State-of-the-art Underwater Communication Standard in ISO/IEC JTC1

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***Abstract*— The maritime industry is currently experiencing huge transformation and growth, with the advancements in various sectors driving the demand for more reliable and efficient communication. As we are moving forward to 6G communication, technology requires innovation. This approaching transformation presents a great opportunity for the breakthrough development of underwater communications. This paper will encompass the working of ISO/IEC SC41 which can be vital for seamless future underwater communications.**

Keywords—Underwater communications, Underwater Wireless communications, standardization, ISO/IEC JTC 1/SC 41/WG 7

I. INTRODUCTION

The recent surge in the maritime industry, for example smart farming, pipeline monitoring, AUV/ROV etc. has led to the growth of good communication infrastructure. In future 6G wireless networks scenario, the underwater communications will play a vital role to the flow of industrial development[1].

Underwater communication refers to the transmission of information beneath the water. UWC consists of various technologies such as Acoustic communications, optical communications etc. [2,3] In the realm of oceanic environments, scientists face a spectrum of challenges and prospects for exploration, so we need to review the SC41 workings to understand it better.

By conducting research in this area, scientists and engineers aim to develop better ways of transmitting information underwater without relying on physical cables. [4] This has the potential to open new opportunities for various applications in underwater environments. The goal is to overcome the challenges offered by the underwater environment. Standards are needed to revitalize the industry by overcoming these technical challenges, and these standards developed by organizations such as SC41.

Currently, specialists actively participating in the formulation of international Information and Communication Technology (ICT) standards are taking an active role in the process of standardization. ISO/IEC JTC 1/SC 41 is a dedicated team concentrating on establishing guidelines for Internet of Things and Digital Twins within the scope of JTC 1. Expanding from the efforts of the Underwater Projects, the creation of Working Group 7 (which encompasses Maritime, Underwater IoT, and Digital Twin applications) gained endorsement during the plenary meeting in May 2021, backed by an agreement within SC 41 about the importance of standardizing maritime and underwater technologies.

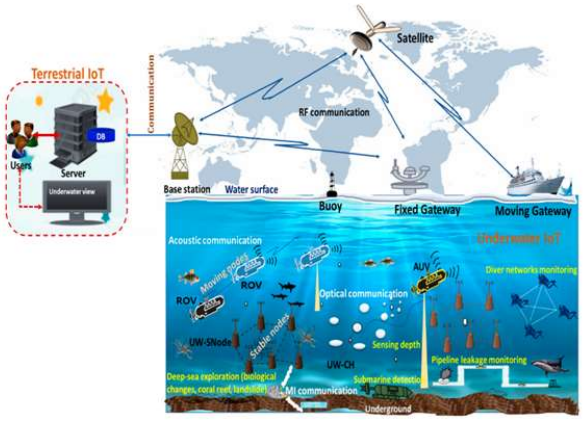

Fig 1. Underwater Communication Architecture [5]

In this paper we review the workings of various working groups under the SC41 organizations and find how their contributions can aid in shaping the future of UWC development. This paper is divided into 4 sections. Section 2, provides an introduction to SC41/WG7, an international organization focused on establishing standards for underwater communications. Section 3, presents an overview of the ongoing standardization efforts within SC41 that hold significance for underwater communication. Section 4 outlines the anticipated directions of standards development in the prospects of underwater communication and Section 5 is the conclusion of this paper.

II. UNDERWATER COMMUNICATION STANDARDIZATION

ISO/IEC JTC1 was established in 1987 to promote international standardization in the field of information technology in cooperation between ISO and IEC. It is a Sub-Committee (SC) that conducts standardization on Internet of Things and digital twins. SC 41 is composed of five working groups (WGs), including the Working group (WG) on marine/underwater IoT and digital twin applications, which was established in 2021 under the leadership of Korea [6].

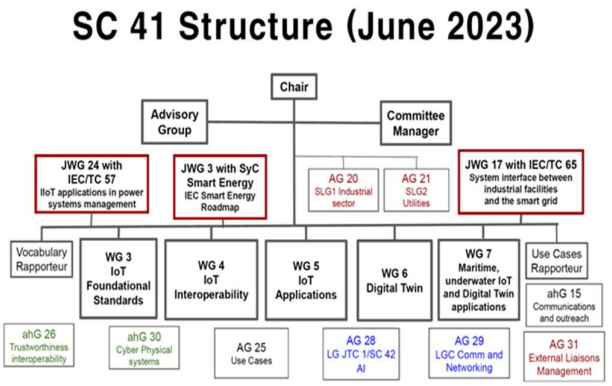

Fig 2. ISO/IEC JTC1/SC41 Structure (Jun 2023)[7]

ISO/IEC JTC1/SC41 has the structure shown in Figure 1. As of June 2023, 44 international standards have been published and various projects are underway in each WG.

WG3 conducts Internet of Things-based standardization, including the Vocabulary of IoT and Digital Twins. There are currently four projects in WG3, including two revisions.

WG4 works standardization in the area of IoT interoperability, connectivity, IoT platform, middleware, conformance and testing. There are currently two projects in WG4.

WG5 conducts standardization in the area of IoT applications and guides use cases, tools, and implementations of related technologies. There are currently six projects in WG5.

WG6 works on the overall standardization of digital twins. There are currently six projects in WG6.

A group for public standards for underwater communication technologies was established at SC41 to investigate and understand what has been done so far.

Our primary emphasis is on WG7, which is dedicated to enhancing underwater projects. This is advantageous for us since our paper aims to enhance underwater communication technology. The following is a detailed introduction to WG7, the underwater communications standards organization.

A. ISO/IEC JTC1/SC41 WG7

ISO/IEC JTC 1/SC 41, a standard development organization, focuses on standardizing Internet of Things and digital twin technologies for maritime and underwater settings. This effort led to the formation of Working Group 7 in 2021 under SC 41's jurisdiction.

WG7 works on the standardization of maritime, underwater, and digital twins, and related technologies for maritime applications such as shipping, energy, aquaculture, and environmental monitoring. There are currently four projects in WG7.

Between 2013 and 2014, a special team called SWG 5 worked under ISO/IEC JTC 1 to set standards for the Internet of Things (IoT).

Later, in November 2016, JTC 1 formed SC 41, which was tasked with addressing the intricate and ever-changing landscape of technologies, markets, and standards development organizations (SDOs) within IoT and Digital Twin realms. Recognizing the distinct technical demands of underwater IoT in contrast to terrestrial IoT, a proposal from the Korean national body (NB) led to the creation of a new working group. This initiative, ISO/IEC JTC 1/SC 41/WG 7, was launched in May 2021 during the plenary meeting. Soo-Hyun Park, representing Korea, was appointed as the convener for WG 7, focusing on the standardization of underwater IoT, which holds significant value as an unexplored area in the field[8].

B. History of standard on WG7

The creation of SC 41/WG 7 led to the expansion of global standards in areas like underwater IoT and digital twin applications for the marine environment. This is predicted to speed up the development of good international standards by involving experts from different countries. The standards history includes ISO/IEC 30140, which is split into four sections.

The ISO/IEC 30140 series defines technologies and standards related to underwater wireless acoustic sensor networks. The underwater wireless acoustic sensor network has a two-dimensional form consisting of sensor nodes built on the seabed and a three-dimensional form built on the seabed and underwater[9]. It provides concepts and definitions of general requirements for these types of underwater wireless acoustic sensor networks, reference architectures including component nodes and models, and related technologies.

The 30140 series is a standard, but it does specify the communication waveform or frequency, which allows the designer or developer to develop the frequency and waveform, that align best with their design objectives.

These parts are titled: "Overview and Requirements" for Underwater Acoustic Sensor Network (UWASN) - Part 1, "Reference Architecture" for Underwater Acoustic Sensor Network (UWASN) - Part 2, "Entities and Interfaces" for Underwater Acoustic Sensor Network (UWASN) - Part 3, and "Interoperability" for Underwater Acoustic Sensor Network (UWASN) - Part 4.

C. Status of standard on WG7

WG7 develops and manages technical standards for Underwater Wireless Acoustic Sensor Network (UWASN), advancing the standardization and mandating of the application of maritime and waterway Internet of Things, digital twins, and related technologies.

As the underwater environment is different from the terrestrial one, it requires different technical expertise than the terrestrial IoT, so it is necessary to develop and progress new standards for the underwater environment by referring to the standards of other WGs.

It is also necessary to consider underwater animals, plants, and environments, so we are working on standards for safety and risks related to them.

The following are some of the standardization efforts currently underway in WG7

- ISO/IEC 30177 ED1 Internet of Things (IoT) - Underwater network management system (UNMS) interworking

  UNMS: An Underwater Network Management System (UNMS) is a specialized software or hardware infrastructure designed to manage and optimize

communication and networking in underwater environments.
It centres on the Underwater Network Management System (U-NMS) and its integration within the framework of the Internet of Things (IoT). It offers a comprehensive explanation of the interworking components within the U-NMS, encompassing the relationships and interactions between the manager, proxy agent, master agent, and sub agent. Furthermore, it addresses the problem statement, explores the advantages of U-NMS interworking, and discusses its potential environmental impact. The document provides an in-depth understanding of how U-NMS can efficiently manage underwater networks in the context of IoT applications.

- ISO/IEC 30183 ED1 Internet of Things (IoT) – Addressing interoperability guidelines between heterogeneous underwater sensor networks (UWASNs) based on underwater delay and disruption tolerant network (U-DTN)

  UDTN: Underwater DTN (Disruption-Tolerant Network) refers to a network architecture designed to address the challenges of communication and data transmission in underwater environments. Similar to terrestrial DTNs, which are designed for situations with intermittent or unreliable connectivity, underwater DTNs are tailored to cope with the unique characteristics of underwater communication. It focuses on establishing interoperability guidelines for heterogeneous underwater acoustic sensor networks (UWASNs) based on underwater delay and disruption-tolerant network (U-DTN) technology. It offers an overview of interworking in such diverse UWASNs, encompassing their architecture, physical entities, and functional entities. The guidelines presented in the document address the need for seamless communication and interconnection services across underwater distances, ensuring smooth and efficient data exchange between different UWASNs.

- ISO/IEC 30185 ED1 Internet of Things (IoT) – Addressing interoperability between IPv6-based network and UWASN

  The document details the interaction between an IPv6-based network and a UWASN, focusing on the role of the underwater gateway (UWA-GW) in facilitating interconnection services over terrestrial-underwater distances. It encompasses an overview, functional interworking, and operation of the connection between the terrestrial and underwater networks. Emphasizing the necessity of interoperability between the IPv6-based network and UWASN, the document specifies various functionalities and operations to achieve seamless communication between these two networks.

- PWI TR JTC1-SC41-12 Internet of Things (IoT) – Environmental and ecological effects, risks, and considerations of underwater acoustic signalling

  This document is a technical report that focuses on conducting a transparent risk assessment and proposing "Mammal-Friendly" standards for underwater Internet of Things (U-IoT) systems. The report emphasizes the need to reduce underwater noise while keeping the system working well. It also recommends keeping a record of all sound transmissions to assess their impact on the environment later. The report talks about different things like how the system is usually used, understanding how it affects animals through studies, and assessing the risks to them. It also looks at ways to lessen the effects on marine mammals.

III. Status of International Standardisation

In the earlier sections, we talked about the JTC1/SC41 WG7. And in SC41, each group outside of WG7 is working on its own project, focusing on a different area. In this section, we'll provide more details about what these projects are and how they relate to the idea of the Underwater Communications (UWC).

A. WG3

WG3 describes and provides overall concepts and terminology for IoT and develops reference architectures (RAs) to support business models.

Since the underwater environment is different from the land, it is necessary to describe the concepts and terms of underwater IoT and develop a reference architecture (RA) that fits the domain of underwater. Therefore, it is necessary to develop a standard for underwater IoT vocabulary, terminology, and reference architecture (RA) by referring to the standards being developed in WG3.

B. WG4

WG4 concentrates on IoT interoperability. It deals with things like how data is handled, how devices work together, and how information is processed. This includes aspects like how networks function, different types of computing, safety, and making hardware and software work well together.

Additionally it supports the idea of fundamental representation of data points and metadata that can be universally applied. It discusses the need for an interoperability language, interoperability points, interoperability cases, and interoperability profiles. The main goal is to improve how we understand and put into practice the idea of devices working together smoothly in IoT and digital twin systems.

C. WG5

WG5 provides a standardized approach for evaluating the performance and reliability of IoT applications and IoT systems.

However, unlike on land, the physical conditions underwater are different because we communicate with water as a medium, so it is necessary to refer to WG5's standards to design principles and approaches for underwater IoT that are appropriate for the underwater domain.

D. WG6

Digital twins, as addressed by WG6, are defined as a digital representation of a real-world entity or system [10]. They are being used intensively in several fields and standardization areas, including smart energy, smart manufacturing, and smart cities. When used systematically, they can significantly improve the performance of some equipment, reduce costs, and improve interoperability.

WG6 is standardizing on the concept, terminology, and reference architecture of digital twins.

With the development of the underwater industry, such as subsea exploration and pipeline maintenance, the application of digital twins should refer to the standards of WG6 to provide standards suitable for the underwater domain.

IV. Forecasting on Future Standardisation in ISO/IEC SC41

In terms of the development trend of the marine industry, technological advances in the field of underwater communication are becoming more important, and ISO/IEC SC41 is expected to develop and update standards related to underwater communication. This will expand to various application fields such as underwater robots, marine sensor networks, and marine environment monitoring, and will promote innovation and development of underwater communication technology for the advancement of each application field.

Underwater communication technology will shift from acoustic communication to optical wireless communication. However, it is expected that efforts will be made to develop network technology to overcome the limitations of communication reach inherent in communication media. It is also expected that attempts will be made to resolve technical hurdles in underwater communication by embracing complex utilization of various communication media, and standards activities by advanced countries will be activated to take the lead in standards based on these technologies.

In addition, as the industry develops, we recognize the importance of eco-friendly to resolve environmental problems that may be caused by underwater communications, and international efforts are being made to reduce the damage to underwater/marine animals.

In an effort to reduce underwater noise from ships and thereby reduce damage to marine animals, the IMO/SDC submitted draft guidelines on underwater noise from commercial shipping to the Marine Environment Protection Committee (MEPC 80) in July 2023[11].

ISO/IEC JTC1/SC41/WG7 has issued a task to measure underwater noise, analyze its impact on marine animals, and predict possible future risks (ref. SC41WG7N060). Activities are underway to build on the findings of the task and incorporate them to reduce possible damage to the underwater environment from future use of underwater communications.

V. Conclusion

With the development of industry and advances in underwater communication technology, underwater communication is evolving from acoustic communication to multi-mode communication using various communication media. In addition, environmental issues such as marine animal protection will be accommodated, and eco-friendly technologies will be added to the structural design and standardization of related technologies.

Therefore, it is predicted that the standardization of technologies that have other frequency bands other than acoustic and have real-time and high data rate characteristics will be actively promoted, and technological advancements will be developed to make them practical, rather than the acoustic communication technologies that are currently used mostly as underwater communication technologies.

Therefore, through the development of communication technology based on this multi-mode communication, the marine industry will develop dramatically and ISO/IEC SC41 groundbreaking works can lead it to further growth. As the field advances, one of the most important areas that is growing a lot is underwater communications. As scientists, engineers, and people involved in the maritime industry welcome these new improvements, the field is set to experience significant expansion and become more efficient in the future.

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