Report on the Workshop on Sustainability in AtoN provision

WORKSHOP REPORT

06 to 10 October 2025

Irish Lights

Dublin, Ireland

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30 October 2025

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International Organization for Marine Aids to Navigation

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Executive Summary

The workshop on Sustainability in AtoN provision was held between 06 and 10 October 2025 in Dublin, Ireland.

The workshop was well attended with 49 participants from 17 countries.

The workshop participants considered the various presentations that were given, and the following were concluded:

- The UN Sustainable Development Goals (UNSDG) remain relevant as guiding principles for sustainability, and that IALA and its members should focus on the most relevant goals to the marine AtoN and VTS community. IALA should consider revising Recommendation R1004 and other relevant publications with this in mind.

- Climate scientists have demonstrated that climate change presents one of the biggest threats to quality of life on Earth, and that all IALA members should do everything possible within their remit to minimise human impact on this.

- The IALA World-Wide Academy should continue to promote training and capacity building initiatives to ensure that the AtoN and VTS operations use qualified and competent personnel, including the development of relevant skills for sustainable operations.

- IALA should develop and promote a sustainability public document based on the discussions and output of this workshop. This is to ensure that sustainable practices are encouraged and supported in the IALA community and beyond, including the future revision of IALA's Strategic Vision.

- IALA should continue to facilitate the sharing of experiences, collaboration and practical application on sustainability matters through IALA events.

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Report of the Workshop on Sustainability in AtoN provision

1. INTRODUCTION

The Irish Lights hosted a workshop in Dublin from 6 to 10 October 2025, to encourage sustainable provision of Marine Aids to Navigation (AtoN) by providing a set of fundamental principles and practical guidance that will help an authority deploy and manage AtoN.

Forty-nine participants from 17 countries participated in the Workshop, plus six members of the IALA secretariat, including IALA WWA.

2. SESSION 1 – OPENING OF THE WORKSHOP

This session was chaired by Alwyn Williams, Chair of the Workshop and IALA ENG Committee. The Secretary was Alisa Nechyporuk, and the Irish Lights organised the logistics for the event. IFAN kindly sponsored the event.

2.1 Introduction from Host, Yvonne Shields O'Connor – Irish Lights

The IALA Sustainability in Aids to Navigation Workshop was officially opened in Dublin by Yvonne Shields O'Connor, Chief Executive of Irish Lights. In her welcoming address, she extended a warm Irish welcome to the Secretary-General, Deputy Secretary-General, the Director of the World-Wide Academy, IALA Secretariat, the Workshop Chair, delegates, speakers, and guests from over 20 countries.

She highlighted the maritime heritage of Dún Laoghaire, where the event is hosted, noting its historic piers, sailing clubs, and the National Maritime Museum. Commended IALA for organising the sustainability workshop in partnership with Irish Lights, emphasising the shared goal of achieving safer, more innovative, and more sustainable seas.

The opening remarks underlined key challenges facing the maritime sector, including decarbonisation, offshore renewables, artificial intelligence, and climate resilience, especially considering recent extreme weather events. Two keynote speakers — Dr. Hans-Martin Füssel and Professor John Sweeney — were introduced for their expertise in climate risk assessment and climate change action.

The Chief Executive also referenced the upcoming International Marine Lighthouse Tourism and Maritime Heritage Conference in Dublin Castle, where over 200 delegates will discuss heritage management and global collaboration. She presented Irish Lights' *Great Lighthouses of Ireland* initiative as a successful model of lighthouse tourism and heritage preservation, with 16 sites contributing €33 million annually to the economy.

Sustainability and safety were described as interlinked priorities in Irish Lights operations. Most lighthouses now operate on solar power and LED systems with remote monitoring, but further work is ongoing to embed sustainability across asset lifecycles, vessel operations, and environmental protection.

The address concluded with an emphasis on shared responsibility within the global AtoN community to ensure resilient, sustainable infrastructure and trustworthy navigation systems for the next generation.

Participants were invited to engage actively in the discussions, field visits, and social events throughout the week.

Yvonne Shields O'Connor closed by expressing gratitude to IALA's Secretariat, Chairs, Irish Lights staff, sponsors, and partners, and wished all attendees a successful and productive workshop.

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

Francis Zachariae, Secretary-General of IALA, on behalf of IALA, extended sincere appreciation to Irish Lights for hosting the Sustainability Workshop and the upcoming ENG Committee meeting, acknowledging the efforts of the Irish Lights team of Yvonne, Clodagh, Chris, Sarah, and the organizing team, as well as the ENG Committee Chair and Vice-Chair, Alwyn and Michel.

He highlighted that Dublin provides an ideal maritime setting for the event, with Ireland's long-standing seafaring heritage and iconic lighthouses symbolizing safety, resilience, and a deep connection to the sea.

A key focus of the upcoming ENG Committee discussions is digitalisation, closely linked with decarbonization and sustainability. IALA supports this transition through initiatives such as Green Corridors and the digitalization of waterways, which can reduce maritime emissions by over 38%. Participants were encouraged to engage actively in discussions, explore new sustainability solutions beyond traditional technologies, and contribute innovative ideas for future IALA initiatives.

The Secretary-General reported that IALA is thriving, with 42 Member States and a total of 350 members — the highest in its history. He announced that in November, the IMO Assembly will endorse a new cooperation agreement with IALA, elevating the Organization's status from consultative to equal partnership with IMO and IHO.

He also confirmed the successful completion of IALA's transition from an Association to an Intergovernmental Organization, with an extraordinary Council meeting scheduled for 20 November to dissolve the former Association and celebrate its achievements formally. An agreement with the French Government will soon enable the purchase of IALA's new headquarters in France.

Looking ahead, the next IALA Conference will be held in Mumbai, India (1–5 November 2027), and preparations are already underway. A VTS Symposium is tentatively planned for January 2029.

The Secretary-General concluded by encouraging all participants to take full advantage of the week's events, including the Sustainability Workshop, working groups, and the ENG Committee meeting, emphasizing collaboration, innovation, and shared purpose toward a greener maritime future.

2.3 Workshop Aims and Objectives, Alwyn Williams

Alwyn Williams opened the session by outlining the aims and objectives of the IALA Sustainability Workshop held in Dublin. He emphasized that the event builds upon existing IALA work, particularly *IALA Recommendation R1004 on Sustainability*, which encourages all IALA members and Marine Aids to Navigation authorities to support the United Nations Sustainable Development Goals, implement formal systems to protect the marine environment, and promote sustainability to minimize the impact on global resources.

He highlighted that the purpose of the Workshop is not to start from scratch but to strengthen the collective understanding of sustainability within the IALA framework. Sustainability, he noted, encompasses not only environmental aspects but also the maintenance of key professional skills, advancement of digitalisation, management of modernisation processes, preservation of maritime heritage, and ensuring operations remain sustainable in the long term.

The Workshop focuses on several key thematic areas relevant to the work of the ENG Committee and IALA as a whole:

- Aids to Navigation Management and how to ensure long-term sustainability of physical and digital infrastructure.
- Vessel Traffic Services Management and the role of VTS in improving operational efficiency and reducing emissions.
- Digitalisation and modernisation, including the integration of new technologies such as AI and automation.
- Engineering and Heritage, addressing the balance between innovation and preservation of historical assets.
- Sustainable Operations, exploring ways to measure and maintain sustainability performance across all maritime domains.

Alwyn Williams also provided an overview of the Workshop structure, which combines presentations, discussions, and collaborative sessions. The programme includes keynote addresses on environmental and climate challenges, technical presentations on IALA sustainability initiatives, and a series of working group meetings aimed at developing practical recommendations.

He underlined the importance of active engagement from all participants, encouraging them to contribute ideas, share examples from their own authorities, and take part in shaping future sustainability practices. The outcomes of the working groups will form the basis for identifying next steps and potential future actions for the ENG Committee and the wider IALA community.

Participants are also invited to attend the *International Marine, Lighthouse Tourism and Maritime Heritage Conference* on Wednesday morning, offering an opportunity to connect sustainability with heritage and tourism. A Workshop Dinner sponsored by IFAN was planned to take place later in the week, providing an informal setting to continue discussions.

In closing, Alwyn Williams reaffirmed that the Workshop's objective is to bring together knowledge, innovation, and collaboration to support IALA's mission of ensuring safe, efficient, and environmentally sustainable navigation for the future.

Presentations from the Workshop can be found on the IALA fileshare.

A list of participants can be found in Annex A.

The full programme of the workshop can be found in Annex B.

2.4 Key Climate Risks, Dr Hans-Martin Füssel – European Environment Agency

Keynote speaker, Dr Hans-Martin Füssel, Senior Expert at the European Environment Agency (EEA), presented insights from the first European Climate Risk Assessment (EUCRA), which he coordinated from 2022 to early 2024. With over 25 years of experience in climate change research and policy, Dr Füssel has worked with leading institutions including the Potsdam Institute for Climate Impact Research, Stanford University, and the European Environment Agency.

EUCRA represents the first systematic assessment of climate risks for Europe, identifying and evaluating over 36 key risks to ecosystems, society, and the economy. The assessment is designed to guide EU institutions and Member States in strengthening resilience and adaptation policies across multiple sectors.

Dr Füssel emphasised that Europe is the fastest-warming continent in the world, with climate impacts becoming more pronounced as global warming approaches 1.5°C above pre-industrial levels. Recent trends show intensifying heatwaves, droughts, wildfires, coastal flooding, and biodiversity loss, posing escalating threats to both natural and human systems.

Certain regions are already emerging as hotspots of climate vulnerability. Southern Europe faces increasing challenges from heat stress, water scarcity, and wildfire risks. Low-lying coastal regions across northwestern Europe are threatened by sea-level rise and storm surges. Mountain areas experience accelerated glacier retreat and changes in freshwater availability. EU outermost territories are exposed to tropical cyclones, ocean acidification, and biodiversity degradation.

Dr Füssel highlighted that climate risks often cascade across sectors. Extreme weather events can disrupt food production, energy supply, and transport infrastructure simultaneously, creating compounding impacts on health and economic stability.

While Europe has made progress in adaptation planning, societal preparedness still lags behind the increasing pace of climate risks. Urgent and coordinated action is required to prevent irreversible impacts, including accelerating adaptation through proactive measures, integrating climate resilience into economic, environmental, and infrastructure policies, and enhancing cross-sectoral cooperation among European, national, and local authorities, as well as with private sector and civil society stakeholders.

Dr Füssel also outlined the European Commission's plans to update the EU Climate Adaptation Strategy and link risk information with financial, transport, and health policies to strengthen systemic resilience.

He underlined that climate risks are directly relevant to the maritime domain. Rising sea levels, changing storm patterns, and coastal erosion affect the reliability and positioning of marine infrastructure, including Aids to Navigation (AtoN), ports, and communication systems. He encouraged IALA Members and Marine Aids to Navigation authorities to consider climate risk assessments and sustainability frameworks in their planning and operations. These efforts align with IALA Recommendation R1004, which encourages members to support the United Nations Sustainable Development Goals (SDGs) and to implement formal systems to protect the marine environment, promote sustainability, and reduce environmental impact.

Dr Füssel concluded by reaffirming the EEA's commitment to supporting evidence-based policymaking through open data, knowledge sharing, and strategic cooperation. He called for continued collaboration between environmental and maritime sectors to ensure that Europe's navigation systems and coastal infrastructures are resilient, sustainable, and prepared for the challenges of a changing climate.

The presentation was followed by a discussion highlighting potential synergies between IALA's sustainability initiatives and the EEA's climate risk assessment work, reinforcing the importance of cross-sectoral dialogue and shared responsibility for environmental stewardship.

Key messages included the need for urgent and anticipatory adaptation measures, long-term policy planning, and cross-sectoral collaboration to build resilience. The EEA continues to support European and national policymakers by providing evidence-based data, fostering partnerships, and promoting informed decision-making to achieve a climate-resilient Europe.

3. SESSION 2 – OPENING OF THE WORKSHOP (CONTINUED)

Alwyn Williams, Chair of the Workshop and IALA ENG Committee, chaired this session.

3.1 Update on Climate Change Predictions, Prof. John Sweeney – Irish Climate Analysis and Research Units (ICARUS)

Keynote speaker, Professor John Sweeney, the Irish representative on several European academic bodies, is a contributor to the reports of the Intergovernmental Panel on Climate Change (IPCC), which was awarded the Nobel Peace Prize in 2007. In 2014, he received the inaugural journalism achievement award from the European Meteorological Society.

He began by highlighting the “issue attention cycle” — the pattern of intense but short-lived public focus on extreme weather events such as flash floods in Dubai, severe storms in North America and recent heatwaves and wildfires across Europe. In 2025, wildfires burned over one million hectares of land across the EU, while heatwaves, droughts and floods affected nearly a quarter of all regions, leading to economic losses exceeding €43 billion, with projections rising to €126 billion by 2029.

Global average temperatures in 2024 reached 15.1°C, marking the warmest year in recorded human history, 0.12°C higher than the previous record in 2023. On 22 July 2024, the daily global average temperature hit 17.16°C, with nearly 44% of the planet under strong to extreme heat stress. Although 2025 is expected to be slightly cooler due to a La Niña phase, it will still rank among the top three hottest years ever recorded. Professor Sweeney illustrated how small shifts in average temperature lead to large increases in the frequency of extreme events. Europe is warming twice as fast as the global average while the Arctic is warming four times faster, intensifying global climate imbalance.

The concentration of atmospheric carbon dioxide has climbed from pre-industrial levels of 280 ppm to 426 ppm today, a level unprecedented in at least half a million years. Emissions are concentrated in industrialized economies of the Northern Hemisphere, while the Global South, least responsible for emissions, suffers the greatest impacts. Ireland emits more greenhouse gases than the world’s 400 million poorest people combined, and Professor Sweeney illustrated this by equating Ireland’s annual emissions to 58 million one-tonne “balloons” of CO_2 — about one per person per month.

Extreme events are no longer rare anomalies. Events occurring every 50 years now occur every 10 years and are projected to become near-annual under a 2°C warming scenario. Among the most concerning developments are potential climate tipping points such as the melting of the Greenland and West Antarctic ice sheets, the collapse of tropical coral reefs and the weakening of the Atlantic Meridional Overturning Circulation, often referred to as the Gulf Stream system. While full AMOC collapse this century remains unlikely, it is projected to weaken by up to 40% within the next 50–60 years, potentially disrupting rainfall patterns and cooling parts of Europe even amid global warming.

Regions most at risk include semi-arid zones in Africa, coastal megacities and low-lying island nations such as Tuvalu, Kiribati and Vanuatu, where communities are already facing cultural and territorial loss due to rising seas. In Bangladesh, more than 160 million people live within six meters of sea level — a demographic equivalent to multiple Irelands. Professor Sweeney also emphasized the principle of climate justice, noting that 50% of global emissions come from the richest 10% of the population, while the poorest half of humanity contributes only 10%.

Ireland, a mid-latitude nation, will experience increased winter precipitation in the west and summer droughts in the east, affecting agriculture, biodiversity and infrastructure, including historic lighthouses already threatened by coastal erosion. Rising sea levels and stronger Atlantic storms pose growing risks to coastal infrastructure and navigational safety. Recent Category 5 hurricanes — two occurring simultaneously in the Atlantic for the first time since 1932 — underline the volatility of ocean systems.

Concluding his presentation, Professor Sweeney emphasized that climate change is an intergenerational challenge. Each generation faces a greater burden of environmental risk and responsibility. He referred to the Okjökull glacier in Iceland, declared “dead” in 2019 and memorialized with a plaque reading: “We know what is happening, we know what needs to be done, only you will know if we did it.”

Professor Sweeney’s address underscored the urgency of climate action, linking global scientific evidence with local realities in Ireland and beyond. His presentation combined decades of research with moral clarity, reminding the audience that climate change is not only an environmental or economic issue but a profound ethical and human one — a call to act while there is still time to prevent irreversible loss.

3.2 Developing Countries' Challenges of Meeting Sustainability Responsibilities – The WWA Experience, Vincent Denamur – Dean of IALA World-Wide Academy

Vincent Denamur, Dean of the IALA World-Wide Academy (WWA), represented the experience of the IALA World-Wide Academy (WWA) in addressing the challenges faced by developing countries in meeting sustainability responsibilities in the field of Marine Aids to Navigation (AtoN). He referred to IALA's Strategic Goal 2, which aims to ensure that all coastal States can fulfil their obligations under SOLAS Chapter V and achieve compliance with relevant IALA Standards.

The World-Wide Academy, established in January 2012, serves as IALA's primary vehicle for delivering training and capacity building. Operating as an independently funded entity, the Academy assists all coastal States regardless of membership status. Through its global activities, the WWA has gained extensive experience in understanding the operational and institutional realities of developing maritime administrations and is therefore well-positioned to observe their sustainability challenges.

Capacity building, as defined by the United Nations, is "the process of developing and strengthening the skills, abilities, processes, and resources that developing states need to survive, adapt, and thrive in a fast-changing world." It forms a central part of the Academy's work and directly supports the 17th Sustainable Development Goal. The WWA contributes to this effort through comprehensive training programmes, including the Level 1.2 Master of AtoN course, which fosters long-term strategic planning and sustainable development within the maritime sector.

Vincent Denamur outlined the three main pillars of sustainability—environmental, social, and economic—and their application in the maritime domain. For coastal States, sustainability includes preventing marine pollution from ships and seabed activities, protecting ecosystems and biodiversity through marine protected areas, addressing climate change impacts by promoting low- and zero-emission technologies in line with the IMO GHG strategy, and fostering sustainable maritime industries such as eco-tourism and renewable energy. He emphasised that AtoN services themselves play an important role by reducing their environmental footprint through remote monitoring, efficient vessel operations, and equipment life-cycle management.

Drawing from WWA field missions, the IALA WWA Dean noted several recurring challenges in developing countries: limited institutional and technical capacity, weak governance, corruption, high staff turnover, and insufficient coordination among maritime entities. Poverty reduction and economic growth often take precedence over environmental considerations, while the high cost of green technologies and limited access to modern infrastructure further constrain sustainability efforts. These factors are exacerbated by rapid urbanization, population growth, and vulnerability to climate change, including sea-level rise and extreme weather events.

He referred to findings from IMO Member State Audits (IMSAS), which highlight common shortcomings in national legislation, interagency coordination, resource allocation, and awareness. Addressing these gaps requires stronger national maritime policies, effective stakeholder engagement, strategic planning, and efficient risk management. Establishing National Maritime Committees can help ensure coordination, legitimacy, and continuity across political, administrative, and operational levels.

Vincent Denamur emphasized that in many regions, weak competent authorities and overreliance on port authorities for AtoN service delivery hinder long-term sustainability. This often leads to non-compliance with IALA Standards, insufficient chart and safety information updates, and inconsistent maritime traffic management.

He underlined the importance of adopting IMO Resolution A.1158 (2021) on Vessel Traffic Services (VTS), which provides a comprehensive framework integrating information services, traffic management, and response to unsafe situations. However, he cautioned that not all coastal States require heavy VTS

infrastructure; scalable, data-driven, and environmentally friendly solutions are preferable where appropriate.

Looking forward, developing countries face both challenges and opportunities as new digital frameworks emerge, such as the VDES and S-100 standards. The speaker encouraged coastal States to pursue remote monitoring of AtoN and data-based policy decisions, supported by satellite and mobile communication technologies. Success depends on targeted training, regional cooperation, and the adoption of a scalable and tailored approach to capacity building.

He concluded by reaffirming that, despite the constraints, developing States can turn sustainability challenges into opportunities for modernization and innovation. With the proper knowledge, technology, and partnerships, they can enhance safety, efficiency, and environmental stewardship—fulfilling IALA's vision of "Successful Voyages, Sustainable Planet."

3.3 Current IALA work on sustainability & UNSDGs, Presentation of IALA relevant documentation (R1004 / G1036, G1137, G1165), Omar Frits Eriksson – IALA Deputy Secretary-General

Omar Frits Eriksson, IALA Deputy Secretary-General, opened his speech by reflecting on the importance of sustainability in the maritime sector, drawing on practical experiences from his three decades in the Danish Maritime Authority. He highlighted the energy challenges faced by marine aids to navigation and shared an example of early low-emission technologies, such as the radioisotope thermoelectric generators (RTGs) once used across the former USSR, noting how technological solutions evolve with environmental awareness and safety responsibility.

Omar Eriksson reiterated that sustainability, as defined by the Brundtland Commission (1987), is development that meets present needs without compromising future generations. He emphasized the three pillars of sustainability—environmental, social, and economic—and how these align with IALA's mission to promote safe, efficient, and environmentally sound navigation.

He outlined the environmental pillar as encompassing climate action, renewable energy, and protection of marine ecosystems; the social pillar as including education, gender equality, and inclusive capacity building; and the economic pillar as promoting innovation, decent work, and responsible use of resources.

Omar Eriksson described how IALA integrates sustainability into its technical and organizational framework through its hierarchy of publications: Standards, Recommendations, and Guidelines. He referred to IALA Standard S1020 on Marine Aids to Navigation Design and Delivery and Recommendation R1004 on Sustainability in the Provision of Aids to Navigation, which provide foundational principles for managing marine navigation systems responsibly and in line with the United Nations Sustainable Development Goals (SDGs).

He highlighted that AtoN services not only prevent maritime disasters—thereby protecting marine and coastal environments—but also must manage their own environmental footprint through waste reduction, sustainable energy use, and pollution prevention. He underlined that every competent authority should establish formal environmental management systems, echoing the guidance provided in IALA Guideline G1036 on Environmental Management in Aids to Navigation.

Omar Eriksson further connected IALA's work to the UN 2030 Agenda, noting strong contributions to several SDGs, particularly Goals 9 (Industry, Innovation, and Infrastructure), 14 (Life Below Water), and 17 (Partnerships for the Goals). He emphasized IALA's collaboration with international bodies such as IMO and IHO to promote unified, sustainable maritime development and capacity building through the World-Wide Academy (WWA).

Concluding his address, IALA Deputy Secretary-General encouraged participants to reflect on how AtoN authorities can further reduce their environmental impact, not only through operational efficiency but also by addressing emissions, energy use, and sustainable management practices across all levels of maritime infrastructure.

4. SESSION 3 – ATON MANAGEMENT

This session was chaired by Guttorm Tomren, Norwegian Coastal Administration (NCA).

4.1 Maintaining Service Performance against the Challenges of Low Environmental Impact Operations – Jim McBrier, NLB

Jim McBrier, from the Northern Lighthouse Board (NLB), presented on maintaining service performance while minimizing environmental impact. He outlined that NLB is responsible for navigation around the Scottish coastline, covering over 10,000 km of coastline and 790 islands. The organization operates under ISO-certified management systems addressing quality, health and safety, environmental management, and information security.

Jim emphasized that environmental considerations are integrated into daily operations, from optimizing the use of heavy machinery to vessel operations and maintenance, reducing both pollution and carbon footprint. He noted that the NLB fleet contributes approximately 81% of the organization's carbon emissions and

described efforts to improve efficiency, implement eco-steaming protocols, and explore alternative fuel solutions to reduce this impact.

The presentation highlighted NLB's strategic approach, which balances environmental, societal, and governance objectives. Environmental stewardship is embedded in project planning, investment approvals, and staff engagement, with leadership commitment and workforce involvement being essential to ensuring the success of these initiatives.

Several case studies were shared. At Start Point in Orkney, a transition from diesel to solar and wind-powered systems allowed emissions-free operation at the site. On the West Coast, refurbishment work at Spear and Kyler included environmental screening, water management, and careful measures to minimize disturbance to local wildlife. At Bass Rock on the East Coast, NLB collaborated with the Royal Society for the Protection of Birds, implementing strict biosecurity protocols and innovative measures, including a trained biodiversity dog, to protect the sensitive seabird population.

Jim also emphasized the importance of staff engagement and innovation. Operational teams suggested improvements, such as enhanced cleaning and management of marine growth, which reduced waste and the carbon footprint. Looking forward, NLB faces the challenge of balancing decarbonization efforts with heritage preservation. Future vessel projects are being designed with hybrid technologies and the flexibility to adopt more sustainable propulsion systems as they become viable. Solarization and other alternative energy solutions are effective in specific contexts and are complemented by other measures to optimize environmental outcomes.

In conclusion, Jim stated that maintaining service performance while minimizing environmental impact is achievable through strong leadership, integration of environmental principles, stakeholder engagement, objective measurement of impacts, continuous improvement, and fostering innovation. Collaboration and knowledge sharing across the sector remain critical for advancing environmental stewardship.

During the discussion, questions were raised regarding the appropriateness of solarization for certain sites, the balance between carbon reduction and heritage preservation, and whether any activities should be stopped. Jim emphasized that solarization is effective when combined with other energy sources, that stakeholder engagement is key to resolving tensions between environmental and heritage goals, and that continuous improvement and collaboration are preferable to discontinuing activities.

4.2 Review of Regulatory Frameworks for Sustainable Practices (e.g., ISO14000) – Will Dunning, GRAD

Will Dunning, Principal Systems Engineer at GLA Research & Development, presented on the regulatory framework for sustainable practices. He has extensive experience in both public and private sectors, previously working as Environment Sustainability Lead at Trinity House and as a sustainability manager in the automotive industry. His presentation explored how regulatory frameworks can drive sustainability across organizations.

The presenter began by defining a regulatory framework as a set of rules, regulations, standards, and guidelines that govern specific sectors to ensure compliance, protect public interests, and promote fair practices. He emphasized the role of laws in establishing mandatory obligations, citing the UK Climate Change Act as an example of legislation that sets targets but leaves operational methods to managers. Regulations, such as those from the International Maritime Organization (IMO), provide detailed requirements for environmental protection, including vessel operations, oil spill preparedness, sewage treatment, waste management, and emissions reduction. He highlighted future IMO frameworks, including greenhouse gas intensity metrics, which encourage vessel operators to reduce emissions over time, with financial incentives and penalties linked to compliance.

Will Dunning also discussed environmental standards, notably ISO 14001, which offers a structured approach for managing environmental responsibilities. While voluntary, the standard helps organizations systematically assess and reduce environmental impact, align with ESG goals, and build stakeholder trust. He noted that successful implementation requires top management commitment and that challenges include costs, complexity, and the potential focus on process over outcomes.

He addressed the Sustainable Development Goals (SDGs), emphasizing the value of setting clear targets and focusing on a subset of goals for practical implementation rather than attempting to adopt all 17 at once. Dunning also highlighted guidelines, such as S1020 and related documents, that address sustainable practices across operational, energy, waste, and environmental management areas.

A key point in his presentation was that organizations with limited resources can start by leveraging existing risk management frameworks as a pathway to environmental stewardship. He explained that environmental risk assessments, integrated with operational and asset risk management, allow organizations to anticipate and mitigate climate change impacts over the long term. He encouraged the use of these frameworks as a foundation for further sustainability development, particularly for authorities and service providers managing Aids to Navigation (AtoN).

In conclusion, presenter stressed that all organizations should commit to complying with relevant local, national, and international laws, regulations, standards, and codes of practice. By doing so, AtoN authorities and service providers can systematically manage their environmental impact while supporting broader sustainability objectives.

4.3 Pollution Mitigation through Aids to Navigation Management – David Lewald, USCG

Guttorm Tomren presented on behalf of R. David Lewald, highlighting the U.S. Coast Guard's work on the regulatory and operational management of Aids to Navigation (AtoNs). He emphasized that AtoNs are critical mitigation tools to prevent groundings and associated pollution, and that effective analysis of waterways is essential to determine appropriate types and placement of AtoNs.

The U.S. Coast Guard has developed the U.S. Aids to Navigation and Information Management System (USAIMS), a digital enterprise solution for managing over 100,000 federal and private AtoNs. The system enables field units to position, track maintenance, and issue Marine Safety Information bulletins efficiently. Recent enhancements to USAIMS include Trends and Analysis, which applies AI to large datasets to predict buoy mooring and beacon structure failures; Waterway Design, which provides coverage mapping, risk analysis, and "tabletop exercises" to evaluate system resilience; and Health and Performance, which evaluates key metrics such as aid availability.

The Waterway Design module contains a risk analysis tool that assesses a design vessel's ability to navigate a channel, considering buoys, leading lights, channel dimensions, and angles of turn. A relative risk score is generated by comparing vessel characteristics with the waterway and AtoNs, then weighted against potential consequences of grounding incidents (e.g., gravel versus petrochemical cargo). Operators can use prebuilt vessel profiles or enter custom vessel data. The system also incorporates historical grounding data to validate risk scores.

Guttorm Tomren concluded that USAIMS is a powerful tool for waterway management, allowing informed decision-making on AtoN deployment, maintenance, and system resilience. Additional capabilities are planned further to enhance the system's predictive and analytical functions, supporting safer and more sustainable navigation.

5. SESSION 4 – KEY SKILLS AND VTS MANAGEMENT

Monica Sundklev, Swedish Transport Agency, IALA VTS Committee Chair, led this session.

5.1 Securing Key Skills for Future AtoN and VTS Operations – Latifa Oumouzoune, IALA World-Wide Academy

Latifa Oumouzoune presented on the IALA World-Wide Academy's (WWA) global training framework, which ensures that personnel involved in Aids to Navigation (AtoN) and Vessel Traffic Services (VTS) are competent, certified, and aligned with international standards. The framework, based on IALA Recommendations R0141, R0149, and R0103, supports capacity-building and sustainable maritime operations worldwide.

The Level 1 courses for AtoN management include foundational training for AtoN Managers (Level 1.1), senior management and strategic planning (Level 1.2), practical application of the IALA Risk Management Toolbox (Level 1.3), and understanding of Global Navigation Satellite Systems and e-Navigation (Level 1.4). Collectively, these courses develop strategic, operational, and analytical competencies essential for sustainable AtoN management. Over 1,400 personnel are certified in these courses globally, though statistics for VTS and Level 2 training remain limited.

She emphasized that sustainability in AtoN and VTS extends beyond environmental considerations, encompassing technical, environmental, institutional, human, economic, and social dimensions. Technical sustainability focuses on reliable systems, preventive and corrective maintenance, and digital integration. Environmental sustainability promotes renewable energy, low-emission technologies, and responsible lifecycle management. Institutional sustainability ensures strong governance, funding mechanisms, inter-agency coordination, and policy compliance. Human capacity sustainability emphasizes skills development, knowledge transfer, and continuous learning. Economic sustainability requires cost-effective infrastructure and operational management, while social sustainability highlights safety, inclusion, and community engagement.

The presentation also highlighted community awareness as a key component of sustainability. Engaging local fishing communities and stakeholders helps protect AtoN infrastructure, fosters trust, and ensures shared responsibility for maritime safety. Latifa Oumouzoune stressed that cross-sectoral competencies—including governance, green procurement, stakeholder engagement, and risk management—are essential for institutional sustainability. Digital literacy, integration, and strategic risk-based thinking support operational resilience, while continuous learning and knowledge transfer ensure long-term competence.

In conclusion, sustainability in AtoN and VTS operations is multidimensional. Balancing technical reliability, environmental stewardship, institutional strength, human capacity, economic efficiency, and social responsibility is essential to maintain safe, resilient, and effective maritime navigation services.

5.2 Sustainable Procurement - How Can Value-For-Money and Environmental Considerations Work Hand-in-Hand? - Richard Aase, Norwegian Coastal Administration

Richard Aase, Senior Engineer at the Norwegian Coastal Administration, presented on sustainable procurement and the management of coastal infrastructure in Norway. He emphasized that sustainable procurement is the process of purchasing goods and services with consideration for their environmental, social, and governance (ESG) impacts, not just cost and quality. Environmental considerations include minimizing the ecological footprint by choosing eco-friendly materials, reducing waste and water usage, and sourcing renewable energy. Social considerations involve ensuring ethical labour practices, fair wages, safe working conditions, and respect for human rights across the supply chain. Governance considerations focus on ensuring compliance with regulations, promoting transparency, and partnering with suppliers who follow strong ethical governance standards.

He provided context on Norway's coastline and maritime responsibilities. Norway has the world's second-longest coastline, over 100,000 km, increased from 85,000 km in 2011 due to more accurate measurement of its fjords and islands, while Canada has the longest coastline at over 200,000 km. Norway controls 1,979,179 km² of sea, divided into three zones: the mainland economic zone of 878,575 km² bordering Sweden, Denmark, the United Kingdom, the Faroe Islands, and Russia; the fishing zone around Jan Mayen of 293,049 km²; and the fishing protection zone at Svalbard of 803,993 km². Three strong driving forces are changing the activity and requirements for coastal infrastructure: climate, digitalization, and the security situation.

Regarding navigation aids, or seamarks, Richard explained that they have different names depending on the type. Beacons are fixed to the seabed or shore, towers are built on the shore or on a submerged rock, especially in calmer waters, and buoys are floating objects usually anchored to a specific location on the seabed or to a submerged object.

Finally, the presenter highlighted the importance of integrating sustainability into all aspects of procurement, including the development and maintenance of equipment and infrastructure, construction processes, and the lifecycle management of installations. Sustainable procurement must balance environmental responsibility, social impact, and governance compliance while ensuring operational efficiency, safety, and public trust.

5.3 Autonomous Vessels - an opportunity to increase efficiency or a resourcing challenge for AtoN and VTS providers? – Maarten Berrevoets, Ministry of Infrastructure and Water Management of the Netherlands

Maarten Berrevoets, Special Assistant to the Director of Maritime Affairs at the Ministry of Infrastructure and Water Management of the Netherlands, presented on the development and future scenarios of Maritime Autonomous Surface Ships (MASS) and their implications for Aids to Navigation (AtoN) and maritime operations. Berrevoets has extensive experience as a policy advisor since 1998, serving as national IR lab coordinator, member of BTS and ARM committees, chair of the MASS Task Force, and participant in the Legal Advisory Panel (LAMP).

He emphasized that MASS technology is at the forefront of innovation, offering opportunities to increase efficiency and address resource challenges for AtoN and PTS providers. For the foreseeable future, the maritime industry will operate a mixed fleet of conventional and increasingly automated or autonomous vessels. While MASS technology is suitable for small and specialized ships, large crewed ships will continue to operate with conventional systems for decades due to technological, legal, and socio-economic constraints. The realization of fully autonomous large ships capable of independent decision-making is expected to be at least 20 to 35 years away.

Berrevoets outlined four scenarios for the short to medium term: many crewed ships with automated functions, few crewless autonomous ships, more crewed ships with automated functions, and some crewless autonomous ships. These scenarios demonstrate how automation and autonomy will increasingly optimise onboard operations and decision-making, with remote-controlled ships potentially serving as interim solutions. Regulatory frameworks established by IMO and national authorities will be pivotal in shaping the development of MASS.

Key drivers for MASS adoption include the potential business case, efficiency gains, operational safety, and environmental considerations. Autonomous ships primarily improve safety by reducing human error. While diesel engines remain maintenance-intensive, fuel optimization and sustainable alternatives can support environmental objectives. Regulatory alignment, seafarer shortages, and technological readiness also influence MASS development timelines.

Regarding AtoN services, Berrevoets concluded that the introduction of MASS vessels will not necessitate major changes. Most of the shipping will remain manned, and existing AtoN infrastructure will continue to support navigation, with MASS vessels integrating into current systems. The workshop outcomes serve as a key planning tool for IALA, guiding the analysis of MASS impacts on AtoN, identifying future service requirements, and prioritizing potential work items for committee consideration.

6. SESSION 5 – ROLE OF MARITIME MODERNISATION

The session was chaired by David Jeffkins, Principal Advisor AtoN Asset Management from Australian Maritime Safety Authority.

6.1 Challenges of Providing Digital Maritime Services with a Minimal Environmental Impact – Sarah Leullier, MSM, and Nikolaos Vastardis, GRAD

Sarah Leullier and Nikolaos Vastardis presented on the challenges and solutions associated with providing digital maritime services while minimizing environmental impact.

Sarah, Business Development Manager at MSM since 2008, has extensive experience managing international projects, particularly in European and African markets, and has led the design, development, and implementation of beaconing projects to improve maritime safety.

Nikolaos, Chartered Engineer and Principal Engineer at GRAD, specializes in software development, systems design, e-navigation, S-100 frameworks, scalable software, and machine learning.

Sarah highlighted the environmental challenges of deploying digital maritime services, which often rely on robust computing and communication infrastructure in remote and harsh environments. To mitigate these impacts, she emphasized the use of renewable energy sources such as solar and wind power, energy-efficient equipment, circular economy practices, and innovative modular design. By integrating Internet of Things (IoT) technology into lanterns and other maritime equipment, maintenance can be monitored remotely, reducing unnecessary travel and operational costs. Modular design also allows components to be replaced or upgraded without discarding entire systems, extending product life cycles and reducing electronic waste. Sarah illustrated these practices with the example of Venice's flood-gate monitoring system, where compact, low-energy lanterns equipped with IoT modules provide remote monitoring and control.

Nikolaos expanded from the digital perspective, defining maritime services as harmonized electronic services for information exchange, as guided by IMO frameworks. Key technical requirements include common system interfaces, security mechanisms, and interoperability. He noted that while deployment of digital maritime services requires significant infrastructure, energy, maintenance, specialized knowledge, and compliance with regulations, these challenges can be offset through resource sharing, monitoring, predictive maintenance, route optimization, traffic analysis, and collision avoidance.

Nikolaos highlighted the application of AI and machine learning to further reduce environmental impact. Projects include training machine vision systems to detect aids to navigation, monitoring station operations, predicting solar energy availability, and generating synthetic AIS trajectories to model "what-if" maritime scenarios such as offshore wind farms or accidents. Techniques employed include Generative Adversarial Networks (GANs) for synthetic data, Reinforcement Learning for rule-compliant navigation behaviour, and Transformers/Diffusion Models for capturing long-range temporal patterns and generating diverse scenarios. These approaches allow digital maritime services to maintain high reliability while minimizing physical and environmental footprints.

In conclusion, Sarah and Nikolaos emphasized that sustainable digital maritime services require a combination of renewable energy, efficient equipment, modular design, interoperable digital systems, and AI-driven optimization. Collaboration among countries, ports, shipping companies, and industry stakeholders

is essential to ensure consistent environmental standards and achieve a more sustainable global maritime sector.

6.2 Industry's Role in Providing Sustainable AtoN Services – Malcolm Nicholson, SPX

Malcolm Nicholson presented on the role of industry in delivering sustainable aids to navigation (AtoN) services. As an engineer specializing in lighting systems for AtoNs and chair of the IALA Engineering Committee Working Group One, Malcolm highlighted the critical role manufacturers play in driving sustainability throughout the product lifecycle.

He emphasized that sustainability now underpins every stage of production, from material selection and component sourcing to energy-efficient design and end-of-life recycling. The increasing regulatory, stakeholder, and environmental pressures, including climate change, carbon reduction targets, and rising storm intensity—are driving innovation in the industry.

Key points included:

- Durable and modular design: Use of lightweight, long-lasting materials (e.g., plastics, composites, recycled materials) reduces maintenance and chemical usage. Modular components allow for easy replacement of damaged parts without scrapping entire units.
- Energy efficiency: Widespread adoption of LEDs and advanced solar technologies, coupled with smart power management and AI-driven predictive maintenance, extends operational life while reducing energy consumption. Some manufacturers are exploring hybrid power systems (wind, fuel cells) and emerging battery technologies.
- Digital and IoT integration: Remote monitoring reduces vessel visits, lowering fuel use and emissions. Modular lanterns and buoys with standalone solar panels and IoT connectivity exemplify these approaches.
- Circular economy and recycling: Manufacturers are increasingly implementing take-back schemes and recycling programs to reduce waste and promote sustainable practices.

Malcolm also highlighted the trade-offs in design and operation: balancing sustainability, performance, cost, and durability in harsh marine environments remains a challenge. He stressed collaboration between ports, authorities, and manufacturers to achieve the most effective solutions.

Case studies included modular polyethylene buoys with replaceable collars and self-contained lanterns, which have demonstrated extended maintenance intervals of up to five years, showcasing the practical benefits of sustainable design.

In conclusion, Malcolm reinforced that the industry's responsibility is to deliver durable, efficient, and environmentally responsible AtoN solutions while supporting operational safety and reducing the sector's environmental footprint.

6.3 The Life Cycle of an AtoN: Reusable vs Disposable Design – Peter Schneider and Lars von Lilienfeld-Toal, WSV

Peter Schneider and Lars von Lilienfeld-Toal presented on the life cycle of aids to navigation (AtoN), focusing on the comparison between reusable and disposable designs. They emphasized that sustainable solutions must balance innovation, functionality, and environmental responsibility.

Reusable designs consist of products that can be reused and repaired multiple times before disposal and often incorporate modular components. Examples include reusable shopping bags, modular smartphones, and self-contained AtoN lights. These designs offer advantages such as durability, sustainability, and potential long-term cost savings. At the same time, they present several challenges, including higher complexity, larger

size, initial production costs, the need for maintenance by qualified personnel, and logistical requirements for spare parts.

Disposable designs are intended for single use and are generally user-friendly and simple. Examples include disposable batteries, LED lanterns, and packaging materials. While these products have lower initial costs, are simple to install, require no maintenance, and offer flexibility, they are less sustainable, have lower durability, and require frequent replacement, which increases long-term procurement efforts.

The presenters highlighted that the greatest opportunities for sustainability arise during the planning and development phase. Close cooperation between nautical and technical departments is essential to ensure optimal location selection, minimal environmental impact, and safe navigation. Using sustainable materials, such as seawater-resistant aluminium alloys, powder-coated metals, durable plastics, and glass, together with modular designs, enhances the longevity of AtoNs. Sustainability considerations must also extend through procurement, manufacturing, installation, operation, monitoring, evaluation, and decommissioning. Reusable designs allow for retrofitting and upgrading, while disposable designs may be appropriate for small, maintenance-free units.

As a case study, Peter and Lars presented the SKA system, which features modular, durable light units with high-quality electrical and mechanical components. The units have a service life exceeding 20 years and provide opportunities for integrating technological innovations, such as AIS. Maintenance is performed every five years, and components are designed for easy inspection and replacement. This system demonstrates how a reusable design can achieve long-term sustainability, operational efficiency, and cost-effectiveness.

In conclusion, the choice between reusable and disposable AtoNs depends on factors such as the unit's size, location, budget, maintenance capacity, and environmental priorities. Wherever feasible, reusable and modular designs are preferred for their sustainability, durability, and adaptability to future technological developments.

7. SESSION 6 – ATON ENGINEERING AND HERITAGE

This session was chaired by Alwyn Williams, Chair of the Workshop and IALA ENG Committee.

7.1 Maintenance Regime for Extending Life of Components and Systems – Peter Dobson, Trinity House

Peter Dobson shared his approach to extending the operational life of aids to navigation (AtoN) by focusing on adaptability, remedial changes, and reuse of existing systems rather than routine maintenance. He emphasized that life extension requires understanding the location-specific challenges, including restricted access, environmental sensitivity, and operational constraints, and that solutions should minimize disturbance, cost, and unplanned downtime.

He illustrated several examples of life extension. The 11-cent module, in service since 1988, was prone to failures caused by simple operational tests. Instead of replacing the entire system, Trinity House redesigned only the failing components to be backward-compatible, allowing existing stock to be used and reducing operational disruption. Similarly, the navigation control cubicle, designed in 1990, required updates to obsolete EPROM and logic chips. By recovering spare components and creating daughter boards for unavailable chips, the functionality was preserved while extending the system's life by an estimated ten years.

In other cases, structural reuse was key. At Gary's lighthouse, outdated panels were adapted with a clamping rail system to support new solar units while retaining original cables and minimizing intervention. At Coquet lighthouse, a rotating optic removed in 1964 and stored in a museum was reintroduced with a modern 24-sided LED light source, achieving better sector coverage, simplified operation, and reduced power

consumption. These examples highlighted the value of modularity, compatibility, and leveraging heritage assets to prolong operational life.

Peter noted challenges, including maintaining the necessary skill sets for legacy hardware and logic systems, managing IT platforms and cybersecurity issues, ensuring stock availability, and supporting equipment through software and configuration updates. Effective life extension relies on careful planning, control of design, and use of maintenance tools such as work orders, help desks, root cause analysis, asset risk registers, engineering change notes, and software portals.

He concluded that life extension benefits include cost avoidance, waste reduction, and improved sustainability, while the trade-offs may include limited technology upgrades and resource requirements. Key enablers are small-scale modifications to existing designs, modular systems, reuse of infrastructure, software and IT compatibility, knowledge transfer, and well-managed stock. Looking ahead, he suggested the development of modular common platforms and adaptable power systems to simplify future upgrades and support long-term sustainability.

7.2 Maritime Heritage, Culture Conservation and Biodiversity – Alan Hayden, Archaeological Projects Ltd (consultant on Skellig UNESCO World Heritage Site)

Alan Hayden, archaeologist and founding director of Archaeological Projects Ltd since 2005, has served as a consultant archaeologist to the OPW and led extensive work on the Skellig UNESCO World Heritage Site. Located approximately 12 kilometres off the coast of Kerry in Southwest Ireland, the Skelligs are renowned for their monastic remains and two historic lighthouses: the Lower Lighthouse, abandoned in 1870, and the Upper Lighthouse, occupied until 1987. The site is exposed to harsh environmental conditions, which presents significant challenges for preservation and access.

The archaeological and architectural work on the island aimed to record and analyse both the monastic and lighthouse structures. The main challenges identified include the site's extreme remoteness, limited accessibility outside summer months, high costs of conservation due to location, and the increasing impacts of climate change. Full conservation for all remote sites is financially unsustainable, necessitating alternative approaches to safeguard the heritage.

The presenter emphasised the methodology of "preservation by record," which focuses on detailed documentation where immediate conservation is not feasible. This approach includes precise measurement and photographic recording of buildings, archaeological excavations to understand site development, capturing intangible heritage such as oral histories of lighthouse keepers, and recording graffiti and inscriptions. The process is non-destructive, ensuring that the site itself remains intact while its cultural and historical information is preserved for future use.

On the Lower Lighthouse, the floors, doorstones, and structural features were largely intact, allowing for detailed reconstruction of construction phases. In the Upper Lighthouse, surviving archival materials, interviews with former keepers, and other historical research provided insight into daily operations and personal histories. Despite their apparent isolation, the lighthouses were closely connected to the regional economic and social history of the mainland.

Hayden highlighted that many of these sites are over 100 years old, with some exceeding 200 years, holding significant architectural, archaeological, and social value. Preservation by record provides a practical, cost-effective alternative for sites where resources or access limitations prevent immediate physical conservation. It allows for the prioritization of sites, the creation of a detailed catalogue, and the use of modern technologies such as 3D scanning and digital modelling to enhance accessibility and education.

In conclusion, the Skelligs lighthouses and monastic remains represent highly significant cultural assets. Preservation by record ensures that the historical and cultural knowledge of these sites is safeguarded, supports future conservation efforts, and allows for informed decision-making in the face of climate change

and resource constraints. This approach provides a meaningful balance between preserving the physical site and maintaining the continuity of its heritage.

8. SESSION 7 – SUSTAINABLE OPERATIONS

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

8.1 Maritime Green Corridors – Guttorm Tomren, Norwegian Coastal Agency

Guttorm Tomren, Chair of the IALA ARM Committee, Senior adviser AtoN, Norwegian Coastal Administration, provided the presentation on maritime green corridors, highlighting the importance of decarbonizing maritime shipping routes and facilitating the adoption of low-emission technologies. Green corridors are defined as specific maritime routes where zero-emission solutions are supported through coordinated infrastructure, regulatory frameworks, and collaboration among ports, shipowners, and governments. They aim to reduce lifecycle greenhouse gas emissions, improve fuel efficiency through optimized routing and vessel design, and ensure compliance with international strategies such as the IMO's Initial Strategy on the Reduction of GHG Emissions from Ships.

He noted that while the maritime industry is critical to global trade, it is currently lagging behind in decarbonization efforts. Achieving interim targets for 2030 and the ultimate zero-emission goals for 2050 presents significant challenges. Green corridors provide a framework to pilot decarbonization initiatives, but they require both top-down governmental support and bottom-up industry engagement. For example, Norway and other Nordic countries have committed to establishing green corridors, with 60 announced globally, most in early development stages. Government initiatives, such as public funding, infrastructural support, and regulatory prioritization, are essential in the initial stages, while shipowners ultimately drive operational adoption and innovation.

Practical implementation of green corridors faces multiple challenges. Fuel availability and bunkering infrastructure remain limited, particularly for alternative fuels such as ammonia, hydrogen, methanol, and biofuels. Each fuel type carries technical and safety considerations; ammonia and hydrogen require specialized storage and handling, while biofuels are limited by feedstock availability. Infrastructure investment is complicated by the distribution of ports along coastlines and the need for co-location of bunkering and cargo operations. Vessel design, energy efficiency measures, real-time performance monitoring, and just-in-time arrival management are key technical tools for optimizing emissions. Norwegian pilot projects include zero-emission ferries using hydrogen for routes where batteries are insufficient, demonstrating early operational solutions while highlighting vendor lock-in and retrofitting challenges.

Regulatory frameworks are evolving to support these initiatives. The IMO MARPOL Annex VI, Energy Efficiency Existing Ship Index (EEXI), Carbon Intensity Indicator (CII), and EU regulations such as FuelEU Maritime and AFIR set technical and operational standards for emissions reductions and shore power requirements. National policies, including shore-side infrastructure, fuel handling, and safety protocols, are critical, especially in sensitive locations such as UNESCO World Heritage Sites, where additional NOx and greenhouse gas requirements apply. Harmonization of regulations across jurisdictions remains a challenge, and effective collaboration between ports, authorities, and shipowners is necessary to ensure safe and efficient operations along green corridors.

The presenter emphasized the role of monitoring and digitalization in the success of green corridors. Coordination between vessel traffic services, ports, and shipping companies is necessary to maintain operational safety, optimize routing, and manage fuel supply. Digital tools, AI, and data collection on goods, vessel performance, and port operations are critical to modelling scenarios, identifying bottlenecks, and scaling solutions. Public and private partnerships, as well as continuous R&D in alternative fuels and vessel technologies, are essential for the long-term success of maritime green corridors.

In conclusion, maritime green corridors are pivotal for achieving global decarbonization targets in shipping. They require multi-stakeholder collaboration, significant technical innovation, regulatory support, and strategic planning for fuel supply and infrastructure. Pilot projects, government facilitation, and industry engagement are all integral to scaling green corridors, with monitoring, digitalization, and knowledge-sharing playing crucial roles in accelerating the transition to zero-emission shipping by 2030 and beyond.

8.2 Keeping the Human at the Centre of a Digitalised World – Monica Lundh, Associate Professor Maritime Studies, Chalmers University of Technology

Monica Lundh began focused on the human-centred implications of digitalization in maritime operations, based on two research projects and a master's thesis. The studies examined the impact of digitalization on maritime safety and the crew's work environment, lessons from support functions to improve maritime safety, and the effect of digitalization on environmental and operational safety in the shipping industry. The objectives were to understand the consequences and magnitude of digitalization on board ships, assess how it affects crew work and incident occurrence, and provide suggestions for targeted measures, tools, and continued research.

The methodology included structured interviews with approximately 40 participants, five focus groups with an average of twelve participants each, and a questionnaire survey with 140 respondents, including seafarers, shipping company staff, and manufacturers. The research adopted a cooperative approach in partnership with the Swedish Shipowners Association, as well as U.S. and European collaborators.

The results show that digitalisation is generally considered beneficial, providing time savings, increased efficiency, and improved access to information compared with analogue systems. However, technical issues are widespread, including software bugs, system freezes, complex interfaces, excessive alarms, and connectivity problems. Multiple unconnected systems increase workload, and updates can overwrite ship-specific data, requiring manual correction. More than 80% of participants reported encountering system issues, 86% noted an increase in daily workload due to digital systems, and over 90% identified additional safety risks when systems fail. Larger companies benefit from internal IT support, while smaller operators often face difficulties in accessing manufacturer support. Incident reporting systems show few documented issues, but minor operational "hassles" are common and often normalized by crew.

Participants recommended early involvement of crew in user-centred system design, effective and accessible support services, especially for smaller companies, and shared understanding between crew and manufacturers regarding operational realities. Standardization of safety-critical systems was suggested where feasible without compromising innovation, and early discussions about equipment acquisition and installation were recommended to ensure expectations are aligned.

In conclusion, digitalization in shipping is here to stay and provides substantial benefits, but significant challenges remain in optimizing safety and operational efficiency. Addressing these challenges requires improved support structures, user involvement in design, knowledge sharing, and careful standardization to ensure technology meets the practical demands of life on board.

9. SESSION 8A – FRAMING AND QUANTIFYING SUSTAINABILITY

The session was chaired by Malcolm Nicholson, SPX Aids to Navigation.

9.1 Learning/Experiences from the carbon-neutral Port operations – Hyerim Bae, PhD, Pusan National University

Hyerim Bae, PhD, from Pusan National University, presented port operations and efforts to reduce greenhouse gas emissions in Korea, focusing particularly on Busan Port. He highlighted the significant contribution of maritime transport to global emissions, noting that over 85% of international trade is carried by shipping and that larger vessels contribute disproportionately to carbon emissions. Despite global regulations and carbon reduction agreements, there remain gaps between policy goals and actual emissions, particularly in regions with limited regulatory frameworks.

Dr Bae emphasized that port operations play a crucial role in carbon reduction, as approximately 60–90% of port emissions fall under scope three, meaning they are related to vessel activity. He outlined Korea's approach to decarbonization, including infrastructure improvements, technological upgrades, and regulatory and incentive measures. Busan Port has developed a comprehensive master plan, Busan Port 2050, targeting carbon neutrality through measures such as onshore power supply installations, alternative fuel bunkering, vessel speed reduction programs, and electrification of port equipment. The port has achieved significant results, including a 73% reduction in particulate matter and a 20% reduction in carbon emissions, while obtaining ISO 14001 certification.

Digitalization and AI are central to these efforts. Dr. Bae explained the development of predictive and optimization algorithms to enhance port productivity while reducing emissions. AI applications allow more accurate vessel arrival predictions, optimized container handling, and real-time carbon emission monitoring. Implementation of AI-based systems has improved operational efficiency by up to 70%, reduced turnaround times by 24%, and cut energy use by 30–33%. The AI models are designed to integrate both qualitative and quantitative operational factors, supporting both safety and environmental goals.

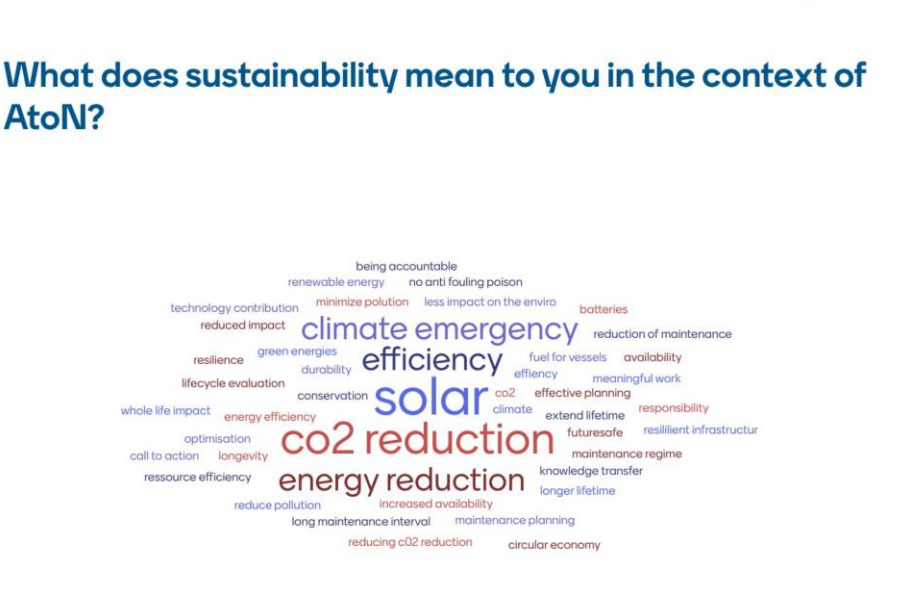
Dr. Bae noted that while the total emissions from Busan Port remain a small fraction of global emissions, the cumulative effect of targeted interventions across ports can substantially contribute to climate goals. He stressed the importance of predictive monitoring systems, collaboration across stakeholders, and continued investment in infrastructure and technology to achieve carbon reduction targets. Overall, the presentation highlighted a holistic approach combining regulation, technology, digitalization, and operational planning to reduce the environmental impact of maritime transport and port operations.

9.2 Assessing and Communicating IALA's Contribution to Sustainability – Minsu Jeon, IALA Technical Director and Sarah Robinson, IALA Consultant Advisor

Minsu Jeon, IALA Technical Director and Sarah Robinson, IALA Consultant Advisor, presented to showcase current sustainability activities in AtoN provision, explore metrics to quantify sustainability impacts, align contributions with the UN Sustainable Development Goals and IMO initiatives, and discuss a framework for sustainability reporting within IALA. Ports were highlighted as gaining attention in carbon neutrality efforts, exemplified by AI-driven initiatives at Busan Port, and IALA's work was positioned as complementary by enabling low-impact, energy-efficient navigation infrastructure that supports greener port operations.

IALA has historically incorporated sustainability implicitly into its work. Solar panels have been used to power buoys for decades, LEDs and low-power electronics have reduced energy consumption, and hybrid setups, along with reduced diesel use, have improved operational sustainability. Lightweight materials such as aluminium for buoys and vessels have lowered environmental impacts, while hydrogen-powered tenders represent a step toward cleaner operations. Automation and digitalization have significantly reduced the number of maintenance visits required, lowering fuel consumption and carbon emissions. Remote monitoring, e-navigation, and the use of drones and AI technologies further enhance operational efficiency and reduce environmental footprints.

Participants were asked to reflect on what sustainability means in the context of AtoN, with responses emphasising whole-life environmental impact, energy and CO2 reduction, recycling and reuse of materials, and optimised maintenance regimes. Sustainability in AtoN operations also indirectly supports safer navigation, fewer accidents, and more efficient port operations. Quantitative metrics discussed included energy savings from solar-powered aids, CO2 emission reductions from fewer maintenance trips, and the impact of digitalization on resource use. For example, converting a single buoy from a diesel generator to solar power could reduce approximately four tonnes of CO2 annually, and optimized anchoring and traffic management could reduce emissions further.



IALA's work aligns with global sustainability goals, contributing directly to SDG 9 on industry, innovation, and infrastructure, SDG 14 on life below water, and SDG 17 on partnerships for the goals. Indirectly, it enables green ports and supports sustainable shipping operations. Areas with the greatest potential for impact include materials, digitalization, maintenance regimes, and operational practices, particularly in integrating with port decarbonization strategies and renewable energy adoption.

The presenters proposed the development of a reporting framework to identify best practice indicators and templates while addressing knowledge gaps in sustainable data. The framework would accommodate varying levels of resources among member states, allow for voluntary reporting, and potentially be endorsed by the

IMO. Suggested indicators include CO2 emissions reduction, energy consumption and renewable energy share, materials recycling and reuse, maintenance visit frequency, digitalization impact on resource use, and contributions to port decarbonization. ISO standards such as ISO 14080 and ISO 14064 were referenced as a basis for quantifying and monitoring sustainability contributions.

The presentation concluded that sustainability in AtoN provision is no longer optional but a central dimension of operations. Existing practices already contribute to sustainability, particularly through energy efficiency, automation, and safer navigation, but formalizing measurement and reporting would make these contributions visible and aligned with global goals. The development of a standardized reporting framework would enable IALA to demonstrate its contributions to the SDGs while accommodating the diverse capabilities of member states. The workshop sessions after the presentation aimed to explore environmental matters, maritime modernization, asset management, and workforce skills in more detail, with a focus on identifying indicators, closing knowledge gaps, and developing templates for reporting and guidance.

Overall, the presentation highlighted that AtoN provision supports sustainability in multiple ways, and that IALA could systematize measurement, monitoring, and reporting to reinforce its role in promoting global maritime sustainability.

10. SESSION 8B – WORKING GROUPS

10.1 Working Group Arrangements – Alwyn Williams, ENG Chair

Alwyn Williams provided details of the arrangements for the working groups. Two concurrent sessions were held in both the morning and the afternoon. Suggested topics guided the discussions, and template presentations were provided to collect comments and conclusions. Volunteers led the groups and reported on the outcomes of the discussions. The sessions took place at Irish Lights HQ, with lunch provided at the Royal Marine Hotel. Participants also had the opportunity to join a technical tour of Irish Lights' facilities. The schedule was as follows: Thursday morning – Environmental Matters and Maritime Modernisation; Thursday afternoon – AtoN Management and VTS Management; Friday morning – Working Group Conclusions.

11. SESSION 9 – 12 – WORKING GROUPS

11.1 WG1 – Environmental Matters

This WG was chaired by Will Dunning, Principal Systems Engineer at GLA Research & Development, United Kingdom.

WG1 reviewed the questions prepared in advance and identified good practices related to sustainability in AtoN manufacturing, maintenance, and lifecycle management. The group discussed the benefits of buyback schemes, reuse, repair, and responsible end-of-life disposal of AtoNs, including positive financial and environmental impacts for local communities. Participants exchanged case studies and explored opportunities for sharing discarded equipment among authorities.

Discussions also covered balancing modernisation with heritage preservation, recognising AtoNs as potential community assets. The group highlighted the importance of durability, technological innovation, and the role of the IALA World-Wide Academy in building awareness of environmental risks. It was agreed that improved education, training, and sustainability reporting — based on shared standards and guidelines — are essential.

The workshop acknowledged challenges in resourcing and organisational capacity, stressing the value of collaboration, transparency, and knowledge exchange between authorities. Participants proposed that IALA could support these goals by defining sustainability at an organisational level, strengthening partnerships with IGOs, and aligning its guidelines with the UN Sustainable Development Goals.

Overall, WG1 held highly constructive discussions and expressed strong motivation to continue this work across Member States, ensuring the momentum on sustainability is maintained.

WG1 had good progress on the topic, and outputs are available in Annex C.

11.2 WG2 – Maritime Modernisation

WG2 was chaired by Peter Dobson, Engineering Manager from Trinity House, United Kingdom.

WG2 held productive discussions on key aspects of maritime modernisation, focusing on resilience, data management, digitalisation, and emerging technologies. The group emphasised the importance of energy and communication resilience as essential foundations for future developments. Discussions also addressed effective data collection, storage, and presentation, noting that clear and structured use of data is vital for decision-making and operational efficiency.

Security challenges, such as spoofing, and the integration of emerging technologies like AI, IoT, and drones, were highlighted as growing priorities. Participants discussed the role of machine learning and "digital twins" in improving system performance, prediction, and preparedness. The group also examined MASS (Maritime Autonomous Surface Ships), noting both the potential benefits and uncertainties surrounding its development.

WG2 recognised the need for standardisation and interoperability to ensure consistent data exchange and sustainable progress. Maintaining a balance between innovation and regulatory alignment was seen as essential. The group also underlined the importance of skills development and knowledge transfer to support modernisation efforts while safeguarding operational continuity.

The discussions concluded that cooperation with other industries, particularly aviation, could offer valuable insights into automation, reliability, and "just-in-time" operations. Overall, WG2's work underscored that technological progress in navigation and VTS must be guided by sustainability, standardisation, and human-centred design.

The group revealed important insights, the outputs are available in Annex D.

11.3 WG3 – Aton Management

This WG was chaired by Guttorm Tomren, Chair of the IALA ARM Committee, Senior adviser AtoN, Norwegian Coastal Administration.

Working Group 3 held comprehensive discussions on balancing AtoN availability, cost efficiency, and sustainability. Participants emphasized that sustainability should become an integral factor in decision-making, alongside safety and operational reliability. The group noted increasing challenges caused by severe weather and changing environmental conditions, as well as the potential use of virtual AtoNs as contingency measures during extreme events.

Discussions highlighted the importance of optimising maintenance practices to reduce emissions and operational costs, for example, by improving voyage planning, using monitoring systems to avoid unnecessary site visits, and adopting predictive maintenance approaches. The need to modernise buoy tender fleets with low-emission or hybrid vessels was also identified as a key step toward achieving net-zero operations.

Participants recognised a growing skill gap in data analysis and integration. While many authorities collect extensive monitoring data, much of it remains underutilized. Strengthening in-house analytical capacity was seen as vital for improving operational insight and reducing reliance on external consultants.

The group agreed that sustainability should be embedded into future IALA recommendations and procurement practices, including the review of availability guidelines. Attention was also given to material

selection for buoys, such as the transition away from fluorescent paints and towards more durable, environmentally friendly alternatives.

Finally, participants stressed the value of data sharing and collaboration between national authorities and agencies, as well as the use of technologies like drones for inspection and risk assessment. Overall, WG3 concluded that achieving a balance between operational performance and sustainability requires data-driven management, innovation, and collective learning across the AtoN community.

WG3 had good progress on the topic, and outputs are available in Annex E.

11.4 WG4 – Key Skills and Training

This WG was chaired by Michael Cousquer, Vice-Chair of the IALA ENG Committee, Deputy Director of the Ports and Navigation Department in Cerema.

Working Group 4 discussed the current status and future development of skills and training within the AtoN community, with a particular focus on sustainability, technological change, and workforce development.

Participants acknowledged the strong role of the IALA World-Wide Academy in providing high-quality training, including master courses and online programmes that already incorporate sustainability principles. The group agreed that continuous updates of the Academy's material are essential to keep pace with emerging technologies, digitalisation, and evolving international regulations.

Discussions also highlighted the importance of attracting young professionals through career development opportunities, apprenticeships, and stronger outreach via digital media and cooperation with educational institutions. Sharing knowledge and best practices across organisations was recognised as a key factor for capacity building.

Identified gaps included a lack of clarity in defining the roles of competent authorities and AtoN providers in some countries, limited awareness of new regulations and VTS resolutions, and the need to enhance procurement frameworks to integrate sustainability criteria. Participants also emphasised the growing demand for digital and data management skills, as well as the importance of soft skills such as communication, leadership, and conflict management.

Finally, the group encouraged IALA to continue supporting training accreditation, to explore the concept of continuing professional development (CPD) within the Academy framework, and to consider the inclusion of sustainability and emerging technologies such as MASS, AI, and drones in future model courses. Overall, WG4 underlined that developing both technical and interpersonal competencies is vital for ensuring an adaptive, forward-looking, and sustainable AtoN community.

The group revealed important insights, the outputs are available in Annex F.

12. SESSION 13 AND 14 – CLOSING SESSION

The session was chaired by Alwyn Williams, Workshop and IALA ENG Chair.

The participants were invited to comment on the Final Conclusions for the Workshop:

- The UN Sustainable Development Goals (UNSDG) remain relevant as guiding principles for sustainability, and that IALA and its members should focus on the most relevant goals to the marine AtoN and VTS community. IALA should consider revising Recommendation R1004 and other relevant publications with this in mind.

- Climate scientists have demonstrated that climate change presents one of the biggest threats to quality of life on Earth, and that all IALA members should do everything possible within their remit to minimise human impact on this.

- The IALA World-Wide Academy should continue to promote training and capacity building initiatives to ensure that the AtoN and VTS operations use qualified and competent personnel, including the development of relevant skills for sustainable operations.

- IALA should develop and promote a sustainability public document based on the discussions and output of this workshop. This is to ensure that sustainable practices are encouraged and supported in the IALA community and beyond, including the future revision of IALA's Strategic Vision.

- IALA should continue to facilitate the sharing of experiences, collaboration and practical application on sustainability matters through IALA events.

The participants were provided with the Working Group Chars reports, which are available in Annexes C, D, E, and F.

12.1 Closing Remarks

Yvonne Shields O'Connor thanked all participants for their engagement during the week and highlighted the importance of the workshop in advancing sustainability. She acknowledged the contributions of the IALA team, the Heritage Committee, and colleagues from the Northern Lighthouse Board and Trinity House. Special thanks were given to the workshop committee and Irish Lights staff for their coordination and support. She concluded by encouraging ongoing collaboration and wished safe travels to those returning home.

In his closing remarks, Omar Eriksson reflected on the workshop's success, noting that the chosen format had worked very well. He highlighted that beginning with presentations from top-level experts provided a strong foundation for discussions, followed by productive reflection and mapping of the lessons learned onto IALA's work. According to him, this approach consistently delivers valuable and sometimes unexpectedly strong outcomes, as evidenced by this workshop.

IALA Deputy Secretary-General emphasized that it was now up to the relevant committees to carry the results forward. He expressed satisfaction that the outcomes were being linked to IALA's core strategic vision, calling it a remarkable achievement, given that the vision had remained largely unchanged for more than a decade.

He also expressed gratitude to all contributors, mentioning IFAN for sponsoring the social event, which he said added an essential human dimension by fostering friendships and professional connections. Finally, he thanked the organizing team for their excellent preparation and execution, and the Irish Lights team for their strong support and hospitality, which greatly contributed to the overall success of the workshop.

13. SOCIAL EVENTS AND TECHNICAL VISIT

13.1 International Marine, Lighthouse Tourism & Maritime Heritage Conference in Dublin Castle

Participants of the IALA Workshop on Sustainability in AtoN Provision had the opportunity to attend the *International Marine, Lighthouse Tourism & Maritime Heritage Conference* held at Dublin Castle on 7–8 October 2025. The event showcased Ireland's coastal assets as key drivers for sustainable growth, cultural renewal, and community development, emphasizing the importance of lighthouses and working harbours in connecting people to history, place, and community.

The two-day conference brought together policymakers, community leaders, industry professionals, and international experts to explore strategies for developing a thriving maritime economy, share global best practices, and discuss innovative approaches to lighthouse tourism and marine heritage management.

As part of the visit, participants attended the Great Lighthouses of Ireland Showcase Event at City Hall. This evening celebration marked the 10th anniversary of the initiative, highlighting the stories, heritage, and experiences of Ireland's iconic lighthouses. Guests, including IALA Workshop participants, engaged with lighthouse partners, celebrated the decade of achievements, and enjoyed a program of Irish seafood provided by Bord Iascaigh Mhara (BIM), music curated by Philip King, and performances by singer Diane Cannon.

Key speakers included Francis Zachariae, Secretary-General of IALA, Mark Barr, Chairman of the Commissioners of Irish Lights, Yvonne Shields O'Connor, CEO of the Commissioners of Irish Lights, and Eamonn Kelly, Assistant Secretary, Maritime Policy, Department of Transport.

On Wednesday morning, 8th October, participants had the opportunity to attend the International Marine, Lighthouse Tourism & Maritime Heritage Conference at Dublin Castle, engaging in two key sessions: Session

4: Protecting and Sharing Maritime Heritage for Future Generations and Session 5: Global Collaboration: Connecting People, Places, and Stories.

These sessions provided IALA Workshop participants with valuable insights into integrating sustainability, community engagement, and international collaboration into their maritime navigation and AtoN strategies, thereby reinforcing the connection between heritage, tourism, and responsible coastal management.

13.2 Technical tour to the Irish Lights buoy yard

During the visit, delegates were invited on a tour of the Buoy Refurbishment and Engineering Facilities, where Irish Lights' technical staff presented the processes for buoy maintenance, light system calibration, and innovation in material design and energy efficiency. The demonstration illustrated how data and technology are being applied to reduce energy use, extend asset life, and minimise the environmental footprint of operations.

13.3 Sustainability Workshop dinner

Participants of the IALA Sustainability Workshop concluded Thursday evening with a memorable dinner at Jonnie Fox's Hooley in the Parlour, enjoying the unique "An Intimate, Collaborative & Interactive Experience." Upon arrival, guests were warmly greeted and shown to their tables, with pre-dinner drinks served. This was followed by a carefully prepared four-course meal, enjoyed in a lively and welcoming atmosphere. Traditional Irish music and humour accompanied the dining experience, setting the tone for an engaging evening. As the lights dimmed and the stage rose, the main event commenced, inviting participants to celebrate with music, dance, and interactive performances. The dinner offered a perfect opportunity for informal networking, cultural immersion, and celebration after a productive day of discussions on sustainability in AtoN provision.

ANNEX A WORKSHOP PARTICIPANTS

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WORKSHOP PROGRAMME

IST	Monday Royal Marine Hotel	Tuesday Royal Marine Hotel	Wednesday Dublin & Royal Marine Hotel	Thursday Irish Lights HQ	Friday Royal Marine Hotel
8:30		Coffee and Tea	07:45 Bus transfer to Dublin Castle	Coffee and Tea	Coffee and Tea
9:00		Session 3: AtoN Management	International Marine, Lighthouse Tourism & Maritime Heritage Conference in Dublin Castle	Working Group 1 / Working Group 2	Session 9: Closing Session
9:30					
10:00	Registration (including tea and coffee)				
10:30		*Workshop Photograph* Break		Break	Break
11:00		Session 4: Key Skills and VTS Management		Working Group 1 / Working Group 2	Session 10: Clossing Session
11:30					
12:00					
12:30	Lunch	Lunch		Lunch at Royal Marine Hotel	Close
13:00			Travel back to Dun Loaghaire and Lunch at Royal Marine Hotel		
13:30	Session 1: Opening Session	Session 5: Role of Maritime Modernisation		Working Group 3 / Working Group 4	
14:00					
14:30					
15:00	Break	Break	Session 7: Sustainable Operations	Break	
15:30	Session 2: Opening Session (cont.)	Session 6: AtoN Engineering and Heritage	Break	Working Group 3 / Working Group 4	
16:00			Session 8: Framing and Quantifying Sustainability		
16:30		Close			
17:00	Close	17:15 Bus transfer to Irish Lights Conference Reception at Dublin Castle	Working Group Arrangements	Close	
17:30			Close		
Evening		18:30 - 20:30 Reception at Irish Lights Conference, Dublin City Hall		Sustainability Workshop dinner Bus departs Royal Marine Hotel: 18:!5	

Day 1 - Royal Marine Hotel

Session	Chair	Time	Subject	Presenter
1 Opening Session	Alwyn Williams	13:30	Introduction from Host	Yvonne Shields O'Connor Irish Lights Chief Executive
		13:45	Address from IALA	Francis Zachariae IALA Secretary-General
		14:00	Workshop Aims and Objectives	Alwyn Williams ENG Committee Chair
		14:15	**KEYNOTE:** Key Climate Risks	Dr Hans-Martin Füssel European Environment Agency
15:00 Coffee Break				
2 Opening Session (cont.)	Alwyn Williams	15:30	**KEYNOTE:** Update on Climate Change Predictions	Prof. John Sweeney Irish Climate Analysis and Research Units (ICARUS)
		16:00	Developing Countries' Challenges of Meeting Sustainability Responsibilities - The WWA Experience	Vincent Denamur Dean of World-wide Academy
		16:30	Current IALA work on sustainability & UNSDGs Presentation of IALA relevant documentation (R1004 / G1036, G1137, G1165)	Omar Frits Eriksson IALA Deputy Secretary-General

Day 2 - Royal Marine Hotel

3 AtoN Management	Guttorm Tomren	9:00	Maintaining Service Performance against the Challenges of Low Environmental Impact Operations	Jim McBrier, NLB
		9:30	Review of Regulatory Frameworks for Sustainable Practices (e.g. ISO14000)	Will Dunning, GRAD
		10:00	Pollution Mitigation through Aids-to-Navigation Management	David Lewald, USCG (Presented by Guttorm Tomren)
10:30 - 11:00 Coffee Break and Workshop Photograph				
4 Key Skills and VTS Management	Monica Sundklev	11:00	Securing Key Skills for Future AtoN and VTS Operations	Latifa Oumouzoune IALA World-Wide Academy
		11:30	Sustainable Procurement - How Can Value-For-Money and Environmental Considerations Work Hand-in-Hand?	Richard Aase, Norway
		12:00	Autonomous Vessels - an opportunity to increase efficiency or a resourcing challenge for AtoN and VTS providers?	Maarten Berrevoets, NL
12:30 - 13:30 Lunch				
5 Role of Maritime Modernisation	David Jeffkins	13:30	Challenges of Providing Digital Maritime Services with a Minimal Environmental Impact	Sarah Leullier, MSM Nikolaos Vastardis, GRAD
		14:00	Industry's Role in Providing Sustainable AtoN Services	Malcolm Nicholson, SPX
		14:30	The Life Cycle of an AtoN: Reusable vs Disposable Design	Peter Schneider and Lars von Lilienfeld-Toal, WSV
15:00 - 15:30 Coffee Break				
6 AtoN Engineering and Heritage	Alwyn Williams	15:30	Maintenance Regime for Extending Life of Components and Systems	Peter Dobson, TH
		16:00	Maritime Heritage, Culture Conservation and Biodiversity	Alan Hayden Archaeological Projects Ltd (consultant on Skelligs UNESCO World Heritage Site)

Day 3 - Dublin Castle and Royal Marine Hotel

07:45 - 09:00 Bus from Royal Marine Hotel for Dublin Castle 09:00 - 13:00 International Marine, Lighthouse Tourism & Maritime Heritage Conference, Dublin Castle 13:00 - 14:00 Bus from Dublin Castle to Royal Marine Hotel				
14:00 - 15:00 Lunch				
7 Sustainable Operations	Omar Frits Eriksson	15:00	Maritime Green Corridors	Guttorm Tomren, Norway
		15:30	Keeping the Human at the Centre of a Digitalised World	Monica Lundh (online/recording)
16:00 - 16:15 Coffee Break				
8a Framing and Quantifying Sustainability	Malcolm Nicholson	16:15	Learning/Experiences from the carbon neutral Port operations	Hyerim Bae, Ph. D
		16:45	Assessing and Communicating IALA's Contribution to Sustainability	Minsu Jeon and Sarah Robinson
8b Working Groups		17:15	Working Group Arrangements	Alwyn Williams, ENG Committee Chair

Day 4 - Irish Lights HQ, Dun Laoghaire

9 Working Groups	TBD	9:00	Working Group 1 / Working Group 2
10:30 - 11:00 Coffee Break			
10 Working Groups	TBD	11:00	Working Group 1 / Working Group 2
12:30 - 13:30 Lunch			
11 Working Groups	TBD	13:30	Working Group 3 / Working Group 4
15:00 - 15:30 Coffee Break			
12 Working Groups	TBD	15:30	Working Group 3 / Working Group 4

Day 5 - Royal Marine Hotel

13 Closing Session	Alwyn Williams	9:00	Report from Working Group Leads	
10:30 - 11:00 Coffee Break				
14 Closing Session (cont.)	Alwyn Williams	11:00	Agreement of Workshop Conclusions	Alwyn Williams, ENG Committee Chair
		11:30	Closing Remarks	Omar Eriksson, IALA Deputy Secretary-General
12:00 Close				

ANNEX C **WORKING GROUPS 1 OUTPUTS**

Working Group 1 – Environmental Matters

Topics:

Climate change:

- Extreme weather conditions (e.g. high/low temperatures, increase storm frequencies)
- Sea-level rises
- Effects on physical infrastructure

How should IALA members implement the UN Sustainability Goals?

- Reduce, reuse, recycle initiatives
- Use of plastics for AtoN
- AtoN support vessel operations, including fuelling
- Pollution control
- Equipment procurement
- Heritage implications

What practices have been identified as being good for sustainability and should continue?

- Manufacturer buy-back on AtoN, recycle, reuse, repair, of existing AtoN at a cost that's lower than the original purchase. Case studies within guidance could help promote this. This recyclability is having a positive impact on the local areas when they're EOL and being disposed of. Case study provided.
- The benefits of durability, extending life, and the purpose of products. Leveraging advancements in technologies. Manufacturers are considering sustainability in their decisions, which has a positive knock-on effect for AtoN providers.
- Also, the reliability of AtoN is considered as an influence in an organisation
- Risk – the academy is doing fantastic work in its role to educate; it already has risk workshops and the value this plays is incredible. If this can be expanded, so that organisations have a better understanding of their operations' impacts on the environment, this would be the precursor to an aspects and impacts register. Even developing further into climate change risks would facilitate the understanding of cascading and interconnecting risks within the IALA community. Huge value to be added if slightly more consideration is given to environmental risks at this stage.
- Vessel optimisation – after being able to measure vessel use, it's enabled
- Carbon footprint – some are doing it well, but need guidance on how to calculate these, set baselines and objectives, etc.
- Recognising that IALA availability and sustainability have a relationship and members have an understanding of the impacts they have on each other. Availability is a performance measure, but also a measure of the performance of your organisation. Do we need to review our focus on availability when it can force us to make un-environmentally friendly decisions? Do we need more acceptance in certain circumstances that availability won't be met because of the environmental

impacts of doing so, or do we need more flexibility in that? Do we need to send a large vessel out instantly, or can we be more conscious and send a smaller vessel in 24-48 hours? Can we reach a common agreement on a use case for instances that impact availability during times of negative impact? How do we communicate with ARM WG3 to push this? We consider H&S when we make decisions, we need to start considering

- Balancing modernisation and heritage, and how they can co-exist. Particularly for AtoN, these are considered community hubs now, not just AtoN. Revisiting the utilisation of old lenses into AtoN, and the modularity of existing control units. Can we send discarded equipment within IALA to countries that are less economically mature?

What areas or practices need improvement to become sustainable (or more sustainable)? How could this be achieved?

- Use of resources during maintenance, when planning we need to better consider the resources we're using. For example, when washing, fresh water was being used; when potted water would suffice.
- Empowering staff to be able to suggest improvements
- Manpower needed to meet the ambitions of the organisations
- Institutional culture
- Vessel use in a sustainable way
- Adherence to guidelines, especially G1036
- Being able to talk about the challenges or negative issues in a 'safe' environment

Are there gaps in knowledge? If so, what are they, and how can they be filled?

- Educational and training tasks are for countries not represented today; sustainability is not a separate matter. The Ocean Leaders module is linked to AtoN management and does cover certain aspects, but for operations management, perhaps a module in 1.1 or 1.2 on sustainability considerations could be suggested.
- Sustainability reporting, how do we do that? Suggested guidelines
- Aspects and impacts, how do we do that?

  Explain the link between understanding your risk (Aspects and impacts), which defines your areas for consideration, which then drive the areas you need to monitor (sustainability reporting)
- We don't know what challenges face organisations in improving their knowledge, especially in less developed areas. Perhaps we need further workshops in these areas to start building that understanding? Action item: regular workshops like this in other parts of the world to build this understanding.
- Understanding which AtoN are at risk from a changing climate, so understanding the projections at a local level
- Observational data missing, or perhaps not missing but just siloed within organisations.

What can IALA as an organisation do to improve or maintain sustainable practices in this area?

- Define sustainability – The Brundtland definition was shown to have value. Perhaps as an umbrella definition, with statement of intent for how member states would facilitate in meeting that obligation. Perhaps this can be communicated in a sustainability policy.

- Climate emergency discussion – do we want to acknowledge a climate emergency as an IGO? Need guidance on how to start these conversations?
- Furthering IALA's partnerships between authorities and other IGOs and NGOs that can help deliver environmental improvements
- Analysis of how member states engage within their local communities, and how IALA can help to improve this
- Facilitate the co-operation between national institutes
- Lobby other IGOs and regulators on the challenges faced. Some issues we face would benefit from pressures at a higher level than operational management. Ask Jim for his explanation on the bird mating
- Co-ordinate with other IGOs in promoting our mission
- Can we visually link our guidelines to the SDGs? Can we review our guidelines and then add which SDG it relates to? This would help engage users and show them how their operations impact the delivery of the SDGs.

Working Group 2 – Maritime Modernisation

Topics:

- Digitalisation infrastructure
- Impact of MASS
- Impact of Artificial Intelligence
- Cost of powering infrastructure
- Standardisation – key to sustainable digital products or threat to innovation?
- Availability of IT skills and knowledge
- Use of IoT technologies to increase monitoring of AtoN

What practices have been identified as being good for sustainability and should continue?

- Powering infrastructure:
  - Adoption of and innovation in solar. Benefit in upgrade vs impact of upgrade
  - Local secure energy is better than importing energy. Provides better resilience to avoid unplanned visits.
- Use of IoT technologies:
  - The adoption of low-power monitoring, with efficiency in content message
  - Inspection of physical AtoN by drone
- Standardisation:
  - Compliance and standardisation of data sharing e.g. S400 for weather information & S200

What areas or practices need improvement to become sustainable (or more sustainable)? How could this be achieved?

- Standardisation:
  - Innovation is essential to progress sustainability, often driven by commercial benefits, which are then standardised.
- Skills and knowledge:
  - Dissemination of experience and knowledge of the existing system.
- Use of IoT:
  - The increase in monitoring for sustainable building conditioning.
  - Use of existing data to improve delivery and enhancements

Are there gaps in knowledge? If so, what are they, and how can they be filled?

- Skills and knowledge:
  - How best to present information so that it is clear to users

- Training in IT technology will be essential for the future or additional support will be needed from the industry.
- To reach sustainability goals, we need to close the gap in IT skills, possibly by other third parties.

- MASS:
  - Support on what is needed from an AtoN to ensure effective, safe and sustainable voyages.

What can IALA as an organisation do to improve or maintain sustainable practices in this area?

- Standardisation:
  - Standardisation is critical for digitisation
  - Data model - Exchange of data needs to be in a standard structure so that the correct information is understood.
- Impact of AI:
  - AtoN performance and digital twin of systems to predict the impact of storms and move resources in advance.
- Impact of MASS:
  - Need to know what is needed by MASS to know what to provide.
  - Is it possible to extend the visual distance of MASS vessels through supported input, e.g. buoys and lighthouses?
  - What can we learn from the airline industry? – supporting collision avoidance

What related topics need further discussion and debate in the marine AtoN and/or VTS community?

- How to improve the reliability and resilience of communications?
- Can we learn from other industries, such as the wind industry, that use AI?
- Would an LLM for VTS be possible?
- Machine learning analysis of monitored data for future potential failures.

Working Group 3 – Aton Management

Topics:

- Balancing AtoN availability with sustainable operational practices (e.g. Eco steaming, working with ecology partners)
- Dealing with the effects of climate change, possibly with more frequent natural events
- Managing changing skill sets within the workforce to provide modern AtoN service (e.g. due to MASS or digitalisation)
- Pollution control
- Sustainable procurement
- Preservation of heritage and culture
    - The issue isn't planned steaming, it's unplanned steaming; the ambition should be to ensure the original product is reliable enough
    - Trinity House has a feeling that changing weather has increased the instances of storm damage, although this is just a feeling and not backed by data
    - AMSA is experiencing more variability with the weather, which is creating a lot of rescheduling
    - Germany, a positive impact in seeing less ice and so reducing the mitigation measures required in AtoN management
    - Some cases that virtual AtoN will have a place and subsequently a positive environmental impact; eventually, maybe this will happen.
    - If you have a zero-emission vessel, then the environmental benefits of virtual AtoN are negated

What practices have been identified as being good for sustainability and should continue?

- Monitoring, reducing the unnecessary time spent attending buoys. After a storm, if buoys are monitored, you know you only need to travel to those and not check everyone.
- Stopped fluorescent colours on buoys, which have extended lifetimes
- Procurement of new lanterns with an interchangeable light source, with a durable housing, and with conscious designing of the light pattern to ensure efficiencies. This has also reduced the vessel requirement.
- The French buoy tender is now a hydrogen fuel.
- Changes in material use, after identifying that UV was breaking down the plastic housing on PV panels. A fabric cover was implemented, which has extended the life.
- The Japan Coast Guard is deploying a drone to establish buoy condition before sending a vessel.
- Including environmental objectives into the organisation's values and into people's objectives.
- Renewal of fleet across member states.

What areas or practices need improvement to become sustainable (or more sustainable)? How could this be achieved?

- Being stricter on vessel use, especially in planned maintenance. Putting the right vessel on the right task. This can be challenging in areas where vessels are required to be multi-purpose, for towage, pollution response or firefighting.
- Using data or systemising the data we are collecting from the AtoN. Can this be used for predictive maintenance? Or fed into AI models? Or used by in-house analysts?
- Can we be more efficient in setting navigational requirements, in terms of how many are set?
- In the level 1.1 course, could we improve guidance on how to optimise your mix of AtoN in fairways and perhaps include environmental considerations?

Are there gaps in knowledge? If so, what are they, and how can they be filled?

- Changes to extreme weather events, reduction in time between events or severity due to climate change would be helpful to know to build into the technical specifications of new installations.
- Climate projections understanding in asset management is a sparse skill set that often has to be bought in.
- Ecological requirements within the UK, like gaining permissions and mandated biodiversity assessments, have to be conducted by qualified ecologists, which is not an in-house skillset.
- Data analyst is a skill set that is missing.
- More environmental factors have to be considered now than ever before.
- Climate change calculations, emissions inventories, and reporting frameworks to be used.

What can IALA as an organisation do to improve or maintain sustainable practices in this area?

- Review R1004
- Include sustainable procurement references in G1036, can we also provide a good example of an aspects and impacts register?
- Review G1077
- Provide tools for carbon emissions calculations alongside its guidelines

What related topics need further discussion and debate in the marine AtoN and/or VTS community?

- Plastic vs steel buoy life cycle comparison. Ed Steijn has the LCA on this, which would be a useful case study to include in documents. Can we extend this to other material uses, light sources or other?
- Can we supply our data to others to progress their work or research? Can we use this monitoring data for research purposes? Can we pull live data from buoy monitoring to help live-time navigation, using the Port of Tanger as an example?
- Can we determine an ROI on sustainable business practices to evidence the effort required in meeting these standards and guidelines?
- Offer liaison to ARM on their review of R1030 to provide sustainability insights.

Working Group 4 – Key Skills and Training

Topics:

- Ensuring key technical, management and operations skills.
- Changing skill sets within the workforce to provide modern AtoN service (e.g. due to MASS or digitalisation).
- Future availability of experts for standards development.
- Heritage and culture expertise.

What practices have been identified as being good for sustainability and should continue?

- WWA Master course – to be considered by Competent Authorities in their strategy and written policies.
- Use of distance learning, remote training and hybrid mode.
- WWA continue promoting the Ocean protection UNESCO concept (UN Ocean Decade).
- Local community engagement – What they should take into account for their coastal and maritime activities.
- Strategic procurement: supplying how to design a tender for sustainability issues (criteria).
- Encouraging work colleagues to share their knowledge and experience.
- Encourage Stakeholder engagement (WWA).
- Technical missions – awareness of developing countries (WWA).

What areas or practices need improvement to become sustainable (or more sustainable)? How could this be achieved?

- Promote career development (use of social media, digital media, school contacts, publications).
- Promote apprenticeships.
- Continue updating training material and teaching strategies (developing new scenarios, new case studies).
- Improving online training.

Are there gaps in knowledge? If so, what are they, and how can they be filled?

- Continuous skills development.
- No clear definition of the respective roles of National Competent Authorities and aids to navigation providers.
- Unclear role and responsibility for competent authority in the new IMO resolution for VTS (for some) - gap covered by a new planned guideline?
- Environmental part of procurement for developing countries.
- Knowledge of digitalisation in general.

- Lack of standards for communicating from ship to shore.

What can IALA as an organisation do to improve or maintain sustainable practices in this area?

- Continue supporting Competent Authorities on the process of accreditation of training organisations and approval of model courses.
- Consider including any matter of sustainability when developing guidance to IALA members.

What related topics need further discussion and debate in the marine AtoN and/or VTS community?

- MASS
- Connectivity (eg S-100 and S-200)
- Skills in new technologies (drones, IoT, AI)
- Heritage management (Key skills or expertise in civil engineering, for example)
- Do more on soft skills (communication (what and the way to), management, health and safety awareness, human development, etc.).

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