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Date: 11 February 2025

Origin: International

Latest date for receipt of comments: 5 March 2025

Project No. 2025/00464

Responsible committee: IOT/1 Internet of Things and Digital Twin

Interested committees:

Title: BS ISO/IEC 3200-1 Internet of Things (IoT) — Multi-modal underwater wireless communication technologies Part 1: Overview and requirements

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



JTC1-SC41/493/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:

ISO/IEC 3200-1 ED1

DATE OF CIRCULATION:

2025-02-07

CLOSING DATE FOR COMMENTS:

2025-04-04

SUPERSEDES DOCUMENTS:

JTC1-SC41/395/NP, JTC1-SC41/421A/RVN

IEC SC 41 : INTERNET OF THINGS AND DIGITAL TWIN

SECRETARIAT:

Korea, Republic of

SECRETARY:

Ms Jooran Lee

OF INTEREST TO THE FOLLOWING COMMITTEES:

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TITLE:

**Internet of Things (IoT) — Multi-modal underwater wireless communication technologies —
Part 1: Overview and requirements**

NOTE FROM TC/SC OFFICERS:

Please note that this project (standard) number was changed from ISO/IEC 63573-1 to ISO/IEC 3200-1.

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CONTENTS

1		
2		
3	FOREWORD.....	3
4	INTRODUCTION.....	5
5	1 Scope.....	6
6	2 Normative reference	6
7	3 Terms and definitions	6
8	3.1 multi-modal underwater wireless communication (MM-UWC) :	6
9	4 Abbreviated terms	6
10	5 MM-UWC overview and application.....	7
11	5.1 Overview	7
12	5.2 Application domain of MM-UWC.....	10
13	5.2.1 Underwater resource exploration and development.....	10
14	5.2.2 Marine ecosystem and environmental monitoring	10
15	5.2.3 Marine science research.....	10
16	5.2.4 Mission-Critical Underwater applications	11
17	5.3 Underwater Communication module: Hardware and Software Component.....	11
18	5.3.1 Communication module	11
19	5.3.2 Working module.....	11
20	5.3.3 Device protection module	12
21	5.3.4 Security module.....	12
22	5.3.5 Other module.....	12
23	6 Characteristics of MM-UWC in terms of the effects of propagation variability	13
24	6.1 Concept of Underwater Wireless Communications	14
25	6.2 Underwater Wireless Optical Communication	14
26	6.2.1 Channel Characteristics.....	14
27	6.2.2 Important factors that affect the UWOC	15
28	6.2.3 Propagation loss.....	16
29	6.2.4 Link configuration of UWOC.....	16
30	6.2.5 Modulation techniques	17
31	6.3 Underwater Wireless RF Communication	18
32	6.3.1 Multipath	18
33	6.3.2 Signal delay.....	18
34	6.3.3 Diversity techniques	18
35	6.3.4 Propagation loss.....	18
36	6.4 Underwater Wireless MI Communication	19
37	6.4.1 Characteristic of technology	19
38	6.4.2 Technology classification.....	19
39	6.4.3 Propagation loss.....	19
40	6.5 Underwater Wireless Acoustic Communication.....	20
41	6.5.1 Acoustic signal strength attenuation	20
42	6.5.2 High propagation delay	21
43	6.5.3 Multipath	21
44	6.5.4 Propagation loss.....	21
45	6.5.5 Noise.....	22
46	7 Differentiators between MM-UWC and UWAC.....	22
47	7.1 Multi-modal based communication reliability	22

48	7.1.1	High data rate reliability application(Critical mission application)	23
49	7.1.2	Multi-mode medium	23
50	7.1.3	Physical Constraint.....	24
51	7.1.4	Core communication	24
52	7.1.5	Network connectivity and Convergence in Underwater Communication	25
53	7.1.6	Cross-layer adaptation in service structures	25
54	7.2	Multi-hop Optical Communication in Underwater network	26
55	7.3	Eco-friendly communication	26
56	8	Specificities of MM-UWC and related requirements	27
57	8.1	System perspective.....	27
58	8.1.1	QoS requirement	27
59	8.1.2	Mission critical.....	28
60	8.1.3	Heterogeneity	28
61	8.1.4	Dynamic channel selection	28
62	8.1.5	Functional requirements	28
63	8.1.6	Performance requirements.....	29
64	8.2	Network perspective	29
65	8.2.1	Routing.....	29
66	8.2.2	Medium access control(MAC)	30
67	8.2.3	Cross layer adaption.....	30
68	8.2.4	Handover	31
69	8.2.5	Security	32
70	8.2.6	Robustness	32
71	8.2.7	Distributed network management.....	33
72	8.3	Device perspective	33
73	8.3.1	Power consumption	33
74	8.3.2	Multi-medium	33
75	8.3.3	Size and weight	33
76	8.3.4	Durability	33
77	8.3.5	Performance	34
78	8.4	Sensor network perspective	34
79	8.4.1	Deployment	34
80	8.4.2	Scalability.....	34
81	8.4.3	Fault efficiency	34
82	8.4.4	Energy efficiency	34
83	8.4.5	Environmental sensors	34
84		Bibliography.....	35

INTERNATIONAL ELECTROTECHNICAL COMMISSION

MULTI-MODAL UNDERWATER WIRELESS COMMUNICATION
TECHNOLOGIES — PART 1: OVERVIEW AND REQUIREMENTS

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This XXX edition cancels and replaces the XXX edition published in [publication_date], Amendment 1:[publication_date] and Amendment 2:[publication_date]. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) ...;

The text of this International Standard is based on the following documents:

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The National Committees are requested to note that for this document the stability date is 20XX..

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INTRODUCTION

In the realm of underwater exploration and communication, the quest for reliable and robust data transmission is a significant challenge, mainly due to the ocean's unpredictable and diverse nature. From its vast depths to the presence of diverse marine life, this environment offers both opportunities and obstacles for our technological endeavors.

Multi-Modal Underwater Wireless Communication (MM-UWC) is a solution to the challenges of underwater data transmission. It integrates various communication methods, such as optical, acoustic, and magnetic induction, to ensure reliable communication in the unpredictable ocean environment. MM-UWC prioritizes eco-friendly approaches like optical and magnetic induction to protect marine life and incorporates Quality of Service (QoS) protocols for adaptability in dynamic underwater conditions. It represents a commitment to responsible exploration and technological innovation in the underwater realm.

In order to build and apply the MM-UWC technology, most suitable methods for managing the network have been developed based on the **ISO/IEC 3200** series.

The **ISO/IEC 3200** series provides requirements, reference architecture (RA) including the entity models and high-level interface guidelines supporting interoperability among MM-UWC to provide the essential MM-UWC construction information to help and guide architects, developers, and implementers of MM-UWC.

The **ISO/IEC 3200** series comprises four parts as shown bellow.

Part 1 provides an overview and requirements of the MM-UWC.

Part 2 provides reference architecture models for MM-UWC.

Part 3 provides descriptions for the entities and interfaces of the MM-UWC.

Part 4 provides information on interoperability requirements among the entities within a MM-UWC and among various MM-UWC.

MULTI-MODAL UNDERWATER WIRELESS COMMUNICATION TECHNOLOGIES — PART 1: OVERVIEW AND REQUIREMENTS

1 Scope

This part of ISO/IEC 00000 provides a general overview and requirements of multi-modal underwater wireless communication (MM-UWC) technologies. It delineates general, functional, and device-specific requirements for MM-UWC, encompassing a range of communication modes including acoustic, optical, magnetic induction (MI), and radio frequency (RF) to enable data transmission under various underwater conditions. It describes their main characteristics in terms of the effects of propagation variability and analyses the main differences with respect to underwater wireless acoustic communication. It further identifies the specificities of MM-UWC and derives some specific and general requirements for MM-UWC.

2 Normative reference

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 30140 Information technology – Underwater acoustic sensor network (UWASN) – Part 1: Overview and requirements

ISO/IEC 30142 INTERNET OF THINGS – UNDERWATER ACOUSTIC SENSOR NETWORK (UWASN) – Underwater Network Management System

ISO/IEC 18405 Underwater acoustics - Terminology

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

IEC Electropedia: available at <http://www.electropedia.org/ISO>

- Online browsing platform: available at <http://www.iso.org/obp>
- Multi-modal underwater wireless communication (MM-UWC) : a technology that adaptively selects the optimal communication medium from among various options such as acoustic, visible light communication (VLC), infrared, and magnetic induction (MI), depending on time-variant underwater environments and conditions.

4 Abbreviated terms

AUV	Autonomous Underwater Vehicle
MI	Magnetic Induction
MM	Multi-Modal
QoS	Quality of Service
RF	Radio Frequency
ROV	Remotely Operated underwater Vehicle
UUV	Unmanned Underwater Vehicle

UWAC	Underwater Wireless Acoustic Communication
UWMIC	Underwater Wireless Magnetic Induction Communication
UWOC	Underwater Wireless Optical Communication
UWRFC	Underwater Wireless Radio Frequency Communication
VLC	Visible Light Communication

5 MM-UWC overview and application

5.1 Overview

As the maritime industry advances, there is a growing demand for underwater communication technology that can handle real-time transmission of large volumes of information, including video data. This necessity is becoming increasingly critical for several reasons:

- **Enhanced Safety and Efficiency:** Real-time data transmission, including video, improves safety in underwater operations. It allows remote monitoring and control of equipment, ensuring quick responses to issues.
- **Environmental Monitoring:** Large data volume transmission aids oceanic environmental monitoring, benefiting marine research and conservation. Real-time data analysis offers rapid insights into marine ecosystem health.
- **Scientific Research:** Researchers in marine ecology and geology rely on real-time data from underwater environments for their work.
- **Industrial Applications:** Industries like offshore oil and gas, aquaculture, mining, and underwater cable installations require efficient underwater communication for managing and optimizing operations.

The cornerstone of addressing these needs is Multi-modal Underwater Wireless Communication (MM-UWC), a technology that employs a fusion of various communication techniques (acoustic, optical, magnetic induction (MI), and radio frequency (RF) and wired communication) to facilitate data transmission in underwater environments. MM-UWC leverages the unique strengths and overcomes the limitations of each communication mode, dynamically selecting and combining the optimal paths and methods for data transmission according to the varying underwater conditions and application requirements. This approach aims to enhance the network's reliability and performance, expanding the scope of applications.

Mission critical underwater communication technology refers to specialized communication systems and technologies designed for use in critical and high-stakes applications within the maritime industry. These technologies are essential for reliable and efficient communication in underwater environments where standard communication methods often fail due to the challenges posed by water's density, salinity, and temperature, among other factors.

The necessity of mission critical underwater communication technology can be summarized as follows:

- **Safety and Security:** It enhances safety in offshore drilling, construction, robotics, and naval operations by facilitating reliable communication in challenging underwater conditions.
- **Remote Operation:** ROVs and AUVs can communicate seamlessly with operators on the surface, enabling precise control and data transmission.
- **Environmental Monitoring:** Researchers can collect continuous data for oceanic assessments, resource exploration, and geological studies.
- **Industrial Operations:** Industries depend on underwater infrastructure and equipment, making reliable communication essential.
- **Data Retrieval and Analysis:** Large data transmission supports decision-making and real-time analysis in the maritime industry.

Figure 1 illustrates the fundamental topology of the mission critical MM-UWC system. This figure outlines the mission critical MM-UWC system, providing a visual representation of how the multi-modal communication links (MM-UWC links) integrate within various underwater environments. These links represent the pathways that enable high-data-rate communication between the core components of the MM-UWC Technology, Service Core, and Underwater Stations. Each MM-UWC link, distinguished by color in the legend, denotes the status of the node link performance, categorized as 'Real time', 'Selective-Real time', 'Non-Real time', and 'Error status'. This classification system is essential in enabling dynamic network adjustments to maintain optimal communication amidst the challenging and diverse conditions found underwater. It highlights the core components: MM-UWC Technology, Service Core, and Underwater Stations. These elements are connected by MM-UWC links, enabling versatile, high-data-rate communication in underwater environments. In the legend of Figure 1, 'MM Link' denotes the MM-UWC Links, referring to the essential pathways within the multi-modal communication system. In underwater communication scenarios, an MM Link serves as the conduit for data transmission, utilizing channels like acoustic, optical, or radio frequency paths. The choice of these paths is based on their appropriateness for the prevalent environmental conditions and specific communication requirements. This technology is essential for several applications, including disaster response, infrastructure inspection, and environmental monitoring.

MM-UWC is the core service infrastructure for ultimately delivering Internet of Underwater Things (IoUT) services. This infrastructure provides reliable communications in the underwater environment, even in critical and emergency situations, and supports real-time data transmission and monitoring in a variety of applications.

MM-UWC revolutionizes data collection, monitoring, and decision-making in the underwater environment by providing stable and reliable communication in the underwater environment. This supports efficient management of underwater resources, environmental protection, safe maritime activities, and scientific research. As one of the core elements of the IoUT, it provides high value for modern applications in underwater environments.

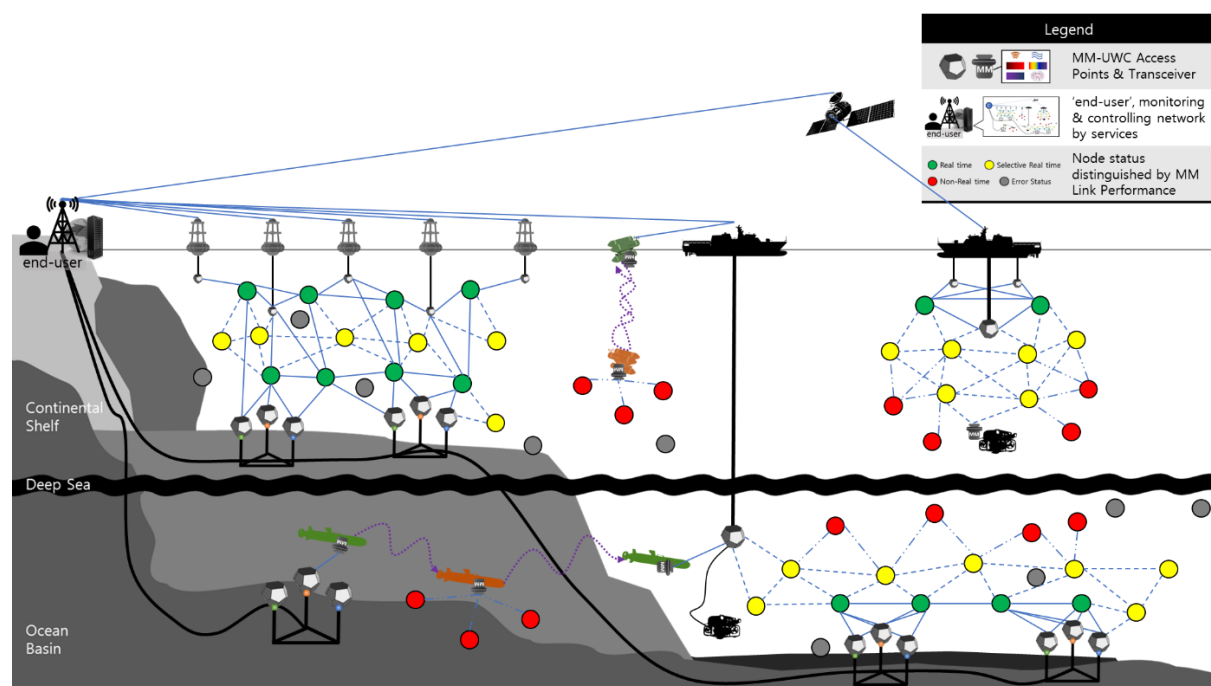


Figure 1 – Concept of Multi-Modal Underwater Wireless Communication

The Internet of Underwater Things (IoUT)[1] represents a dynamic ecosystem where underwater sensors are interconnected with internet servers, enabling precise control and data management for a wide range of applications. Due of its potential uses in numerous fields, such as maritime research, environmental monitoring, offshore enterprises, and military, this novel approach has drawn considerable attention. IoUT development has obstacles like

the hostile underwater environment, scarce energy supplies, and the requirement for reliable communication systems. To increase the reach and capabilities of IoUT, scientists and engineers are constantly developing new underwater sensors, communication technologies, and energy-efficient systems.

This IoUT comprises three primary components: applications, communication, and sensing devices, each contributing significantly to its functionality and versatility.

- Applications

IoUT applications encompass a broad spectrum, ranging from passive monitoring activities to active and mission-specific endeavors. This diversity allows IoUT to serve various domains, such as marine research, environmental monitoring, offshore industry, and underwater exploration. The ability to transition seamlessly between monitoring and executing specific missions makes IoUT an asset in underwater operations.

In the application context, there arises a critical need for mission-critical MM-UWC. With the help of this technology, early warning systems for disasters and tsunamis can be established, allowing for prompt alerts and perhaps life-saving actions. MM-UWC also plays a pivotal role in the inspection of underwater facilities, ensuring the integrity and safety of underwater infrastructure. Furthermore, it is instrumental in the construction, maintenance, and repair of offshore wind structures, optimizing operational efficiency. Additionally, MM-UWC facilitates the remote control and monitoring of costly devices submerged in aquatic environments, reducing operational risks and costs. Finally, it is essential for determining the locations of seabed pipelines, enabling the exact and effective installation of crucial underwater pipelines.

- Network

The network architecture in the Internet of Underwater Things (IoUT) is a complex and specialized system designed to facilitate communication and data exchange between terrestrial and underwater components, as well as between various underwater components. IoUT relies on a combination of technologies and protocols tailored to the unique challenges of underwater environments.

The communication aspect of IoUT involves the transmission of data between underwater sensing devices and remote servers. It leverages multiple communication mediums, including acoustics, optics, MI and RF (Radio Frequency), tailored to the unique challenges posed by underwater environments. Given the underwater communication characteristics in this situation, communication requires careful consideration of elements like signal propagation, attenuation, and interference.

- Sensing Devices

The underwater sensing devices, which comprise an array of sensors designed to capture various environmental parameters, enable the acquisition of critical data for real-time monitoring and decision-making, making them pivotal in executing underwater missions efficiently. The versatility of these sensors empowers IoUT to adapt to a wide array of tasks, from studying marine life behavior to supporting offshore infrastructure maintenance.

Effective communication is crucial for both autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs) engaged in underwater exploration and infrastructure monitoring. AUVs, as sensor nodes, autonomously navigate predetermined or self-determined paths, continuously gathering crucial data while maintaining a wireless connection to the mother ship. This capability facilitates real-time monitoring of survey progress and supports the simultaneous use of multiple AUVs for tasks such as pipeline surveying and underwater infrastructure monitoring. On the other hand, ROVs that are operated remotely from a mother ship and perform tasks like pipeline inspection and infrastructure monitoring rely on a tethered link for both power and communication. To ensure real-time monitoring and accurate remote control, high-data-rate communication is a crucial component of both AUV and ROV operations. This ensures the efficiency and reliability of the AUV/ROV industry.