ISO/IEC 30140-1

Edition 1.0 2018-02

INTERNATIONAL STANDARD

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



ISO/IEC 30140-1:2018-02(en)



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2018 ISO/IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about ISO/IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

ISO/IEC 30140-1

Edition 1.0 2018-02

INTERNATIONAL STANDARD

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 35.110

ISBN 978-2-8322-5372-4

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD 5
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms and definitions 7
4 Abbreviated terms 9
5 UWASN overview and applications 9
5.1 Overview 9
5.2 Application domain of UWASN 11
6 Characteristics of UWASN in terms of the effects of propagation variability 12
6.1 Underwater acoustic communication 12
6.2 Acoustic signal strength attenuation 12
6.3 High propagation delay 12
6.4 Multipath 13
6.5 Propagation loss 13
6.6 Noise 14
7 Differences between UWASN and terrestrial sensor network 14
7.1 Types of underwater communication technologies 14
7.2 Housing case 16
7.3 Costs associated with sensor nodes 16
7.4 Omni-directional and directional transducers for data transmission and reception 16
7.5 Underwater object and event localization and 3D relay node 17
7.6 Energy harvesting technology for UWASN 18
8 Specificities of UWASN and related requirements 18
8.1 Three structural scales of UWASN network 18
8.2 Deployments of 2D and 3D topology 21
8.2.1 General 21
8.2.2 Two-dimensional UWASN architecture 21
8.2.3 Three-dimensional UWASN architecture 22
8.3 Cross layering 24
8.4 Underwater acoustic modem 25
8.5 Doppler spread 25
8.6 Deployment considering water depths 26
8.7 Underwater wired and wireless communication 26
8.8 Time synchronization 27
8.9 Data transmission period for energy saving 28
8.10 Routing 29
8.11 Network coding 31
8.12 Data compression 31
8.13 Delay and disruption tolerant network (DTN) 31
9 UWASN further general requirements 32
9.1 General 32
9.2 General requirements for UWASN – Cross layering 32
9.3 General requirements for the UWASN – Communication technology 32
9.4 General requirements for the UWASN – Other system requirements 33

Annex A (informative) Selected applications of UWASN 34
A.1 Environmental monitoring – Chemical and biological changes 34
A.1.1 Description 34
A.1.2 Physical entities 35
A.1.3 Normal flow 35
A.1.4 Conditions 35
A.2 Detection of pipeline leakages 35
A.2.1 Description 35
A.2.2 Physical entities 36
A.2.3 Normal flow 36
A.2.4 Conditions 37
A.3 Exploration of natural resources 37
A.3.1 Description 37
A.3.2 Physical entities 38
A.3.3 Normal flow 38
A.3.4 Conditions 39
A.4 Fish farming 39
A.4.1 Description 39
A.4.2 Physical entities 40
A.4.3 Normal flow 40
A.4.4 Conditions 40
A.5 Harbour security 40
A.5.1 Description 40
A.5.2 Physical entities 41
A.5.3 Normal flow 41
A.5.4 Conditions 42
Bibliography 43

Figure 1 – Overview of a UWASN 10
Figure 2 – Omni-directional and directional transducers for data transmission and reception 17
Figure 3 – Underwater cluster network 18
Figure 4 – Underwater ad-hoc network 19
Figure 5 – UWA-UN communication network 19
Figure 6 – UWA-UN communication network using fixed gateway 20
Figure 7 – UWA-EUN communication network 21
Figure 8 – Two-dimensional UWASN architecture 22
Figure 9 – Three-dimensional UWASN architecture 23
Figure 10 – UWA-cross layer protocol stack 25
Figure 11 – Underwater wired and wireless communication 27
Figure 12 – Time synchronization for data transmission 28
Figure 13 – Using active and sleep modes for energy saving 29
Figure 14 – UWASN routing 30
Figure A.1 – Illustration of the environmental monitoring use case 34
Figure A.2 – Oil and gas pipeline leakage monitoring use case 36
Figure A.3 – Flow – Oil and gas pipeline leakage monitoring 37

Figure A.4 – Underwater resource exploration use case 38
Figure A.5 – Fish farming and monitoring use case 39
Figure A.6 – Harbour security monitoring use case 41

Table 1 – UWASN market segments and their current and future applications list 11
Table 2 – Summary of the features of acoustic, radio, and optical waves in seawater environments 15
Table 3 – Differences between underwater communication technologies [10][12] 15
Table 4 – Comparison between 2D and 3D UWASNs. 24

INFORMATION TECHNOLOGY – UNDERWATER ACOUSTIC SENSOR NETWORK (UWASN) –

Part 1: Overview and requirements

FOREWORD

1) ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

2) The formal decisions or agreements of IEC and ISO on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees and ISO member bodies.

3) IEC, ISO and ISO/IEC publications have the form of recommendations for international use and are accepted by IEC National Committees and ISO member bodies in that sense. While all reasonable efforts are made to ensure that the technical content of IEC, ISO and ISO/IEC publications is accurate, IEC or ISO cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees and ISO member bodies undertake to apply IEC, ISO and ISO/IEC publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any ISO, IEC or ISO/IEC publication and the corresponding national or regional publication should be clearly indicated in the latter.

5) ISO and IEC do not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. ISO or IEC are not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or ISO or its directors, employees, servants or agents including individual experts and members of their technical committees and IEC National Committees or ISO member bodies for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication of, use of, or reliance upon, this ISO/IEC publication or any other IEC, ISO or ISO/IEC publications.

8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this ISO/IEC publication may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 30140-1 was prepared by subcommittee 41: Internet of Things and related technologies, of ISO/IEC joint technical committee 1: Information technology.

The list of all currently available parts of the ISO/IEC 30140 series, under the general title *Information technology – Underwater acoustic sensor network (UWASN)*, can be found on the IEC and ISO websites.

This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

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

INTRODUCTION

Water covers approximately 71 % of the surface of the Earth. Modern technologies introduce new methods to monitor the body of water, for example pollution monitoring and detection. Underwater data gathering techniques require exploring the water environment, which can be most effectively performed by underwater acoustic sensor networks (UWASNs). Applications developed for the UWASNs can record underwater climate, detect and control water pollution, monitor marine biology, discover natural resources, detect pipeline leakages, monitor and locate underwater intruders, perform strategic surveillance, and so on.

The ISO/IEC 30140 series provides general requirements, reference architecture (RA) including the entity models and high-level interface guidelines supporting interoperability among UWASNs in order to provide the essential UWASN construction information to help and guide architects, developers and implementers of UWASNs.

Additionally, the ISO/IEC 30140 series provides high-level functional models related to underwater sensor nodes and relationships among the nodes to construct architectural perspective of UWASNs. However, the ISO/IEC 30140 series is an application agnostic standard. Thus, ISO/IEC 30140 series specifies neither any type of communication waveforms for use in UWASNs nor any underwater acoustic communication frequencies. Specifying communication waveforms and/or frequencies are the responsibility of architects, developers and implementers.[1]

Acoustical data communication in sensor networks necessitates the introduction of acoustical signals that overlap biologically important frequency bands into the subject environment. These signals may conflict with regional, national, or international noise exposure regulations. Implementers of acoustical communication networks should consult the relevant regulatory agencies prior to designing and deployment of these systems to ensure compliance with regulations and avoid conflicts with the agencies.

The purpose of the ISO/IEC 30140 series is to provide general requirements, guidance and facilitation in order for the users of the ISO/IEC 30140 series to design and develop the target UWASNs for their applications and services.

The ISO/IEC 30140 series comprises four parts as shown below.

Part 1 provides a general overview and requirements of the UWASN reference architecture.

Part 2 provides reference architecture models for UWASN.

Part 3 provides descriptions for the entities and interfaces of the UWASN reference architecture.

Part 4 provides information on interoperability requirements among the entities within a UWASN and among various UWASNs.

---

[1] Architects, developers and implementers need to be aware of the submarine emergency frequency band, near and below 12 kHz, and it is recommended to provide a provision for such submarine emergency band in their UWASN design and applications.

INFORMATION TECHNOLOGY – UNDERWATER ACOUSTIC SENSOR NETWORK (UWASN) –

Part 1: Overview and requirements

1 Scope

This part of ISO/IEC 30140 provides a general overview of underwater acoustic sensor networks (UWASN). It describes their main characteristics in terms of the effects of propagation variability and analyses the main differences with respect to terrestrial networks. It further identifies the specificities of UWASN and derives some specific and general requirements for these networks.

2 Normative references

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 29182-2, *Information technology – Sensor networks: Sensor Network Reference Architecture (SNRA) – Part 2: Vocabulary and terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 29182-2 and the following 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

3.1
ad-hoc node
device in a wireless ad-hoc network

Note 1 to entry: A wireless ad-hoc network is defined in ISO/IEC 27033-6:2016[1],[2] 3.12, as a “decentralized wireless network which does not rely on a pre-existing infrastructure”.

3.2
cross-layer
technology that permits communication between different layers by allowing one layer to access data of another layer to exchange information and enable interaction

3.3
management cross-layer
technology that provides a system-level management service to all or selected OSI layers in a wireless network system

---

2 Numbers in square brackets refer to the Bibliography.