

# Congested Area Detection and Projection – the User's Requirements

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**ABSTRACT:** Shanghai Maritime University and Gdynia Maritime University have decided to join forces on research program titled “Online detecting and publishing of congested zones at sea”. This research seems to be in harmony with e-Navigation concept presented by IALA. The authors have attempted to identify the Congested Area Detection and Projection System user's requirements.

## 1 BACKGROUND

A number of institutions worldwide are taking actions to assure, improve and promote safety of navigation and marine environment protection. Some of them focus on legal issues, others on technical standards and improvements of equipment quality, communication systems or seafarers training standards.

These actions are usually not well coordinated, whilst connection of individual elements in one coherent system, might result in positive influence on reaching the goals: safety of navigation and marine environment protection.

One of the international institutions which see the need of integration of presently separately operating systems or its elements is International Association of Marine Aids to Navigation and Lighthouse Authorities, (IALA). IALA has made an effort to designing of complete system known as e-Navigation.

In short, one may say, that IALA defines e-Navigation as gathering, integration, exchange and projection of information on board of the ship and shore station alike.

The main tasks of IALA e-Navigation concept are following:

- to improve safety of navigation by providing hydrographic data, navigational warnings and information,
- to improve communication, data and information exchange,
- to secure transport and improve logistics hinterland effectiveness,
- to support effective rescue action in distress, and to collect and archive relevant data for future investigation,
- to integrate and present information on board and on shore,
- to assure global range of coherent norms, compatibility and interoperability of equipment, devices, systems, operational procedures and symbols used,
- to assure adequate accuracy, integrity and continuity so the system could be considered as safe in critical conditions,
- to minimize number of autonomous ship and shore based systems,
- to facilitate effective utilization of waterways for vessels of different classes.

It is highly probable, that elaboration and implementation of uniform standards for e-Navigation will take considerable period of time. Meanwhile, the presently operating systems supporting safe navigation will continue to develop. This considers also the marine traffic monitoring research conducted by Gdynia Maritime University from several years.

This research seems to be in harmony with e-Navigation concept presented by IALA.

## 2 SMU-GMU JOINT PROJECT

### 2.1 *Project Introduction*

Recently, Shanghai Maritime University and Gdynia Maritime University have decided to join forces on research program titled "Online detecting and publishing of congested zones at sea".

This scientific co-operation is based on Agreement between the Government of the Republic of Poland and the Government of the People's Republic of China about technical and scientific co-operation, signed in Beijing on 13th of April 1995.

### 2.2 *Marine Traffic Monitoring System*

In accordance to IMO requirements, maritime states, including China and Poland have introduced Marine Traffic Monitoring Systems utilizing shore based and ships based devices of automatic identification, (AIS). This system facilitates the real time movement monitoring of the vessels fitted in devices of AIS class A or B. AIS class A devices (dedicated for ships), transmits with variable frequency information which include: geographical position, vector of movement as well as declared draught, port of destination and voyage plan as option. Data declared are entered manually by navigating officers. Class B devices (dedicated for fishing vessels and small crafts), transmits with much lesser frequency, information about position and vector. Declared information is not available in this system. In the case of Poland, implementation of such system had been required by Copenhagen Declaration and EC Directive 2002/59, similarly as for remaining Baltic Sea EU member states.

At present marine traffic monitoring is conducted on the Polish waters by the passive mode, and concentrated mainly on data recording. The full use of obtained information by processing them, making available for other users and presenting in useful form, in accordance with e-Navigation concept, may have positive impact on safety of navigation and marine environment protection.

### 2.3 *Marine Safety Information Exchange System*

In addition to Marine Traffic Monitoring System, Poland, similarly to the other EU maritime states, has implemented Marine Safety Information Exchanging System in accordance with IMO COM-SAR/Circ.15, form 9<sup>th</sup> of March 1998, utilizing AIS PL network. This system facilitates transmission by VTS operators of current marine safety information

and local warnings to the ships by means of AIS base station. Polish AIS system, (AIS-PL), consists of 11 land based stations (8 marine and 3 inland) linked via a national server to HELCOM network. Although stations spatial distribution was designed to broadcast VHF signals in A1 zone, the whole Polish responsibility area is not permanently covered (Fig. 1).

Required levels of system performance were established in order to satisfy traffic surveillance and maritime safety requests. There is evidence that effective AIS coverage depends on propagation conditions due to weather and pressure. However, anomalous propagation which results in extended VHF range is relatively rare, there are days when single station range increases from 35 to 200 miles and opposite side of Baltic is accessible. Major traffic regions, like VTS Zatoka Gdanska and VTMS Zatoka Pomorska were designed to have extra coverage redundancy in case of system outages or poor propagation. For that purpose there are alternative base stations and additional communication links.

### 2.4 *Information available to Marine Traffic Monitoring System users*

The scope of AIS information obtained to ship in relation to those available by VTS stations is basically the same. However, number of ships providing such information is different in both of the cases. This difference in number is caused both by limit of ships transmission range particularly of AIS class B devices, as well as by additional VTS stations possibilities to utilize own system of receiving antennas and to obtain additional AIS information available from the other VTS stations.

VTS centres have access to wider information which is covering bigger area than ships have. National Marine Safety System in Poland is currently under reconstruction and additional information from cameras, and shore radar stations would be available to VTS.

The Figure 2 demonstrates current possibilities of obtaining and recording traffic information by AIS PL system.

Data recorded by AIS PL might be used for purpose of joint SMU-GMU project.

In distinct to VTS stations, the ships might observe in close distance the objects not fitted in AIS devices, which might remain to be not visible for cameras and shore based radar stations. Therefore possibilities of exchanging information are important as safety of navigation and environment protection is concern.

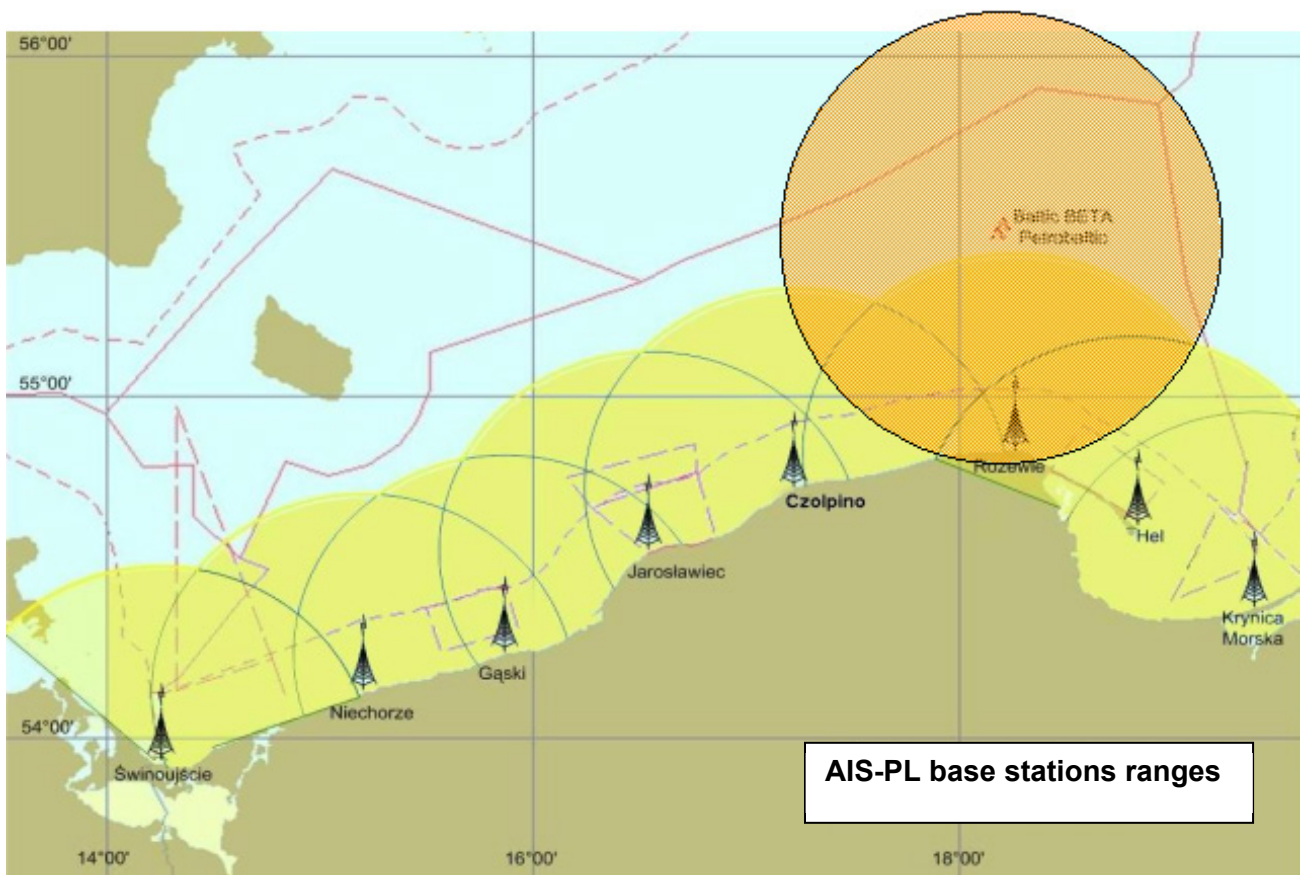


Fig. 1. AIS-PL base stations estimated signal ranges [3]

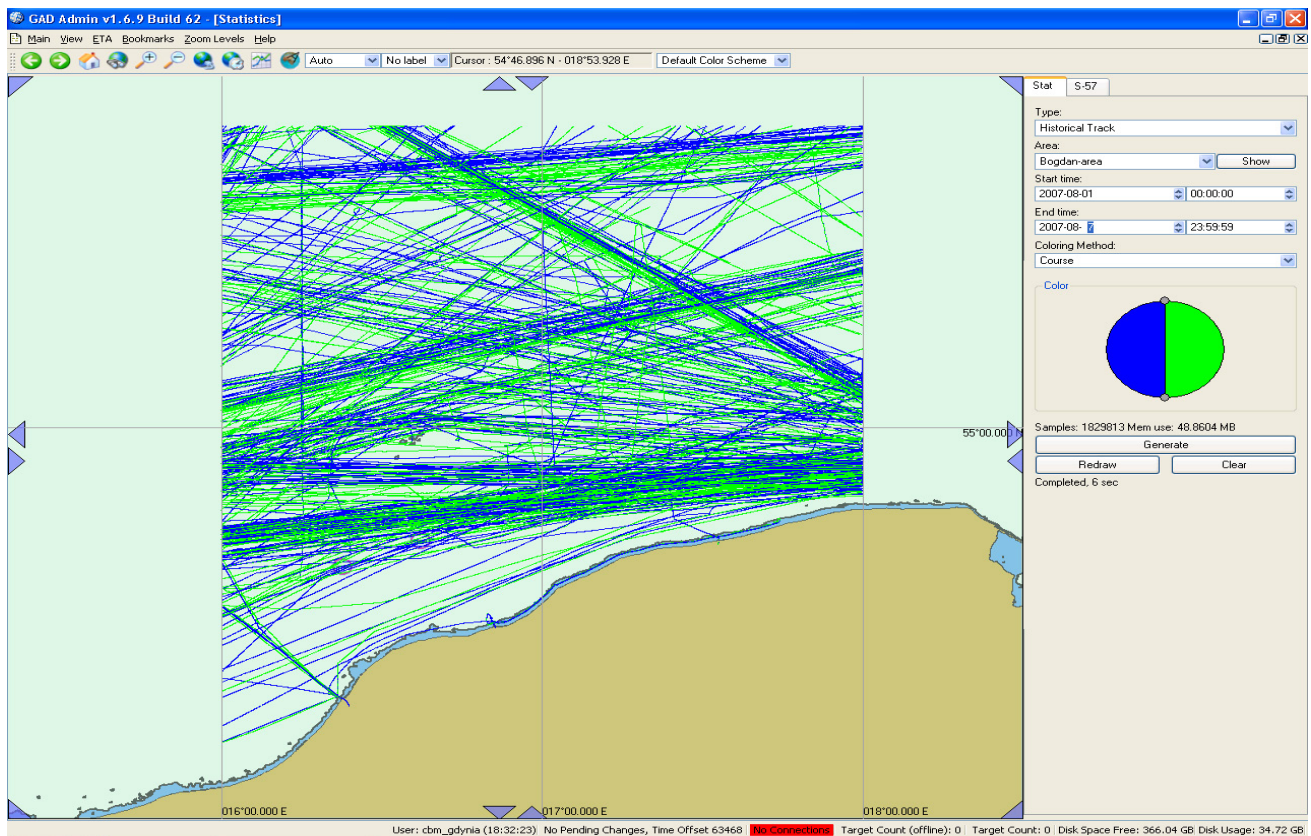


Fig.2. South Baltic Sea traffic flow pattern recorded by AIS PL form 1<sup>st</sup> to 7<sup>th</sup> August 2007 [2]

## 2.5 SMU-GMU joint project description

The main goal of joint SMU-GMU research is to design identification, prediction, and real time projection algorithmic models of congested area.

The figure 3 presents basic idea of the system, as proposed by the authors of this paper.

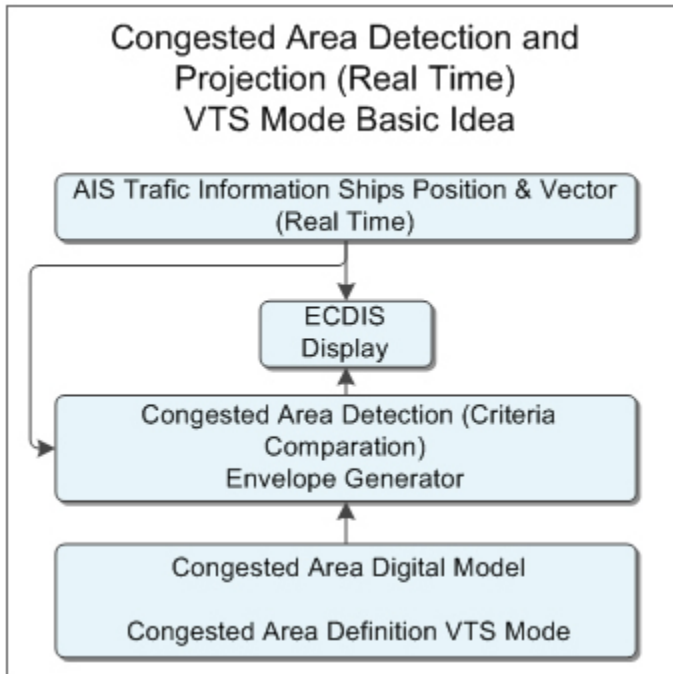


Figure 3. Congested Area Detection and Projection – VTS Mode, Basic Idea

One of the first scientific problems will concern defining and building of mathematical model of congested areas. Due to specific traffic flow pattern on Chinese and Polish waters, each team intends to define congested area in a different way:

- Chinese research team, by utilizing DBSCAN algorithm and the fuzzy modelling distance matching criterion,
- Polish research team, by planning routes of movement of vessels, on the basis of information received from the Automatic Identification System, using a variant of evolutionary algorithms, in accordance with treat of collision criterion.

The definition of congestion adopted by Polish team might require prediction of vessel position in a longer time horizon. This results in need to add prediction option to basic concept of the system. See figure 4.

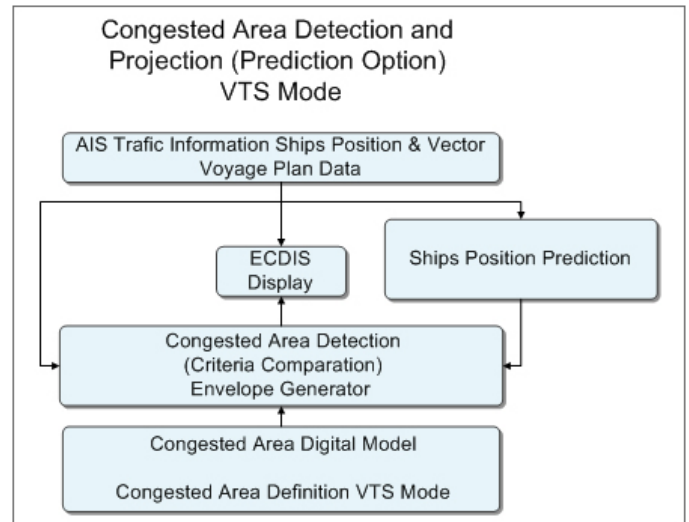


Figure 4. Congested Area Detection and Projection – VTS Mode, Prediction Option

Following tasks will to be performed by GMU research team:

- 1 Conduct surveys on the movement of vessels in Polish maritime areas and development of:
  - Procedures for on-line tracking of vessels under the AIS information.
  - Assumptions algorithm modelling areas with particularly high density of maritime traffic through the planning of routes of movement of ships.
- 2 Create models of passage routes of ships in an environment with static and dynamic constraints and develop and implement alternative evolutionary algorithms for planning paths of movement of vessels on the basis of information from the AIS.
- 3 Develop heuristics analyzing changes in the environment and reasoning on action, the selection of operators, exploration and exploitation of a set of solutions.
- 4 Investigate the simulation and test variants of evolutionary algorithms of traffic flow on the basis of different variants of information from the AIS in Polish maritime areas.
- 5 Analyze and elaborate results of evolutionary algorithms of traffic flow and identification of congested areas or with particularly high density of maritime traffic.

The GMU project provides that traffic information data would be obtained, processed and projected on the screen in a useable form by the VTS station and VTS would be a primary user of the system. However taking in to consideration e-Navigation requirements, the authors suggest, that system should also facilitate availability of selected information addressed to all ships in the region as well as information addressed to the single vessel.

This would require that system has to process data in both, VTS and Own Ship mode. See Figure 5.

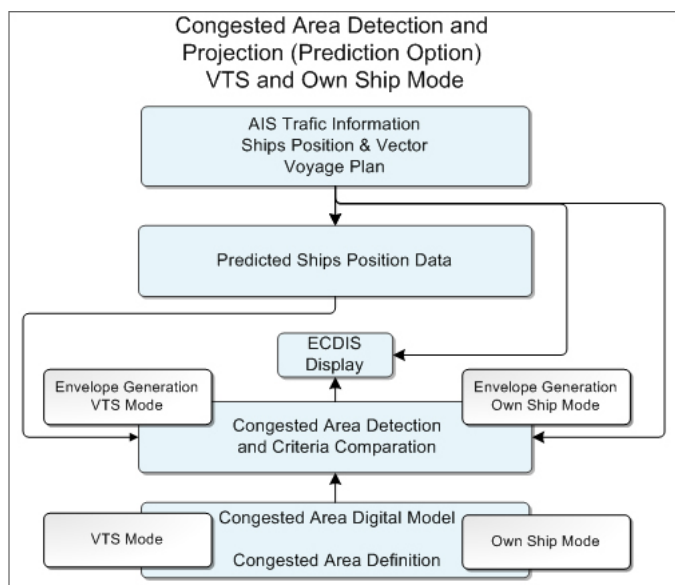


Figure 5. Congested Area Detection and Projection – VTS & Own Ship Mode.

The system for relying of processed data and information would provide for displaying of congested area on the navigation bridge in a real time, as defined according to selected criteria, as well as the early warnings of the collision treats, which might appear in the future on the selected region or single vessel track.

### 3 USER'S REQUIREMENTS

Regardless of the aims of the SMU and GMU research teams in connection to detection and projection of congested area, the authors have attempt to identify the system user's requirements, both VTS operators and the navigating officers. Taking in to consideration technical feasibility and scientific potential of the partners, these requirements are possible to be met in the frame of the joint project.

#### 3.1 VTS operators requirements

The authors have identified following VTS operators requirements:

Feasibility of detection and projection of the congested area on which, due to the traffic intensity, its flow is reduced or constrained.

Feasibility of detection and projection of congested area on which, traffic intensity exceeds safe margins required to facilitate safe navigation, taking in to account current hydro-metrological conditions.

Feasibility of early detection of collision treat for a single vessel or common treat for group of ships and presentation of potential collision area with indication of time and number of ships involved.

Feasibility of short term prediction of changes in location, shape, range and character of congested area, and in case of collision impended area prediction of time and number of vessels involved.

Detected area in course of time may smoothly change its location, shrink, enlarge, change character, divide, merge or vanish. In the future, the system operators basing on above changes may learn to draw conclusions concerning congestion level and navigation safety.

Early detection of area impendent by the congestion feasibility might be restricted in the case of lack of voyage plan transmission by class A ships. This data transmission is not obligatory at the moment. Therefore authors postulate obligatory voyage plan transmission on the area covered by VTS, on the same base as obligatory VHF reports are required at present.

The voyage plan information covering controlled area obtained from all ships equipped in AIS class A, would facilitate preparation of reliable forecasts of areas impendent by congestion and would facilitate effective traffic management.

Scientific analyze of recorded changes of congested area might open new prospects in long term forecasting of congestion or collision treats. This analyze would contribute to design new methods of congested area traffic management and elaboration of the new, presently unknown navigation aids, dedicated to voyage planning in the form of charts, modelled on Pilot or Routing Charts.

#### 3.2 Navigating officers' requirements

The authors have identified following navigating officer's requirements:

- 1 Feasibility of Internet access to real time presentation of ship's movements in selected VTS area including detected congestion boarders and short term prediction of the following:
  - area of slow or constrained traffic flow,
  - area with traffic intensity exciding safe margins,
  - area impended by collision treat.
- 2 Feasibility of receiving facsimile transmission of information described in point 1, in equal time intervals, for example every one hour.
- 3 Feasibility of obtaining automatically, or by an action of VTS operator of early SMS warning about impendent situation on the ships track, boarders of suspected area and time of reaching these boarders.
- 4 Feasibility of receiving automatically SMS message about treat diminishing due to own vessel early action or action of the other vessels involved.

The authors anticipate that both teams would analyze identified in this paper user's requirements and consider to implement them in the course of research.

If presented proposals would meet the interest of research teams, the authors are ready to engage in preparation of detailed specification of the user's requirements which might facilitate including such requirements in the joint project.

#### 4 CONCLUSION

Implementation on the laboratory level of SMS early warnings or messages related to collision impendent area, after conducting required tests might in the future be developed in the direction of Automatic Collision Impendent Area Avoidance Advisory System.

As the next step, the scope of the automatic advices might be extended to Congested Area Avoidance System.

Automatic messages related to congestion avoidance might compose an element of that future Con-

gested Area Traffic Management System, which seems to be in harmony with IALA e-Navigation concept.

Authors express view, that present joint SMU-GMU project could be a great opportunity as a start point for future fruitful cooperation that would benefit of all seafarers, marine environment and both nations.

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