

# **Research proposal: “Methodology to assess ports and waterways on safety and capacity”**

**TRAIL Research School, October 2014**

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## **Abstract**

This paper exposes the research proposal for a methodology to assess ports and waterways on safety and capacity and their designs. Due to the large increase in maritime transport in these areas, manoeuvrability becomes more complex and there are more hazardous situations. In order to reduce risks, the research will result in a simulation-based assessment tool that takes into account the most important issues related to the performance of ports and waterways. This tool will allow to make a quantitative evaluation and comparison of different solutions, both with respect to infrastructure changes and traffic management measures. The aim of the research described in this proposal is to prevent hazardous situations in current infrastructures, and prepare ports and waterways to accommodate future growth. The methodology will be applied and validated in two of the most important ports both in the Netherlands and China.

## **Keywords**

Safety, capacity, ports and waterways, assessment methodology, AIS data, vessel simulation model.



# 1 Introduction

Globalization trends in maritime transport are leading to rapidly growing ship dimensions and increasing flows in ports and waterways. This growth makes traffic and manoeuvrability more complex and may lead to unsafe situations. Port authorities are aware of these problems and try to mitigate the existent hazards, and anticipate future hazards. Due to the complexity of the problem and the lack of tools to support port authorities researchers have shown interest in this topic. This research proposal contains an overview of the development of a new assessment methodology for ports and waterways based on a vessel simulation model.

Chapter 2 presents the problem description, the basis for the development of this research. Chapters 3 and 4 present objectives and innovations of the research. An overview of the whole research area is presented in the research approach, in chapter 5 and chapter 6 presents the different steps that will be developed. Finally, chapter 7 summarizes the expected results that are going to be obtained from the complete research.

## 2 Problem description

Ports and waterways are quite inflexible infrastructures and difficult to expand. This implies that the aforementioned increase in vessel movements leads to more hazardous situations. Since there is an increasing social conscience about avoiding hazards, dangerous situations and accidents, especially in urban areas, an extensive research exists related to quantitative risk assessments (QRA) (Li et al. 2012). Another approach to quantify risk is through the development of risk based index assessments (Degré 2003).

Furthermore, ports need to handle a higher traffic demand that implies longer waiting times for vessels, which reduces the capacity of the system. There are some simulation models to assess the capacity of different port processes, such as Harboursim (Groenveld 1983), based on an event-driven model. Although this simulation model has been used, its results are not enough accurate and cannot represent reality in a proper way.

Because of the increasing demand, ports and waterways need to be optimized or expanded or new ports have to be designed. In all cases, both safety and capacity of the system should be guaranteed.

As indicated before, there are two independent main lines of research for ports and waterways, one focused on individual risks and the other on capacity, in terms of operations performance. The purpose of this research is the development of an assessment methodology relating several indicators for ports and waterways, including and combining safety and capacity. This research is multidisciplinary and it involves many different aspects, resulting in an assessment methodology with general applicability for existent and new designs.

### 3 Objectives

The main goal of this research is to develop an assessment methodology for ports and waterways based upon a microscopic simulation model that is currently being developed at the TU Delft.

This methodology will:

- Describe and quantify safety and capacity in ports and waterways.
- Take into account different performance indicators in a unique tool.
- Support and assess the planning phase of new ports or the expansion of existing ones.
- Assess and improve port designs due to the identification of bottlenecks.
- Assess risk and traffic management strategies with quantitative evaluation that user can use to adapt or redesign them in order to improve the current situation or design.

### 4 Innovations

Since research already developed do not consider the combination and influence between safety and capacity, this methodology will link both safety and capacity as well as other relevant performance indicators that are involved into the system. Contrary to existing tools that are based on risk assessment or event-driven models, this tool will use a microscopic simulation tool as the basis for the performance assessment.

Another innovative aspect is that it will be a tool to be applicable to assess and optimize any new design as well as to assess existent designs, traffic management strategies and changes in navigational rules.

### 5 Research approach

In this section, the different parts of the research are introduced in order to have a clear overview of all the different aspects considered.

Figure 1 identifies the different aspects that may be taken into account, in order to identify the most relevant performance indicators or to get useful information from each of the items.

The methodology is going to identify and consider needs or requirements from different stakeholders and actors that are related to the Port and vessel navigation and directly involved in the field. This will be done in order to make a method generally applicable and acceptable by stakeholders or actors. Moreover, vessel behaviour and vessel interaction with the port infrastructure and its traffic performance will be analysed.

As mentioned before, the assessment methodology is based on a simulation model that is currently being developed by TU Delft. This model will include vessel behaviour, human factors and external conditions, like hydraulic and weather conditions. Moreover, based on game theory, bridge team behaviour will be the base for this innovative microscopic traffic simulation tool.

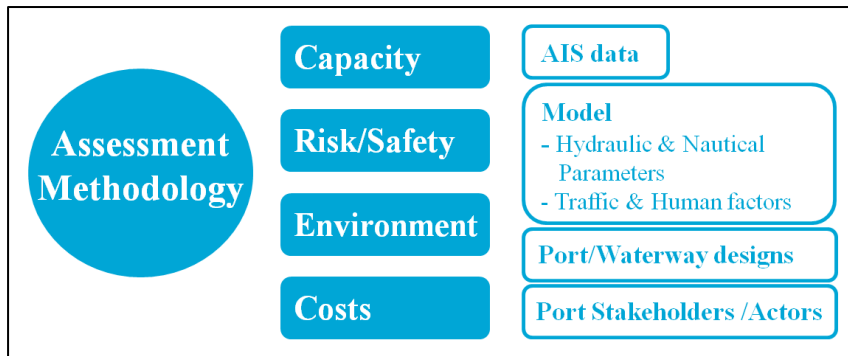


Figure 1: Research overview

AIS (Automatic Identification System) records vessel’s motion and manoeuvring, among other relevant information, and it will provide new data for the calibration and validation of the model and it will be useful to have better knowledge of vessel navigation and it will help to develop and improve the methodology.

Figure 2 shows an approach of the different parts of the research that is going to be developed and it will be explained in detail in the next chapter. The process to develop this methodology will consider the current state of the art and AIS data analysis as an assessment of the model input or for new model requirements. These will be used as the base for the development of the method. Additionally, the new requirements will be evaluated also in accordance to the needs and requirements from port stakeholders or actors, that will assess both, model and methodology.

From the output of the model, the different performance indicators will be analysed and assessed in order to link them and develop the assessment methodology in busy waterways and ports with a dynamic analysis.

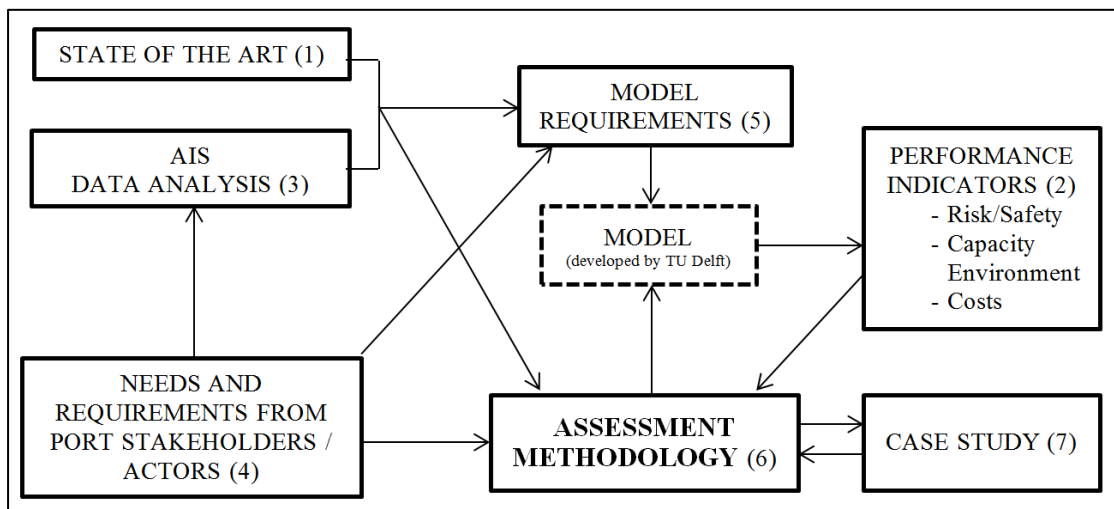


Figure 2: Research approach (numbers in brackets correspond to each research step)

At the moment of applying (as it is currently under development), the model will be construct valid and the methodology linked to it will have been tested with it.

The final tool will be tested and applied to real cases, that is why it will be tested in real ports, in order to show that is really applicable.

## 6 Research steps

In order to achieve the objectives, the research has been divided into several steps which are detailed below.

### 6.1 State of the art

A deep literature review of existing studies on capacity and safety of vessels in ports and waterways will give an insight into different approaches of the problem. This review will also focus on existing assessment methodologies related to this field and the identification of other relevant parameters that should be considered in the research.

It will include capacity (how is this defined in maritime transportation and in other fields) and safety classifications (existing risk or safety classifications useful in identifying the hazards or risks of the research). Further literature research will be done to identify other important indicators and they will be evaluated and taken into account.

This step will provide a state of art of the current literature research already developed and it will highlight which needs should be considered to extend and fill the gaps in the current research area. It will be also analysed how it is possible to combine safety and capacity and other relevant indicators into an assessment methodology.

### 6.2 Performance indicators

The main indicators, which have to be defined are the capacity in ports and waterways, how to evaluate safety and its link with the capacity. In addition to these indicators, the literature review might reveal other indicators, which also will be defined in this step.

Firstly, a capacity study will be the starting point for the definition of the capacity indicator. By simulating some typical scenarios occurring in ports, the factors influencing port network capacity can be identified. The aim of this capacity study is to define how to define and quantify the capacity of a port or waterway network. Therefore, after research in other fields, such as into traffic flow theory on roads, capacity in port and waterway (networks) will be defined. This may lead to a new approach to network capacity estimation methodology, not properly defined before, as a whole, taking into account the influence from parts of the network on the whole system.

Secondly, safety has to be evaluated and linked to capacity once all the main risks and hazards have been identified from real data from the AIS data analysis. Furthermore, vessel and waterway classification is desired to be developed in order to have a general approximation of the problem and to be able to analyse the complete system, since there are multiple types of vessels. Otherwise, a general method cannot be developed because each scenario would be unique and independent from the rest.

Moreover, since all infrastructures need high investments, decisions have to be evaluated under the economical perspective. Because of this, one of the most important factors to take into account to expand or build new infrastructures is the cost of each component and how it should influence the choice of one thing or another depending on economic aspects. Main costs will lead to the definition of relevant economical indexes.



On the other hand, environment and sustainability is always a relevant aspect to take into account when a new infrastructure has to be modified or designed, that is why decisive environmental parameters will be evaluated.

### **6.3 AIS data analysis**

An exhaustive analysis of all the existing data from AIS will be useful to get a more clear insight on vessel behaviour. Moreover, the analysis should help in the definition of some performance indicators, as capacity in previous step, and it should reveal the indicators needed as an output from the simulation model used.

This step, together with state of the art, should rather lead to clear assessment objectives that should lead to a more accurate structure for the development of the assessment methodology.

### **6.4 Port Stakeholders / Actors analysis**

Since there are many different port stakeholders or actors with different interests, this project is multidisciplinary. Their knowledge and their concerns and needs are an essential input for the research and will help to identify or quantify relevant indicators.

Interviews will be carried out with the different parts in order to identify the main points and problems or daily hazards that can improve the existing model and to make sure that the results from the research will be accepted by them, thus creating support for the new methodology.

### **6.5 Model requirements**

Steps above will give an overview of requirements for the currently developed model. These requirements will allow the assessment and improvement of the model with some new functionalities. Thanks to the assessment of the model based on achievements and results from previous steps, its outputs will be the base for the development and application of the whole methodology.

The steps below may lead to additional requirements that will be studied and considered at the right moment.

### **6.6 Development of the assessment methodology**

The development of the assessment methodology will be done relating all the previous steps. Once the main criteria and performance indicators are analysed and identified, it will allow the generation of some multi-criteria analyses (MCA). MCA results will be the base of this suitable tool for the assessment of safety and capacity in ports and waterways. It should allow to be used and applied in any desired scenario, based on the cited MCA.

## 6.7 Case study

Through the case study, the methodology developed will be tested and assessed in two scenarios, Port of Rotterdam (the Netherlands) and Yangtze River or Shanghai Port (China), which will allow the overhaul and improvement of the methodology as well as to test its validity and applicability.

## 7 Expected results

The main result of the project described in this research proposal is a reliable simulation-based methodology for the assessment and the design of ports and waterways taking into account the individual vessel behaviour and the interaction between vessels. In addition, the different phases of this research will lead to other remarkable contributions, such as a new port network capacity definition and estimation method, insights into port operations as a whole based on AIS data, safety analysis of infrastructure and traffic management, environmental effects and economical relevance of them into the whole system of ports and waterways.

## Acknowledgements

The work presented is funded by the Netherlands Organisation for Scientific Research (NWO).

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