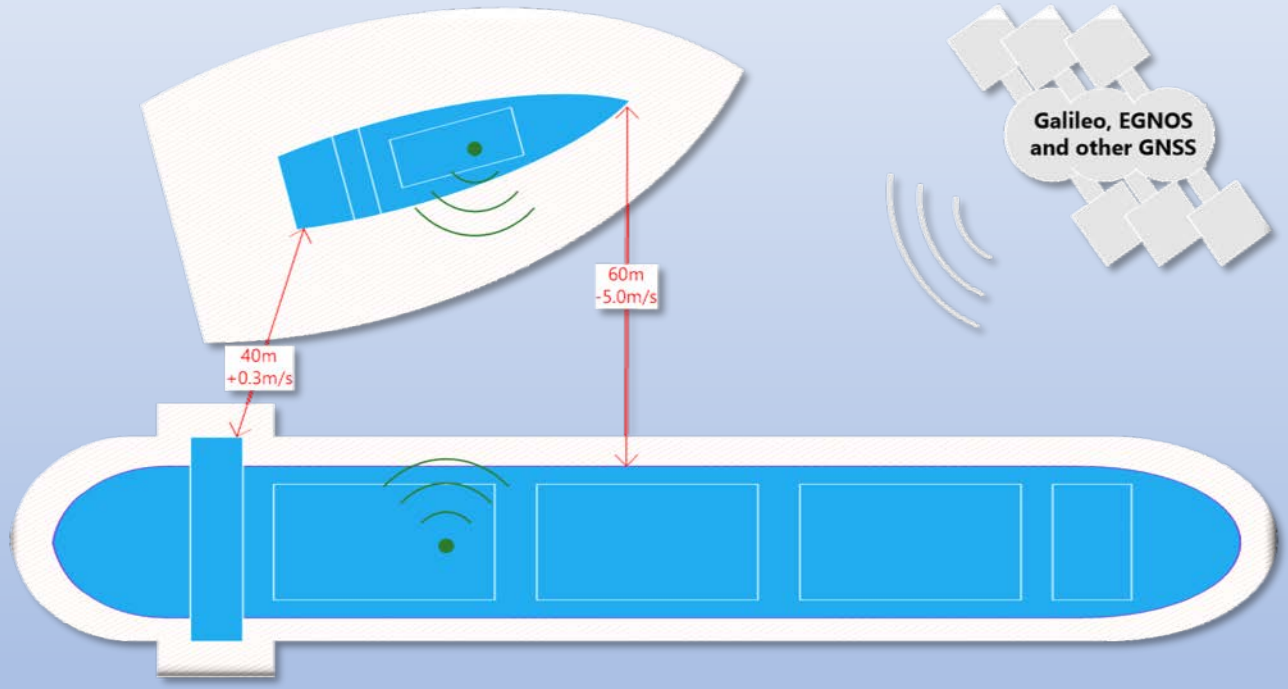
HULL TO HULL

HORIZON 2020



A Public API Supporting Autonomous Navigation

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SINTEF Ocean AS

2nd International Conference on Maritime Autonomous Surface Ship - ICMASS

Trondheim, 14th of November 2019

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Agenda

- The Hull-to-Hull (H2H) project
- H2H Conceptual and Domain Model
- H2H Interfaces
- Open API Initatives and Open API Specification
- H2H REST and WebSocket API
- Signal K open source project as a candidate for H2H public framework
- Summing up

Hull to hull Objective

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.

Hull to hull supports both traditional navigation as well as autonomous vessels

Hull-to-Hull (H2H) Project

HULL TO HULL

- Funding from the European GNSS Agency (GSA) under the European Union's Horizon 2020 R&I programme grant agreement No. 775998

- 3 years project started 01.11.2017

- 5 Partners

GALILEO EGNOS

European Global Navigation Satellite Systems Agency HORIZON 2020

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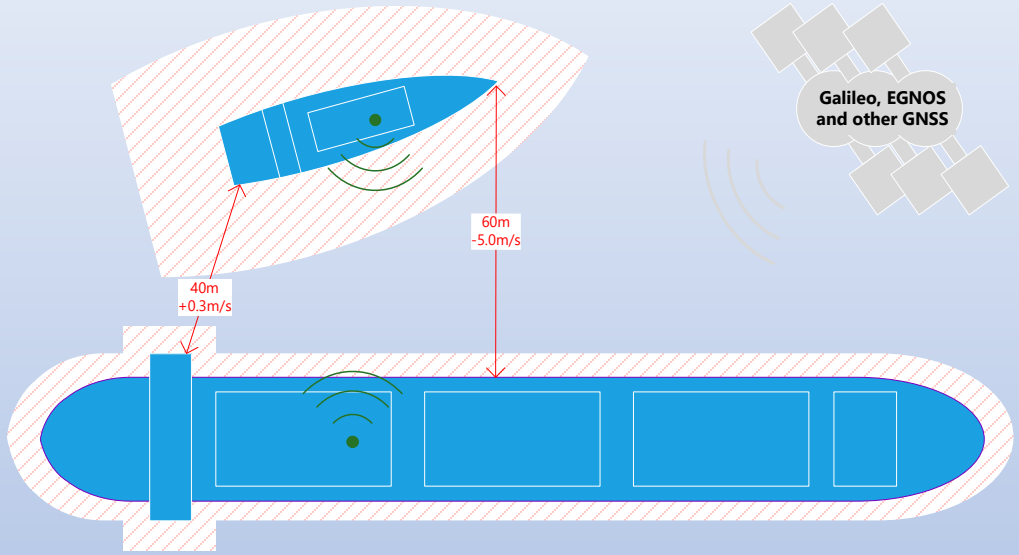
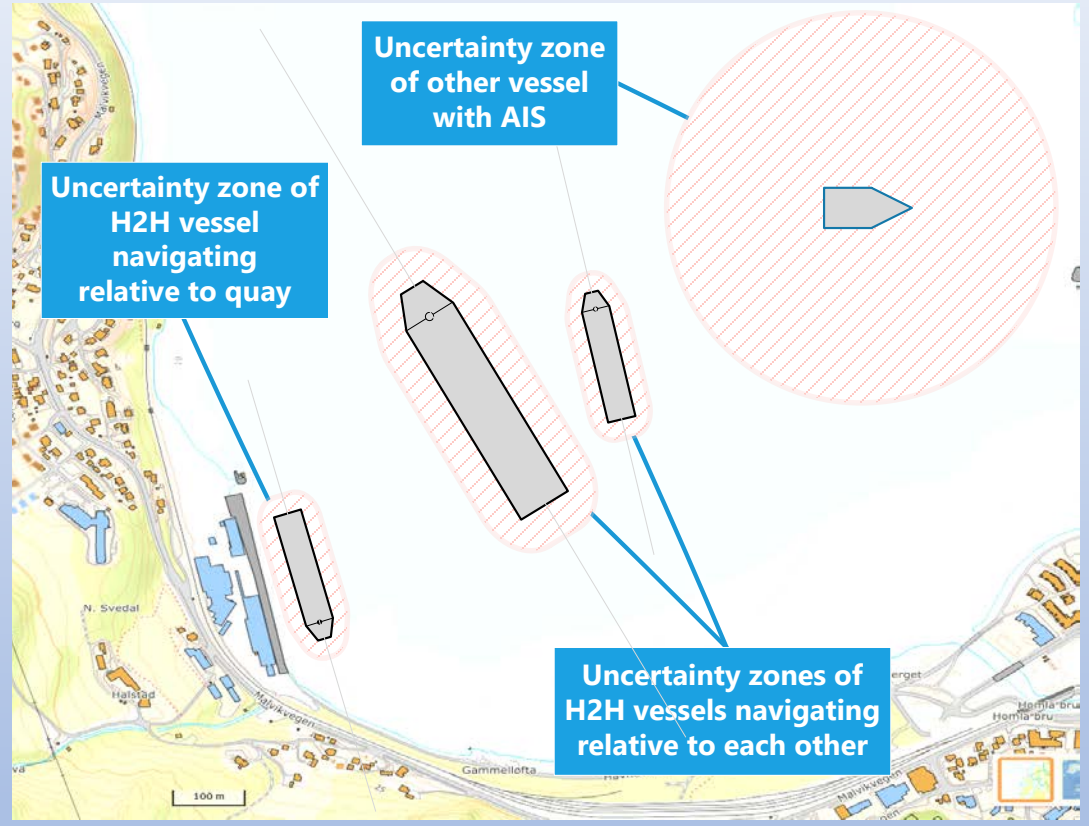
Basic Concept

- Hull-to-hull positioning based on 3D models and position measurements
- Vessel to vessel data exchange:
  - 3D vessel models
  - Sensor measurement, e.g. position, orientation.
- Open concept with standardized data exchange
- Uncertainty zones for own vessel as well as neighbouring objects indicate position accuracy



More on uncertainty zone

- Represents the uncertainty in the outer boundary of the geometry of vessels and objects of interest
- In maritime domain we define the uncertainty zone to represent a probability of 95% or 2σ
- Represented as:
  - For a 3D object it is a volume around the object
  - For a 2D object it is an area around the object
  - For a single point (e.g. non-H2H vessel with no geometry data) it is a circular area



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Yara Birkeland top view

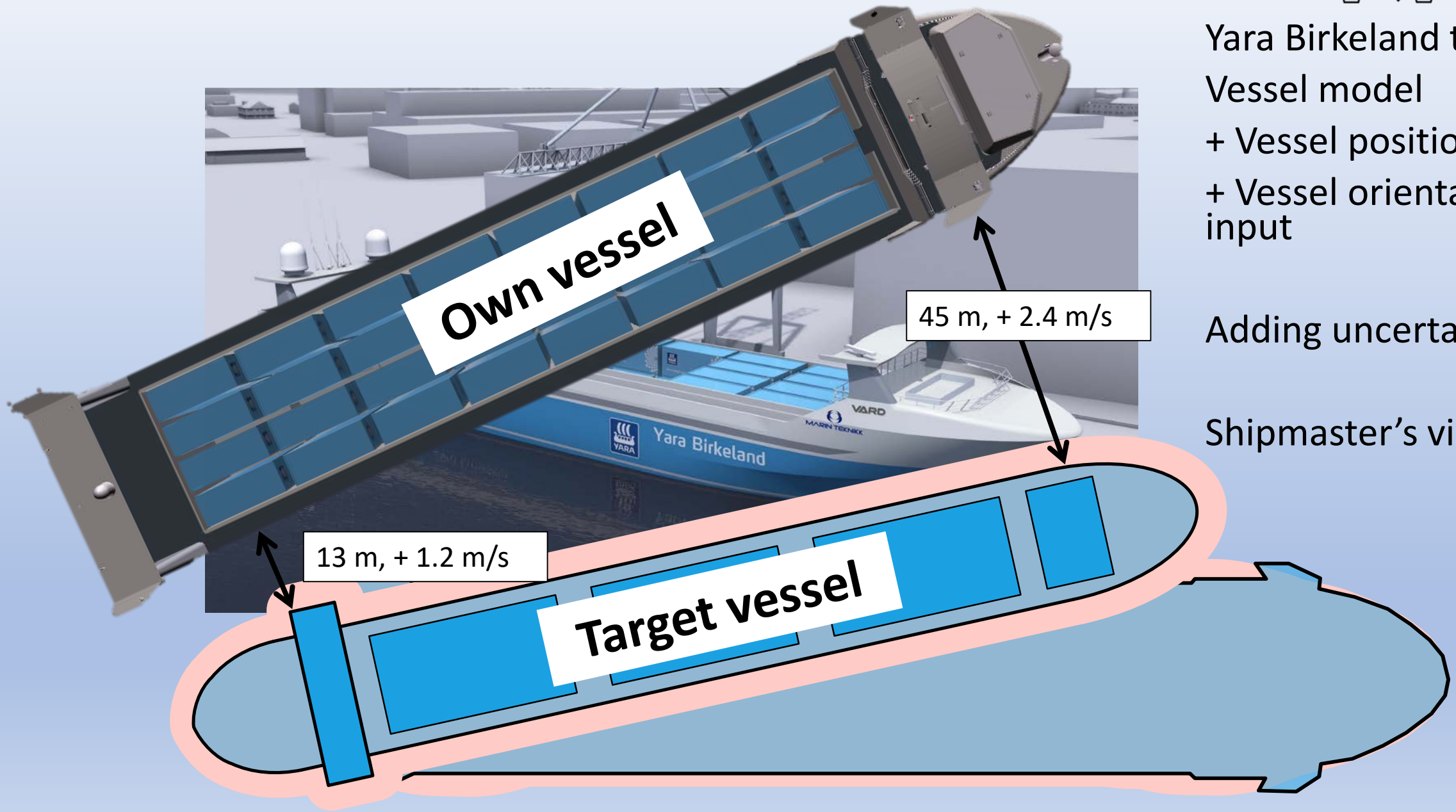
Vessel model

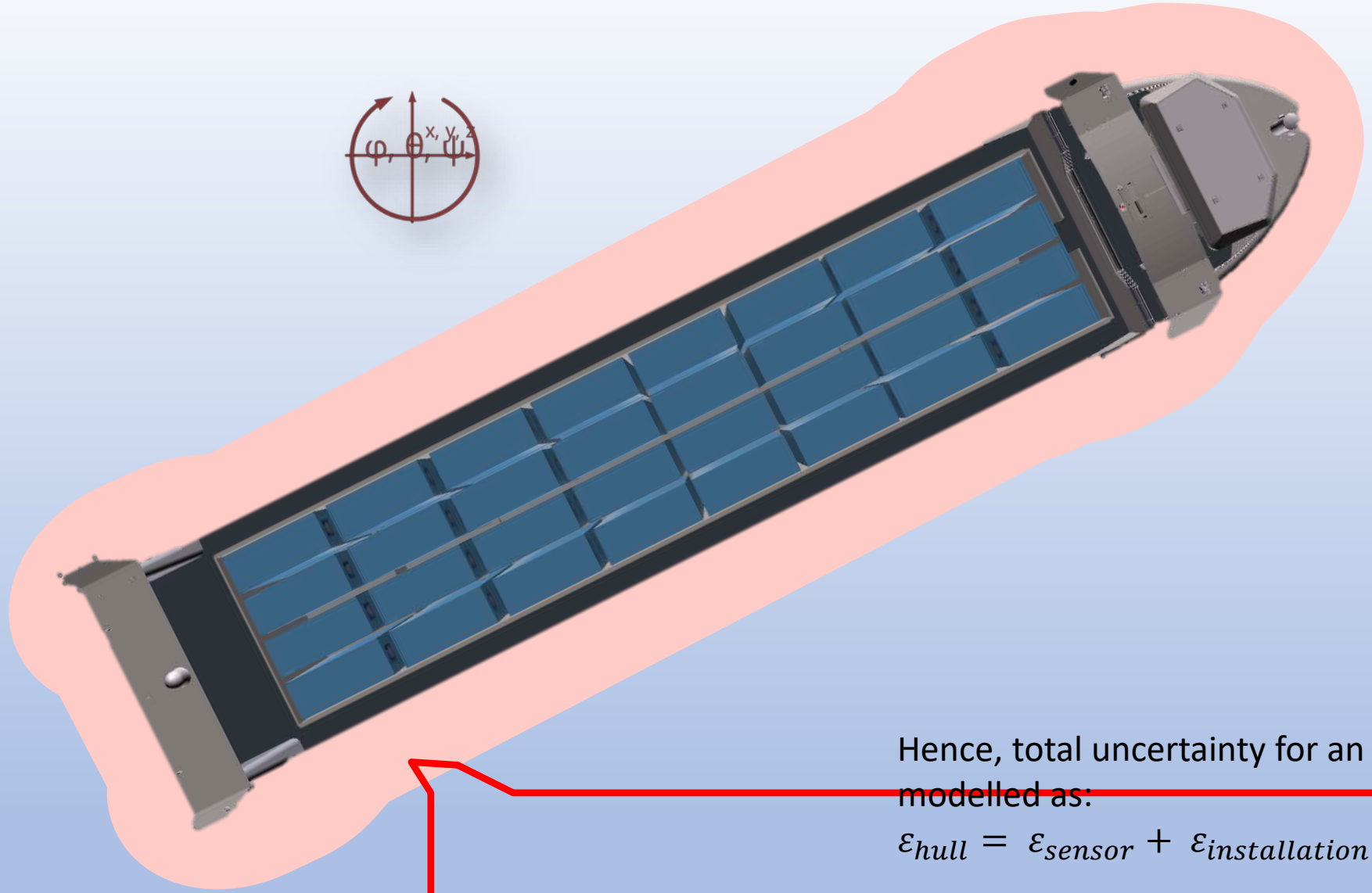
+ Vessel position input

+ Vessel orientation input

Adding uncertainty zone

Shipmaster's view





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Uncertainty zone shall encompass actual hull with 95% probability

Contributions to uncertainty:

- Sensor errors:
  - measurement error, ε_{sensor}
  - installation error, $\varepsilon_{installation}$
- Geometrical model error, $\varepsilon_{3Dmodel}$

Hence, total uncertainty for an arbitrary point on the hull can be modelled as:

$$\varepsilon_{hull} = \varepsilon_{sensor} + \varepsilon_{installation} + \varepsilon_{3Dmodel}$$

3 pilot demonstrations

HULL TO HULL

- Simultaneous operation in Norway
- Inland waterways in Belgium
- Auto-mooring in Belgium

Zulu 04, Barge from BLL

Ocean Space Drone 1 and 2

Cogge, 1:8 scale model of a barge

HULL TO HULL

H2H Conceptual model

HULL TO HULL

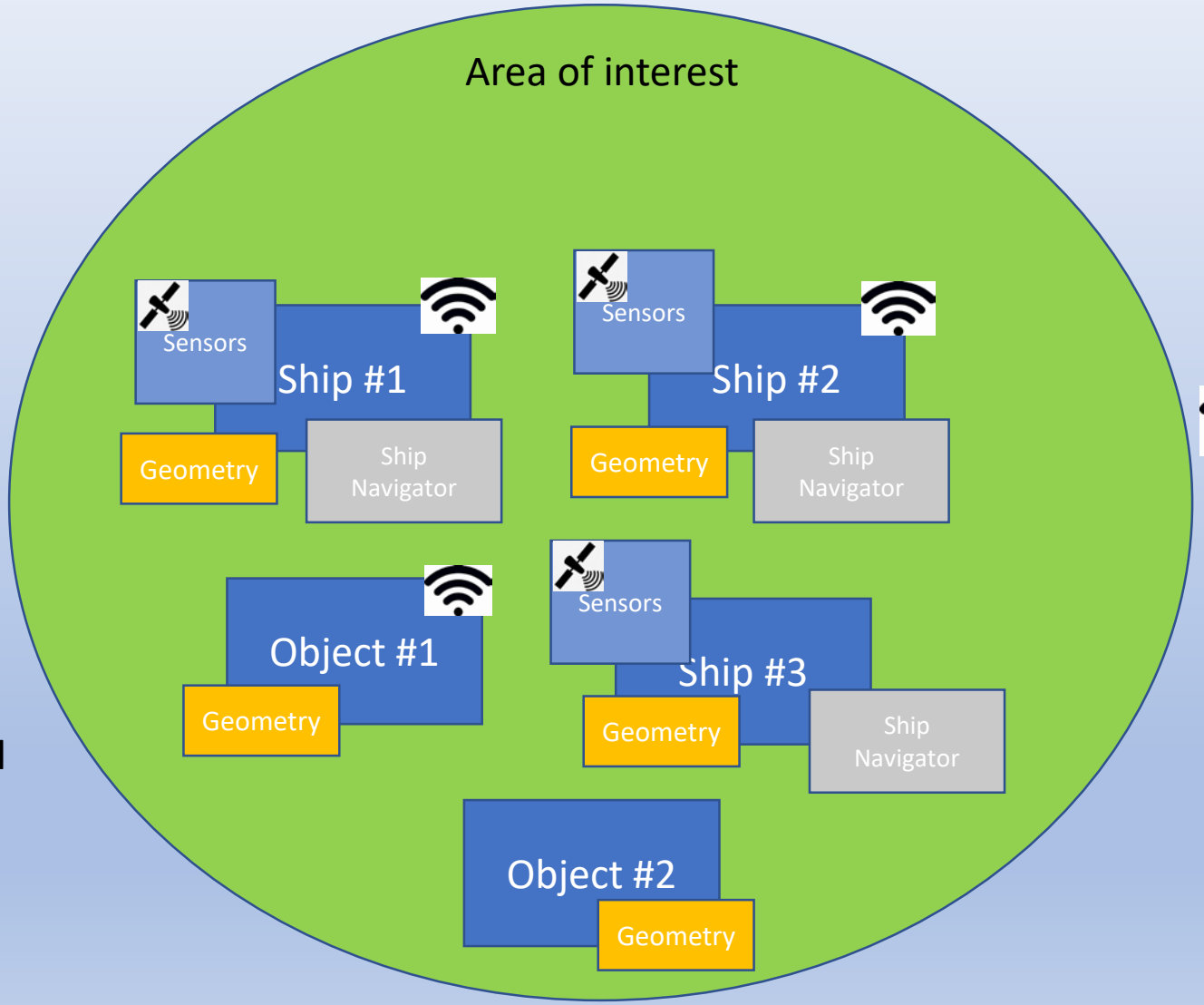
Stakeholders (users)

Navigator

Shore control centre

VTS

AIS
- Terrestial
- Satelite

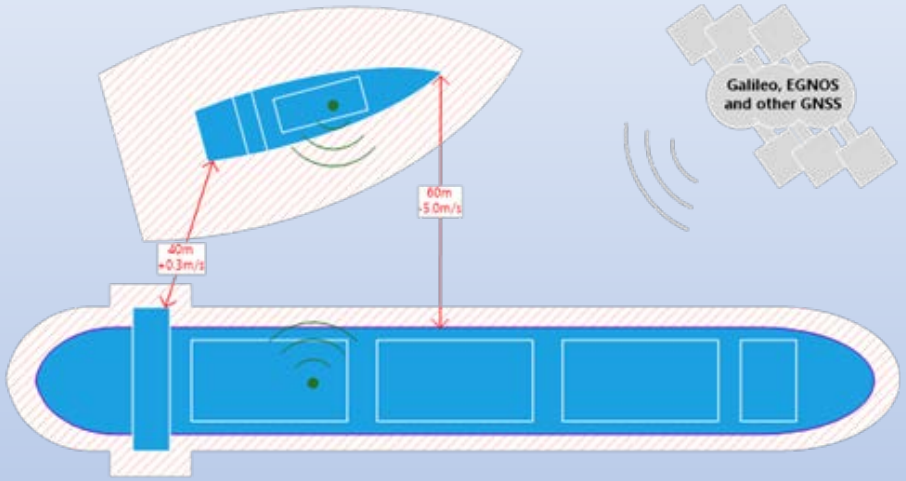


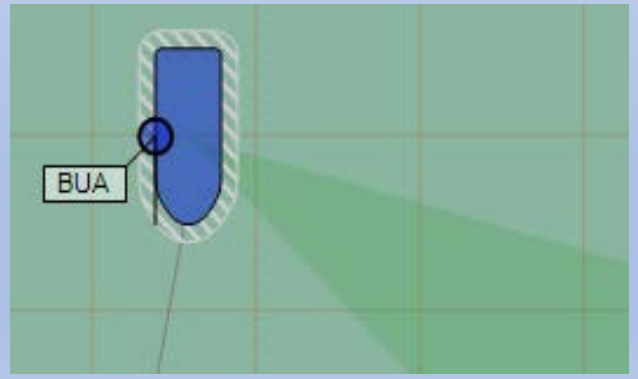
Sensors
- GNSS
- IMU
- Pos sensor
- (AIS)

Wireless
- WiFi
- Satelite
- MBR

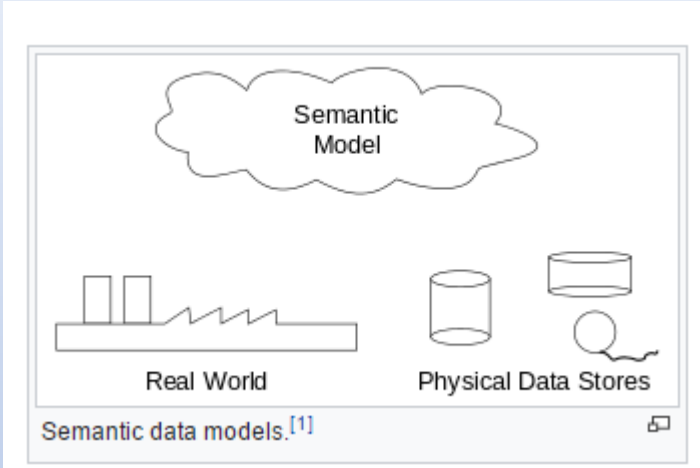
= Satelite

Domain and semantic data model





- Operation
- Objects (movable, fixed)
- Sensors
- Communications
- Geometries
- Uncertainty zone
- Operational zone
- Meta data (configuration)

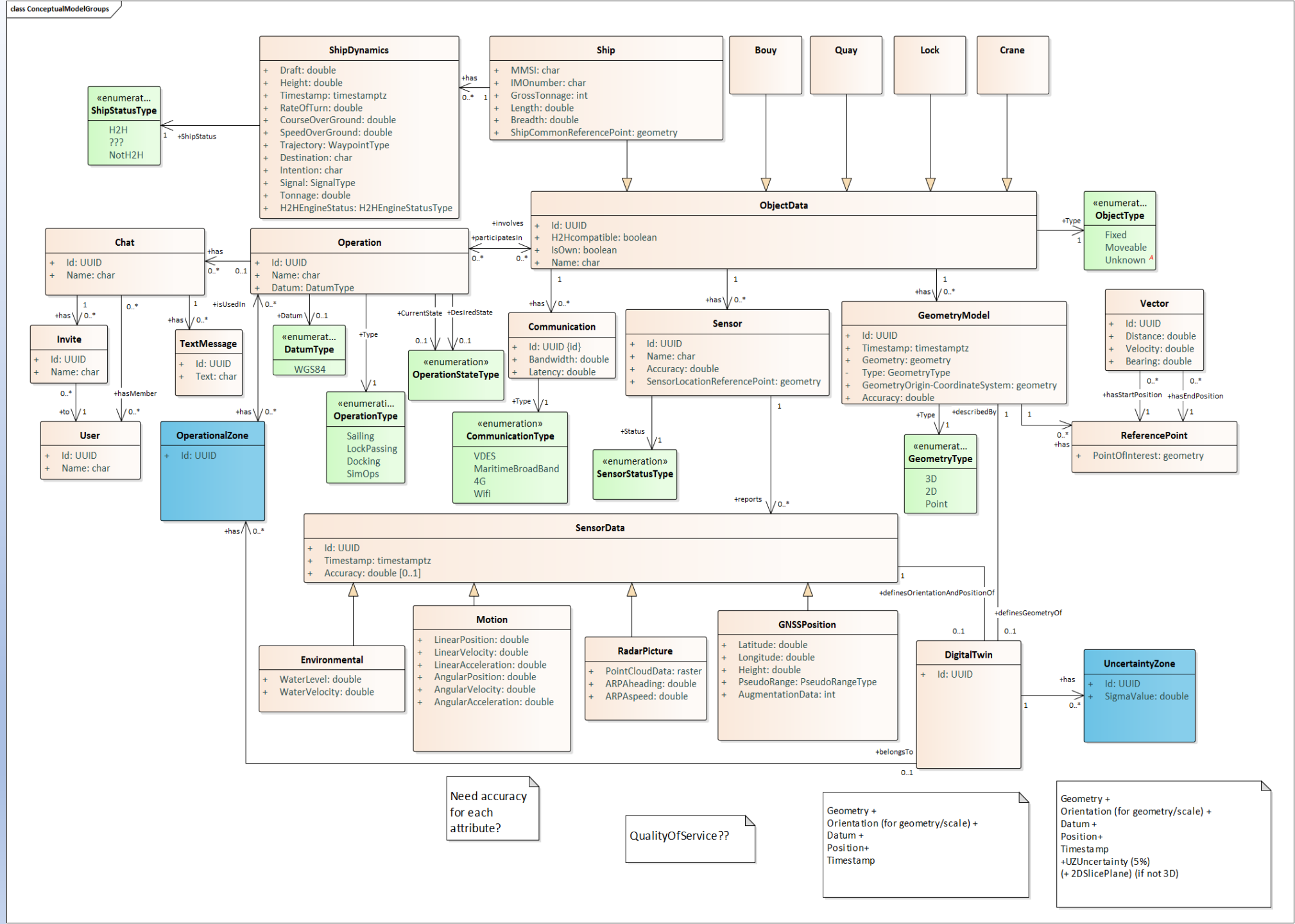


It is a conceptual data model in which semantic information is included. This means that the model describes the meaning of its instances. Such a semantic data model is an abstraction that defines how the stored symbols (the instance data) relate to the real world.[1]

Digital representation of the H2H concept

Part 1 Data Engine-Engine

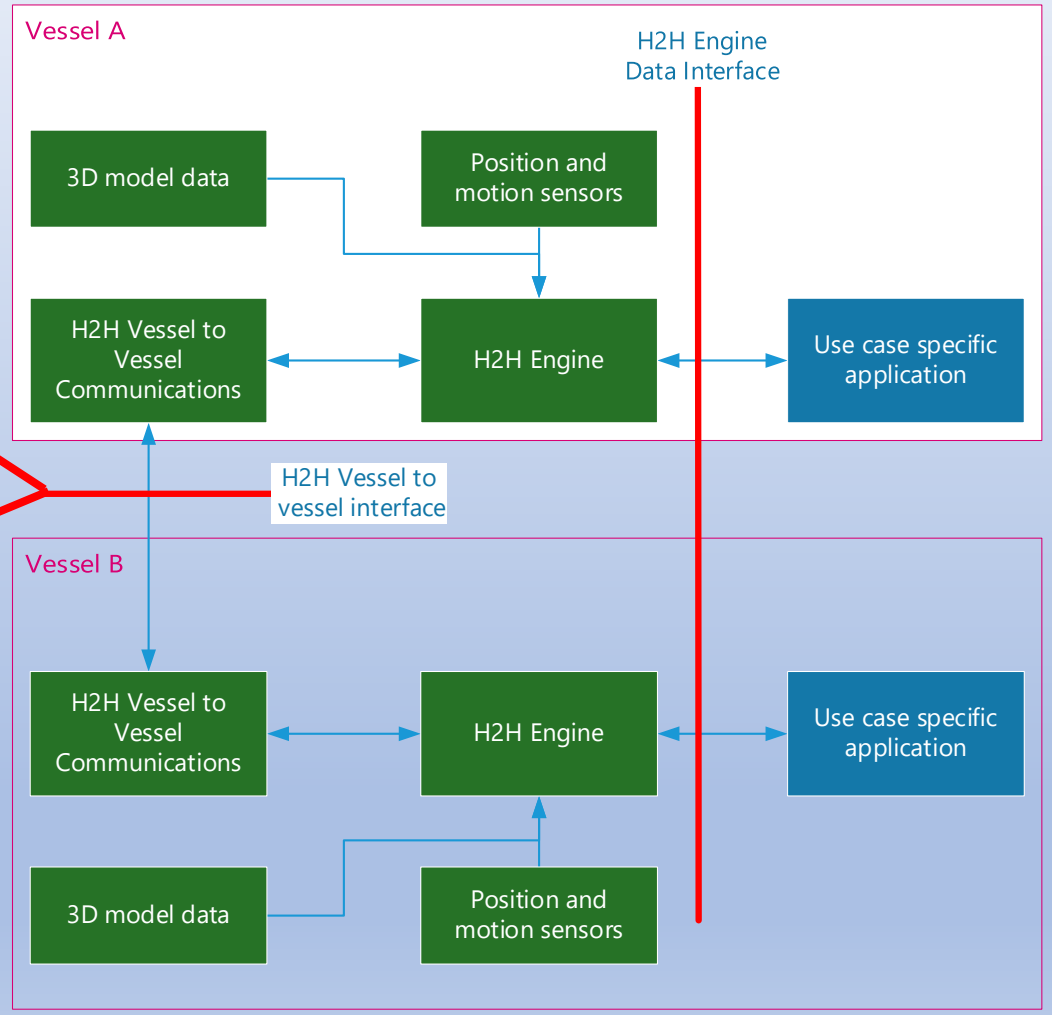
1. An object is either ship, bouy, quay, lock or crane.
2. ShipDynamics: Ship properties that may change during the voyage
3. Each object has some Communications, some Sensors and some GeometryModels
4. Each sensor has an accuracy, a reference point related to a geometry model and a set of sensor data.
5. DigitalTwin is the combination of a geometry model and a set of sensor data at a certain timestamp.
6. UncertaintyZone and OperationalZone are related to a DigitalTwin
7. OperationalZone can be related directly to an operation (no digital twin needed)
8. Blue: E2A, otherwise E2E



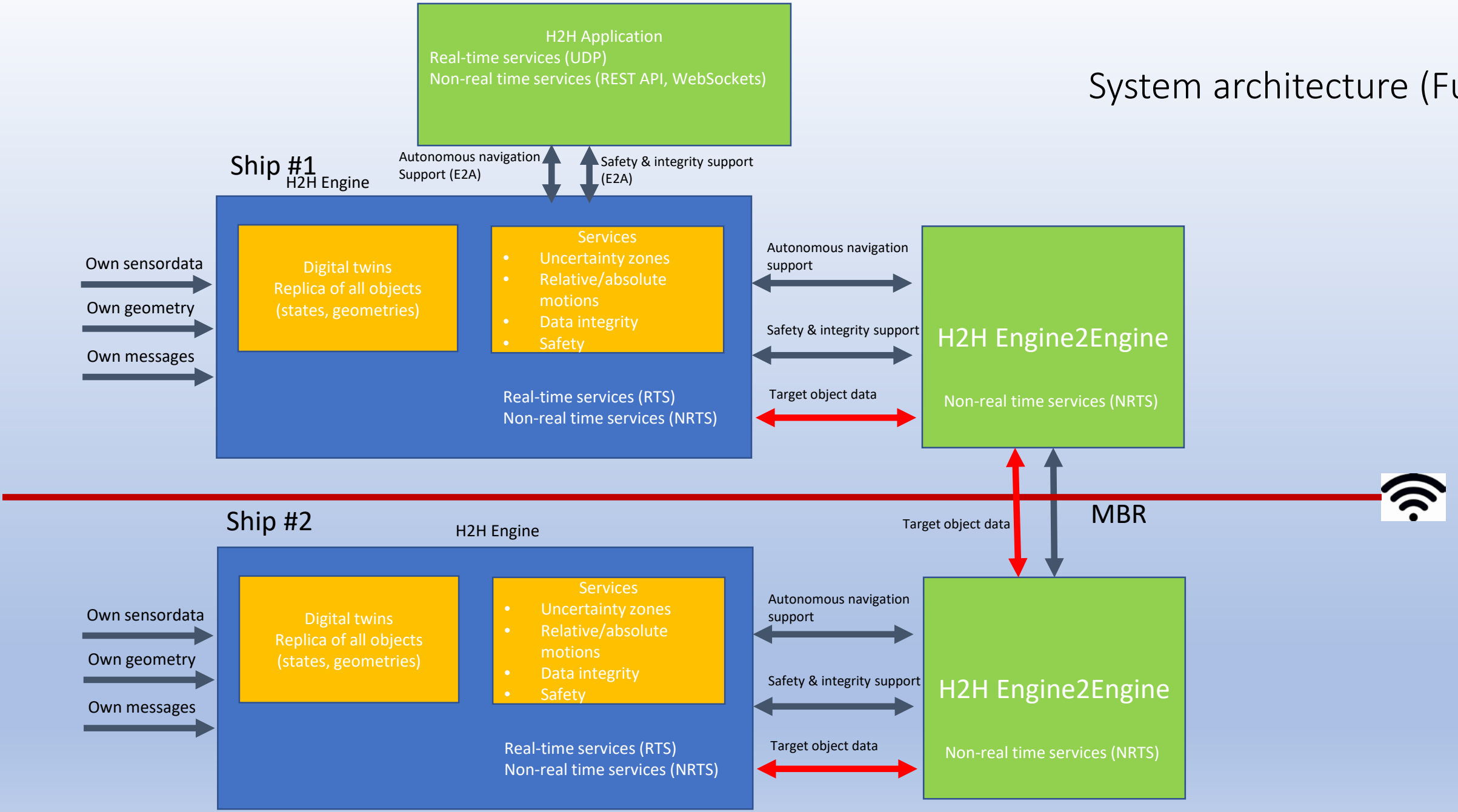
H2H Vessel-to-vessel interface

- 3D models
- Position measurements
- Auxiliary data

- Supports safe and secure communication



System architecture (Full)



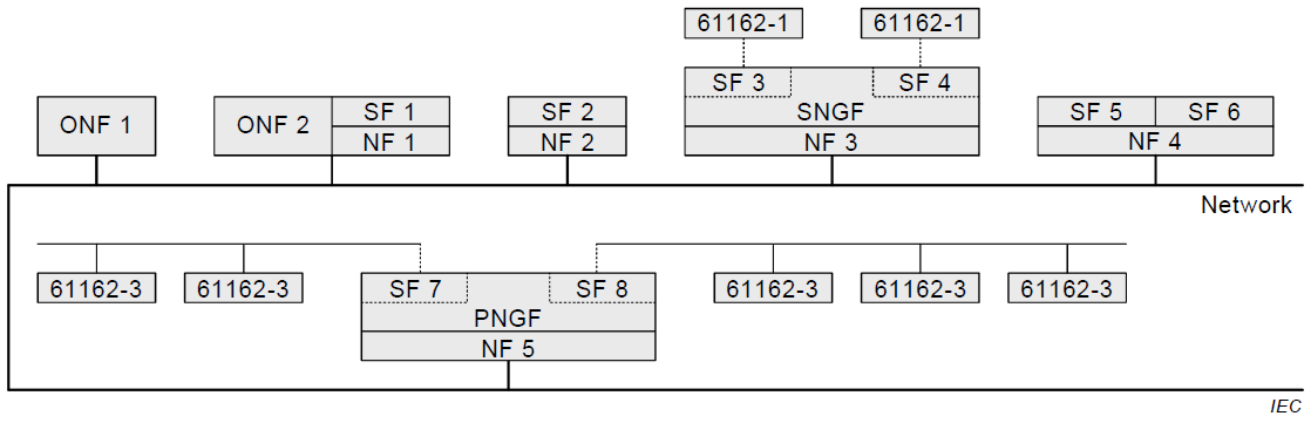
Typical own ship network topology

HULL TO HULL

IEC FDIS 61162-450

TITLE:

Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 450: Multiple talkers and multiple listeners – Ethernet interconnection



Key

SF	system function block
NF	network function block
SNGF	serial to network gateway function block
ONF	other network function block
PNGF	PGN to network gateway function block

Figure 1 – Network topology example

61162-1 = NMEA 0183

61162-3 = NMEA 2000

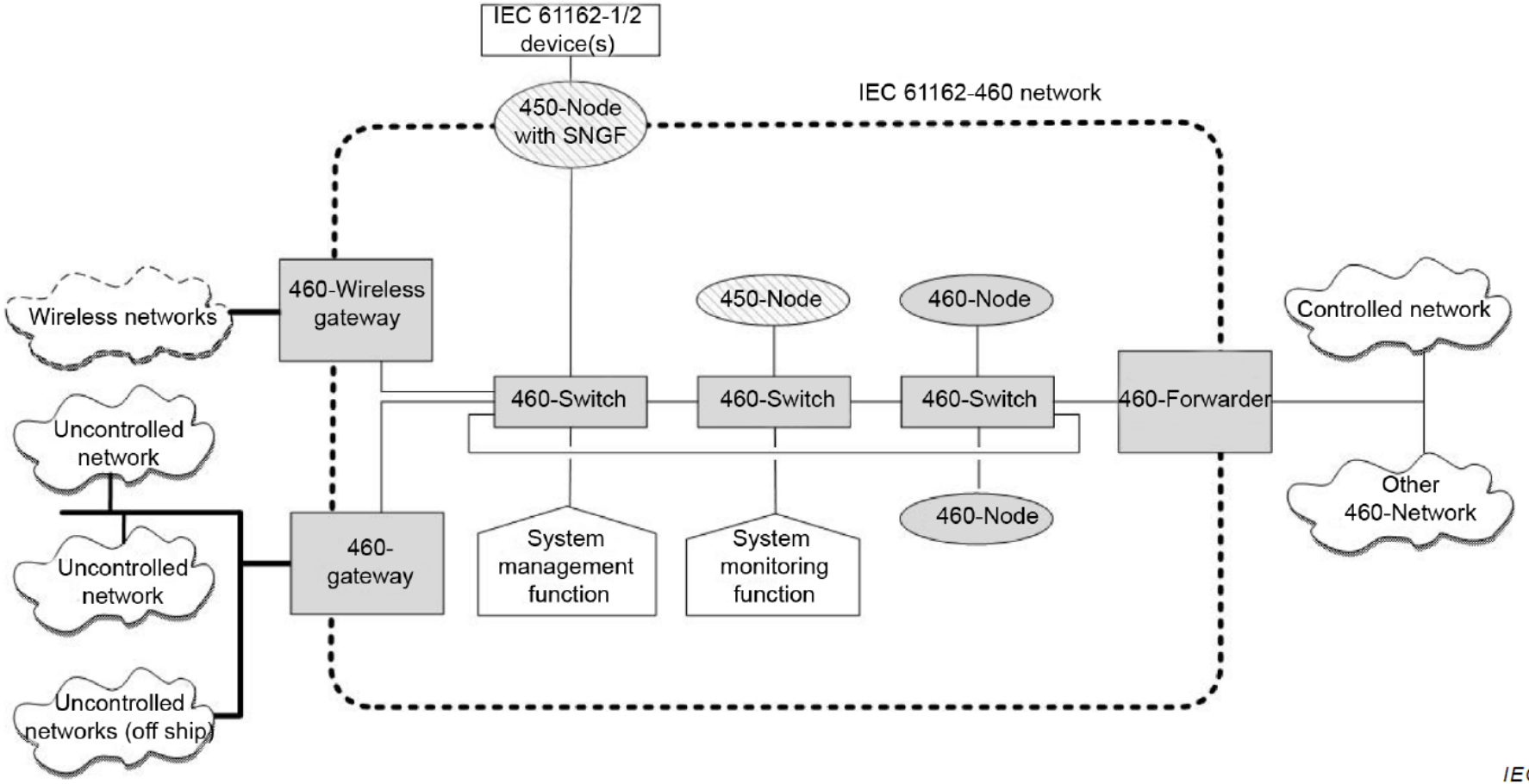
SF2, NF2 = GNSS

IEC FDIS 61162-460

HULL TO HULL

TITLE:

Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 460: Multiple talkers and multiple listeners – Ethernet interconnection – Safety and security



H2H Own ship network topology

HULL TO HULL

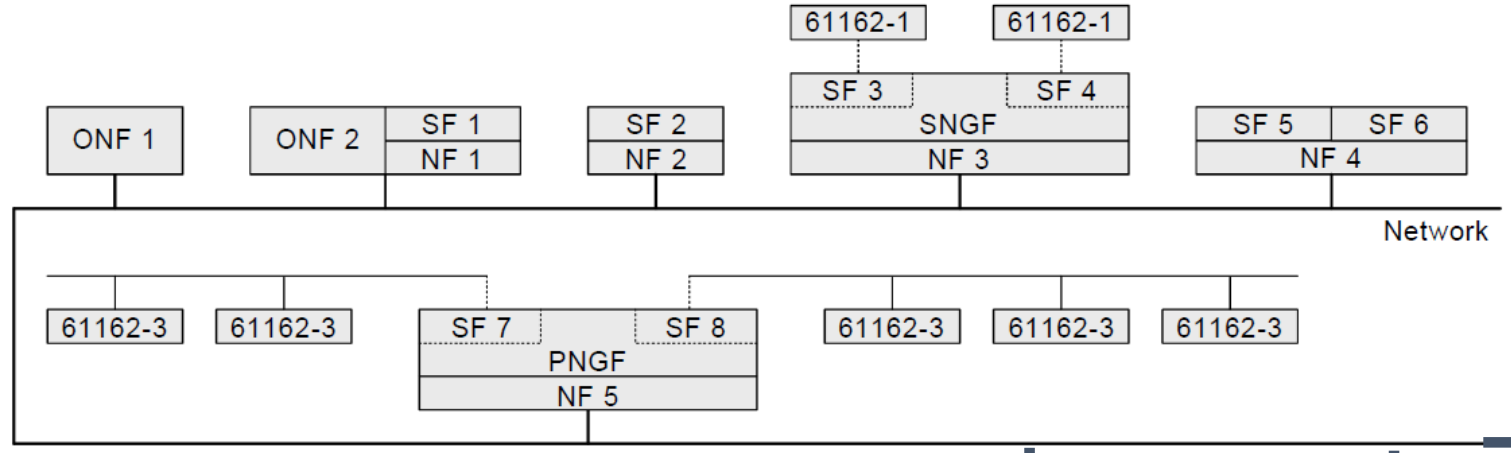


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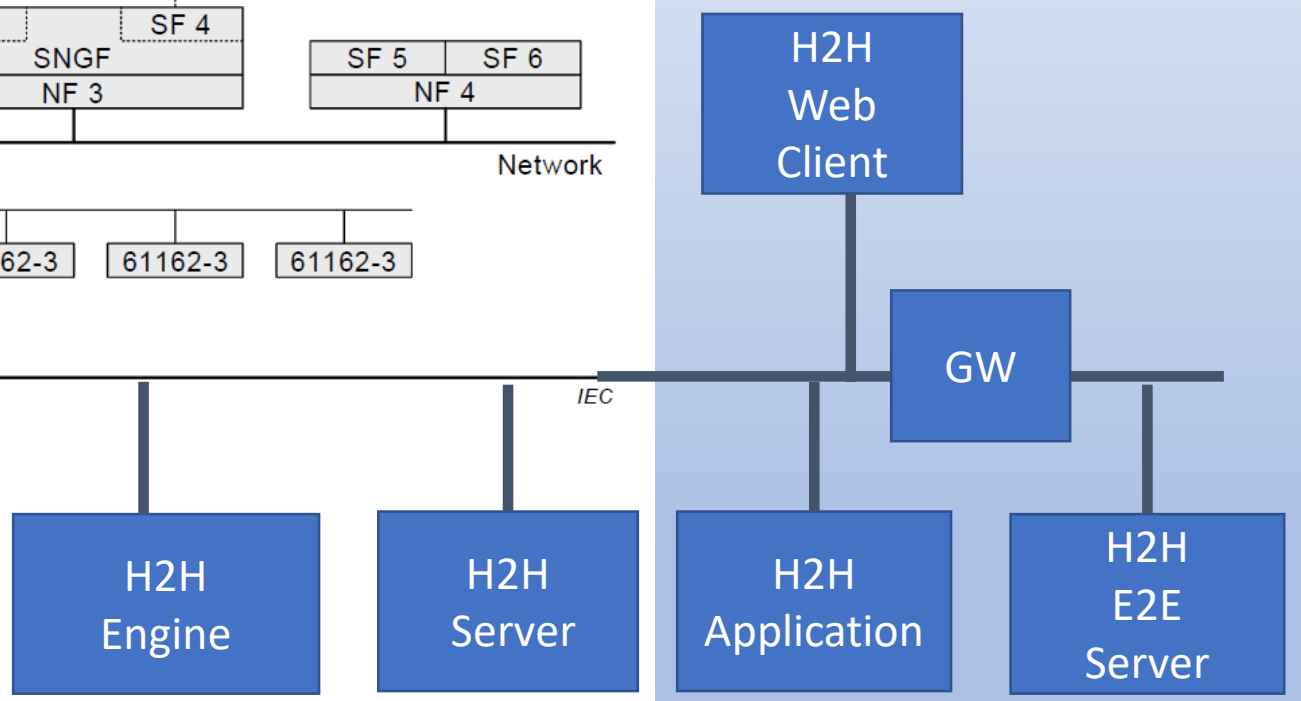
Figure 1 – Network topology example



Open API Initiatives

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- *"The Open API initiative (OAI) focused on creating, evolving and promoting a vendor neutral description format. APIs form the connecting glue between modern applications. Nearly every application uses APIs to connect with corporate data sources, third party data services or other applications. Creating an open description format for API services that is vendor neutral, portable and open is critical to accelerating the vision of a truly connected world"*
- *Two different technologies*
  - *REST API*
  - *Remote Procedure Calls (RPC)*

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REST API

- *REST* (Representational State Transfer) is a software architecture style used for creating web services (REST APIs) that provide interoperability between internet applications
- HTTP/1.x protocol
- End-to-end data communication (TCP/IP)
- Swagger (https://swagger.io) offers tools for using Open API specification file
- Automatic generation of code for server and client side in different programming languages

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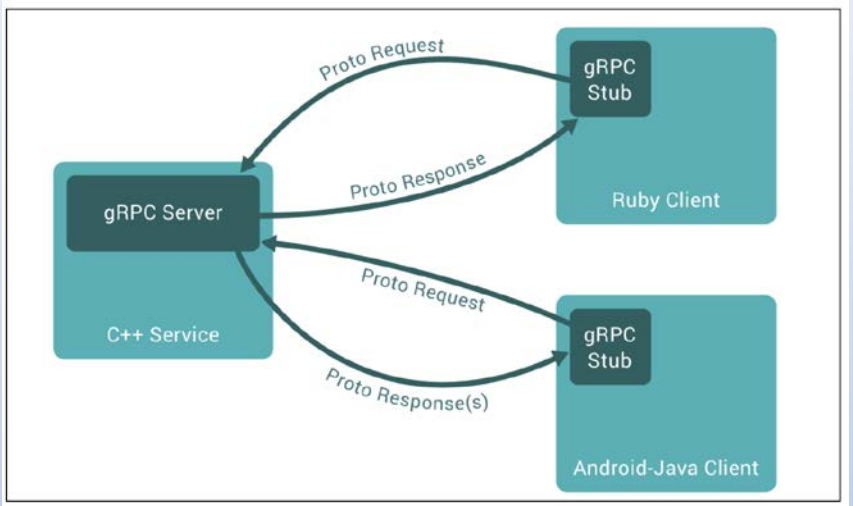
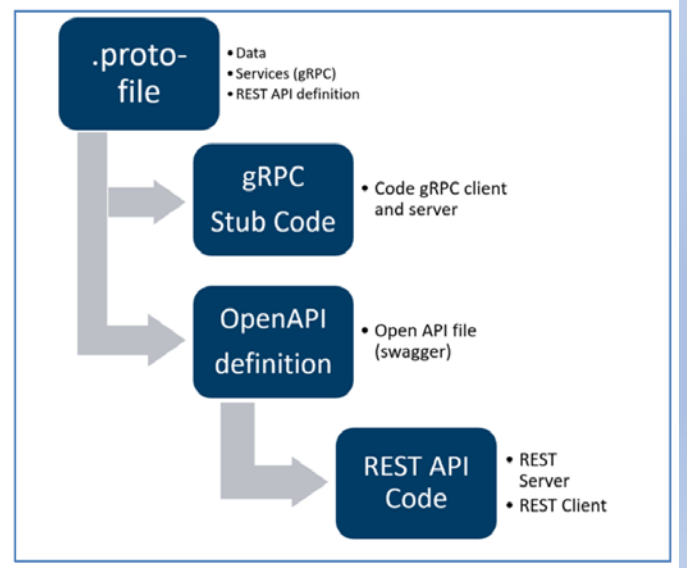
Remote Procedure Calls (RPC)

- User defined code can be executed in a different address space (computer or network)
- Data shared on network
- gRPC
  - Google Protocol Buffer to optimize payload
  - Generates code stubs in different languages
  - HTTP/2 (allows streaming both ways)





Relevant standards

Data model/communications standards

- S-100
- STEP/ISO-10303
- ISO-28005
- RTCM 10403.1
- IEC 62940
- IEC 61108
- Inland AIS
- Inland ENC (Inland ECDIS Standard 2.3)
- IEC 61162-1/2/3/450/460 (NMEA 0183/2000)

Safety standards

- EN 50159
- IEC 61508
- IEC 61784

S-100 Framework

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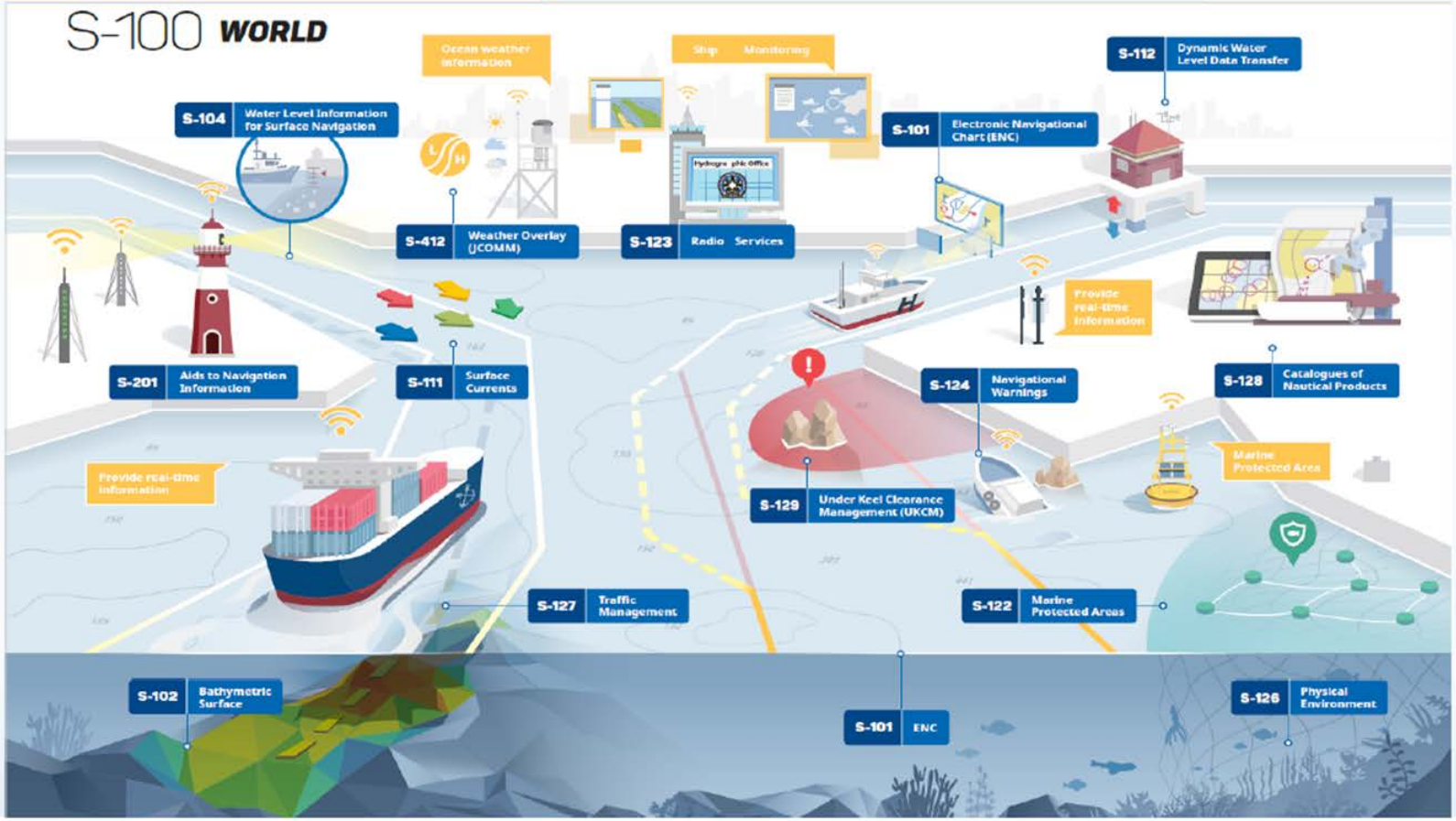
S-100 Universal Hydrographic Data Model



International Hydrographic Organization
Organisation Hydrographique Internationale

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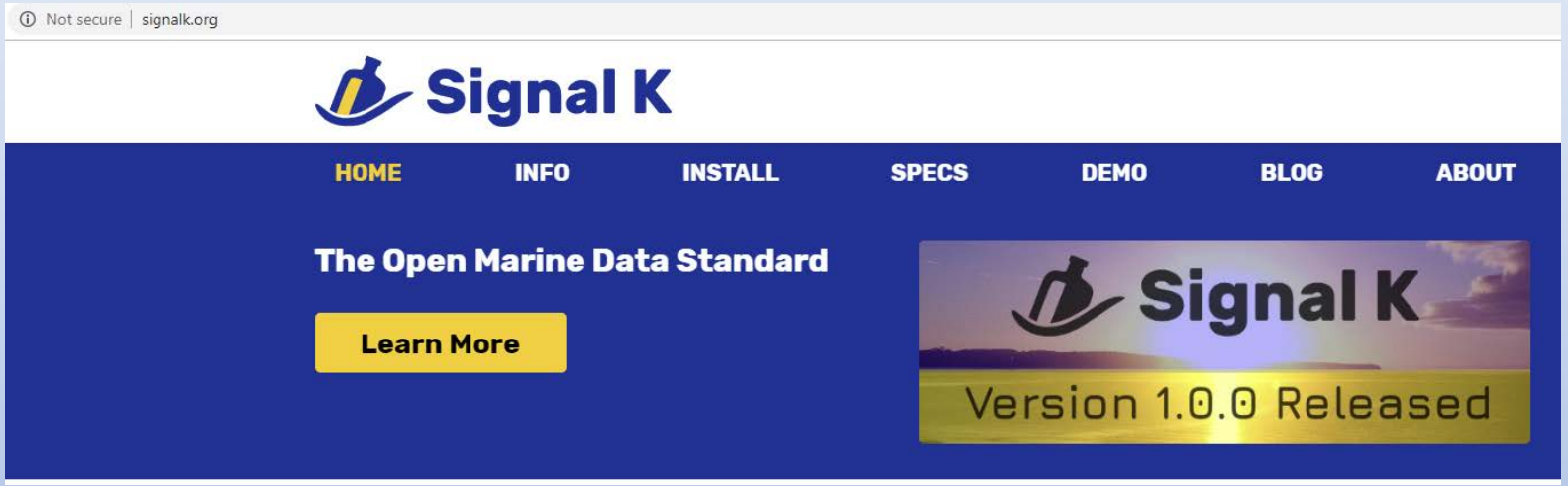
Open source project for Marine Data Exchange



- Open source project on GitHub
- Used by smaller yachts, fishing vessels
- Sharing data on WiFi, cellphones, tables and Internet

Signal K (https://signalk.org/)

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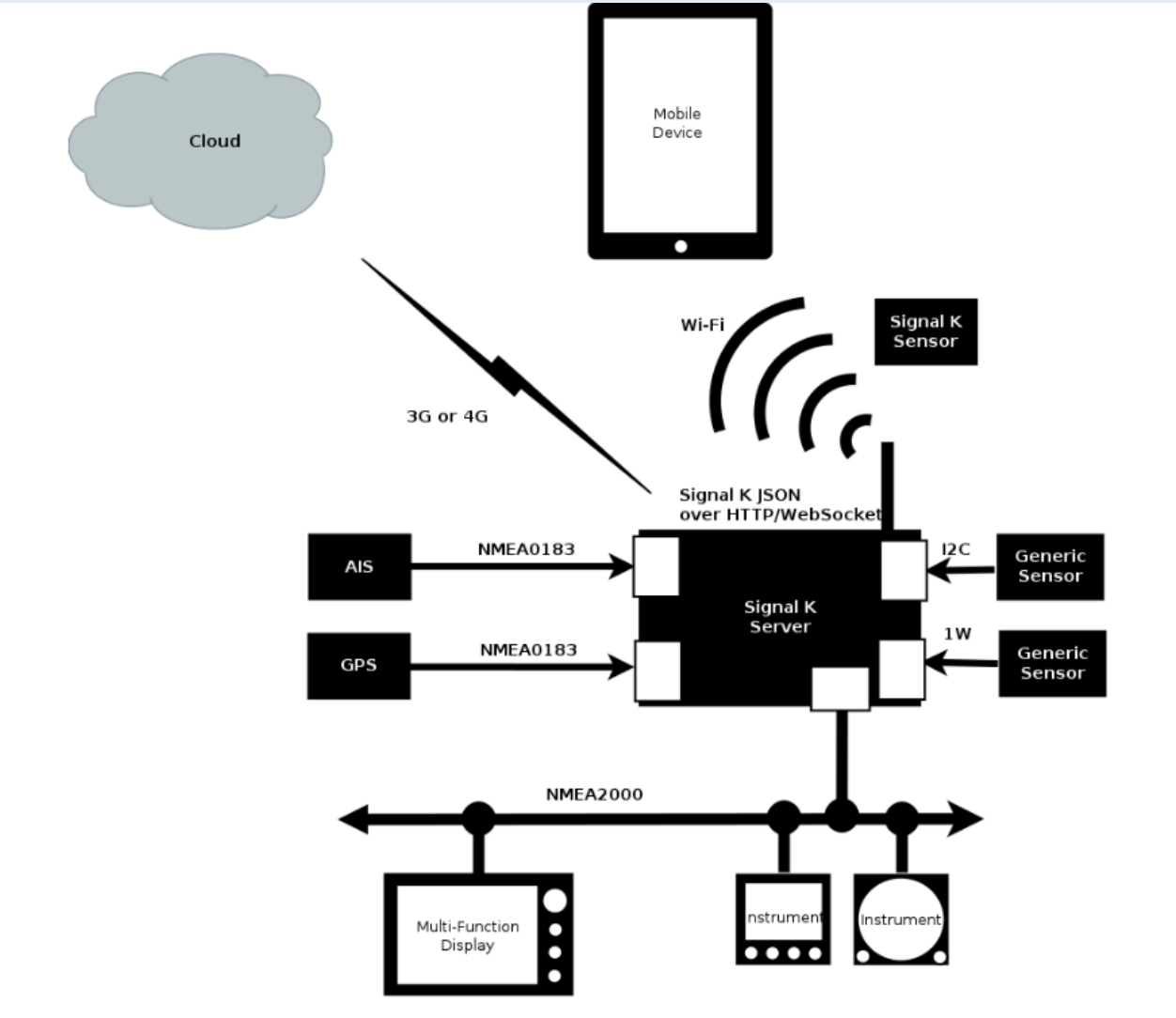


"The Open Marine Data Standard"

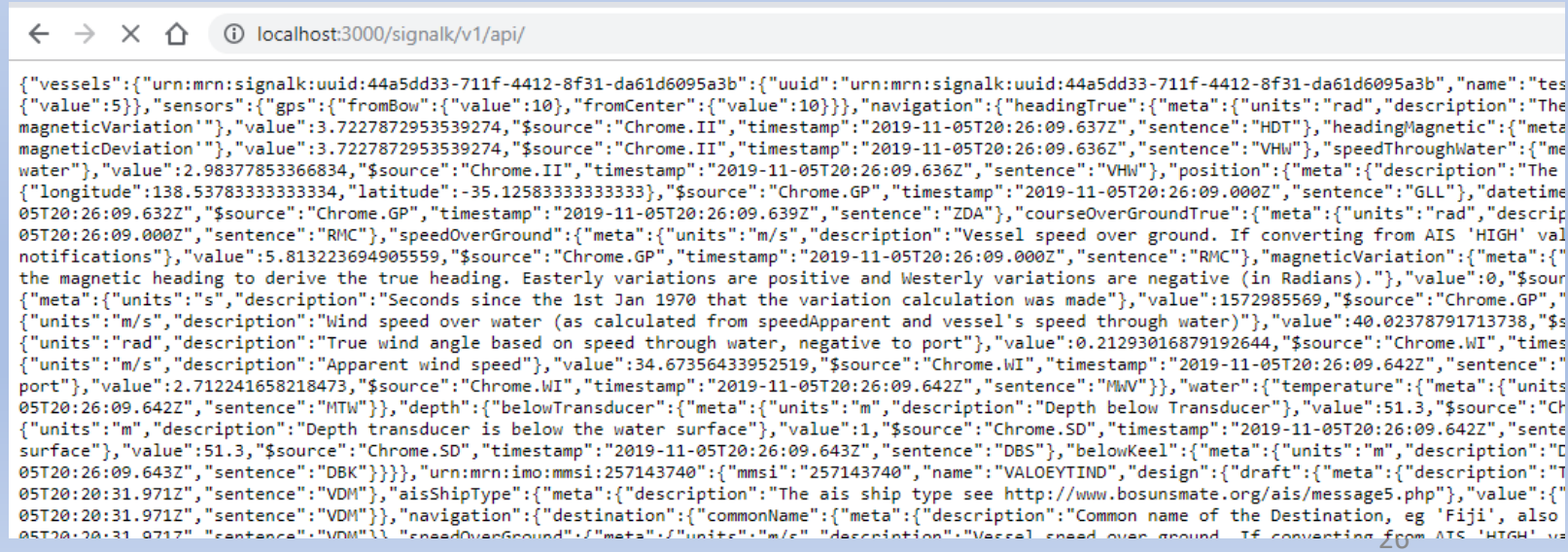
Signal K JSON over HTTP/WebSocket


```
{
  "vessels": {
    "urn:mrn:signalk:uuid:705f5f1a-efaf-44aa-9cb8-a0fd6305567c": {
      "navigation": {
        "position": {
          "value": {
            "altitude": 0.0,
            "latitude": 37.81479,
            "longitude": -122.44880152
          },
          "source": {
            "label": "ttyUSB0",
            "type": "NMEA0183",
            "talker": "GP",
            "sentence": "PRMC"
          },
          "timestamp": "2017-05-16T05:15:50.007Z"
        }
      }
    }
  }
}
```

Signal K server

HULL TO HULL

- Inputs
  - NMEA0183 (also AIS messages), NMEA 2000, onboard sensors..
- Transport protocols:
  - HTTP, WebSocket, TCP, UDP, Serial connections
  - Security supported: SSL/TSK (https, wss)
- REST API based on Signal K project
  - signalk/authenticate
  - signalk /v1/api
  - signalk /v1/stream



Signal K Example

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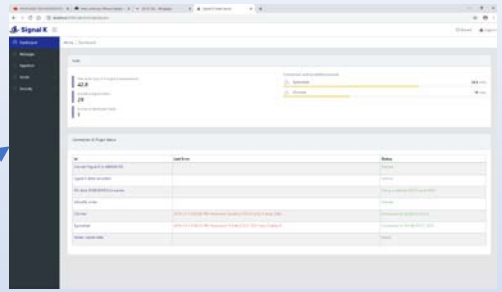
REST API

WebSocket

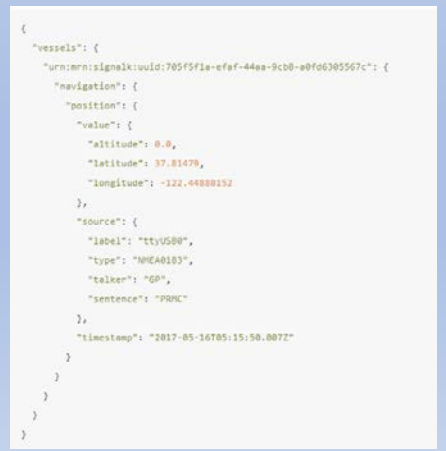


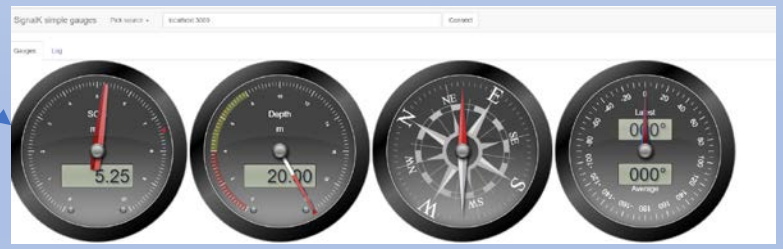
Kystverket AIS port

NMEA simulator
(own data)

Signal K
server

JSON





Influx database

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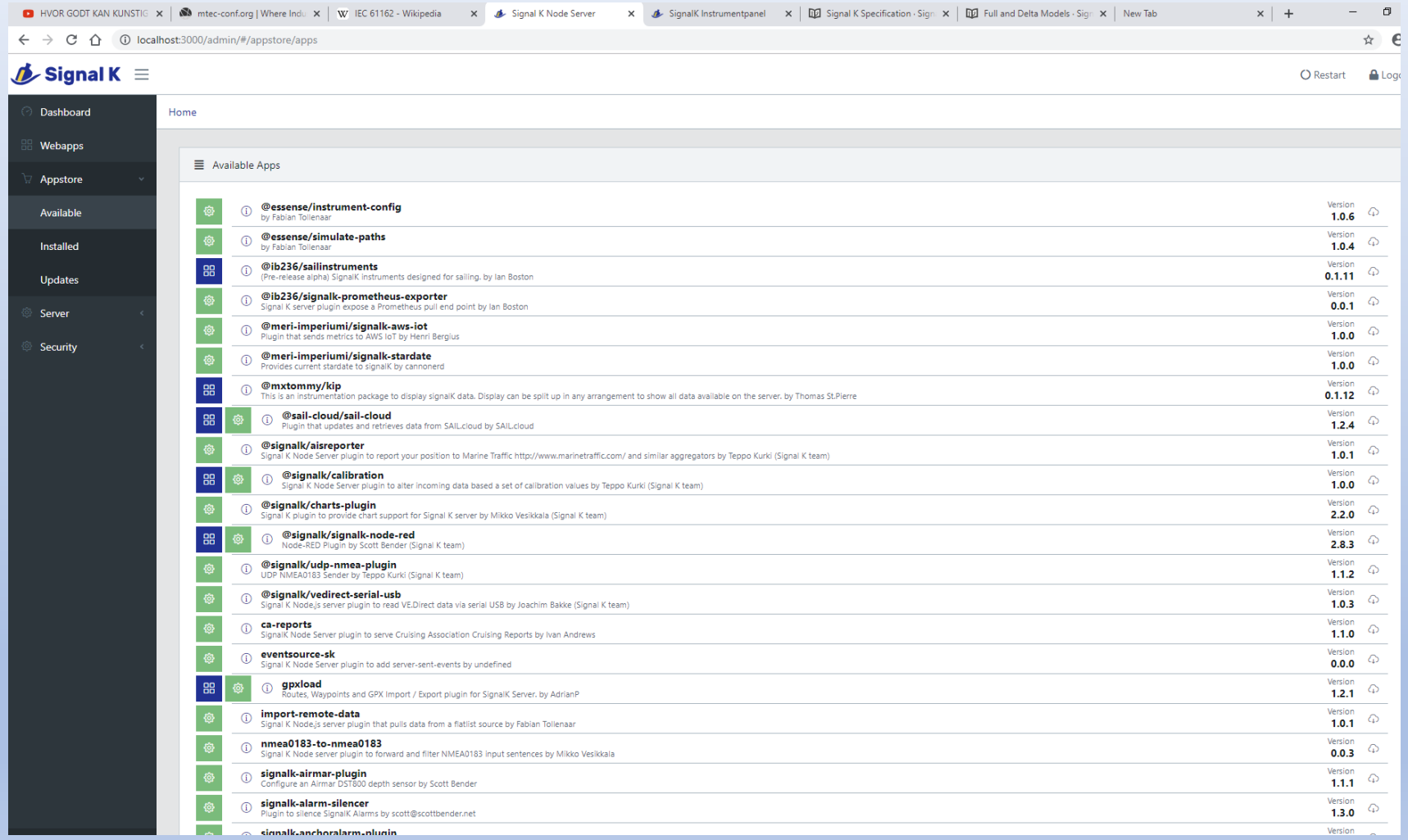
Signal K Example



Plugins Apps

What is missing to comply with the H2H requirements?

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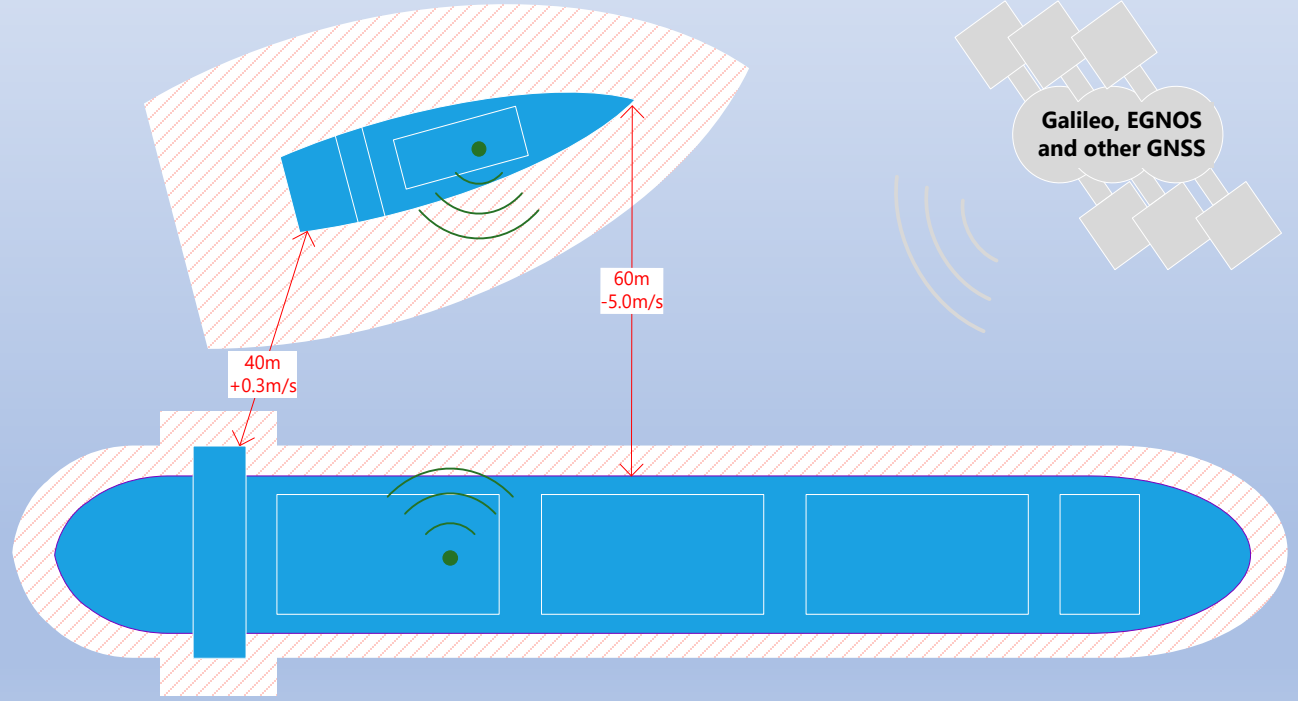
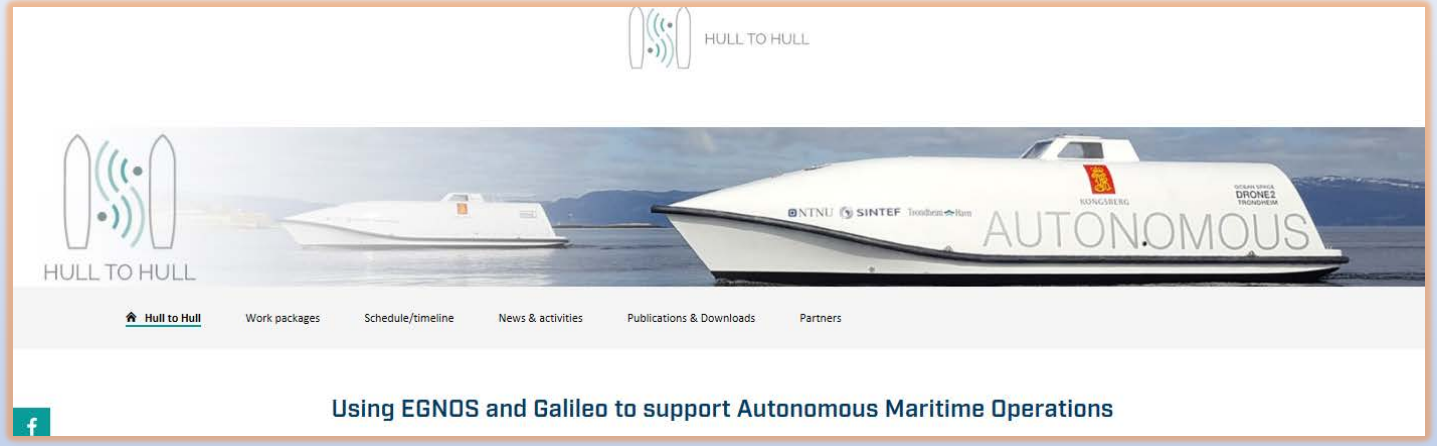
- Implement H2H data model
  - Geometry data (object geometry)
  - Uncertainty zones
  - Operational zones
  - Relative distances and velocities between objects
- New APIs
  - RTCM interface
  - H2H Engine interface
  - H2H Application interface (S-100 compatible)

Summary

- Signal K is a candidate for open maritime data API
- Uses maritime standards as far as possible (IEC 61162-series)
- JSON messages for data exchange to 3rd party applications and plugins
- Must append new data models for geometries, relative distances and velocities for safe navigation
- Encryption possible with secure http and ws



Public information



1st year flyer

2nd year flyer

https://www.sintef.no/projectweb/hull-to-hull/