accidents

| Series | Number of 5 year simulation periods | Total number of collisions | Expected number of collisions per year | Mean time between collisions [year] |
|---|---|---|---|---|
| 1.No increase of traffic | 800 | 50 | 0.0125 | 80 |
| 2.Traffic increase of 100% | 800 | 105 | 0.0262 | 38.1 |

## CONCLUSIONS

The results presented in fig. 5 and fig. 6 gives general overview of collision risk places in analyzed area. The most risk affected place in analyzed area is precaution area near AIS gate xkp. This area should be covered and protected by future VTS with special care. The ships in this area significantly change its courses enforcing other ships to predict its maneuvers. New routing measures could be considered in this place in the future to increase the navigational safety (ex. roundabout traffic scheme).

Traffic increase in Koper Port will scientifically increase the risk of ships collision in analyzed area (Tab.2) which should be the reason of protecting the area by active VTS.

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