# Using the AIS Data to enhance smart port congestion optimizing model

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**Article History**: Received: 10 January 2021; Revised: 12 February 2021; Accepted: 27 March 2021; Published online: 20 April 2021

**Abstract—**Nowadays, ports are in need to maximize their incomes, and this based on the fierce competition. For this reason, all ports stakeholders should be involved to contribute in the design and the development of a policy of scheduling and priority.This project owned by the Vessel Call Service Planning Service in the port of Tanger Med as the "Tanger Med Port Authority", and it output was to report the summarized the work done and the methods behind it.The main goal is to develop a simulator model that includes all kind of operations and the operational process by choosing the appropriate KPIs that are fully reflecting the congestion transferred by port vesselsFirst, it aims to define the operating assumptions and the fundamental concepts on which our simulation model will be based and to present the data that were used for the implementation of the simulation as well as the origin of these data.Secondly, it aims to validate and calibrate the model by presenting some improvements that could be made to the simulator in order to make it more precise and more representative and to ensure automation of the processing of inputs and outputs. While towards the end we conclude with the presentation of congestion situations, the results obtained and their use in decision making.AIS data is another factor has been added to help in getting best results, this helped in vessels planification in/out predictive process while automating the use of our simulator with the AIS Data receipt from SatelliteThis part of project is in to give the smart aspect to our simulator results by using smart technology.

**Keywords—** Harbor, Vessel, Terminal, Performance, Priority, Delay, Call, Congestion, Simulation, AIS, Data**.**

## 1. Introduction

In a global economy characterized by intensifying competition, ports are now considered "engines of development",[2][9] as they are no longer viewed as passive logistics equipment and facilities for import and export only.[2]

Now the ports are becoming real systems that produce their own model.[10] The challenge is knowing how to identify and evaluate resources for progress and wealth creation.

The unit responsible for the movement of vessels within the port must guarantee the quality of the maritime support services (pilotage, towing, mooring, etc.) and also the view of the distant horizon.[3]

Such a vision is only possible if the service has the strategic, tactical and operational tools to be effective and anticipate possible delays,[11][12] port congestion, at a cost for many interested parties (shipping companies, transport agents, terminals, passengers, ocean liners, factories).) as well as all the parameters that may cause disturbances along the control chain of port calls.[6]

In this sense, we proposed the creation of a decision-making tool to anticipate port congestion (heavy maritime traffic) and reduce waiting times for ships in the port of Tanger-Med.

To make the reading of this article easier, we note the following acronyms:

AIS: Automatic Identification System.
API: Application Programming Interface.
LOA: Length overall of vessel
DES: Discrete-event simulation
ETA: Estimated time of arrival.
TMP: Tangier Med port
TMPA: Tanger Med Port Authority
SADT: Structured analysis and design technique
PAR: Post Allocation Request.
TMIS: Tanger Med Information System
VTS: Vessel Traffic Service

VSO: VTS Supervision Officers
IPO: Intervention Port Officers
ARENA: Event simulation and automation software
TC1: Tanger Med container terminal 1
TC2: Tanger Med container terminal 2

## 2. Modeling of operational processes

This part will be used to present the many diagrams of all stopover processing operations. (Fig. 1)


Starting from Macro to Micro, we used the SADT method of functional analysis for a modeling of the stopover process which clearly and globally represents the process, with the inputs, outputs and existing constraints.

**A.** Stopover processing

The following diagram can demonstrate how the call handling is processed from the booking request by the shipping agent, this last is considered as the shipping company's representative in point of view of the port authority until the departure of the ship. As mentioned, the reservation request, done by the harbor master's office "Post Allocation Request" is made by the shipping agent at the moment of call done by the ships he represents intends to the Tangier Med port.

The PAR is made through a system called TMIS (Tanger Med Information System) this information system is available to stakeholders in the port community by TMPA.

Once the request is done, the SPO "Stopover Planning Office" receive it, which has the possibility of rejecting it in the event of non-compliance, or accepting it with a provisional status until receiving confirmation of compliance.

In the event of compliance, the vessel is authorized to begin the port maneuver.

**B.** Docking and departure process

The VSO officers (VTS Surveillance Authorities) notify the IPO (Intervention Port Officers) of the arrival of the vessel, who will be in charge of monitoring the docking equipment once the operation is finished, they will inform the VTS. Docking and mooring operations require collaboration between the VTS, the pilot, terminal agents, mooring agents, and the IPO. The reverse action, or reconciliation, took place in the same way.

## 3. Statistical analysis of input data for the model

Stochastic systems, such as a port system or a call management system, have one or more random characteristics that affect the system.

Starting from the methods already mentioned for the inputs of this system, we are interested in analyzing the time between arrivals of entities, the time of different processes, different deadlines (for example, administrative processing).

Most simulation data have an implicit delay time, such as the time between arrivals, check times, etc., and for other data, a probability part, such as the probability of sending a tug and boat. probability of pilot, pilot and tug availability, etc.

Then we can get a definition of system history data. This process is called "data collection" in simulation terminology.

**C.** Description and origin of the data

For a proper modeling of the system, efficiency in data collection and statistical processing phase is considered essential

Depending on the circumstances, an attempt was made to obtain system data from two main sources.

The stopover history databases are belonging to each terminal from 2015 to 2017, for each day, it contains the number of stopovers done, the arrival and departure dates of ships, the commercial operation, etc. constitute the first source.

While estimates proposed by the leaders constitute the second source. Indeed, although the statistical reports made it possible to extract a significant amount of information, this proved to be insufficient to complete the simulation.

**D.** Choice of random distribution

To confirm the effectiveness of the input data, we perform a detailed statistical analysis of the collection of this data.

Let’s start by estimating the distribution of maneuvering times while following the distribution logic, i.e., according to the size and type of vessel (terminal).

In this way, using the statistical software MINITAB, the statistical software and the "Input Analyzer" module of the ARENA software, which enables statistical analyzes, we send the entered data to hypothesis tests to test whether a particular data group can be modeled with a certain level of confidence in the distribution law. For this, two measurements were made.

**E.** Mean square error

For example, we start from a container terminal 2 for vessels smaller than or equal to 140 m.

On the Minitab and Input Analyze devices, we present the number and duration of coupling motions and the settings stored in the database.

For each distribution, the mean square error relative to the actual data is calculated. Figure below:

| Function | Sq Error |
|---|---|
| Beta | 0.0125 |
| Gamma | 0.0126 |
| Erlang | 0.0126 |
| Weibull | 0.0133 |
| Lognormal | 0.017 |
| Normal | 0.0175 |
| Triangular | 0.0363 |
| Exponential | 0.0675 |
| Uniform | 0.0775 |

Fig. 8.

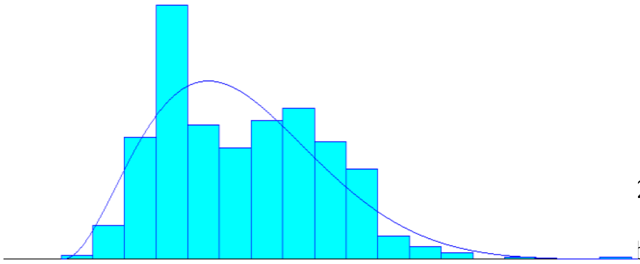
Fig. 9. Mean square error for each random distribution.

This measure corresponds to the average of the differences between the relative frequency observed in each cell of the histogram and the relative frequency of the corresponding distribution.

The distribution with the smallest mean square error should be maintained.

**F.** *Match Test*

Second, the level of correspondence for each distribution is calculated using the Kolmogorov-Smirnov test [14]. The result of this test is a value between 1 and 0 for the parameter p, which allows testing the null hypothesis (Ho).



2 Size <= 140 m

etween the data and the distribution, while a value greater than 0.10 is considered to indicate a good match between the two data sets and a valid H0.

When fitting this series to the theoretical distribution, it is concluded that the most suitable distribution is the beta distribution with parameters (3.21, 9.75).

## 4. Model validation and calibration

The verification and validation phase of the developed model is necessary to ensure that the simulation model is consistent with the real system.

The following figure summarizes the tests performed to determine the Statistical Law.

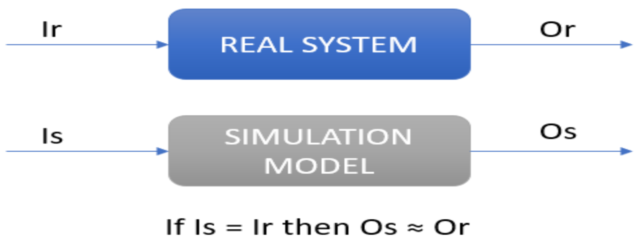



Fig. 11. Principle of validation of simulation models

**G.** *Choice of random distribution*

Validation takes place throughout the development of the model, first at the start of the study, and continues until it ensures that the model behaves credibly and produces behavior that is similar to the actual system.

Each of these scenarios has been simulated ten times to obtain ten simulated values, and the results presented are obtained from the averages calculated from these ten simulation rounds, which are compared to the actual value obtained.

As can be seen from Table 1, there are not many differences between the initial values and the values obtained by simulation.

It can be seen that the relative difference is quite small with docking times and device and the differences are larger with dwell times.

The main purpose of this work is to contribute to the assessment of TMP's performance at the level of port vessel traffic, especially due to delays due to vessel waiting times to secure berths and voyages. It then attempts to assess port performance by analyzing capacity analyzes with a set of criteria and key performance indicators.

TABLE I.

TABLE II. COMPARISON BETWEEN HISTORICAL MEASUREMENTS AND SIMULATION RESULTS.

| | **Real system history** | **Obtained values by simulator** | **Difference in percent** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Docking time for TC1 in minutes LOA>= 300m | 73 | 60 | **17%** |
| Departure time for TC1 in minutes LOA>= 300m | 63 | 53 | **16%** |
| Docking time for TC2 in minutes LOA <= 140m | 46 | 42 | **9%** |
| Departure time for TC2 in minutes LOA <= 140m. | 44 | 30 | **32%** |
| Residence time at TC1 quay in hours LOA >= 300m | 12 | 7 | **22%** |
| Residence time at TC2 quay in hours LOA <= 140m | 10 | 7.5 | **25%** |
| Residence time at miscellaneous goods terminal quay in hours LOA>= 180m | 14 | 13 | **7%** |

Efficiency and performance factors are an important part of the analysis and present the results of the latest empirical studies based on port statistics. The scientific and economic benefits of this study are important to provide decision-making tools based on DES simulations to change professionals to make decisions that improve port performance and customer satisfaction.

## 5. Enhancement using ais data

**H.** Using Marine Traffic API

Marine Traffic API is a common middleware interface that is giving real time vessels data, these data are transmitted through Satellite by using AIS Antenna.

This kind of data can also be illustrated over a map. [fig.5]

The data receipt from AIS can contain these attributes as shown in [Table 2][16]:

**I.** Integration with our simulator system

The objective is to get vessels information in real time, and then get our simulator data input updated.

Based on the vessel position (GPS: longitude and latitude), speed we can simulate it arrival. The most important thing is that we disown the climate impact on vessel movement, so, the real time call to vessel position can enhance our predictive view about vessel activity on the sea.

TABLE III. MARINE TRAFFIC AIS DATA TYPE EXAMPLE

| Field Name | Data Type | Description |
|---|---|---|
| MMSI | integer | Maritime Mobile Service Identity - a nine-digit number sent in digital form over a radio frequency that identifies the vessel's transmitter station |
| IMO | integer | International Maritime Organisation number - a seven-digit number that uniquely identifies vessels |
| SHIP_ID | integer | A uniquely assigned ID by Marine Traffic for the subject vessel |

| | | |
|---|---|---|
| LAT | real | Latitude - a geographic coordinate that specifies the north-south position of the vessel on the Earth's surface |
| LON | real | Longitude - a geographic coordinate that specifies the east-west position of the vessel on the Earth's surface |
| SPEED | integer | The speed (in knots x10) that the subject vessel is reporting according to AIS transmissions |
| COURSE | integer | The course (in degrees) that the subject vessel is reporting according to AIS transmissions |
| STATUS | integer | The AIS Navigational Status of the subject vessel as input by the vessel's crew - more. There might be discrepancies with the vessel's detail page when vessel speed is near zero (0) knots. |
| TIMESTAMP | date | The date and time (in UTC) that the subject vessel's position was recorded by Marine Traffic |

The Table 3 show how including the AIS Data has enhanced the predictive view about vessel activity within the port.


Fig. 12. AIS Data on a map example

TABLE IV. COMPARISON BETWEEN SIMULATION RESULTS AND BY INTEGRATING AIS DATA

| | **Real system history** | **Using Simulator & AIS** | **Difference in percent** |
|---|---|---|---|
| Docking time for TC1 in minutes LOA>= 300m | 73 | 62 | **15%** |
| Departure time for TC1 in minutes LOA>= 300m | 63 | 55 | **13%** |
| Docking time for TC2 in minutes LOA <= 140m | 46 | 44 | **4%** |
| Departure time for TC2 in minutes LOA <= 140m. | 44 | 32 | **27%** |
| Residence time at TC1 quay in hours LOA >= 300m | 12 | 9 | **25%** |
| Residence time at TC2 quay in hours | 10 | 8 | **20%** |

| | | | |
|---|---|---|---|
| LOA <= 140m | | | |
| Residence time at miscellaneous goods terminal quay in hours LOA>= 180m | 14 | 13,5 | **4%** |

## 6. Results

As shown above, we can say that now with this simulation and its results, the proposals can be implemented with the benefits achieved.

The estimated collection is relative since it depends on each ship, its technical characteristics and the estimated waiting time.

Starting with the fact that ships with a higher priority index have a longer delay, the ship or terminal will be notified in advance of the change in the ETA when we dock the delayed ship.

The integration of the AIS Data to the simulator has been used a corrector to simulator when receiving the vessel data in real time, means that this integration has enhanced enough our simulator, and gave it output data more maturity.

## 7. Conclusion and future work

First, the logic of the simulator was developed using diagrams resulting from discussions with managers about different processes and predefined details. A simulator was developed from these two elements.

Subsequently, tests were carried out to calibrate and validate the model, and adjustments were made to the model to make it more stable and accurate before performing the tests and analyzing the results obtained.

Important role is played by integrating the AIS Data to our simulator, this can be qualified as a real factor to calibrate our simulator data results.

Finally, we present a smart platform-based congestion simulation, which is a tool to automate the processing of inputs and outputs of this model, and which also allows adequate visualization of the results to facilitate optimal decision-making;

Apart from integrating AIS Data in out simulator, we are currently in a way investigating on how this model can be auto-calibrated by using predictive artificial intelligence algorithm.

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