IALA

IALA WORKSHOP ON MARINE ATON IN THE AUTONOMOUS WORLD

JCG JAPAN COAST GUARD

WORKSHOP REPORT

20, 24 to 28 May 2021

Virtual workshop

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Workshop Secretary

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Report of the workshop on Marine Aids to Navigation in the autonomous world

Executive Summary

The workshop on Marine Aids to Navigation in the autonomous world was held on 20 and from 24 to 28 May 2021 as a virtual IALA workshop.

The workshop was very well attended by 109 participants from 29 countries.

The workshop participants considered the various presentations that were made and the results of the two working groups, resulting in the following outcomes:

- There are **already** some ships operating in degree two and three, in particular non-SOLAS ships **(up to 300 tonnes less than 24 metres)** such as survey vessels.
- Global standards for equipment and software associated with MASS, and their ongoing maintenance, need to be adopted to ensure satisfactory levels of connectivity, safety and efficiency. It is envisaged that standardization on MASS equipment and software will be carried out at IMO, ITU, IEC, IACS and other international organizations, and that IALA and relevant authorities should work in close cooperation with these organizations.
- The increasing number of testbeds being conducted globally provides an opportunity for engagement to facilitate a greater understanding of the implications for Marine Aids to Navigation as automation technologies evolve and mature.
- There is a growing need for IALA standards to embrace the digital domain to facilitate the advent of MASS.
- Marine Aids to Navigation will continue to be essential infrastructure for all degrees of maritime autonomy on vessels and will continue to be required to support safe, efficient and pollution free transits. This includes identifying options for position, navigation and timing (PNT). This may lead to the development of adaptive AtoN to support different degrees of autonomous vessels.
- MASS will require a robust and resilient communication 'system of systems' to support complex and vital communication needs, allowing communication between ships, remote control centres, VTS, AtoNs and other elements that may be required in a MASS operating environment.
- The management of ship traffic to ensure the safety and efficiency of ship movements by VTS will evolve with the advent of MASS. This may involve managing 'big data', interacting with MASS using digital means, with possibly centralised, distributed and/or virtualised VTS 'centres' in the future.
- All developments in the provision of AtoN to support MASS must consider their role in a mixed maritime environment which includes both conventional vessels and MASS, and be fully compatible with both.
- Developments in technology and the regulatory environment to support MASS, as well as ethical / value expectations of society should be considered in the development of MASS and systems related to MASS.

This report takes into consideration these key findings. The report will be forwarded within IALA to the Policy Advisory Panel (PAP), the IALA MASS task group and IALA Committees (ARM, ENG, ENAV and VTS) for further consideration.

Contents

List of Figures

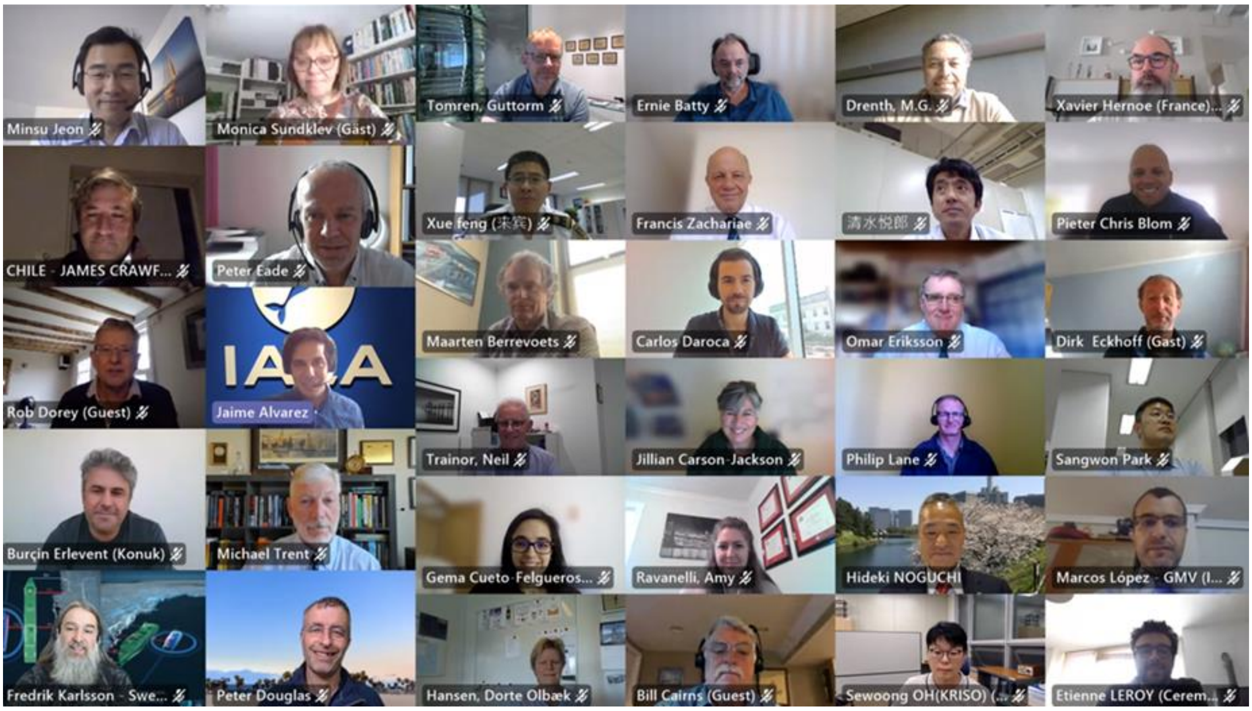
List of Tables

Report of the workshop on Marine Aids to Navigation in the autonomous world

1. INTRODUCTION

The workshop on Marine Aids to Navigation in the autonomous world was held on 20 May 2021 and from 24 to 28 May 2021 as a virtual IALA workshop.

The workshop was attended by 109 participants from 29 countries plus three members of the IALA secretariat. The list of participants is attached as ANNEX A.



Workshop participants were provided with the working arrangements and tools available for the exchange of documents, communications between participants, conduction of presentations and discussions.

The dedicated website for the workshop is https://events.iala-aism.org/iala-events/marine-aids-to-navigation-in-the-autonomous-world/

2. KICK-OFF SESSION

2.1 Welcome from Hideki Noguchi, Chair of the workshop, Japan Coast Guard

This session, aimed at setting the scene for the week, was chaired by Hideki Noguchi, and he welcomed participants to the first virtual IALA workshop due to the Covid 19 pandemic. The chair explained that the workshop was originally planed to be held in Tokyo in February 2021 in conjunction with ENAV 28.The workshop is also unique because it involves the four IALA Technical Committees: Aids to Navigation Requirements and Management (ARM); Engineering and Sustainability (ENG); e-Navigation Information Services and Communications (ENAV); and Vessel Traffic Services (VTS) due to the high impact of Maritime Autonomous Surface Ships (MASS) on Marine Aids to Navigation including physical AtoN and VTS and the rapid development of these technologies. The chair recalled the outcome of the Regulatory Scoping Exercise (RSE) for the use of MASS conducted by the IMO Maritime Safety Committee (MSC) and accomplished on the 103 session. The document is shared with all participants for the study and analyses.

2.2 Working program of the week and expectations

The Chair introduced the programme for the week (ANNEX B) which also can be found on the workshop fileshare and on the programme tab on the workshop website. The workshop was divided into three main blocks:

- the kick-off session informed all participants about the aims and goals of the event and how the workshop was structured. The kick-off session provided guidance information for participants on the tools which would be used during the workshop;
- presentations and discussions from a range of expert speakers covering topics related to MASS, including plans, technologies and autonomy in other transport sectors and the general sharing of views and opinions; and
- the working group sessions where the participants were split into two working groups: WG1 chaired by Neil Trainor and instructed to consider the impact of present and near future MASS and the WG2 chaired by Jillian Jackson-Carson dealing with the impact on future and long term MASS

The reason to divide into two working groups was that some autonomous technologies had already been developed and were in operation, for instance: small boats carrying out surveys in oceanic waters. On the other hand, further developments in fully autonomous SOLAS ships are foreseen, which was considered during the session led by Jillian Jackson-Carson.

The focus of the workshop was on identifying the impact of MASS on AtoN (including physical AtoN and VTS), raising questions and gaps with regards with MASS from the participants' various perspectives, explaining and analysing the different degrees of autonomy. Ideally, envisaging a possible input for the IALA Committee working programs regarding MASS.

Finally, the Chair read the terms of reference to the working groups which can be found in the file-share.

2.3 Presentation of input papers

Under this agenda item, the documents were presented which were proposed to be read by the participants to start the discussions with the latest updates, and useful information produced by the IMO, other organisations and IALA member States. Other useful links to different initiatives on MASS were published in the pre-reading section of the website.

2.4 Working arrangements for the week

Jaime Alvarez, secretary of the workshop and secretary for the ENG and ENAV Committees, presented the working arrangements for the week through the presentation of the dedicated website. The areas prepared to enable participants to work effectively during the working period were as follow:

- Workshop description providing brief information of the scope of the workshop, goals and logistics
- Programme depicting the slots and meeting links for presentations and working group sessions
- Speakers biography and presentation's abstract
- Registration for participants
- Pre-readings which were recommended to be read and studied before the formal start
- MASS on Twitter with update news on the Twitter community about MASS initiatives
- Workshop news which included the latest arrangements and daily updates for the workshop
- Working arrangements presented the high level organisation, structure and tools

- [Working groups]() providing the preparation of WG1 and WG2
- [File-share]() where the documents were stored, shared and open to contributions

3. OPENING OF THE WORKSHOP

3.1 Welcome from IALA, Francis Zachariae - IALA Secretary-General

Francis Zachariae, IALA Secretary-General, welcomed participants to this workshop highlighting that even the name 'MASS' is controversial to some people and for sure there are some topics within the MASS concept which are controversial to some organisations. Secretary-General believed the workshop would be an excellent start for the newly formed task Group on MASS organised by the Policy Advisory Panel.

Then, the Secretary-General thanked the Japan Coast Guard and especially the Chair, Hideki Noguchi, for taking the initiative to host the workshop taking which was initially arranged to take place in Tokyo.

The Secretary-General underlined the high number of views on MASS. Some people are convinced that it is just around the corner and that it will change the maritime sector totally and others are sceptical and think that the impact will be less important. Secretary-General thought that the world is changing towards a more digital future and we must prepare.

The future for completely unmanned ships on a large scale is perhaps not just around the corner, but automization is here, and it will develop quickly. The Secretary-General recalled the success of risk reduction in aviation by digital assistance to the pilot – and considers that we must learn from that. Too many accidents take place at sea.

The Secretary-General called attention to the fact that with more automization and less trained and experienced people on the bridge, risks must be consider and handled. These are – among others - resilient position navigation and timing and cyber threats which are addressed at a workshop later organised by the Canadian Coast Guard.

Like many other e-Navigation initiatives, MASS projects have been driven by local or national projects all around the globe. The Secretary-General informed about the testbeds in Session 2 from some of the best experts from Europe and Asia which are very important, but the results – as best practice- need to be globally harmonised and this is a job for international organisations like IALA.

Harmonisation is done by issuing standards for the users and industry to follow, and IALA – through the work of the committees – has already issued many guidance documents on MASS related matters, and there are more to follow.

The Secretary-General pointed out that a very interesting insight about MASS is that it - as mentioned by the chair on Thursdays kick off – involves all four committees and almost all seven IALA standards. It is considered as a very complicated area that also requires a total review of all former guidance documents and legal aspects. Henrik Tunfors updated participants on IMOs Scoping exercise during Session 1. The Secretary-General concluded that IALA would have to do the same at some stage.

The Secretary-General felt that, as in other complex projects, participants have perhaps already solved many of the complicated technical issues, and now the real challenge is the international acceptance, coordination and harmonisation in order to implement MASS world-wide. This requires strong and determined international organisations like the IMO, ITU, IHO and IALA.

The Secretary-General drew the participants' attention to a project about to be materialised and that could help MASS on its journey. The change of status of IALA from an NGO to an IGO. The Convention was adopted in Kuala Lumpur last year and so far, 7 States have signed, and one state has ratified the Convention. When 30 states have ratified the convention, it enters into force and IALA will be an IGO just like the sister organisations IMO, ITU and IHO. IALA members will then speak with a much louder voice and have much more influence on international negotiations and decisions and that will benefit the MASS project.

The Secretary-General expressed the view that many more countries are about to sign the Convention and asked participants to use their possible influence to make this happen in their countries soon.

Finally, Secretary-General wished participants the best of luck for the week.

3.2 Recalling working program of the week and expectations, Hideki Noguchi – Japan Coast Guard

The Chair welcomed all the participants to the formal opening of the workshop. He recalled the working program and expectation for the week. Both documents; outputs expected and the Terms of Reference are available in the file share area for the well conduction and understanding of the week workstreams.

3.3 General view on MASS development, Minsu Jeon - IALA

Minsu Jeon, Technical Manager of IALA, presented the general view on MASS development. His presentation was comprised of MASS trends that could affect the Marine Aids to Navigation and the possible impacts and the work of IALA on MASS. The presentation raised several questions to trigger discussions and sharing knowledge during the workshop.

Minsu started the presentation emphasising the increasing importance of Marine Aids to Navigation for the autonomous systems and shared a result of technology trend analysis of autonomous cars from the point of view of AtoN. He reviewed the developments of the sensing modality with vision cameras, radar radio detection and ranging, Lidar and their software process. Also, he introduced a couple of reference reports of road infrastructure on different automation strategies and Infrastructure support levels for automated driving.

Another part of the presentation covered additional requirements of AtoN for autonomous systems. The maritime authorities could review the services with MASS, and the quality and quantity could examine with new requirements.

ENAV and VTS committees started drafting guidance documents on MASS, and PAP established a MASS task force group to identify possible future scenarios and analyse the potential impact of MASS.

3.4 Outcome of IMO MASS Regulatory Scoping Exercise (RSE), Henrik Tunfors - IMO

Henrik Tunfors, Senior maritime advisor and currently the Focal point for autonomous shipping and smart ships at the Swedish Transport Agency, and Chairman for the IMO Working Group on MASS briefed about the outcome of the RSE for the use of MASS. Henrik first defined the scope of the RSE as the work in IMO on the determination of which IMO provisions apply or not to MASS and may preclude or not MASS operations (as currently drafted). Besides, IMO RSE identifies common gaps and common themes to analyse the best way to proceed the MASS operation in IMO instruments. MASS was also defined in the RSE as " a ship wich, to a varying degree, can operate independent of human interaction". The degrees of autonomy was also agreed as part of the work in IMO MSC:

- Degree One - **Ship 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 ship with seafarers on board**: The ship is 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 ship without seafarers on board**:The ship is controlled and operated from another location. There are no seafarers on board.

- Degree Four - **Fully autonomous ship**:The operating system of the ship is able to make decisions and determine actions by itself.

Henrik believes that degrees three and four are extremely challenging for the MASS operations and IMO instruments.

During the MSC task on MASS, thirteen conventions and nineteen codes were analysed in twenty-five work packages with contributions by members States and other supporting members. The outcome of the RSE is reported in working paper 8 from MSC103, particularly in the sections depicted below of the document:

- Most appropriate way of addressing MASS in IMO instruments → Annex 2
- Assumptions for the RSE → 5.1
- Common potential gaps and themes → 5.2
- High, medium, low priority based on identification of gaps and themes on current instruments→ 6.7-6.9
- High priority issues → 5.4-5.8
- New instrument → 6.2

There are fours ways of addressing gaps and themes would be:

- equivalences as provided for by the instruments or developing interpretations; and/or
- amending existing instruments; and/or
- developing a new instrument; or
- none of the above as a result of the analysis.

As a key note from the speaker, for degree one, there will be no need for any action from IMO and the group did not reach any clear conclusion for STCW code (which is the most human centred instrument in IMO) which regards for instance in new instruments. New instruments and amendments are needed afterwards in degree two, three and four. There will be no separated regime on MASS, applying the same principles as outline in colorless (refer to the diagram on slide 12). Some of the gaps and themes identified among others and expected to be addressed in the most imminent future in IMO are:

- remote control of the ship
- remote operator as a seafarer
- meaning of Master, crew or responsible person

Henrik underlined the priorities in IMO, starting with the need of continuing developing tests, legislations, experiences, guidelines etc. for the upcoming meetings in IMO (refers to section 6.11.3 RSE). Facilitation (FAL) and legal (LEG) committees are also close to finalise their work on MASS for 2021-2022. Marine Environment Protection Committee (MEPC) is getting involved on the matter as well.

The IMO's interim guidelines for MASS trials were addressed and are intended for industry and administrations to focus on risk management and information/reporting sharing whenever trials are conducted. Henrik finalised the lecture summing up the key elements of this RSE, this high level exercise being accomplished in MSC 103/WP8 is waiting for MEPC feedback. Interim guidelines for MASS trials are in effect, and there is a need to stakeholders being active, share information and try to influence police makers and industry.

3.5 MASS terminologies, Jillian Carson-Jackson – The Nautical Institute

Jillian Carson-Jackson, President of The Nautical Institute and a Director of GlobalMET, provided an overview of MASS terminologies. Jillian asked the participants to share what are the challenges of providing AtoN in an autonomous world, the challenges more repeated by the participants were regulation, training, technology, communication, PNT, integrity, accuracy and harmonisation.

Jillian focused on the importance of agreed, shared vocabulary and terminology to ensure that everyone involved understands clearly, unambiguously and without exception what is being said. Her presentation covered fours parts: anchoring knowledge on existing terms worldwide and bringing into focus of new developing terms related to machine learning and more, a review of the work in progress on terminology related to MASS and autonomous systems, and possible next steps.

As an opening insight related to the common understanding of similar terms, Jillian gave the example of Digitization vs Digitization and Automation vs Autonomous / Autonomy. Jillian presented on the developments in artificial neural networks (ANN) and their role in Artificial Intelligence (AI), highlighting the further work on Machine Learning (ML) as a subset of AI. Looking at the concept of a massive ANN, Jillian explained the further subset of AI and ML, known as 'deep learning'.

Jillian underlined the work in progress in IALA related to MASS, including the draft recommendation and guideline developed by the ENAV Committee, WG2, which were made available in the workshop folder. An overview of the past work on levels of autonomation (Sheridan and Verplank) were referenced, and linked to the IMO degrees of autonomy used for the Regulatory Scoping Exercise (RSE).

The work in ISO/TC8/WG10 was presented noting the link with AtoN and VTS, with specific reference to definitions being developed related to 'operator control mode', monitoring, strategic, tactical and direct control. The presentation was summarized by focusing on three key areas: Effective Regulations; Robuts Technology and Values and Ethics. The consideration of all three whas highlighted as being critical to further development of 'trusted systems' within the MASS operational environment. In conclusion, Jillian highlighted that, when looking ahead to the future of providing AtoN, including VTS, in an increasingly autonomous environment what are the questions we need to be asking around the legal regime, the technology expectations and limitations, and the ethics of what we are doing.

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3.6 Business case, Ann Till - Ocean Infinity

Ann Till, Chief Vessel Operator for Ocean Infinity (OI) depicted the potential markets, the factors that can influence timescales and business models of operating remotely controlled vessels and the importance of ensuring operational safety and compliance is kept at the heart of how commercial operators use uncrewed maritime technologies.

She explained the levels of autonomy, where the human is located and what is its duty wherever is. Safety is the backbone of the phased approach to operations in every step of the implementation: crewed operations, crew 'Hands Off', Crew 'In Vicinity' and Fully Uncrewed. Feasibility studies, risk assessments, test plans and other assets are progressing. The primarily line of sight craft operated by OI are currently split around the globe (USA, UK and Australia).

Ann presented the Armada fleet with a number of capabilities, size and design in order to cope different clients' expectations and purposes in a large economy of scale and long term success. Assets and qualified personel (seafarers, IT, operators) are also being involved in each step of this project. A number of questions are being raised as the work progresses related to the remote control centres, the role of the Master, the liabilities of the ship flag state vs the remote control centre and its requirements, operations perspective from the regulatory point of view and how this adapts to the new assets, operations and procedures when dealing with MASS. Ann explained areas of interest and potential markets for MASS operations that are being analysed.

4. MASS TESTBEDS, MAARTEN BERREVOETS - THE MINISTRY OF INFRASTRUCTURE AND WATER MANAGEMENT OF NETHERLANDS

Maarten Berrevoets from the Ministry of Infrastructure and Water Management of Netherlands, Chair of the IALA MASS task force, moderated the session on MASS testbeds addressing the latest updates from the most advanced countries developing such trials and testbeds.

4.1 Norway testbed, Ørnulf Jan Rødseth - Norway

Ørnulf Jan Rødseth, senior scientist at SINTEF Ocean, general manager in Norwegian Forum for Autonomous Ships (NFAS) and the coordinator for the International Network for Autonomous Ships (INAS), gave a presentation of the state of art of MASS developments in Norway. He provided the drivers, port assests and commercial projects on this MASS environment. Also, Ørnulf presented the overview of the companies, contributors, EU funding projects and initiatives developing the different workstreams to implement autonomous ships in Norwegian waters.

Ørnulf explained the shore part facilitating innovation and testing of the ship and the shore infrastructure as well. The testing areas located in different parts of Norway are working in cooperation to facilitate the testing plan and results. Ørnulf also mentioned the work to be done on MASS terminology. He concluded stressing the fact that MASS will is called to be part of transport system in Norway, using more and smallers ships that will provide higher flexibility in the transport system (both for passenger and for cargo). The testing areas represents more ressources for the development of MASS and Trondheim is open internationnaly for such purpose.

4.2 Finland testbed, Anne Miettinen - Finland

Anne Miettinen, Senior Ministerial Adviser in the Automation Unit of the Ministry of Transport and Communications Finland, Head of Delegation of IMO FAL and participates in the IMO MSC, presented the test bed in Finland. The driver to progress on MASS developments is the potential benefits to all the society of all transport modes automation. Since, 2018 some testbeds of remotely operated and fully autonomous passenger ships were conducted. Different firstly elements were arranged to conduct test bed as guidelines at EU level, cooperatives ecosystems catalising MASS needs and requirements, a political endorsement of such initiative and national legislation (Bill on ships' crews and the safety management of ships (Amendment 976/2018), Remote pilotage in Finish Pilotage Act (Amendment 51/2019)) enabled test and pilots. One important development area is intelligent fairway which leads from open sea to fairway and to port. It also takes into consideration importance of intelligent ports as test platforms in multimodal logistics corridor. The concept of the intelligent fairways includes digital, physical and data infrastructure which are corner stones of testbeds in addition to ecosystems and ship technology. Intelligent traffic control and vessel traffic services were also developed. Some initiatives inputting their results in the MASS ecosystem also included neighborhood countries as Sweeden and it was also implemented RAAS research ecosystem to support tests with research. The whole cooperative different workflows are bein endorsed by the Finnish Government with a view on safer, more efficient and more sustainable transport automation carried on a human-centric, transparent, cooperative exchange of data and technology neutral regulatory framework.

4.3 Japan testbed, Captain Satoru Kuwahara - Japan

Captain Satoru Kuwahara, Captain of NYK Line and currently belongs to Japan Marine Science Inc, introduced the overview of the Japan testbeds. Satoru also underlined the need to work in a collaborative way from stakeholders and partners that will be addressed in an open innovation environment aiming at improving safety and efficiency of navigation. The presentation provided the different projects and initiatives involving a great number of stakeholders. Four cases were developed in the framework of autonomous navigation.

Related to case 1 - Satoru focused on a specific example developed: Auto Avoidance System using Geometric Model that complies with the IMO Interim Guidelines. One of the key points is the use of radar echo data information to match with AIS data. Below is represented the high level scheme of the system:

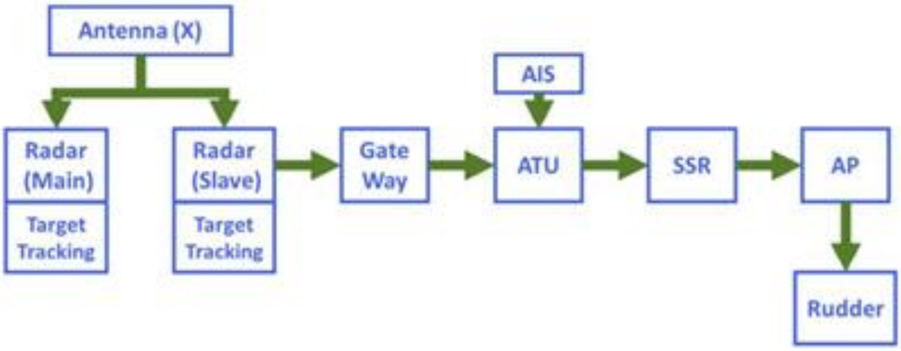


Figure 1 - Recognition system of surrounding situation

Case 2 - Remote Navigation: remote operation in TOKYO Bay through ECDIS from a remote operation centre. The results stressed the awareness evaluation methods when quantifying the risk sensations of experts navigators and displaying areas of potential collisions.

Case 3 - Auto Avoidance System using AI in order to make avoidance operations safely in various locations.

Case 4 - Crewless MASS derived to solve the issue of shortage of domestic crew. It is expected to develop a remote operation centre and the autonomous navigation system on board that will be connected through a robust communication infrastructure (terrestrial and satellite).

Finally, Satoru highlighted the role of marine AtoN to understand own vessel's surrounding, improve the level of situational awareness, or maybe when evolving some Marine Aids to Navigation worldwide for MASS operations.

4.4 Singapore testbed, Captain Segar – Singapore

Captain M Segar, Assistant Chief Executive (Operations) of the Maritime and Port Authority of Singapore (MPA) and vice-Chair of the MASS task force dedicated his slot to share on Singapore's Approach to Test-bedding MASS technologies. Capt. Segar explained the Regulatory Sandbox framework for MASS trials, and the need to consider the entire ecosystem including regulatory and testbed guidelines, communications, smart ports, con-ops services, insurance coverage among others.

Segar presented three pilot projects conducted in collaboration with different partners:

- IntelliTug: Supervised autonomous control with on-board Master, Autonomous navigation with optimised passage planning, Real-time collision detection and collision avoidance
- Smart Maritime Autonomous Vessel: aiming at developing a shore command centre capable of autonomous waypoint navigation and remote control
- Project MINERVA: also aiming at developing a shore command centre capable of remote control and monitoring of vessel's engine and thruster

These projects provide different level of autonomy and different procedures for the implementation of command centres. Capt. Segar underlined that the industry has a huge undertaking ahead with the developments on MASS and the evolving MASS concept.

4.5 Question and answer session

The question below was asked from the floor and the discussion highlighted the following:

- Related harmonization across testbeds: was there any cooperation between testbeds and harmonization in this sense?
  - There was no formal cooperation between testbeds but some communication and coordination in the frame of international initiatives of countries dealing with MASS testbeds.
  - Capt. Segar hoped IALA could be the global coordination body on MASS testbed initiatives.
  - MASS port network initiative and the European Commission for high level steering group on MASS promoted this coordination as well.
  - As per the Japanese speaker point of view, the testbeds are an important element, but at present, there are no testbeds in Japan yet. As shipping operator and also as a developer, I wish the testbeds are set in a specific area in Japan, such as Finland, China and so on. We hope to that discussion with the government agency and set an efficient test field. But the most important thing to succeed in the field test at actual sea is that sufficient and efficient shore test like factory acceptance test in advance. We're testing many time before going to actual sea area, and confirm available levels to operate safely, finally going to the demonstration.
  - The workshop Chair recalled the initiative taken by IALA with the e-Navigation testbeds coordination point, which collects e-Navigation initiatives and could also provide the same support for MASS testbeds.

5. AUTONOMOUS TECHNOLOGIES – R. DAVID LEWALD, US COAST GUARD

Robert Dave Lewald, US Coast Guard, chaired the session on autonomous technologies bringing to the scene the number of initiatives in other transport domains or technologies that could apply to the maritime domain and feed the discussions during the working group sessions.

5.1 Autonomous technology for road, Yasuyuki Koga - Secretariat of Science, Technology, and Innovation Policy of Japan

Yasuyuki Koga, head of the national research initiative Cross-ministerial Strategic Innovation Promotion Program on automated driving for universal services (SIP-adus) in the Secretariat of Science, Technology, and Innovation Policy, Cabinet Office, Government of Japan, gave an overview of the national initiatives for implementing automated driving in Japan. Yasusyuki presented the levels of driving automation defined by the Society of Automotive Engineers (standardisation body), comprising 5 levels divided into two blocks:

- Driver support:
  - Level one - Driver assistance: The system controls the vehicle's movements either in longitudinal or lateral directions (f.i: automatically stops, automatically stops, keeps the vehicle in its lane)
  - Level two - Partial Driving Automation: The system controls the vehicle's movements in longitudinal and lateral directions (f.i: follows the car in front while keeping the lane, automatically overtakes slower vehicles, automatically merges into or exits from the traffic on expressways.
- Automated driving:

- Level three - Conditional Driving Automation: The system drives the vehicle under certain conditions (if request by system, the driver must appropriately respond to the system's take-over).
- Level four - High Driving Automation: The system drives the vehicle under certain conditions (system deals with situations in which the vehicle has difficulty going on).
- Level five - Full Driving Automation: It is always the system that drives the vehicle

Something to note in these levels is related to level four and level three, the system is limited to pre-defined conditions according to the parameters (Operational Design Domain – ODD) Speed, Geography, Roadway, Environment, Traffic, Temporal, etc. The difference between them is the need for a back-up human in level three and level four will act over these ODD.

The structure on the automated driving system was explained combining the equipment on board (in-vehicle sensor information) and charts/surrounding data (dynamic map including dynamic, semi-dyn., static and semi stat. data,). Important for data to be easy scalable, non-costly and easy to update and refresh for dynamic data. Both sources feed the traffic environment information. Two roadmaps are envisaged: one for logistic and mobility as a service, the other for private cars.

Road automation is leveraged by an structured industry, academia, government collaboration creating R&D programme aiming at not only performing research but to put automation solutions into practical and commercially optimal. Equally, this framework looks into promoting regulatory reform.

The status around road automation in Japan is now focused on developing and building the Traffic Environmental Information which is also represented in the roadmap and is mainly located in the Tokyo waterfront city area, providing traffic signal information with dedicated communication systems. These prove of concepts are dedicated to public transportation.

The safety case was presented through the simulation platform (Driving Intelligence Validation Platform) that replaces real vehicle evaluations with sensor achieving the safety evaluations of automated driving in various traffic environments.

The cybersecurity challenges came along the speech and the research are also in place to cover it.

Finally, the presentation stressed the international effort made by Japan to collaborate globally through Dynamic map / Connected Vehicle / Human Factors / Cybersecurity among others working groups, international standardisation in ISO, IEC, ITU and others workshops progressed.

5.2 Autonomous technology for aviation, Manuel Santos – European Satellite Service Provider

Manuel Santos, Aviation Consultancy Expert in European Satellite Service Provider (EGNOS Service Provider), provided a presentation with the objective of introducing several concepts related to the way that the Instrument Flight Procedures used in aviation are defined and designed for the different phases of the flight, encouraging the marine audience to think about the potential applicability of a similar concept in the future MASS scenarios.

At the first place, main concepts related to the Instrument Flight Procedures (predefined and published routes which will be flown by all aircraft for all phases of the flight) together with their main purpose (ensure obstacle clearance, both laterally and vertically, orderly Flow of air traffic and separation between aircraft) were carefully explained. Then, the process for defining these Instrument Flight Procedures, which was summarized in three main steps, was mentioned:

- Flight Procedure Design step: in which the Instrument Flight Procedures are designed according to ICAO criteria.

- Publication phase: where Instrument Flight Procedures are published in the Aeronautical Information Publication as aeronautical charts.
- End Users step: where Instrument Flight Procedures are flown by pilots and airliners, according to the published aeronautical charts.

At the second place, the concept of Total System Error and its relation with the Protection Areas (containment area where the aircraft is expected to remain) associated with the Instrument Flight Procedures was detailed. The Protection Areas are provided for the whole flight and they will be changing along with the flight in accordance with the Total System Error and the phase of flight.

Linked to the concept of the Protection Areas, the on-board performance monitoring and alerting functionally was also mentioned during the presentation. This functionality allows the air crew to detect whether or not the RNP system satisfies the navigation performance. This information is presented to the aircrew on board and will ease the containment of the aircraft within the protection areas.

Finally, in order to better understand all the previous concepts, a practical example of a flight from Barcelone to Madrid was included. An important idea that was highlighted during the presentation was the Flight Plan and its relation with the Instrument Flight Procedures. A Flight Plan, which must be submitted before the departure of the flight, provides information to air traffic controllers, regarding the route to be followed (including all published instrument flight procedures).

Airliners include in the Flight Plan the most convenient route, since the departure until the approach phase, taking into account: the published instrument flight procedures for the different phases of the flight, the on-board equipment and pilots and aircraft certification and qualification.

5.3 Autonomous technology for aviation and maritime, Ifor Bielecki – SeaBot XR

Ifor Bielecki, Chief Operation Officer of SeaBot XR spoke about how aviation and maritime could work together permitting that the lesson and knowledge from autonomy and automation learned in aviation could be used in maritime.

It is assumed that aviation autonomy is further implemented than in maritime, however, maritime crafts operate in a highly complex environment compared with aviation which is extremely controlled, therefore the challenge to implement autonomous systems increases significantly. Another differentiation between maritime and aviation is that in the latest, the trend is to fly on fleets of similar aircraft (those of Airbus and Boeing) all collecting data and therefore a few of people processing this data whereas ships tend to be very bespoke and so data gathering in volume is difficult.

The evolution of flight instruments and systems in the cockpit within the 20th century was also explained to conclude that behind such developments as the Engine Instrument and Crew Alerting (EICAS) there is a system monitoring the status of the engine and the airplane in general and updating and alerting the crew when they needed. The flight engineer is at this stage replaced by such systems, and this could be seen as the first automation process in aviation. The developments are continuously progressing, enabling more automation (Boeing 787), presenting digital information, dealing with problems safely and providing robust systems no matter wherever the plane is flying.

The aviation information flow shows how relevant the training is and its conception to increase human performance, regulator and Original Equipment Manufacturers (OEM) are at the same level. Training in aviation is a daily task and commitment. The Aviation Information flow ensures everyone has the information they need to keep up to date. Nothing should happen in silos, especially where the introduction of new technology or ways of working are being implemented. When speaking about data, engine and flight data monitoring are continuously sent back to the ground. Much more data is available and freely shared to the OEMs, engineering team and between airlines (more than the one recorded in the black box). Data is key to the management of operational risk. Autonomy is just another tool, but also a risk factor.

Autonomous Taxiing, Take-Off and Landing (ATTOL) project was initiated by Airbus to explore how autonomous technologies, including the use of machine learning algorithms and automated tools for data labelling, processing and model generation, could help pilots focus less on aircraft operations and more on strategic decision-making and mission management. In completing this project, Airbus has achieved autonomous taxiing, take-off and landing of a commercial aircraft through fully automatic vision-based flight tests using on-board image recognition technology. But they're reliant on external infrastructure like Instrument Landing System (ILS) or GPS signals. Before the conclusion of this project, many aircraft were already able to land automatically; ATTOL aims to make this possible solely using on-board technology to maximise efficiency and to reduce infrastructure cost. To conclude, there are already a lot of automation in maritime (autopilot) and aviation but the big step forward is when the machine takes the decision and the human just monitor them.

To conclude, automated systems knowledge became the key to operate safely and the training on the rational and logique about what the automatic system is doing. Automation should be a tool, not the goal itself and Humans are at the heart of automation. Accidents and mistakes will eventually happen, but there should be open and transparent access to the results of processing the data coming from these eventualities.

5.4 Managing and adapting new technologies, Kevin Heffner - Pegasus Research & Technologies

Kevin Heffner, independent researcher and President of Pegasus Research & Technologies, provided insights on the use of new technologies to cope with MASS expectations, needs and requirements. He started highlighting that even if there are concepts defining the levels of autonomy, but it has not a universal character in its usability, questions as how, where and why autonomy (and MASS) implementation supposes a beneficial approach to operations. Defining needs and technologies should also be considered. Autonomy ecosystem includes the vessel itself, communication infrastructure and remote control centre. MASS at the same time is a component of the multimodal supply chain, and therefore all of the parts of this ecosystem (including remote control centre, VTS among others) should cohabit and be connected effectively with the rest of the land and air domain. Artificial intelligence (AI) is a disruptive technology providing situational awareness, but even if AI were able to effectively and reliably perform complex decision-making in safety-critical systems, the testing, validation, certification (speaking also about training), and legal frameworks are not yet mature enough. It remains unclear when the human should take over the machine, for the time being, Humans are better than machines for most complex decision-making tasks and should be the primary decision-maker.

When speaking about MASS, the challenge of insurance & liability perspectives becomes essential. Risk management across all the stakeholders is going to determine how and when MASS become operational.

From the speaker view, digital information sharing is the key to successful MASS integration. The other component is this data should be connected through the MASS to the port. Training component and simulations of complex scenarios were proved in aviation that being extremely effective to preserve safety operations. Digital twins implemented for ships, shore, offshore infrastructure and waterways seems to be an applicable technology to share a representation of the infrastructure, the ship, the surrounding and the ports enabling to feed the connected network: traffic management systems and vessels.

Standardization is seen as a tool to reach interoperability, Kevin went through the different levels of interoperability: organizational, system, technical. A challenge observed there is to create a flow of standards and implementations that need to be connected and interoperable. Frameworks on Intelligent Transport Systems (ITS) have been used on successful way allowing designers and creators from government and industrial to put together the services, infrastructure and needed collaboration links to progress further MASS within the rest of transport system.

Virtual reality and augmented reality could be also required to be implemented as immersive environments to create testbeds for remote control centres for instance providing highly reconfigurable support, digital twin concept and suited for operational use.

5.5 Question and answer session

A number of questions and thoughts were addressed from the floor and the discussion highlighted the following:

- **Do aircraft have a mechanism to share their IFPs with each other, or is it just shared with ATC**?

Manuel Santos explained:

IFPs are published at public websites under the states responsibility, then airliners based on the published IFPs are responsible for submitting the flight plan to the ATC before the flight. Nowadays, the flight plan is only shared with ATC; nevertheless, in future aviation concept, it is expected that the flight plan will be shared among all aircraft.

Additionally, currently, aircraft have the capability to share only their current position for situational awareness which is used, among other aspects, for safety nets (such as collision avoidance).

Ifor Bielecki pointed out:

Not directly, though using ADS-B aircraft do communicate with each other in a slightly more sophisticated way than AIS, for example.

- **In aviation, what is the role of the ATC in instrument flight procedures?**

Manuel Santos explained:

ATC is one of the main relevant stakeholders when implementing any instrument flight procedure. They have involved in the procedure design concept, mainly operational issues, including also the safety assessment processes.

In addition, during the flight, ATCs are also responsible for monitoring the flight plan and provide instructions to aircraft along with the flight. Even ATC can modify the route defined in the flight plan (if needed) in order to ensure the aircraft separation.

Ifor Bielecki also informed:

ATC manages the flow and gives clearance to aircraft to start the procedure. Procedures can be flown without ATC input, but obviously, this massively impacts the safety and flow throughput. It is very much a team effort! Radar vectoring is often used by ATC to manage flow, which means they take over responsibility for navigation and traffic separation. They will then take the aircraft to a point to pick up the procedure, or crews can fly the procedure fully right from the start.

- **Noting that IFPs are now based on waypoints rather than ground navaids, are ground navaids used at all to check for GNSS errors?**

Manuel Santos explained:

Although RNP concept is primarily based on waypoints (and not necessarily based on ground navaids), a minimum operational network of conventionally based flight procedures is/will be kept in case of issues with GNSS.

Ifor Bielecki informed:

Aircraft systems use space based and ground based aids to manage their navigation accuracy and performance.

- **How have the systems designed to assist the transits that are external to the units (cars, planes) changed to reflect the increase in autonomous systems? (thinking of those systems that could be akin to Aids to Navigation in maritime)**

Ifor Bielecki explained:

Ground based navigation aids are still very important in aviation and act as redundancy and a more controlled method of providing positioning. GPS etc. is brilliant, but not without its own issues. There have also been issues with data throughput for some areas, such as comms systems. As aviation tends to use VHF comms primarily for both data and voice, then this has low bandwidth. When CPDLC (Controller Pilot Datalink Communications) was introduced using VDL Mode 2, there were significant problems as it was scaled up, and ultimately it was scrapped, and a new method was utilised. As for ground aids, "5th Generation DME" is being rolled out as part of SESAR to increase navigational accuracy and throughput. Distance Measuring Equipment (DME) is incredibly useful and one of the most accurate ground based aids.

- **There were some questions on the training hours**

Ifor Bielecki explained:

Total time is 240hrs including aircraft time. Tends to be around 185hrs in the simulator.

- **There were some questions on redundant systems**

Ifor Bielecki explained:

Aircraft redundancy is essential to safe remote operation. It is the same with MASS vessels, they need to have redundancy as a matter of course, whereas crewed vessels deal with failure by having human crew to fix things. No people, it means you need redundancy! Maritime does have redundancy built-in though, for many systems. DP2 or DP3 requires it, for example.

- **To what extent can aircraft automation currently deal with the unexpected? Do the crew still routinely take over in the events?**

Ifor Bielecki explained:

Not very well! The on-board systems work within parameters and tend to struggle with multiple failures. Automation on board is usually rule based rather AI-based, so it can only deal with what it is programmed to do. For example, the Qantas A380 incident at Singapore where an uncontained engine failure caused multiple system failures. The crew still used the automation to fly the aircraft whilst they managed the incident, but the onboard troubleshooting systems couldn't cope with the multiple failures at once, so the crew had to diagnose the failures themselves. It was a textbook example of how humans and automation need to work together and how well-trained humans are essential when things go wrong. Automation has its limits!

- How to link external data with AtoN: communication from ATC, reliability of these systems.

6. WORKING GROUP SESSIONS

6.1 Working group 1 - Impact of present and near future MASS

6.1.1 Executive summary

The workshop was held from 24 – 28 May 2021 with the working group session conducted 25 – 27 May.

The focus of working group 1 was on-going developments within autonomous technologies that may have implications for the provision of VTS and AtoN in the present and the near future. The issues in accordance with the Terms of Reference (see ANNEX C) were also considered by the working group.

Outcomes from the group include:

1. **Key implications of present and near future MASS**. These include:

- **VTS Communications and interaction**, that is:
    - Embracing digital communications.
    - Data and information exchange, including automated exchange.
    - Managing a mix of traditional VHF voice, digital communications and automated data exchange.
    - The need for MASS to communicate their degree classification (e.g. pre-entry report.
- **VTS Operations**, including:
    - How VTS receives, assimilates and processes data and information from MASS.
    - How does VTS interact with both conventional ships and MASS.
    - How does the VTS interact with the entity in control of the ship (Master/RCC/automated systems).
    - How VTS manages ship traffic, including:
        - A mix of conventional ships and MASS.
        - The use of message markers such as warning, advice and instruction to achieve its purpose.
    - How VTS responds to the development of unsafe situations (conventional ships and MASS).
    - Knowing the degree of MASS for individual ships.
    - Interaction with MASS of degrees 2 and 3 – managing the interaction between crew and RCC.
    - Managing interaction with multiple RCC's.
    - Emerging situations where a ship needs to be contained / controlled to mitigate incident effects (national governments, VTS, other agencies).

Determination of these implications was based on the following assumptions:

- MASS will be required to participate in VTS in the same manner as conventional ships. That is the same:
    - regulatory reporting requirements, and
    - obligations with regards to the issue of advice, warnings and instructions as deemed necessary.
- MASS will be subject to COLREG, as amended.
- The degrees of MASS as defined in the RSE will evolve following completion of the RSE exercise and additional levels may be adopted, noting the levels being suggested by ISO, Sheridan and other industry initiatives.
- MASS will rely on different sources of PNT (as GNSS) and AtoN among others for navigation.
- MASS will have sensors which can use and interpret current visual, sound and electronic AtoN signals.
- MASS will require robust communication systems and those systems must have equally robust cyber security protocols.
- Secure and resilient communications will need to be developed to support MASS.

2. **Recommendations**

The Group identified the following recommendations for further consideration by IALA:

- Relevant authorities should set up national/regional/local rules and guidance for MASS as appropriate for VTS areas, ports and other areas, as deemed necessary.
- Mandatory regulations for the software maintenance regime for navigation and utility equipment should be safeguarded by life-cycle arrangements with Original Equipment Manufacturer (OEMs).
- Vessel and associated shore-based equipment/software should be maintained and updated through compliance with agreed international standards.
- That IALA liaise with agencies and organisations conducting testbeds with a view to incorporating the outcomes and lessons learnt from test beds in their evaluations and reports. Further, agencies conducting testbeds should be encouraged to engage VTS and AtoN providers during their trials and evaluations to ensure the implications for VTS and AtoN are considered.

3. Degrees of MASS

Consideration was also given to implications for MASS Degrees 1, 2 and 3 by adopting scoping work being undertaken VTS Committee Task Group 1.2.5. This identified assumptions and questions that should be considered further in evaluating the implications and adopting appropriate IALA guidance.

These are provided at Section 6.1.3.1 of the report.

4. IALA Standards, Recommendations and Guidelines

A preliminary review of IALA documentation that may need to be revised, or new guidance prepared, this was undertaken on the basis of identifying key documentation that would be required in the near future and those which would be required in the longer term.

These are provided at Section 6.1.3.5 of the report.

6.1.2 Introduction

Neil Trainor opened the Working Group session welcoming participants, noting:

- The advent of MASS is progressing rapidly with many ‘test beds’ being conducted world-wide as demonstrated in Session 2 of the Workshop.
- Immense change on the horizon but maritime is not alone – lessons from rail, road and air as demonstrated in Session 3.
- Safety and efficiency is a primary concern for VTS and AtoN authorities and it will be necessary to achieve a balance in maintaining high safety standards as well as keeping up with rapid technological developments.
- The workshop is extremely timely and provides an opportunity for IALA and its Committees to collectively address challenges and to achieve alignment of standards for operating MASS globally.

Participants noted:

1. The focus on of the workshop is on the on-going developments within autonomous technologies that may have an impact on VTS and AtoN, including a range of topics, such as:
    - AtoN/VTS requirements;
    - AtoN/VTS operations;
    - Technologies, and
    - Regulations.

2. The Terms of Reference for WG1 for the Working Group. That is:

- *"Consider the gaps and themes that exist between the current marine aids to navigation (AtoN) (including physical AtoN and VTS) and near future MASS of all types and sizes that are still controlled by human, i.e. Degree 1, 2 and 3 IMO autonomous levels that were used for the Regulatory Scoping Exercise (RSE); ;*
- *Identify the impact and questions related to the marine AtoN (including physical AtoN and VTS);*
- *If possible, propose topics that may be considered in future IALA work programme for IALA Committee and other IALA bodies regarding the current and near future MASS with a possible road map; and*
- *Submit a report to plenary by Thursday 27 May 2021."*

3. The MASS related work currently on the Committee's 2018-2022 work programme (*C72-11.1.2 Committee Work Programme for 2018-2022*), including:

Table 1 - MASS related work currently on the Committee's 2018-2022 work programme

	Guidance being prepared	**Purpose**
VTS Committee	Guideline on Implications of Maritime Autonomous Surface Ships (MASS) from a VTS Perspective	To assist authorities interact with all ships and contribute to the safety and efficiency of ship movements in the VTS area, recognising: • The advent of MASS within VTS areas and their interaction with conventional ships. • The data and information exchange between MASS, conventional ships, VTS and allied services.
ARM Committee	Recommendation on Maritime Autonomous Surface Ships	RECOMMENDS National members and other appropriate Authorities providing marine aids to navigation services comply with this recommendation during trials, testing and implementation of AtoN, communications and monitoring systems to support MASS.
	Guideline on Developments in Maritime Autonomous Surface Ships	To provide guidance to IALA members and other stakeholders who may be undertaking testing and trials of MASS systems.

Participants also noted that both Committees intend to review their work programmes, taking into account the outcomes from this workshop.

4. The eight 'highlights' identified at the 14th IALA Symposium – 'Enhanced maritime Safety and Efficiency by Connectivity' (12-16 April 2016). That is:

   1. *VTS will be essential for digital information exchange and therefore central to the successful digital transformation within the maritime world.*
   2. *Maritime connectivity is paramount for progressing e-Navigation. It is time to settle on the standards for the first generation of a worldwide connectivity and data communication solution so industry can move forward with innovative solutions.*

3. *VDES R-Mode can act as terrestrial backup for GNSS by using time-synchronised ranging information. VDES also provides improved communication capabilities.*
4. *Advanced decision support systems will assist both VTS operators' and navigators' situational awareness, facilitate risk assessment, and improve the safety and efficiency of navigation.*
5. *The provision of S-100 digital maritime services is a key enabler for e-navigation. Global harmonization of standards is required for a successful implementation of the ambitious digital maritime agenda.*
6. *Successful VTS training is a crucial factor for delivering VTS in a professional and harmonized way. New skill sets for VTS personnel to meet changing demands will be essential and should be taken into account by relevant authorities.*
7. *VTS will be fundamental in implementing harmonized digital data to prepare for management of mixed traffic areas with both conventional and autonomous vessels.*
8. *Autonomous systems, driven by a business case with defined user needs and requirements, are becoming operational and stakeholders need to be prepared. Standardisation, harmonization and definition of responsibilities is required to guide current and future activities.*

Recommendations

That the report from the 14th IALA Symposium – 'Enhanced maritime Safety and Efficiency by Connectivity' be made available as soon as possible.

General discussion concluded that to complete its tasks as outlined in the ToR WG-1 should break into 2 Sub-Groups. That is:

- SG-1 VTS (Chair – Neil Trainor, Rapporteur – Kerrie Abercrombie)
- SG-2 AtoN (Chair - David Lewald, Rapporteur - W. Christian Adams)

6.1.3 Discussion

In opening session the Chair introduced the '*five thesis*' and '*seven ideas*' raised by Mathias Jonas, IHO Secretary-General, in his opening address at the recent IALA Symposium 2021. That is:

Five thesis on the quality and the state of being connected:

1. *Internet at sea will never be as stable as ashore. It remains a decentralized concept of local data replications at the vessel to give decision support.*
2. *For a number of reasons ... VTS will play an emerging role in remote decision support towards a model known from aviation in congested situations.*
3. *Broadband data exchange is also a gateway for manipulation of the critical technical components - data security and prevention of cyber threats is crucial.*
4. *Bridge equipment are often a collection of poorly integrated single devices delivered by different manufacturers and maintained with varying quality.*
5. *Higher integration and consistency of the on board navigation landscape is a precondition to elevate ship and shore interaction on the next level.*

Seven ideas to act:

1. *Mandatory regulations for software maintenance regime for navigation and utility equipment safeguarded by life-cycle contracts with OEMs.*

2. *Regulatory compliance through strict type approval procedures for on board navigation equipment including hardware and software maintenance.*
3. *Adoption of best practices of existing local solutions in collaborative VTS <-> Vessel traffic management global solutions.*
4. *Anticipation of the uptake of mixed traffic situations with autonomous shipping to enable VTS for their surveillance.*
5. *Global standardization of data model and distribution formats for dispatch of marine data.*
6. *Motivate national administrations, regional and international frameworks to set up harmonized baseline data provisions to feed next level marine services.*
7. *Development and application of strong data encryption technologies and other preventive measures against cyber threat according to international standards*

Items 1, 2, and 4 of the '*seven ideas*' were commented on as follows:

1. Mandatory regulations for software maintenance regime for navigation and utility equipment safeguarded by life-cycle contracts with OEMs.	• It is important that software maintenance regimes are in place for both on-board ships and the shore such as VTS and AtoN. • Participants raised concerns to who, and how this would be regulated.
2. Regulatory compliance through strict type approval procedures for on board navigation equipment including hardware and software maintenance.	• A balance needs to be achieved with regards to "strict type approval" as this often results in slow development/adoption of technologies. It is important that the performance specifications do not get drawn into the technical aspects of the technology. • It was agreed that the second idea should be rewritten to focus on both the shore and ship. The following revised text was proposed: *Regulatory compliance for vessel and associated shore based equipment through compliance with performance based specifications, appropriate ITU and IEC (and other) equipment standards along with strict software maintenance.*
4. Anticipation of the uptake of mixed traffic situations with autonomous shipping to enable VTS for their surveillance.	• This should be included as an assumption in identifying the implications of MASS. • An operational condition of MASS should be assessed prior to entering port through use of a systems status report which would include details on condition of hardware (navigational sensors, etc.) and software updates.

Recommendations

- Mandatory regulations for the software maintenance regime for navigation and utility equipment should be safeguarded by life-cycle contracts with OEMs.

- Regulatory compliance for vessel and associated shore-based equipment through compliance with performance based specifications, appropriate ITU and IEC (and other) equipment standards along with strict software maintenance.

6.1.3.1 Degree of MASS - A ‘common’ understanding’

To facilitate a common understanding, the degrees of MASS adopted by the Maritime Safety Committee to undertake the Regulatory Scoping Exercise (RSE) were reviewed as a means to ensure a common understanding between participants and identify and areas where clarification is required.

General consensus was:

- The degrees of MASS as defined in the RSE will evolve following completion of the RSE exercise and additional levels may be adopted, noting the levels being suggested by ISO, Sheridan and other industry initiatives.
- It should be recognised that many ships operating today in degree one.
- There are some ships operating in degree two and three, in particular non-SOLAS ships such as survey vessels.
- The outcomes and lessons learnt from test beds need to be documented/shared. Agencies conducting testbeds should be encouraged to engage VTS and AtoN providers during trials and evaluations to ensure the implications for VTS and AtoN are considered.

Assumption

- The degrees of MASS as defined in the RSE will evolve following completion of the RSE exercise and additional levels may be adopted, noting the levels being suggested by ISO, Sheridan and other industry initiatives.

Recommendations

- The outcomes and lessons learnt from test beds need to be documented/shared.
- Agencies conducting testbeds should be encouraged to engage VTS and AtoN providers during their trials and evaluations Agencies conducting testbeds should be encouraged to engage VTS and AtoN providers during trials and evaluations to ensure the implications for VTS and AtoN are considered.

Participants noted the work being undertaken by the VTS Committee TG-1.2.5 MASS with regards to the degree of MASS and assumptions, comments and implications. It was agreed that the working group should adopt the associated table as outlined below to facilitate a common understanding on the degrees of MASS and considering its implications.

Table 2 - Degrees of MASS and implications for VTS and AtoN

OVERALL ASSUMPTIONS
• MASS will be required to participate in VTS in the same manner as conventional ships. That is the same: o regulatory reporting requirements, and o obligations with regards to the issue of advice, warnings and instructions as deemed necessary. • MASS will be subject to COLREG, as amended. • MASS will be dependent on services such as GNSS and AtoN for navigation. • MASS will have sensors which can use and interpret current visual, sound and electronic AtoN signals. • MASS will require robust communication systems and those systems must have equally robust cyber security protocols. • MASS must be able to use traditional AtoN signals such as lights and colour to operate safely. • Secure and resilient communications will need to be developed to support MASS.

Degree of autonomy	Assumption/s	Comments / questions	Implications

Degree one
Ship 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.
	MASS of degree one is considered as a conventional ship with some additional functions to support human decision making.
	The specific automated process and decision support are not considered due to their diversities.
	Ship will most likely behave similar to conventional ships in port approach situations, forming bridge team for the approach instead of performing daily routine tasks.
	MASS of degree one are already operating throughout the world and are not necessarily SOLAS vessels.
		• Interaction between crew and DST?
		• How does the human remain in the loop?
		• Is there some automated information exchange?
		• IMO predicts a lack of available skilled crew in the near future?
		• It is recognized that navigation today utilizing ECDIS or ECS is heavily reliant on GNSS and the mariner uses traditional visual AtoN to verify the proper operation of these navigation systems. Removal of the on-board mariner from the navigation process will require introduction of additional digital (electronic) navigation capabilities in the form of sensors as well as GNSS/PNT redundancies. Additionally, a review of GNSS Standards should be undertaken to accommodate any new or additional requirements.
			• Minimal impact on VTS and AtoN
			  ○ There is a need to monitor advances in the automated process and decision support onboard
			  ○ Implications for crew / qualifications and training

Degree two Remotely controlled ship with seafarers on board: • The ship is controlled and operated from another location.	No matter if MASS can be operated from another location, seafarers on board are assumed to be able to meet all the operation and control requirements. Degree two status should be considered as potentially high risk:	• Interaction / connectivity between Crew and remote control centre? • (see above: technical, but also time difference, language barriers) • Interaction / connectivity between Crew and VTS?	• Communications and interaction with participating ships (Voice / data exchange). This may include communications between ships (MASS and Traditional). Considerations include:

Degree of autonomy	Assumption/s	Comments / questions	Implications
• Seafarers are available on board to take control and to operate the shipboard systems and functions.	1. Can be difficult for VTS to determine who's in control of the vessel (RCC or crew?). 2. There is an extra line of communication outside VTS (RCC <> crew). 3. Extra decision making entity (crew vs RCC). MASS of degree two are already operating throughout the world and are not necessarily SOLAS vessels.	• Is there also automated processes and decision support / how do these interact? • Interaction / connectivity between VTS and remote control centre? • On board responsibility for reporting? • On board responsibility for information, warning, advise and instruction? • Responsibility for ship/navigation? • Same level of situational awareness all parties? Shared mental model VTS / RCC / Crew? • Handover procedures RCC / crew? What are the critical elements in decision tree in order to instigate handover? Role VTS in case of developing scenario? Can VTS order handover procedure from RCC to crew on board? • Additional sensors and sensor capabilities will need to be introduced to on board navigation systems to utilise visual and electronic AtoN signals. • MASS will need to have the ability to correlate navigation information provided by visual/electronic AtoN signals. • MASS will need to be able to observe and report AtoN outages and discrepancies.	○ Interaction/management with 3 entities (VTS, Crew and RCC) ○ Who is control of ship (crew/RCC) ○ Comms between crew and RCC ○ Comms between VTS and crew/RCC ○ Who takes control in developing situation (crew/RCC) ○ Implications for developing situations ○ Processes/workload associated with translating digital exchange to voice at the VTS • Location of RCC • Is the VTS assumed to provide/broadcast a full digital traffic image to MASS • VTS training re MASS • Operational procedures between the VTS, RCC and crew on-board the ship.

Degree of autonomy	Assumption/s	Comments / questions	Implications

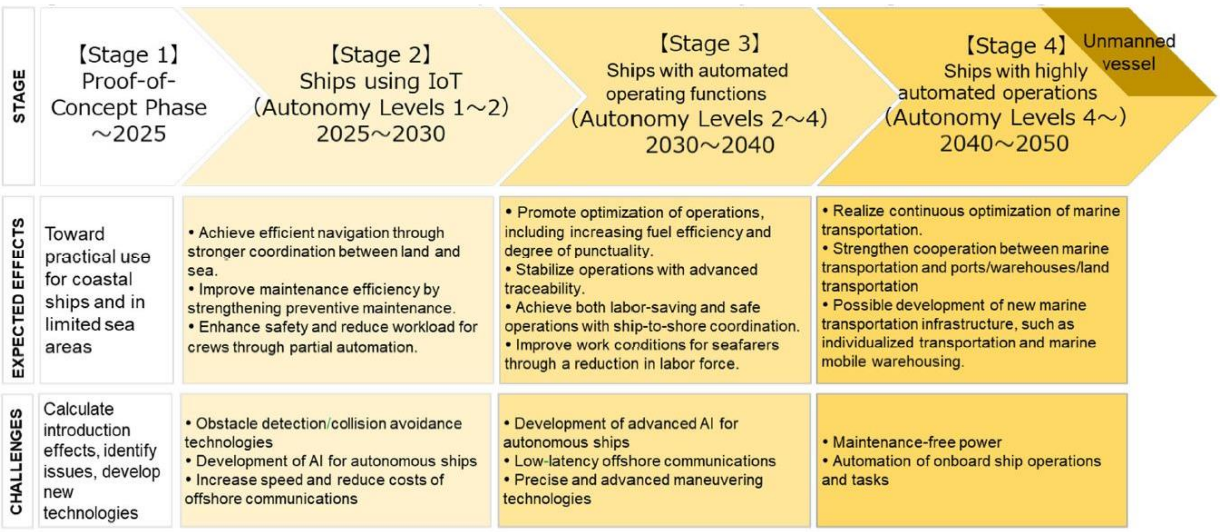
Degree three
Remotely controlled ship without seafarers on board:
• The ship is controlled and operated from another location.
• There are no seafarers on board.
	The ship is controlled and operated from another location with no seafarers on board.
	MASS of degree three are already operating throughout the world and are not necessarily SOLAS vessels.
		• Should MASS be subject to mandatory / recommendatory pilotage arrangements?
		• How is 'intent' information communicated (route, passing, etc)?
		• Interaction between ship and:
		  ○ Other ships?
		  ○ VTS?
		• Interaction between VTS remote control centre?
		• National laws considering pilotage? (digital pilot station?)
		• Assurance local knowledge RCC operator? (Manoeuvring and shiphandling in other traffic, wind, current, use of allied services?)
		• Is it feasible in this stage to develop from VTS centre to Local Port Control centre, in order to keep control on overall traffic (instead of having to deal on an operational level with a multitude of SCC's (or FCC's) located all over the world?)
		• Requirements for AtoN in degree two must be met before widespread proliferation of degree three.
			• As above, plus:
			• Managing interaction with multiple RCC's. For example:
			  ○ How a VTS interacts with ship traffic.
			  ○ How a VTS manages ship traffic (conventional ships and MASS).
			  ○ How a VTS monitors and responds to the development of unsafe situations.
			• Emerging situation where ship needs to be contained / controlled to mitigate incident (national gov't, VTS, other agencies)

Degree four Fully autonomous ship:	The operating system of the ship is able to make decisions and determine actions by itself.	• All of the above • Should VTS interact / respond to MASS differently with MASS?	**See report from WG2**

Degree of autonomy	Assumption/s	Comments / questions	Implications
• The operating system of the ship is able to make decisions and determine actions by itself. • There are no seafarers on board.		• How does the ship receive its instructions (route, etc)? • How does the ship receive its instructions plus instructions from VTS? • Sailing plan similar legal status as Flight plan. To be checked and approved by authority before sailing? • Interaction / connectivity to reach decisions and manage changes • Changing env. Conditions (e.g. high wind) and interaction/connectivity? • When / how to use allied services in relation with previous point? • Commonality between on-board and shore station software in decision making?	

6.1.3.2 Expected time frames for Degree 1, 2 and 3 ships to become operational

General discussion with regards to anticipated timeframes for the rollout of MASS highlighted there was little information available other than the suggested timeframe by MITSUI & Co. (Mitsui & Co. Global Strategic Studies Institute Monthly Report September 2019) as shown below.



Source: Compiled by MGSSI based on the Ministry of Land, Infrastructure, Transport and Tourism's report regarding initiatives to be pursued to promote the productivity revolution in the maritime industry (June 2018; follow up to a report issued on June 3, 2016).

Figure 2 - Overview of autonomous ship introduction and major technological challenges

6.1.3.3 VTS and MASS

Management of ship traffic in a VTS area

Participants noted the IMO regulatory regime for VTS in terms of capabilities, purpose and reporting requirements as shown below:

Table 3 - IMO regulatory regime for VTS in terms of capabilities, purpose and reporting requirements

<table>
<tr><td colspan="3">SOLAS Chapter V Regulation 12
VTS contribute to safety of life at sea, safety and efficiency of navigation and protection of the marine environment</td></tr>
<tr><td colspan="3">IMO Resolution for VTS</td></tr>
<tr><td>Capability</td><td></td><td>Purpose/Actions</td></tr>
<tr><td>• Interact with ship traffic
• Respond to developing situations within a VTS area</td><td></td><td>Mitigating the development of unsafe situations through:
• Provision of timely and relevant information on factors that may influence the ship's movements and assist onboard decision-making.
• Monitoring and management of ship traffic
• Responding to developing unsafe situations</td></tr>
<tr><td colspan="3">Information, Warning, Advice, and Instruction</td></tr>
</table>

SOLAS Chapter V Regulation 12		
VTS contribute to **safety of life at sea, safety** and **efficiency of navigation** and **protection of the marine environment**		
IMO Resolution for VTS		
Capability		**Purpose/Actions**
Participating Ships • Provide reports or information required by VTS • Take into account the information provided, or **advice** and **warnings** issued by VTS • Comply with the requirements and **instructions** given to the ship by VTS		

Participants considered how the VTS area would be viewed by a VTSO with the advent of MASS using the following example.

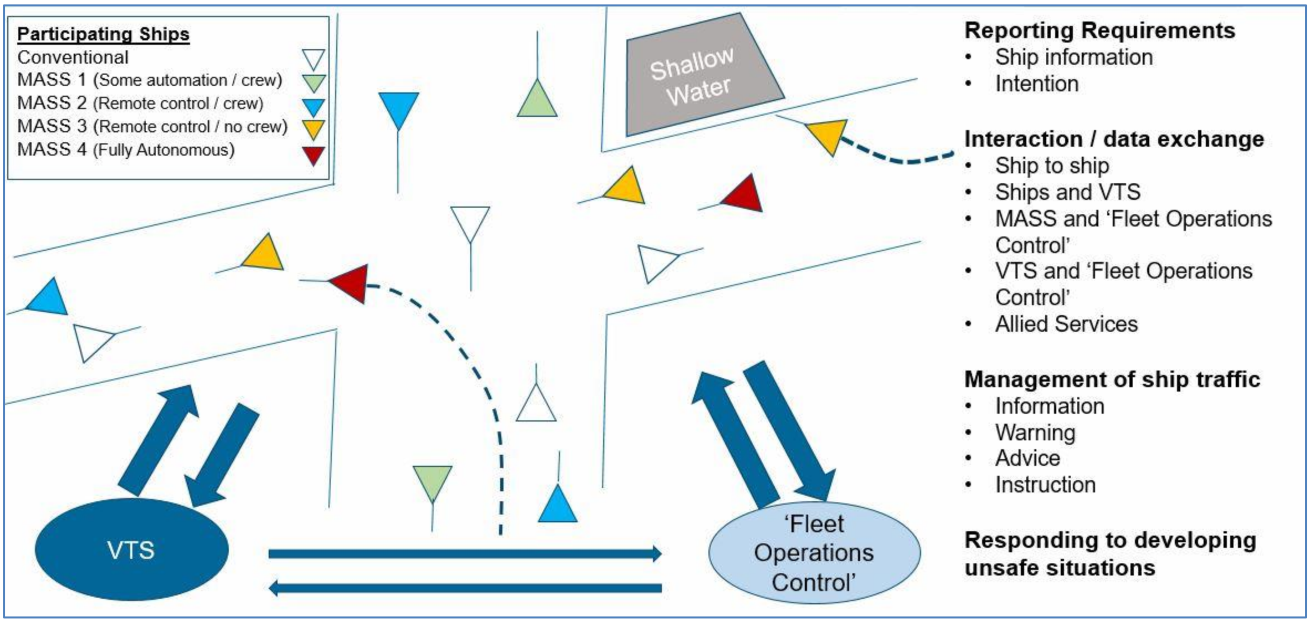


Figure 3 - View of the VTS area by the VTSO in a MASS environment

In considering the future scenario above consensus was that the key implication for the existing regulatory framework is how the VTS interacts/communicates with both conventional ships and MASS as shown below.

Table 4 - Key implication for the regulatory framework concerning VTS interaction with conventional ships and MASS

<table>
<tr><td colspan="3">SOLAS Chapter V Regulation 12
VTS contribute to safety of life at sea, safety and efficiency of navigation and protection of the marine environment</td></tr>
<tr><td colspan="3">IMO Resolution for VTS</td></tr>
<tr><td>Capability</td><td></td><td>Purpose/Actions</td></tr>
<tr><td>• Interact with ship traffic
• Respond to developing situations within a VTS area</td><td></td><td>Mitigating the development of unsafe situations through:
• Provision of timely and relevant information on factors that may influence the ship's movements and assist onboard decision-making.
• Monitoring and management of ship traffic
• Responding to developing unsafe situations</td></tr>
<tr><td colspan="3">Information, Warning, Advice, and Instruction</td></tr>
<tr><td><u>Conventional Ship</u>
(VHF Voice)</td><td></td><td><u>MASS</u>
(Digital interaction / data exchange)
• MASS-to-shore
• Remote Control Centre-to-shore
• Allied Services
• ???</td></tr>
<tr><td colspan="3">Participating Ships
• Provide reports or information required by VTS
• Take into account the information provided, or advice and warnings issued by VTS
• Comply with the requirements and instructions given to the ship by VTS</td></tr>
</table>

Key considerations for VTS for the advent of MASS include:

- How a VTS interacts with ship traffic.
- How a VTS manages ship traffic (conventional ships and MASS).
- How a VTS monitors and responds to the development of unsafe situations.

Data and information exchange will be a focal point for consideration. Similarly, all parties will need to be more engaged in developing the framework for MASS operations and the implications for the IMO regulatory regime and IALA standards.

General discussion also highlighted:

- A need for discussion to whether MASS should be treated differently to conventional ships in the VTS area. It was agreed that all participating ships should comply with the requirements of the VTS area both from a regulatory or safety perspective.

  It was noted that the IMO RSE is considering this. Specifically, it was recognised that all ships should be treated the same in interaction/communications.

- The same degree of safety should be maintained for MASS as for conventional ships. However consideration should be given to exploring opportunities to further enhance the degree of safety with MASS and RCC operations through, for example:
  - Communication between VTS and RCC;
  - Exchanging Traffic Image and other information which VTS centre to RCC has, and;
  - Obtaining route planning information from MASS or RCC.
- It is inevitable that communications between VTS and RCC will increase, leading to increased loads on existing bandwidth capabilities associated with the frequent exchange of information. While there is the opportunity to exchange more information between shore-to-shore, consideration will need to be given what information needs to be exchanged before new equipment is developed.
- Route exchange offers many benefits to VTS and allied services.
- VTS should have knowledge of which vessels are MASS, to facilitate managing traffic and respond to developing unsafe situations in the VTS area. It will be important for both VTS and other ships in the area to know the degree of MASS ship (eg crewed, uncrewed or fully autonomous). Further, the interaction with degree 2 and 3 ships it will be important to manage the interaction between crew and the remote control centre.
- There needs to be a greater education on the capabilities of MASS and the implications in interacting with MASS ships.
- There should be a requirement for MASS to communicate their degree particularly in emerging situations.
- Relevant authorities should set up national or regional/local rules and guidance for MASS in VTS areas, ports etc

Martijn Drenth informed participants on Remote Ship management which supports and operates autonomous vessels from a Remote Control Centre. Further information can be found at their website at https://seafar.eu/

Implications

- VTS Operations, that is:
  - How VTS receives, assimilates and processes data and information from MASS;
  - How VTS interacts with ship traffic (conventional ships and MASS);
  - How VTS manages ship traffic (conventional ships and MASS); and
  - How VTS responds to the development of unsafe situations (conventional ships and MASS).

- Communications and interaction
    - Data and information exchange
    - Knowing degree of MASS vessel important for the VTS / equally important for ships to know
    - Who does the VTS interact with and how they interact with the RCC?
    - Interaction with degree 2 and 3 – managing the interaction between crew and RCC
    - Need for MASS to communicate their degree (e.g. pre-entry report), particularly emerging situations

Recommendation

- Relevant authorities should set up national or regional/local rules and guidance for MASS in VTS areas, ports etc

Implications for IMO Regulatory Regime for VTS

General discussion highlighted the IMO regulatory regime does not appear to need any revision in the short to medium term in the advent of MASS.

Recommendation

That IALA liaise with agencies and organisations conducting testbeds with a view to incorporating the outcomes and lessons learnt from test beds in their evaluations and reports. Further, agencies conducting testbeds should be encouraged to engage VTS and AtoN providers during their trials and evaluations to ensure the implications for VTS and AtoN are considered.

6.1.3.4 AtoN and MASS

General discussion highlighted consideration should be given to:

- VTS to broadcasting their traffic image to MASS/RCCs.
- Continuing to provide AtoN services intended for human use.
- Standardising the exchange of data to utilizing the S-200 data modelling.
- Adding an AIS message on the degree of the MASS. For example, remote control with seafarer, fully remote control and full automation.

6.1.3.5 Implications for IALA Standards, Recommendations and Guidelines

With regard to VTS general discussion highlighted that:

- In the short term, focus should be on S1040 Vessel Traffic Services and S1070 Information Services.
- In the longer term, the focus should then shift to S1010 AtoN Planning and Service Requirements and S1050 - Training and Certification.

Key IALA documentation relating to VTS that should be reviewed/updated, noting the implications identified during the workshop include:

Table 5 - IALA documentation relating to VTS implicated on MASS

IALA Standard 1040 Vessel Traffic Services			
Scope	**Recommendation**	**Guideline**	**Priority Long term / Short term**
VTS implementation	Recommendation 0119 - The Implementation of Vessel Traffic Services	Guideline 1150 - Establishment of Vessel Traffic Services	**Long Term**
		Guideline 1071 - Establishment of a Vessel Traffic Service Beyond Territorial Seas	**Long Term**
		Guideline 1083 - Standard Nomenclature to Identify and Refer to VTS Centres	**Long Term**
		Guideline 1142 - The Provision of Local Services Other Than VTS	**Long Term**
VTS operations	Recommendation 0127 – VTS Operations	Guideline 1089 - Provision of a VTS	**Short term**
		Guideline 1141 - Operational Procedures for Vessel Traffic Services.	**Short term**
		Guideline 1110 - Use of Decision Support Tools for VTS Personnel.	**Short term**
		Guideline 1131 - Setting and Measuring VTS Objectives.	**Long Term**
		Guideline 1045 - Staffing Levels at VTS Centres.	**Long Term**
		Guideline 1118 - Marine casualty / incident reporting and recording, including near-miss situations as it relates to VTS.	**Long Term**
		Guideline 1144 - Promulgating the Requirements of a VTS to Mariners – A VTS Users Guide Template	**Long Term**
VTS data and information management	R0125 - The Use and Presentation of Symbology at a VTS Centre	N/A	**Short term**
	R1014 - Portrayal of VTS Information	Guideline 1105 - Shore-Side Portrayal Ensuring Harmonization with E-Navigation Related Information	**Short term**
VTS communications	Recommendation 1012 – VTS Communications	IALA Guideline 1132 VTS VHF Communications and Phraseology	**Short term**
VTS technologies	Recommendation 0128 - Operational and Technical	Guideline 1111 - Preparation of Operational and Technical	**Short term**

IALA Standard 1040 Vessel Traffic Services			
Scope	**Recommendation**	**Guideline**	**Priority Long term / Short term**
	Performance of VTS Systems	Performance Requirements for VTS Systems	
VTS auditing and assessing	Recommendation 1013 - Auditing and Assessing Vessel Traffic Services	Guideline 1101 - Auditing and Assessing VTS	**Long Term**
		Guideline 1115 - Preparing for an IMO Member State Audit Scheme (IMSAS)	**Long Term**

IALA Standard 1070 Information Services			
Scope	**Recommendation**	**Guideline**	
Data models and data encoding	Recommendation 0145 - The Inter-VTS Exchange Format (IVEF) Service	N/A	**Short term**

General discussion highlighted that consideration be given to adopting/expediting preparation of the following tasks within the IALA committees work programme:

- ARM Committee:
  - Research and develop as necessary guidelines on how to assess the degree of risk which the various degrees of MASS will introduce to a waterway.
  - Look for "low tech" solutions to provide enhanced visual AtoN signal to assist MASS (e.g., IR technologies.
  - Produce recommendations and guidelines as necessary to implement AtoN signals intended to support navigation of MASS.
- ENG Committee:
  - Research various low-cost technologies which can be used to support onboard navigation systems with proper recognition of visual and electronic AtoN signals.
- ENAV Committee:
  - Continue with research and development of communications systems used both ashore and on board to enhance safe operation of MASS.
- VTS Committee:
  - Guidance on MASS from a VTS perspective
  - Guidance for digital interaction / communications
  - Guidance on Maritime services
  - Work programme tasks highlighted as short term in the table above.

Recommendations

That IALA Secretariat is requested to liaise with IHO with regards to foreseeable changes to charting requirements to support MASS and if these changes will require action by IALA committees.

That the IALA Committees give consideration to adopting/expediting preparation of the following tasks within their work programmes:

- **ARM Committee**:
  - Research and develop as necessary guidelines on how to assess the degree of risk which the various degrees of MASS will introduce to a waterway.
  - Look for "low tech" solutions to provide enhanced visual AtoN signal to assist MASS (e.g., IR technologies.
  - Produce recommendations and guidelines as necessary to implement AtoN signals intended to support navigation of MASS.
- **ENG Committee**:
  - Research various low-cost technologies which can be used to support onboard navigation systems with proper recognition of visual and electronic AtoN signals.
- **ENAV Committee**:
  - Continue with research and development of communications systems used both ashore and on board to enhance safe operation of MASS.
- **VTS Committee**:
  - Guidance on MASS from a VTS perspective
  - Guidance for digital interaction / communications
  - Guidance on Maritime services

6.1.3.6 List of WG1 participants

Participant	Affiliation	Member Country	Sub-Group
Mr Neil TRAINOR	Australian Maritime Safety Authority	Australia	SG-1
Mrs Kerrie ABERCROMBIE	Australian Maritime Safety Authority	Australia	SG-1
Ms Karen DUNN	Canadian Coast Guard	Canada	SG-1
CDR James CRAWFORD	Armada de Chile, Dirección General del Territorio Marítimo y Marina Mercante - DIRECTEMAR	Chile	SG-1
Mrs Dorte HANSEN	Defence Command Denmark	Denmark	SG-1
Mr Jakob BANG	Danish Maritime Authority	Denmark	SG-2
Mr Tuomas MARTIKAINEN	Finnish Transport Infrastructure Agency	Finland	?
Mr Xavier HERNOË	Direction des Affaires Maritimes	France	SG-2
Mr Dirk ECKHOFF	Federal Waterways & Shipping Administration	Germany (VTS Vice chair)	SG-1
Mr Minsu JEON	IALA		SG-1 / SG-2

Participant	Affiliation	Member Country	Sub-Group
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Mr Hisayoshi FUKUI	Japan Coast Guard	Japan	SG-1
Mr Tomoya NAKAJIMA	Japan Coast Guard	Japan	
Mr Koji MURAI	TST Corporation -Tokyo University of Marine Science and Technology	Japan	
Mr Naoki SAITO	TST Corporation - ClassNK	Japan	
Mr Takuya FUKUDA	Tokyo Keiki Inc.	Japan	SG-1
Mr Martijn DRENTH	Dutch Pilots' Corporation	Netherlands	SG-1
Mr Jan Remi HOEVE	Ministry of Infrastructure and Water Management	Netherlands	SG-1
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Mr Peter EADE	Vissim AS	Norway	SG-1
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Mr Xiao FENG	China Maritime Safety Administration	People's Republic of China	SG-1
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Mr Sangwon PARK	Korea Maritime Institute	Republic of Korea	SG-1
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Capt Michael TRENT	Radio Technical Commision for Maritime Services	RTCM	SG-1
Mr Peter DOUGLAS	Northern Lighthouse Board	Scotland	SG-2
Mr Pieter-Chris BLOM	South African Maritime Safety Authority	South Africa	SG-2
Mr Carlos GARCIA DAROCA	ESSP SAS	Spain	SG-2
Mr Enrique Tortosa	Puertos del Estado	Spain	SG-1
Mr Herman DEL FRADE	E.P.E. Sociedad de Salvamento y Seguridad Maritima (SASEMAR)	Spain	
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Captain Phil DAY	Northern Lighthouse Board	UK (ARM Chair)	SG-1 / SG-2
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Mr, Darin MATHIS	US Coast Guard	USA	
Mr Dave LEWALD	US Coast Guard	USA (ARM Vice Chair)	SG-2

Participant	Affiliation	Member Country	Sub-Group
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Akihiko HORI	TST	Japan	
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6.2 Working group 2 – Impact on Future and Long Term Mass

6.2.1 Executive summary

Working Group 2: 'Impact on Future and Long Term MASS' was held from 25 to 27 May during the IALA workshop on Marine Aids to Navigation in the Autonomous World which was held from 24 to 28 May 2021. Working Group 2 was Chaired by Jillian Carson-Jackson.

The focus of Working Group 2 was the functionalities and technologies and related issues required for VTS and AtoNs to support the needs of vessels at IMO degree of autonomy levels three and four. Noting the focus on future and long-term aspects of MASS, the group did not address current IALA standards and tasks. Key activities of Working Group 2 included:

- Identification of key issues related to the elements of a 'trusted system' (using a mind map).
- Gap analysis of functionalities and technologies, related standards and approaches to address the potential requirements for VTS and AtoN to support MASS.
- Consideration of the use of Intelligent Adaptive Systems
- Consideration of parallels with the aero industry such as precision approaches.

Key findings of Working Group 2 included:

- Marine Aids to Navigation will be essential infrastructure on the all degrees of autonomy and will continue to support maritime together with sources of the positions, navigation and timeing. This may lead to the development of adaptive AtoNMASS will require a robust and resilient communication 'system of systems' to support the complex and vital communication needs of MASS, allowing communication between ships, remote control centres, VTS, AtoNs and any other elements that may be required in a MASS operating environment.
- The role of VTS is expected to evolve to meet the needs of future and long-term MASS. This may involve managing 'big data', interacting with MASS using digital means, with possible centralised and/or virtualised VTS 'centres' in the future.
- All developments in MASS must consider its interaction in a mixed maritime environment which includes both conventional vessels and MASS, and be fully compatible with both.
- Technology, the developments of the regulatory environment to support MASS as well as ethical / value expectations of society. This road map would be linked to MASS development, rather than set dates or time-lines.

It is essential that technologies are standardized, with a need to certify systems and ensure interoperability. This may include the potential requirement for a new 'classification society' for MASS with involvement from all international bodies representing both ship and shore requirements.

6.2.2 Introduction

Jillian Carson-Jackson opened the initial session of the working group (WG) and introduced Philip Lane as the rapporteur for the WG. Each participant then had a chance to introduce themselves, indicating their areas of interest in MASS, and the role of AtoN and VTS in the increasingly autonomous world.

The group noted the value of the excellent presentations, which provide value for the discussion with expertise provided from maritime, road and aviation. J Carson-Jackson drew the groups attention to the IALA workshop file share areas, walking the members through the access to the site, the file structure and the relevant documents in both the reference area and the folder for WG2.

6.2.2.1 Scope

The WG reviewed the terms of reference, noting the focus on the future and long-term MASS developments. The group agreed to address:

- The concepts of trusted services
- Gaps and potential issues
- Impact and questions related to AtoN and VTS
- Possible topics and possible road map

Noting the focus on future and long-term aspects of MASS, the group did not address current IALA standards and tasks.

In addition to full group discussions, the work process included breaking into two sub groups:

- Subgroup 1 – Autonomy and functionality / Gap analysis (led by Philip Lane)
- Subgroup 2 – Intelligent adaptive system (led by Kevin Heffner)

6.3 Discussions

During the discussions, the following key points were noted:

- Autonomous shipping will not operate on GNSS alone, but will require a secondary means for PNT. This could be a future generation of 'adaptive' AtoN.
- All operations in future will continue to work within a combined environment – crewed and autonomous vessels, small vessels and pleasure craft.
- The future and long-term road map for MASS should reflect the status of development of technology, the developments of the regulatory environment to support MASS as well as ethical / value expectations of society. This road map would be linked to MASS development, rather than set dates or time-lines.

- It is essential that technologies are standardized, with a need to certify systems and ensure interoperability. This may include the potential requirement for a new 'classification society' for MASS with involvement from all international bodies representing both ship and shore requirements.

The working group discussions focused on: A Systems Perspective; Implications of MASS – Future Vision; Provision of AtoN (including VTS) to support MASS.

6.3.1 Systems Perspective

Noting the concept of 'trust', as identified in Figure 4 -Figure 4, the WG discussed effective regulations, values and ethics, and robust technology.

It was initially suggested that we take a system perspective, an example given was an intelligent adaptive system which presents a user interface that adapts to the environment and the mission context, and which takes into account the human element.

Regarding the **regulatory environment**, it was noted that international regulations (UNCLOS/SOLAS), national and local (States/individual ports) all need to be considered.

Regarding **values and ethics**, it was suggested that there needs to be consideration of how the trust system overcomes bias that is known to be inadvertently built into some systems. Safety (collision avoidance) needs to be weighed against efficiency (JIT delivery/port efficiency).

Regarding **robust technology**, consideration needs to be given to making systems physically robust, including supporting infrastructure such as power supplies, and sustainability / environmental friendliness needs to be considered. Robustness should also include cyber resilience, blockchain may be a candidate technology. It was noted that the systems that IALA works with tend to be deterministic, will this need consideration in an autonomous shipping context?

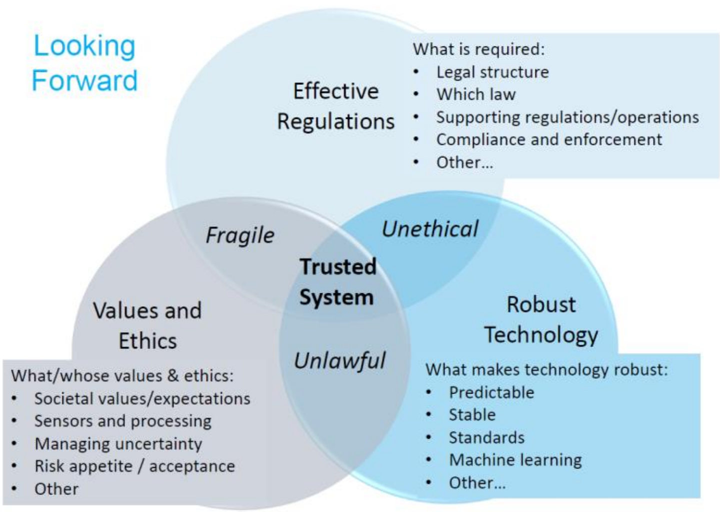

Figure 4 - Vision of 'trusted system' for MASS

Issues that cut across between regulation and technology is that trust needs to be established in both the operation of new systems and their interaction with existing systems, in this case, existing manned vessels interacting with autonomous vessels. The overall system needs to work for both ends of the spectrum.

There was a discussion on the cultural acceptance of autonomous systems. A number of questions were identified:

- Will people trust machines to do complex tasks?
- Will trust be built and reinforced over time?
- Can we ever build it to a point where the community will allow a machine to act by itself without oversight?

In considering this, the Group referred to the diagram shown in Figure 5 which was part of the presentation given by Yasuyuki Koga on 'National Initiatives for Implementing Automated Driving in Japan', and shows the progression through levels of autonomy and freedom of movement towards a fully automated society.

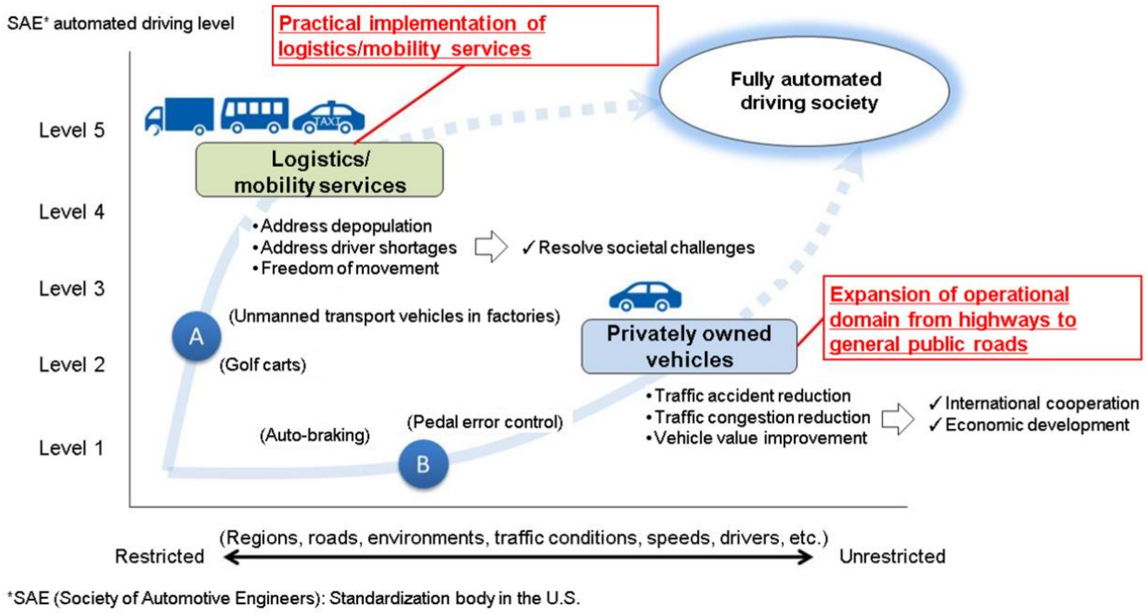

Figure 5 - Developments in automated driving

In addition, it was noted that users might trust autonomous systems more if they know that they meet stringent standards and are well regulated.

Leading on from this, a cross-cutting issue across all elements is system audits, these need to consider the regulatory environment, robustness of technology and values/ethics.

The outcomes of mind map exercises are provided in ANNEX D

6.3.2 Implications of MASS - future vision

Sub-group 1 led by Phil Lane

The tasks set for Breakout Group WG2-1 were:

- to start work on a gap analysis of the functionalities and technologies required for VTS and AtoNs to support the needs of vessels at IMO degree of autonomy levels three and four, and
- to consider whether the four degrees of autonomy were adequate, or whether more degrees might be required.

For VTS, key issues raised included the role of VTS in a MASS environment (rights, responsibilities, centralization, autonomy), how to manage communication between a ship, a remote control centre, and VTS, response to emergencies, the role of the pilot, interaction between MASS and conventional shipping, and Where will we get our harbour masters from when there are no mariners with experience of being at sea?

For AtoN, the group took the view that there will always be a role for AtoNs as a secondary means of navigation backing up GNSS. Robustness is key to this role, so there is a need for redundancy in supporting systems such as power supplies etc. The group considered physical AtoNs and the use of optics, will this need to be modified / augmented to meet the needs of MASS? and could there be a feedback look whereby MASS can provide information back to AtoN operators to verify that AtoNs are on station and operating correctly? AtoNs could take on additional roles, providing more information to vessels, they could be communications hubs for VDES, and provide met data, and provide a role in resilient PNT. The group considered multiple roles for virtual AtoNs, from quickly identifying new isolated danger areas to providing a full port to port virtual roadway.

Regarding the IMO degrees of autonomy, the group identified the need for a level between three and four for vessels that are autonomous for the majority of a passage but are controlled by an operator or pilot for certain parts of the voyage, such as berthing or port manoeuvres.

The current draft of the table created is provided below. It is noted that there is further work to be done to review and complete this table.

WG 2 focused on Degree 3 and Degree 4.

Table 6 - Degrees of MASS and implications for VTS and AtoN

Degree of autonomy	Assumptions	Functionalities / technologies required	What technologies / Standards are affected	Options to address (liaison, activities)
Degree one Ship 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.	MASS of degree one is considered as a conventional ship with some additional functions to support human decision making. The specific automated process and decision support are not considered due to their diversities.	**VTS**		
		AtoN		
Degree two Remotely controlled ship with seafarers on board: • The ship is controlled and operated from another location. • Seafarers are available on board to take control and to operate the shipboard systems and functions.	No matter if MASS can be operated from another location, seafarers on board are assumed to be able to meet all the operation and control requirements	**VTS**		
		AtoN		

Degree of autonomy	Assumptions	Functionalities / technologies required	What technologies / Standards are affected	Options to address (liaison, activities)
Degree three Remotely controlled ship without seafarers on board: • The ship is controlled and operated from another location. • There are no seafarers on board.	The ship is controlled and operated from another location with no seafarers on board.	**VTS**		
		(see also Degree three + four, below) -Management of multi-way communications requirements between ship, remote control centre and VTS. What protocols and communication channels will be required? -How do we identify and communicate the chain of command? who is in control at any point? -Should VTS have the ability to take control of a remotely controlled vessel in emergency situations or if contact has been lost by the remote control centre? -How is the handover between pilot and remote control centre managed? Pilot needs to be able to take control of any MASS independent of operator or service providers. Need a Standard pilotage control channel – usable worldwide, and very robust	*(see Degree three + four, below)*	*(see Degree three + four, below)*
		AtoN		
		(see also Degree three + four, below) -What is the role of optics for remotely controlled ships? e.g. need to be visible to remote OOW Remote operator could use visual indictors in the same way as today	*(see Degree three + four, below)*	*(see Degree three + four, below)*

Degree of autonomy	Assumptions	Functionalities / technologies required	What technologies / Standards are affected	Options to address (liaison, activities)
Degree four Fully autonomous ship: • The operating system of the ship is able to make decisions and determine actions by itself. • There are no seafarers on board.	The ship is controlled and operated with no seafarer interaction (completely autonomous)	**VTS**		
		(see also Degree three + four, below) -How will VTS communicate / interact with fully autonomous systems? -Does VTS have a role to take control of fully autonomous ships in emergencies? How would this be done? -What new commands or functionality might be required? E.g. dynamic positioning -Could VTS become a completely autonomous system, interacting with MASS as part of a 'system of systems, providing autonomous 'air traffic control', berth management port traffic etc.? -How will the handover between pilot and autonomous system be managed?	*(see Degree three + four, below)*	*(see Degree three + four, below)*
		AtoN		
		(see also Degree three + four, below) -AtoN management: MASS could provide autonomous user feedback that AtoNs are on station and working correctly. -Port to port navigation using virtual AtoNs (entire voyage)	*(see Degree three + four, below)*	*(see Degree three + four, below)*

		-Is there a role for optics for fully autonomous ships? Machine vision required, could additional information be embedded in the light characteristics with extra rich information – e.g. identity and location		
Degree three + four		**VTS**		
		-How will VTS communicate with MASS? (robust communications links and protocols will be required). -Monitoring MASS movements: a 'big data' operation? what is the role of VTS in this and what new infrastructure and systems will be needed? -Is there a need for 'air traffic control' style processing of route plans / pilotage plans providing a mutual picture for all stakeholders? -Is there a need for alarm management / prioritisation - What is the role of VTS in managing the interaction between MASS and conventional shipping? -Could VTS be centralised? (Medway port is an example/ model for the future) - Training and aptitude tests will be required for shore control operators,	There is a need for a resilient multi-way communication 'system of systems', which could include VHF, MF/HF, VDES, Satellite comms, Inmarsat FleetBroadband, VSATs, and IMT / 5G. A model for this system of systems could be the Worldwide Radionavigation System as defined in IMO Resolution A.1046(27), and the multi-system shipborne radionavigation receiver equipment defined in IMO Resolution MSC.401(95). Also resilient PNT is a model for this where multiple GNSS systems are employed. There are also parallels with signals of opportunity	Multiple stakeholders will need to be involved in the development of a communication 'system of systems', including: IMO, ITU, Inmarsat, VSAT operators, 3GPP, VDES operators etc. Also, we need to remember the work with ITU on IMT-2020 developments.

		-How do we ensure harmonisation of shore control training? -New processes, rules and regs need to be backwards compatible - IMO carriage requirements will need to allow for interaction with MASS by all shipping.	need commitment from service providers. Need to understand operational performance.	
		AtoN		
		-Role of AtoNs: a secondary means of navigation will always be required - What is the future role of physical AtoNs? Will they become more complicated than just visual lights? what additional features will they need to provide? what will be required on board to enhance understanding of environment that the vessel is in? -Should every physical buoy have AIS? -Physical AtoNs could have multiple roles, e.g. acting as communication hubs, e.g. relaying met. data, resilient PNT, relaying VDES or other communications infrastructure, 5G base stations? -How do we ensure the robustness of physical AtoNs providing these new roles? e.g. redundant power supplies etc. -What is the role of Racons for MASS? -Uses of virtual AtoNs: quickly identifying new danger areas, a 'roadway' around port, danger	Candidate technologies include : AIS, VDES Ranging mode ERPS, Earth observation, e.g. Copernicus Digital signatures (security of AtoNs) Access to AtoNs via mobile phone apps, eRacons, IMT / 5G AtoN may also require access to the communication 'system of systems' as set out above -Do we need new IALA standards for future AtoN or can we revise what we have?	Suggest consideration by the ENG committee – but will need liaison with users / IMO to develop requirements. -Need for new or revised IMO performance standards

		areas, and the coast, provision for potential loss of physical AtoNs, e.g. pre-hurricane. -Could virtual 'AtoN roadways' assist in the detection of divergence from planned routes? -How do we ensure the robustness of virtual AtoNs against cyber risks, errors etc.? How should they be managed? - Crew/operator training on the new modes of operation		

6.3.3 Provision of AtoN

Sub-group 2 led by Kevin Heffner

The sub-group noted the introduction of the concept of Intelligent Adaptive Systems, as provided in a presentation from K Heffner (Figure 6). The differences between an Intelligent System and an Intelligent Adaptive System were noted. The key differences related to the operators state and the introduction of an adaptation engine, working to manage the human-machine partnership.

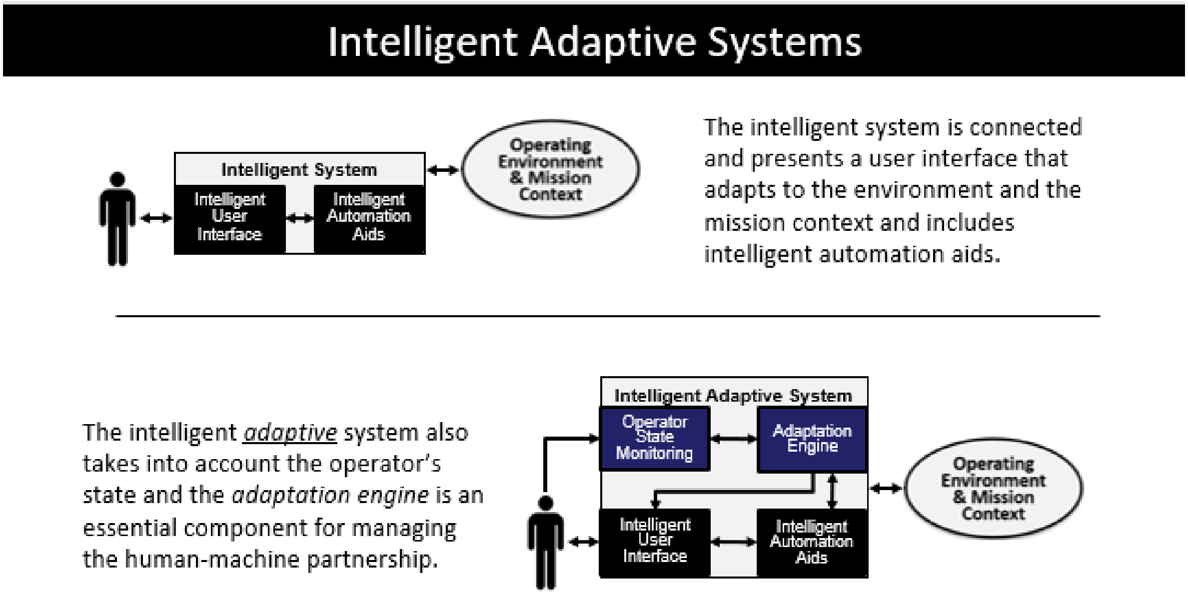

Figure 6 - Intelligent Adaptive Systems

The sub group then reviewed the outcomes of the IALA ENAV27 meeting, the draft IALA Guideline on developments in maritime autonomous surface ships, with specific reference to the provision of terrestrial AtoN in the aerospace environment.

Tasks of sub-group 2-2:

- Consider Intelligent Adaptive Systems
- Consider digital maturity / possible categories of systems

Key points from the discussions of sub-group 2-2:

- Technology versus procedures and regulation
- Big challenge – digital information sharing
- Port / VTS / Pilot / Tug interactions and operations
- Requirements for AtoN

The draft of the table created is provided below. It is noted that there is further work to be done to review.

MASS be required to participate in VTS and use AtoN. What will be required from VTS and AtoN to accommodate the both conventional ships and MASS.

Comments:

The role of the intelligent adaptive system – what is it in the maritime context; how does it apply to AtoN and VTS? What is the level of digital maturity of the port to provide AtoN and VTS to vessels with different levels of autonomy / autonomous systems?

Work based on the ENAV27 – Draft MASS Guideline: *The avionic domain has a various categories for types of airports. It appears that a similar system can be used for AtoN in the various maritime environments.*

Table 7 - Aviation categories for types of airports and similarity to AtoN in the various maritime environments.

Aviation Environment		Maritime Environment	
Level	**Description**	**Level**	**Description**
Non- precision Approach Runway	An instrument runway served by visual aids and nonvisual aid providing at least directional guidance adequate for a straight-in approach	1. Vessel provides vessel traffic management authorities with advanced notice (e.g., 3, 6, 24 hours) prior to arrival in controlled traffic management zone.	Advanced notice – Cargo, manifest, identification, typically using AIS. Port operations and pilot services are derived from AIS. Do we need an **enriched AIS** for Autonomous Vessels ? Autonomous vessels need to receive information about the regional requirements for precision navigation and maritime domain awareness, e.g., • How will the shores know where the vessels are ? What are the procedures that will define the trigger points and the decision trees ?
Precision Approach Runway, CAT I	A precision instrument approach and landing with a decision height not lower than 200 feet (60 meters) and with either a visibility of not less than 800 meters or a Runway Visual Range of not less than 550 meters	2. Entering controlled traffic management zone.	This level does not currently use technology. Uses mostly visual cues, such as radar. No specific AtoN is required. In future, visual cues need to be communicated to vessel using digital information format (so it can be ingested by machine system).
Precision Approach Runway, CAT II	A precision instrument approach and landing with a decision height lower than 200 feet (60 meters) but not lower than 100 feet (30 meters) and a Runway Visual Range of not less than 350 meters	3. Entering VTS AOR. Passing reporting points.	Contact with VTS authority. Currently AtoN (e.g. Sea buoy) might mark entrance to port, waterway. In future, AtoN may need to package and publish its information for use by machine.

Aviation Environment		Maritime Environment	
Level	**Description**	**Level**	**Description**
			Reporting points at pre-determined locations, e.g. digital charts. In future could be electronically triggered, in accordance with regional procedures and reporting requirements. Autonomous vessel needs to know the reporting requirements and other procedures. It needs to receive information from local jurisdictions, (see level 1).
Precision Approach Runway, CAT IIIA	A precision instrument approach and landing with a decision height lower than 100 feet (30 meters) or no decision height, and a Runway Visual Range of not less than 200 meters	4. Slotted berthing times for maritime approaches are allocated. Currently, first-come first-serve is de facto mode. Future might need to have a more organized approach. Ports that do not have VTS available or other services may move responsibility to pilots. Use of tugs may be required. For autonomous vessels.	This includes minimal time and physical distances. Autonomous vessel may provide information to ports concerning vessel state. Underkeel clearance requirements and port may use information concerning sea state, weather conditions to determine optimal and fair berthing times. Future electronic information exchange could include this type of information. AIS messages currently sent to ports. Future AIS messages may provide more information. Future VTS may need to contribute to Traffic Separation Scheme determined by VTS with closer coordination with ports, i.e., that includes automated information exchanges.

<table>
<tr><th colspan="2">Aviation Environment</th><th colspan="2">Maritime Environment</th></tr>
<tr><th>Level</th><th>Description</th><th>Level</th><th>Description</th></tr>
<tr><td>Precision Approach Runway, CAT IIIB</td><td>A precision instrument approach and landing with a decision height lower than 50 feet (15 meters) or no decision height, and a Runway Visual Range of less than 200 meters but not less than 50 meters</td><td>5. Automated Berthing. Smart Berthing.</td><td>Could Utilize Digital Twin of Port and Ship and waterway.
LiDAR etc. requirements for redundant and complementary radars and other sensors.
Port AtoN.
Underkeel Clearance. Requires draft to calculate the clearance accurately.
Which ports are capable of receiving autonomous ships ?

E.g. Port digital maturity level</td></tr>
<tr><td>Precision Approach Runway, CAT IIIC</td><td>A precision instrument approach and landing with no decision height and no Runway Visual Range limitations</td><td></td><td></td></tr>
</table>

6.3.4 Recommendations

Working Group 2 suggests that the following elements should be considered in IALA's roadmap towards supporting future and long term MASS:

- Continue work the work started at this workshop on a gap analysis to consider the functionality and technologies that will be needed by AtoNs and VTS to support MASS in the long term.
- Undertake a scoping exercise to determine the work required on IALA's standards, recommendations to support the required developments in VTS and AtoNs that will be needed to support MASS.
- Consider what external technical standards, recommendations etc. that are outside of IALA's direct control will need to be developed or revised to support the required developments in VTS and AtoNs that will be needed to support MASS.
- Consider which external bodies IALA will need to liaise with to further the work identified above, and the scope of the cooperation required.
- Identify a new 'classification society' for MASS with involvement from all international bodies, representing both ship and shore requirements. It may be suitable for this to be organised by IACS to provide one forum for key stakeholder organisations including IALA, IMO, ITU etc. The aim would be to develop and implement the new required infrastructure and technical capability.

Noting the proposed elements of the roadmap identified above, it is suggested that the work at IALA should aim to stay in step with the wider developments in MASS, recognising the key themes of legislative framework, robust technology and values, ethics and societal expectations.

IALA's work on supporting developments in MASS should keep in mind the guiding principle of 'trusted systems' which are based on effective regulation, robust technology, and values and ethics.

It is suggested that IALA develops position/vision paper to capture IALA's view of the technical, infrastructure, regulatory and social/ethical considerations for future MASS, and its interaction in a mixed maritime environment which includes both conventional and MASS vessels.

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7. CLOSING SESSIONS

The chair of the workshop informed that due to the limitation of time, the draft report was not available on the file share at this point but would be available after the closing session. Consequently the comment to the draft report would be accepted one week from the draft report was posted on the file share. The workshop reviewed the draft report displayed on screen and there were two comments regarding the highlights of the executive summary made from the participants. The chair accepted the comments and the draft report would be modified accordingly. After the review the chair thanked the working group chairs, the sub-group chairs, the secretariat and the all participants for their work and contribution to the workshop. The chair also thanked the all presenters, especially those who were not IALA members even not working in the maritime field for kindly accepting the invitation and providing their specialty to the workshop. Then the chair invited the Secretary General to give the closing remarks.

The Secretary General thanked the all participants for their contribution, especially the workshop chair, working group chairs and sub-group chairs for their hard work. The Secretary General also expressed his appreciation to the presenters for their valuable presentations. The Secretary General mentioned that the discussion and consideration on autonomous ships was just started by some of the technical committees at the last session and would be started soon by the remaining committees at the next session so the result of this workshop would become very beneficial to the work of IALA. Finally the Secretary General again thanked and congratulated the participants for the success of the workshop.

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ANNEX B PROGRAMME FOR THE WEEK

KICK-OFF – Thursday, 20th May 2021

Time (UTC)	Activity	
1000 – 1100	**Session 0 – Workshop kick-off**	**Chair: Hideki Noguchi**
5 min	Welcome	Hideki Noguchi
15 min	Working programme of the week and expectations	Hideki Noguchi
15 min	Presentation of input papers	Hideki Noguchi
15 min	Working arrangements for the week	Jaime Alvarez
10 min	Q&A	

DAY 1 – Monday, 24th May 2021

Time (UTC)	Activity	
1000 – 1130	**Session 1 – Opening of the Workshop**	**Chair: Hideki Noguchi**
5 min	Welcome from IALA	SG / DSG
10 min	Recalling working programme of the week & expectations	Hideki Noguchi
15 min	General view on MASS development	Minsu Jeon
15 min	Outcome of IMO MASS RSE	Henrik Tunfors
15 min	MASS Terminologies	Jillian Carson-Jackson
15 min	MASS business case	Ann Till
15 min	Q&A	
1130 – 1145	Break	
1145 – 1300	**Session 2 – MASS testbeds**	**Chair: Netherland: Maarten Berrevoets**
15 min	Testbed Norway	Ørnulf Jan Rødseth
15 min	Testbed Finland	Anne Miettinen
15 min	Testbed Japan	Captain Satoru Kuwahara
15 min	Testbed Singapore	Captain Segar
15 min	Q&A	

DAY 2 – Tuesday, 25th May 2021

Time (UTC)	Activity	
1000 – 1115	**Session 3 - Autonomous technologies (Industrials/other transport sectors)**	**Chair: R. David Lewald**
15 min	Autonomous technology for road	Yasuyuki Koga
15 min	Autonomous technology for aviation	Manuel Santos
15 min	Autonomous technology Aviation and maritime	Ifor Bielecki
15 min	Managing and adapting new technologies	Kevin Heffner
15 min	Q&A and establishment of WG	
1130 – 1145	Break	
1145 – 1300	**WG Session – IALA Guidance and roadmap**	**Chair: Jillian Carson-Jackson**
	Split into working groups: • WG1 Impact of present and near future MASS • WG2 Impact of future MASS	Chair WG1: Neil Trainor Chair WG2: Jillian Carson-Jackson

DAY 3 – Wednesday, 26th May 2021

Time (UTC)	Activity	
1000 – 1055	**WG session**	
1055 – 1105	Break	
1105 – 1200	**WG session**	
1200 – 1210	Break	
1210 – 1300	**WG session**	

DAY 4 – Thursday, 27th May 2021

Time (UTC)	Topics	
1000 - 1115	WG session	
1115 – 1130	Break	
1130 - 1200	Session 4 – Report of WG	Chair: Hideki Noguchi
15 min	WG1 report	Neil Trainor
15 min	WG2 report	Jillian Carson-Jackson

DAY 5 – Friday, 28st May 2021

Time (UTC)	Activity	
1000 – 1100	Session 5 – Documentation review and closing	Chair: Hideki
50 min	Review findings and draft report	Hideki
5 min	Closing of the workshop	SG/DSG
5 min	Closing of the workshop	Hideki

ANNEX C TERMS OF REFERENCE OF THE WORKING GROUPS

WG1 - Impact of present and near future MASS

Based on the presentations, comments and questions made at the plenary, WG1 is instructed to;

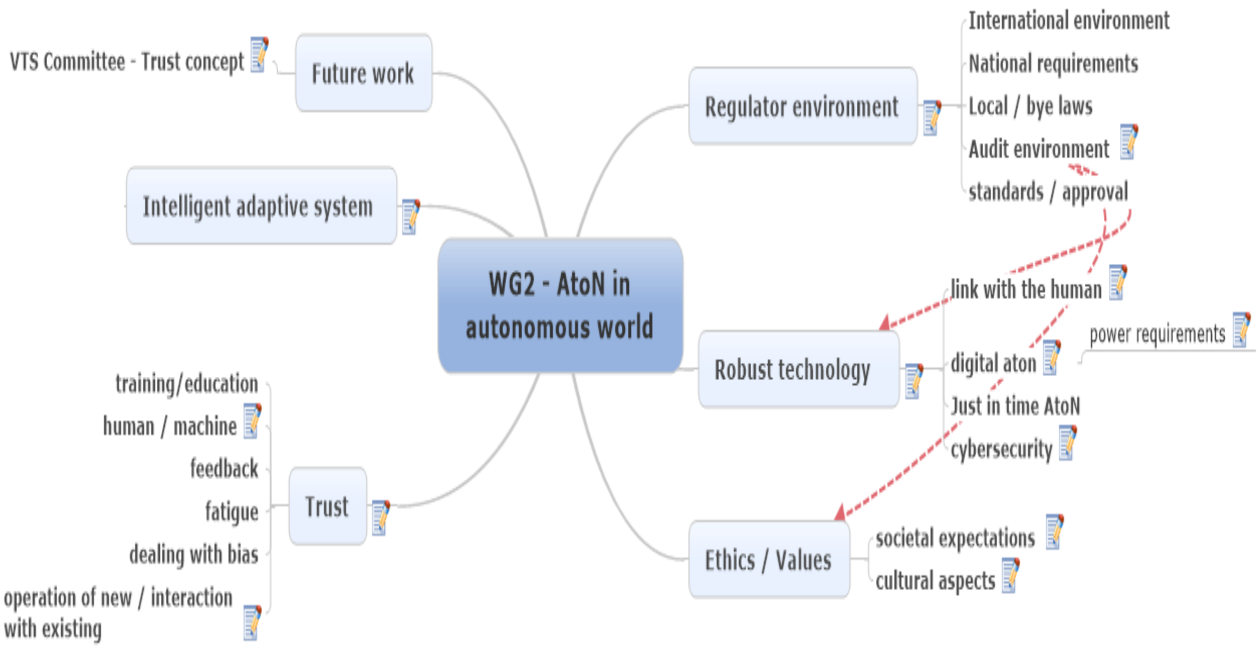
- consider the gaps and themes that exist between the current marine aids to navigation (AtoN) (including physical AtoN and VTS) and near future MASS of all types and sizes that are still controlled by human, i.e. Degrees 1, 2 and 3 IMO autonomous levels that were used for the Regulatory Scoping Exercise (RSE);
- identify the impact and questions related to the marine AtoN (including physical AtoN and VTS);
- if possible, propose topics that may be considered in future IALA work programme for IALA Committees and other IALA bodies regarding the current and near future MASS with a possible road map; and
- submit a report to plenary by Thursday 27 May 2021.

WG 2 – Impact on future and long term MASS

Based on the presentations, comments and questions made at the plenary, WG2 is instructed to;

- consider the gaps and themes that exist between the current and future marine AtoN (including physical AtoN and VTS) and the future MASS of all types and sizes including i.e.. Degree 3 and 4 IMO autonomous levels that were used for the RSE;
- identify the impact and questions related to the marine AtoN (including physical AtoN and VTS);
- if possible, propose topics that may be considered in future IALA work programme for IALA Committees and other IALA bodies regarding the future and long term MASS with a possible road map; and
- submit a report to plenary by Thursday 27 May 2021.

ANNEX D THE ELEMENTS OF A 'TRUSTED SYSTEM'



1 Regulatory environment

Under regulatory environment: international (UNCLOS/SOLAS) vs national vs local (States/individual ports

1.1 International environment

1.2 National requirements

1.3 Local / bye laws

1.4 Audit environment

See also: Robust technology , Ethics / Values

cover all three regimes

1.5 standards / approval

2 Robust technology

- Many systems IALA works with are deterministic
- Looking at future - just in time AtoN system, AtoN available as vessels transit
- linking to geofencing / provision of to services

2.1 link with the human

- robust human/machine interfaces
- Trusted human/machine interfaces

2.2 digital aton

- digital services must be reliable
- power is critical
- need to provide power, but environmentally friendly power

2.2.1 power requirements

- robust
- redundant / back up

2.3 Just in time AtoN

2.4 cybersecurity

- cyber attacks
- spoofing
- Different technologies

3 **Ethics / Values**

3.1 societal expectations

i.e. do we want to fly in an airplane without a captain?

do we trust to have vessels in busy channels without crew?

- Society trust that a system will work (reliability)
- Change in trust due to other perspectives

3.2 cultural aspects

- global environment, different cultural expectations

4 **Trust**

- Dynamic environment
- collaboration
- focus on the system perspective

<u>Concept of trust changes:</u>

- Dispositional trust
- Situational trust

As the human uses the system, the confidence in the system changes.

What happens to the human before entering the interaction / what happens after that interaction.

4.1 training/education

4.2 human / machine

- Machine and human working together
- Different systems
    - VTS
    - Ship

ANNEX E ABBREVIATIONS

ADS-B	Automatic Dependent Surveillance Broadcast
AI	Artificial Intelligence
AIS	Automatic Identification System
ANN	Artificial Neural Network
AtoN	Aids to Navigation
ATC	Air Traffic Control
ATTOL	Autonomous Taxiing, Take-Off and Landing
CPDLC	Controller Pilot Datalink
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
DME	Distance Measuring Equipment
DP	Dinamic positioning
EGNOS	European Geostationary Navigation Overlay Service
EICAS	Engine Instrument and Crew Alerting
GNSS	Global Navigation Satellite System
IACS	International Association of Classification Societies
IALA	International Association of marine Aids to Navigation and Lighthouse Authorities
IEC	International Electrotechnical Commission
IFP	Instrument Flight Procedures
IGO	Intergovernmental Organization
IHO	International Hydrographic Organization
ILS	Instrument Landing System
IMO	International Maritime Organization
INAS	International Network for Autonomous Ships
IoT	Internet of Things
ITS	Intelligent Transport Systems
ITU	International Telecommunication Union
ISO	International Organization for Standardisation
MASS	Maritime Autonomous Surface Ship
ML	Machine Learning
MSC	Maritime Safety Committee
ODD	Operational Design Domain
OEM	Original Equipment Manufacturers
OEP	Original Equipment Parts
PAP	Policy Advisory Panel
PBN	Performance Based Navigation
PNT	Positioning, Navigation and Timing
NFAS	Norwegian Forum for Autonomous Ships
NGO	Non-governmental organisation
RCC	Remote Control Centre (in MASS context) / Rescue Control Centre (in maritime context)
RSE	Regulatory Scoping Exercise
SESAR	Single European Sky ATM Research

VDES	VHF Data Exchange System
VDL	VHF Data/Digital Link
VTS	Vessel Traffic Services
VTSO	Vessel Traffic Services Operator