CORRIGENDUM 2 TO DRAFT NEW RECOMMENDATION ITU-R M.[8C/XA]
(WITH CHANGES SUGGESTED BY IALA SPECIAL WORKING GROUP ON AIS;
ON REQUEST)

TECHNICAL CHARACTERISTICS FOR A UNIVERSAL SHIPBORNE AUTOMATIC IDENTIFICATION SYSTEM USING TIME DIVISION MULTIPLE ACCESS IN THE MARITIME MOBILE BAND

Summary

This draft new Recommendation sets out the technical characteristics of a Universal shipborne Automatic Identification System (AIS) using Self-Organised Time Division Multiple Access (SOTDMA) in the maritime mobile band.

The Recommendation explains the need for such a system, describes the characteristics of the system in terms of the physical, link, network and transport layers, in accordance with the Open Systems Interconnection (OSI) model.

The ITU Radiocommunication Assembly,

considering

a) that the International Maritime Organisation has a requirement for a Universal Shipborne Automatic Identification System,

b) that the use of a Universal Shipborne Automatic Identification System would allow efficient exchange of navigational data between ships and between ships and shore stations, thereby improving safety of navigation;

c) that a system using Self-Organised Time Division Multiple Access (SOTDMA) would accommodate all users and meet the likely future requirements for efficient use of the spectrum;

d) that such a system should be used primarily for surveillance and safety of navigation purposes in ship to ship use, ship reporting and vessel traffic services (VTS) applications;. It could also be used for communications, provided that the primary functions were not impaired;

e) that such a system would be autonomous, automatic, continuous and operate primarily in a broadcast, but also in an assigned and in an interrogation mode using TDMA techniques;

f) that such a system would be capable of expansion to accommodate future expansion in the number of users and diversification of applications,

recommends

that the AIS should be designed in accordance with the operational characteristics given in Annex 1 and the technical characteristics given in Annexes 2, 3 and 4.

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* This Recommendation should be brought to the attention of the International Maritime Organisation (IMO), the International Civil Aviation Organisation (ICAO), the International Association of Lighthouse Authorities (IALA) and the Comité International Radio Maritime (CIRM).

ANNEX 1

Operational characteristics of a Universal Shipborne Automatic Identification System using Time Division Multiple Access (TDMA) techniques in the maritime mobile band.

1 Objectives

1.1 The AIS should improve the safety of navigation by assisting in the efficient operation of ship to ship, ship reporting and VTS applications.

1.2 The system should enable operators to obtain information from the ship automatically, requiring a minimum of involvement of ship's personnel, and should have a high level of availability.

1.3 The system may be used in SAR operations.

2 General

2.1 The system should automatically broadcast ships dynamic and some other information to all other installations in a self-organised manner.

2.2 The system installation should be capable of receiving and processing specified interrogating calls.

2.3 The system should be capable of transmitting additional safety information on request.

2.4 The system installation should be able to operate continuously while under way or at anchor.

3 Identification

For the purpose of ship *and message* identification, the appropriate Maritime Mobile Service Identity (MMSI) should be used.

4 Information

4.1 Static

- IMO number.
- Call sign and name.
- Length and beam.
- Type of ship.
- Location of position-fixing antenna on the ship (aft of bow and port or starboard of centreline).

4.2 Dynamic

- Ship's position with accuracy indication and integrity status.
- Time in UTC
- Course over ground.
- Speed over ground.
- Heading.
- Rate of turn.
- Optional - Angle of heel. (field not provided in basic message).
- Optional - Pitch and roll. (field not provided in basic message).
- Navigational Status (e.g. NUC, at anchor, etc. - manual input.)
- Provision must be made for inputs from external sensors giving additional information.

4.3 Voyage related

- Ship's draught.
- Hazardous cargo (type; as required by a competent authority)..
- Destination and ETA (at masters discretion).
- Optional - Route plan (waypoints; field not provided in basic message).

4.4 Short safety related messages

A safety related message is a message containing an important navigational or an important meteorological warning.

4.5 Information update rates for autonomous mode

The different information types are valid for a different time period and thus need a different update rate.

Static Information:	Every 6 minutes and on request.
Dynamic Information:	Dependent on speed and course alteration according to Table 1
Voyage related information:	Every 6 min, when data has been amended, and on request.
Safety related message:	As required.

TABLE 1

Type of ship	**Reporting interval**
Ship at anchor	3 min
Ship 0-14 knots	12 sec
Ship 0-14 knots and changing course	4 sec
Ship 14-23 knots	6 sec
Ship 14-23 knots and changing course	2 sec
Ship > 23 knots	3 sec
Ship > 23 knots and changing course	2 sec

Ship Reporting Capacity - the system should be able to handle a minimum 2000 reports per minute, to adequately provide for all operational scenarios envisioned.

5 Frequency band

The AIS should be designed for operation in the maritime mobile band, on either 25 kHz or 12.5 kHz simplex or duplex channels in half duplex mode, in accordance with ITU-R Radio Regulations (RR) Appendix 18 and Recommendation ITU-R M.1084-2, Annex 3.

ANNEX 2

Technical characteristics of a Universal Shipborne Automatic Identification System using Time Division Multiple Access (TDMA) techniques in the maritime mobile band

1 Structure of this Annex

This annex is structured in accordance with the OSI-model (Open System Interconnection Model) as defined by the ISO.

7 Application layer
6 Presentation layer
5 Session layer
4 Transport layer
3 Network layer
2 Link layer
1 Physical layer

FIGURE 1

This annex covers layers 1 to 4 of the model.

2 Physical Layer

The Physical Layer is responsible for the transfer of a bit-stream from an originator out, on to the data link. The performance requirements for the physical layer are summarised in tables 2.1.1.1 to 2.1.3.1.

2.1 Parameters

2.1.1 General

Table 2.1.1.1

Symbol	**Parameter Name**	**Min**	**Max**
PH.RFR	Regional Frequencies	156.025 MHz	162.025 MHz
PH.CHS	Channel Spacing (encoded acc.to A18 with footnotes)	12.5 kHz	25.0 kHz
PH.AIS1	AIS Channel 1 (ch 87B)	161.975 MHz	161.975 MHz
PH.AIS2	AIS Channel 2 (ch 88B)	162.025 MHz	162.025 MHz
PH.CHB	Channel Bandwidth	12.5 kHz	25.0 kHz
PH.BR	Bitrate	9600 bps +/- 50 ppm	9600 bps +/- 50 ppm
PH.TS	Training Sequence	24 bits	32 bits
PH.TST	Transmitter Settling Time Transmit power within 20% of final value, Frequency stable to within +/-1.0 kHz of final value	-	1.0 ms
PH.TXP	Transmit Output Power	1 Watt	25 Watt

2.1.2 Constants

Table 2.1.2.1

Symbol	**Parameter Name**	**Value**
PH.DE	Data Encoding	NRZI
PH.FEC	Forward Error Correction	Not used
PH.IL	Interleaving	Not used
PH.BS	Bit Scrambling	Not used
PH.MOD	Modulation	Bandwidth Adapted GMSK/FM

2.1.3 Bandwidth Dependent Parameters

Table 2.1.3.1 below defines settings dependent on parameter PH.CHB.

Symbol	Parameter Name	PH.CHB(12.5 kHz)	PH.CHB(25.0 kHz)
PH.TXBT	Transmit BT-product	0.3	0.4
PH.RXBT	Receive BT-product	0.3/0.5	0.5
PH.MI	Modulation Index	0.25	0.50

2.1.4 Transmission media

Data transmissions are made in the maritime mobile VHF band. Data transmissions shall default to AIS 1 and AIS 2 unless otherwise specified by a competent authority, as described in 4.1 and Annex 3. See also Annex 4 concerning Long Range Applications.

2.2 Bandwidth

The AIS shall be capable of operating with a channel bandwidth of 25 kHz or 12.5 kHz according to Recommendation ITU-R M.1084-2 and Appendix 18 of the Radio Regulations. 25 kHz bandwidth shall be used on the high seas whereas 25 kHz or 12.5 kHz channel bandwidth shall be used as defined by the appropriate authority in territorial waters, as described in 4.1 and Annex 3.

2.3 Transceiver Characteristics

The transceiver shall perform in accordance with recognized international standards.

2.4 Modulation Scheme

The modulation scheme is Bandwidth Adapted Frequency Modulated Gaussian Minimum Shift Keying - GMSK/FM.

2.4.1 GMSK

The following applies to the GMSK coding:

2.4.1.1. The Non-Return to Zero Inverted (NRZI) encoded data shall be GMSK coded before frequency modulating the transmitter.

2.4.1.2. The GMSK Modulator Bandwidth Time product (BT-product) used for transmission of data shall be 0.4 maximum when operating on a 25 kHz channel, and 0.3 when operating on a 12.5 kHz channel.

2.4.1.3. The GMSK Demodulator used for receiving of data shall be designed for a BT-product of maximum 0.5 when operating on a 25 kHz channel and 0.3 or 0.5 when operating on a 12.5 kHz channel.

2.4.2 Frequency Modulation

The GMSK coded data shall frequency modulate the VHF transmitter. The Modulation Index shall be 0.5 when operating on a 25 kHz channel and 0.25 when operating on a 12.5 kHz channel.

2.5 Data Transmission Bit Rate

The transmission bit rate shall be 9600 bits/s ±50 ppm.

2.6 Training Sequence

Data transmission shall begin with a 24 bit demodulator training sequence (preamble) consisting of one segment synchronisation. This segment shall consist of alternating zeros and ones (0101....). This sequence may begin with a 1 or a 0 since NRZI encoding is used. Optionally, a 32 bit training sequence may be used when the environment so requires. In this case, a reduction in distance delay may be used to compensate. The default operation of the transponder shall use a 24 bit training sequence. ~~*Changes to the training sequence shall be by assignment.*~~*The size of the training sequence is determined by the Link Management Entity (LME) in the Link Layer.*

2.7 Data Encoding

The NRZI waveform is used for data encoding. The waveform is specified as giving a change in the level when a zero (0) is encountered in the bitstream.

2.8 Forward Error Correction

Forward Error Correction is not used.

2.9 Interleaving

Interleaving is not used.

2.10 Bit Scrambling

Bit Scrambling is not used.

2.11 Data Link Sensing

Data link occupancy and data detection are entirely controlled by the Link Layer.

2.12 Transmitter Settling Time

The RF settling characteristics shall ensure that the transceiver requirements in 2.3 are met.

2.12.1 Transmitter RF Attack time

The transmitter RF attack time shall not exceed 1 ms after TX-ON signal according to the following definition: RF attack time is the time from TX-ON signal until the RF Power has reached 80% of the nominal (steady state) level (refer to Figure 2).

2.12.2 Transmitter Frequency Attack time

The Transmitter Frequency Attack (stabilisation) time, which shall be ± 1.0 kHz within 1.0 ms after TX-ON, shall also be according to 2.3.

2.12.3 Transmitter RF Release Time

The Transmitter RF power must be switched off within 1 ms from the TX-OFF signal.

2.13 Transmitter Power

2.13.1 Transmitter output power should not exceed 25 W at the highest power setting.

2.13.2 Provision should be made for two levels of nominal power (high power, low power) as required by some applications. *The power level is determined by the Link Management Entity (LME)* *of the Link Layer.*

2.13.3 The nominal levels for the two power settings shall be 2 watts and 12.5 watts. Tolerance shall be within ± 20%.

2.14 Shutdown Procedure

2.14.1 An automatic transmitter hardware shutdown procedure and indication should be provided in case a transmitter does not discontinue its transmission within 0.5 seconds of the end of its assigned slot.

3 Link Layer

The Link Layer specifies how data is packaged in order to apply error detection and correction to the data transfer. The Link Layer is divided into three (3) sublayers.

3.1 Sublayer 1: Medium Access Control (MAC)

The MAC sublayer provides a method for granting access to the data transfer medium, i.e. the VHF data link. The method used is a Time Division Multiple Access (TDMA) scheme using a common time reference.

3.1.1 TDMA Synchronisation

TDMA synchronisation is achieved using an algorithm based on a synchronisation state as described below. The Sync State Flag within SOTDMA Communication State (refer to 3.3.7.2.2) and within ITDMA Communication State (refer to 3.3.7.3.2), indicates the synchronisation state of a station.

3.1.1.1 UTC Direct

A station, which has direct access to UTC timing with the required accuracy shall indicate this by setting its synchronisation state to UTC Direct.

3.1.1.2 UTC Indirect

A station, which is unable to get direct access to UTC, but can receive other stations which indicate UTC Direct, shall synchronise to those stations. It shall then change its synchronisation state to UTC Indirect. This state is correct for any number of levels of indirect synchronisation.

3.1.1.3 Synchronised to Base Station (Direct or Indirect)

Mobile stations, which are unable to attain Direct or Indirect UTC synchronisation, but are able to receive transmissions from base stations, shall synchronise to the base station which indicates the highest number of received stations*. The number of received stations is contained within the SOTDMA Communication State – Sub Message on the occasion that the parameter SlotTimeOut of the SOTDMA Communication State has the value three (3)*. *The station which is thus synchronised to a Base Station* ~~It~~ shall then change its synchronisation state to *"Base Station" to* reflect this. This state is correct for any number of levels of indirect access to the base station.

When a station is receiving several other base stations which indicate the same number of received stations, synchronisation shall be based on the station with the lowest MMSI.

3.1.1.4 Number of Received Stations

A station, which is unable to attain UTC Direct or UTC Indirect synchronisation, shall synchronise to the station indicating the highest number of other stations received. *This station then changes its synchronisation state to "Number of Received Stations" (refer to 3.3.7.2.2 for SOTDMA Communication State and to 3.3.7.3.2 for ITDMA Communication State).* When a station is receiving several other stations, which indicate the same number of received stations, synchronisation shall be based on the station with the lowest MMSI. That station becomes the *semaphore* on which synchronisation shall be performed.

3.1.2 Time Division

The system uses the concept of a frame. A frame equals one (1) minute and is divided into 2250 slots. Access to the data link is, by default, given at the start of a slot. The frame start and stop coincide with the UTC minute, when UTC is available. When UTC is unavailable the procedure, described below shall apply.

3.1.3 Slot Phase and Frame Synchronisation

3.1.3.1 Slot Phase Synchronisation

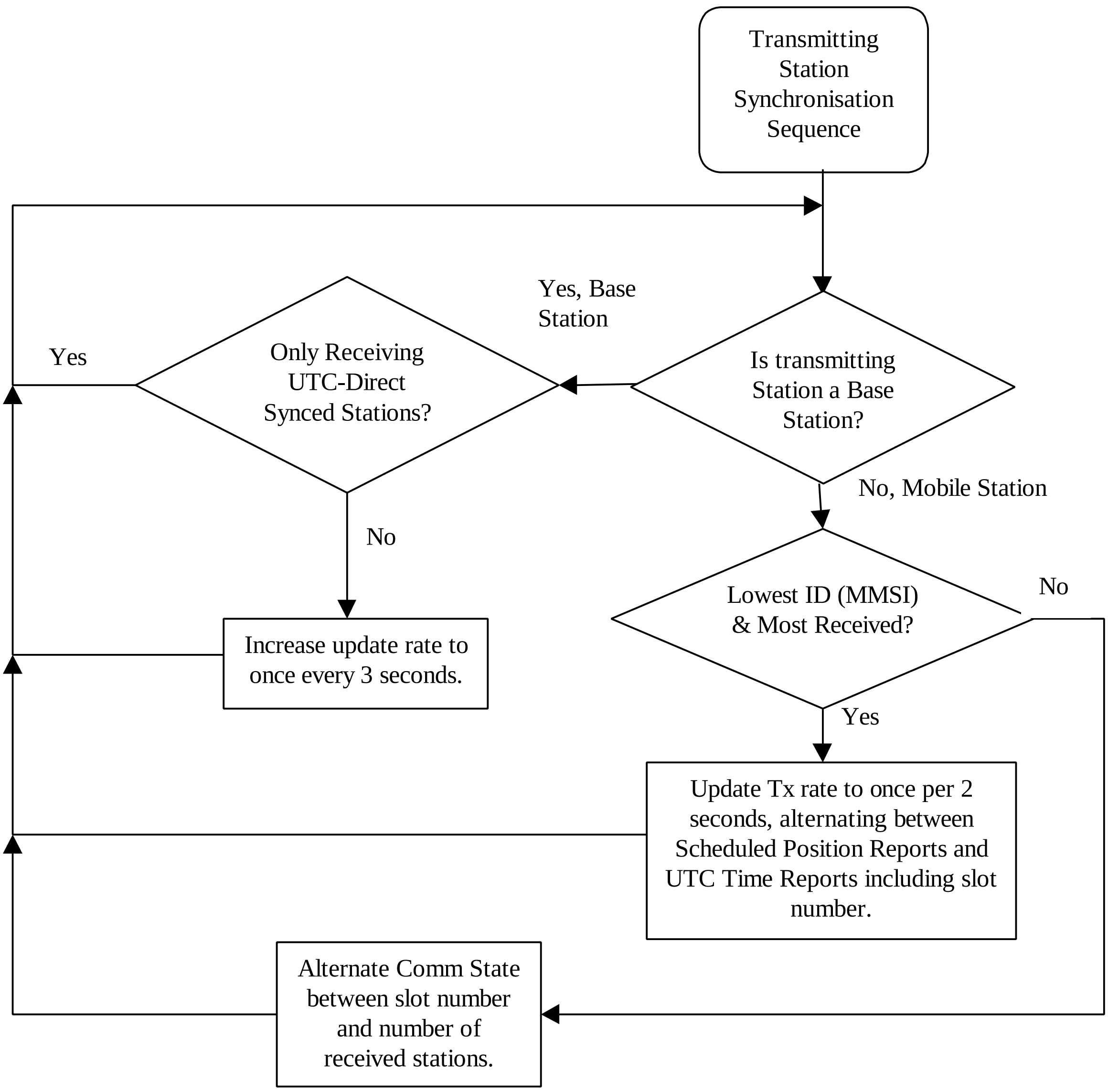
Slot Phase Synchronisation is the method whereby one station uses the messages from other stations or base stations to re-synchronise itself, thereby maintaining a high level of synchronisation stability, ensuring no message boundary overlapping or corruption of messages.

Decision to slot phase synchronise shall be made after receipt of end flag and valid FCS. (State T3, figure 5). At T5, the station resets its *Slot_Phase_Synchronisation_Timer*, based on Ts, T3 and T5 (Figure 5).

3.1.3.2 Frame Synchronisation

Frame Synchronisation is the method whereby one station uses the current slot number of another station or base station, adopting the received slot number as its own current slot number. *The current slot number of a received station is contained within the SOTDMA Communication State – Sub Message on the occasion that the parameter SlotTimeOut of the SOTDMA Communication State has the value two (2).*

3.1.3.3 Synchronisation - Transmitting Stations



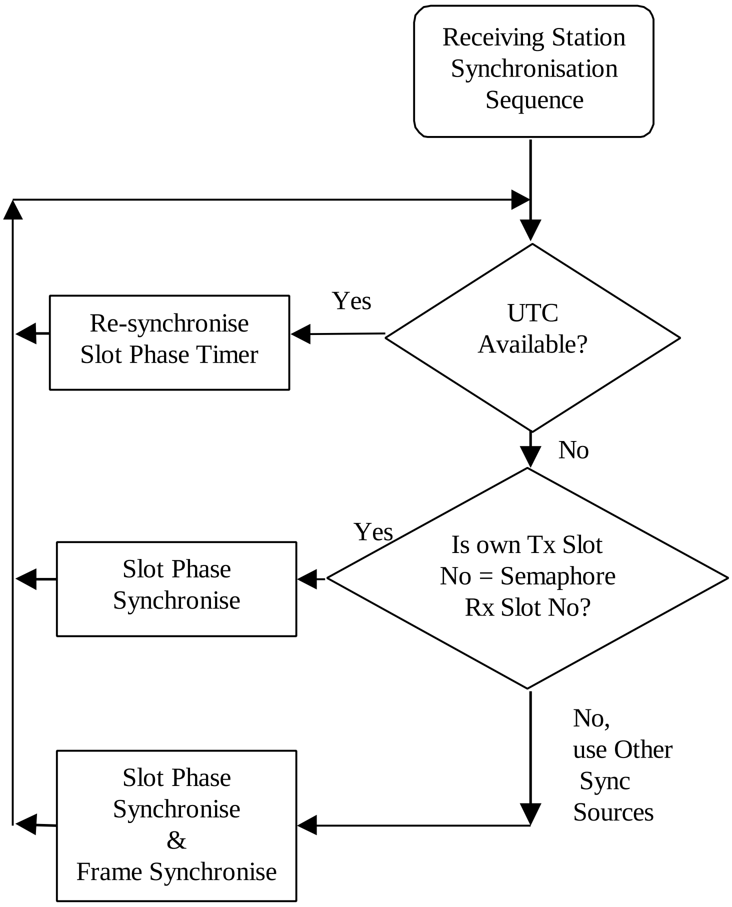
3.1.3.3.1 Base Station Operation

The base station will operate nominally until it detects one or more stations which are lacking UTC direct synchronisation. It will then increase its update rate to transmit periodical reports once every 3 seconds.

3.1.3.3.2 Mobile Station Operation

When a mobile station determines that it is the semaphore (see section 3.1.1.4), it will start using a reporting interval of once every 2 seconds at minimum. It will also start to alternate between the scheduled position report and the UTC reply message including current slot number.

3.1.3.4 Synchronisation - Receiving Stations



3.1.3.4.1 UTC Available

A station, which has direct or indirect access to UTC, will continuously re-synchronise its transmissions based on the UTC source.

3.1.3.4.2 Own Transmission Slot No Equal to No of Received Semaphore Slot

When the station determines that its own internal slot number is equal to the semaphore slot number, it is already in Frame Synchronisation and it will continuously Slot Phase synchronise.

3.1.3.4.3 Other Synchronisation Sources

Other possible synchronisation sources, which can serve as basis for Slot Phase- and Frame synchronisation, are listed below in the order of priority:

1. A station which has UTC time and which is semaphore qualified.
2. A base station which is semaphore qualified.
3. Other station(s) which are synchronised to a base station.
4. A mobile station, which is semaphore qualified.

See section 3.1.1.4 for semaphore qualification. *A station is semaphore qualified if it is indicating the most number of received stations. If more than one indicate the same amount, the one with the lowest identifier rules. The station with the highest sync state can also be semaphore qualified if that is the sole station with that sync state.*

3.1.4 Slot Identification

Each slot is identified by its index (0-2249).

3.1.5 Slot Access

Transmission in a slot is commenced by turning on the transmitter at the slot start. The transmitter shall begin to output RF at slot start.

The transmitter should be turned off after the last bit of the transmission packet has left the transmitting unit. This event must occur within the slots allocated for own transmission. The default length of a transmission occupies one (1) slot. The slot access is performed as shown in Figure 2:

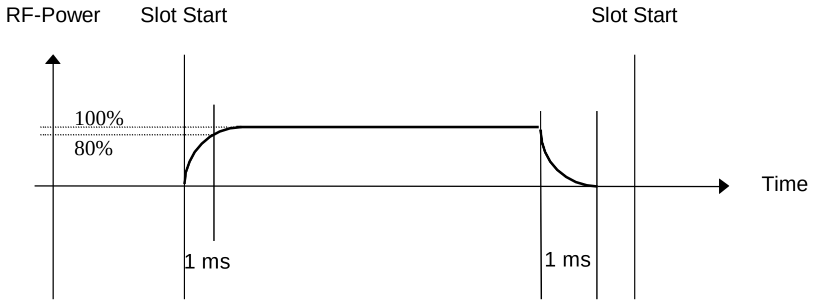


FIGURE 2

Each slot can be in one of the following states:

1. FREE: meaning that the slot is available for use by anyone;
2. INTERNAL ALLOCATION: meaning that the slot is allocated by the own equipment and can be used for transmission;
3. EXTERNAL ALLOCATION: meaning that the slot is allocated for transmission by another data link user and cannot be used by the own equipment.
4. AVAILABLE: meaning that the slot is used by the most distant stations.

3.2 Sublayer 2: Data Link Service (DLS)

The DLS sublayer provides methods for:

1. data link activation and release.
2. data transfer.
3. error detection and control.

3.2.1 Data Link Activation and Release

Based on the MAC sublayer the DLS will listen, activate or release the data link. Activation and release is done in accordance with Section 3.1.4 above. A slot, marked as free or externally allocated, indicates that the own equipment should be in receive mode and listen for other datalink users.

3.2.2 Data Transfer

Data transfer is performed using a bit-oriented protocol which is based on the High-Level Data Link Control (HDLC) as specified by ISO/IEC 3309, 5th edition 1993-12-15,- definition of packet structure. Information packets (I-Packets) are used with the exception that the control field is omitted (see Figure 3).

3.2.2.1 Bit stuffing

The bitstream is subject to bit stuffing. This means that if more than 5 consecutive 1s are found in the output bit stream, a zero is inserted. This applies to all bits except the databits of HDLC flags.

3.2.2.2 Packet Format

Data is transferred in a broadcast mode using a transmission packet as shown in Figure 3:

TRAINING SEQ	START FLAG	DATA	FCS	END FLAG	BUFFER

FIGURE 3

The packet is sent from left to right. This structure is identical to the general HDLC structure, except for the training sequence. The training sequence is used in order to synchronise the VHF receiver and is discussed in 3.2.2.3. The total length of the default packet is 256 bits. This is equivalent to 1 slot.

3.2.2.3 Training Sequence

The training sequence is a bit pattern consisting of alternating 0's and 1's (010101010...). 24 bits of preamble are transmitted prior to sending the flag (unless a 32 bit training sequence is assigned, see paragraph 2.6). This bit pattern is modified due to the NRZI mode used by the communication circuit. See Figure 4.

Unmodified bit pattern:

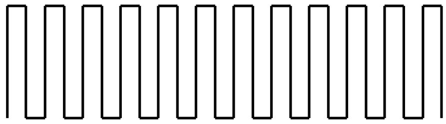


FIGURE 4A

Modified by NRZI:

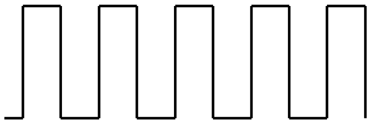


FIGURE 4B

The preamble is chosen so that it will not be subject to bit stuffing.

3.2.2.4 Start Flag

The start flag is 8 bits long and consists of a standard HDLC flag. It is used in order to detect the start of a transmission packet. The HDLC flag consists of a bit pattern, 8 bits long: 01111110 (7Eh). The flag is not subject to bit stuffing, although it consists of 6 bits of consecutive ones.

3.2.2.5 Data

The data portion is 168 bits long in the default transmission packet. The content of data is undefined at the DLS. Transmission of data, which occupy more than 168 bits, is described in Section 3.2.2.11 below.

3.2.2.6 FCS

The FCS (Frame Check Sequence) uses the Cyclic Redundancy Check (CRC)-CCITT 16 bit polynomial to calculate the checksum as defined in ISO/IEC 3309 5th edition 1993-12-15. This is a 16-bit value. The CRC bits are preset to one (1) at the beginning of a CRC calculation. The HDLC address and data portion are included in the CRC calculation.

3.2.2.7 End Flag

The end flag is identical to the HDLC Flag as described in 3.2.2.4

3.2.2.8 Buffering

The buffering is 24 bits long and is used for:

Bitstuffing	4 bits
Distance delay	12 bits
Repeater delay	2 bits
Synchronisation Jitter	6 bits

3.2.2.8.1 Bit Stuffing

A statistical analysis of all possible bit combinations in the data field shows that 76% of combinations use 3 bits or less, for bit stuffing. Adding the logically possible bit combinations, shows that 4 bits are sufficient for virtually all messages.

3.2.2.8.2 Distance delay

A time equal to 12 bits is reserved for distance delay. This is equivalent to 202.16 nm. This distance delay provides protection for a repeater range of up to 100 nm.

3.2.2.8.3 Repeater delay

The repeater delay provides for a turn-around time in a duplex repeater.

3.2.2.8.4 Synchronisation jitter

The synchronisation jitter bits preserve integrity on the TDMA data link, by allowing a jitter in each time slot, which is equivalent to 6 bits (± 3 bits). Transmission timing error shall be within ± 104 µs of the synchronisation source. Timing errors are additive. The accumulated timing error can be up to ± 312 µs.

3.2.2.9 Summary of the Default Transmission Packet

The data packet can be summarised as shown in table 3.2.2.9.1 below:

Ramp Up	8 bits	
Training Sequence	24 bits	Necessary for synchronisation
Start Flag	8 bits	In accordance with HDLC.
Data	168 bits	Default
CRC	16 bits	In accordance with HDLC.
End Flag	8 bits	In accordance with HDLC.
Buffering	24 bits	Bit stuffing and distance delays.
Total	**256 bits**	

3.2.2.10 Transmission timing

Figure 5 shows the timing events of a standard position report transmission. The data block plus overhead is shown and the RF TX-ON & OFF events. At the situation where the down ramping of the RF power overshoots into the next slot, there shall be no modulation of the RF after the TX-OFF event. This prevents undesired interference, due to false locking of receiver modems, with the succeeding transmission in the next slot.

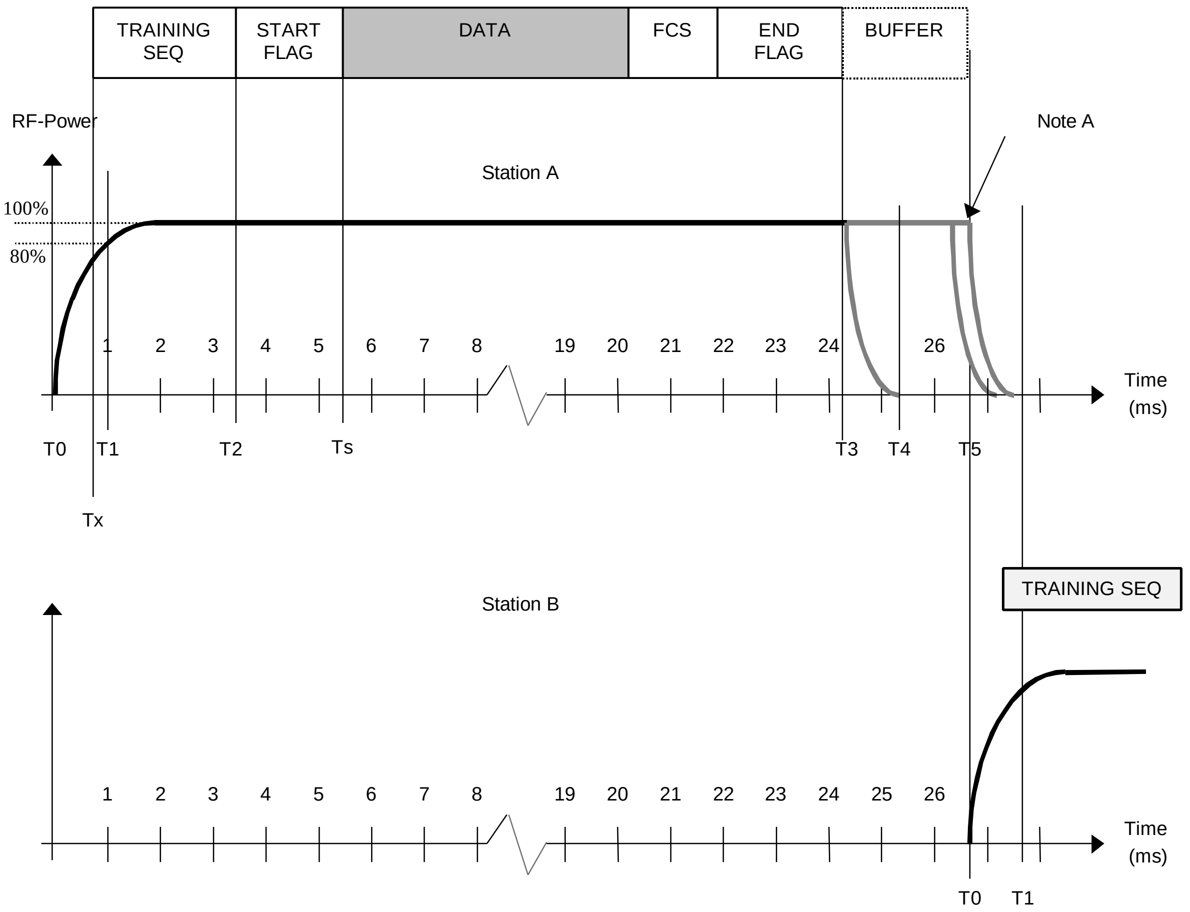


FIGURE 5

Transmission timing

T(n)	Time (ms)	Description
T0	0.000	Slot start. RF power is applied (TX-ON).
Tx	0.832	Beginning of training sequence.
T1	1.000	RF power and Frequency stabilisation time.
T2	3.328	Start of transmission packet (Start flag). This event can be used as a secondary synchronisation source should the primary source (UTC) be lost.
Ts	4.160	Slot Phase Synchronise Marker. End of start flag, beginning of data.
T3	24.128	End of transmission, assuming zero bit stuffing. No modulation is applied during TX-OFF. In case of a shorter data block, the transmission may end earlier.
T4	T3 + 1.000	The time when RF power shall have reached zero.
T5	26.670	End of slot. Beginning of next slot.

NOTE A: Should a transmission end exactly at the beginning of the next slot, the TX-down period for UNIT A will overlap into the next slot as shown. Transmission, of the training sequence, is not impaired by this. This occasion would be extremely rare, and it would occur only in the event of a propagation anomaly. Even in this case, the operation of the AIS is not impaired.

3.2.2.11 Long Transmission Packets

A station is allowed to occupy at maximum 5 consecutive slots for transmission. Transmission in these slots, shall be optimised with respect to overhead (ramp up, training sequence, flags, FCS, buffering) and communication environment. Thus, the maximum length of a packet shall be shorter than 5 slots.

3.2.3 Error Detection and Control

Error detection and control is handled using the CRC-CCITT polynomial as described in 3.2.2.6. CRC errors are forwarded to the Link Management Entity of the Link Layer. The error detection and control is limited to each transmitted packet. Errors related to packet sequencing and groups of packets, are forwarded to the network layer.

3.3 Sublayer 3: Link Management Entity (LME)

The LME controls the operation of the DLS, MAC and the physical layer.

3.3.1 Access to the Data Link

There are four different protocols for controlling access to the data transfer medium. The application and mode of operation determine the protocol to be used. The protocols are:

Self Organised Time Division Multiple Access (SOTDMA), Incremental Time Division Multiple Access (ITDMA), Random Access Time Division Multiple Access (RATDMA) and Fixed Access Time Division Multiple Access (FATDMA). SOTDMA is the basic scheme used for scheduled repetitive transmissions from an autonomous station. When, for example, the update rate has to be changed, or a non-repetitive message is to be transmitted, other access protocols are used.

3.3.1.1 Co-operation on the Data Link

The access protocols operate continuously, and in parallel, on the same physical data link. They all conform to the rules set up by the TDMA (as described in 3.1).

3.3.1.2 Candidate Slots

Slots, used for transmission, are selected among *candidate slots*. There shall always be at minimum 4 candidate slots to choose from. The candidate slots are primarily selected from free slots (see section 3.1.5). When required, available slots are included in the candidate slot set. When selecting a slot from the candidates, any candidate has the same probability of being chosen, regardless of its state.

When selecting among candidate slots for transmission in one channel, the candidates in both channels shall be considered. If, a slot in either channel, is occupied by a station which is at close range, that slot shall be omitted from the candidate slots.

3.3.2 Modes of Operation

There are three modes of operation. The default mode is autonomous and can be switched to/from other modes as required by a competent authority.

3.3.2.1 Autonomous and Continuous

A station operating autonomously determines its own schedule for transmission of its position. The station will automatically resolve scheduling conflicts with other stations.

3.3.2.2 Assigned

A station operating in the assigned mode is using a transmission schedule assigned by a competent authority’s Base or Repeater station.

3.3.2.3 Polled

A station operating in polled mode responds to interrogations from a ship or competent authority. Operation in the polled mode shall not conflict with operation in the other two modes.

3.3.3 Initialisation

At power on, a station will monitor the TDMA channels for one (1) minute to determine channel activity, other participating member IDs, current slot assignments and reported positions of other users, and possible existence of shore stations. During this time period, a dynamic directory of all stations operating in the system is established. A frame map is constructed, which reflects TDMA channel activity. After one (1) minute has elapsed, the station enters operational mode and starts to transmit according to its own schedule.

3.3.4 Channel Access Protocols

The access protocols, as defined below, shall co-exist and operate simultaneously on the TDMA channel.

3.3.4.1 Incremental Access TDMA - ITDMA

The ITDMA access protocol allows a station to pre-announce transmission slots of non-repeatable character, with one exception: During data link network entry, ITDMA slots are marked so that they will be reserved for one additional frame. This allows a station to pre-announce its allocations for autonomous and continuous operation.

ITDMA is used on three occasions:

1. Data link network entry,
2. Temporary changes and transitions in periodical report rates,
3. Pre-announcement of safety related messages.

3.3.4.1.1 ITDMA Access Algorithm

A station can begin its ITDMA transmission by either substituting a SOTDMA allocated slot or, by allocating a new, unannounced slot, using RATDMA. Either way, this becomes the first ITDMA slot.

The first transmission slot, during data link network entry, is always allocated using RATDMA. That slot is then used as the first ITDMA transmission.

When above layers dictate a temporary change of report rate or the need to transmit a safety related message, the next upcoming SOTDMA slot may be used for an ITDMA transmission.

Prior to transmitting in the first ITDMA slot, the station randomly selects the next following ITDMA slot and calculates the relative offset to that location. This offset is inserted into the ITDMA Comm State so that receiving stations will be able to *mark the slot, indicated by this offset, as "externally allocated"* ~~the next slot~~ *(refer to 3.3.7.3.2 and to 3.1.5)*. The Comm State is transmitted as a part of the ITDMA transmission. During network entry, the station also indicates that the ITDMA slots shall be reserved for one additional frame. The process of allocating upcoming slots, continues as long as required. In the last ITDMA slot, the relative offset is set to zero.

3.3.4.1.2 ITDMA Parameters

The following parameters control ITDMA scheduling:

Table 3.3.4.1.2.1

Symbol	Name	Description	Min	Max
LME.ITINC	Slot Increment	The slot increment is used to allocate a slot ahead in the frame. It is a relative offset from the current transmission slot. If it is set to zero, no more ITDMA allocations are done.	0	8191
LME.ITSL	Slots	Indicates the number of consecutive slots, which are allocated, starting at the slot increment.	1	5
LME.ITKP	Keep Flag	This flag is set to TRUE when the slot(s), allocated ahead in the frame, shall be reserved for the next frame also. The Keep flag is set to FALSE when the allocated slot shall be freed immediately after transmission.	FALSE	TRUE

3.3.4.2 Random Access TDMA - RATDMA

RATDMA is used when a station needs to allocate a slot, which has not been pre-announced. This is generally done for the first transmission slot during data link network entry, or for messages of a non-repeatable character.

3.3.4.2.1 RATDMA Access Algorithm

The access protocol uses a probability persistent (p-persistent) algorithm as described in this section.

Messages, which use the RATDMA access protocol, are stored in a priority FIFO. When a candidate slot (a slot which is marked available for use) is detected, the station randomly selects a probability value (LME.RTP1) between 0 and 100. This value is compared with the current probability for transmission (LME.RTP2). If LME.RTP1 is equal to, or less than LME.RTP2, transmission will occur in the candidate slot. If not, LME.RTP2 is incremented with a probability increment (LME.RTPI) and the station waits for next candidate slot in the frame.

3.3.4.2.2 RATDMA Parameters

The following parameters control RATDMA scheduling:

Table 3.3.4.2.2.1

Symbol	Name	Description	Min	Max
LME.RTPRI	Priority	The priority that the transmission has when queuing messages. Safety related messages always have priority.	1	0
LME.RTPS	Start Probability	Each time a new message is due for transmission, the process sets LME.RTP2 equal to LME.RTPS	10	20
LME.RTP1	Derived Probability	Calculated probability for transmission in the next candidate slot. Shall be less than or equal to LME.RTP2 for transmission to occur. This value is randomly selected for each transmission attempt.	0	100
LME.RTP2	Current Probability	The current probability that a transmission will occur in the next candidate slot.	LME.RTPS	100
LME.RTPI	Probability Increment	Each time the algorithm determines that transmission shall not occur, LME.RTP2 is incremented with LME.RTPI.	1	50

3.3.4.3 Fixed Access TDMA - FATDMA

FATDMA is used by base stations and controlling stations only. FATDMA allocated slots are used for repetitive messages.

3.3.4.3.1 FATDMA Access Algorithm

Access to the data link is achieved with reference to frame start. Slot zero (0) is always at the start of the frame. Each allocation is pre-configured by the competent authority, and not changed for the duration of the operation of the station or, until re-configured.

3.3.4.3.2 FATDMA Parameters

The following parameters, control FATDMA scheduling.

Table 3.3.4.2.3.1

Symbol	Name	Description	Min	Max
LME.FTST	Start Slot	The first slot (referenced to frame start) to be used by the station	0	2249
LME.FTI	Increment	Increment to next block of allocated slots. An increment of zero indicates that the station transmits one time per frame, in the start slot.	0	1125
LME.FTBS	Block Size	Default block size. Determines the default number of consecutive slots which are to be reserved at each increment	1	5

3.3.4.4 Self Organised TDMA - SOTDMA

The SOTDMA access protocol is used by mobile stations operating in autonomous and continuous mode. The purpose of the protocol is to offer an access algorithm which quickly resolves conflicts without intervention from controlling stations. Messages which use the SOTDMA access protocol are of a repeatable character and are used in order to supply a continuously updated surveillance picture to other users of the data link.

3.3.4.4.1 SOTDMA Access Algorithm

The access algorithm and continuous operation of SOTDMA is described in the section 3.3.5, Autonomous and Continuous Operation, below.

3.3.4.4.2 SOTDMA Parameters

The following parameters, control SOTDMA scheduling.

Table 3.3.4.4.2.1

Symbol	**Name**	**Description**	**Min**	**Max**
NSS	Nominal Start Slot	This is the first slot used by a station to announce itself on the data link. Other repeatable transmissions are generally selected with the NSS as a reference.	0	2249
NS	Nominal Slot	The nominal slot is used as the centre around which slots are selected for transmission of position reports. For the first transmission in a frame, the NSS and NS are equal. Any NS is derived using the equation below: **NS = NSS + (n * NI); (0 <= n < RR)**	0	2249
NI	Nominal Increment	The nominal increment is given in number of slots and is derived using the equation below: NI = 2250 / RR	75	1225
RR	Report Rate	This is the desired number of position reports per frame. When a station uses a report rate of less than one report per frame, ITDMA allocations are used. Otherwise SOTDMA is used.	1/3	30
SI	Selection Interval	Selection Interval. The selection interval is the collection of slots which can be candidates for position reports. The SI is derived using the equation below: SI = {NS – (0.1 * NI) to NS + (0.1 * NI)}	0.2 * NI	0.2 * NI
NTS	Transmission Slot	The slot, within a selection interval, currently used for transmissions within that interval.	0	2249
TMO_MIN	Minimum Timeout	The minimum number of frames that an SOTDMA allocation will occupy a specific slot.	3	3
TMO_MAX	Maximum Timeout	The maximum number of frames that an SOTDMA allocation will occupy a specific slot.	TMO_MIN	8

3.3.5 Autonomous and Continuous Operation

This section describes how a station operates in the autonomous and continuous mode. Figure 6 shows the slot map accessed using SOTDMA.

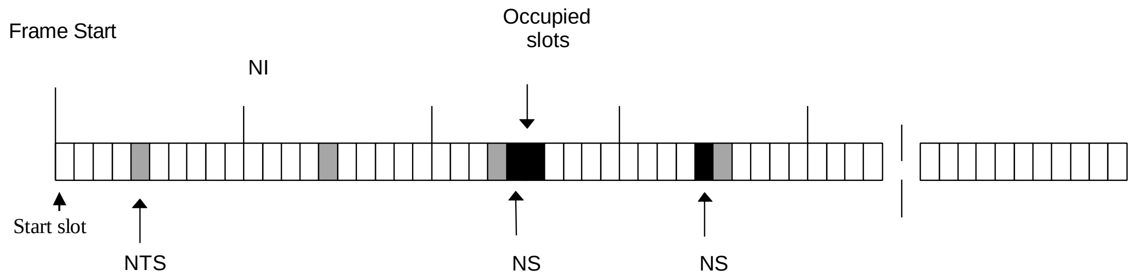


FIGURE 6

3.3.5.2 Initialisation Phase

The Initialisation phase is described using the flowchart below.

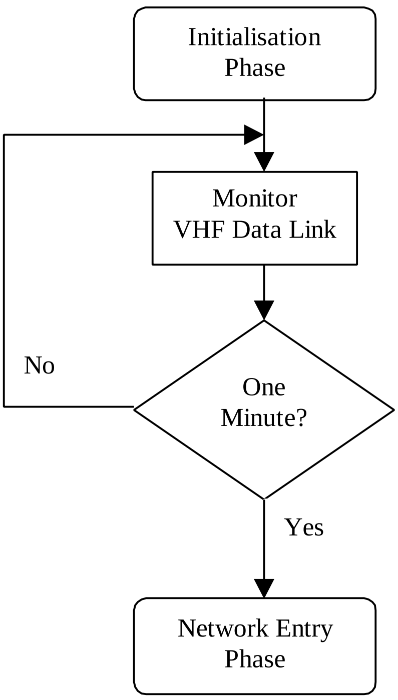


FIGURE 7

3.3.5.2.1 Monitor VHF data link (VDL)

At power on, a station will monitor the TDMA channel for one (1) minute to determine channel activity, other participating member IDs, current slot assignments and reported positions of other users, and possible existence of shore stations. During this time period, a dynamic directory of all members operating in the system is established. A frame map is constructed, which reflects TDMA channel activity.

3.3.5.2.2 One Minute

After one (1) minute has elapsed, the station enters the network and starts to transmit according to its own schedule, as described below.

3.3.5.3 Network Entry Phase

During the network entry phase, the station selects its first slot for transmission in order to make itself visible to other participating stations. The first transmission is always the default position report.

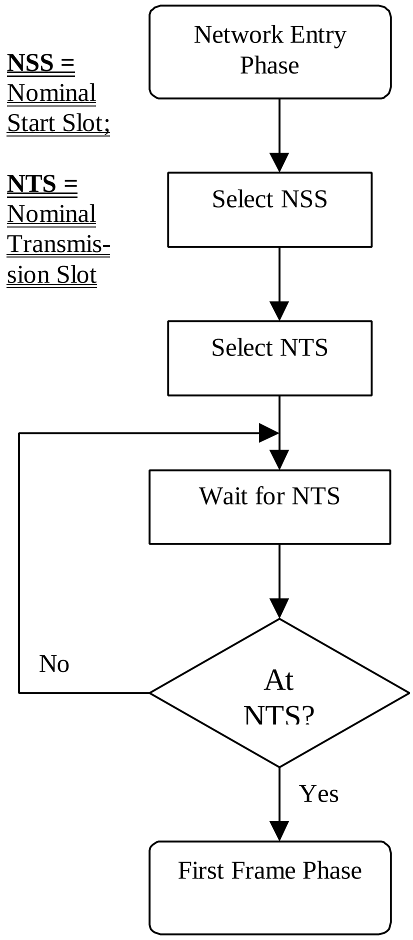


FIGURE 8

3.3.5.3.1 Select Nominal Start Slot (NSS)

The Nominal Start Slot (NSS) is randomly selected between current slot and Nominal Increment (NI) slots forward. This slot is the reference when selecting Nominal Slots (NS) during the first frame phase. The first NS is always equal to NSS.

3.3.5.3.2 Select Nominal Transmission Slot (NTS)

Within the SOTDMA algorithm the Nominal Transmission Slot (NTS) is selected as follows: A slot is randomly selected among candidate slots within the Selection Interval (SI). This is the NTS, which is then marked as internally allocated and assigned a random time-out between TMO_MIN and TMO_MAX.

3.3.5.3.3 Wait for NTS

The NTS was selected ahead in the frame. The station now waits until this slot is approached.

3.3.5.3.4 At NTS

When the frame map indicates that the NTS is coming up the station enters the First Frame Phase.

3.3.5.4 First Frame Phase

During the first frame phase, the station continuously allocates its transmission slots and transmits default position reports using ITDMA access.

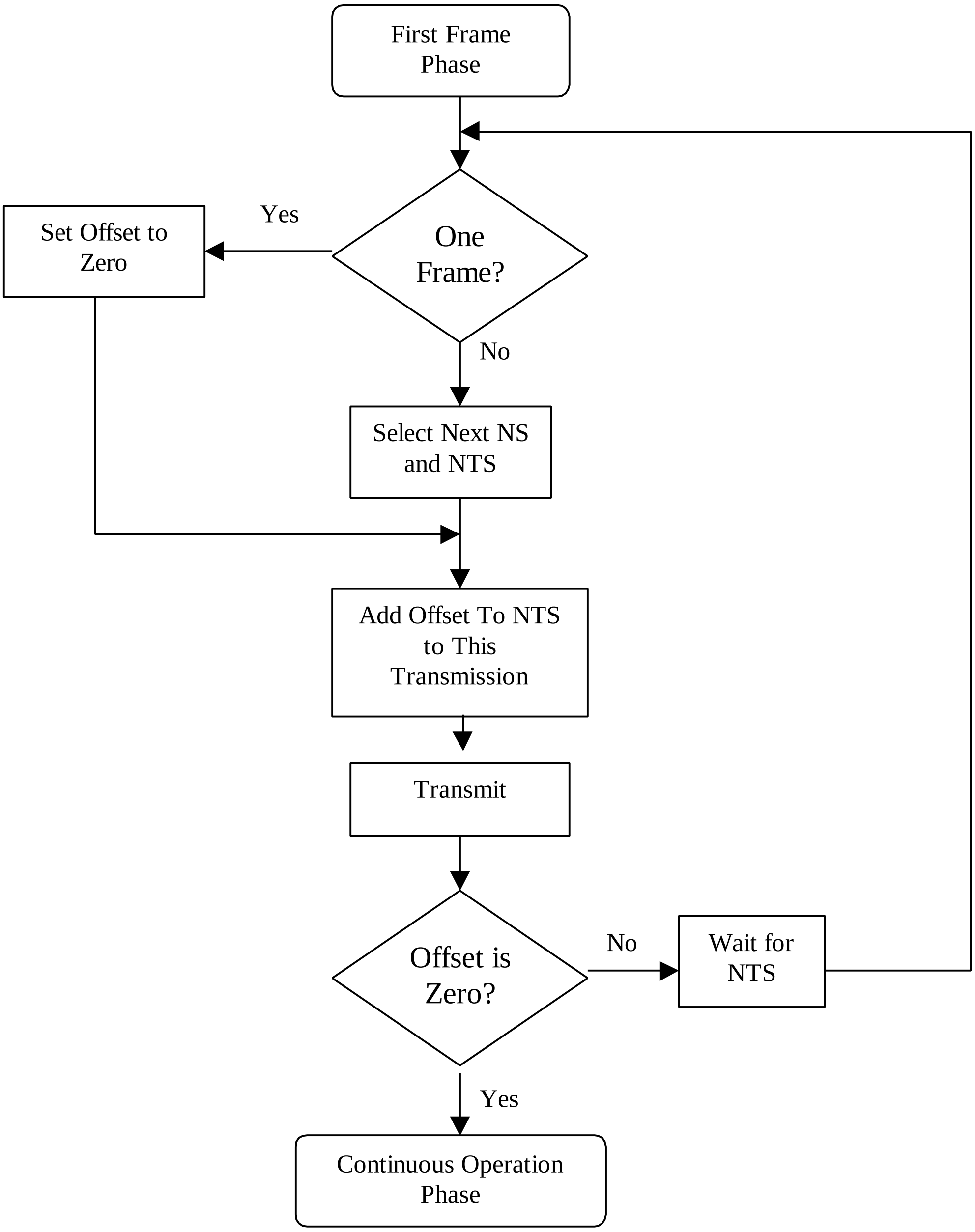


FIGURE 9

3.3.5.4.1 One Frame

When one frame has elapsed, the initial transmissions have been allocated and it is time to enter nominal operation.

3.3.5.4.2 Set Offset to Zero

The offset is used in the first frame when all transmissions use the ITDMA access scheme. The offset indicates the relative distance from the current transmission to next intended transmission. It is an incremental update of the intention of the station.

3.3.5.4.3 Select Next NS and NTS

Prior to transmitting, the next NS is selected. This is done by keeping track of the number of transmissions performed so far (from n to RR – 1). The NS is selected using the equation described in Table 3.3.4.4.2.1.
Nominal Transmission Slot is selected using the SOTDMA algorithm as follows: A slot is selected among candidate slots within the Selection Interval (SI). The NTS is then marked as internally allocated.
The offset to next NTS is calculated and saved for the next step.

3.3.5.4.4 Add Offset to This Transmission

All transmissions in the First Frame Phase use the ITDMA access scheme. This structure contains an offset from the current transmission to the next slot in which a transmission is due to occur. The transmission also sets the keep flag so that receiving stations will allocate the slot for one additional frame.

3.3.5.4.5 Transmit

A scheduled position report is entered into the ITDMA packet and transmitted in the allocated slot. The SlotTimeOut of this slot is decremented by one.

3.3.5.4.6 Offset is Zero

If the offset was set to zero, the First Frame Phase has ended. The station now enters the Continuous Operation Phase.

3.3.5.4.7 Wait for NTS

If the offset was non-zero, the station waits for the next NTS and repeats the sequence.

3.3.5.5 Continuous Operation Phase

The station remains in the Continuous Operation Phase until shut down, enters assigned mode or is changing report rate.

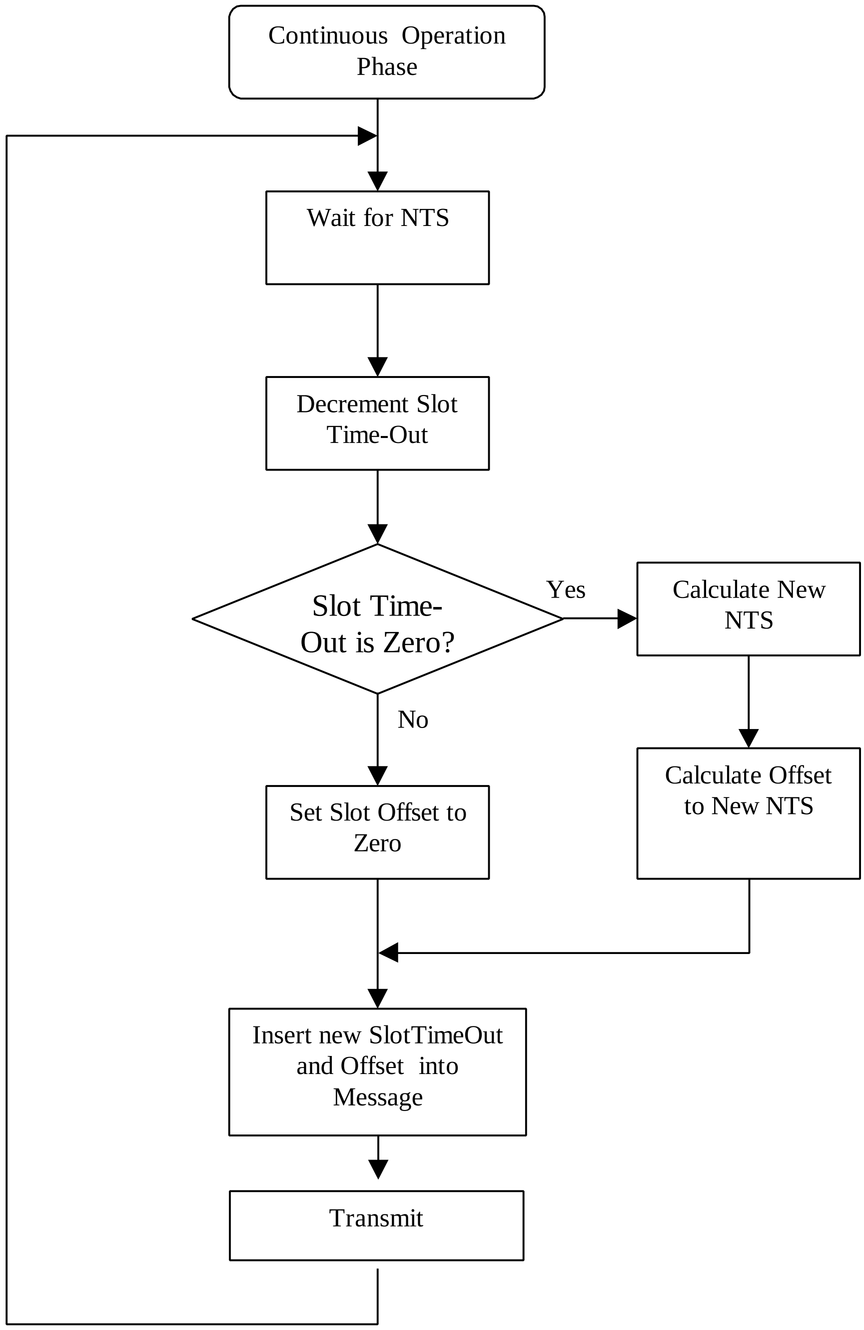


FIGURE 10

3.3.5.5.1 Wait for NTS

The NTS was selected ahead in the frame. The station now waits until this slot is approached.

3.3.5.5.2 Decrement Slot Time-Out

Upon reaching the NTS, the SOTDMA time-out counter, for that slot, is decremented. This time-out specifies how many frames the slot is allocated for. The time-out is always included as part of the SOTDMA transmission.

3.3.5.5.3 Slot Time-Out is Zero

If the slot time-out is zero, a new NTS shall be selected. The SI around the NS is searched for candidate slots and one of the candidates is randomly selected. The offset from the current NTS and the new NTS is calculated and assigned to the slot offset attribute. The new NTS is assigned a time-out with a randomly selected value between TMO_MIN and TMO_MAX.

If the time-out is more than zero, the slot offset attribute is set to zero.

3.3.5.5.4 Add Time-Out and Offset to Packet

The time-out and slot offset are inserted into the SOTDMA Comm State (refer to 3.3.7.2.2).

3.3.5.5.5 Transmit

A scheduled position report is inserted into the SOTDMA packet and transmitted in the allocated slot. The time-out associated with the slot is decremented by one. The station then proceeds by waiting for the next NTS.

3.3.5.6 Changing Report Rate

When the nominal report rate shall change, the station enters Change Report Rate Phase. During this phase, it will reschedule its periodical transmissions to suit the new desired reporting rate.

The procedure, described in this section, is used for changes which will persist for at least 2 frames. For temporary changes, ITDMA transmissions are inserted between SOTDMA transmissions for the duration of the change.

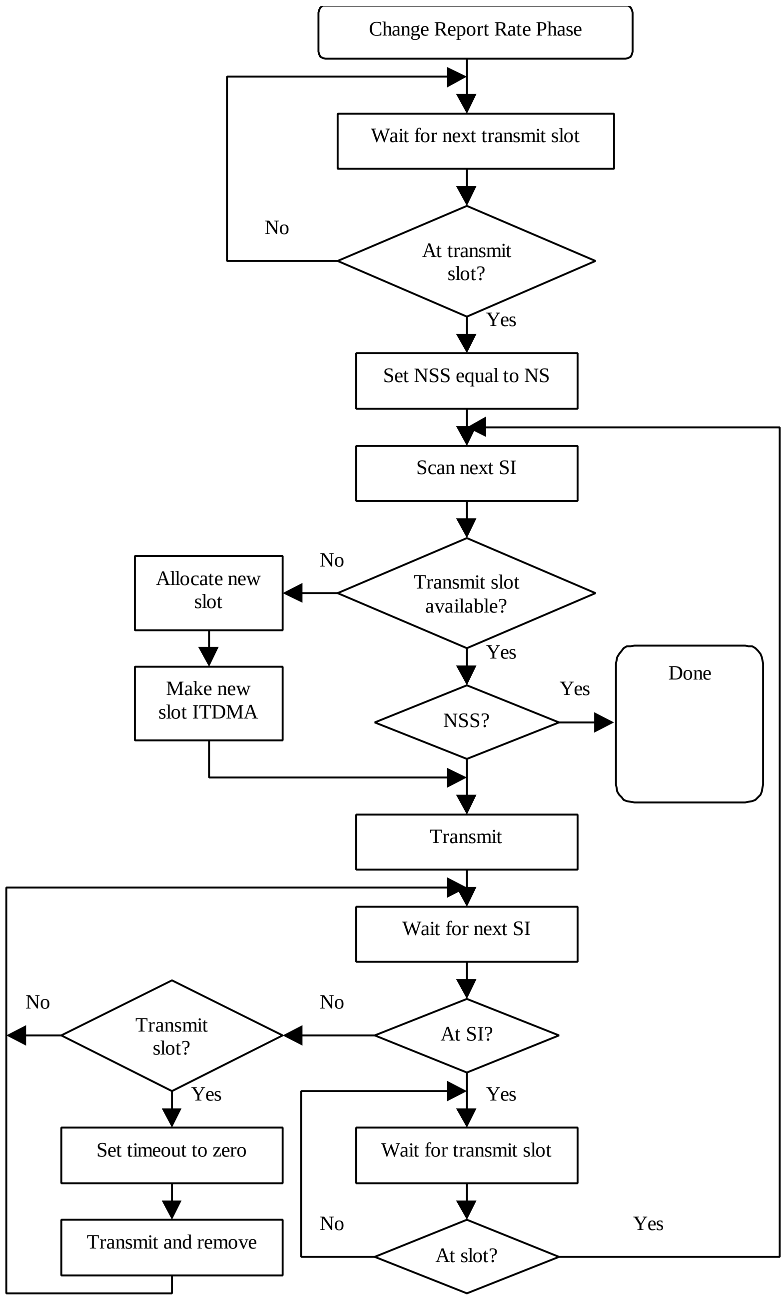


FIGURE 11

3.3.5.6.1 Wait for Next Transmit Slot

Prior to changing report rate, the station waits for the next slot, which is allocated for own transmission. Upon reaching this slot, the associated nominal slot (NS) is set to the new nominal start slot (NSS). The slot, which was allocated for own transmission, is checked to make sure that the SlotTimeOut is non-zero. If it is zero, it is set to one.

3.3.5.6.2 Scan Next Selection Interval (SI)

Using the new report rate, a new nominal increment (NI) is derived. With the new NI, the station examines the area which is covered by the next selection interval (SI). If a slot is found, which is allocated for own transmission, it is checked to see if it is connected to the NSS. If so, the phase is complete and the station returns to nominal operation. If not, the slot is kept with a timeout above zero.

If a slot was not found within the SI, a slot is allocated. The offset, in slots, between the current transmit slot and the new allocated slot, is calculated. The current transmit slot is converted into an ITDMA transmission which holds the offset with the keep flag set to TRUE.

The current slot is then used for transmission of periodical message such as a position report.

3.3.5.6.3 Wait for Next SI

While waiting for the next SI, the station continuously scans the frame for slots which are allocated for own transmission. If a slot is found, the slot timeout is set to zero. After transmission in that slot the slot is freed.

When the next SI is approached, the station begins to search for the transmit slot allocated within the SI. When found, the process is repeated again.

3.3.6 Assigned Operation

An autonomous station can be commanded to operate according to a specific transmission schedule, defined by a competent authority. Assignments are limited in time and will be re-issued by the competent authority as needed. Two levels of assignments are possible:

3.3.6.1 Assignment of Reporting Rate (RR)

When assigned a new Reporting Rate, the mobile station will remain in the autonomous and continuous mode, but adjust its Reporting Rate as instructed. The process of changing Reporting Rate is the same as described in 4.3, Reporting Rates.

3.3.6.2 Assignment of transmission slots

A station can be assigned the exact slots to be used for repeatable transmissions, by a competent authority *using a shore to mobile Message No [16] (refer to 4.5)*. This type of assignment puts the station into assigned mode.

3.3.6.2.1 Entering Assigned Mode

Upon receipt of this command, the station will allocate the specified slots and begin transmission in these. It will continue to transmit in the autonomously allocated slots with a zero SlotTimeOut and a zero slot offset, until those slots have been removed from the transmission schedule. A transmission with a zero SlotTimeOut and a zero slot offset indicates that this is the last transmission in that slot with no further allocation in that selection interval.

3.3.6.2.2 Operating In the Assigned Mode

The assigned slots are using the SOTDMA access protocol, with the timeout value set to the assigned SlotTimeOut. The assigned SlotTimeOut is between 3 and 8 frames. For each frame, the SlotTimeOut is decremented.

3.3.6.2.3 Returning To Autonomous and Continuous Mode

Unless a new assignment is received, the assignment is terminated, when the SlotTimeOut reaches zero of any assigned slot. At this stage, the station returns to autonomous and continuous mode.

The station will initiate the return to autonomous and continuous mode as soon as it detects an assigned slot with a zero SlotTimeOut. This slot will be used to re-enter the network. The station will randomly select an available slot from candidate slots within a nominal increment (NI) of the current slot and make this the nominal start slot (NSS). It will then substitute the assigned slot for an ITDMA slot and use this to transmit the relative offset to the new nominal start slot (NSS). From this point on, the process is identical to the network entry phase (see section 3.3.5.3).

3.3.7 Message Structure

Messages, which are part of the access protocols, have the following structure shown in Figure 12 inside the data portion of a data packet:

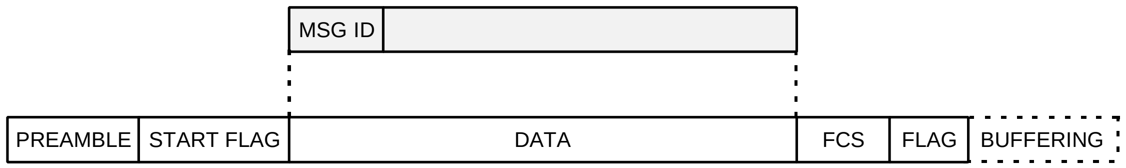


FIGURE 12

3.3.7.1 Message ID (MSG ID)

The message ID is 6 bits long and range between 0 and 63. The message ID identifies message category as well as the mode of the originator. The station can be in autonomous mode, assigned mode or a base station mode.

3.3.7.2 SOTDMA Message Structure

The SOTDMA message structure supplies the necessary information in order to operate in accordance with 3.3.4.4. The message structure is shown in Figure 13:

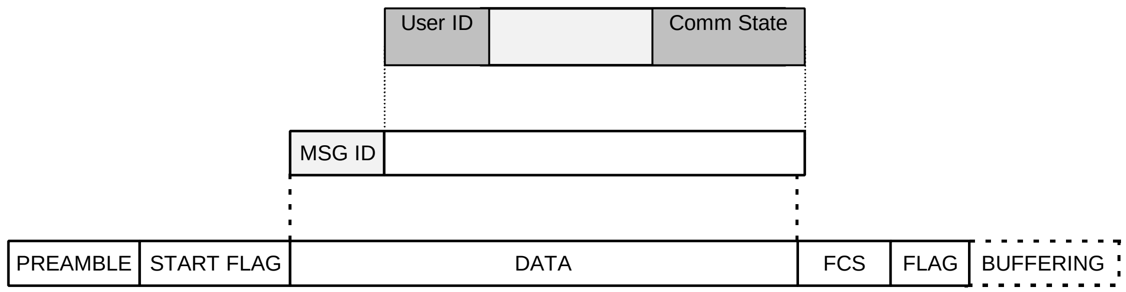


FIGURE 13

3.3.7.2.1 User ID

The User ID is the MMSI. The MMSI is 30 bits long.

3.3.7.2.2 SOTDMA Communication State

The communication state provides the following functions:

1. It contains information used by the slot allocation algorithm in the SOTDMA concept.
2. It indicates if the transmission is synchronised to the time base. Synchronised transmissions can be used as an alternative only if the own station lacks an accurate time base.

The SOTDMA Communication State is structured as shown below:

Table 3.3.7.2.2.1

Parameter	**No of Bits**	**Description**
Sync State	2	0 UTC Direct *(refer to 3.1.1.1)*. 1 UTC Indirect *(refer to 3.1.1.2)*. 2 *Station is synchronised to a* Base Station *(refer to 3.1.1.3).* 3 *Station is synchronised to a* Number of Received Stations *(refer to 3.1.1.4)*
SlotTimeOut	2	Specifies frames left until a new slot will be selected. 0 means that this was the last transmission in this slot. 1-2 mean that 1 or 2 frames respectively are left until slot change. 3 means that 3 or more frames are left until change.
Sub Message	14	The sub message depends on the current value in slot time out as described in the table below.

3.3.7.2.3 Sub Messages

Table 3.3.7.2.3.1

Slot Timeout	**Sub Message**	**Description**
3	Received Stations	Number of stations which the station currently is receiving. Between 0 and 16383.
2	Slot Number	Slot number used for this transmission. Between 0 and 2249.
1	UTC Hour/Minute	If the station has access to UTC, the hour and minute is indicated in this sub message. Hour (0-23) is coded in bits 13 to 9 of the sub message (bit 13 is MSB). Minute (0-59) is coded in bit 8 to 2.
0	Slot Offset	If the SlotTimeOut value is 0 (zero) then the slot offset will indicate the relative jump to the slot in which transmission will occur during next frame. (± 2047 or –2048 which means offset information is not given). If the slot offset is zero, the slot is de-allocated after transmission.

3.3.7.3 ITDMA Message Structure

The ITDMA message structure supplies the necessary information in order to operate in accordance with 3.3.4.1. The message structure is shown in Figure 14:

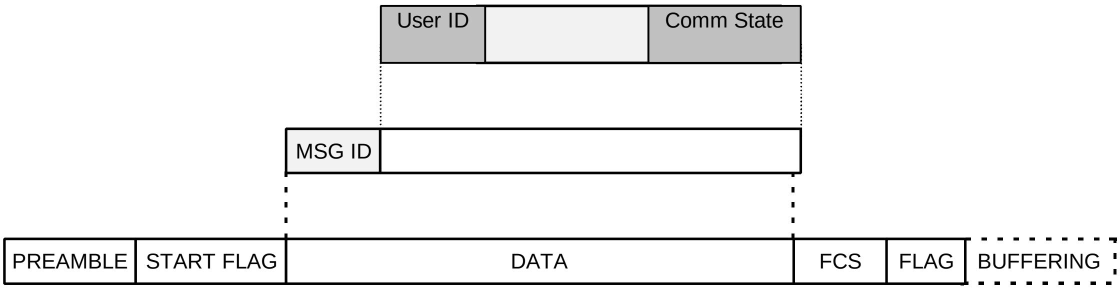


FIGURE 14

3.3.7.3.1 User ID

The user ID is the MMSI. The MMSI is 30 bits long.

3.3.7.3.2 ITDMA Communication State

The communication state provides the following functions:

1. It contains information used by the slot allocation algorithm in the ITDMA concept.
2. It indicates if the transmission is synchronised to the time base. Synchronised transmissions can be used as a alternative only if the own station lacks an accurate time base.

The ITDMA Communication State is structured as shown below:

Table 3.3.7.3.2.1

Parameter	No of Bits	Description
Sync State	2	0 UTC Direct *(refer to 3.1.1.1)*. 1 UTC Indirect *(refer to 3.1.1.2)*. 2 *Station is synchronised to a* Base Station *(refer to 3.1.1.3)* 3 *Station is synchronised to a* Number of Received Stations *(refer to 3.1.1.4)*
Slot Allocation	13	Offset to next slot to be used, or zero (0) if no more transmissions.
No of Slots	2	Number of consecutive slots to allocate. (0 = 1 slot, 1 = 2 slots, 2 = 3 slots, 3 = 4 or 5 slots).
Keep Flag	1	Set to TRUE if the slot shall remain allocated for one additional frame.

3.3.7.4 RATDMA Message Structure

The RATDMA access scheme can use message structures determined by message ID and thus lack a uniform structure.

3.3.7.5 FATDMA Message Structure

The FATDMA access scheme can use message structures determined by message ID and thus lack a uniform structure.

3.3.8 Message Types

This section describes all messages on the TDMA data link.

3.3.8.1 Message Summary

The defined messages are summarised in the table 3.3.8.1.1 below.

Table 3.3.8.1.1

Msg. ID	Name	Description	Category	Op mode	Comm State
1.	Position	Scheduled position report	F/S	Autonomous	SOTDMA
2.	Assigned Position	Scheduled position report	F/S	Assigned	SOTDMA
3.	Position	Special position report	F/S	Autonomous	ITDMA
4.	Base Station Report	Contains position, UTC, Date and slot number	F/S	Assigned	SOTDMA
5.	Static and Voyage Related Data	Scheduled position report and static vessel data report	F	Autonomous	N/A
6.	Binary Msg to mobile or fixed station	Free binary Data for addressed communication from mobile station	F	N/A	N/A
7.	Binary acknowledge from mobile	ACK of received binary data	S	N/A	N/A
8.	Binary broadcast Message	Free binary Data for broadcast communication from mobile station	F	N/A	N/A
9.	Periodical Alternate Message	Binary Message that can replace one transmission of Message 1	F	Autonomous	SOTDMA
10.	UTC/Date inquiry	Request UTC time	F	Autonomous	N/A
11.	UTC/Date Response	Current UTC time if available	F	Autonomous	SOTDMA
12.	Safety Related point to point Message	Binary data for addressed communication	F	Autonomous	N/A
13.	Safety Related ACK	ACK of received binary data Message	S	Autonomous	N/A
14.	Safety Related broadcast Message	Binary data for broadcast from fixed station	F	Autonomous	N/A
15.	Interrogation	Request for a specific message type (multiple responses)	F	Autonomous	N/A
16.	Assignment	Assignment of a specific report behaviour	F/S	Autonomous	N/A
17.	Differential Corrections	In accordance with recommendation ITU-R M.823, message 1, 2 and 9.	F	Assigned	N/A
18.	not used	not used	-	-	-
19.	VTS Surveillance Footprint	Third source target input	F	Assigned	N/A
20.	Data Link Management	Pre-reserve slots for base station(s).	S	Assigned	N/A
21.	Proprietary Data	Reserved for Proprietary and/or local use.	F	N/A	N/A
22.	Channel Assignment	Assignment of channels and modes by a base stations.	S	Assigned	N/A

F = Functional Message

S = System Management Message

N/A = Not Applicable

3.3.8.2 Message Descriptions

All positions are to be transmitted in WGS 84 datum.

3.3.8.2.1 Message 1, 2, 3: Position Reports

Table 3.3.8.2.1.1

Parameter	No of Bits	Description
Message ID	6	Identifier for this message 1, 2 or 3.
DTE	1	Data Terminal Ready (0 = Available 1 = Not Available)
Data Indicator	1	Indicates data available to transmit (0 = Not Available 1 = Available)
User ID	30	MMSI number.
Navigational Status	2	0 = Under Way, 1= At Anchor, 2 = Not Under Command, 3 = Restricted Manoeuvrability
Rate of Turn	8	± 127 degrees/min. (-128 indicates not available). External sensor
SOG	10	Speed Over Ground in 1/10 knot steps (0-102.4 knots) .
Position Accuracy	1	1 = High (< 10m) 0 = low (> 10m)
Longitude	29	Longitude in 1/10000 minute (180 degrees, East = positive, West = negative)
Latitude	28	Latitude in 1/10000 minute (90 degrees, North = positive, South = negative)
COG	12	Course Over Ground in 1/10 degree (0-3599).
Heading	9	degrees (0-359) (511 indicates not available). External sensor
Time stamp	6	UTC second when the report was generated (0-59, or 63 if the Positioning system is inoperative).
Spare	9	Not used
Comm State	18	See below.
Total no of bits	**168**	

Message ID	Comm State
1	SOTDMA Communication status as described in 3.3.7.2.2.
2	SOTDMA Communication status as described in 3.3.7.2.2.
3	ITDMA Communication status as described in 3.3.7.3.2.

3.3.8.2.2 Message 4: Base Station Report

Message 11: UTC and Date Response

Table 3.3.8.2.2.1

Parameter	No of Bits	Description
Message ID	6	Identifier for this message 4, 11
Spare	2	
User ID	30	MMSI number.
UTC Year	6	
UTC Month	4	
UTC Day	5	
UTC Hour	5	
UTC Minute	6	
UTC Second	6	
Position Accuracy	1	1 = High (< 10m) 0 = low (> 10m)
Longitude	29	Longitude in 1/10000 minute (180 degrees, East = positive, West = negative)
Latitude	28	Latitude in 1/10000 minute (90 degrees, North = positive, South = negative)
Type of Nav Sensor	4	*binary coded; 0 = GPS, 1 = GLONASS, 2 – 15 = **TBD***
Spare	18	Not Used. Shall be set to zero.
Comm State	18	SOTDMA Communication status as described in 3.3.7.2.2
Total no of bits	**168**	

3.3.8.2.3 Message 5: Ship Static & Voyage related data

Table 3.3.8.2.3.1

Parameter	**No of bits**	**Description**
Message ID	6	identifier for this message 5.
Spare	2	Not used. Shall be set to zero
User ID	30	MMSI number.
Spare	2	Not used. Shall be set to zero
IMO Number	30	Maximum 9 numeric characters
Call Sign	36	6 x 6 bit ASCII characters
Name	120	Max 20 characters 6 bit ASCII
Type of ship & Cargo Type	8	As defined 3.3.8.2.3.1
Position of GNSS antenna	30	Also indicates the dimension of ship in meters (See Figure 15 and 3.3.8.2.3.2)
Type of Nav Sensor	4	*binary coded; 0 = GPS, 1 = GLONASS, 2 – 15 =* ***TBD***
ETA	19	MMDDHHMM
Actual Draught	8	in 1/10 m, max 25.5 m
Destination	120	Max 20 characters
Total number of bits	**415**	

Message occupies 2 slots.

3.3.8.2.3.1 Type of ship.

Table 3.3.8.2.3.1.1

Symbols to be used by ships to report their type and in the ADDRESS of calls directed to a group of ships in a VTS area	
Symbol No.	Special craft
50	Pilot boats
51	Search and rescue vessels
52	Tugs
53	Port tenders
54	Vessels with anti pollution facilities or equipment
55	Law enforcement vessels
56	spare - for assignments to local vessels
57	spare - for assignments to local vessels
58	Medical transports (as defined in 1949 Geneva Conventions and additional Protocols
59	spare - for assignments to local vessels
Other ships	
First digit	Second digit
6 - Passenger ships	0 - All ships of this type
7 - Cargo ships	1 - Carrying DG, HS, or MP IMO hazard or pollutant category A
8 - Tanker(s)	2 - Carrying DG, HS, or MP IMO hazard or pollutant category B
9 - Other types of ships	3 - Carrying DG, HS, or MP IMO hazard or pollutant category C
	4 - Carrying DG, HS, or MP IMO hazard or pollutant category D
	5 - Not under command
	6 – Restricted by her ability to manoeuvre
	7 – Constrained by her draught
	8 – Spare
	9 - No additional information

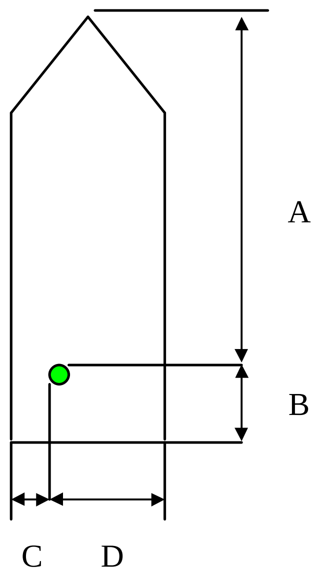
DG: Dangerous goods

HS: Harmful substances

MP: Marine pollutants

NOTE - The symbol should be constructed by selecting the appropriate first and second digits. For example, a message addressed to ”all tankers” would use symbol No 80 while an identification report from a passenger ship containing no additional information would use symbol No 69.

3.3.8.2.3.2 Position of GNSS antenna in use



	No of bits	Bit fields	Distance in meters
A	9	0 - 8	max 511
B	9	9 - 17	max 511
C	6	18 - 23	max 63
D	6	24 - 29	max 63

FIGURE 15

3.3.8.2.4 Message 6, 12: Addressed Binary and Safety Related Message

Table 3.3.8.2.4.1

Parameter	**No of bits**	**Description**
Message ID	6	Identifier for this Message 6, 12
Spare	2	Not used. Shall be zero
Source ID	30	MMSI number
Spare	2	Not used. Shall be zero
Destination ID	30	MMSI number
Spare	2	Not used. Shall be zero
Data	936	117 bytes maximum
Buffer	184	23 bytes maximum.
Total No of bits	**1192**	

Buffer bits may be used for data if the data contents produces less bit stuffing than the buffer contains. Data may then be extended as:

Data = Data + Buffer – Bit stuffing.

3.3.8.2.5 Message 7, 13: Binary and Safety Related Message Acknowledgement

Table 3.3.8.2.5.1

Parameter	**No of bits**	**Description**
Message ID	6	Identifier for this Message 7, 13
Spare	2	Not used. Shall be set to zero
Source ID	30	MMSI number
Spare	2	Not used. Shall be set to zero
Destination ID	30	MMSI number
Spare	2	Not used. Shall be set to zero
Destination ID	30	MMSI number
Spare	2	Not used. Shall be set to zero
Destination ID	30	MMSI number
Spare	2	Not used. Shall be set to zero
Destination ID	30	MMSI number
Spare	2	Not used. Shall be set to zero
Total No of bits	**168**	Shorter is allowed.

3.3.8.2.6 Message 8, 14, 19, 21: Broadcast Binary Message

Table 3.3.8.2.6.1

Parameter	**No of bits**	**Description**
Message ID	6	Identifier for this Message 8, 14 ,19, 21
Spare	2	
Source ID	30	MMSI number
Spare	2	Not used. Shall be set to zero
Data	968	121 bytes maximum
Buffer	184	23 bytes maximum.
Total No of bits	**1192**	

Buffer bits may be used for data if the data contents produces less bit stuffing than the buffer contains. Data may then be extended as:

Data = Data + Buffer – Bit stuffing.

3.3.8.2.7 Message 10: UTC Time Inquiry

Table 3.3.8.2.7.1

Parameter	No of bits	Description
Message ID	6	Identifier for this Message 10
Spare	2	Not used. Shall be set to zero
Source ID	30	MMSI number
Spare	2	Not used. Shall be set to zero
Destination ID	30	MMSI number
Spare	98	Optional. Shall be set to zero, if inserted
Total No of bits	**168**	

3.3.8.2.8 Message 15: Interrogation

Table 3.3.8.2.8.1

Parameter	**No of bits**	**Description**
Message ID	6	Identifier for this Message 15.
Spare	2	Not used. Shall be set to zero.
Source ID	30	MMSI number
Spare	2	Not used. Shall be set to zero.
Destination ID 1	30	MMSI number
Message ID 1	6	Requested message type
Slot offset 1	12	Response slot offset
Message ID 1	6	Requested message type
Slot offset 1	12	Response slot offset
Destination ID 2	30	MMSI number
Message ID	6	Requested message type
Slot offset	12	Response slot offset
Spare	14	Not used. Shall be set to zero.
Total No of bits	**168**	

3.3.8.2.9 Message 17: DGNSS Broadcast Binary Message

Table 3.3.8.2.9.1

Parameter	**No of bits**	**Description**
Message ID	6	Identifier for this Message 17.
Spare	2	Not used. Shall be set to zero.
Longitude	18	Longitude in 1/10 minute (180 degrees, East = positive, West = negative)
Latitude	17	Latitude in 1/10 minute (90 degrees, North = positive, South = negative)
Spare	5	Not used. Shall be set to zero
Data	1000	Differential Correction data (see below).
Total No of bits	**1048**	

The Differential Correction data section shall be organised as listed below:

Parameter	**No of bits**	**Description**
Message Type	6	ITU-R M.823 Message type 1, 2 or 9.
Station ID	10	ITU-R M.823 Station identifier.
Z Count	13	Time value in 0.6 seconds (0-3599.4).
Sequence Number	3	Message sequence number (cyclic 0-7).
N	5	Number of satellite records.
Health	3	Reference station health (specified in ITU-R M.823).
RTCM Record	N*40	Satellite records excluding parity.
Total No of bits	**1000**	Assuming N = 24

3.3.8.2.10 Message 20: Data Link Management Message

Table 3.3.8.2.10.1

Parameter	**No of bits**	**Description**
Message ID	6	Identifier for this Message 20
Spare	2	Not used. Shall be set to zero.
Source Station ID	30	MMSI number
Spare	2	Not used. Shall be set to zero
Slot offset number 1	12	Reserved slot offset number
Number of slots 1	4	Number of reserved consecutive slots
Time out 1	3	Time out value
Increment 1	11	Increment to repeat reservation block 1.
Slot offset number 2	12	Reserved slot offset number
Number of slots 2	4	Number of reserved consecutive slots
Time out 2	3	Time out value
Increment 2	11	Increment to repeat reservation block 2.
Slot offset number 3	12	Reserved slot offset number
Number of slots 3	4	Number of reserved consecutive slots
Time out 3	3	Time out value
Increment 3	11	Increment to repeat reservation block 3.
Slot offset number 4	12	Reserved slot offset number
Number of slots 4	4	Number of reserved consecutive slots
Time out 4	3	Time out value
Increment 4	11	Increment to repeat reservation block 4.
Spare	8	Not used. Shall be set to zero.
Total No of bits	**168**	

3.3.8.2.11 Message 22: Channel Management

Table 3.3.8.2.11.1

Parameter	No of bits	Description
Message ID	6	Identifier for this Message 22
Spare	2	Not used. Shall be set to zero.
Station ID	30	MMSI number
Spare	2	Not used. Shall be set to zero.
Channel 1	12	Channel number according to Recommendation ITU-R M.1084-2, Annex 3.
Channel 2	12	Channel number according to Recommendation ITU-R M.1084-2, Annex 3.
Mode	4	0=Tx1/Tx2, Rx1/Rx2 1=Tx1, Rx1/Rx2
Power	1	0=High, 1=Low
Longitude 1	18	Longitude in 1/10 minute (180 degrees, East = positive, West = negative)
Latitude 1	17	Latitude in 1/10 minute (90 degrees, North = positive, South = negative)
Longitude 2	18	Longitude in 1/10 minute (180 degrees, East = positive, West = negative)
Latitude 2	17	Latitude in 1/10 minute (90 degrees, North = positive, South = negative)
Training sequence	1	0 = 24 bit, 1 = 32 bit
Spare	28	Not used. Shall be set to zero.
Total No of bits	**168**	

4 Network layer

The network layer is responsible for:

1. establishing and maintaining channel connections,
2. distribution of transmission packets between channels,
3. data link congestion resolution.

4.1 Dual channel operation

Dual channels will allow for:

1. Use by fishing vessels and leisure craft,
2. Additional communication services (in addition to AIS),
3. Redundancy (to cope with interference problems).

4.2 Distribution of transmission packets

4.2.1 The user directory

This is internal to the AIS - A directory of all users that the station receives (Transponder IDs, bearing and distance, relative speed, 30 minute + history).

4.2.2 Routing of transmission packets

1. Position reports are distributed to Presentation Interface.
2. Own position is reported to Presentation Interface and VHF channel.

4.3 Reporting Rates

The parameter Reporting Rate (RR) is defined in 3.3.4.4.2. The following describes how this parameter is set during operation by the Network Layer by a mobile station itself or by a shore station (refer also to 3.3.6). All changes to Reporting Rate do not affect the mode of operation, disregarding the origin of the need to change (internal to the mobile or external by a command from a shore station).

The default value of the Reporting Rate is set to once per 12 seconds (refer to Table 1 in Annex 1).

When a mobile station uses a report rate of less than one report per frame, ITDMA allocations are used. Otherwise SOTDMA is used.

4.3.1 Autonomously Increased Reporting Rate (Continuous and Autonomous Mode)

When a ship *increases speed and / or* changes course, a higher update rate is required *according to Table 1 in Annex 1*. *An increase of speed is determined with respect to the current COG information.*

The update rate is increased according to Table 1 in Annex 1 if the Rate-of –Turn exceeds 10° per minute: If no Rate-Of-Turn input via the Presentation Port is available, ~~*A*~~*a* change of course is determined by calculating the mean value of the heading for the last 30 seconds and comparing the result with the present heading. ~~*If the difference exceeds 5°, an ITDMA message type 3, with the higher update rate of 3 seconds between reports, is applied.*~~

The increased rate is maintained until *the Rate-Of-Turn, if available to the AIS device via the Presentation Interface, drops below 10° per minute for more than 20 seconds, or if* the difference between the mean value of heading and present heading has been less than 5° for more than 20 seconds*, if no external Rate-Of-Turn-input should be available.*

4.3.2 Autonomously Decreased reporting rate in Continuous and Autonomous Mode

When the vessel is at anchor or moored, an ITDMA message type 3 is used with a reporting rate of 3 minutes. This function is selected by an external command via the Presentation Interface. The type 3 message is transmitted three minutes after the type 5 message.

4.3.3. Assigned Reporting Rates

A competent authority may assign a Reporting Rate to any mobile station by transmitting Message No [16] from a base or repeater station.

4.4 Data link congestion resolution

When the data link is loaded to such a level that the transmission of safety information is jeopardised, the method described in 4.4.1 is used to resolve the congestion.

4.4.1 The Robin Hood algorithm

If the link load exceed 90% of the theoretical maximum, SOTDMA selects the most distant station allocations and uses their slot(s). This is conditional on the distance exceeding 12 nm and on not selecting the same distant station more than once per frame.

5 Transport layer

The transport layer is responsible for:

1. converting data into transmission packets of correct size;
2. sequencing of data packets;
3. interfacing protocol to upper layers.

5.1 Definition of transmission packet

A transmission packet is an internal representation of some information which can ultimately be communicated to external systems. The transmission packet is dimensioned so that it conforms to the rules of data transfer.

5.2 Source of a transmission packet

The transport layer handles transmission packets from several sources:

1. Position sensors, such as a GNSS,
2. From session layer,
3. From the network layer.

5.3 Conversion of data into transmission packets

5.3.1 Presentation interface

The interface between the transport layer and above layers (i.e. the session layer) is called the Presentation Interface.

5.3.2 Conversion to transmission packets

The transport layer will convert data, received from the session layer, into transmission packets. If the resulting length of a transmission packet will result in a datalink message longer than three slots, the presentation interface message must be divided into two or more transmission packets.

5.3.3 Conversion to presentation interface messages

Each received transmission packet has a corresponding presentation interface message. The transport layer is responsible for converting between these formats and to sequence the messages correctly.

5.4 Transmission packets

5.4.1 Addressed mode

In the addressed mode the data transfer packet has a destination user and expects an acknowledgement. A timeout of 4 seconds is allowed between retries. The number of retries should be configurable. The result of a transmission is forwarded to above layers. The acknowledgement is between transport layers in two stations.

5.4.1.1 Broadcast

In the broadcast mode the packet lacks destination, receiving stations shall not acknowledge broadcast packets.

5.4.1.2 Sequencing for the Presentation Interface

Transmission packets received from the network layer are forwarded to the presentation interface in the order they were received regardless of message category. Each packet is assigned a sequence number.

5.4.2 Binary Messages

If a text and binary messages is addressed to the own station, the message must be acknowledged. The acknowledgement is put first in the data transfer queue.

5.5 Presentation interface protocol

Data, which is to be transmitted by the AIS device, is input via the Presentation interface; data, which is received by the AIS device, is output through the Presentation interface. The formats and protocol used for this data stream are defined by IEC.

5.5.1 The NMEA-0183 and IEC 1162 Standards for Communication

Applicable parts of NMEA-0183/IEC 1162 are used as the presentation interface protocol with the following amendments:

1. Communication is full duplex. Hardware handshaking is not required.
2. Communication interfaces may use RS232, RS485/422 standards.
3. Communication shall be capable of using a bitrate of 38400 bps.

5.5.1.1 Message structure

The message structure uses the features of NMEA-0183. Each message has the general structure shown in figure 16 below:

$	PAIS	,	<Msg Id>	,	<DATA>	*	<FCS>	<CR>	<LF>

FIGURE 16

$ Hex 24. Marks the start of a message.

PAIS id for this system.

<Msg Id> Three characters identifying specific messages by id number.

<DATA> Data portion. Unique for each message id.

* Hex 2A. Marks the end of data in the message.

<FCS> Two characters, in ASCII hexadecimal format. Each character represents a nibble of the checksum calculated by exclusive-OR of all characters between, but not including '$' and '*'.

<CR><LF> Hex 0D and 0A. Marks the end of a complete message.

ANNEX 3

1 Channel management

1.1 Operating Frequency Channels

Two frequency channels have been designated by the WRC-97 for AIS use worldwide, on the high seas and in all other areas, unless other frequencies are designated on a regional basis for AIS purposes. The two designated frequencies are

AIS 1 (Channel 87B, 161.975 MHz) and

AIS 2 (Channel 88B, 162.025 MHz).

The AIS shall default to operation on these channels. Operation on other channels shall be accomplished by one of three means: Manual input commands (manual switching), TDMA commands from a Base station (automatic switching by TDMA telecommand), or DSC commands from a Base station (automatic switching by DSC telecommand).

1.2 Normal default Mode

The normal default mode of operation shall be a two-channel operating mode, where the AIS simultaneously receives on both channels in parallel. In order to accomplish this performance, the AIS transponder shall contain two TDMA receivers. Regular scheduled transmissions shall alternate between the two channels.

1.3 Regional Operating Frequencies

Regional operating frequencies shall be designated by the four-digit channel numbers specified in Recommendation ITU-R M.1084-2, Annex 3. This allows for simplex, duplex, 25 kHz and 12.5 kHz channels for regional options, subject to the provisions of Appendix 18 of the Radio Regulations.

1.4 Regional Operating Areas

Regional operating areas shall be designated by a Mercator projection rectangle with two reference points. The first reference point shall be the geographical coordinate address of the northeastern corner (to the nearest tenth of a minute) and the second reference point shall be the geographical coordinate address of the southwestern corner (to the nearest tenth of a minute) of the rectangle.

1.5 Transitional Mode Operations Near Regional Boundaries

The AIS device shall automatically switch to the two-channel transitional operating mode when it is located within five nautical miles of a regional boundary. In this mode the AIS device shall transmit and receive on the primary AIS frequency specified for the occupied region, and it shall also transmit and receive on the primary AIS frequency of the nearest adjacent region. Only one transmitter is required. Additionally, when operating in this mode, the reporting rate shall be doubled and shared between the two channels (alternate transmission mode).

Regional boundaries should be established by the competent authority in such a way that this two-channel transitional operating mode can be implemented as simply and safely as possible. For example, care should be taken so as to avoid having more than three adjacent regions at any regional boundary intersection. For purposes of this discussion, the high seas area shall be considered to be a region. The IMO has also requested that regions be as large as possible. For practical purposes, in order to provide safe transitions between regions, these should be no smaller than 20 miles on any boundary side. Examples of acceptable and unacceptable regional boundary definitions are illustrated below:

UNACCEPTABLE REGIONAL BOUNDARY DEFINITION

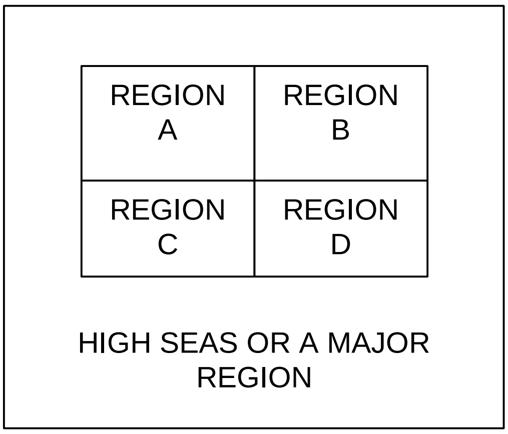


FIGURE 1 A

ACCEPTABLE REGIONAL BOUNDARY DEFINITION

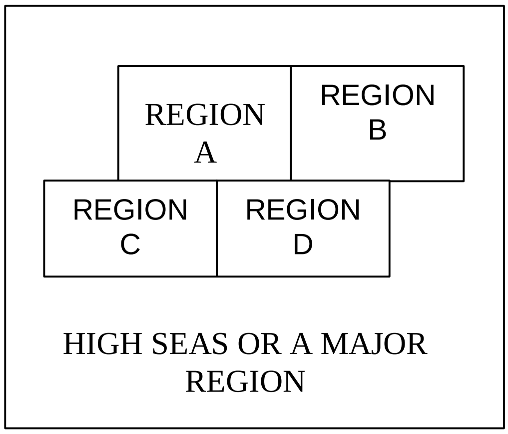


FIGURE 1 B

2 DSC Compatibility

2.1 General

The AIS shall be capable of performing limited AIS-related DSC operations. These operations shall not include either Annex 2 of Recommendation ITU-R M.825-2 or distress-related features of Recommendation ITU-R M.493. In order to accomplish this performance, the AIS device shall contain a dedicated DSC receiver that is tuned to channel 70. However, a dedicated DSC transmitter is not required.

DSC-equipped shore stations may transmit DSC all-ships calls on channel 70 to specify regional boundaries and regional frequency channels to be used by the AIS in those specified regions. For this purpose, Expansion Symbols No. 09, 10, 11, 12, and 13 shall be added to Table 5 of Recommendation M.825 as specified below. The AIS device shall be capable of responding to such calls by performing operations in accordance with paragraphs 1.0 to 1.5 with the regional frequencies and regional boundaries specified by these calls.

2.2 Scheduling

Shore stations that transmit DSC all-ships calls to designate AIS regions and frequency channels should schedule their transmissions such that ships transiting these regions will receive sufficient notice to be able to perform the operations in paragraphs 1.0 to 1.5. A transmission interval of 15 minutes is recommended, and each transmission should be made twice, with a time separation of 500 milliseconds between the two transmissions, in order to insure that reception by AIS transponders is accomplished.

DSC operations performed by the AIS shall be scheduled subject to the TDMA operations such that the TDMA operations are not impaired or delayed.

2.3 Regional Channel Designation

For designation of regional AIS frequency channels, Expansion Symbols No. 09, 10 and 11 shall be added to Table 5 of Recommendation ITU-R M.825-2. Each of these Expansion Symbols shall be followed by two DSC symbols (4 digits) which specify the AIS regional channel(s), as defined by Recommendation ITU-R M.1084-2, Annex 3. This allows for simplex, duplex, 25 kHz and 12.5 kHz channels for regional options, subject to the provisions of Appendix 18 of the Radio Regulations. Expansion Symbol No. 09 shall designate the primary regional channel, and Expansion Symbol No. 10 or 11 shall be used to designate the secondary regional channel.

When single-channel operation is required, then only Expansion Symbol No. 09 shall be used. For two-channel operation, either Expansion Symbol No. 10 shall be used to indicate that the secondary channel is to operate in both transmit and receive modes, or Expansion Symbol No. 11 shall be used to indicate that the secondary channel is to operate only in receive mode.

2.4 Regional Area Designation

For designation of regional areas for utilizing AIS frequency channels, Expansion Symbols No. 12 and 13 shall be added to Table 5 of Recommendation ITU-R M.825-2. Expansion Symbol No. 12 shall be followed by the geographical coordinate address of the northeastern corner of the Mercator projection rectangle to the nearest tenth of a minute. Expansion Symbol No. 13 shall be followed by the geographical coordinate address of the southwestern corner of the Mercator projection rectangle to the nearest tenth of a minute.

ANNEX 4

Long Range Applications

The AIS transponder shall provide a two-way interface for equipment which provides for long range communications.This interface shall comply with IEC 1162.