e-Navi

Available online at http://www.e-navi.kr/
e-Navigation Journal

Original article

Collection and Provision of Sensor Information Based on International Standards for the Smart AtoN Project☆

Geonung KIM[a*], Byeonguk MOON[b], Gyei-Kark PARK[b]

[a*] Dept. of Computer Engineering, Mokpo National Maritime University, Korea, kgu@mmu.ac.kr, Corresponding Author

[b] Dept. of Logistics and Maritime Studies, Mokpo National Maritime University, Korea, gkpark@mmu.ac.kr

Abstract

The Smart AtoN(Aids to Navigation) project aims to upgrade the facilities of AtoN to provide new additional information to nearby ships and unmanned ships. This paper deals with methods for collecting various sensor data through standardized interfaces; the NMEA-0183(serial line), the NMEA-2000(CAN), and the NMEA OneNet(IPv6). The AIS(Automatic Identification System) and the AIS-ASM(Application Specific Message) are considered as communication means for providing sensor information to nearby ships.

In this paper, we summarize existing NMEA sentences for collecting sensor data and AIS-ASM messages that can be used to deliver sensor data to ships. Information provided from the smart AtoN through AIS, ASM, etc. may be presented on the shipborne displays that complies with the IEC62288:2021 standard.

Keywords: AtoN, Sensor, AIS, ASM, NMEA Sentences

https://doi.org/10.52820/j.enavi.2023.20.001

1. Introduction

The Smart AtoN(Aids to Navigation) project aims to upgrade the facilities of AtoN and to provide new additional information to surrounding ships, MASS(Maritime Autonomous Surface Ship)s, and the Korean SMART-Navigation ships. In this project, we develop the power supply unit, the battery package robust to marine environment, the integrated operating platform supporting multiple interfaces, and AI(Artificial intelligence) based fault diagnosis system, optimal communication systems allowing coverage extensions and data exchange, and three prototypes (fixed, large-sized, middle-sized) of smart aids to navigation [1].

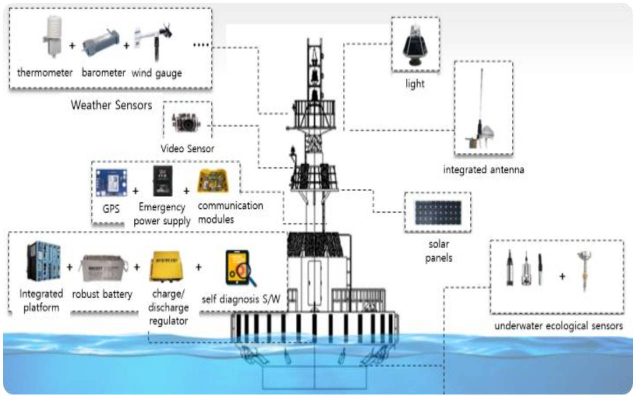


Figure 1: Concept of the Smart AtoN Facilities [1]

The Figure 1 shows the concept of Smart Aids to Navigation Facilities. There are core elements of the AtoNs; light and solar panels, various sensors including weather sensors, underwater ecological sensors and video cameras; the integrated platform to process these data; communication modules for transmitting information to ships. This requires more power and reliability, so there are robust battery units and self-diagnosis S/W.

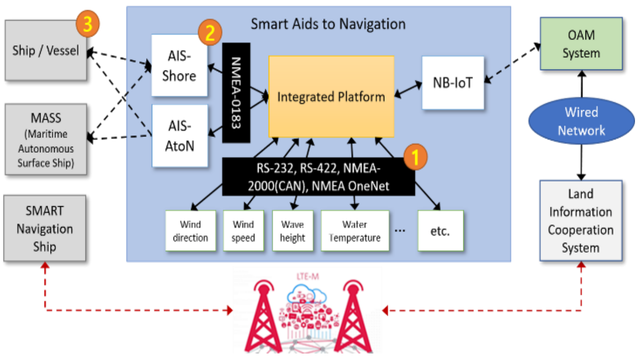


Figure 2: Information flow in the Smart AtoN [2]

Figure 2 describes the information flow in the smart AtoN; (1) the collection of various sensor data, (2) the propagation of the information to ships through AIS(Automatic Identification System) devices, and (3) the presentation process on shipborne navigational displays [2].

AIS is a communications system using four worldwide channels in the VHF maritime mobile band, for the exchange of navigation data. There are numerous AIS devices, known as stations, which are identified by a unique MMSI(Maritime Mobile Service Identity) and use an international open standard to communicate [3][4]. AIS was originally developed as a means for positive identification and tracking of ships, this was accomplished by transmitting and receiving static, dynamic, and voyage-related data about ships, as well as short safety-related messages. In particular, AIS may use binary messages for transmission of ASM (Application-Specific Messages) as a means for certain types of limited communications. AIS message #6 and #8 can be used to deliver binary data to individual vessels or to all vessels within the receiving distance. ASM uses these AIS #6 and #8, so it can be an appropriate means of delivering necessary sensor information to ships. [5].

This paper is organized as follows. In section 2, we describe how to collect data from various sensors. This includes NMEA-0183[6] message sentences for sensors and various interfaces such as NMEA-2000 [7][8][9] and NMEA OneNet[10]. In section 3, we introduce how to deliver the collected sensor information to nearby ships, especially selected AIS-ASMs [5]. In Section 4, we introduce how to display relevant information on the shipborne displays using the IEC-62288:2021 standard [11]. Finally, we conclude the paper in section 5.

2. Sensor data collection for smart AtoN

The Smart AtoN project collects data from various sensors, which aims to collect data based on standards to prevent them from being dependent on specific company's sensor product or specific communication technologies.

NMEA 0183 is the Standard for Interfacing Marine Electronic Devices. The first version of NMEA 0183 was published in 1983, and the latest version is 4.11 which was published in 2018. The NMEA 0183 standard consists of a definition of a hardware interface (one-way serial communication) and a definition of the message syntax to be exchanged on it. Section 3 of the NMEA 0183 defines the hardware specification, and the section 5 defines the data format protocol. NMEA-0183 devices are designated either talkers or listeners, and data are transmitted in the form of sentences. There are 3 basic kinds of sentences; talker sentences, proprietary sentences and query sentences [6].

IEC(International Electrotechnical Commission) 61162 contains the requirements for data communication between maritime electronic instruments, navigation and radiocommunication equipment when interconnected via an appropriate system. IEC 61162 is intended to support one-way serial data transmission from a single talker to one or more listeners. The first edition of IEC 61162-1 was published in 2000, and it is closely aligned with NMEA 0183 version 2.3. The latest version of IEC61162-1 (Ed.5.0) was published in 2016[12].

2.1 Message sentences for sensor data collection

Methods of utilizing various sensor information in AIS Class-A devices are presented, and are actually in operation. The Annex B of the IEC 61993-2 provides the AIS interface overview [13].

Figure 3 shows the block diagram of AIS. There are 3 channels for sensor inputs. Minimum required input sentences for sensors are Position, SOG(Speed on ground), COG(Course on ground), Heading, and RoT(Rate of Turn)[13].

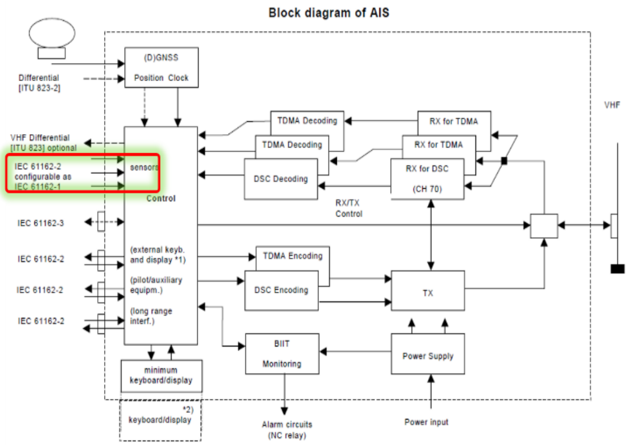


Figure 3: Block diagram of AIS [13]

The Smart AtoN project aims to provide ships sailing around with information collected from various marine sensors, including wind direction, wind speed, water temperature, salinity, ocean current direction, ocean current speed, visibility, and weather information. Therefore, in addition to the sentences required by the above-mentioned AIS device, it is necessary to support other sentences for sensors. The selected sentences among the sentences defined in the IEC 61162-1 standard are shown in Table 1 below.

Table 1: Selected Sentences for Smart AtoN

mne monic	name
CUR	Water current layer – Multi-layer water current data
DBT	Depth below transducer
DPT	Depth
GLL	Geographic position – Latitude/longitude
MTW	Water temperature
MWD	Wind direction and speed
MWV	Wind speed and angle
VHW	Water speed and heading
XDR	Transducer measurements

Source: IEC 61162-1:2016 8.3.1 ~ 8.3.125 [12]

The XDR sentence is for Measurement data from transducers that measure physical quantities such as temperature, force, pressure, frequency, angular or linear displacement, etc. Data from a variable number of transducers measuring the same or different quantities can be mixed in the same sentence [12]. General sensor data can be provided in the XDR syntax, and if specific sentences for other sensors such as air and fine dust sensors are required, it will be additionally defined and used.

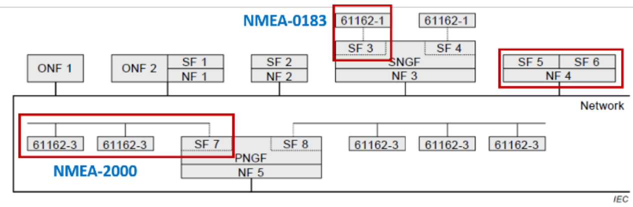
2.2 Interfacing marine electronic devices

NMEA 0183 devices are employing an asynchronous serial interface, and the talker output comply with EIA RS-422 standard [6].

NMEA 2000 that was introduced in 1997 uses binary rather than textual, and employs integrated circuit implementation of a network access protocol commonly known as CAN(Controller Area Network). The network size of NMEA 2000 can be up to 50 connections, up to 254 addresses, and up to 200 meters at 250kbps [7][8][9].

The goals of NMEA OneNet are as follows; embrace Ethernet for marine networking; simple installation, configuration, and use; interoperate with established marine standards; secure device communications; extendible, scalable architecture; support high bandwidth applications [10].

IEC 61162-450 provides an example of linking various network technologies based on Ethernet [14]. The following Figure 4 is a partial revision of Figure 1 of IEC61162-450.



Key

SF system function block
NF network function block
SNGF serial to network gateway function block
ONF other network function block
PNGF PGN to network gateway function block

Figure 1 – Network topology example

Figure 4: Network topology example - revision [14]

3. Delivery of sensor information to ships using AIS-ASM

IEC 62320-2 specifies the operational and performance requirements, methods of testing and required test results for AIS AtoN Stations [15]. Table 14 of [15] shows the standard sentences for AIS AtoN stations. There are sentences for AIS messages and for configuration of AIS AtoN applications.

Table 1 of [5] provides a list of the revised/new AIS Application-Specific Messages for international use. The ASM FI(Function Identifier)=31 message is the Meteorological and Hydrographic data for the distribution of meteorological and hydrographic information. Table 1.1 of [5] specifies the data format of the FI=31 message. The following figures relate sensors to parameters of the ASM FI=31 message.

Wind gauge / anemometer

parameter	bits	description
Message ID	6	
Repeat indicator	2	
Source ID	30	
Spare	2	
IAI	16	DAC = 001; FI = 31
Longitude	25	
Latitude	24	
Position Accuracy	1	1 = high (<10 m; Differential Mode of, e.g., DGNSS receiver), 0 = low
Time Stamp		
UTC Day	5	
UTC Hour	5	
UTC Minute	6	
Average Wind Speed	7	Average of wind speed values for the last 10 minutes, in 1 knot steps.
Wind Gust	7	Maximum wind speed reading during the last 10 minutes, in 1 knot steps.
Wind Direction	9	Direction of the average wind during the last 10 minutes, in 1 degree steps
Wind Gust Direction	9	Direction of the maximum wind during the last 10 minutes, in 1 degree steps.

Figure 5: FI=31 parameters and related sensors (1) [1]

Thermometer / hygrometer
barometer
horizontal visibility sensor
water level / current flow sensor

parameter	bits	description
Air Temperature	11	Dry bulb temperature in degrees Celsius in 0.1 degree steps
Relative Humidity	7	Relative Humidity, in 1% steps.
Dew Point	10	Dew point temperature in degrees Celsius in 0.1 degree steps
Air Pressure	9	Air pressure, defined as pressure reduced to sea level, in 1 hPa steps
Air Pressure Tendency	2	0 =steady, 1 =decreasing, 2 =increasing, 3 =not available(default)
Horizontal Visibility	8	Horizontal visibility, in 0.1 Nautical Miles steps
Water level (incl. tide)	12	Deviation from local chart datum, in 0.01 metre steps.
Water Level Trend	2	
Surface Current Speed (incl. tide)	8	Speed of Current measured at the sea surface, in 0.1 knot steps.
Surface Current Direction	9	Direction of Current at the sea surface, in 1 degree steps.
Current Speed, #2	8	Speed of Current 2 measured at a chosen level below the sea surface, in 0.1 knot steps.
Current Direction, #2	9	Direction of Current 2, in 1 degree steps.
Current Measuring level, #2	5	Measuring level below sea surface, in 1 metre increment.
Current Speed, #3	8	Speed of Current 3 measured at a chosen level below the sea surface, in 0.1 knot steps.
Current Direction, #3	9	Direction of Current 3, in 1 degree steps.
Current Measuring level, #3	5	Measuring level below sea surface, in 1 metre steps

Figure 6: FI=31 parameters and related sensors (2) [1]

water temperature / salinity sensor
weather sensor

parameter	bits	description
Significant Wave Height	8	Height of the waves, in 0.1 metre steps.
Wave Period	6	Wave period, in 1 second steps.
Wave Direction	9	Direction of waves, in 1 degree steps.
Swell Height	8	Height of the swell, in 0.1 metre steps.
Swell Period	6	Swell period, in 1 second steps
Swell Direction	9	Direction of swells, in 1 degree steps.
Sea State	4	Beaufort Scale, as defined in Table 1.2
Water Temperature	10	Temperature of the water in degrees Celsius in 0.1 degree steps.
Precipitation (type)	3	According to WMO 306 Code table 4.201: 0 = reserved, 1 = rain, 2 = thunderstorm, 3 = freezing rain, 4 = mixed/ice, 5 = snow, 6 = reserved, 7 = not available = default
Salinity	9	Salinity, in 0.1‰ (ppt) steps
Ice	2	0 = No, 1 = Yes, 2 = (reserved for future use), 3 = not available = default
Spare	10	
Total	360	

Figure 7: FI=31 parameters and related sensors (3) [1]

The ASM FI=26 message provides environmental information from 1 to 8 sensor reports. Although 11 sensor report types are defined, there are 9 report types related to the actual sensor.

Table 12.4
Environmental Message Sensor Report Types

Value	Description
0	Site Location
1	Station ID
2	Wind
3	Water level
4	Current Flow (2D)
5	Current Flow (3D)
6	Horizontal Current Flow
7	Sea State
8	Salinity
9	Weather
10	Air gap/Air draft
11-15	(reserved for future use)

Figure 8: FI=26 message sensor report types [5]

4. Presentation on shipborne navigational displays

IEC 61128:2021 specifies the general requirements, methods of testing, and required test results, for the presentation of navigation-related information on shipborne navigational displays including AIS data reports and the AIS Application [11]. Table J.1 of [11] specifies display layers and display sub-layers of AIS ASM and additionally specifies the symbols.

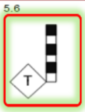
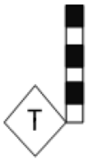
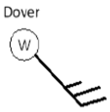
Display layer	Display sub-layer	Symbol ᵃ	AIS ASM parameters to be available from cursor pick of the symbol	Source FI
Hydrological Data	Water level	5.6 	Combined from Source FI 26 (Site Location) 26 (Station ID report) 26 (Water level report) 31 (Meteorological and Hydrographic data)	
			Site ID (from header)	26
			Time stamp (from header)	26, 31
			Data timeout (from site location)	26
			Latitude (from site location)	26, 31
			Longitude (from site location)	26, 31
			Position Accuracy	31
			Name (Station ID report)	26
			Water Level Type	26
			Sensor Data Description	26
			Water Level / Water level (incl, tide)	26, 31
			Water Level Trend	26, 31
			Vertical Reference Datum	26
			Forecast Water Level Type	26
			Forecast Water Level	26
			Valid Time of Forecast	26
			Duration (forecast)	26

Figure 9: Definition of sensor-related display layers, sub-layers, and symbols in Table J.1 of [11]

Figure 9 shows the definition related to the water level in Table J.1. When the navigator selects the symbol, the water level information obtained from the AIS ASM parameters is presented on the water level sublayer of the hydrological data layer. Tables 2 shows the symbols that related sensor data [11].

Table 2: Selected Symbols that related Sensor Data

Symbol	Layer	Sublayer
	Hydrological Data	Tidal window Water level
	Hydrological Data	Current Sea state
	Meteorological Data	Wind
	Meteorological Data	Weather
	Navigational Services	Air Gap
	Meteorological Data	Weather (observation report from ship)

Source: IEC 62288:2021 Annex J.2 [11]

5. Conclusions

In this paper, we introduce a method to collect, deliver and present sensor information based on international standards for the Smart AtoN Project. NMEA 0183, NMEA 2000, NMEA OneNet, IEC61162-1:2016, IEC61162-450:2018, IEC62288:2021 are analyzed and applied to form the entire process.

Currently, we are implementing functions that collect data from sensors such as wind direction, wind speed, temperature, humidity, salinity, ocean current, weather, and air quality, functions that delivers sensor information through AIS-ASM #26 and #31, and a program to present selected symbols and information on a simple display.

Acknowledgements

This research was a part of the project titled 'The advancement of smart aids to navigation facilities (20210636)', funded by the Ministry of Oceans and Fisheries, Korea.

References

1. Geonung KIM, “Information Service for the smart Aids to Navigation using AIS-ASM”, Proceedings of 2022 Conference of the Korean Association of Ocean Science and Technology Societies, June, 2022
2. Geonung KIM, “Universal Sensor Interface for Smart AtoN Project”, Proceedings of 2023 Conference of the Korean Association of Ocean Science and Technology Societies, May, 2023
3. IALA Guideline 1082 “An overview of AIS”, Ed.2.0, 2016
4. IALA Rec. R0126 (A-126) “The Use of the Automatic Identification System(AIS) in Marine Aids to Navigation Services” Ed. 2.0, 2021
5. IMO Ref. T2-OSS/2.7.1 SN.1/Circ.289, “Guidance on the use of AIS Application-Specific Messages”, 2010
6. https://www.nmea.org/content/STANDARDS/NMEA_0183_Standard
7. https://en.wikipedia.org/wiki/NMEA_2000
8. Frank Cassidy, “NMEA 2000 Explained - The Latest Word”, Mar. 1999
9. “A guide to NMEA 2000 installations for yachts”, Yachting Pages, June 2020
10. “NMEA OneNet Extension, NOT Replacement”, Actisense
11. IEC 62288:2021 “Maritime navigation and radiocommunication equipment and systems - Presentation of navigation-related information on shipborne navigational displays - General requirements, methods of testing and required test results”, 2021
12. IEC 61162-1 “Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 1: Single talker and multiple listeners”, Ed.5.0, 2016
13. IEC 61993-2 “Maritime navigation and radiocommunication equipment and systems – Automatic identification systems (AIS) – Part 2: Class A shipborne equipment of the automatic identification system (AIS) – Operational and performance requirements, methods of test and required test results”, Ed.3.0, 2018
14. IEC 61162-450 “Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 450: Multiple talkers and multiple listeners – Ethernet interconnection”, Ed. 2.0, 2018
15. IEC 62320-2 “Maritime navigation and radiocommunication equipment and systems – Automatic identification system (AIS) – Part 2: AIS AtoN Stations – Operational and performance requirements, methods of testing and required test results” Ed. 2.0, 2016

Received 28 May 2023

Accepted 15 June 2023