Article

Encoding AIS Binary Messages in XML Format for Providing Hydrographic-related Information

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Abstract

A specification is proposed to enable hydrographic and maritime safety agencies to encode AIS messages using Extensible Markup Language (XML). It specifies the order, length, and type of fields contained in ITU-R.M.1371-1. A XML schema validates the message definitions, and a XSLT style sheet produces reference documentation in 'html' format. AIS binary messages in XML are an effective means to communicate dynamic and real-time port/waterway information. For example, tidal information can be continuously broadcast to maritime users and applied to a "tide-aware" ENC. The XML format aligns with the type of data encapsulation planned for the IHO Geospatial Standard for Digital Hydrographic Data (S-100).

Résumé

Une spécification est proposée pour permettre aux agences hydrographiques et de sécurité maritimes d'encoder les messages AIS (systèmes d'informations automatisés) à l'aide du langage à balises extensible (XML). Celle-ci précise l'ordre, la longueur et le type de champs contenus dans ITU-R.M.1371-1. Un schéma XML valide les définitions du message et une feuille de style XSLT produit une documentation de référence au format "html". Les messages binaires AIS en XML constituent un moyen efficace de communiquer des informations dynamiques et en temps réel sur les ports et les voies navigables. Les informations sur les marées peuvent, par exemple, être diffusées en continu aux utilisateurs maritimes et appliquées à une ENC dans laquelle les marées sont prises en compte. Le format XML s'aligne sur le type d'encapsulation des données prévu pour les normes géospatiales de l'OHI pour les données hydrographiques numériques (S-100).

Resumen

Se propone una norma que permita a las agencias hidrográficas y de seguridad marítima codificar mensajes AIS utilizando Extensible Markup Languaje (XML). Especifica el orden, longitud y tipo de campos contenidos en ITU-R.M. 1371-1. Un esquema XML valida la definición de mensajes y una hoja tipo XSLT produce documentación de referencia en formato 'html'. Los mensajes binarios AIS en XML son un medio efectivo para comunicar información dinámica y en tiempo real de puertos y/o vías de navegación. Por ejemplo, información sobre mareas puede ser continuamente trasmitida a los usuarios marítimos y ser aplicada a 'aviso de marea' de ENC. El formato XML se alinea con el tipo de datos encapsulados planificado para el Estándar Geoespacial de Datos Hidrográficos Digitales de la OHI (S-100).

Introduction

Automatic Identification System (AIS) is an autonomous and continuous broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. AIS operates in the VHF maritime mobile band using Time Division Multiple Access (TDMA) technology to be able to meet high broadcast rates, while ensuring reliable and robust operation.

Chapter V of the 1974 SOLAS Convention [1] requires mandatory carriage of AIS equipment on all vessels constructed after 1 July 2002. Implementation for other types and sizes of SOLAS Convention vessels was required to be completed not later than 31 December 2004.

As stated in SOLAS Chapter V, Regulation 19, section 2.4.5, [1] AIS shall:

1 *provide automatically to appropriate equipped shore stations, other ships and aircraft information, including ship's identity, type, position, course, speed, navigational status and other safety-related information;*
2 *receive automatically such information from similarly fitted ships;*
3 *monitor and track ships; and*
4 *exchange data with shore-based facilities.*

In this regard, the IMO Performance Standards for AIS [2] states that:
The AIS should improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment, and operation of Vessel Traffic Services (VTS), by satisfying the following functional requirements:
1 *in a ship-to-ship mode for collision avoidance;*
2 *as a means for littoral States to obtain information about a ship and its cargo; and*
3 *as a VTS tool, i. e. ship-to-shore (traffic management).*

Further, AIS should be capable of providing to ships and to competent authorities, information from the ship, automatically and with the required accuracy and frequency, to facilitate accurate tracking. Transmission of the data should be with the minimum involvement of ship's personnel and with a high level of availability. As shown in Table 1, the contents of an AIS message contain detailed information regarding the location and movement as well as other information related to vessel identification, cargo, etc.

AIS enables both ships and maritime safety administrations (e.g., U.S. Coast Guard) to effectively track the movement of vessels in coastal waters (See Figure 1). In addition, AIS can contribute to safety-of-navigation and protection of the environment by providing additional information. This includes meteorological and hydrographic data, carriage of dangerous cargos, safety and security zones, status of aids-to-navigation, and other ports/waterway safety information. It is intended that this information be broadcast from shore-side AIS Base Stations to ships that are underway at-sea or in port.

Binary Message Formats

In May 2004, the IMO issued SN/Circular 236 on "Guidance on the Application of AIS Binary Messages" [3] More specifically, a set of seven (7) messages were defined with the intent that they would undergo a 4-year trial period. The criteria for selecting the trial messages included a demonstrated operational need, wide cross-section of users (e.g., ships, VTS, pilots, port authorities), and AIS-related messages that had already been developed in terms of format and content.

While it is IMO that defines the content of AIS Messages, it is ITU-R M.1371 that specifies the technical characteristic and the structure of the binary AIS messages [4]. These messages have to be distinguished from Addressed Safety-Related Messages and Broadcast Safety Related Messages both of which allow the exchange of format-free ASCII-text. Binary messages are intended to reduce the need for verbal communications, and to enhance reliable information exchange.

To date, the content of AIS messages have been primarily defined using text tables. Although the tables cover a wide range of information, they are not in a machine-readable format that facilitates rapid AIS binary message generation. While the ITU specifies the technical structure and IMO defined the content (i.e., the "**What**"), there is a need to define "**How**" to efficiently generate binary AIS messages. In short, a XML AIS Definition Language provides the method how to create an AIS Binary Message that accomplishes what the tables list.

Parameter	No. of bits	Description
Message ID	6	Identifier for this message 1, 2 or 3
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated. Refer to § 4.6.1; 0-3; 0 = default; 3 = do not repeat any more
User ID	30	MMSI number
Navigational status	4	0 = under way using engine, 1 = at anchor, 2 = not under command, 3 = restricted manoeuvrability, 4 = constrained by her draught, 5 = moored, 6 = aground, 7 = engaged in fishing, 8 = under way sailing, 9 = reserved for future amendment of navigational status for ships carrying DG, HS, or MP, or IMO hazard or pollutant category C (HSC), 10 = reserved for future amendment of navigational status for ships carrying DG, HS or MP, or IMO hazard or pollutant category A (WIG); 11-14 = reserved for future use, 15 = not defined = default
Rate of turn ROTAIS	8	±127 (-128 (80_h) indicates not available, which should be the default). Coded by ROT_{AIS} = 4.733 SQRT(ROTINDICATED) degrees/min $ROT_{INDICATED}$ is the rate of turn (720°/min), as indicated by an external sensor. +127 = turning right at 720°/min or higher -127 = turning left at 720°/min or higher
SOG	10	Speed over ground in 1/10 knot steps (0-102.2 knots) 1 023 = not available, 1 022 = 102.2 knots or higher
Position accuracy	1	1 = high (< 10 m; differential mode of e.g. DGNSS receiver) 0 = low (> 10 m; autonomous mode of e.g. global navigation satellite system (GNSS) receiver or of other electronic position fixing device); 0 = default
Longitude	28	Longitude in 1/10 000 min (±180°, East = positive, West = negative. 181° ($6791AC0_h$) = not available = default)
Latitude	27	Latitude in 1/10 000 min (±90°, North = positive, South = negative. 91° (3412140_h) = not available = default)
COG	12	Course over ground in 1/10° (0-3599). 3600 (E10h) = not available = default. 3 601-4 095 should not be used
True heading	9	Degrees (0-359) (511 indicates not available = default)
Time stamp	6	UTC second when the report was generated (0-59) or 60 if time stamp is not available, which should also be the default value or 62 if electronic position fixing system operates in estimated (dead reckoning) mode or 61 if positioning system is in manual input mode or 63 if the positioning system is inoperative)
Reserved for regional applications	4	Reserved for definition by a competent regional authority. Should be set to zero, if not used for any regional application. Regional applications should not use zero
Spare	1	Not used. Should be set to zero
RAIM-flag	1	RAIM (Receiver autonomous integrity monitoring) flag of electronic position fixing device; 0 = RAIM not in use = default; 1 = RAIM in use
Communication state	19	Described in § 3.3.7.2.2 or § 3.3.7.3.2
Total number of bits	168	

***Table 1**: AIS message numbers 1-3 (Class A vessel position report) [Source: ITU-R 1371-1, Table 15a, p. 43.].*

Current AIS Binary Messages

There are at least four (4) formats that have been developed for the transmission of water level over AIS. One example is the IMO/IALA "Metrological and Hydrological Data" trial binary message specified by IMO [3] and developed by IALA [5]. As shown in Table 2, this type of message contains human-readable text. However, this method of definition can inadvertently lead to unforeseen ambiguities. For instance,

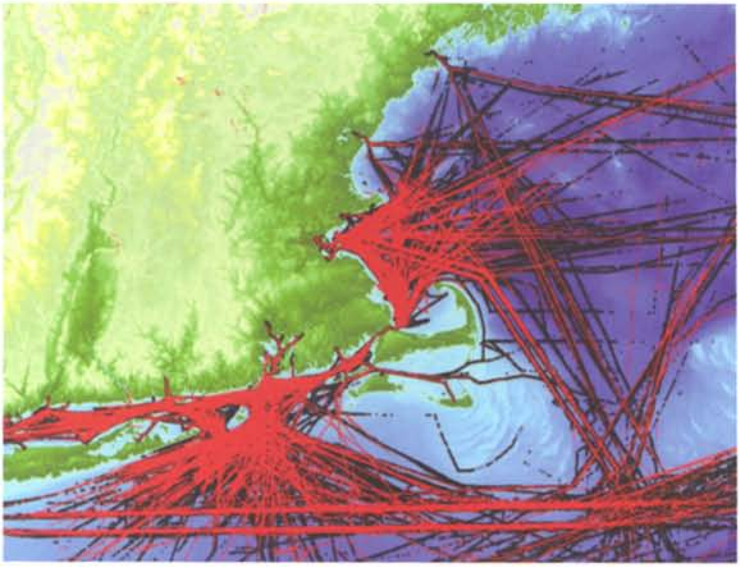

Figure 1: Vessel traffic off the New England Coast (USA) tracked using the US Coast Guard's AIS. April 2006 traffic is plotted in black and May 2006 traffic is in red. (Image courtesy Michael Thompson, NOAA Stellwagen Bank National Marine Sanctuary).

the hydrographic portion contains a range of data types that require scalings and offsets that are not explicitly described. In turn this can cause problems during software development. An example of a simple ambiguous field is the "Ice" field. The field can have values 0 through 3. It is not clear which number applies to "yes" and "no?" Additionally, if the highest number (3) is taken to be "no data available" or "unknown", there remains one possible value with an undefined meaning. Another example is that the order of Latitude and Longitude is different than in the rest of the ITU-R M.1371-1 messages [4]. The core messages lists Longitude first, then Latitude.

Using a more orderly and structured format such as XML, provides an effective means to overcome these problems.

Proposed XML Format for AIS Binary Messages

It is proposed that Extensible Markup Language (XML) [6] be used to define the binary content (payload) for maritime-based AIS binary messages. By providing a bit-level description in XML, producers of binary messages will be able to more clearly specify messages to software engineers implementing communication systems that must handle AIS messaging. The same XML descriptions of messages can be used to generate portions of the human-readable specification document. Using a XML specification allows for rapid development of additional AIS applications such as database interfaces (e.g., *PostGIS*) [7] and custom graphical user interfaces (e.g., a message construction tool for testing in the reference implementation).

In developing a more robust AIS binary message, there are several goals:

- Specifications that are readable by both humans and machines.
- Allow automated testing and validation of implementations based on the specification.
- Provide specification of the order of fields, length of fields, and type of fields.
- Specify the scaling and offset to be applied to the field between the application and the AIS network layer.
- Declare the units of each field when appropriate (e.g. meters, seconds, degrees Celsius).
- The specification must be independent of programming language (e.g., can be implemented in C, C++, Java, Python).

AIS XML Definition Language

To reduce ambiguities and ease the processes of creating AIS software and documentation, the use of an AIS XML Definition Language is proposed. Appendix 1 contains a reference implementation written in *Python* [8] that gives a sample implementation of code to generate encoders/decoders for an AIS binary message. The AIS XML Definition Language is informally known as the "AIS Binary Decoder Ring."

The AIS XML Definition Language draws on the best of many existing systems. The most relevant specification is "RFC 1832 - XDR: External Data Representation" [9] The AIS binary message XML specification is a simplification of RFC-1832 converted to XML with additions that fit the specific requirements of AIS. For example, extensions include:

Parameter	No. of bits	Description
Message ID	6	Identifier for Message 8; always 8
Repeat Indicator	2	Used by the repeater to indicate how many times a message has been repeated.
Source ID	30	MMSI number of source station
Spare	2	Not used. Should be set to zero.
IAI	16	DAC=001; FI=11
Latitude	24	Measuring position, 0 to +/-90 degrees, 1/1000th minute
Longitude	25	Measuring position, 0 to +/-180 degrees, 1/1000th minute
Date and time	16	Time of transmission, Day, hour, minute, (ddhhmm in UTC)
Average wind speed	7	Average of wind speed values for the last 10 minutes
Wind gust	7	Wind gust is the maximum wind speed value reading during the last 10 minutes, 0-120 kts, 1kt
Wind direction	9	0-359, 1 degree
Wind gust direction	9	0-359, 1 degree
Air temperature	11	Dry bulb temp. – 60.0 to +60.0 degrees Celsius 0.1 of a degree
Relative humidity	7	0-100, 1%
Dew point	10	- 20.0 - + 50.0 degrees, 0.1 degree
Air pressure	9	800-1200 hPa, 1hPa
Air pressure tendency	2	0 = steady, 1 = decreasing, 2 = increasing
Horizontal visibility	8	0-25.0, 0.1 NM
Water level (incl. tide)	9	Deviation from local chart datum, -10.0 to 30.0 m
Water level trend	2	0 = steady, 1 = decreasing, 2 = increasing
Surface current direction	9	0 – 359 degrees, 1 degree
Current speed, #2	8	Current measured at a chosen level below the sea surface, 0.0 – 25.0 kts, 0.1 kt
Current direction, #2	9	0 – 359, 1 degree
Current measuring levevl #2	5	Measuring level in m below sea surface, 0-30m, 1 m
Current speed, #3	8	0.0 – 25.0 knots, 0.1 knot
Current direction, #3	9	0 – 359 degrees, 1 degree
Current measuring level, #3	5	Measuring level in m below sea surface, 0-30 m, 1 m
Significant wave height	8	0.0 – 25.0 m, 0.1 m
Wave period	6	Period in seconds, 0-60 s, 1 s
Wave direction	9	0-359 degrees, 1 degree
Swell height	8	0.0 – 25.0 m, 0.1 m
Swell period	6	Period in seconds, 0 – 60 s, 1 s
Swell direction	9	0 – 359 degrees, 1 degree
Sea state	4	According to Beaufort scale (manual input?), 0 to 12, 1
Water temperature	10	-10.0 - + 50.0 degrees, 0.1 degree
Precipitation (type)	3	According to WMO
Salinity	9	0.0 – 50.0 0/00, 0.1 0/00
Ice	2	Yes/No
Spare	6	
Total Number of bits	**352**	**Occupies 2 slots**

Table 2: IMO Meterology and Hydrology Message as specified in IMO SN/Circ.236, Annex 2, Application 1 . Also described in AIS, Vol 1, Part 1, Operational Issues, Ed. 1.3. IALA Guildeline No 1028, p. 131.

- Bit level field lengths allowing for non-byte align data
- Scaling and offsets of encoded data to increase information density
- Units
- Mandatory human-readable description of each field

AIS XML Definition Language meets all of the goals and relies on industry standard technologies. There are many libraries that support reading and validation of XML documents.
XML schemas can be crafted to validate binary message definitions. These schemas might be written in XML Schema [10], *Schematron* [11], or *RelaxNG* [12]. Designers can validate draft message definitions using these schema and/or additional validation programs.

Using an AIS XML Definition Language allows for the packaging of test data to validate both encoding and decoding of messages. For each message, a number of example messages can be defined such that the major corner cases are tested by all AIS software vendors. Each example XML test message will contain:
- ASCII encoded binary containing the bit stream represented by "0" and "1" characters
- The NMEA strings as they would be returned by an AIS modem
- The fields broken out with scaling removed

The reference software contains several example XML test messages. They are encoded in a general way such that a new format is not required for each new message type. One practical example would be for Maritime Domain Awareness (MDA). MDA is an initiative within the US Department of Homeland Security that seeks to rapidly process massive amounts of maritime data and information [22]. XML interoperability standards and exchange formats would allow software to access the critical information contained within AIS messages without having to directly comprehend the AIS binary format.

Basic Format

The XML specification for one message is encapsulated in a XML "message" tag. The message contains the necessary information to serialize and deserialize AIS message information to and from the AIS binary message payload and the local machine representation used within an application. Messages are wrapped within a XML header and an outer "AIS-binary-message" tag. This tag can contain multiple messages. *XInclude* [13] allows inclusion of predefined standard structures such as time stamps and positions, which are used in many of the messages.

The message tag contains attributes that specify the name, AIS message number, the Designated Area Code (DAC), and the Functional ID (FID). The attributes for DAC and FID are repeated inside of the XML message definition as fields to facilitate parsing of messages. In order to know what message is being examined, the first bits of the message must be decoded. The ITU 1371 specification of messages 6 and 8 states that the message begins with 16 bits of the application ID. The DAC is the designated area code (e.g., 1 for IMO, 366 for the USA). The FID indicates for which application this data is intended. The IMO trial Met/Hydro format message has a DAC of "1" and a FID of "11."

For AIS binary messages, AIS message number can be "6", "8", or "6 8" depending on if the message is addressed to a recipient or broadcast to all listeners. Message 6 is the AIS Address Binary Message (ABM) where as message 8 is the Broadcast Binary Message (BBM). As the ITU AIS specification is revised, there may be additional message numbers that carry binary message data.

These additional message attributes provide assistance to other applications that might want to develop new AIS technologies that are driven by the XML definition. For example, in Appendix 1, the designer of the AIS XML Definition Language specification for Met/Hydro suggests that displayed Met/Hydro messages be titled by the userID (i.e., MMSI). The reference *Python* code uses this to title *Google Earth* popup messages.

An AIS Binary message is composed of a list of fields. At a minimum, each field contains a name, number of bits, and type attributes. The name is comprised of alphanumeric and underscore characters. Each field is required to have a human-readable description tag. This tag will appear in the "Description" column for all of the generated message documentation (e.g., text documents and web pages).

Each field has XML tags and attributes that specify information about the field and its representation. Each field must have a data encoding type selected from one of the available types listed in Table 3. If a field requires a non-varying specific AIS binary encoded value, it would be listed in a "required" tag. For example, messages that can only be sent as binary broadcast messages will have this value be set to 8 for the "MessageID" field. For fields that can change, it is possible to apply scaling and offsets to the values to pack them into smaller numbers of bits than might be otherwise available. If the number of bits provides a greater range than is needed, the field can be limited using a "range". For instance, current flow direction requires nine bits for a range of 0-359 degrees. In terms of binary coding this means that 29 (512) is required to achieve at least 359 positions. Usually a particular value is selected to represent that no information is available from the sender for this field. All fields must have a 'units field' if units are appropriate. Units might be degrees (as in compass direction), degrees Celsius, meters, seconds, etc.

An example of the end result of using the AIS XML

Name	Description	Size
bool	boolean	1 bit
uint	unsigned integer	variable (1..64 bits)
int	signed integer	variable (1..64 bits)
udecimal	unsigned decimal	variable (1..64 bits)
decimal	signed decimal	variable (1..64 bits)
float	ieee floating point	32 bits
double	ieee floating point	64 bits
aisstr6	as defined in the AIS specification	6 bits
ascii7	ASCII character codes	7 bits
binary	binary blob	variable

***Table 3**: Binary message field data types*

Definition Language is shown in Table 4. In terms of content, this table contains the same IMO Meteorology and Hydrography messages as Table 2. However, the information used to generate Table 4 is both human and machine-readable – and far easier to implement. Appendix 2 provides an example of a XML message definition converted to a webpage using a XSLT style sheet. This webpage describes the name, number of bits, array length, type, units and a brief description. In turn, this matches the style of other AIS standards specifications.

Application

AIS binary messages have a wide range of potential applications that would benefit the hydrographic and maritime user community. In concept, AIS can be an effective means to digitally communicate relevant ports/waterways information related to dynamic and real-time information [14]. One example of a relevant application would be the "Next Generation" Electronic Chart whereby tidal information is continuously broadcast to maritime users either inport or underway and applied to "tide-aware" Electronic Navigation Charts (ENC) capable of accommodating x, y, z, and time [15, 16].

In the USA, the challenges to accomplish these applications are more organisational than technical. The process requires establishing the necessary infrastructure to take the water level information at a particular tide station zone/area from the NOAA Physical Oceanographic Real-Time System (PORTS) [17] and the NOAA CO-OPS [18] systems, convert it into an XML message, and then transmit it via USCG AIS Base Stations to ships in the area. To accomplish the process will require a fair amount of cooperation between government agencies, ECDIS manufactures, and maritime user groups.

Where water levels are transmitted over AIS, finite element modeling software such as TCARI [19] can be used produce a new water surface every six (6) minutes. Potentially, this can be used by both commercial navigators and for hydrographic surveys. Hydrographers would be able to immediately integrate highly-accurate water levels into their processing software to produce better initial results prior to completing the survey cruise. In the future, when electronic chart data is based on gridded data format, each node on the grid could contain a "z" value (i.e., depth) that is made "tide-aware" [20].

Research is ongoing at NOAA, USCG, and UNH as to the best means to convert predicted, forecast, and "nowcast" water levels into an AIS Binary Message format. At present, existing water level messages do not contain the required water level information needed for finite element modeling. However, the

Parameter	No. of bits	Description
MessageID	6	AIS message number. Must be 8
RepeatIndicator	2	Indicated how many times a message has been repeated
UserID	30	MMSI number of transmitter broadcasting the message
Spare	2	Reserved for definition by a regional authority.
dac	10	Designated Area Code - part 1 of the IAI
fid	6	Functional Identifier - part 2 of the IAI
latitude	24	Location of the vessel. North South location
longitude	25	Location of the vessel. East West location
day	5	Day 0..31
hour	5	Hour 0..23
min	6	Min
avewind	7	Average wind speed values for the last 10 minutes.
windgust	7	Wind gust is the max wind speed value reading during the last 10 minutes.
winddir	9	Wind direction
windgustdir	9	Wind direction for the gust.
airtemp	11	Dry bulb temperature
relhumid	7	Relative humidity
dewpoint	10	Dew Point
airpressure	9	Air pressure
airpressuretrend	2	Air pressure trend
horizvis	8	Horizontal visibility
waterlevel	9	Water level (incl. tide)
waterleveltrend	2	Water level trend
surfcurspeed	8	Surface current speed
surfcurdir	9	Surface current direction
curspeed2	8	Level 2 current speed
curdir2	9	Level 2 current direction
curlevel2	5	Measuring level below sea surface for level 2
curspeed3	8	Level 3 current speed
curdir3	9	Level 3 current direction
curlevel3	5	Measuring level below sea surface for level 3
sigwaveheight	8	Significant wave height
waveperiod	6	Wave period
wavedir	9	Wave direction
swellheight	8	Swell height
swellperiod	6	Swell period
swelldir	9	Swell direction
seastate	4	Sea state according to the Beaufort scale
watertemp	10	Water temperature
preciptype	3	According to WMO
salinity	9	Salinity
ice	2	Yes or no for the presence of ice
Spare	6	Must be zero
Total bits	**352**	**Takes 2 slots with 72 pad bits to fill the last slot**

***Table 4**: IMO Meterology and Hydrology messages, 01-11 as displayed from XML definition. Note that fields such as datetime and IAI have been explicitly broken out.*

AIS XML Definition Language has potential to allow for rapid prototyping and testing of proposed messages to ensure the final message definition meets maritime users requirement for critical real-time data.

Advantages

Using XML to define Binary AIS Message formats has a number of advantages:

- XML is both human and machine-readable, and provides a central definition that can be transformed into required computer code.
- Although it it is the IMO and maritime safety administrations that will decide what should be the content of AIS messages, the XML AIS Binary format provides a means on how current and/or future requirements can be met.
- XML lends itself to the development of additional tools/processes that are open-source and freely-available.
- In addition to maritime/hydrograhpic applications, XML can be used for River Information Systems (RIS) and other inland/river applications.

Alignment with IHO S-100

The XML formats align quite well with what IHO is planning to do in terms developing a better means of data encapsulation based on the new IHO Geospatial Standard for Digital Hydrographic Data (S-100) [21]. S-100 is the standard intended to be used for the exchange of digital hydrographic data between hydrographic offices, and for the distribution of hydrographic data to manufacturers, mariners and other data users (e.g., environmental management organizations). It was developed so that the transfer of all forms of hydrographic data would take place in a consistent and uniform manner. To date, S-57 Edition 3.0/3.1 has been used almost exclusively for encoding Electronic Navigational Charts (ENCs) for use in Electronic Chart Display and Information Systems (ECDIS). However, there are changing requirements, customers and technology for hydrographic data and as S-57 is intended to support all types of hydrographic data, not solely ENCs, it needs to be expanded in order to accommodate these new requirements.

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18 NOAA, Chesapeake Bay Operational Forecast System (CBOFS), [http://www.co-ops.nos.noaa.gov/CBOFS/cbofs.shtml].

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Appendix 1


```
<?xml version="1.0" encoding="utf-8"?>

<ais-binary-message version="1.0" xmlns:xi="http://www.w3.org/2001/XInclude">

  <!-- XInclude is not used in this file.  Here for demonstration only -->
  <xi:include href="structs-inc.xml"/>

  <struct name="pos_small" postgis_type="POINT">
    <description>Generic representation of position on the WGS84
 sphereoid.  Smaller number of bits than standard position.
 Lat/Lon reversed.
    </description>

    <field name="latitude" numberofbits="24" type="decimal">
      <description>North South location</description>
      <range min="-90" max="90"/>
      <unavailable>91</unavailable>
      <units>degrees</units>
      <scale>60000</scale>
      <decimalplaces>4</decimalplaces>
      <testvalue>37.42446</testvalue>
    </field>

    <field name="longitude" numberofbits="25" type="decimal">
      <description>East West location</description>
      <range min="-180" max="180"/>
      <unavailable>181</unavailable>
      <units>degrees</units>
      <scale>60000</scale>
      <decimalplaces>4</decimalplaces>
      <testvalue>-122.16328</testvalue>
    </field>

  </struct>

  <message name="imo_met_hydro" aismsgnum="8" dac="001" fid="11" titlefield="UserID">

    <description>IMO meteorological and hydroglogical data.  Specified
 in SN/Circ.236 Annex 2.  Also defined in IALA Guidelines on AIS,
 Vol 1, Part 1, Ed. 1.3. Guildeline No 1028.
    </description>
    <note>All unavailable values are defined to be the highest
    possible number in the next following</note>

    <messagesize>352</messagesize>

    <field name="MessageID" numberofbits="6" type="uint">
      <description>AIS message number.  Must be 8</description>
      <required>8</required>
    </field>
```

```
<field name="RepeatIndicator" numberofbits="2" type="uint">
  <description>Indicated how many times a message has been repeated</description>
  <unavailable>0</unavailable>
  <lookuptable>
<entry key="0">default</entry>
<entry key="3">do not repeat any more</entry>
  </lookuptable>
  <testvalue>1</testvalue>
</field>

<field name="UserID" numberofbits="30" type="uint">
  <description> MMSI number of transmitter broadcasting the message</description>
  <note> This might be from a basestation or AtoN.
        The transmitter might not be at the same location as the Met/Hydro station</note>
  <testvalue>1193046</testvalue> <!– Default value for all NAUTICAST devices –>
</field>

<field name="Spare" numberofbits="2" type="uint">
  <description>Reserved for definition by a regional authority.</description>
  <required>0</required>
</field>

<field name="dac" numberofbits="10" type="uint">
  <description>Designated Area Code - part 1 of the IAI</description>
  <required>1</required>
</field>

<field name="fid" numberofbits="6" type="uint">
  <description>Functional Identifier - part 2 of the IAI</description>
  <required>11</required>
</field>

<include-struct name="Position" struct="pos_small">
  <do_not_mangle_name/>
  <description>Location of the vessel.</description>
</include-struct>

<field name="day" numberofbits="5" type="uint">
  <description>Day 0..31</description>
  <units>days</units>
  <testvalue>3</testvalue>
</field>

<field name="hour" numberofbits="5" type="uint">
  <description>Hour 0..23</description>
  <unavailable>31</unavailable>
  <range min="0" max="23"/>
  <units>hours</units>
  <testvalue>21</testvalue>
</field>

<field name="min" numberofbits="6" type="uint">
```

```xml
  <description>Min</description>
  <unavailable>63</unavailable>
  <range min="0" max="59"/>
  <units>minutes</units>
  <testvalue>58</testvalue>
</field>

<field name="avewind" numberofbits="7" type="uint">
  <description>Average wind speed values for the last 10 minutes.</description>
  <range min="0" max="120"/>
  <units>knots</units>
  <unavailable>127</unavailable>
  <testvalue>23</testvalue>
</field>

<field name="windgust" numberofbits="7" type="uint">
  <description>Wind gust is the max wind speed value reading during the last 10 minutes.</description>
  <range min="0" max="120"/>
  <units>knots</units>
  <unavailable>127</unavailable>
  <testvalue>35</testvalue>
</field>

<field name="winddir" numberofbits="9" type="uint">
  <description>Wind direction</description>
  <range min="0" max="359"/>
  <units>degrees</units>
  <unavailable>511</unavailable>
  <testvalue>329</testvalue>
</field>

<field name="windgustdir" numberofbits="9" type="uint">
  <description>Wind direction for the gust.</description>
  <range min="0" max="359"/>
  <units>degrees</units>
  <unavailable>511</unavailable>
  <testvalue>293</testvalue>
</field>

<field name="airtemp" numberofbits="11" type="decimal">
  <description>Dry bulb temperature</description>
  <range min="-60.0" max="60.0"/>
  <units>degrees Celsius</units>
  <unavailable>102.3</unavailable>
  <scale>10</scale>
  <decimalplaces>1</decimalplaces>
  <testvalue>-40.1</testvalue>
</field>

<field name="relhumid" numberofbits="7" type="uint">
  <description>Relative humidity</description>
  <range min="0" max="100"/>
```

```
  <units>percent</units>
  <unavailable>127</unavailable>
  <testvalue>99</testvalue>
</field>

<field name="dewpoint" numberofbits="10" type="decimal">
  <description>Dew Point</description>
  <note>FIX: should this be a udecimal??</note>
  <range min="-20.0" max="50.0"/>
  <units>degrees Celsius</units>
  <unavailable>51.1</unavailable>
  <scale>10</scale>
  <decimalplaces>1</decimalplaces>
  <testvalue>-19.2</testvalue>
</field>

<field name="airpressure" numberofbits="9" type="udecimal">
  <description>Air pressure</description>
  <range min="800" max="1200"/>
  <units>hPa</units>
  <unavailable>1311</unavailable>
  <scale>1</scale> <!– no scale –>
  <offset>800</offset>
  <decimalplaces>0</decimalplaces>
  <testvalue>1150</testvalue>
</field>

<field name="airpressuretrend" numberofbits="2" type="uint">
  <description>Air pressure trend</description>
  <lookuptable>
 <entry key="0">steady</entry>
 <entry key="1">decreasing</entry>
 <entry key="2">increasing</entry>
 <entry key="3">unavailable</entry>
  </lookuptable>
  <unavailable>3</unavailable>
  <testvalue>2</testvalue>
</field>

<field name="horizvis" numberofbits="8" type="udecimal">
  <description>Horizontal visibility</description>
  <range min="0" max="25.0"/>
  <units>nm</units>
  <unavailable>25.5</unavailable>
  <scale>10</scale>
  <decimalplaces>1</decimalplaces>
  <testvalue>11.9</testvalue>
</field>

<!– This field is probably wrong –>
<field name="waterlevel" numberofbits="9" type="decimal">
  <description>Water level (incl. tide)</description>
```

```
  <range min="-10.0" max="30.0"/>
  <units>m</units>
  <unavailable>41.1</unavailable>
  <scale>10</scale>
  <decimalplaces>1</decimalplaces>
  <testvalue>-8.9</testvalue>
</field>

<field name="waterleveltrend" numberofbits="2" type="uint">
  <description>Water level trend</description>
  <lookuptable>
<entry key="0">steady</entry>
<entry key="1">decreasing</entry>
<entry key="2">increasing</entry>
<entry key="3">unavailable</entry>
  </lookuptable>
  <unavailable>3</unavailable>
  <testvalue>0</testvalue>
</field>

<field name="surfcurspeed" numberofbits="8" type="udecimal">
  <description>Surface current speed</description>
  <range min="0" max="25.0"/>
  <units>knots</units>
  <unavailable>25.5</unavailable>
  <scale>10</scale>
  <decimalplaces>1</decimalplaces>
  <testvalue>22.3</testvalue>
</field>

<field name="surfcurdir" numberofbits="9" type="uint">
  <description>Surface current direction</description>
  <range min="0" max="359"/>
  <units>degrees</units>
  <unavailable>511</unavailable>
  <testvalue>321</testvalue>
</field>

<field name="curspeed2" numberofbits="8" type="udecimal">
  <description>Level 2 current speed</description>
  <range min="0" max="25.0"/>
  <units>knots</units>
  <unavailable>25.5</unavailable>
  <scale>10</scale>
  <decimalplaces>1</decimalplaces>
  <testvalue>12.7</testvalue>
</field>

<field name="curdir2" numberofbits="9" type="uint">
  <description>Level 2 current direction</description>
  <range min="0" max="359"/>
  <units>degrees</units>
```

```
  <unavailable>511</unavailable>
  <testvalue>122</testvalue>
</field>

<field name="curlevel2" numberofbits="5" type="uint">
  <description>Measuring level below sea surface for level 2</description>
  <unavailable>31</unavailable>
  <units>m</units>
  <testvalue>29</testvalue>
</field>

<field name="curspeed3" numberofbits="8" type="udecimal">
  <description>Level 3 current speed</description>
  <range min="0" max="25.0"/>
  <units>knots</units>
  <unavailable>25.5</unavailable>
  <scale>10</scale>
  <decimalplaces>1</decimalplaces>
  <testvalue>19.2</testvalue>
</field>

<field name="curdir3" numberofbits="9" type="uint">
  <description>Level 3 current direction</description>
  <range min="0" max="359"/>
  <units>degrees</units>
  <unavailable>511</unavailable>
  <testvalue>93</testvalue>
</field>

<field name="curlevel3" numberofbits="5" type="uint">
  <description>Measuring level below sea surface for level 3</description>
  <unavailable>31</unavailable>
  <units>m</units>
  <testvalue>28</testvalue>
</field>

<field name="sigwaveheight" numberofbits="8" type="udecimal">
  <description>Significant wave height</description>
  <range min="0" max="25.0"/>
  <units>m</units>
  <unavailable>25.5</unavailable>
  <scale>10</scale>
  <decimalplaces>1</decimalplaces>
  <testvalue>22.8</testvalue>
</field>

<field name="waveperiod" numberofbits="6" type="uint">
  <description>Wave period</description>
  <note>FIX: How does to fit to the power spectrum?</note>
  <range min="0" max="60"/>
  <units>sec</units>
  <unavailable>63</unavailable>
```

```
  <testvalue>2</testvalue>
</field>

<field name="wavedir" numberofbits="9" type="uint">
  <description>Wave direction</description>
  <note>FIX: please define this better</note>
  <range min="0" max="359"/>
  <units>degrees</units>
  <unavailable>511</unavailable>
  <testvalue>187</testvalue>
</field>

<field name="swellheight" numberofbits="8" type="udecimal">
  <description>Swell height</description>
  <range min="0" max="25.0"/>
  <units>m</units>
  <unavailable>25.5</unavailable>
  <scale>10</scale>
  <decimalplaces>1</decimalplaces>
  <testvalue>0.2</testvalue>
</field>

<field name="swellperiod" numberofbits="6" type="uint">
  <description>Swell period</description>
  <note>FIX: How does to fit to the power spectrum?</note>
  <range min="0" max="60"/>
  <units>sec</units>
  <unavailable>63</unavailable>
  <testvalue>59</testvalue>
</field>

<field name="swelldir" numberofbits="9" type="uint">
  <description>Swell direction</description>
  <note>FIX: please define this better</note>
  <range min="0" max="359"/>
  <units>degrees</units>
  <unavailable>511</unavailable>
  <testvalue>1</testvalue>
</field>

<field name="seastate" numberofbits="4" type="uint">
  <description>Sea state according to the Beaufort scale</description>
  <note>Taken from http://en.wikipedia.org/wiki/Beaufort_scale</note>
  <range min="0" max="12"/>
  <units>Beaufort scale</units>
  <lookuptable>
<entry key="0">Calm</entry>
<entry key="1">Light air</entry>
<entry key="2">Light breeze</entry>
<entry key="3">Gentle breeze</entry>
<entry key="4">Moderate breeze</entry>
<entry key="5">Fresh breeze</entry>
```

```
<entry key="6">Strong breeze</entry>
<entry key="7">Near gale</entry>
<entry key="8">Gale</entry>
<entry key="9">Strong gale</entry>
<entry key="10">Storm</entry>
<entry key="11">Violent storm</entry>
<entry key="12">Hurricane</entry>
<entry key="13">Reserved</entry>
<entry key="14">Reserved</entry>
<entry key="15">unavailable</entry>
 </lookuptable>
 <unavailable>15</unavailable>
 <testvalue>12</testvalue>
</field>

<field name="watertemp" numberofbits="10" type="udecimal">
 <description>Water temperature</description>
 <range min="-10.0" max="50.0"/>
 <units>degrees Celsius</units>
 <unavailable>92.3</unavailable>
 <scale>10</scale>
 <offset>-10</offset>
 <decimalplaces>1</decimalplaces>
 <testvalue>48.8</testvalue>
</field>

<field name="preciptype" numberofbits="3" type="uint">
 <description>According to WMO</description>
 <note>FIX: need a reference to the document describing this!</note>
 <range min="0" max="6"/>
 <units>WMO scale index</units>
 <lookuptable>
<entry key="7">unavailable</entry>
 </lookuptable>
 <unavailable>7</unavailable>
 <testvalue>2</testvalue>
</field>

<field name="salinity" numberofbits="9" type="decimal">
 <description>Salinity</description>
 <note>FIX: by what standard?  Measured how?</note>
 <range min="0.0" max="50.0"/>
 <units>0/00</units>
 <unavailable>92.3</unavailable> <!– FIX: check –>
 <scale>10</scale>
 <decimalplaces>1</decimalplaces>
 <testvalue>0.9</testvalue>
</field>

<field name="ice" numberofbits="2" type="uint">
 <description>Yes or no for the presence of ice</description>
 <note>FIX: what types of ice constitute a yes??</note>
```

```
    <lookuptable>
   <entry key="0">Not sure.  Maybe no ice?</entry>
   <entry key="1">Not sure.  Maybe yes ice?</entry>
   <entry key="2">Not sure.  Maybe not allowed?</entry>
   <entry key="3">Unknown?</entry>
    </lookuptable>
    <testvalue>1</testvalue>
   </field>

   <field name="Spare" numberofbits="6" type="uint">
    <description>Must be zero</description>
    <required>0</required>
   </field>

 </message> <!– imo_met_hydro" aismsgnum="8" dac="001" fid="11"  –>

</ais-binary-message>
```

Appendix 2

Met/Hydro Binary AIS Message rendered by XSLT style sheet from the XML definition.

Name	Bits	Array Length	Type	Units	Description
MessageID	6		uint		AIS message number. Must be 8
RepeatIndicator	2		uint		Indicated how many times a message has been repeated **0**: default **3**: do not repeat any more
UserID	30		uint		MMSI number of transmitter broadcasting the message
Spare	2		uint		Reserved for definition by a regional authority.
dac	10		uint		Designated Area Code - part 1 of the IAI
fid	6		uint		Functional Identifier - part 2 of the IAI
latitude	24		decimal	degrees	Location of the vessel. North South location
longitude	25		decimal	degrees	Location of the vessel. East West location
day	5		uint	days	Day 0..31
hour	5		uint	hours	Hour 0..23
min	6		uint	minutes	Min
avewind	7		uint	knots	Average wind speed values for the last 10 minutes.
windgust	7		uint	knots	Wind gust is the max wind speed value reading during the last 10 minutes.
winddir	9		uint	degrees	Wind direction
windgustdir	9		uint	degrees	Wind direction for the gust.
airtemp	11		decimal	degrees Celsius	Dry bulb temperature
relhumid	7		uint	percent	Relative humidity
dewpoint	10		decimal	degrees Celsius	Dew Point
airpressure	9		udecimal	hPa	Air pressure
airpressuretrend	2		uint		Air pressure trend **0**: steady **1**: decreasing **2**: increasing **3**: unavailable
horizvis	8		udecimal	nm	Horizontal visibility
waterlevel	9		decimal	m	Water level (incl. tide)
waterleveltrend	2		uint		Water level trend **0**: steady **1**: decreasing **2**: increasing **3**: unavailable
surfcurspeed	8		udecimal	knots	Surface current speed

Name	Bits	Array Length	Type	Units	Description
surfcurdir	9		uint	degrees	
curspeed2	8		udecimal	knots	Level 2 current speed
curdir2	9		uint	degrees	Level 2 current direction
curlevel2	5		uint	m	Measuring level below sea surface for level 2
curspeed3	8		udecimal	knots	Level 3 current speed
curdir3	9		uint	degrees	Level 3 current direction
curlevel3	5		uint	m	Measuring level below sea surface for level 3
sigwaveheight	8		udecimal	m	Significan wave height
waveperiod	6		uint	sec	Wave period
wavedir	9		uint	degrees	Wave direction
swellheight	8		udecimal	m	Swell height
swellperiod	6		uint	sec	Swell period
swelldir	9		uint	degrees	Swell direction
seastate	4		uint	Beaufort scale	Sea state according to the Beaufort scale **0**: Calm **1**: Light air **2**: Light breeze **3**: Gentle breeze **4**: Moderate breeze **5**: Fresh breeze **6**: Strong breeze **7**: Near gale **8**: Gale **9**: Strong gale **10**: Storm **11**: Violent storm **12**: Hurricane **15**: unavailable
watertemp	10		udecimal	degrees Celsius	Water temperature
preciptype	3		uint	WMO scale index	According to WMO **7**: unavailable
salinity	9		decimal	0/00	Salinity
ice	2		uint		Yes or no for the presence of ice **0:** Not sure. Maybe no ice? **1:** Not sure. Maybe yes ice? **2:** Not sure. Maybe not allowed? **3:** Unknown?
Spare	6		uint		Must be zero