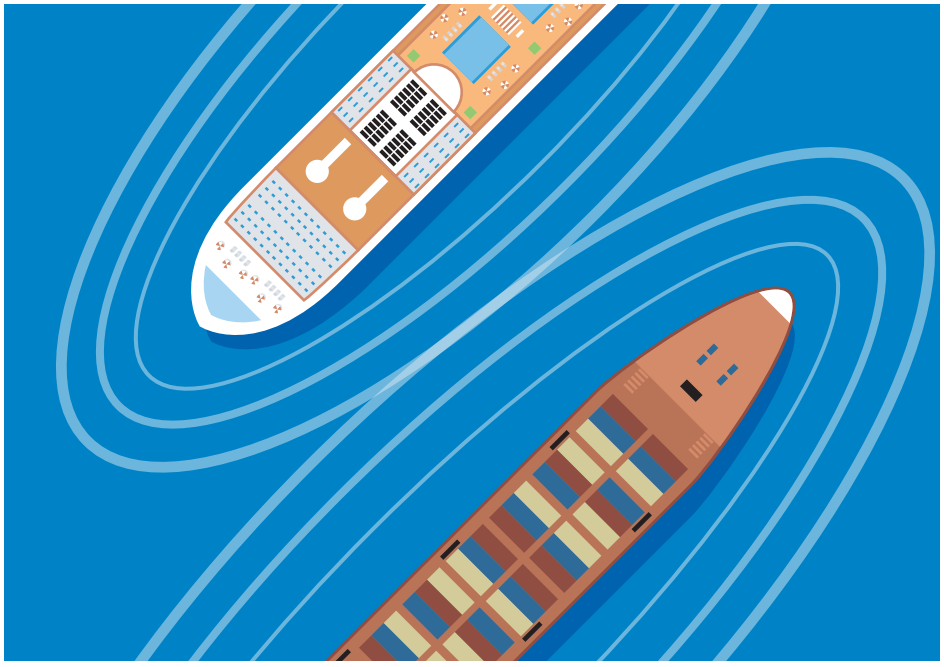
Defining normal ship behaviour and safety distance to other ships in open waters

When ships approach each other, there are recommendations on the minimum distance to keep. The geometrical shape that this distance forms around the vessel is defined as the ship domain and it has been studied since the early 1970s. The progress in computer capacity and the introduction of Automatic Identification Systems (AIS) challenge SSPA to further investigate the domain and use new methods and knowledge. When performing maritime spatial planning, e.g., when implementing traffic separation schemes or when building maritime infrastructure, it is very important to understand normal ship behaviour. A poor understanding of how a ship normally behaves may lead to unreliable estimations of risks at sea. To assess how ship domains vary under different geographical settings and in different types of meetings, SSPA performed a case study. Our researchers studied over 600,000 ship encounters at 36 locations around the Swedish coast. The conclusion is that the ship domain has the shape of an ellipse with half axes radii of 0.9 and 0.45 nautical miles in open waters. In contrast to previous research, it has also been discovered that the ship domain is unrelated to the length of the ship.



Normal behaviour is considered to be safe behaviour at sea, i.e. vessels that deviate from normal behaviour may be regarded as uncomfortable for the other vessels and therefore result in an increased risk of collision.

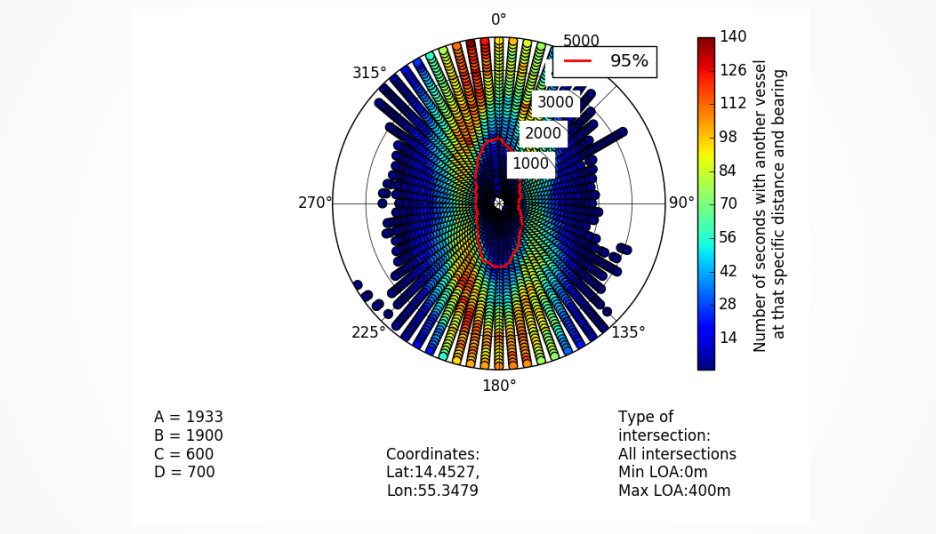
All vessels are expected to comply with international regulations and practices as they navigate in open waters and in waterways. As ships approach each other, the distance between them must be "well clear". This "well clear" area surrounding the ship is often referred to as the ship domain and has no fixed or defined minimum distance according to the regulation. Normal behaviour is considered to be safe behaviour at sea, i.e. vessels that deviate from normal behaviour may be regarded as uncomfortable to the other vessels and thereby result in an increased risk of collision.

For example, the width of a Traffic Separation Scheme (TSS) is related to the traffic flow and the ship domain, therefore, a large ship domain requires a large TSS and a small ship domain may interfere with the safety when the traffic becomes too dense. In the case of maritime infrastructure, an underestimate of the probability of collisions may lead to an increased risk of collisions and grounding accidents, whereas overestimating may lead to excessive costs when building maritime infrastructure.

Practical implications and defining normal ship behaviour

To assess how ship domains vary under different geographical settings and in different types of meetings, SSPA performed a case study, using a new method. The researchers used AIS data collected by the Swedish Maritime Administration during the entire year of 2016. In total 36 different locations were studied, 24 in open waters and 12 in restricted waters. The data volumes for one year are enormous and in order to handle it, all data was transferred from GPS positions into lines.

Two circles are drawn for each of the 36 locations, all ships passing the inner circle are treated as Own Ships (OS) and all ships passing the outer circle at the same time as an OS is present are treated as Target Ships (TS). Then the lines for both OS and TS are split into points every second and the distance and bearing between them are measured. The long list of OS, TS, bearing and distance are now filtered and grouped on each 5° bearing and arranged by distance. Since the chosen definition of the ship domain in this research is where it is normal to pass each other, therefore everything greater than two sigma is considered normal. The ship domain is the border between normal and abnormal, which is marked as the red line in the figure on top of the next page.



This represents seconds of meetings at one of the locations in the Bornholmsgatt southeast of Sweden. Red indicates many meetings and blue few, the red line (95%) is the ship domain.

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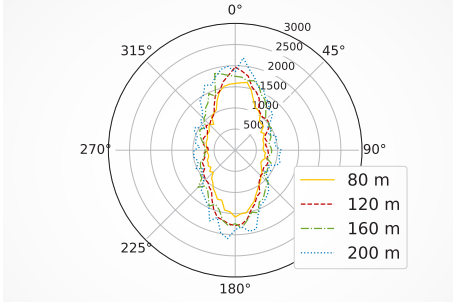
Geographical characteristics influences the shape and size

The ship domain is relatively constant in open waters, but restricted waters influence the size and shape of the ship domain. The open water locations at the Kattegat and Bornholmsgatt locations, have a rather similar size and shape, and represent what is typical for open waters with predefined routes and/or TSS. In contrast, the Öresund – Drogdgen channel is a narrow passage, which illustrates that the two-sigma line forms an oblong shape. Furthermore, Öresund – East of Ven represents an example with dense crossing traffic, which renders a two-sigma line with a more circular and smaller shape. This is, of course, expected since ships keep a closer distance rather than risk running aground; it also proves that the static shape and size of the ship domain becomes dynamic in restricted waters.

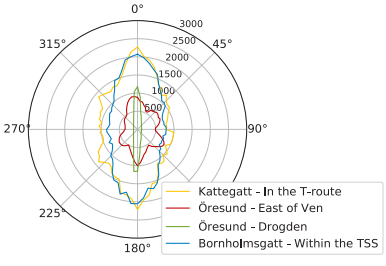
In the figure below to the right is the ship domain separated between overtaking and crossing situations. In overtaking situations the major axis of the elliptic ship domain is directed in the same direction for all vessels, hence in crossing situations the direction of the major axis is mixed, and the larger axis of the ellipse is turned. Therefore, the ship domain in overtaking situations resembles an ellipse, whereas in crossing situations, the ship domain resembles a circle.

As mentioned previously, the ship domain was introduced in the early 1970s and was then defined as an ellipse with radiis of 4 x 1.6 ship lengths. Measuring the ship domain in the "unit" ship lengths has since then been the standard.

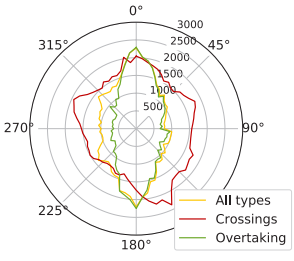
The average shape of the ship domain in open waters is an ellipse with radiis of 0.9 x 0.45 Nautical Miles.



The ship domain for different ship sizes compiled from all open water locations. The length of the ships (both OS and TS) is grouped into 40-metre intervals.



Example of ship domains in different locations.



Example of ship domains in different types of intersections.

Our experts' new findings show that the ship domain has the shape of an ellipse with half axes radii of 0.9 and 0.45 nautical miles in open waters. In contrast to previous research, it has been discovered that the ship domain is unrelated to the length of the ship. This means that smaller ships pass each other at the same distance as larger ships, see the figure above.

The change of passing distance is probably due to better risk management on-board and the introduction of Automatic Identification Systems (AIS) which shows both small and large ships.

The findings are described in detail in an article written in The Journal of Navigation. The project will run until 2022, currently financed by Vinnova, Interreg ÖKS, Logistik och Transportstiftelsen and Norwegian Public Road Administration.

All illustrations by SSPA.