## HSSC13-07.2B Rev1

## Paper for Consideration by HSSC-13

## Proposal for Establishment of a Maritime Autonomous Surface Ships (MASS) Navigation Working Group / Project Team

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| ***Submitted by:*** | UK Hydrographic Office (UKHO), Norwegian Hydrographic Service (NHS), Maritime and Port Authority of Singapore (MPA) |
| ***Executive Summary:*** | HSSC to endorse setting up a Working Group / Project Team for Maritime Autonomous Surface Ships (MASS) Navigation |
| ***Related Documents:*** | N/A |
| ***Related Projects:*** | N/A |

## Summary

Within the International Hydrographic Organization (IHO) under the umbrella of the Hydrographic Services and Standards Committee (HSSC) a gap has been identified due to the lack of a current Working Group or Project Team specifically tasked to address the subject of Maritime Autonomous Surface Ships (MASS).

MASS are the future of navigation and are becoming an increasingly important sector within world shipping. MASS have different requirements from manned vessels due to the nature of their navigation, therefore data needs to be richer, machine readable, readily available, and always up to date.

This paper describes in further detail, the different operation models within MASS, the issues that the MASS face, some potential solutions, data requirements and how S100 can offer part of the solution. It also touches on some of the activities the UK Hydrographic Office (UKHO), Norwegian Hydrographic Service (NHS) and the Maritime and Port Authority of Singapore (MPA) have been engaging in.

The UK, Norway and Singapore recommend that it is the right time for the HSSC to endorse setting up a new Working Group / Project Team for MASS navigation to ensure a collaborative, joined and holistic approach is adopted and to start and define the new standards for MASS navigation. This will enable further understanding of MASS requirements and the data required etc. in collaboration with other Member States to ensure the safe navigation of the MASS. It will also contribute to the identified necessary transition of Hydrographic Offices towards a data centric production line.

## Background

The maritime world is changing, and the impact of new technologies to allow for reduced manning onboard vessels, leading eventually to unmanned large ships has taken huge steps forward over the last decade.

These vessels utilise powerful onboard processing and software to read, interpret and combine sensor data, (typically from AIS, Radar, Cameras, Lidar) and align this with historical onboard data about the world around them (typically traditional electronic static charts).

They create a digital world model and make decisions on safe navigational routes that not only comply with COLREGS but also move them towards their end goal or destination.

As interest in MASS grows and autonomous ships become larger, they will enter into the regulatory landscape and eventually will be able to truly operate independently of human operators. One area of concern is the current lack of specific navigational data that is required to “drive” a MASS or more importantly the lack of any stated rules, regulations or standards relating to navigational data in a MASS.

What does autonomous mean?

It is important here to describe what we mean by autonomous, as the term is often used to describe several modes of operation. The International Maritime Organization (IMO) has defined 4 distinct degrees of autonomy as shown below:

**Degree one:** Ships with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.

**Degree two:** Remotely controlled ships with seafarers on board: The ships are controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.

**Degree three:** Remotely controlled ships without seafarers on board: The ships are controlled and operated from another location. There are no seafarers on board.

**Degree four:** Fully autonomous ships: The operating system of the ship can make decisions and determine actions by itself.

## Analysis

Definition of the problem

Whilst shore controlled vessels (degrees two and three) can use traditional navigational data such as charts and publications due to the human operation, the fully autonomous vessel (degree four) can’t operate with these traditional products. Whilst MASS will become self-aware and use sense and avoid technologies, these vessels will still need navigational data to get from A to B, to avoid dangerous or regulatory areas and operate appropriately when entering a specific area (e.g. Ports, Environmental Protected Areas, MARPOL boundaries, routes).

To suggest that MASS will use digital ENC data in its current form is inappropriate for the following reasons:

* Electronic Navigational Charts (ENCs) (or any electronic chart) are still fundamentally designed to be viewed and interpreted by a human being and they are used to inform the mariner and help him/her make decisions based on the chart information, their knowledge and what they see out of the window.
* A lot of ENCs are derived or constructed using traditional Paper Charts production techniques or ENCs are derived as a result of Paper Chart production, and as such inherit subjective cartographic practices (such as data generalisation or aggregation) and therefore may only represent “ground truth”.
* ENCs suffer from data inconsistencies (i.e. features aren’t always on charts that cover the same area at different scale bands, usually because of cartographic practices), which a human can identify and resolve.
* ENCs suffer from horizontal inconsistencies (i.e. edge matching one ENC against another can highlight differences, usually because of cartographic practices), which a human can identify and resolve.

Position Fixing

It is expected that MASS will have a dependency on Global Positioning System (GPS) to know where they are at any given time and make navigation decisions in relation to other objects to avoid or sail towards. However, what happens when a fully autonomous vessel loses or is denied a GPS signal or is subject to GPS spoofing. What alternate means of positioning can be used by a MASS and therefore how can the data we supply help in this situation. Something new and different to what we supply today is needed to resolve this issue.

Updating of Chart Data

Clearly whatever navigational services are required by MASS, the crucial aspect of maintaining and updating the data is as important in an autonomous environment as it is in today’s manned shipping environment.

Today the maintenance and updating of charts and publications is a Safety of Life at Sea (SOLAS) requirement and should follow suit for MASS. The current process for updating products (digital or paper) is based on a weekly update cycle and in some cases vessels wait for a CD or DVD to be sent to the vessel to update their Electronic Chart Display and Information System (ECDIS) and Back of Bridge PCs with data. This builds in a delay between products being updated and CDs or DVDs being distributed and vessels receiving the updates to install on their ECDIS, in some cases this delay can be several weeks if a vessel is away from Port for prolonged periods.

Some vessels do elect to download product updates from the internet, however, due to satellite communications being expensive at sea, this is limited to the wealthier shipping companies. To compound this issue most shipping companies, restrict their vessels to a 5mb download limit, however, updates can often be much larger, particularly if a vessel has a large portfolio of ENCs and associated products.

## Justification and Impacts

Potential future solutions

The UKHO, Norwegian Hydrographic Service and MPA are beginning to explore some potential solutions to the issues mentioned above and are working with the MASS industry and community to explore what the next generation of products and services will need to look like for large ocean-going MASS.

An unmanned vessel will need to make navigational decisions within a detailed, constantly updating digital world model that is a combination of known / historical data and calculated results from live sensor feeds. The richer the static and dynamic information the more complete the model and the safer the navigation will be.

The potential exists for significant quantities of data to be re-introduced to the navigational systems. MASS could easily consume this rich data without fear of overload, and this would present a ground truth of the surface of the seabed to avoid the risk of grounding or collision.

A likely solution is the introduction of high-resolution gridded bathymetry in a single surface model giving a true picture of the seabed. This could even be used as an alternative means of positional fixing and some experimentation has been done in this space, drawing on the methods employed in submarine navigation. S102 offers the potential solution to this issue.

Alternate Position Fixing Methods

With regards to alternate position fixing, several options exist, not least of which is using the high-resolution bathymetry as previously mentioned, but to augment this, other means of positional fixing could be employed.

Mariners still use visually conspicuous objects on the coastline to triangulate a fix, we highlight features in ENCs as visually conspicuous for this reason. It is conceivable to use modern technologies to provide data in a format that the MASS, using advanced optical sensors, could use to determine its position.

Digital Twins are a logical evolution in the marine domain. Digital Twins are a digital replica of a living or non-living physical entity, which can interact with the real world or simulated world through sensor feeds or software interactions. The Digital Twin concept has been used throughout the autonomous automotive industry for some time for driverless car technologies and therefore, it is highly likely that Digital Twins of the coastline, Port environment and wider marine environment could be approaches that becomes the new digital norm for MASS navigation.

Concepts such as astral navigation is a possible alternative for open ocean navigation and as technology improves this should become a viable alternative to GPS if the need arises.

The UKHO will be conducting several research and development projects with Her Majesty’s Nautical Almanac team (based at the UKHO) and academia to investigate possibilities in this area.

Listening for Updates

In the world of MASS, it is expected that communications between the vessel and shore will be on at all times and as such this could enable more frequent or real-time updates to be pushed from official sources from the Hydrographic Office community.

The vessels “listen” out for and update their navigational database and products automatically irrespective of where they are in the world. This would be an advantage over the current situation in the manned shipping environment, however, thought would need to be given to prove that a MASS has indeed got the latest available update and applied it.

Today that function is carried out by mariners and confirmed by Port State Inspectors. An equivalent model will need to be defined and used to provide the assurance that the vessel is up to date and conforming to SOALS regulations regarding navigational data and situational awareness.

S100 Impact on Autonomous Navigation

Although S100 and the associated product specification (S1xx) series of standards represent a significant step forwards at present they are still in relatively early stages of development and are being designed with a human end user in mind. It is estimated that the S-101 product specification (next generation ENC) will not be available for operation until 2022.

At present the S101 implementation will make minor improvements to S57 however there will be no significant improvements regarding making the data more machine readable than is currently possible with S57.

The main benefit of the S100 framework is that it is extensible and therefore the data model can be adapted as new requirements emerge. It is vital that these future requirements are considered now to ensure MASS can utilise the data produced by hydrographic offices around the world.

UKHO Activities

The UKHO have been engaging with several industry experts and project initiatives surrounding MASS to try and understand the navigation data needs as momentum gathers in this area.

We have found that these organisations are currently using available traditional navigation products (such as ENCs and paper charts) due to the lack of alternatives but these products require various work arounds or adjustments for compatibility and suitability with autonomous vessels.

In most cases, the people who are building these vessels and the systems used on board ships, don’t know what they don’t know, in other words they aren’t aware that they need something different and don’t know who to ask when they need more diverse data, usually sourced from the original maritime survey data.

UKHO have proactively sought out a number of organisations such as Thales, Atlas Electronik and TGP Polaris and discussed the issues with current products and services and have provided data to stimulate discussions about what they see as gaps in the current offering and identify the new products going forward.

UKHO have also been supplying data into two key projects and associated geographical areas where MASS trials are conducted.

In our work with industry operators, UKHO have supplied data to facilitate discussion and allow operators to explore what the future navigation service might look like.

Norwegian Activities

The Norwegian Hydrographic Service is a member of the Norwegian Forum for Autonomous Ships (NFAS), which is an interest group for organisations interested in autonomous shipping. The group acknowledges the important role that autonomous ships will play in the future global transport system, however it also recognises a number of challenges that must be overcome. Research into the necessary rules and navigational products needed to operate autonomous ships as well as conducting national tests is one of the key objectives.

NFAS aims to contribute to building an international network of similar organisations in other countries.

MPA Activities

MPA is a member of MASSPorts, a network formed by like-minded States and organisations to address the challenges and achieve alignment of standards for MASS trials and operation of MASS in ports. Objectives include developing guidelines for MASS trials in ports, establishing commonality across ports (e.g. in terminology, communication standards, ship reporting), and facilitate port-to-port MASS trials.

MPA has also taken steps to build up a vibrant MASS ecosystem in Singapore across its multiple roles as port and coastal state, and flag state. Under MPA’s regulatory sandbox approach towards MASS trials in Singapore port waters, MPA has carried out several trials with multiple stakeholders. Stakeholders include Wärtsilä, PSA Marine, Lloyd’s Register, the Technology Centre for Offshore and Marine Singapore, ST Engineering Marine, POSH, ABS, and M1. Further trials are planned as part of Singapore’s regulatory sandbox for MASS.

In addition to the regulatory sandbox for MASS trials, MPA in collaboration with the National University of Singapore and the Singapore Maritime Institute established the Centre of Excellence for Autonomous and Remote Operations for Ships (CEOAPS). CEAOPS’ research and development focus areas include metocean model for CONOPs experimentation and fast prototyping, and autonomous navigation enablers.

## Conclusions

Whilst the UKHO, Norwegian Hydrographic Service and MPA have been involved in exploring some of the concepts, due to the international nature of shipping the problems outlined above are also an international challenge. Whatever the future looks like for navigational data for unmanned ships, the problems above can only be solved on an international level.

No one Member State can produce and define its own approach to navigation services, ultimately the solutions must be governed by international standards and mandated by the IMO.

The IHO community should therefore start to work together to address these challenges and start to look ahead and build and test the concepts now, as the MASS industry and developments within it gather pace.

The IHO Community needs to be ready to support the transition from manned vessels to unmanned vessels and work collaboratively in doing so to ensure that the future of navigation remains safe.

## Recommendation

It is recommended that it is the right time for the HSSC to increase its focus on autonomous vessels through endorsing the establishment of a new Working Group / Project Team for MASS navigation to ensure a collaborative, joined and holistic approach is adopted and to start and define the new standards for MASS navigation.

## Action Required of HSSC

The HSSC-13 is invited to:

* Note this paper,
* Endorse the recommendation to establish a Maritime Autonomous Surface Ships (MASS) Navigation Working Group / Project Team this year (2021).

## Annex

## Maritime Autonomous Surface Ships (MASS) Navigation Working Group / Project Team

## Terms of Reference and Rules of Procedure

## 1. Objective

The objective of this Working Group/Project Team is to ensure future requirements are considered now to ensure that Maritime Autonomous Surface Ships (MASS) can utilise the data produced by Hydrographic Offices around the world.

## 2. Authority

This Working Group/Project Team is a subsidiary of the HSSC. Its work is subject to HSSC approval.

## 3. Composition and Chair

a) The WG/PT shall comprise representatives of IHO Member States (MS), Expert Contributors (EC), observers from accredited NGIOs, and a representative from the IHO Secretariat. A membership list shall be maintained and posted on the IHO website.

b) EC membership is open to entities and organizations that can provide a relevant and constructive contribution to the work of the WG/PT.

c) The Chair and Vice-Chair shall be a representative of an MS. The election of the Chair and Vice-Chair shall be decided at the first meeting of the WG/PT after each ordinary session of the Assembly and shall be determined by vote of the MS present and voting.

d) If a secretary is required, it should normally be drawn from a member of the WG/PT.

e) If the Chair is unable to carry out the duties of the office, the Vice-Chair shall act as the Chair with the same powers and duties.

f) ECs shall seek approval for membership from the Chair.

g) EC membership may be withdrawn in the event that a majority of the MS represented in the WG/PT agrees that an EC's continued participation is irrelevant or unconstructive to the work of the WG/PT.

h) All members shall inform the Chair in advance of their intention or inability to attend meetings of the WG/PT.

i) In the event that a large number of EC members seek to attend a meeting, the Chair may restrict attendance by inviting ECs to act through one or more collective representatives.

## 4. Procedures

a) The WG/PT should work by a combination of correspondence, teleconferences, group meetings, workshops or symposia. The WG/PT should meet at least once a year. When meetings are scheduled, and in order to allow any WG/PT submissions and reports to be submitted to HSSC on time, meetings should not normally occur later than nine weeks before a meeting of HSSC.

b) Decisions should generally be made by consensus. If votes are required on issues or to endorse proposals presented to the WG/PT, only Members may cast a vote. Votes at meetings shall be on the basis of one vote per Member represented at the meeting. Votes by correspondence shall be on the basis of one vote per Member represented in the WG/PT.

c) The WG/PT should liaise with other IHO bodies, international organizations and industry representatives to ensure the relevance of its work and timely notice of changes to the standards.

d) The WG/PT should report to HSSC on its activities and submit a rolling two-year work plan, including expected time frame.