DQWG15 - 06.1A

Paper for Consideration by DQWG
Concept of Uncertainty Zone of individual ships

Submitted by:	DQWG Chair on behalf of S-100WG Chair on behalf of SINTEF OCEAN
Executive Summary:	Address the need of the maritime community to safely navigate in close proximity of other vessels and objects being stationary or moving.
Related Documents:	https://www.sintef.no/projectweb/hull-to-hull
Related Projects:	S-100, S-101 PS and FC.

Introduction / Background

This paper is introduced by SINTEF OCEAN (Norway) as part of the H2020-project H2H (https://www.sintef.no/projectweb/hull-to-hull). The overall objective of the project is to address the need of the maritime community to safely navigate in close proximity of other vessels and objects, being stationary or moving

Analysis/Discussion

SINTEF OCEAN has made the following request to the Chair of the S-100WG:

Please find attached an input paper that may be relevant for the next S-100 WG5 meeting.

The paper convers work done as part of the H2020-project H2H and describes the concept of Uncertainty Zone that indicates that a ship or object is positioned inside its zone with a probability of 95%.

As we think this concept is closely related to the S-100 Framework, we would like to further explore how it can be handled in this context. In addition to UncertaintyZone, we have discribed the concept of relative distance and speed between two ships/objects, or more correctly: Between a point on the geometry model of one ship/object to a point on the geometry model of another ship/object.

Conclusions and recommendations

None at this time. The author has been invited to attend the S-100WG5 meeting (March 2020).

Justifications and impacts

None at this time.

Actions required of the DQWG

The DQWG is invited to:

a. note this paper
b. discuss its content
c. provide feedback to the upcoming S-100WG5 meeting
d. take any further actions as deemed necessary

Uncertainty Zones and Relative Distance/Speed for Objects in Simultaneous Operations

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Introduction

This input paper briefly presents those parts of the work done in the H2H project[2] that is relevant for standardization in the S-100 Framework.

The Uncertainty Zone Concept

The concept of **Uncertainty Zone (UZ)** is used to assist navigators and operators to perform safe navigation of objects (ships) in proximity to other objects (other ships or fixed objects as quays or locks).

> *The **Uncertainty Zone (UZ)** represents the uncertainty in the outer boundary of the geometry of a ship or a fixed object within an operational area, at a given time, see two examples of UZs as red shaded areas in* Figure 1.

Each Uncertainty Zone is calculated based on data from position sensors (GNSS data[3]), inertial sensors onboard the ships, range-and angle sensors, and geometry models (2D or 3D) of the objects. Each UZ is calculated based on data from **all objects** that participate in the simultaneous operation. Each object is responsible for calculating all uncertainty zones, that is, both its own UZ and the UZ of all objects participating in the operation.

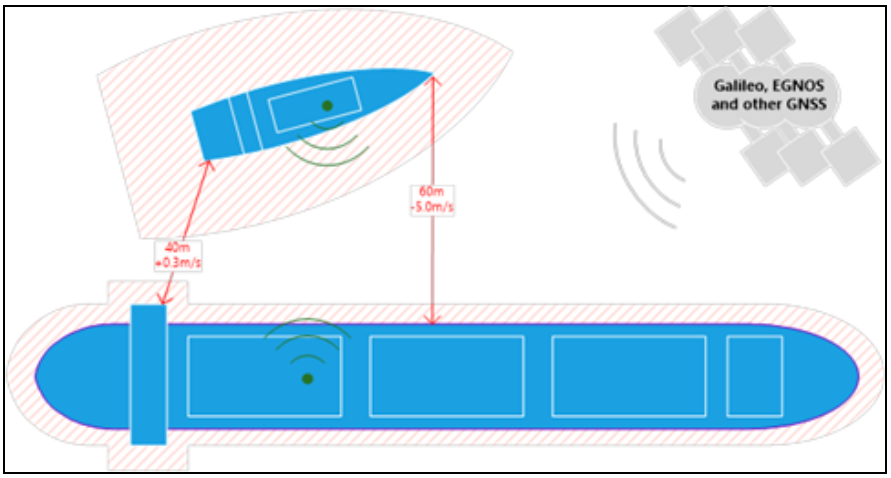

Figure 1 Uncertainty Zone (red, shaded area) for to ships in a simultaneous operation

An example is shown in Figure 1 where the large ship calculates its own UZ and also the UZ of the smaller ship that participates in the operation. And similarly, the small ship calculates its own UZ and the UZ of the larger ship. This means that the UZs may look different onboard each of the ships,

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[2] https://www.sintef.no/projectweb/hull-to-hull/

[3] Including Galileo and EGNOS

dependent on the information available for doing the calculations. It also means that data must be shared and communicated amongst the ships and other objects to be able to perform these calculations. Work will be done to propose this as a standardized protocol as part of IEC 61162 to ensure that any equipment implementing Uncertainty Zones will be compatible, independent of the actual provider.

An integrity requirement is added to the uncertainty zone specifying that:

- The probability is 95% that each position of a point on the hull is inside the uncertainty zone. In other words: The extent of the uncertainty zone from the hull represents a probability of 95% that the hull is inside this UZ.

If less data is available for the calculation of an UZ, for instance, only position data from AIS, the UZ may be simplified to be a circle and the ship may be presented as a point or a rectangle representing the length and breadth of the ship, Figure 3.

Several sources of uncertainties are handled when calculating the UZ, Figure 2. This includes:

- The installation error, that is, the difference between the physical location of a sensor and the location in the geometrical model.
- The error in the actual data received from the sensor
- The error in the geometrical model compared to the physical object (ship or fixed object).

These three factors can in addition to the 95% probability when calculating the size and shape of the UZ.

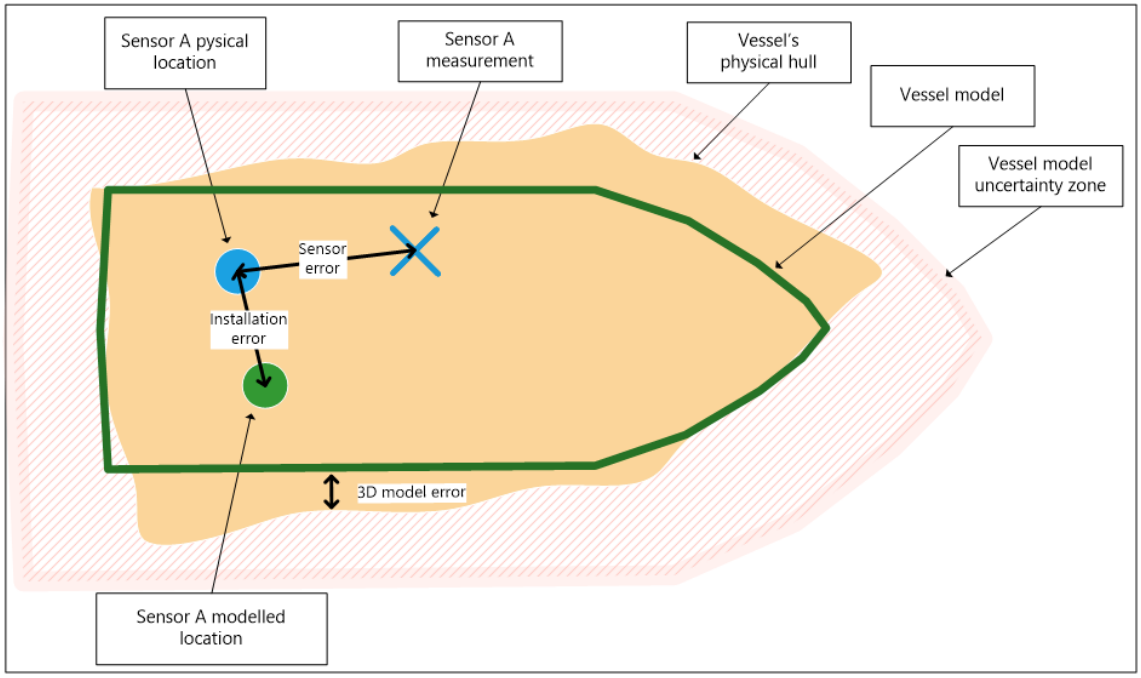

Figure 2 Error factors in the Uncertainty Zone

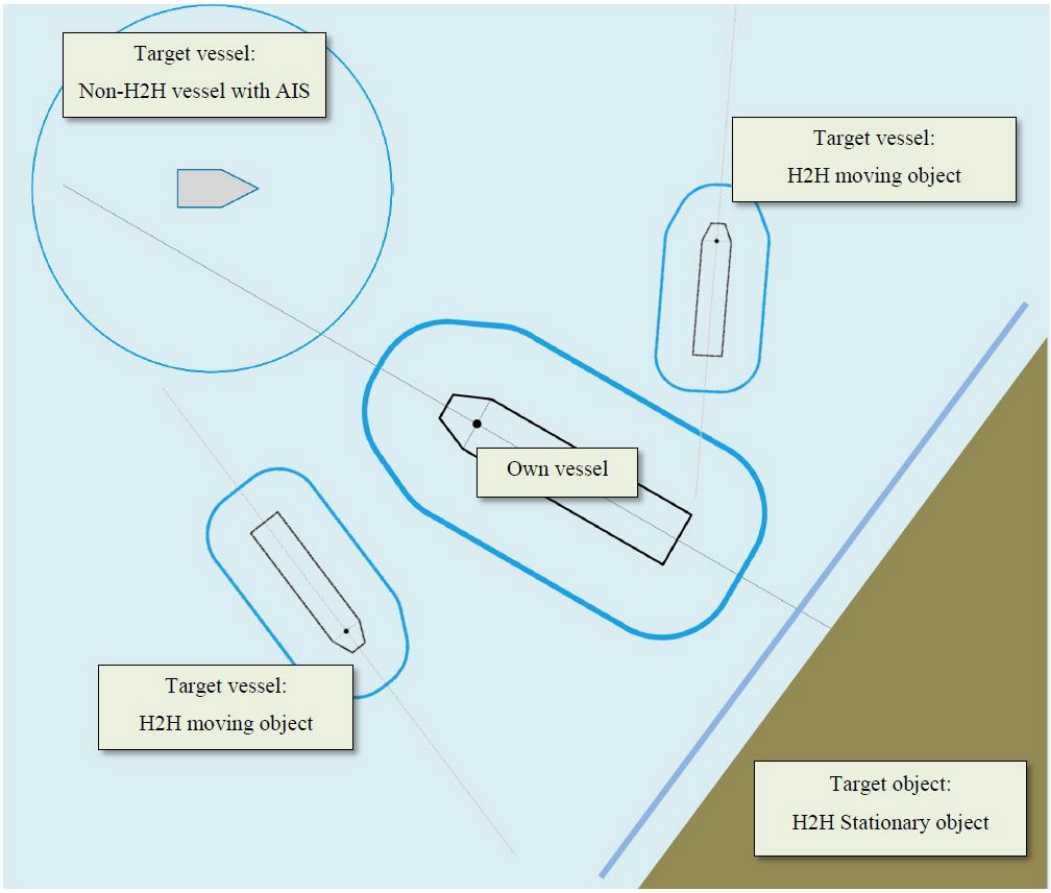

Figure 3 Examples of Uncertainty Zones

Display of Uncertainty Zones and Ships/Objects

The display of the uncertainty zones must be updated each time the underlying data describing this UZ is updated, and also each time the UZ itself is updated. Especially, if communication to at least one of the other ships/objects in the operation is lost, the UZ may suddenly get larger due to an increased uncertainty. This must be reflected in the presentation of the UZ.

If the geometrical model of the ship/object is available, this model, either 2D or 3D, can be used in the presentation. If only the ships/objects dimensions are available, this can be used to present a simplified view of the objects. Zooming of UZs and ships must be handled accordingly.

Other Measurements

In addition to have a picture of the UZ, the operator can also select a point on his own ship's/object's geometry and another point on a target ship's/object's geometry. Then, the calculated relative speed and relative distance between these two points must be presented. Figure 1 shows the relative speed and distance between two points on each of the ship's outlines.

Draft Class Definitions

Figure 4 shows the draft class for describing an uncertainty zone. The UncertaintyZone:Geometry-attribute includes the LAT/LON for each point on the UZ, in the datum used for the presentation. The Sigma attribute represent the probability of having the ship/object fully inside the UZ, where 1 sigma is 95% probability and 2 sigma is 95% probability.

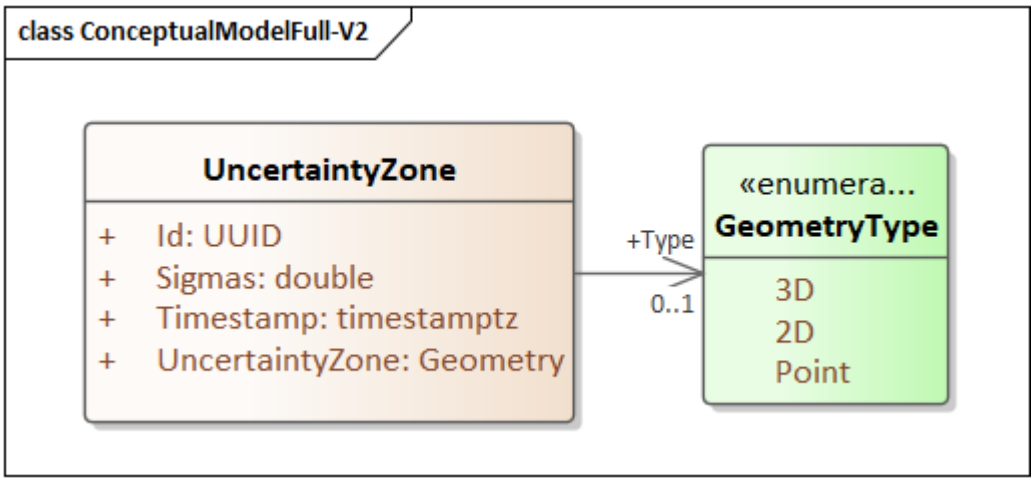

Figure 4 Draft Class for Uncertainty Zone

Figure 5 shows the draft classes for the object geometry, reference points and relative distances and speeds between two points on the object geometry. Each reference point is related to an object geometry. The relative distance and speed are related to a start and end reference point through the class VirtualSensorMontionState, since the relative distance and speed is dependent of the actual measurements for the start and end points. New measurements in at least one of the start and end point will require new calculations of the relative distance and speed.

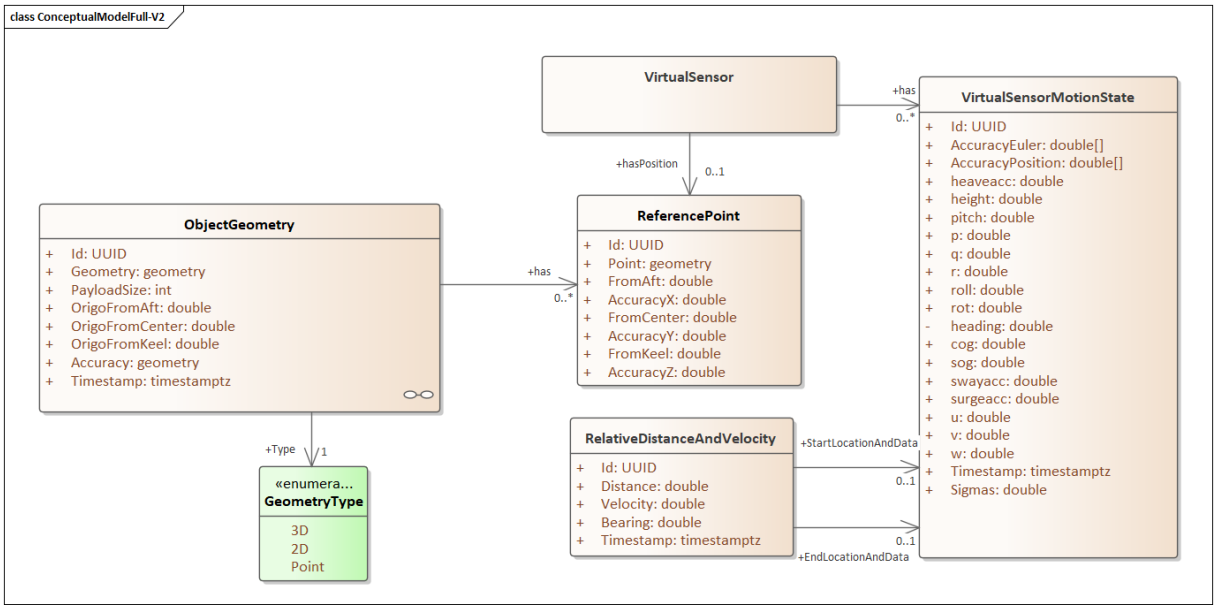

Figure 5 Draft Classes for Object Geometry and Relative Distance/Speed