A new method to identify close situations between vessels

As part of the MonaLisa 2.0 project, SSPA has developed a geometric method for identifying close situations between vessels, as well as a very fast mathematical implementation of that method. The method is used for de-conflicting voyage plans in the project as well as analysing traffic from SSPA's large AIS database.

In the MonaLisa 2.0 project, SSPA develops tools and services for added efficiency and safer transport. One of the services separates voyage plans so that they does not overlap, as an effort towards safer voyages in the planning phase. This service is centred around a method, developed in this project, which compares voyage legs for one ship and determines if there is an overlap with previously checked voyages for other ships.

This text describes both the method, i.e. the rules that define a conflict, and the technical details on how this method is implemented, in the text referred to as the implementation.

Conflict candidates

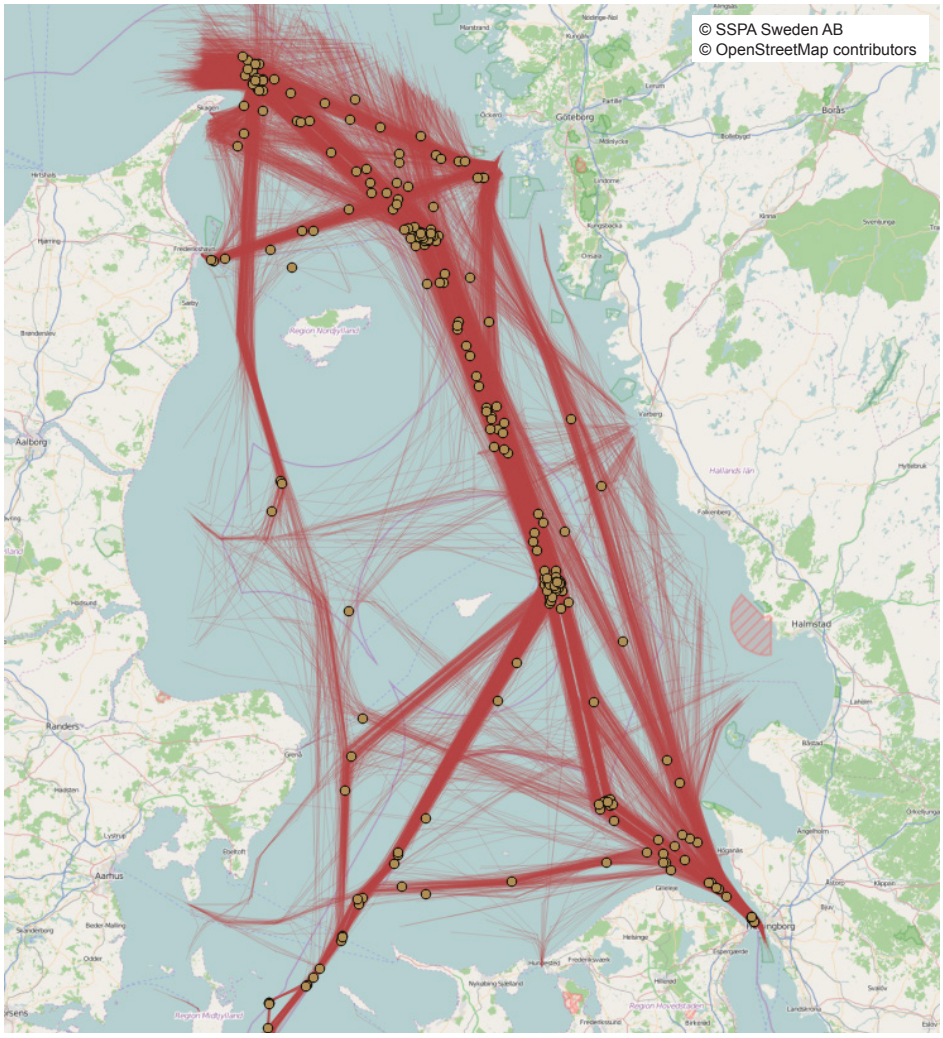
The geometric method for identifying close situations, called "conflict candidates", acts on vessels modelled as ellipses.

Conflict candidates are defined as two vessels where:

A. The safety ellipses of each vessel overlap, both spatially and in time, while travelling on their route leg
B. The ellipses constructed from the length and beam of each vessel overlap, both spatially and in time, while travelling on the extended section of each route leg.

In order to allow room for manoeuvring, the safety ellipse is larger than the vessel dimensions, usually by a factor of four or more.

The extended section in the definition is labelled as an FTA segment, an abbreviation of "Failure to Take Action". The FTA segment adds room for error at each waypoint, i.e. the vessel may miss the waypoint and continue at the same speed and course, and even then, there are no intersecting routes for a specified amount of time.



Identified conflicts over one month of all commercial traffic in the Kattegat. Performed using the conflict candidate method developed by SSPA, based on AIS-data provided by the Swedish Maritime Administration.

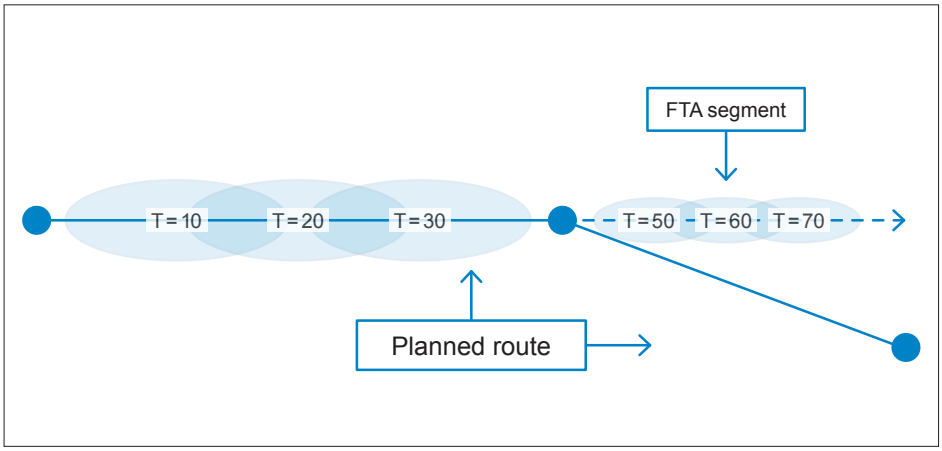
SSPA AIS database

SSPA has stored years of AIS data, both from Swedish coastal waters gathered by the Swedish Maritime Administration (SMA), and from across Europe via the crowd sourcing initiative AIS Hub. At SSPA we also have the ability to load any AIS data in NMEA format for customer-specific analysis.

Mathematical implementation of the method

The benefit of modelling vessels as ellipses is that the expressions are analytical in the mathematical sense, i.e. instead of being line segments or polygons they can be represented with continuous mathematical functions. As such, there are ways to simplify and derive useful results.

A basic implementation of the method would be to, for each predefined time step length, compare one ellipse against the other, point by point. This means that all points on the contour



Safety ellipse travelling on the route and ellipse with vessel length and beam on the FTA segment.

of one ellipse need to be compared to all points on the contour of the other ellipse, i.e. a lot of comparisons, which takes a lot of time, especially when handling large amounts of AIS data. It also means that the step size has to be selected carefully. This introduces problems, since compromises then have to be made.

To solve this problem, to avoid missing any conflict candidates and to retain fast computational time, a numerical implementation has been developed, inspired by collision detection algorithms in computer games. The original algorithm was used as a ballistic method in first-person shooter games to identify where bullets will hit.

The implementation compares the signs and values of the roots of the equation system of two ellipses, i.e. the characteristics between the ellipses. There are a limited number of interactions that can occur between two ellipses; adjacent, overlapping in two points, three points, etc. The characteristics for these interactions are pre-calculated and then compared to the ellipses in question. If they match the pre-calculated values then there is an overlap, which means that the two vessels are in conflict, both in time and space. The fact that many values in the interactions are pre-calculated and the limited amount of comparisons is what makes this implementation very fast.

Method Analysis

The most commonly used software at SSPA for maritime traffic risk analysis is "IWRAP Mk2" (IALA Waterway Risk Assessment Program), currently developed by GateHouse in Denmark and recommended by IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) as the standard program. IWRAP can import AIS data files and, given that the user defines a traffic model over the area, IWRAP can calculate the number of collision candidates.

An advantage of the developed method compared to IWRAP is that there is no need to define a model, the method calculates conflicts using all the given data. Another is that the developed method is time dependent, i.e. it can be used for studying ship routes separated in both time and space. IWRAP is a statistical method that calculates ship-on-ship collision frequencies time independently.

To evaluate the difference between the methods, an end-to-end comparison was made using the same input data, and then comparing the end output of both programs. Two input datasets were created in order to get two reference points in the comparison. One with all commercial traffic in the Kattegat as well as a smaller set with only the transit traffic in the area, both with a duration of one month.

The relative difference, which is frequently used when comparing risks, is almost identical. For IWRAP the relative difference between the data sets is 5.5 and for the developed method, it is 6.0.

The method will behave similarly to IWRAP with relative measurements, although some adjustments may be needed for the absolute values.

Conclusion

Both the described method and the technical implementation are important elements in the overall capabilities of AIS traffic analysis at SSPA. With constantly growing datasets – Big Data – the bar continues to be raised when it comes to high performance computing, and this method, and especially the implementation, is one step on that path, further strengthen SSPA's position at the forefront of marine traffic and risk analysis.

Henrik Holm

Project Manager.
Henrik studied on the Masters program Complex Adaptive Systems, in the Engineering Physics Department, at Chalmers University of Technology. Previously he has worked as Product Manager at Playscan AB and as Software Architect at Avail Intelligence, both in Gothenburg, Sweden. Since starting at SSPA in January 2013, he has been involved in various research projects developing route optimisation and mathematical modelling.

Contact information
E-mail: henrik.holm@sspa.se

Peter Grundevik

Vice President,
Head of SSPA Research.
Peter received his Ph.D. in physics from the University of Gothenburg/ Chalmers University of Technology in 1982. He then worked at Ericsson Radio Systems developing sensor techniques. In 1993 he became president of Dyning Utveckling, developing communication systems. He joined SSPA in 1997 and has worked with e-navigation technologies, intermodal transport and project co-ordination.

Contact information
E-mail: peter.grundevik@sspa.se

MONA LISA 2.0 SECURING THE CHAIN BY INTELLIGENCE AT SEA

"The MONALISA 2.0 project contributes to a continuous improvement and development of efficient, safe and environmentally friendly maritime transport in the European Union by implementing concrete pilot actions and studies that will foster deployment of new maritime services and processes."

Co-financed by the European Union
Trans-European Transport Network (TEN-T)

SWEDISH MARITIME ADMINISTRATION

REGION VÄSTRA GÖTALAND