IALA Workshop Digital maritime communications

WORKSHOP REPORT

20 to 24 February 2023

Etchujima Campus of the Tokyo University of Marine Science and Technologies - Tokyo, Japan

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24 February 2023

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International Association of Marine Aids to Navigation and Lighthouse Authorities
Association Internationale de Signalisation Maritime

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Report of the IALA workshop on Digital maritime communication

Executive Summary

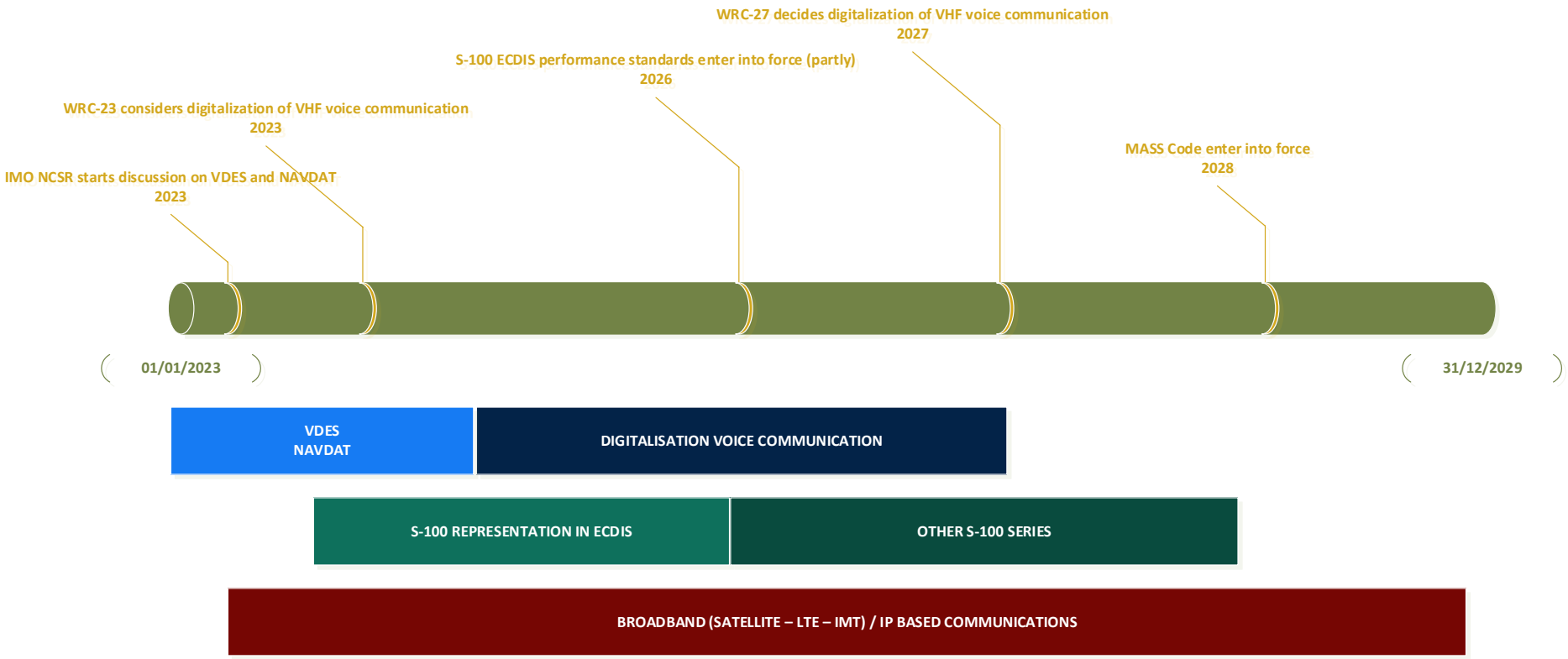
The IALA workshop on Digital maritime communication was held between the 20 and 24 February 2023 at Etchujima Campus of the Tokyo University of Marine Science and Technologies, Japan.

The workshop was very well attended with 97 participants from 20 countries.

The workshop participants considered the various presentations that were given, and the work conducted in the WGs and it was concluded that:

- Considering IALA's expanding role as a technical authority on digital communications:
    - IALA should incorporate the availability, reliability, quality and integrity of communication systems into the general provision of Marine AtoN Services based upon the volume of traffic and degree of risk.
    - The leadership provided by IALA related to Maritime Services (MS) and digitalisation of maritime communication is evolving to support services not limited to IALA remit.

- IALA should encourage members to consider the roles, responsibilities, and potential overlap of responsibilities within their own national organization for the provision of Marine AtoN, Maritime Safety Information (MSI), and related services to address the requirements of Digital Maritime Communication (MARCOM) for the purpose of establishing a cohesive harmonized delivery scheme.
- IALA should recognize that a shift in vessel management philosophy of shipping companies is evolving from the sole responsibility of a vessel's Captain and crew to a shoreside management paradigm. Furthermore, it should be noted that this philosophy is not exclusive to MASS operations.
- Digitalization of the provision of Marine AtoN services brings cybersecurity risk which must be mitigated. Unencrypted communications have additional cybersecurity risks that must be managed. It is therefore imperative that IALA develop recommendations and guidelines to support the use of secure Digital Maritime Communication services. "Always secure unless technically impossible or undesirable".
- IALA should recognize the benefits of Digital Maritime Communications and the potential relationship of UN Sustainable Development Goals (SDGs) to include decarbonization.
- IALA should continue to contribute with expertise to IMO, ITU, IHO and other bodies to ensure harmonization, standardization and interoperability relating to Marine AtoN, including VTS.
- The benefit of digitalisation of VHF voice communication is the increased efficiency within the finite maritime mobile band. Digitalisation must ensure similar or better quality and intelligibility than that of analogue. Equipment must support backward compatibility should be accounted for, as there will be a long transition time.
- Infrastructure both aboard and ashore should support Quality of Service to accommodate different and simultaneous communication over the same link. It is recommended that guidance is developed by relevant bodies, in cooperation with IALA, to incorporate these technologies in solutions for vessels and shore authorities.
- The following roadmap was agreed:


WRC-27 decides digitalization of VHF voice communication
2027
S-100 ECDIS performance standards enter into force (partly)
2026
WRC-23 considers digitalization of VHF voice communication
2023
MASS Code enter into force
2028
IMO NCSR starts discussion on VDES and NAVDAT
2023
01/01/2023
31/12/2029
VDES
NAVDAT
DIGITALISATION VOICE COMMUNICATION
S-100 REPRESENTATION IN ECDIS
OTHER S-100 SERIES
BROADBAND (SATELLITE – LTE – IMT) / IP BASED COMMUNICATIONS

Contents

Report of the joint IALA/IHO workshop on S-100/200 development and portrayal

1. INTRODUCTION

The IALA workshop on Digital maritime communication was held between the 20 and 24 February 2023 at Etchujima Campus of the Tokyo University of Marine Science and Technologies, Japan.

97 participants from 20 countries participated in the Workshop plus 4 members of the IALA secretariat.

Workshop participants were provided with the details of the file sharing system which will be available for the exchange of documents, presentations and photographs.

2. SESSION 1 – OPENING OF THE WORKSHOP

This session was chaired by Hideki Noguchi, Chair of the Workshop.

2.1 Welcome from JCG, Rear Admiral Tsuguo Awai and IALA Council Member

Tsuguo Awai, Rear Admiral of the Japan Coast Guard and IALA Councillor welcomed participants on behalf of the JCG to Tokyo.

On behalf of the Japan Coast Guard, Rear Admiral Tsuguo Awai extended a warm welcome to Sec. Gen. Francis Zagarie, and other staff members of the Secretariat and to the experts from around the world who were participating in the Workshop on Maritime Digital Communication co-hosted by IALA and JCG. Tsuguo Awai thanked Captain Segal, IALA Councillor for Singapore, and Maarten Berrevoets, IALA Councillor for the Netherlands, for taking time out of their busy schedules to visit Japan for the workshop. Tsuguo Awai was very pleased to find many familiar faces in Tokyo. Tsuguo Awai also thanked everyone involved at the Tokyo University of Marine Science and Technology for providing an excellent location for the workshop. Vice President Professor Shoji, accepted to moderate the panel discussion on day one, and has provided support for the technical tour. Tsuguo Awai recognised his deepest appreciation for the full support provided for the Workshop by the University. The GMDSS has been in place since the late 1980s, when Tsuguo Awai worked at IMO Secretariat, and the term "digital technology enabled" was used in the GMDSS, but there was no Internet, no cell phones, no cloud services, not even a Windows OS at that time. The only satellite communication system available at sea was Inmarsat, and the meaning of the term "digital communication" has completely changed between then and now. Now, all the IT infrastructure on the shore-side is about to extend out to the maritime domain, and the satellite constellation is about to cover the entire globe. In light of these dramatic changes in the communications environment over the past 30 years, the JCG is very excited, and believes that everyone in attendance is as well, that a true "digitalization of maritime communications" is underway. The program was lined with excellent presentations by prominent experts in their fields, and the JCG were very much looking forward to listening to what they have to say and what kind of discussions will take place. Finally, Tsuguo Awai, Hideki Noguchi, the chairperson of the IALA E-NAV Committee, and the JCG staff expressed their fully support to the event to ensure its success and a pleasant stay for all participants, and Tsuguo Awai also appreciated participant's cooperation in this endeavour.

2.2 Welcome from IALA, Francis Zachariae – IALA Secretary-General

Secretary General Francis Zachariae welcomed participants on behalf of IALA to the workshop on Digital Maritime Communications. Sec. Gen expressed his gratitude to see the large number of participants.

Francis Zachariae thanked the host Japan Coast Guard – Rear Admiral Awai and Hideki Noguchi and the Team for the hospitality and all the work that went into organizing the event. Francis Zachariae recognised the fact that Hideki Noguchi is considered a truly a frontrunner in IALA and is showing the way with dedication, skills and friendly, diplomatic leadership. Francis Zachariae highlighted the long term dedication of Hideki Noguchi and expressed on behalf of IALA the gratitude for his contribution and inspiration.

Francis Zachariae recognized that Digitalization is everywhere. It was almost impossible to enter Japan without a smartphone, scanning of QR codes etc. Francis Zachariae recalled a Council workshop some years ago to establish the most important work items for IALA for the future, digitalization came in as a clear winner. Just digitalization, nothing about what should be digitalized, how and when.

Francis Zachariae noted that there is no doubt that digitalization has brought many good things and made many transactions and operations much more efficient and safer. Think about how payments are currently made across the globe, booking tickets, buying stuff on the internet etc. But it has also brought new risks and crime that should be considered.

It was recognized that communication in all its forms is key to success. In business, projects, teamwork and relationships. Without communication nothing can work. Communication was key during the pandemic, and several lessons learnt were identified. Communications need to be fast, reliable and trustworthy.

Considerations should be given also for the maritime sector when talking about digital communications. Francis Zachariae again expressed that shipping is driven by business case and regulation - and behind all digital initiatives there should be a good business case and it should solve problems for the user.

Francis Zachariae expressed his deep appreciation to the many experts from around the world for participating and preparing the briefings.

IALA will of course continue to be the framework for discussions of matters that were raised during the week and IALA also created smaller technical groups linked with the current workshop which consider different aims and purposes (MCC, VDES Alliance, Open Digital Incubator etc.) and all of this will be inputs to the committees during the next work program 2023 to 27.

IALA has a long tradition of working with sister international organizations to properly develop and harmonize the systems and improve maritime communication and data exchange. This work is extremely important and Francis Zachariae felt very happy to see participants from IALA sister organizations and other international organizations among the participants.

Francis Zachariae also appreciated the conference took place in Japan, a strong supporter of IALA, both as a Council member, and as an active participant in all four Committees, while also being a truly driving force in the ENAV Committee. Francis Zachariae also enjoyed to visit Tokyo, this amazing city which is one of his favorites.

Then, Francis Zachariae expressed the wish to all the participants to take part in frank debate in an informal atmosphere in the well-known spirit of the IALA family, to help promote understanding between authorities, manufacturers, academia and users, to stimulate cooperation on concepts and technologies, and generally to progress discussions on the future of digital communication and related strategy and policy aspects. From Francis Zachariae' part, IALA will take the outcomes of this workshop to heart, both in its technical work and in the activities of the World-Wide Academy.

Finally, Francis Zachariae concluded the welcome address looking forward to listening to the presentations and discussions planned for the week, ensuring that all shall learn from them and come to fruitful conclusions.

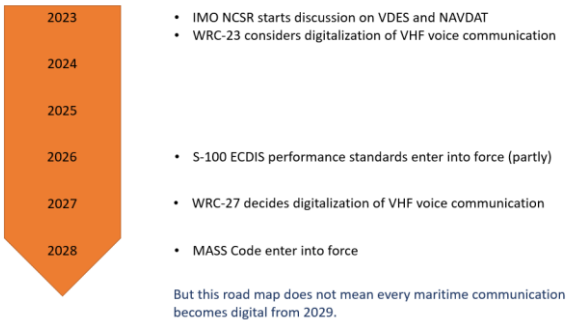
2.3 Administration and safety briefing, – , JCG

Presentations can be found on the fileshare here. A list of participants can be found in ANNEX A.

2.4 Working programme of the week and expectations, Hideki Noguchi - Chair of the IALA ENAV Committee

Hideki Noguchi, Chair of the ENAV Committee and Japan Coast Guard member introduced the technical programme (ANNEX B).

Hideki Noguchi provided a roadmap and deadlines presenting the different digitalisation workflows that are of interest of IALA members:



The expectation for the week is to identify issues on digitalization of maritime communication by AtoN and shore authorities such as:

- Do we need to change every communication to digital?
- How we need to prepare the digitalization?
- What technologies we need to introduce?

- How can we utilize commercial service for the safety of navigation?
- How many years we need to migrate analogue to digital?
- Do we need education and training for the staff?
- and to bring such issues to the IALA technical committees for its consideration and development of guidelines, recommendations and standards during the new IALA working period starts from Rio de Janeiro Conference 2023.

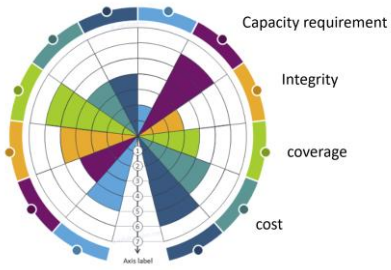
2.5 IALA documentation on digital MARCOM, Minsu Jeon – Technical Operations Manager, IALA

Minsu Jeon presented an overview of IALA's organizational structure and the various outputs it produces, including standards, recommendations, guidelines, manuals, and model courses. He then discussed the standards that address digital communications, such as Marine AtoN planning, radionavigation services, and digital communication technologies. Jeon's presentation then shifted to focus on the historical evolution of maritime communications, highlighting the development of communication means from analogue and mechanical equipment for ship-to-ship and ship-to-shore communication.

Efficient and safe navigation has been a longstanding goal in the maritime industry, and e-Navigation has been a logical step towards achieving this goal by promoting the harmonized collection, generation, and exchange of data by electronic means, including data modelling, PNT, and communications.

Jeon identified three key points of focus during his presentation;

- the need to identify and define the required bandwidth for maritime services in the context of e-Navigation, which is critical to ensuring that the communication infrastructure can support the various services and applications.
- the importance of providing mariners with a secure and efficient communication channel, irrespective of their location. This point acknowledges that there may be areas with limited or no coverage, which must be addressed to ensure that communication channels are available at all times.
- the importance of close cooperation between international bodies, which is essential for the development and adoption of harmonized standards and guidelines for maritime communication.



Rose chart for the requirements (example only)

Selecting the most appropriate communication technologies is a critical task for coastal states, to that end, IALA has developed the Maritime Radiocommunication Plan (MRCP) which is currently being reviewed and transformed into the MARCOM Manual. Jeon provided an overview of some sections of this draft manual, outlining the different applications and services for digital maritime communications. These applications must be developed based on agreed-upon requirements and considerations such as capacity, integrity, coverage, security, and backwards compatibility to enable coastal authorities to select those that meet stakeholders' expectations and safety levels.

2.6 AtoN communication/ requirement and challenge, Dave Lewald – Program Analyst - Navigation Systems, USCG

Dave Lewald informed the participants about the tasks assigned to coastal authorities: Delivery and Collection of MSI and monitor the status/ performance of critical AtoN. Besides, they are tasked to be aligned

with the eNavigation framework. Maritime authorities still are thinking on what the future digital communication channels will be to fulfil with the tasks assigned. He then provided an overview of the web-based services to provide MSI and AtoN discrepancy reporting tools make available by maritime authorities. Internal communication systems are used for AtoN monitoring which are heavy and complexes systems and suppose a challenge for the procurement and seeking for cost-effective contracts, as well as the obsolescence of such communication systems. Finally, the main question on how digital communications can support the requirements addressed by maritime authorities is on his view relevant to be answered during the week.

2.7 VTS communication/ requirement and challenge, Tuomas Martikainen - Finnish Transport Infrastructure Agency

Tuomas Martikainen started his presentation explaining the purpose and operation approach of the VTS Maritime Service according to IMO. User needs from a VTS perspective and the applicability on specific cases for using such information in digital format were depicted: providing timely and relevant information; managing ship traffic; Responding to unsafe situations are some of them. The technical services will potentially be built. Route exchange is a service that will take advantage of digital communication means and ideally provided by VTS. A number of challenges and questions were exposed impacting the messages used, the way VTS provide information to ships, the differentiation of types of messages (advice vs instructions), digital acknowledgement capabilities considering the different nature of acknowledgement and the possible construction of a responsibility scheme between stakeholders involved. The speaker finally presented the fact that a number of different communication means are to be provided and used and linked further open questions were exposed type and timing of information, cost, IP vs maritime tailored channels, expectations to the maritime authorities among others.

Dirk Eckhoff took the floor to provide a more technical including requirements perspective related to the communication VTS/ship. Based on the following two assumptions: the conversion of machine data to human readable information and vice versa must be unambiguous and the data must be specified in that detail that every operator or machine on both ends of the communication derives the same information from the data provided digitally. The different types or format of the information exchange implicates a sometimes difficult to comply with these requirements. The following matrix depicts the conversion machine data / human information:

Receiver / Sender	Voice	Text	Graphic/symbol	Machine readable data
Voice	com link is digital (VoiP)	language translation, SMCP only	keywords needed	no check of contents
Text	SMCP only	standardized language translation	prevent free text	use AI
Graphic/symbol	define and add syntax	predefined match tabel symbol to text	harmonized symbology	predefined match tabel symbol to data
Machine readable data	syntax, SMCP only	SMCP only	predefined list of symbols	standardized definition and format

Dirk Eckhoff evaluates then the comparison between a communication from an human operator in the VTS to a vessel again a machine (VTS) to machine (vessel) communication and implicates the requirement to achieve the definition of certain parameters, the standardisation of some messages and harmonisation of software, identification of targets, definition of the channel used, others considerations regarding AI etc. These steps allowing to follow up the same process a human operator perform during his duty. The speaker finalised the presentation with the following conclusions: standardise considering the sender and receiver; be align with IMO (and IHO) time line; digital data and communication protocols are subjects to be standardise; consider the need to standardize the conversion process to prevent ambiguity (machine data to human readable information and vice versa and on board and ashore).

3. SESSION 2 – THE CASE FOR DIGITAL MARCOM

This session was chaired by Jillian Carson-Jackson, Nautical Institute.

3.1 The case for digital maritime communications – Guy Platten, President, ICS

Guy Plattern provided an speech on behalf of ICS – the global ship owner and operators representing 80% of the world merchant fleet. ICS recognises the challenges faced by sea farers nowadays and is sensitive with the need of connectivity of seafarers with their people back home when they are on board. An important development on accessing to internet by seafarers was endorsed by the International Labour Organisation. Equal concerns are given to cyber security and cyber threats; therefore crews should also been prepared for these threats. VDES, NAVDAT and Iridium inclusion on GMDSS are seen as important steps to provide more cost-effective solutions and better services. Increasing connectivity also implies the robustness of these. IBS are even more complex with the introduction of autonomous shipping and seafarers are expected to assume post on shore to continue the development of shipping. ICS also is supportive with sustainability goals in maritime, precisely through the decarbonisation of maritime trades. The shaping of the seafarer of the future is a workflow for ICS. Three key points were highlighted: seafarer welfare is key; cyber security is a concern and the documentation and guidance in this sense will help the industry, the seafarers and maritime stakeholders to tackle with such challenge and finally the opportunities of digital transformation, job roles evolution and trainings will follow.

3.2 Digital Communications supporting seafarer welfare – Anuj Chopra, ESG

The briefing of Anuj Chopra was focus on seafarer welfare and the implications on their mental health and behaviours on board. This will at the end on the correct operation of ships. Increasing connectivity, communications among other aspects on board is therefore key. Access to the social media, understanding the different cultures, different generations on board and genders will be required to build a healthy environment. The level of rights, capabilities and tools should be given on board, same as shore. In a nutshell, investing in the seafarer, implicates better operational performances and safety environment.

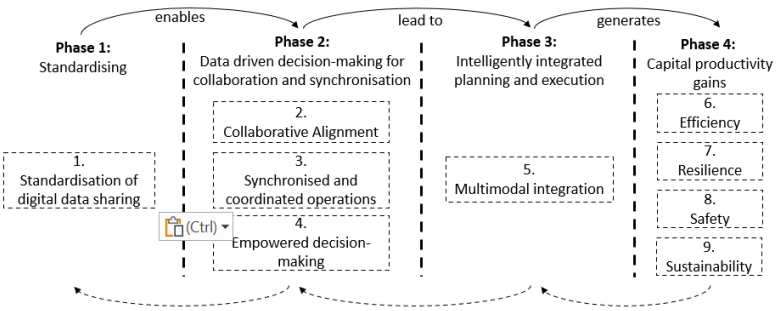
3.3 Demand for maritime digitalisation - Maritime Informatics – Mikael Lind, RISE

Mikael Lind provided thoughts on maritime informatics creating high performance and sustainable maritime industry. Maritime informatics will be capable to define and characterise mathematically the maritime ecosystem. The new trends cause paradigms on companies: balance between the capital productivity and environmental sustainability and the managing supply chain performance and global commons could be achieved through leveraging the power of Collaboration and Digitalization to finally reach positive Economic and Societal impact. The first application area for maritime informatics was the emerging support collaborative decision making (started in the aviation domain). Three focus areas of maritime informatics increasing efficiency, safety, ecological sustainability, resilience of the maritime industry, are:

- Digital Collaboration
- Digital Data Sharing and Decision-Making
- Data Analytics

Maritime informatics relies on four foundational viewpoints: Information sharing communities, Appointment economy, Standardization and Collaborative alignment. Sustainable smarts ports, smart ships and intelligent cargo are considered englobing the focus of informatics. Data analytics are on the base for such developments.

The first phase of informatics is the standardization however, their effects should also been evaluated, the following diagram depicts the phases of maritime informatics:



In the view of the expert, digitalization and collaboration is a symbiosis for economic and social progress. However, it faces two challenges: the nature opaque of the supply chain networks and the requirement to respond of the sustainability of maritime trades. A number of conclusions providing what is maritime informatics, what permits and in what is based were addressed.

3.4 Digital Comms to support shipping (case study) – Yushu Horie, TST Corporation

Yushu Horie provided a view on port VTS in Japan – 33 stations stand along the busiest port of the coast of Japan. The VTS duties are gathered in the Port and Harbor Act and include Navigational assistance, advice, warnings, information, and coordination of traffic. The speaker also provided some figures of the number of VHF communications in some busy ports:

Average Number of VHF Communication per day	360.6
Average Number of VHF Communication per hour	15.0

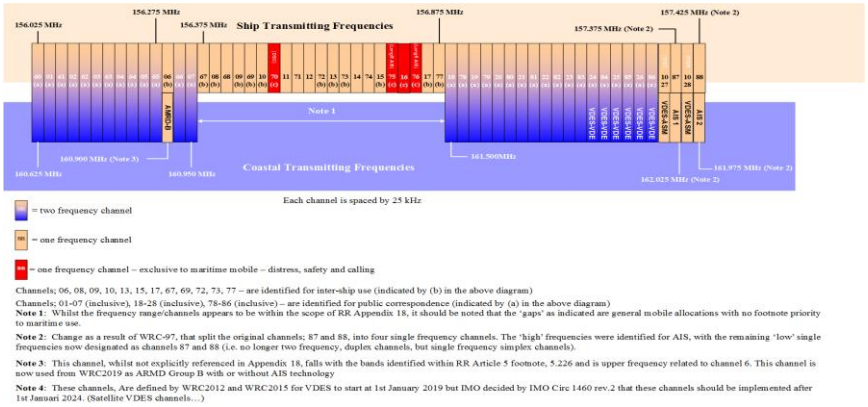
The highest amount of VHF communications take place in morning hours from 7 to 8 am with an average rate of 37,5 calls. An analysis of the content of such communications was also provided. Navigation support (Traffic control signal, berth flag, etc) is the content most addressed during such communications. An assessment on number of communications and content during PM time was also depicted. Then, the speaker presented the challenges faces by the VTS provider in Japan: large number of communications with the subsequent issue to decrease the monitorisation of ships and a shortage of qualified staff. The question on the digital communications advantage for solving these issues was then addressed and it was seen that VTS can take advantage of digital communications for routine ones shore to ship and vice versa.

3.5 Digital VHF Voice in port (case study/operational trials) - Derek Love, CML / Jeffrey van Gils, RWS

Jeffrey van Gils and Derek Love shared the presentation on Digital VHF Voice in port of Rotterdam trials. Channels for communications available for larger ports, such as Rotterdam, are shared with GMDSS, DSC, AIS and FM analogue voice. Therefore, it implies a limited number. At the same time, current developments, VDES, AMRD for instance, will continue to decrease the availability of channels for voice communication - already limited for EU states from 1st of January 2023 ECC Decision (19)03:

- VDES terrestrial services remove 2 x 100kHz (8 channels) from the pool
- VDES sat services remove 2 x 50 kHz (4 channels from the pool)
- ASM channels remove 2 x 25 kHz (2 channels)
- AMRD catB removes 1 channel (2006)

The following overview coming from ITU framework showing the decrease availability of communication channels.



At the same time, ports like Rotterdam or Antwerp which are situated in a very limited geographical area require lots of voice channels for everyday operation (including ship to ship approaches to coastal area, port operations for both ports, different VTS areas and locks operations, IWW communications, so that a very busy area, as well as coping with traffic travelling along the English Channel and North Sea coastline. In addition, it has been demonstrated that the spectral efficiency of the communication channels is low; marine VHF uses 25 kHz per voice channel in contrast with LMR/PMR and public safety digital channels being 6.25 kHz per voice channel → for one analogue channel, you can have 4 digital channels. Therefore, there were important arguments to consider and test digital maritime channels, mainly in the Port of Rotterdam with the aim to improving the spectrum efficiency and so provide sufficient operating channels to support the efficient operation of the port. A comparison was then launched between analogue and digital channels, taking advantage of the commercially availability of LMR equipment supporting both analogue FM and dPMR modes. Cooperation between the different stakeholders of the Port of Rotterdam was effectively put in place during the testing. The coverage area was about 15 miles and the result provided easier to listen to / less tiring, better voice quality, noise reduction, but still allowed the detection of "abnormalities" (drunk speaker). English and Dutch was tested and the CODEC used in the equipment was the one advised by the dPMR association. The ETSI dPMR standard does not specify a CODEC, and it is left to the manufacturer to choose, based on commercial and operational constraints. It was noted that there are at least three different codecs compatible with the dPMR system and the maritime industry needs to make a choice to ensure interoperability of equipment.

3.6 Question and answer session

A number of questions were then asked from the floor. Highlights included the following:

- Use and misuse of mobile phone and the subsequent banning of them in the bridge could be controversial due to the increase of digital platforms for marine operations. The judicious use of these terminals is required. PPU is a clear example of gathering a huge amount of data for port and coastal operations in a single terminal. Restrictions or blockers of some applications in mobile terminals was seeing as a technical benefit for avoiding personal communications in the bridge. How maritime authorities pass the message to seafarers and operators that personal communications should be avoided is also a task to be progressed.
- The question on prevention of different traffic information in the bridge and VTS was raised when the operators use mobile applications. For instance, data as ETD / ETA in a VTS area could come from digital means in the future as well as currently in analogue via VHF. How can one be sure that the digital information is broadly informed to all the ships in the vicinity.
- Single channel has limitations because of interferences / overlapping of communications, the question of multichannel and enhance/ secure AIS in operation was raised to further develop in the technical working group.
- How digital coms can support psychological behaviours, for instance abnormal and normal determination of some communications was raised.

4. SESSION 3 – OVERVIEW FOR DIGITAL MARCOM

This session was chaired by Jorge Arroyo, USCG.

4.1 State of art digital MARCOM technologies – Yoshihiko Imada, JRC

Yoshihiko Imada provided an overview of maritime communication systems across the decades and the current situation which in terms of GMDSS data communication systems includes Satellite - Inmarsat C and Terrestrial: VHF band-DSC, MF/HF bands-DSC, NAVTEX and NBDP. The evolution of the satellite communications through the different generations adding new frequencies was presented and permits a transformation from analogue to digital, circuit switch to packet switch and a usage-based to fixed rate. A well known milestone achieve on radionavigation services but operationally seen as a radiocommunication system was the introduction of AIS making easier to obtain vessel information and the transfer of such data to other electronic equipment of the IBS. The challenge of the huge amount of AIS data and channel congestion was again addressed. Developments of VDES and NAVDAT could then respond to such congestion of data traffic over the AIS channels. NAVDAT will be entitled to broadcast maritime safety and search and rescue related information in the same way as NAVTEX. The efficient use and optimisation of spectrum resources as well as the introduction of new telecommunications facilities and frequency allocations is according to the speaker the work axis to be performed. It was also highlighted that the update of the current satellite communication providers and the proliferation of new constellations (LEO, HF and BeiDou among others) will also support the maritime communications.

4.2 IMT technologies based maritime evolution – Hyounhee Koo, 3GPP

Hyounhee KOO (3GPP Liaison Person for IALA / SyncTechno Inc.) made the presentation with the title 'IMT technologies-based maritime evolution'. Her presentation highlighted the relationship between IMT technologies and 3GPP standards within 3GPP framework and the process for how 3GPP standards become ITU-R Recommendations. It was emphasized that 3GPP standardization is not limited to the development of specifications for radio interfaces related to ITU-R Recommendations, but also includes core networks that enable terminals to connect to external networks such as the internet and access a variety of services. It was noted that IMT technologies based on 3GPP standards currently dominate the market, and various organizations from different industries join 3GPP as members to influence the standardization process according to the specific needs of their respective industries.

Hyounhee Koo presented the 3GPP standardization efforts for maritime sector, which began with the Rel-16 MARCOM (Maritime Communication Services over 3GPP Systems) standardization between August 2016 and December 2018, and have since continued in collaboration with IALA starting in 2019. As a result of these joint efforts between IALA and 3GPP, eight candidates of Rel-18 technologies were selected from a maritime perspective and prioritized maritime requirements were presented at the 3GPP SA Release 18 workshop in September 2021.

It was informed that ITU-R WP5D is currently working on a preliminary draft new report (PDNR) ITU-R M.[IMT.APPLICATIONS] that aims to introduce various IMT application usages from different industries. In the first quarter of 2022, 3GPP contributed to its development by submitting a reply liaison to ITU-R WP5D. The maritime usage introduced in WP5D document was developed based on FS_MARCOM and Release 16 MARCOM standardizations within 3GPP. Furthermore, she mentioned that she had another opportunity to revisit this report, and an update to this PDNR was made in February 2023 for maritime usage. This update introduced a new section focused on the maritime sector, covering various IMT-based maritime usages. These included areas such as autonomous surface ships, virtual marine aids to navigation, and maritime safety services, as well as pilotage and tug services introduced via 3GPP reply liaison. Additionally, an annex was included in the update to provide a case study on an autonomous surface ship utilizing an IMT system in the PDNR ITU-R M.[IMT.APPLICATIONS].

Hyounhee KOO presented a case study on the applicability of 5G/5G-Advanced to MASS (Maritime Autonomous Surface Ships). This case study provided examples of specific types of work required for the further evolution and optimization of 5G and beyond systems, in order to better cater to the wireless communication requirements of the maritime sector. Three categorizations were given as examples to describe the work related to unmanned and automated moving objects, such as autonomous surface ships, in terms of 3GPP standardization. Additionally, it was emphasized that the digital transformation of the external environment should proceed in tandem with the evolution of moving objects, such as autonomous surface ships. In the case of an autonomous surface ship, it was mentioned that AtoN (Aids to Navigation) systems can be considered as part of the external environment.

An example related to the 3GPP works for satellite communications was given to explain 5G enabling technologies related to coverage expansion that are necessary for the digital transformation of the external environment and the evolution towards unmanned automation of moving objects. Additionally, it was mentioned that there have been recent news reports on 5G smartphones supporting satellite access. As 3GPP continues to develop further enhancements to support satellite access over 5G and beyond systems, it is expected that more diverse types of devices will be introduced in the near future.

4.3 Digital voice over VHF radio – David Rowe, Rowetel

David Rowe presented the open source speech Codec 2 (patent and license free) operating on low bit rate (3200 to 700 bits/s). The users are amateur radio community for digital voice HF and VHF over 10 years. David provided the hardware and other operational information where Codec is supported. The speaker informed about the speech coding, what is needed to provide an intelligible and natural (human) speech at the receiver and what could be withdrawn. It was also explained that when designing a codec software, the voice and the data are different. Then, the matter of royalties and patents was addressed: around 5% of the codec algorithm are original and patent, so that the 95% are public. The Codec 2 organisation was presented whose mission is to deliver a quality open source speech codecs. David finally presented the roadmap for codec aiming at addressing technical development and organisational challenges improving the speech quality,

building a maintenance and cross platform support, Integration into products used by commercial companies among other goals. In the scope of IALA, the speaker highlighted the opportunity to customise for IALA use case, for example a fallback low bit rate “safety” mode that doubles the range compared to FM, and extends battery life.

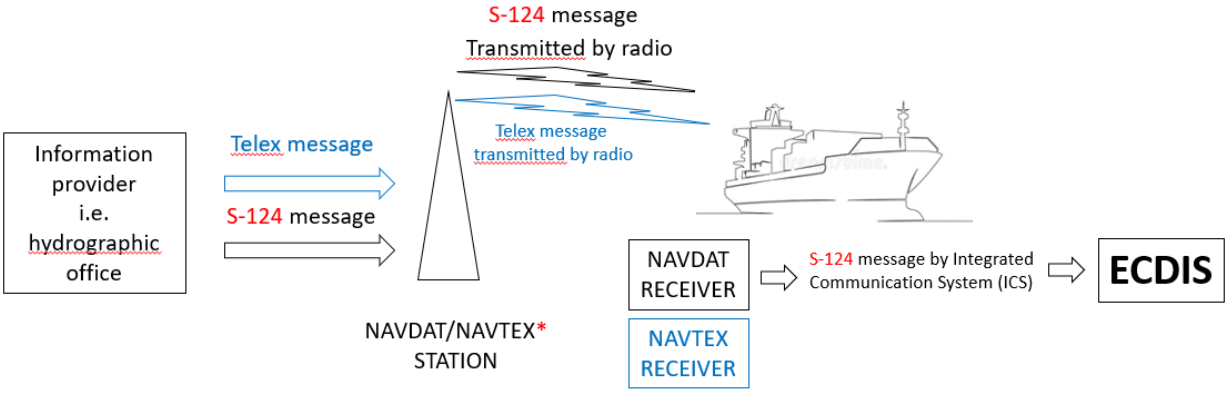
4.4 NAVDAT – Jean Charles Cornillou, Cerema

Jean Charles Cornillou provided the picture from the beginning of the GMDSS developments and the current modernization of GMDSS with the Scoping exercise to establish the need for a review of the elements and procedures of the GMDSS starting in June 2009 - MSC86). As all maritime radio systems and frequencies are prepared at ITU, the IMO/ITU expert group was a key element during all the development of the GMDSS modernization as an important link between the two organizations. In April 2022, the MSC 105 adopted relevant draft amendments to SOLAS chapters II-1, III, IV and V, and many related instruments. The GMDSS functional requirements do not change because they are adapted to any format of communication (Telex, voice or digital) and any radiocommunication system (terrestrial or satellite). Digital communications developments are in line with the strategic implementation plan on e-navigation. The switch from NAVTEX to NAVDAT is a clear example of this. ITU in parallel has reached to adopt the following recommendations:

- In November 2011, Recommendation ITU-R-M 2010, NAVDAT 500 kHz and
- In February 2014, Recommendation ITU-R M.2058, NAVDAT HF
- In November 2018, Report ITU-R M.2443, NAVDAT Guidelines
- In November 2019, WRC 19 confirmed the use of all frequency bands for NAVDAT: 500 kHz, 4226 kHz, 6, 8, 12, 16, 18/19, 22 & 25/26 MHz

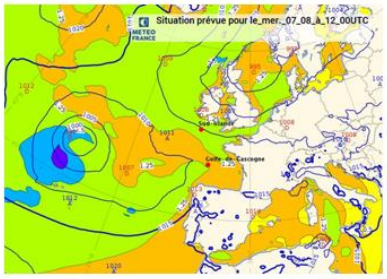
After the presentation of the test measurement from China and France of NAVDAT system under real conditions in NCSR7, during MSC 103, it was accepted to include the new output for GMDSS on Development of performance standards for a digital navigational data system (NAVDAT).

The test measurements demonstrated that digital files whatever their format (JPG, pdf or S-124) could be directly transferred on board through NAVDAT. It is then possible to input S-124 files to the integrated communication system and be portrayed in the ECDIS. The following scheme present the flow of data:

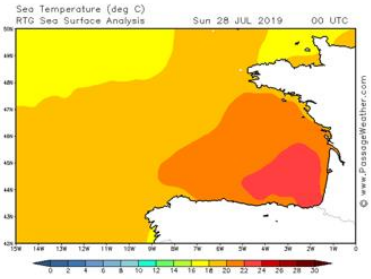


The test area in France - Ushant Island with NAVDAT 4 MHz, was tested with fishing vessels and in China – Shanghai with NAVDAT 500 kHz was tested with merchant ships in transit. It was demonstrated that despite the electromagnetic radiations on board fishing vessels the data was received on board. Besides, Digital Modulation allows more important flow 15 to 25 kbit/s in a 10 kHz channel (more than 300 times than the NAVTEX transmission), the faster transmission time per message and the transmission files allowing different formats are some of the advantages of such digital technology. The following information for interest to fishermen, professional or non-professional navigators could be graphically provided on simple manner:

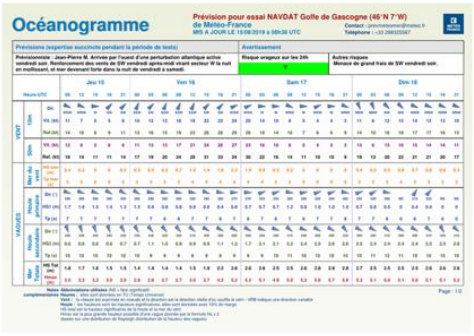
Examples of decoded files transmitted



isobaric weather chart
(Météo France)



temperature chart
(Passage Weather)



data and forecast in Biscay Bay
(Météo France)

NAVDAT also allows to broadcast information to all ships, to a group of ships (selective) or a unique ship through a dedicated MMSI number. Besides, the NAVDAT system offers the possibility of operating in SFN (Single Frequency Network) mode, using several transmitters operating on the same frequency and broadcasting the same information at the same time and at the end simplifying the distribution of the time slots among other advantages. But this latest broadcast mode requires the messages to NAVDAT coast stations provide from the same server.

In order to prepare a smooth transition from NAVTEX to NAVDAT, it is possible to use the same coast radio station and transmitter to broadcat NAVTEX and NAVDAT message. On the other hand, ships need a new equipment to receive digital files transmitted by NAVDAT, but this equipment will provide much more flexibility and will be more user friendly than present NAVTEX receiver.

4.5 Maritime Communication with Satellite - Overview – Woo-Seong Shim, KRISO

Woo-Seong Shim started his briefing recalling the purpose of eNavigation, then the speaker moved to the specific developments in Republic of Korea in the scope of eNavigation. A special focus was put to the satellite component: Woo-Seong Shim explained the different constellations (LEO / MEO / GEO) and their principals characteristics allowing communication requirements for some users, f.i. permitting low latency services. On his view coverage and other operational performances should be carefully look at for maritime communication. Equally, the increasing demand of data in the maritime also requires the developments of such satellite component. Other relevant aspect is the decrease of cost when launching satellites with the newest nano satellite technology and the processes and technologies permitting to re-use them. However, still some constraints when using and operating the satellites are expected: big initial capex, the user dependency and the operational performances are still not guaranteed for many cases. New developments as 5G mobile communications by satellite and the continuous work on VDES sat are seeing as enables to leverage communications in maritime. Two ways coms, data privacy, global coverage and supportive to maritime trends are key aspects of the VDES. However, some challenges are still ahead starting with the need to continue the standardisation and regulation of some aspects of the service/system.

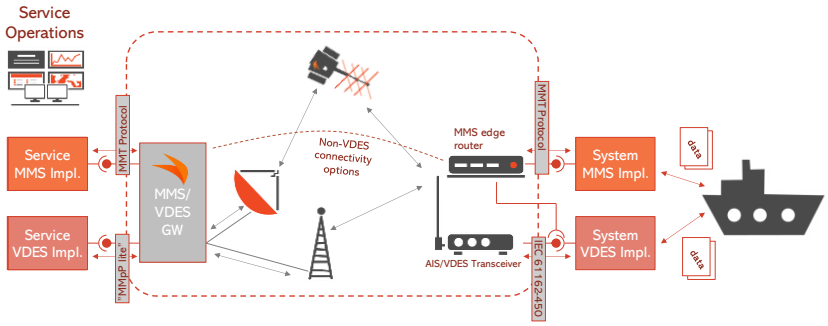
4.6 VDES Satellite – Digital data exchange – Lars Moltsen, Sternula

Lars Moltsen provided a summary of relevant insights reached during the evolution of VDES sat and resulting to the current launch of a VDES satellite (“STERNULA-1” launched on 03 January 2023) and the path of Sternula being a VDES satellite service provider. VDES has enabled the evolution of AIS to a new generation, which is an extension of the system. VDES is then expected to become a component of the SOLAS minimum carriage requirement according to the speaker. It was noted that 16 satellites will permit at least global real time service (achieved by 2026) and to continue the satellite launches align with the user needs. Lars Moltsen also presented the feasibility study under ESA to assess Satellite network sharing (“roaming”), IoT-type services and VHF DSC distress monitoring. The goal of Sternula is to be fully operational from 2023 and providing a realtime coverage from 2028.

The VDES sat will provide connectivity to ships in remote locations and will include commercial services on a Global, and standardized data transfer. A number of applications were presented aligned with the activity of the potential customer (maritime authorities, commercial service providers, ship owners among others.) It is

expected a huge market evolution (from now to 2030) on the number of VDES receiver leveraged by the IMO amendments and the main demand is expected to come from fishery. The launch of satellites (LEO nano satellites) from now to 2028 is also estimated to increase and the roadmap was presented, the number of satellites will be aligned with the number of users (receivers). 16 satellites will permit at least global real time service (2026) and to continue the launches align with the user needs. Lars Moltsen also presented the feasibility study under ESA to assess Satellite network sharing ("roaming"), IoT-type services and VHF DSC distress monitoring. The goal of Sternula is to be fully operational from 2023 and providing a realtime coverage from 2028.

In Sternula infrastructure, it is projected to support MMS and the MCP during the implementation of digital maritime services over VDES because it adds digital authentication and other features on top of VDES. The architecture will be as follows, also including the first MMS edge router in the market:



5. SESSION 4 – OPEN FORUM / PANEL DISCUSSION

This session was moderated by Ruri Shoji, TUMST.

5.1 Panel discussion: Sec. Gen. / Japan / Singapore / Netherlands – Sec. Gen. Francis Zachariae / Tsuguo Awai / Capt. Segar / Maarten Berrevoets

A set of question were asked to the panellists:

Does Digitalization of maritime communication need to be speed up?
It was agreed that a strong business case will leverage the digitalisation and if there is not the case, then establishing regulation will be required.
Besides, robust maritime shore infrastructure, requests for sharing more data gathered by industrials. Data protection and cybersecurity are also key factors for speeding up digitalisation.

Does the shore authority need to use or establish all services and systems?
If the business case is positive, the investments will follow. Parallelism with the short term of finding a vaccine for COVID or the industry reconversion to supply mask, globes, hydrogels etc in order to cope with the demand was presented.
In addition, the system should be attractive to users to make investments coming from the coastal authorities.
Infrastructure and equipment for all these services and systems will be required to be secured by design and providing more reliable information. IALA is requested to elaborate guiding principles for shore authorities to implement this kind of infrastructure. Sustainability is as well at the edge of the evolution of these systems.

In the view of the panellists, what is the role of IALA in the digitalization of maritime communication and what do they expect to IALA on the digitalization?
IALA will continue being the framework where these discussions and plans are agreed and harmonised. IALA will continue to monitor the test projects of eNavigation and digitalisation to harmonise the solution. IALA should also be clear when advising on the feasibility of a project.

IALA should take the lead on shore/ship communications and product specification of services. Continue the development of technical and product specification with a specific focus on supporting under development countries and small island to cope with the safety requirements of maritime navigation under the scope of IALA. Best practices between industry partners could also be a workflow for IALA.

Can IALA members expand the customers of this digital communication infrastructure?
Militars / Navy are also customers of digital coms. Non-SOLAS ships could also be a target for VDES for instance (in the same way there are AIS class A and class B). However, there are some regulatory restrictions to use it. The scalability of the product will also permit a decrease of the cost of the equipment.
Focusing in VDES, it is seen as a potential carriage requirement for ships, VDES industrial should create the good business case. The building of maritime services should be on top of the communication channels. VDES will then be a mean to transfer such service from shore to the users or between users. Corridors of connectivity could be the case for business where shipowners would like to get involved.

6. SESSION 5 – DIGITAL MARCOM: WHERE WE ARE TODAY

This session was chaired by Axel Hahn, DLR

6.1 General requirements – Alexander Schwarz, IMO

Alexander Schwarz provided an historic overview of the maritime radiocommunication regulations starting with the first international conference that took place in 1906 and aiming at consolidating the international regulation of maritime radiocommunication. Continuing with the advent of GMDSS (90's) being the reason why there is still very detailed regulation relating to maritime distress, urgency and safety contained in ITU's Radio Regulations. ITU has established a set of rules to give regulatory protection to frequency spectrum which is being used for distress communication and for the dissemination of MSI (f.i.: Appendix 15 of the Radio Regulations, no interference on such frequencies is acceptable). The speaker also recalled the creation of AIS as a major milestone for maritime safety. It was noted that, technically, the AIS is a radiocommunication system, as it transmits a GNSS position together with other relevant data in a data burst via VHF channels. From IMO's view, the AIS is a radionavigation system which clearly fits into the regulation of today's SOLAS chapter V and relating instruments.
The expert then started to explain the position in regards with VDES, stating its creation will continue the story of success of the AIS. However, the inclusion of the VDES into the Radio Regulations happened prior to a definition of the VDES by IMO performance standards: ITU member states had brought the need for frequency regulation of a new maritime system to WRC-12. As a consequence, WRC-15 and, for much of the satellite part, WRC-19 allocated VHF channels to the new VDES. It is not before NCSR 10 in May 2023, that IMO will begin the consideration of new VDES performance standards. The preliminary agenda of NCSR 10 contains the agenda item on Development of amendments to SOLAS chapters IV and V and performance standards and guidelines to introduce VHF data exchange system (VDES). Alexander Schwarz is on the view to take up the regulations of both SOLAS chapter IV, Radiocommunication, and chapter V, Safety of Navigation, and see how things will fit in and what can and should be done to improve maritime safety. Such developments require to progress on the join work from the technical experts in IALA, with the nautical and regulatory experts in IMO. Virtual meetings being enables to further progress the cooperation between IALA and IMO.
The speaker referred to the G1117 and recalled that the frequencies for distress communication and for dissemination of MSI are given a high degree of regulatory protection which are considered as part of the use cases of VDES. If the VDES would be considered useful by IMO for distress communication and for dissemination of MSI, the relating VDES channels would not only need what ITU calls primary status, and which they already have, but they should possibly also be included in Appendix 15 of the Radio Regulations, which gives them sort of super-primary status, and which is already applied to the existing distress and MSI channels. Such inclusion would however need a new agenda item for a future WRC. However, it is important to note that, the frequency spectrum for satellite VDES has been granted secondary status only. In line with this matter, once IMO has developed performance standards for the VDES and the VDES R-mode, consequential amendments of ITU's regulation in place for the VDES, and new regulation for the R-mode, may probably need to be considered. Similar situation as with the VDES – that is frequency regulation by

WRCs has been achieved, but IMO has not yet developed performance standards – the 18th meeting of the Joint IMO/ITU experts group in December 2022 consequentially noted the need to begin the work relating to R-mode and VHF digital voice communication immediately within IMO. In order to enable the NCSR sub-committee to consider a new work item, such as the VDES R-mode, it is up to IMO member states to file submissions to MSC, and request a new output. Such a process needs to be taken to ITU as well.
Alexander Schwarz closed his remarks with two positives ideas:

- the view that IMO needs to consider the creation of VDES and VDES R-mode performance standards; and,
- if ITU would really need an amendment of Article 5 and Appendix 18 of the Radio Regulations to introduce R-mode over VDES having the example of locating functionality in cellular mobile telephone networks, which has been implemented without a specific entry for that purpose in the table of frequency allocations in the Radio Regulations.

6.2 Manufacturer view – Richard Doherty, CIRM

Richard Doherty introduced the role of CIRM as the International association of marine electronics companies, its status in IMO and membership and its technical scope of interest centred in navigation and communication ship equipment and systems. He provided some general thoughts on digital maritime comms which are included both in regulated IMO bridge and SAR equipment and non-regulated environments (commercial satcom). The views expressed hereafter are on behalf of individual companies, and they are not necessarily the official positions of CIRM.

In regards with views on specific technologies, it was expressed that:

- For VDES:
    - VDES has the ability to help address AIS cyber security issues, data rate restrictions and VDL saturation
    - Capacity of the VDES system should be align with the applications proposed as use case
    - Again, authentication is key for the system
    - Implications to the VDES being considerate as an optional carriage requirement and the proliferation of other services like 3GPP & satellite internet
- For NAVDAT:
    - IMO will develop performance standards
    - Offers much higher data rates and improved capabilities
    - NAVDAT & NAVTEX are currently only viable MSI alternatives to Satellite MSI
    - Attractive solution for the recreational / small boat market
    - There is a risk it will be overtaken by other services like 3GPP & satellite internet
- For Satcom:
    - Great profusion of commercial solutions available over non-regulated services
    - Demand for bandwidth and higher data rates will only increase

Richard Doherty provided further insights on behalf of individual companies on maritime 5G, digital VHF voice, S100 among others that can be consulted in his presentation. CIRM will organise a workshop with the theme “Future of Maritime Communications” and the report and outcomes of this workshop will be an input to the CIRM workshop.

6.3 Inmarsat services – Peter Broadhurst, Inmarsat

Peter Broadhurst presented the satellite connectivity and why taking a strategic approach to connectivity is becoming increasingly important. The speaker started with an overview of the number of satellite owned by Inmarsat in orbit providing a number of services in different coverage area and frequencies (including polar

areas). LEO satellites are also being launched by Inmarsat to permit connectivity over multiple paths and permitting a huge increase of data exchange. According to the speaker, LTE and 5G network will provide the level of service that the maritime user will require. It was also recognised that sat operators can maintain the communication requirements of shipping in the hotspots around the world. Increase data usage on board is a reality and the price per mega byte is falling which is a benefit for the user. Both for the ship owner and for the seafarer, the need to get access to connectivity is increasing: Voyage optimisation / decarbonization / Remote operations / Crew welfare and connectivity. Peter Broadhurst provided a use case of exchanging data from the ship to shore (ship owner / operator) concerning the transfer of the VDR data to shore. The use of such data would increase the safety on board and the situational awareness. The VDES integration within Inmarsat ecosystem is also possible. Peter Broadhurst explained the issue of sharing data and the ownership of such data. The idea of having a very good business case was also expressed.

6.4 Other satellite services – Richard Smale, OneWeb

Richard Smale presented the OneWeb network and the LEO constellation for maritime industry. High speed (upto 200 Mbps) with low latency (under 100ms) broadband connectivity is the main focus of OneWeb. 648 satellites are in orbit and a tailored maritime service launch is expected for April 2023. OneWeb also operates the ground stations in different locations enabling the downlink of data from the satellite to the ground stations. OneWeb envisages the maritime connectivity will permit to enhance the crew welfare, advanced navigation, machinery optimisation among other applications. The detail of each application is explained in the presentation and requires increase bandwidth, low latency and the possibility to get connected to cloud applications.

6.5 Question and answer session

A number of questions were then asked from the floor. Highlights included the following:

- The question of the killing applications for digital maritime communications was raised. Environmental related applications are relevant since the decarbonisation is underway.
- The question of the platforms used in 10 or 15 years was also addressed with a view that mobile phones will be at the centre of digital maritime communication platforms.

7. SESSION 6 – DIGITAL MARCOM: LOOKING TO THE FUTURE

This session was chaired by Omar Eriksson, IALA – Deputy Secretary General.

7.1 ITU – digitalisation of Mobile band – Stefan Bober, WSV

Stefan Bober, IALA representative in ITU provided information on the digitalization of Mobile band. Two frameworks regulate the radiocommunication systems:

- Radiocommunication Working Party 5B - Maritime mobile service, Global Maritime Distress and Safety System (GMDSS)
    - responsible for regulation, standardisation, coordination and development of international radiocommunication systems,
- World Radiocommunication Conference (held every 4 years) aims:
    - to address the global demand for spectrum for the growth and development of information and communication technologies,
    - to update ITU Radio Regulations (RR) which determines the worldwide use of the radiospectrum, e.g. dedicated VHF maritime mobile band in RR Appendix 18 frequency allocations.

Stefan Bober depicted the main characteristics of the maritime mobile service (high operational requirements, regulated, terrestrial and satellite. Specific examples as the evolution from NAVTEX to NAVDAT were provided showing the increase of digitalization and operational aspects. The role of IALA to progress on

the agenda items in the WRC was demonstrated with the outcomes coming from the ENAV Committee in regards with VHF digital voice communication and VDES R-mode. Besides, IALA has also produced a number of guidelines and recommendation identifying candidate technology for digital voice, R-mode integration in the VDES that provides resilient terrestrial PNT system for the backup of GNSS. Other sister organizations are also aligned with the developments of VDES R-mode as RTCM.

7.2 IHO – S100 / SECOM – Svein S. Skjaeveland, PRIMAR

Svein S. Skjaeveland presented the work of PRIMAR on standardisation of data exchange and communication from a service provider perspective. PRIMAR provides a number of S100 series product specification including water level, ENC, nautical products, surface currents, UKC and bathymetric. PRIMAR works with a large number of hydrographic offices to distribute their S100 products to distributors and then reaching the SOLAS fleet. In the standardisation and regulatory side, the provision of S100 products shall take into account the following:

- The revised ECDIS performance standard entering into force from 1 January 2029 states that new systems must comply with the new IMO Resolution on ECDIS Performance Standards (MSC.530(106)).
- Besides, IEC issued 63173-2 SECOM in 2022 which is designed for S-100 products – ensuring exchange of maritime information in a secure way and online. Thus, facilitating more dynamic and to the point data delivery.

The online transfer of data is ensured by broadband satellite internet constellation as LEO. As it was mentioned on previous presentations, the performances in terms of low latency, high availability, worldwide coverage area, cost effective rates and supporting static and dynamic exchange data are advantages taken from this type of constellation. In parallel, PRIMAR provides a remote update through which the user can directly implement the data from them.

7.3 Maritime Service Platforms – Axel Hahn, DLR

Axel Hand presented and application driven motivation for digital platforms in the context of maritime digital communication. He stated that existing communications means like AIS, VHF etc and also VDES have serious cyber security issues. Available technologies higher bandwidth like LTE-M ore LEO can be secured properly.
In combination with digital platform they can also help to increase the security of VDES.
He summarized IALA G1161 with requirements for digital platforms as a basis for future end efficient and secure implementation of Maritime Services and gave an overview of the supportive services of the Maritime Connectivity Platform (MCP).

7.4 Future skill sets in a digital MARCOM world – Ann Pletschke, Ocean Infinity

Ann Pletschke introduced the topic from a MASS operational perspective. MASS in operation around the world have the same strong requirement to efficiently communicate to shore and with other vessels. Redundant links, more than one communication channel and different remote control centres in operation for the same area of MASS are required. The design of MARCOM systems is essential to be based on reliability and redundancy, no risk of obsolescence and the space for training is essential. The effort on regulatory spaces remains huge due to the necessity to roll out the GMDSS remotely from remote control centres. The following table depicts the skills required for future MASS operators; in yellow are highlighted the areas where seafarers are not trained in:

Table 1. Knowledge required for future MASS operators (Mallam, Nazir, and Sharma 2019).

Classifications of Skills	Knowledge and Skills
Aspect of ability	(1) Leadership and communication
	(2) Obedience and execution
	(3) Psychological stress resistance
Aspect of knowledge	(1) Traditional nautical knowledge
	(2) Network communication knowledge
	(3) Automatic control knowledge
	(4) Data mining knowledge
	(5) Artificial intelligence knowledge
Aspect of technology	(1) Autonomous navigation
	(2) Fault diagnosis
	(3) Remote control
	(4) Environmental information perception
	(5) Internet of Things

Finally, Ann Pletschke presented the following open questions on her view that would need further consideration:

- How does the training for maritime personnel need to be changed?
- What 'expert' knowledge is needed to handle vessel-based communications?
- Can vessel RCCs learn from VTS in dealing with human factors?
- What knowledge will VTS and port operatives need to have to be ready to effectively communicate with and handle MASS?
- How can we address the risk of a digital divide opening up within the industry?
- What role does STCW have in providing the skills to use digital MarCom technologies?
- What skill sets do our MET instructors need for digital MarCom technology and how can they stay relevant?
- What are the risks of developing technology in advance of standards?

7.5 Question and answer session

A number of questions were then asked from the floor. Highlights included the following:

8. ESTABLISH WORKING GROUPS

Hideki Noguchi, Chair of the Workshop, reminded participants of the three working groups and their suggested outcomes (**Error! Reference source not found.**). Participants then divided into three groups to begin the work.

8.1 WG1 - Operation

The full working group report can be found in ANNEX C

8.1.1 Executive Summary

WG1-Operations considered the operational requirements necessary to implement digital communications in the maritime domain. Recognizing that the scope of the topic far exceeds the capacity of the group in a one-week workshop setting, it was decided that a review of the operational considerations was appropriate, and our recommended findings be considered and addressed during the IALA 2023-27 work program.

At the establishment of WG1-Operations, a review of individual impressions of the presentations was conducted to organize our work as defined by the Workshop WG1 Terms of Reference (ToR). Several key points of view were discussed and categorized as observations, questions, and recommendations for IALA PAP Committee, IALA ENAV Committee, IALA VTS Committee and IALA ARM Committee consideration. Additionally, the WG identified seven high level themes which may influence the evolution of IALA's remit.

- As IALA's role as a technical authority on digital communications advances, it should incorporate the availability and reliability of communication systems into the general provision of Maritime AtoN Services in the context of e-navigation based upon the volume of traffic and degree of risk.
- Considering IALA's role as a digital communications technical authority is expanding and IALA's responsibilities to provide standards, recommendations, and guidelines related to Maritime Services (MS) in the context of e-navigation, IALA's role must evolve to support services not within IALA's remit.
- IALA should encourage member states to consider the roles, responsibilities, and potential overlap of responsibilities within their own national organization for the provision of Marine AtoN, Marine Safety Information (MSI), and related services to address the requirements of Digital Marine Communication (MARCOM) for the purpose of establishing a cohesive harmonized delivery schema.
- IALA must recognize that a shift in vessel management philosophy of shipping companies is evolving from the sole responsibility of a vessel's Captain and crew to a shoreside management paradigm. Furthermore, it should be noted that this philosophy is not exclusive to MASS operations.
- Cyber security must become a core consideration in all spheres within IALA's remit. Digitalization of the provision of Marine AtoN services must include consideration of Cyber security risk and mitigation solutions. Furthermore, the recognition that Cyber security risks exist with open communication links. It is therefore imperative that IALA develop recommendations and guidelines to support the use of Digital Maritime Communication services.
- IALA should recognize the benefits of Digital Marine Communications and the potential relationship of UN sustainability goals to include decarbonization sustainability.
- IALA should bring in expertise and advice to IMO for the integration of Maritime AtoN service performance requirements. This includes harmonization and standardization on all levels of interoperability including:
    - Communication level (VHF, VDES, IP based, etc.),
    - S-100 Product Specification and Application Specific Messaging (ASM),
    - Communication protocols (IEC-SECOM, etc.), Technical Service Specifications,
    - Orchestration (registration process),
    - Application layer to include portrayal and functionality.

8.2 WG2 - Technologies

The full working group report can be found in ANNEX D

8.2.1 Executive Summary

Work group 2 was chaired by Martijn Ebben (Port of Rotterdam) and vice-chaired by Michael Strandberg (Danish Maritime Authority). The work group had several discussions on various topics with regards to technology. The major findings of the work group are:

- For the most part, it is transparent to the end user if analogue or digital voice communication is used and a list of user requirements should be used to determine the need for – and benefits from the digitalisation of VHF voice and if so, which codec would be the best option. Options for digital voice communication using other technologies, e.g. a smartphone, are not considered viable, as it is not a broadcast medium and relies on third parties/infrastructure. Backward compatibility should be accounted for, as there will be a long transition time from analogue to digital.
- When considering alternatives to regulated technology, it may be useful for non-SOLAS vessels, but should only be used in addition to the regulated system.
- On the topic of user requirements, WG2 collected a list of potential new technologies that may assist users, whether seafarer or authority in more efficient, safer or more comfortable ways to perform their duties. This applies in particular to non-SOLAS vessels. All information / communication should

be categorised in terms of importance. This will eventually lead to requirements and/or SLA's.

- The WG worked on the table in appendix 1 of the draft Marcom Manual that is an input document for the workshop. The table was amended, both in data on the mentioned technologies, but also added technologies that appear to belong in the table.
- The WG worked on the draft table with S-100 services and their properties from ENAV30, that is input for the workshop. In a plenary discussion, the rows and columns of the table were evaluated and altered or amended to.
- WG2 had a plenary discussion on cyber security aspects of the technologies and services named and identified. As cybersecurity was mentioned in almost every presentation during the first 5 sessions of the workshop, the WG started the discussion from the standpoint "Always secure unless technically impossible or undesirable". This standpoint leads to the general recommendation to develop all future technology in a cyber resilient manner.
- There are several ready-to use networking technologies, like Quality of Service (QoS) and bandwidth management available to ensure that safety information is received (or transmitted) is prioritised, but that is no common practice to implement these on vessels, as this is advanced network configuration. The WG recommends that guidance is developed by relevant bodies, in corporation with IALA, to incorporate these technologies in solutions for vessels. Furthermore, the WG suggests that IALA actively seeks to include more advanced network/IP knowledge in the committees as many future technologies depend on internet-based technology.
- Suggested tasks for the new work programme:
    - Develop guidance for shore authorities on building shore-to-ship communication infrastructure that can support e-navigation services (e.g. MCP), referencing ENAV action items 2.3 and 2.4 in the work programme
    - Develop guidance on harmonised communication technologies used for the promulgation of S-xxx data
    - Develop information (e.g. in the Marcom Manual) on the capabilities and limitations of satellite communication technologies and the differences of various satellite service providers and the characteristics of LEO versus MEO and GEO. For some regions there may be specific features to include, that are still investigated within IALA.

8.3 WG3 - Human factor Human factor

The full working group report can be found in ANNEX E

8.3.1 Executive summary

WG3 – Human Factors – considered the human factor aspects of digital maritime communications, as instructed within the terms of reference:

a) Consider human factors including portrayal on digital maritime communication/ benefits and issues to be addressed when deploying and using digital communication both voice and data, especially
   - Cognitive factors (affecting how we think)
   - Distractions / added stress / information overload
   - Prioritisation (information / presentation of information)
   - Use interface / interaction with the technology

b) Identify human issues including training and educational needs for the digitalization of maritime communication
c) Identify issues to bring forward to the work period 2023-2027
d) Submit a report to the plenary by 23 February.

At the establishment of WG3, a review of individual impressions of the presentations was conducted in an effort to organize the work within the framework of the ToR. Several key points of view were discussed and categorized and are provided for further consideration by IALA and the IALA Committees.

In addressing these aspects, the WG referenced existing literature and guidance on human factors, including the IMO MSC.1/Circ.1512 (Guideline on Software Quality Assurance and Human-Centred Design for E-Navigation) and IALA G1171 (Human Factors and Ergonomics in VTS).

The WG3 discussion started with a note on definition on Digitization and Digitalization followed by discussion on the individual perspective on Human factor and digital maritime communication. The discussions focused on the specific aspects of human factors related to the introduction of digital maritime communications, noting the commonalities with general human factors research.

9. WORKSHOP CONCLUSIONS

The workshop participants considered the various presentations that were given and the work conducted in the WGs. The conclusions were agreed and gathered in the executive summary of this report.

9.1 Review workshop report

The report was reviewed on-screen and agreed upon.

9.2 Closing of the workshop from JCG

Rear Admiral Tsuguo Away highlighted the extensive and relevant work ahead to do in IALA, these are busy times on the technical domain as well as in the IGO transition. Tsuguo Away thanked all the experts that have contributed to the workshop and the secretariat, Tokyo University and Marine Science, and the organisation coming from the Japan Coast Guard. He also wishes a smooth and safety trip back to the home countries.

9.3 Closing of the workshop, Omar Frits Eriksson – IALA Deputy Secretary General

Omar Frits Eriksson thanked the workshop organizers and participants on behalf of IALA for all their energy and hard work.

Omar Frits Eriksson made the announcement of a virtual meeting the 3rd of March – Webinar on the VTS model course approved by Council.

Deputy Sec. Gen. noted as well that the participation was more than expected and therefore the contributions were technically very high level. There had been many important and interesting discussions that would benefit future IALA documentation. He wished all a pleasant weekend and a safe journey home.

10. SOCIAL EVENTS AND TECHNICAL VISIT

10.1 Workshop icebreaker

The workshop icebreaker was held in the Marine Science cafeteria premises and was the opportunity to network and catch up with colleagues and friends.

10.2 Workshop dinner at Hilton Tokyo Odaiba

JCG offered in Hilton Tokyo a wonderful dinner where a part from being the place where participants had the opportunity to talk further with their peers, Sec. Gen and Rear Admiral provided some speech.

10.3 Technical visit, tour to the Marine Science Campus

The technical tour provided very valuable presentation on MASS workflows and WISE project and a comprehensive overview of the bridge simulator and ECDIS.

10.4 Industrial exhibition

The industrial exhibition was held on the first day. The Japanese IALA industrial members, Furuno Electric Co., Ltd., Japan Radio Co., Ltd. and Toyo-shingo-tsushinsha (TST) Co. exhibited their proto type products and panel on use cases. The participants actively exchanged views, information, etc. with the exhibitors.

ANNEX A WORKSHOP PARTICIPANTS

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ANNEX B TECHNICAL PROGRAMME

DAY 1 – Monday, 20th February 2023

Time	Activity	
0930-1000	Registration for Workshop participants – Industrial exhibition	
1000 – 1130	Session 1 – Opening of the Workshop	Chair: Hideki Noguchi – JCG
5 min	Welcome from JCG	Rear Admiral Tsuguo Awai – JCG
5 min	Welcome from IALA	Sec. Gen. Francis Zachariae
5 min	Administration and Safety Briefing	JCG staff
15 min	Working programme of the week and expectations	Hideki Noguchi
20 min	IALA documentation on digital MARCOM	Minsu Jeon – IALA
20 min	AtoN communication/ requirement and challenge	Dave Lewald – USCG
20 min	VTS communication/ requirement and challenge	Tuomas Martikainen – Finnish Transport Infrastructure Agency / Dirk Eckhoff – WSV
1130 – 1145	Group photo	
1145 – 1300	Lunch - Industrial exhibition	
1200 – 1300	Registration for open forum participants	
1300 – 1430	Session 2 – The case for Digital MARCOM	Chair: Jillian Carson-Jackson – NI
15 min	The case for digital maritime communications	Guy Platten – ICS
15 min	Digital Communications supporting seafarer welfare	Anuj Chopra – ESG
15 min	Demand for maritime digitalisation - Maritime Informatics	Mikael Lind – RISE
15 min	Digital Comms to support shipping (case study)	Yushu Horie – TST Corporation
15 min	Digital VHF Voice in port (case study/operational trials)	Derek Love – CLM / Jeffrey van Gils – RWS
15 min	Q & A	
1430-1500	Break - Industrial exhibition	
1500 – 1630	Session 3 –Overview for Digital MARCOM	Chair: Jorge Arroyo – USCG
15 min	State of art digital MARCOM technologies	Yoshihiko Imada – JRC
15 min	IMT technologies based maritime evolution	Hyounhee Koo – 3GPP
15 min	Digital voice over VHF radio	David Rowe – Rowetel
15 min	NAVDAT	Jean Charles Cornillou – Cerema
15 min	Maritime Communication with Satellite - Overview	Woo-Seong Shim – KRISO
15 min	VDES Satellite – Digital data exchange	Lars Moltsen – Sternula
1630-1700	Break - Industrial exhibition	
1700 – 1800	Session 4 – Open forum / Panel discussion	Moderator: Ruri Shoji – TUMST
45 min	Panel discussion: Sec. Gen. / Japan / Singapore / Netherlands	Francis Zachariae / Tsuguo Awai / Capt. Segar / Maarten Berrevoets

10 min	Q&A	
5 min	Summary of day	Hideki Noguchi
1800– 1930	**Workshop Icebreaker** Venue: Marine café in the Tokyo University Dress code: Casual	

DAY 2 – Tuesday, 21st February 2023

Time	Activity	
0900 – 1015	**Session 5 – Digital MARCOM – where we are today**	**Chair: Axel Hahn – DLR**
15 min	General requirements	Alexander Schwarz – IMO
15 min	Manufacturer view	Richard Doherty – CIRM
15 min	Inmarsat services	Peter Broadhurst – Inmarsat
15 min	Other satellite services	Richard Smale – OneWeb
15 min	Q&A	
1015 – 1045	Break	
1045 – 1200	**Session 6 – Digital MARCOM – looking to the future**	**Chair: Omar Eriksson – IALA**
15 min	ITU – digitalisation of Mobile band	Stefan Bober – WSV
15 min	IHO – S100 / SECOM	Svein S. Skjaeveland – PRIMAR
15 min	Maritime Service Platforms	Axel Hahn
15 min	Future skill sets in a digital MARCOM world	Ann Pletschke – Ocean Infinity
15 min	Q & A / close of Open Forum	
1200 - 1300	Lunch	
1300-1500	**Working Groups**	**Chair: Hideki Noguchi**
20 min	Introduction of WG (5 min introduction each) Introduction of WG1 "Operation" Introduction of WG2 "Technologies" Introduction of WG3 "Human factor	 WG1 Chair: Dave Lewald WG2 Chair: Martjin Ebben – Port of Rotterdam WG3 Chair: Jillian Carson-Jackson
10 min	Guidance for the Working Groups	Minsu Jeon
90 min	WG Meetings	WG Rooms assigned: WG1 – Operation WG2 – Technologies WG3 – Human factor
1500 – 1530	Break	
1530 – 1700	**Session 7 – WG meetings**	

DAY 3 – Wednesday, 22nd February 2023

Time	Topics	
0900 – 1030	**Session 8 – WG meetings**	
1030 – 1100	Break	
1100 – 1300	**Session 9 – WG meetings**	
	Continue development of guidance development, moving from defining structure to writing content.	
1300 – 1400	Lunch	
1400 – 1730	**Technical visit**	
1900 - 2100	**Workshop Dinner** Venue: Dress code: Casual	

DAY 4 – Thursday, 23rd February 2023

Time	Activity	
0900 – 1030	**Session 10 – WG meetings**	
1030 – 1100	Break	
1100 – 1300	**Session 11 – WG meetings**	
1300 – 1400	Lunch	
1400 – 1530	**Session 12 – Plenary**	**Chair: Hideki Noguchi**
	WG reports and develop the report including roadmap	
1530 – 1600	**Break**	
1600 – 1730	**Session 13 - Plenary**	**Chair: Hideki Noguchi**

	Develop the report including roadmap	

DAY 5 – Friday, 24th February 2023

Time	Activity	
0900 – 1030	**Session 14 – Plenary**	**Chair: Hideki Noguchi**
90 min	Review the report	
1030 – 1100	**Break**	
1100 – 1215	**Session 15 – Plenary**	**Chair: Hideki Noguchi**
75 min	Review the report	
1215 – 1230	**Session 16 – Closing**	**Chair: Hideki Noguchi**
5 min	Closing remarks from JCG	
5 min	Closing remarks from IALA	
5 min	Closure	

ANNEX C WG 1 OPERATION

Chair: Dave Lewald – Vice Chair ARM Committee

Vice-chair: Dirk Eckhoff – Vice Chair VTS Committee

The outcomes worked towards by WG1 were:

At the establishment of WG1-Operations, a review of individual impressions of the presentations was conducted to organize our work as defined by the Workshop WG1 Terms of Reference (ToR). Several key points of view were discussed and categorized as observations, questions, and recommendations for IALA PAP Committee, IALA ENAV Committee, IALA VTS Committee and IALA ARM Committee consideration. Additionally, the WG identified seven high level themes which may influence the evolution of IALA's remit.

- As IALA's role as a technical authority on digital communications advances, it should incorporate the availability and reliability of communication systems into the general provision of Maritime AtoN Services in the context of e-navigation based upon the volume of traffic and degree of risk.
- Considering IALA's role as a digital communications technical authority is expanding and IALA's responsibilities to provide standards, recommendations, and guidelines related to Maritime Services (MS) in the context of e-navigation, IALA's role must evolve to support services not within IALA's remit.
- IALA should encourage member states to consider the roles, responsibilities, and potential overlap of responsibilities within their own national organization for the provision of Marine AtoN, Marine Safety Information (MSI), and related services to address the requirements of Digital Marine Communication (MARCOM) for the purpose of establishing a cohesive harmonized delivery schema.
- IALA must recognize that a shift in vessel management philosophy of shipping companies is evolving from the sole responsibility of a vessel's Captain and crew to a shoreside management paradigm. Furthermore, it should be noted that this philosophy is not exclusive to MASS operations.
- Cyber security must become a core consideration in all spheres within IALA's remit. Digitalization of the provision of Marine AtoN services must include consideration of Cyber security risk and mitigation solutions. Furthermore, the recognition that Cyber security risks exist with open communication links. It is therefore imperative that IALA develop recommendations and guidelines to support the use of Digital Maritime Communication services.
- IALA should recognize the benefits of Digital Marine Communications and the potential relationship of UN sustainability goals to include decarbonization sustainability.
- IALA should bring in expertise and advice to IMO for the integration of Maritime AtoN service performance requirements. This includes harmonization and standardization on all levels of interoperability including:
    - Communication level (VHF, VDES, IP based, etc.),
    - S-100 Product Specification and Application Specific Messaging (ASM),
    - Communication protocols (IEC-SECOM, etc.), Technical Service Specifications,
    - Orchestration (registration process),
    - Application layer to include portrayal and functionality.

Action Items:
The following observations, questions, and recommendations for the IALA PAP Committee, IALA ENAV Committee, IALA VTS Committee, and IALA ARM Committee are recommended for inclusion in the 2023-27 Work Program.

IALA PAP Committee:

Observations:

- PAP Committee should be cognizant of evolving drivers and trends related to the transition to digital communications and that the need for continued collaboration with other bodies will be necessary to enable successful implementation. Similarly, PAP should be cognizant of potential implications of mandatory IMO/IHO/ITU performance requirement amendments to shoreside service providers.
- PAP Committee should recognize IALA's responsibility to give guidance to service providers for SOLAS and Non-SOLAS vessels alike. Similarly, IALA should consider all available communications services and data formats.
- PAP Committee should coordinate with IMO, IHO, and ITU regarding the introduction of IALA related Products Specifications into the shipboard environment. This coordination requires inclusion of IALA PS into IMO/IHO/ITU timelines and interoperability standards.
- PAP Committee should recognize the reality of third-party service providers within the digital communication sphere. Development of Recommendations and Guidelines related to digital communication systems may include service level agreement standards commensurate with service delivery requirements based upon the volume of traffic and degree of risk. Functional and performance requirements should be considered when developing a system design/architecture; to include but not all inclusive:
    - Reliability
    - Availability
    - Capability
    - Viability
    - Hardware durability with regards to environmental conditions
    - Software (Cyber Security and Maintenance)
    - Technical solutions
    - Life Cycle Management to include Support and Maintenance

Recommendations:

- PAP Committee should include IHO S-100 implementation roadmap timelines in scheduling of S-125 and S-2xx development.
- PAP Committee should recognize the role of S-128 to support machine to machine (M2M) management of S-124, S-125, S-2xx currency.
- PAP Committee should consider use of IEC SECOM during the development of Technical Services descriptions.
- PAP Committee should recognize and consider the impact of the transition from shipside to shoreside decision making philosophy and incorporate this paradigm shift into consideration of drivers and trends.

IALA ENAV Committee

Observations:

- ENAV Committee should recognize the need to development of Digital Communications Guide "Digi-guide" similar in context to the IALA Navguide. This guide should include an overview of existing technologies and their application within the IALA domain. The guide may include emerging technologies and their potential improvements to the provision of Marine AtoN services.

Questions:

- What are the challenges to introduction of digital communication systems globally and what are the potential impacts to timelines related to standards development and implementation of those standards?

Recommendations:

- ENAV is encouraged to continue the migration of the existing Maritime Radiocommunication Plan (MRCP) to a Maritime Communications Manual (MARCOM Manual). This migration should reflect the developments in maritime communications, with a focus on digital communications. Part of this work should include a resource to assist marine AtoN authorities, other shore authorities and IALA members to understand the developments in maritime communications.
- ENAV Committee should develop a Digital Communications Guide "Digi-guide" similar in context to the IALA NAVGUIDE.
- ENAV Committee should lead an inter-committee effort to explore digital communication capabilities and identify key functional requirements to meet emerging operational trends.
- ENAV Committee should develop Recommendation and Guidelines related to minimum level of service and digital communications availability and reliability.
- ENAV Committee should consider technical requirements of digitalized systems and consider development of supporting Recommendation and Guidelines. Note: ENAV Committee is encouraged to engage the IALA ENG Committee regarding PNT requirements related to Digital Communications.

IALA VTS Committee

Observations:

- VTS Committee should consider the potential of digital communication capabilities to reduce dependency on voice communications with emphasis on the following elements;
    - When transitioning to digital voice VHF consider new possibilities of use of text messaging via digital VHF, and Identification validation of transmission source and position,
    - Use of application specific messaging,
    - Development of Product Specifications to include portrayal,
    - Development of Technical Service specifications.
- VTS Committee should identify and develop potential services to enhance vessel traffic management to include consideration of;
    - the appropriate communication delivery method,
    - the appropriate data formats.
- VTS Committee should consider the necessary digital communication infrastructure requirements to support MASS vessels operation within the VTS environment and identify what unique services may be required.
- VTS Committee should provide detailed guidance regarding expectations of MASS vessel requirements to safely operate within the VTS environment.
- VTS Committee should consider and identify future training requirements for VTS personnel related to digital communications and MASS vessel operations within a VTS.
- VTS Committee should identify communication methods such as "push" or "pull" information services in the provision of Maritime Service (MS) Technical Service Descriptions.
- VTS Committee should consider the message acknowledgement management process in digital communication.

- VTS Committee should note that information may be delivered directly to vessels from other sources and VTS Committee should consider how to ensure that VTS has the same information available to achieve common understanding aboard and ashore.

Questions:

- What is the digital communications arrangement between MASS Remote Operating Center (ROC) and VTS Center?
- What will be the implications of IMO's MASS code on VTS communication requirements?
- What changes are foreseen in VTS Standard Operating Procedures (SOP)?

Recommendations:

- VTS Committee should define communication processes to include closed loop "end to end" authentication.
- VTS Committee should define closed loop communication in the digital environment.
- VTS Committee should consider IHO S-1xx implementation timeline and develop strategies to incorporate S-2xx PS.
- VTS Committee should consider appropriate communications methods.
- VTS Committee should recognize the requirement to include S-128 catalogue revision with S-2xx updates when developing the technical service description.

IALA ARM Committee

Observations:

- ARM Committee should consider IHO S-1xx implementation timeline and develop strategies to incorporate S-2xx PS.
- ARM Committee should consider appropriate delivery communications methods.
- ARM Committee should identify communication methods such as "push" or "pull" information services in the provision of Maritime Service (MS) Technical Service Descriptions.

Questions:

- What are the available communication methods for providing the S-1xx / S-2XX layer to a vessel?
- What are the potential impacts on AtoN regarding the digitalization of vessels to facilitate increased conspicuous marking of AtoN and potentially include Artificial Intelligence (AI) recognition?

Recommendations:

- ARM Committee should continue to develop Product Specifications within their remit and the development of these PS should include recommendations for implementation by a member state and identify recommended communication methods.
- ARM Committee should define MSI and AtoN monitoring communication requirements.
- ARM Committee should identify communication methods such as "push" or "pull" information services in the provision of Maritime Service (MS) Technical Service Descriptions.
- ARM Committee should recognize the requirement to include S-128 catalogue revision with S-125 updates when developing the technical service description.

ANNEX D WG 2 TECHNOLOGIES

Chair: Martijn Ebben – Port of Rotterdam

Vice-chair: Michael Strandberg – Danish Maritime Authority

The outcomes worked towards by WG2 were:

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

- Consider the current and future digital communication technologies for both voice and data / advantages and disadvantages of digital technologies, especially
  - A comparison of digital versus analog voice communication, including different encodings;
  - Considering the technology that is regulated (by IMO / SOLAS) versus non-regulated technology;
  - Considering the user requirements and the need for digital technologies, from a seafarer point of view and an authority point of view
- Identify technological issues for the future digital maritime communication infrastructure, especially
  - Bandwidth requirements for the desired data transfer, in particular data used in S-100 services;
  - (Cyber)security aspects and opportunities in the use of new digital technologies;
  - The shared use of technological resources for both safety (MSI) and GMDSS purposes and non-regulated data usage, like crew social – and entertainment usage;
- Develop the road map of the digital maritime communication infrastructure, if possible; and
- Submit a report to the plenary by 23 February

Furthermore, WG2 received a draft Guideline (Marcom manual) as an input paper, requesting review and amendments and a draft table from ENAV30 specifying S-100 properties and requirements towards used technologies.

The work was performed during 6 sessions in which the working group worked on the items mentioned above.

Session 6: A comparison of digital versus analogue voice communication, including different encodings

During session 6 (Tuesday 21 February 2023 13:30 – 15:00), WG2 discussed the options there are for digital voice over VHF, including the pros and cons of known available codecs, in particular the three codecs presented in earlier sessions; AMB+2, RALCWI and Codec 2. Participant Derek Love provided additional information on dPMR protocol and the availability of an additional data stream in the protocol.

The WG named several advantages of the application of digital voice over analogue voice:

a **Higher spectral efficiency** – in analogue VHF voice, a 25 kHz (bandwidth) channel is used, whereas digital voice only requires 6,25 kHz of bandwidth (with dPMR protocol), so up to 4 digital voice channels can be used in the same frequency bandwidth as one analogue channel.

b **Better audio quality** – Digital voice is much clearer and noise is reduced, which makes it friendlier for the end user.

c **Additional data can be sent**. dPMR offer an additional data channel in the protocol, that is limited in capacity (max 600 bps for the data channel), but may be utilised for various purposes, like transmission of a call sign or location. Depending on the applied encryption technology, this might even be suitable for the transfer of a security key or hash if desired.

The WG also named some disadvantages on digital VHF voice:

a **Higher cost** – applying digitalisation will probably lead to higher cost of VHF radios, depending on costs for licencing and code implementation, either in software or hardware

b **More complexity** may be introduced when using an open source codec as it may only exist as code, but no actual implementation options are available and must be created before the codec can be applied to VHF voice. It does, however, offer the option to edit the actual code, which may be an advantage.

c **Additional indication of signal strength** (RSSI) – in analogue voice, when signal reception becomes low, there will be a much of noise, whereas in digital, the audio may simply stop, which makes is hard for the user to determine if a message is not sent or not received in some cases.

The WG concluded that it is for the most part transparent for the end user if analogue or digital voice communication is used and that a list of user requirements should be used to determine the need for – and benefits from the digitalisation of VHF voice and if so, which codec would be the best option.
Options for digital voice communication using other technologies, eg a smartphone, are not considered viable, as it is not a broadcast medium and relies on third parties/infrastructure.

Backward compatibility should be accounted for, as there will be a long transition time from analogue to digital.

Other findings are:

a VHF voice communication, either analogue or digital, remains a robust communication method for the maritime industry as it does not depend on a third party, like a service provider, but is direct communication between sender and receiver, while everyone in the vicinity is able to hear the communication, as a result of the broadcast technology.

b When used in MASS (in the context of remotely operated vessels), VHF voice communication will have to be sent over another technology to the actual operator, but there is yet no regulation for that data transfer.

c When used in MASS (in the context of autonomous vessels), there will be no human available to reply verbally to a VHF call. The WG suggests to have a ship send automated, standardised or AI-generated audio replies in that situation. As this is currently a hypothetical situation, no conclusions were drawn.

d Special attention should be paid to VTS stations, as migration to digital voice will lead to high investments.

e Not all channels have to be digitised, analogue channels may remain and equipment will work with both in most cases. Especially channels designated for safety communication may remain analogue.

f When utilising an additional data channel for GNSS information, it should be noted that an integrated or connected GNSS receiver must be present to be able to sent the data.

As part of the input draft guideline, a review and update was performed to the table in Appendix 2 of the draft Marcom Manual; a comparison between analogue and digital voice.

#	Consideration	Digital Maritime VHF Voice Radio	Analogue Maritime VHF Voice Radio
1.	RF Spectrum efficiency	Up to 4 voice channels per 25 kHz	1 voice channel per 25 kHz

#	Consideration	Digital Maritime VHF Voice Radio	Analogue Maritime VHF Voice Radio
2.	RF spectrum co-existence properties	Similar to Analogue Maritime VHF Voice Radio	
3.	Speech quality	Consistent until the Bit Error Rate (BER) exceeds the capability of the FEC to correct errors, at which point it goes silent. There is some tolerance to low values of packet loss. Removal of background noise leads to lower stress on the listener. User feedback can be provided based on the Signal Quality Indication (SQI).	Degrades with signal strength when approaching low signal to noise ratio i.e. <12dB SINAD. As the signal degrades, the stress on the user increases due to the attention that needs to be paid to understand all messages. Analogue radio degrades elegantly.
4.	Forward Error Correction (FEC)	Forward Error Correction (FEC) compensates for bit errors.	None
5.	Data channels other services	MMSI or ATIS identification/addressing is built-in to the protocol when using ETSI TR 103 784. Slow data channel available for GNSS reporting during a voice call, enhancing safety and security. Status and SMS style message facilities available in the protocol. Protocol can be expanded for future uses. Other protocols may offer similar features, but are not optimised for maritime operation	Not available. DSC for addressing and alerting is available on a separate RF channel.
6.	Range	Similar to Analogue radio (using COTS equipment from LMR/PMR).	
7.	Priority allocation	Possible.	Only available through the DSC service.
8.	Intellectual Property (IP)	Protocol is open (ETSI TS 102 490 and TR 103 784). Codecs have IP but are available under FRAND (AMBE+2 and RALCWI). One “open-source” option (Codec-2) is available but requires evaluation and development.	None.
9.	Regulation	IMO, ITU, IALA, CEPT, etc.	IMO, ITU, IALA, CEPT, etc.
10.	Testing	IEC, NMEA, ETSI	IEC, NMEA, ETSI

This table is also included in the attached Excel file

Session 7: Considering the technology that is regulated (by IMO / SOLAS) versus non-regulated data (transport)

The workgroup discussed that there are 3 variations of technology with regards to regulation

1 Fully regulated technology/communication, mainly by SOLAS. Regulation applies to equipment used, the transport mechanisms and the service/messaging. This is mainly the case for MSI communication.

2 Data transport is non-regulated; a good example is ECDIS, where the system and presentation of data is regulated, whereas the means of transporting the data to the system is not.

3 Data and transport technology are not regulated.

A fourth category may be specified where local (national/port) regulations apply, for example port call regulations.

The WG noted the following:

a SOLAS regulation only applies to SOLAS vessels, while there are many more non-SOLAS vessels then there are SOLAS-vessels.

b MSI should primarily be received via GMDSS for SOLAS vessels. Non-SOLAS vessels may be allowed to use non-regulated methods.

c In the second variation, attention should be paid to cyber security aspect, as a regulated device may not adhere to all modern cyber security standards. The used transport mechanism (e.g. internet), may introduce cyber risks.

d If users (seafarers) depend on non-regulated devices in daily use, like a smartphone app instead of their ECDIS, they may "forget" how to properly use the regulated devices in the case of an emergency, which may lead to additional safety risk.

Based on these observations, WG2 comes to the conclusion that alternatives to regulated technology may be useful for non-SOLAS vessels but should only be used in addition to the regulated system. The room for innovation is mainly in variations 2 and 3, but attention must be paid to cyber security risks.

Session 7: Considering the user requirements and the need for digital technologies, from a seafarer point of view and an authority point of view.

On the topic of user requirements, WG2 collected a list of potential new technologies that may assist users, whether seafarer or authority in more efficient, safer or more comfortable ways to perform their duties. This applies in particular to non-SOLAS vessels:

i Additional navigational information, like a second view on a smartphone or tablet. This may be useful for both seafarers as for shore authorities and may be internet / API based.

ii As an example, for pilotage: most important is what information is needed by a pilot to perform its job. Connectivity is very important in this matter; LTE/4G/5G is available when close to the coast, but what is the alternative when a pilot is further out? The pilot may utilise a high speed internet connection provided by the vessel.

iii In a MASS situation, all extra information is welcome, from situational awareness to steering wheel position. There are many connectivity options available.

1. In ports or close to the coast, LTE/4G/5G technology, or maybe directed Wi-Fi may be used.
2. More than 10 NM off the coast, there may be options like 5G repeating or a mesh network.
3. On open sea, satellite communication is the only viable option.
4. Redundancy in communication technologies is recommended, like multiple

satellite providers or LTE + VDES.

The WG took note of two relatively new standards:

- DECT-2020 (ETSI TS 103 636-1) that may offer viable options for the coastal areas and in mesh networks. The standard was added as an appendix.
- ETSI EN 303 276: Maritime Broadband Radiolink in the 5 GHz band. The standard was added as an appendix.

iv A seafarer may benefit from extra data sources for navigation, namely from VTS stations. These could be e.g. environmental services or other aids to navigation.

v Ships may function as additional, mobile sensors (radar, AIS) for VTS shore stations to improve the VTS data quality.

vi A VTS authority may be a data provider for ships and provide valuable information, like port call information.

vii Internet-based services for crew welfare and non-safety or ship-owner information like engineering information, supplies, predictive maintenance data and non-urgent medical communication

All information / communication should be categorised in terms of importance. This will eventually lead to requirements and/or SLA's.

Session 8: Bandwidth requirements for the desired data transfer, in particular data used in S-100 services.

The WG worked on the table in appendix 1 of the draft Marcom Manual that is an input document for the workshop. The table was amended, both in data on the mentioned technologies, but also added technologies that appear to belong in the table. The table has not been finalised by the WG, and it is suggested that the VTS or ENAV committee works on the contents of this table during the new working period.

The WG worked on the draft table with S-100 services and their properties from ENAV30, that is input for the workshop. In a plenary discussion, the rows and columns of the table were evaluated and altered or amended to. The table itself was not filled and the WG suggests that it is filled by the ENAV committee during the new working period. The WG concluded that this table may provide valuable insights and support decision making on technology choices for S-100 data in the future.

Both tables are in attachment.

Session 9: (Cyber) security

Based on the findings in the previous sessions, WG2 had a plenary discussion on cyber security aspects of the technologies and services named and identified. As cybersecurity was mentioned in almost every presentation during the first 5 sessions of the workshop, the WG started the discussion from the standpoint

"Always secure unless technically impossible or undesirable".

This standpoint leads to the general recommendation to develop all future technology in a cyber resilient manner.

With that in mind, the following questions were asked for each technology and service:

- Why would we NOT encrypt this communication/data?
- Why would we NOT authenticate this communication/data?
- Should the communication or access to the data be subject to authorisation?
- How can the communication/data be encrypted and/or authenticated?

The result is included in the table in attachment.

Session 9: The shared use of technological resources for both safety (MSI) and GMDSS purposes and non-regulated data usage, like crew social – and entertainment usage

The WG2 had a short discussion on the shared access of communication and technology. In the near future, it is likely that vessel communication links, in particular internet links, will be shared for both safety and other use, like crew entertainment. This may lead to conflicts that result in safety issues.

The conclusion of the discussion is that there are several ready-to use networking technologies, like Quality of Service (QoS) and bandwidth management available to ensure that safety information is received (or transmitted) is prioritised, but that is no common practice to implement these on vessels, as this is advanced network configuration. The WG recommends that guidance is developed by relevant bodies, in corporation with IALA, to incorporate these technologies in solutions for vessels.
Furthermore, the WG suggests that IALA actively seeks to include more advanced network/IP knowledge in the committees as many future technologies depend on internet-based technology.

Session 10 was used for a review of the preliminary report of WG2.

Session 11: Develop the road map of the digital maritime communication infrastructure, if possible

The general understanding of the WG is that this item may contribute to the work program of IALA for the new working period and that it should contribute to existing timelines as already defined by IALA or other bodies.
The following topics were identified by WG2:

- Digital voice
    - The WG acknowledges the action items on the digitization of VHF voice already defined for the new working period.
- VDES
    - Provide guidance on the implementation of VDES for shore authorities as stated in the work programme for the new work period.
- NAVDAT
    - The WG acknowledges the action items on the implementation of shore infrastructure for relevant shore authorities already defined for the new working period.
- S-101 ECDIS (from 1-1-2026)
    - Develop guidance for shore authorities on building shore-to-ship communication infrastructure that can support e-navigation services (e.g. MCP), referencing ENAV action items 2.3 and 2.4 in the work programme.
- Other S-xxx services
    - Develop guidance on harmonised communication technologies used for the promulgation of S-xxx data.
- Satellite services / internet
    - Develop information (e.g. in the Marcom Manual) on the capabilities and limitations of satellite communication technologies and the differences of various satellite service providers and the characteristics of LEO versus MEO and GEO. For some regions there may be specific features to include, that are still investigated within IALA.

The WG noted that the work programme for the new working period has a work item on digital voice that speaks of MASS which might be out of context.

ANNEX E WG 3 HUMAN FACTOR

Chair: Jillian Carson-Jackson

Vice-chair: D Kumaran Raju

WG3 worked within the scope the terms of reference:

a) Consider human factors including portrayal on digital maritime communication/ benefits and issues to be addressed when deploying and using digital communication both voice and data, especially
   - Cognitive factors (affecting how we think)
   - Distractions / added stress / information overload
   - Prioritisation (information / presentation of information)
   - Use interface / interaction with the technology

b) Identify human issues including training and educational needs for the digitalization of maritime communication
c) Identify issues to bring forward to the work period 2023-2027
d) Submit a report to the plenary by 23 February.

In consideration of ToR element 1, the human issues including training and educational needs to be considered. Possible actions for IALA work period 2023-2027 are included as recommendations, as appropriate, within the different sections of the WG 3 report.

1 CHALLENGES AND OPPORTUNITIES

At the establishment of WG3-Human Factors, the WG members discussed observations of the presentations, identifying challenges and opportunities to address these challenges. The results of the discussion are consolidated in Table 1.

Table 1 Overview of challenges identified from Presentations

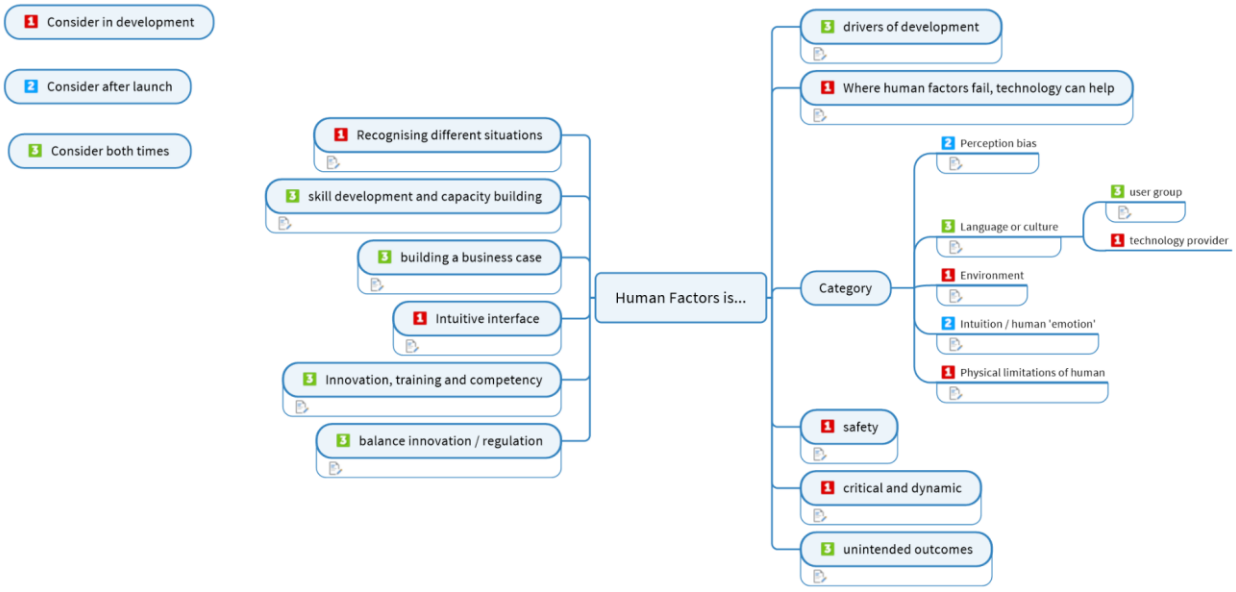
Challenge	Options to address	Comments
Cyber Security	• Develop additional skill for seafarers / VTS operators • Firewall / technical solutions	• Concept of 'cyber hygiene' • Ongoing monitoring • Use of tools to alert of possible un-secure operations
Fatigue	• Manage workload / work hours • Distributing roles and responsibility (delegating based on user roles) • Presentation of content 'as needed'	• Considering 'noise' and fatigue – environment, multiple task, human limitations • digital communications methods use rule base to provide information in intuitive manner, based on user roles.
Information overload	• Prioritising information, use of tools to assist decision making	• Criticality / need for action – must do, should do, could do, delegate
Managing conflicts and individual perception	• Addressing different operational needs, cultural norms & aspects, including language • Options in digital tools to reflect cultural norms	• Global approach - Setting agreed standards, recommendations, guidelines / common standards (objectives) • Gather and manage user expectations, perceptions of challenges
Generational aspects	• Training • mentoring up – technically confident support those who are becoming confident with digital marcom	• Adapting to technology; thinking differently

Challenge	Options to address	Comments
		• Opportunity to learn from other industries / digital areas – i.e. gamification, edutainment
Digital Competence (digital intelligence)	• Training / knowledge on what technology should do, knowing when it isn't working	• Digital competence will change over time / generational changes

1.1 Defining Human Factors in Digital Maritime Communications

The working group discussed aspects of human factors with a specific reference to digital maritime communications. The summary of the outcomes of the discussion were captured in a mind map, which is available on the workshop file share. The overview of the mind map discussion is provided in Figure 1.

Figure 1 *Mind Map on Human Factors within digital maritime communications*



The WG noted the concepts of Human Factors are well established in research, including PhD Thesis (as provided to the WG) and IMO MSC.1/Circ.1512 (Guideline on Software Quality Assurance and Human-Centred Design for E-Navigation) and IALA G1171 (Human Factors and Ergonomics in VTS).

The concepts within IALA G1171 were highlighted, and this Guideline could be reviewed at a holistic level, providing guidance beyond the VTS specific operational environment.

1.2 Observations

Human Factors is well established, with specific guidance available within the maritime industry. There is opportunity to build on this, and the work of other industries, in the digital transformation of the maritime environment, with a specific focus on digital maritime communications.

1.3 Recommendation

IALA consider transferrable elements from G1171 for possible relevance in other areas of IALA.

2 HUMAN FACTOR CONSIDERATIONS IN DIGITAL MARITIME COMMUNICATIONS

With specific reference to element 1 of the ToR, the WG considered human factors including portrayal on digital maritime communication/ benefits and issues to be addressed when deploying and using digital communication both voice and data, with a focus on:

- Cognitive factors (affecting how we think)
- Distractions / added stress / information overload
- Prioritisation (information / presentation of information)
- Use interface / interaction with the technology

The working group also reviewed work on digital VHF voice communications.

The concept of trust was highlighted, and discussion on how to achieve this trust. Options can include addressing expectations, providing tools that support operational requirements with reliable, relevant and authenticated data.

2.1 Cognitive factors

Noting that cognition is ''*the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses'* the WG identified that digital communication could be designed to work with the human. This included:

Two-way communication

- digital data to be provided, but then also the concept of response (i.e. 'being read').
- Option for automated responses in some cases, with indication that the information was received and responded to.
- Depending on the priority of information, a hierarchy for response was discussed, where more critical communications required human intervention, and routine communications would not require human intervention.

Display of digital data

Digital data could be displayed in a 'language independent' manner, using pictographs for common elements and the option to display in language of choice

display of data, including alerting, to reflect time of day and circadian rhythms. For example, during night operations, visual and audio alerts to address the natural 'low' and changed response time of operators.

The concept of 'sensory display' was discussed, with options for tactile information. For example, use of wearables to provide vibration when critical digital information is received.

2.2 Distractions / information overload

The ever-increasing digital data provision has already resulted in 'information overload'. Effective human machine interaction can result in a reduction, or management of, distractions and information overload.

Existing measures, such as single window concept, were noted. Additional elements identified include:

- Standard operating procedures that reflect human-machine interaction (machines doing what they do best, humans doing what they do best, with a focus on a specific outcome)
- The use of Artificial Intelligence within the digital maritime communications concept; a 'software assistant' to support the user to manage the amount of data
- Building in training program systems to support the user and address 'upgrades' in systems.

2.3 Prioritisation (information, presentation of information)

In the discussion on prioritisation of information, presentation of information, reference was made to existing priorities for communications within the maritime industry. With this in mind, at a high level, the following priorities were noted:

- make a task of list of the information: first come // first addressed, but noting priority of communications
- make a classification of the information:

    1. distress

2. urgency
3. safety
4. important
5. general information

- delegate the responsibility to the authorised personnel (included the decision making
- determined SOP in giving instructions based on the prioritisation of information

2.4 User interface / interaction with technology

There are many existing references to human factors and user interface / interaction with technology. Specific with regards to digital maritime communications, the WG noted that some issues are also benefits, with additional comments as noted in Table 2

Table 2 User interface/interaction with technology

Issues	Benefits	Comments
Lots of information	Lots on information	Manage information overload / use technical tools to assist
Need for customization	Ease of interaction	recognise the human / the role
Security of information	Trust information	Need to consider cyber security
Alarms / alarm overload	Provide alarms and alerts	Can have too many or too few Relates to cognitive factors, time of day / circadian rhythms
Automation leading to complacency	Automation of functions – routine activities	i.e. VTS operations – ETA/ETD – reference TST presentation
Interaction with digital data	Sensory display / haptic	Confirming, building trust Consider 'language independent'

The WG highlighted the need for training that focuses on digital intelligence and addresses the generational aspects. Elements that may also be considered: student based – existing/those joining the industry; Recertification; continuing professional development and competence. There is a need to address the transitional period as well as look to the future worker base and changing requirements for training.

2.5 Observations

Digital maritime communications provide opportunities to share the cognitive load, but only if human factors are considered at all levels of development. Specific examples include:

- Human-machine interface – georeferencing positions and information; language independent communications (pictographs)
- Digital VHF voice communications – voice intelligibility and quality, retaining ambient noise (supporting situational awareness and context)
- Digital data transfer for frequent, routine communications – for example, ETA/ETD notification in VTS
- Provision of text to supplement voice – providing a record of communications, enabling translation to language of choice

Addressing transitional and generational aspects of digitalisation goes beyond structured training, and includes:

- mentoring (mentoring-up);

- providing intuitive user interface;
- addressing time-of day aspects / circadian rhythms
- minimizing errors through 'rules' in the system

The requirement to address training in digital maritime communications, and digitalisation in general, will reduce through familiarity with the tools.

3 DIGITAL VHF VOICE COMMUNICATIONS

The WG reviewed the developments of digital VHF voice, listening to a series of different phrases through three specific CODEC (enCOde/DECode). Based on the discussion, it was noted the following elements will be critical in considering digital VHF voice:

- Clarity of the voice – sounds human (not like a robot)
- Voice intelligibility (able to understand what is being said)
- Voice quality (able to understand tone, inflection, state of mind)
- Degradation (graceful) – at edge of range, still hear, same as existing
- Reduction of, but maintain ability to hear, ambient noises (background sounds)
- Addressing the generational aspect – expectations / need to adapt
- Introduction / Transition to digital VHF – both analogue and digital working at the same time (multi-mode radios that can use both digital and analogue)
- Address the different accents / voice intonation – note non-English speakers using maritime English (SMCP, IALA G1138)
- Suitable for all users – fixed and hand-held devices, small craft (pleasure craft, fishing vessels, yachts)

3.1 Recommendation

To evaluate the different options for digital voice over VHF radio, the WG recommends a staged approach:

VTS Committee

- The VTS Committee be requested to provide files on digital voice communications – using G1138 and SMCP phrases from persons who are not English first language speakers record 8 phrases (suggest to choose 5 phrases from G1138 using message markers Information; Question; Recommendation; Advice; Instruction; a phrase using two message markers; a security broadcast and an urgency (Pan Pan) broadcast. Each person recording to use the exact wording, to facilitate 'like for like' comparison.
- These phrases can be recorded on computer or smart phone devices, ideally saved in a wave file. These files to be forwarded to the ENAV Committee
- VTS Committee to prepare an assessment rubric for review of the voice files once put through different codec. There are existing rubrics that can be reviewed, which could be adapted noting the list of elements identified in section 3.

ENAV Committee

- Experts in the ENAV Committee to convert these using different codec available. D Love agreed to review the files and put through different codec.

VTS and ARM Committee

- VTS and ARM Committee review the resulting audio files and assess based on an intelligibility and quality assessment methodology developed by the VTS Committee.
- The outcomes to be considered by IALA, and forwarded, as appropriate, to ITU for consideration in the ongoing agenda item on digital VHF voice in the maritime mobile band.

4 THE 'WHO' AND 'WHY' OF DIGITAL MARCOM

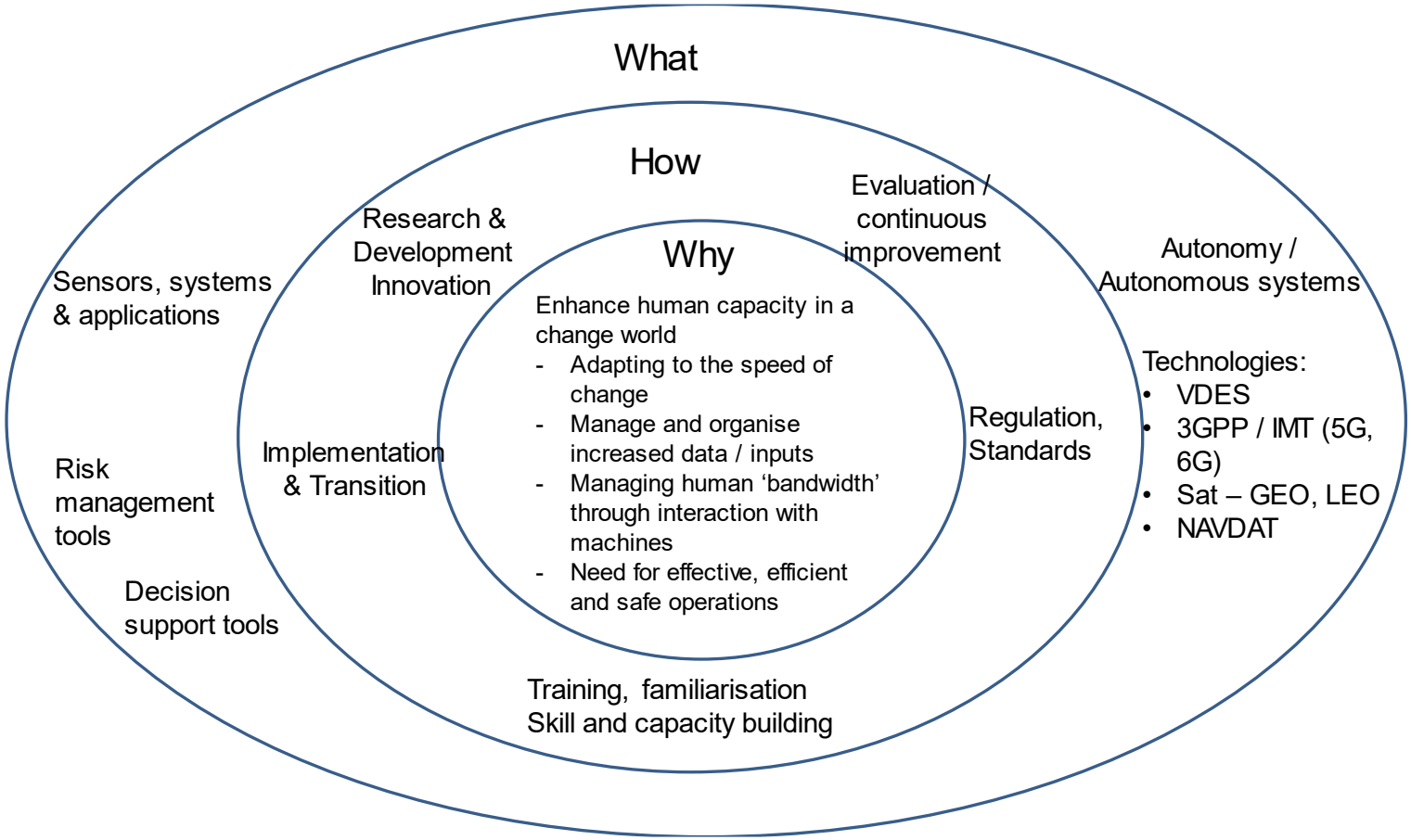
The WG considered the expectations for, and of, digital marcom from different perspectives. These were compiled into a Mendelow Matrix table (Figure 2) to address the need to communicate developments in digital marcom and a 'Golden Circle' (as referenced by Simon Sinek 'Start with Why') (Figure 3).

Figure 2 *Mendelow Matrix for 'stakeholders' in digital marcom*

NOTE – POWER has two elements – Economic (E) and Regulatory (R)

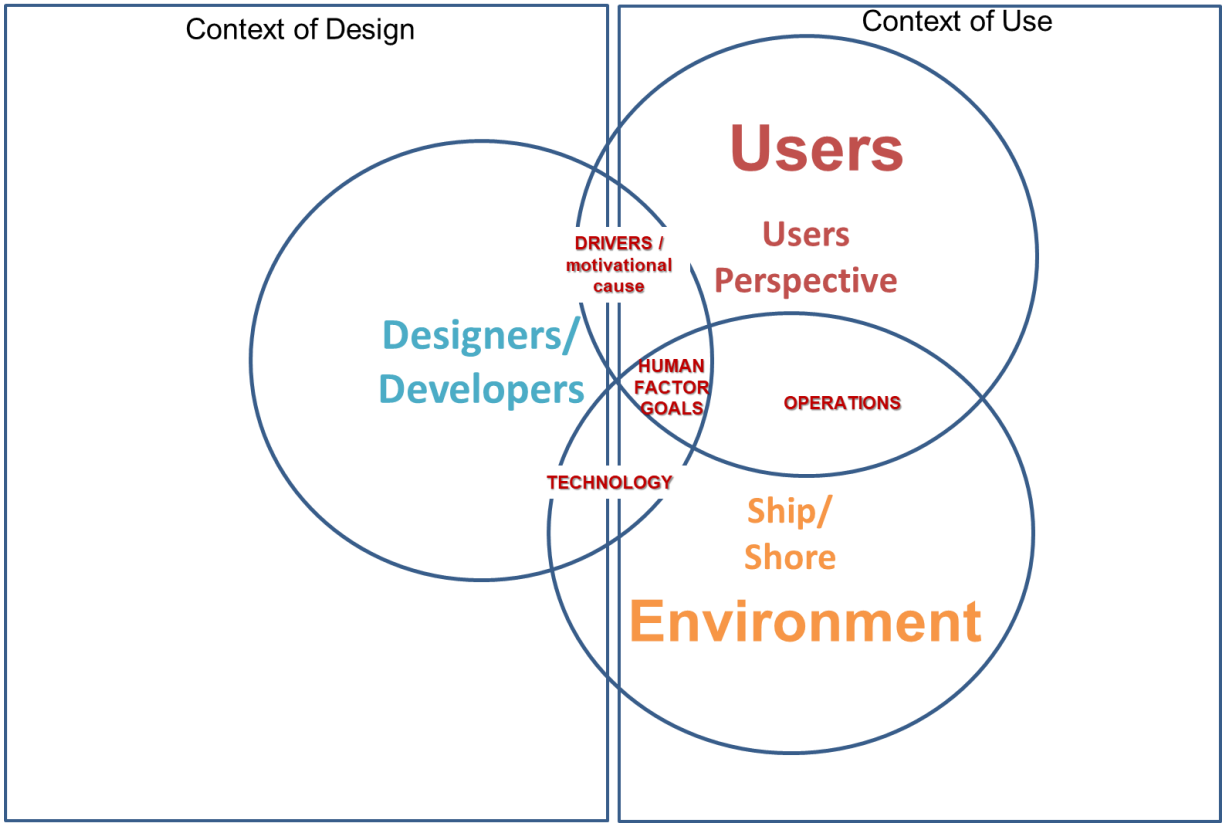
Power	Low Interest	High Interest
High	**Keep Satisfied** • Allied Services	**Manage Closely** • Government Authorities • Port Operators • Vessel operators – seafarers • Coast Guard • Ship owner (E) • IALA (R) • IMO (R) • ITU (R) • SAR • Meteorological Station • Applied research & Development
Low	**Monitor** • General public	**Keep Informed** • Contractors to implement • Service Provider • Training institute • Small boat users – pleasure craft / fishermen • VTS/Coast Radio Station Operator • Pilots • Customs • Innovators / start-ups (commercial) • Research & Development (academic)

Figure 3 The 'Why' for digital marcom



5 CONTEXT OF DESIGN AND USE

Noting the input received by the group, the concept of design / concept of use of digital marcom was discussed. This resulted in the development of a concept document, which may be considered for further development within IALA.



6 SUMMARY OF DISCUSSIONS

The WG summarized the overall discussions on digital marcom:

- Effective and efficient communications
- Focus on the 'why' for communications / benefits of digital communications
- Recognising human factors in at all levels and throughout the development life-cycle
- Continual improvement / sustainability for safe and secure operation
- Optimal use of the resources without loss of usability
- Assess potential risks to develop solutions (technology to support operations, not operations designed for technology)

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