RECOMMENDATION ITU-R M.1371*

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

(Question ITU-R 28/8)

(1998)

Summary

This Recommendation sets out the technical characteristics of a universal shipborne automatic identification system (AIS) using self-organised time division multiple access (SOTDMA) in the VHF 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 (IMO) has a requirement for a universal shipborne AIS;

b) that the use of a universal shipborne AIS 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 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 time division multiple access (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

1) 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 AIS using TDMA techniques in the VHF 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 search and rescue (SAR) operations.

2 General

2.1 The system should automatically broadcast ships dynamic and some other information to all other installations in a self-organized 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 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 (COG).
- Speed over ground (SOG).
- Heading.

* Derived from IMO MSC 69 Recommendation on performance standards for a universal shipborne AIS.

– 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. not under command (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 estimated time of arrival (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 min 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 s
Ship 0-14 knots and changing course	4 s
Ship 14-23 knots	6 s
Ship 14-23 knots and changing course	2 s
Ship > 23 knots	3 s
Ship > 23 knots and changing course	2 s

Ship reporting capacity – the system should be able to handle a minimum 2 000 reports per minute, to adequately provide for all operational scenarios envisioned.

5 Frequency band

The AIS should be designed for operation in the VHF maritime mobile band, on either 25 kHz or 12.5 kHz simplex or duplex channels in half duplex mode, in accordance with Radio Regulations (RR) Appendix S18 and Recommendation ITU-R M.1084, Annex 4.

ANNEX 2

Technical characteristics of a universal shipborne AIS using TDMA techniques in the maritime mobile band

1 Structure of this annex

This annex is structured in accordance with the OSI-model, as shown below:

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

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 summarized in Tables 2 to 4.

2.1 Parameters

2.1.1 General

TABLE 2

Symbol	Parameter Name	Minimum	Maximum
PH.RFR	Regional frequencies (MHz)	156.025	162.025
PH.CHS	Channel spacing (encoded according to Appendix S18 with footnotes) (kHz)	12.5	25
PH.AIS1	AIS channel 1 (ch 87B), (2087)[(1)] (MHz)	161.975	161.975
PH.AIS2	AIS channel 2 (ch 88B), (2088)[(1)] (MHz)	162.025	162.025
PH.CHB	Channel bandwidth (kHz)	12.5	25
PH.BR	Bit rate bit/s	$9\,600 \pm 50 \times 10^{-6}$	$9\,600 \pm 50 \times 10^{-6}$
PH.TS	Training sequence (bit)	24	32
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 (W)	1	25

(1) See Recommendation ITU-R M.1084, Annex 4

2.1.2 Constants

TABLE 3

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

NRZI: non-return to zero inverted

GMSK/FM: see § 2.4

2.1.3 Bandwidth dependent parameters

Table 4 below defines settings dependent on parameter PH.CHB.

TABLE 4

Symbol	Parameter Name	PH.CHB (12.5 kHz)	PH.CHB (25 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

BT – product: bandwidth time product

2.1.4 Transmission media

Data transmissions are made in the maritime mobile VHF band. Data transmissions should 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 should be capable of operating with a channel bandwidth of 25 kHz or 12.5 kHz according to Recommendation ITU-R M.1084 and RR Appendix S18. 25 kHz bandwidth should be used on the high seas whereas 25 kHz or 12.5 kHz channel bandwidth should be used as defined by the appropriate authority in territorial waters, as described in § 4.1 and Annex 4.

2.3 Transceiver characteristics

The transceiver should 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 NRZI encoded data should be GMSK coded before frequency modulating the transmitter.

2.4.1.2 The GMSK modulator BT-product used for transmission of data should 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 should 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 should frequency modulate the VHF transmitter. The modulation index should 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 should be 9 600 bit/s $\pm$ 50 $\times 10^{-6}$.

2.6 Training sequence

Data transmission should begin with a 24-bit demodulator training sequence (preamble) consisting of one segment synchronization. This segment should 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 should use a 24-bit training sequence. Changes to the training sequence should be by assignment.

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 0 is encountered in the bit stream.

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 should ensure that the transceiver requirements in § 2.3 are met.

2.12.1 Transmitter RF attack time

The transmitter RF attack time should not exceed 1 ms after the TX-ON signal according to the following definition: the 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 Fig. 3).

2.12.2 Transmitter frequency attack time

The transmitter frequency attack (stabilization) time, which should be ±1.0 kHz within 1.0 ms after TX-ON, should 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.

2.13.3 The nominal levels for the two power settings should be 2 W and 12.5 W. Tolerance should 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 s 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 TDMA scheme using a common time reference.

3.1.1 TDMA synchronization

TDMA synchronization is achieved using an algorithm based on a synchronization state as described below. The sync state flag within SOTDMA communication state (refer to § 3.3.7.2.2) and within incremental TDMA (ITDMA) communication state (refer to § 3.3.7.3.2), indicates the synchronization state of a station.

3.1.1.1 UTC direct

A station, which has direct access to UTC timing with the required accuracy should indicate this by setting its synchronization 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, should synchronize to those stations. It should then change its synchronization state to UTC indirect. This state is correct for any number of levels of indirect synchronization.

3.1.1.3 Synchronized to base station (direct or indirect)

Mobile stations, which are unable to attain direct or indirect UTC synchronization, but are able to receive transmissions from base stations, should synchronize to the base station which indicates the highest number of received stations. It should then change its synchronization state 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, synchronization should 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 synchronization, should synchronize to the station indicating the highest number of other stations received. When a station is receiving several other stations, which indicate the same number of received stations, synchronization should be based on the station with the lowest MMSI. That station becomes the *semaphore* on which synchronization should be performed.

3.1.2 Time division

The system uses the concept of a frame. A frame equals 1 min and is divided into 2 250 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 should apply.

3.1.3 Slot phase and frame synchronization

3.1.3.1 Slot phase synchronization

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

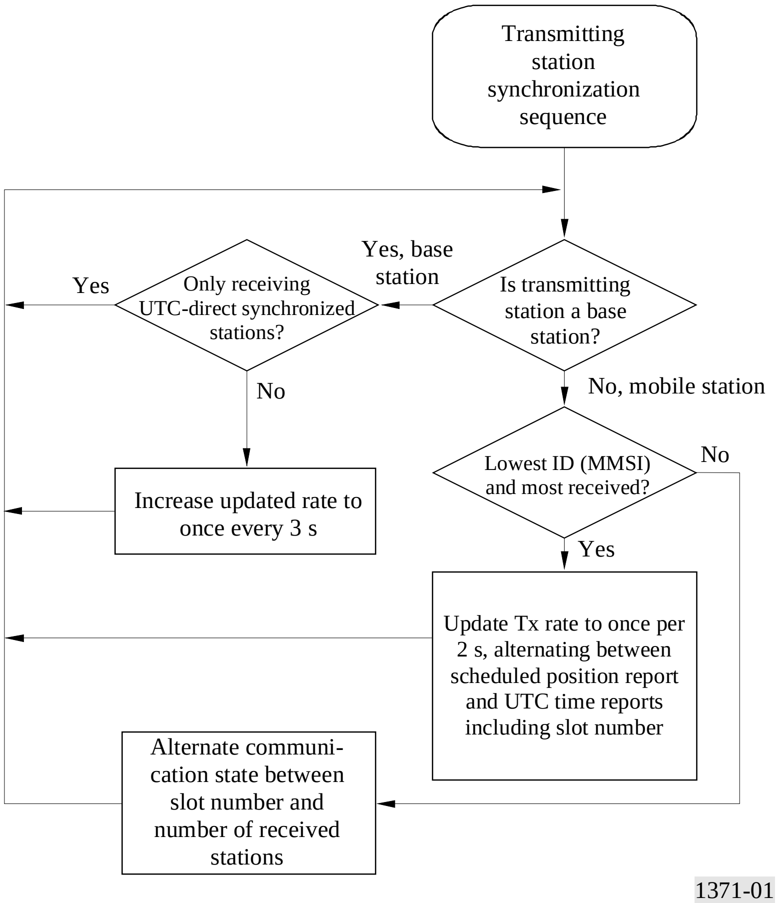
Decision to slot phase synchronize should be made after receipt of end flag and valid frame check sequence (FCS). (State T3, Fig. 6.) At T5, the station resets its *Slot_Phase_Synchronization_Timer*, based on Ts, T3 and T5 (Fig. 6).

3.1.3.2 Frame synchronization

Frame synchronization 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.

3.1.3.3 Synchronization - Transmitting stations

FIGURE 1



3.1.3.3.1 Base station operation

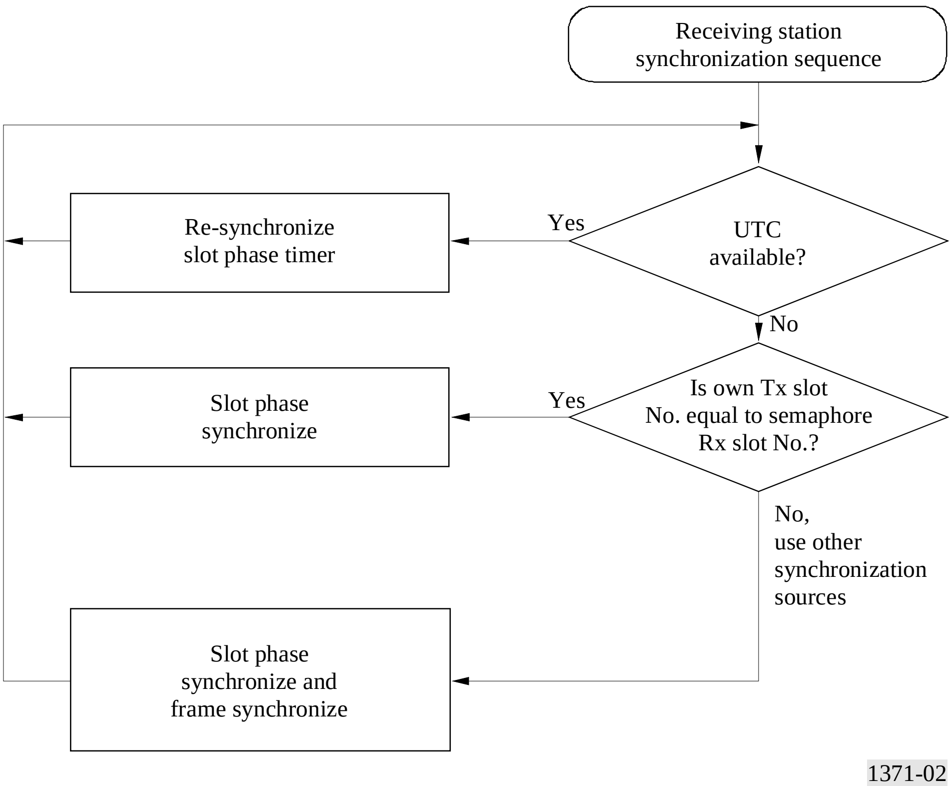
The base station will operate nominally until it detects one or more stations which are lacking UTC direct synchronization. It will then increase its update rate to transmit periodical reports once every 3 s.

3.1.3.3.2 Mobile station operation

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

3.1.3.4 Synchronization - Receiving stations

FIGURE 2



3.1.3.4.1 UTC available

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

3.1.3.4.2 Own transmission slot number equal to the received semaphore slot number

When the station determines that its own internal slot number is equal to the semaphore slot number, it is already in frame synchronization and it will continuously slot phase synchronize.

3.1.3.4.3 Other synchronization sources

Other possible synchronization sources, which can serve as basis for slot phase and frame synchronizations, are listed below in the order of priority:

– a station which has UTC time and which is semaphore qualified;

– a base station which is semaphore qualified;

– other station(s) which are synchronized to a base station;

– a mobile station, which is semaphore qualified.

See § 3.1.1.4 for semaphore qualification.

3.1.4 Slot identification

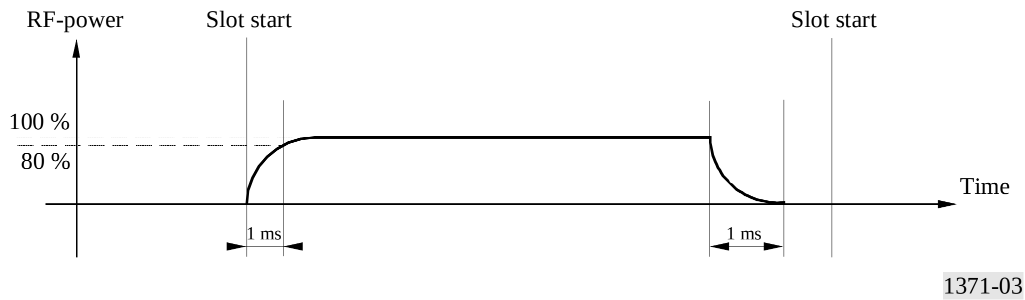
Each slot is identified by its index (0-2249). Slot 0 should be defined as the start of the frame.

3.1.5 Slot access

The transmitter should begin transmission by turning on the RF power 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 slot. The slot access is performed as shown in Fig. 3:

FIGURE 3



Each slot can be in one of the following states:

– FREE: meaning that the slot is available for use by anyone;

– INTERNAL ALLOCATION: meaning that the slot is allocated by the own equipment and can be used for transmission;

– EXTERNAL ALLOCATION: meaning that the slot is allocated for transmission by another data link user and cannot be used by the own equipment.

– 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:

– data link activation and release;

– data transfer; or

– 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 § 3.1.4. A slot, marked as free or externally allocated, indicates that the own equipment should be in receive mode and listen for other data link users.

3.2.2 Data transfer

Data transfer should use a bit-oriented protocol which is based on the high-level data link control (HDLC) as specified by ISO/IEC 3309, 1993 – Definition of packet structure. Information packets (I-Packets) should be used with the exception that the control field is omitted (see Fig. 4).

3.2.2.1 Bit stuffing

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

3.2.2.2 Packet format

Data is transferred in a broadcast mode using a transmission packet as shown in Fig. 4:

FIGURE 4

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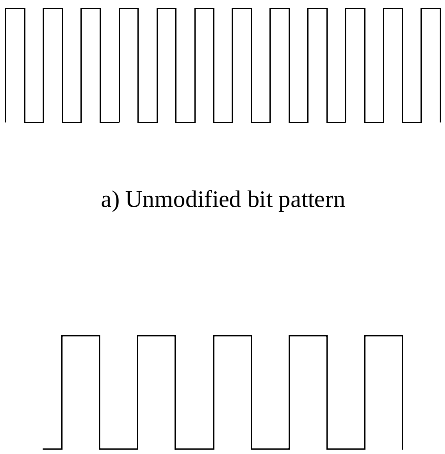
The packet should be sent from left to right. This structure is identical to the general HDLC structure, except for the training sequence. The training sequence should be used in order to synchronize the VHF receiver and is discussed in § 3.2.2.3. The total length of the default packet is 256 bits. This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

3.2.2.3 Training sequence

The training sequence should be a bit pattern consisting of alternating 0’s and 1’s (010101010...). Twenty four bits of preamble are transmitted prior to sending the flag (unless a 32-bit training sequence is assigned, see § 2.6). This bit pattern is modified due to the NRZI mode used by the communication circuit. See Fig. 5.

FIGURE 5



a) Unmodified bit pattern

b) Modified bit pattern by NRZI

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The preamble should not be subject to bit stuffing.

3.2.2.4 Start flag

The start flag should be 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 ($7E_h$). The flag should not be subject to bit stuffing, although it consists of 6 bits of consecutive 1's.

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 § 3.2.2.11.

3.2.2.6 FCS

The FCS uses the cyclic redundancy check (CRC)-ITU-T 16-bit polynomial to calculate the checksum as defined in ISO/IEC 3309, 1993. The CRC bits should be preset to 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:

– bit stuffing: 4 bits
– distance delay: 12 bits
– repeater delay: 2 bits
– synchronization 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 nautical miles (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 Synchronization jitter

The synchronization 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 should be within ±104 μs of the synchronization source. Since timing errors are additive, the accumulated timing error can be as much as ±312 μs.

3.2.2.9 Summary of the default transmission packet

The data packet is summarized as shown in Table 5:

TABLE 5

Ramp up	8 bits	
Training sequence	24 bits	Necessary for synchronization
Start flag	8 bits	In accordance with HDLC ($7E_h$)
Data	168 bits	Default
CRC	16 bits	In accordance with HDLC
End flag	8 bits	In accordance with HDLC ($7E_h$)
Buffering	24 bits	Bit stuffing and distance delays
Total	256 bits	

3.2.2.10 Transmission timing

Figure 6 shows the timing events of a standard position report transmission. The data block plus overhead is shown and the RF TX-ON and OFF events. At the situation where the ramp down of the RF power overshoots into the next slot, there should 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.

3.2.2.11 Long transmission packets

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

3.2.3 Error detection and control

Error detection and control should be handled using the CRC-ITU-T polynomial as described in § 3.2.2.6. CRC errors should be 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, should be 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 should be 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:

SOTDMA, ITDMA, random access TDMA (RATDMA) and fixed access TDMA (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 may be used.

3.3.1.1 Cooperation 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).

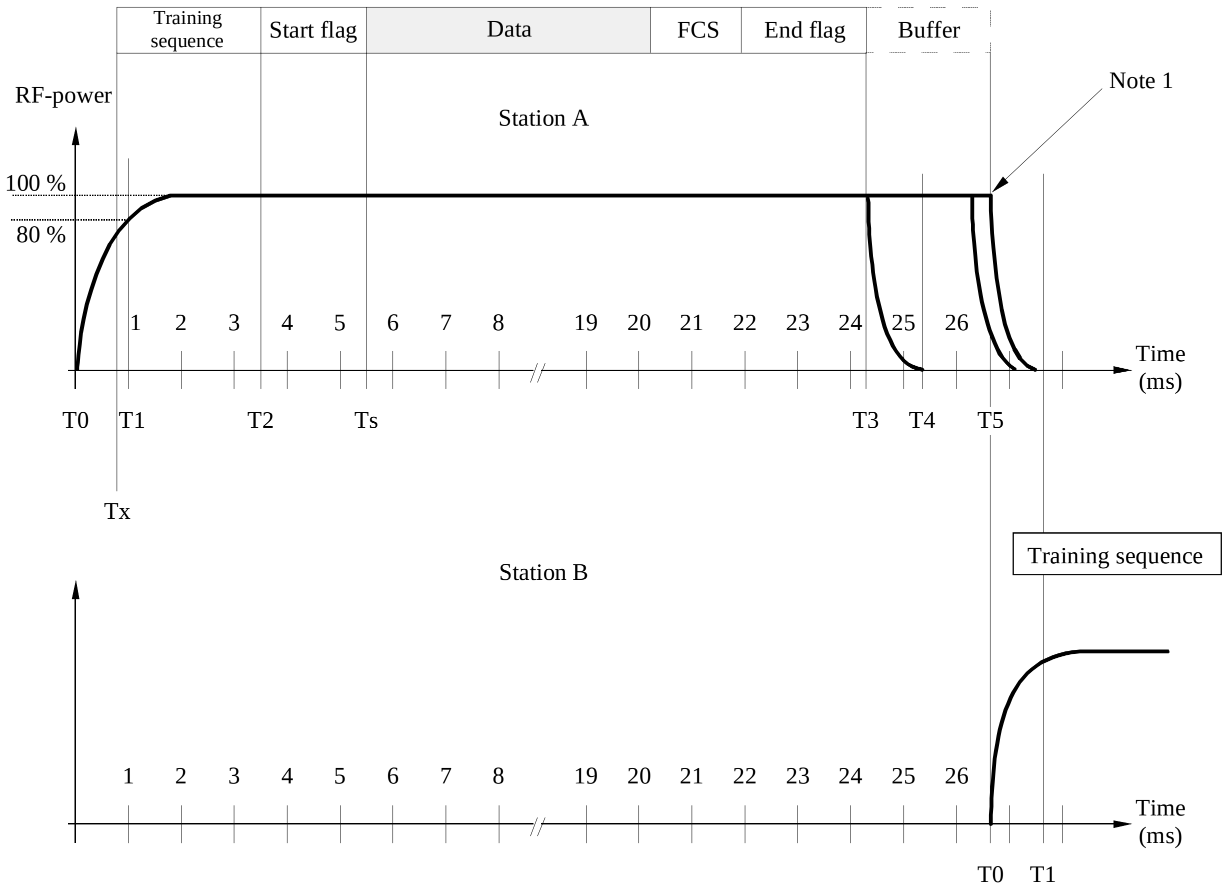
3.3.1.2 Candidate slots

Slots, used for transmission, are selected among *candidate slots*. There should always be at minimum four candidate slots to choose from. The candidate slots are primarily selected from free slots (see § 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 should be considered. If a slot in either channel is occupied by a station which is at close range, that slot should be omitted from the candidate slots.

FIGURE 6

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 stabilization time
T2	3.328	Start of transmission packet (start flag). This event can be used as a secondary synchronization source should the primary source (UTC) be lost
Ts	4.160	Slot phase synchronization 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 should have reached zero
T5	26.670	End of slot. Beginning of next slot

Note 1 – Should a transmission end exactly at the beginning of the next slot, the TX-down period for station A will overlap into the next slot as shown in Fig.6. 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.

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3.3.2 Modes of operation

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

3.3.2.1 Autonomous and continuous

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

3.3.2.2 Assigned

A station operating in the assigned mode should use a transmission schedule assigned by a competent authority's base or repeater station.

3.3.2.3 Polled

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

3.3.3 Initialization

At power on, a station should monitor the TDMA channels for 1 min 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 should be established. A frame map should be constructed, which reflects TDMA channel activity. After 1 min has elapsed, the station should enter the operational mode and start to transmit according to its own schedule.

3.3.4 Channel access protocols

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

3.3.4.1 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 should be marked so that they are reserved for one additional frame. This allows a station to pre-announce its allocations for autonomous and continuous operation.

ITDMA should be used on three occasions:

– data link network entry,

– temporary changes and transitions in periodical report rates,

– 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, should be allocated using RATDMA. That slot should then be 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 should be inserted into the ITDMA communication state so that receiving stations will be able to allocate the next slot. The communication state is transmitted as a part of the ITDMA transmission. During network entry, the station also indicates that the ITDMA slots should 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, as shown in Table 6:

TABLE 6

Symbol	Name	Description	Minimum	Maximum
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 should be done.	0	8 191
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 should be set to TRUE when the slot(s), allocated ahead in the frame, should be reserved for the next frame also. The keep flag is set to FALSE when the allocated slot should be freed immediately after transmission.	FALSE	TRUE

3.3.4.2 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 algorithm

The RTDMA protocol should use a probability persistent algorithm as described in this paragraph.

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

3.3.4.2.2 RATDMA parameters

The following parameters control RATDMA scheduling, as shown in Table 7:

TABLE 7

Symbol	Name	Description	Minimum	Maximum
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, LME.RTP2 should be set equal to LME.RTPS	10	20
LME.RTP1	Derived probability	Calculated probability for transmission in the next candidate slot. It should be less than or equal to LME.RTP2 for transmission to occur, and it should be 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 should not occur, LME.RTP2 should be incremented with LME.RTPI	1	50

3.3.4.3 TDMA – FATDMA

FATDMA should be used by base stations and controlling stations only. FATDMA allocated slots should be used for repetitive messages.

3.3.4.3.1 FATDMA algorithm

Access to the data link should be achieved with reference to frame start. Each allocation should be 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, as shown in Table 8:

TABLE 8

Symbol	Name	Description	Minimum	Maximum
LME.FTST	Start slot	The first slot (referenced to frame start) to be used by the station	0	2 249
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	1 125
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 SOTDMA

The SOTDMA protocol should be 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 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 algorithm

The access algorithm and continuous operation of SOTDMA is described in the § 3.3.5, autonomous and continuous operation.

3.3.4.4.2 SOTDMA parameters

The following parameters control SOTDMA scheduling, as shown in Table 9:

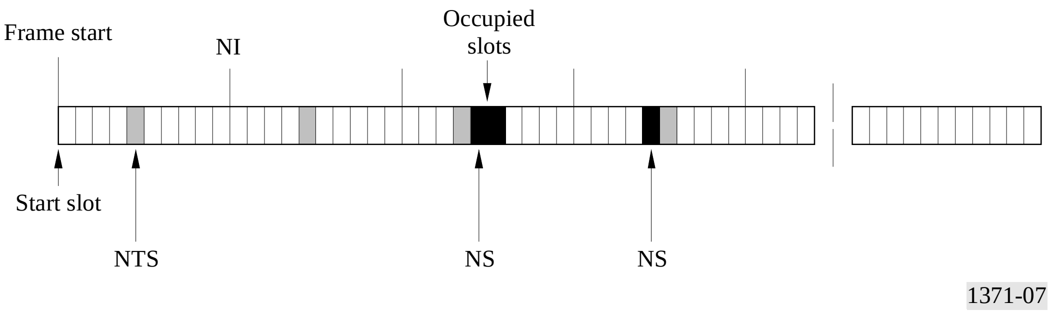
TABLE 9

Symbol	Name	Description	Minimum	Maximum
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	2 249
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: $NS = NSS + (n \times NI)$; $(0 \leq n < RR)$	0	2 249
NI	Nominal increment	The nominal increment is given in number of slots and is derived using the equation below: $NI = 2250 / RR$	75	1 225
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: $SI = \{NS - (0.1 \times NI)$ to $NS + (0.1 \times NI)\}$	$0.2 \times NI$	$0.2 \times NI$
NTS	Nominal transmission slot	The slot, within a selection interval, currently used for transmissions within that interval.	0	2 249
TMO_MIN	Minimum time-out	The minimum number of frames that a SOTDMA allocation will occupy a specific slot.	3	3
TMO_MAX	Maximum time-out	The maximum number of frames that a 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 7 shows the slot map accessed using SOTDMA.

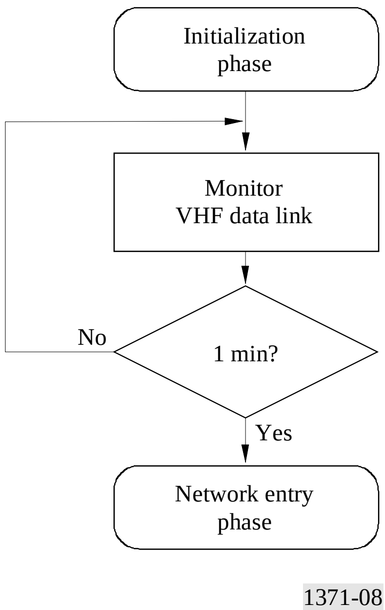
FIGURE 7



3.3.5.1 Initialization phase

The initialization phase is described using the flowchart shown in Fig. 8.

FIGURE 8



3.3.5.1.1 Monitor VHF data link (VDL)

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

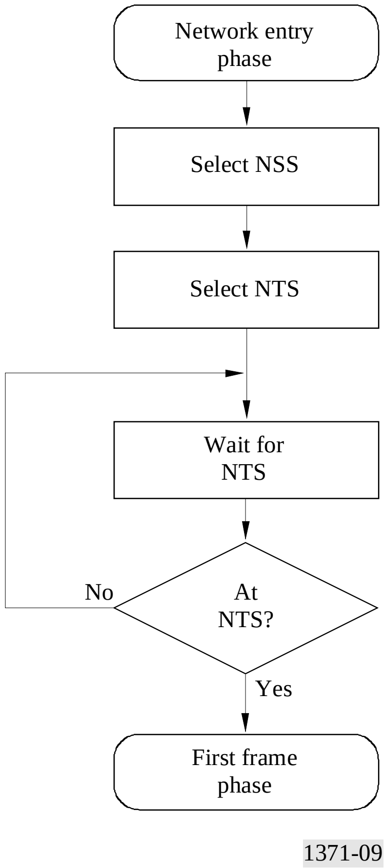
3.3.5.1.2 One minute

After 1 minute has elapsed, the station should enter the network and start to transmit according to its own schedule, as described below.

3.3.5.2 Network entry phase

During the network entry phase, the station should select its first slot for transmission in order to make itself visible to other participating stations. The first transmission should always be the scheduled position report.

FIGURE 9



3.3.5.2.1 Select NSS

The NSS should be randomly selected between current slot and NI slots forward. This slot should be the reference when selecting NS during the first frame phase. The first NS should always be equal to NSS.

3.3.5.2.2 Select NTS

Within the SOTDMA algorithm the NTS should be randomly selected among candidate slots within the SI. This is the NTS, which should be marked as internally allocated and assigned a random time-out between TMO_MIN and TMO_MAX.

3.3.5.2.3 Wait for NTS

The station should wait until the NTS is approached.

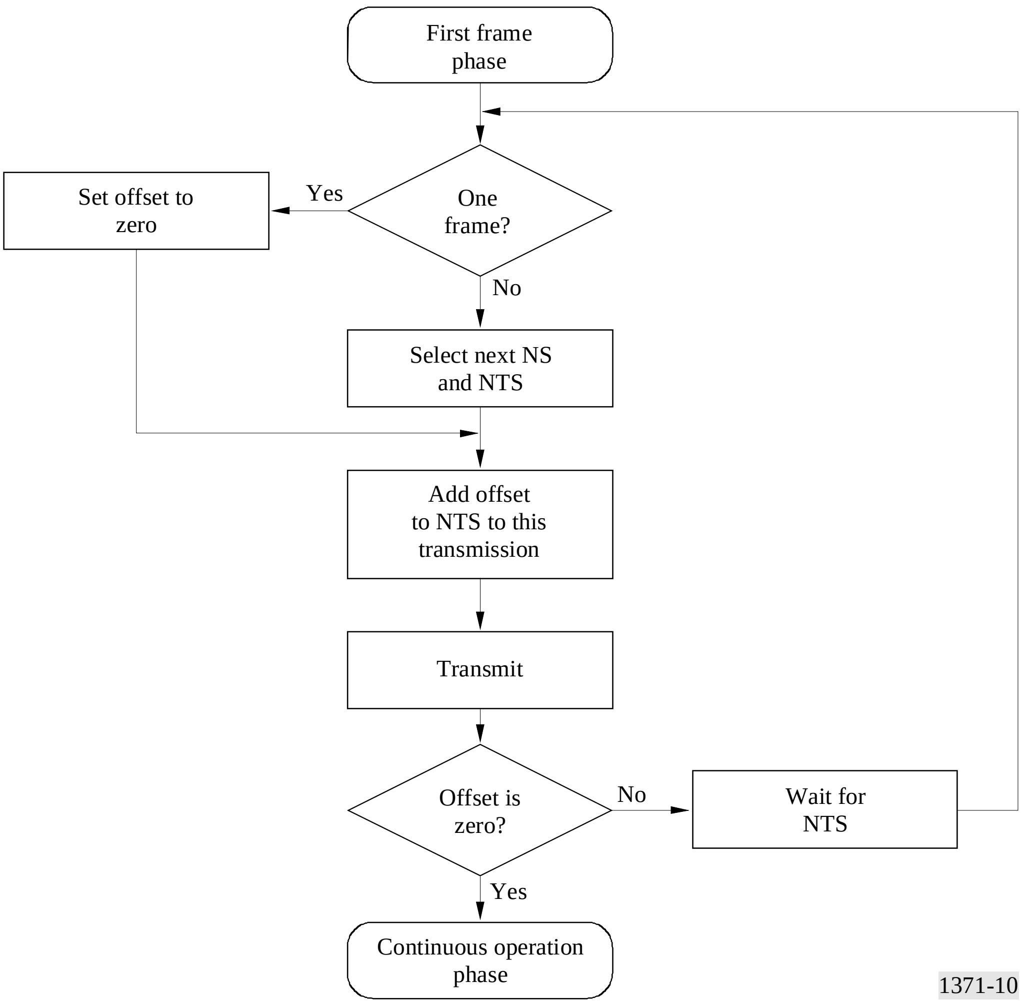
3.3.5.2.4 At NTS

When the frame map indicates that the NTS is approaching, the station should enter the first frame phase.

3.3.5.3 First frame phase

During the first frame phase, the station should continuously allocate its transmission slots and transmit scheduled position reports using ITDMA.

FIGURE 10



3.3.5.3.1 One frame

When one frame has elapsed, the initial transmissions should have been allocated and nominal operation should commence.

3.3.5.3.2 Set offset to zero

The offset should be used in the first frame when all transmissions use the ITDMA protocol. 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.

3.3.5.3.3 Select next NS and NTS

Prior to transmitting, the next NS should be selected. This should be done by keeping track of the number of transmissions performed so far (from *n* to *RR* – 1). The NS should be selected on the basis of the information contained in Table 10.

Nominal transmission slot should be selected using the SOTDMA algorithm to select among candidate slots within SI. The NTS should then be marked as internally allocated. The offset to next NTS should be calculated and saved for the next step.

3.3.5.3.4 Add offset to this transmission

All transmissions in the first frame phase should use the ITDMA protocol. 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.

3.3.5.3.5 Transmit

A scheduled position report should be entered into the ITDMA packet and transmitted in the allocated slot. The slot time-out of this slot should be decremented by one.

3.3.5.3.6 Offset is zero

If the offset has been set to zero, the first frame phase should be considered to have ended. The station should now enter the continuous operation phase.

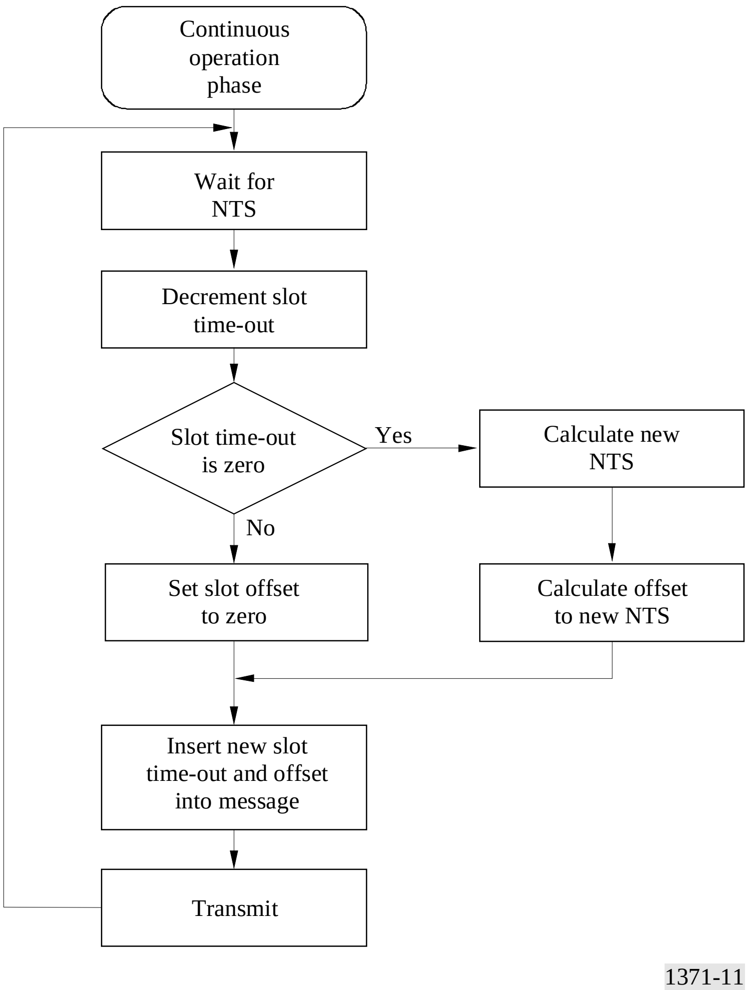
3.3.5.3.7 Wait for NTS

If the offset was non-zero, the station should wait for the next NTS and repeat the sequence.

3.3.5.4 Continuous operation phase

The station should remain in the continuous operation phase until it shuts down, enters assigned mode or is changing its report rate.

FIGURE 11



3.3.5.4.1 Wait for NTS

The station should now wait until this slot is approached.

3.3.5.4.2 Decrement slot time-out

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

3.3.5.4.3 Slot time-out is zero

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

If the slot time-out is more than zero, the slot offset value should be set to zero.

3.3.5.4.4 Assign time-out and offset to packet

The time-out and slot offset values are inserted into the SOTDMA communication state (refer to § 3.3.7.2.2).

3.3.5.4.5 Transmit

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

3.3.5.5 Changing report rate

When the nominal report rate should change then, the station should enter change report rate phase (see Fig 12). During this phase, it will reschedule its periodic transmissions to suit the new desired reporting rate.

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

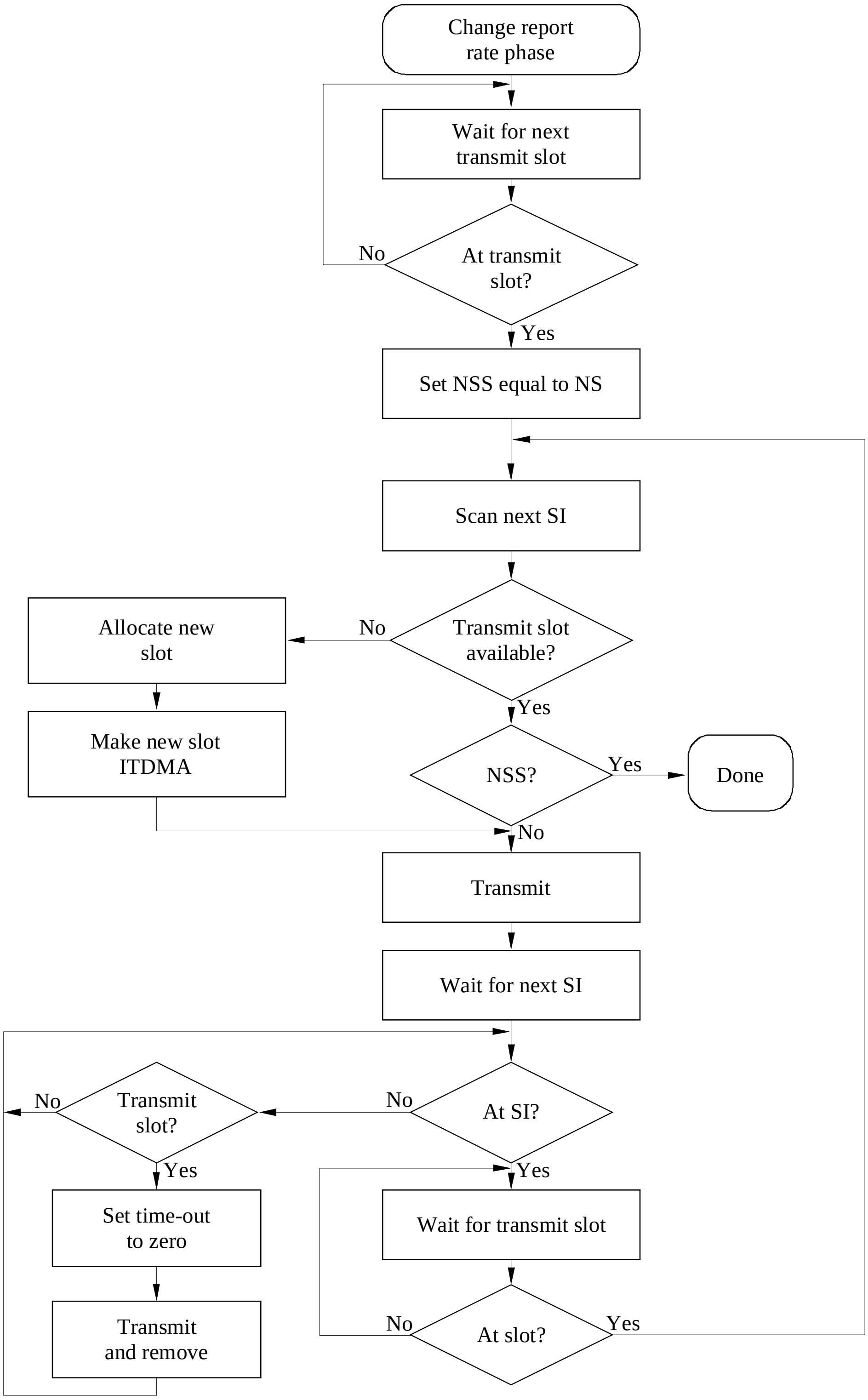
3.3.5.5.1 Wait for next transmit slot (TS)

Prior to changing its report rate, the station should wait for the next slot, which has been allocated for own transmission. Upon reaching this slot, the associated NS is set to the new NSS. The slot, which was allocated for own transmission, should be checked to make sure that the slot time-out is non-zero. If it is zero, the slot time-out should be set to one.

3.3.5.5.2 Scan next SI

When using the new report rate, a new NI should be derived. With the new NI, the station should examine the area which is covered by the next SI. If a slot is found, which is allocated for own transmission, it should be checked to see if it is associated with the NSS. If so, the phase is complete and the station returns to nominal operation. If not, the slot is kept with a time-out above zero.

FIGURE 12



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

The current slot should then be used for transmission of periodic messages such as a position report.

3.3.5.5.3 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 time-out should be set to zero. After transmission in that slot, the slot should be freed.

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

3.3.6 Assigned operation

An autonomous station may 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

When assigned a new reporting rate, the mobile station should remain in the autonomous and continuous mode, but should 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 may be assigned the exact slots to be used for repeatable transmissions by a competent authority. This type of assignment puts the station into an assigned mode.

3.3.6.2.1 Entering assigned mode

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

3.3.6.2.2 Operating in the assigned mode

The assigned slots should use the SOTDMA protocol, with the timeout value set to the assigned slot time-out. The assigned slot time-out should be between 3 and 8 frames. For each frame, the slot time-out should be decremented.

3.3.6.2.3 Returning to autonomous and continuous mode

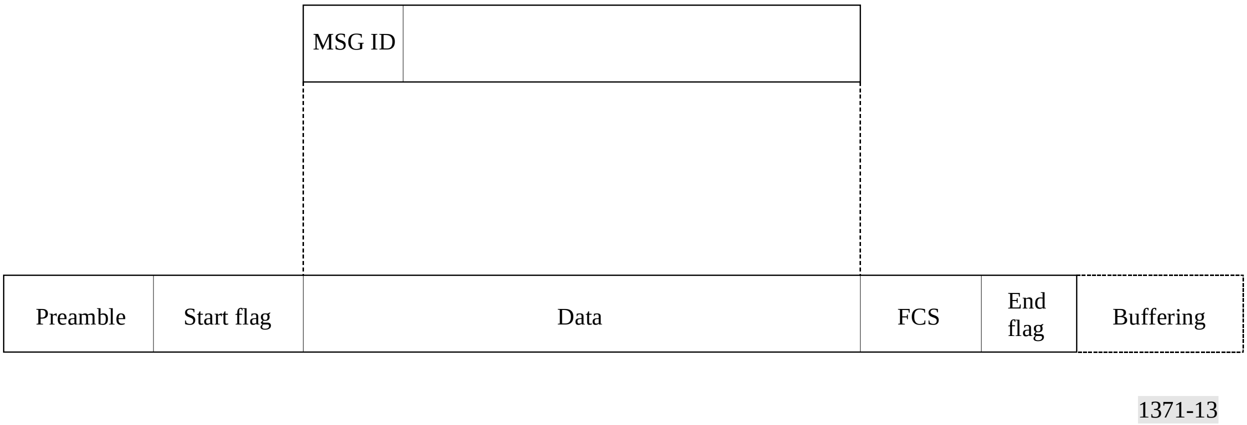
Unless a new assignment is received, the assignment should be terminated, when the slot time-out reaches zero of any assigned slot. At this stage, the station should return to autonomous and continuous mode.

The station should initiate the return to autonomous and continuous mode as soon as it detects an assigned slot with a zero slot time-out. This slot should be used to re-enter the network. The station should randomly select an available slot from candidate slots within a NI of the current slot and make this the NSS. It should then substitute the assigned slot for an ITDMA slot and should use this to transmit the relative offset to the new NSS. From this point on, the process should be identical to the network entry phase (see § 3.3.5.2).

3.3.7 Message structure

Messages, which are part of the access protocols, should have the following structure shown in Fig. 13 inside the data portion of a data packet:

FIGURE 13



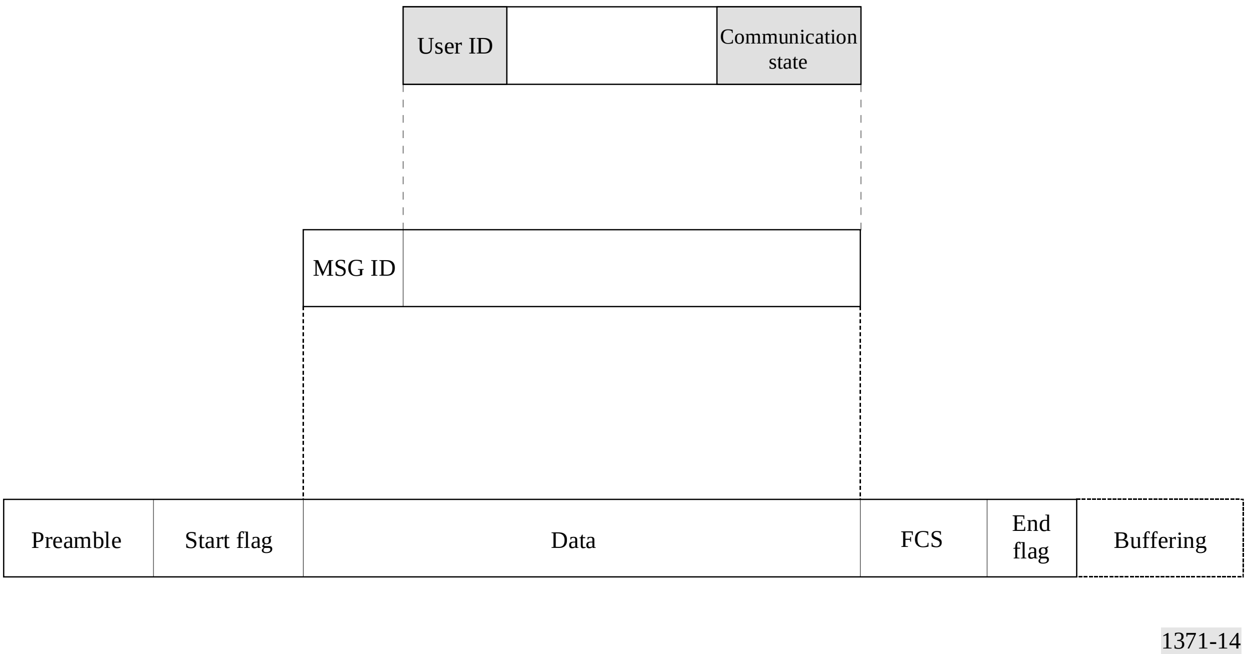
3.3.7.1 Message ID (MSG ID)

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

3.3.7.2 SOTDMA message structure

The SOTDMA message structure should supply the necessary information in order to operate in accordance with § 3.3.4.4. The message structure is shown in Fig. 14:

FIGURE 14



3.3.7.2.1 User ID

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

3.3.7.2.2 SOTDMA communication state

The communication state provides the following functions:

– it contains information used by the slot allocation algorithm in the SOTDMA concept;

– it indicates if the transmission is synchronized to the time base. Synchronized transmissions may be used as an alternative only if the own station lacks an accurate time base.

The SOTDMA communication state is structured as shown in Table10:

TABLE 10

Parameter	Number of bits	Description
Sync state	2	0 UTC direct. 1 UTC indirect. 2 Base station 3 Number of received stations
Slot time-out	2	Specifies frames remaining until a new slot is selected 0 means that this was the last transmission in this slot 1-2 means that 1 or 2 frames respectively are left until slot change 3 means that 3 or more frames are left until slot change
Sub message	14	The sub message depends on the current value in slot time out as described in the Table 11

3.3.7.2.3 Sub messages

TABLE 11

Slot time-out	Sub message	Description
3	Received stations	Number of stations which the station currently is receiving (between 0 and 16 383)
2	Slot number	Slot number used for this transmission (between 0 and 2 249)
1	UTC hour and minute	If the station has access to UTC, the hour and minute should be indicated in this sub message. Hour (0-23) should be coded in bits 13 to 9 of the sub message (bit 13 is MSB). Minute (0-59) should be coded in bit 8 to 2
0	Slot offset	If the slot time-out value is 0 (zero) then the slot offset should indicate the relative jump to the slot in which transmission will occur during next frame. (±2 047 means offset information is not given). If the slot offset is zero, the slot should be 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 similar to that of SOTDMA (see Fig. 14).

3.3.7.3.1 User ID

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

3.3.7.3.2 ITDMA communication state

The communication state provides the following functions:

– it contains information used by the slot allocation algorithm in the ITDMA concept;

– it indicates if the transmission is synchronized to the time base. Synchronized transmissions maybe used as an alternative only if the own station lacks an accurate time base.

The ITDMA communication state is structured as shown in Table 12:

TABLE 12

Parameter	Number of Bits	Description
Sync state	2	0 UTC direct 1 UTC indirect 2 Base station 3 Number of received stations
Slot allocation	13	Offset to next slot to be used, or 0 if no more transmissions
Number 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 should remain allocated for one additional frame

3.3.7.4 RATDMA message structure

The RATDMA protocol may use message structures determined by message ID and may thus lack a uniform structure.

3.3.7.5 FATDMA message structure

The FATDMA protocol may use message structures determined by message ID and may thus lack a uniform structure.

3.3.8 Message types

This paragraph describes all messages on the TDMA data link.

3.3.8.1 Message summary

The defined messages are summarized in Table 13.

TABLE 13

Message ID	Name	Description	Category	Operation mode	Communication 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 message 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, messages 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 station	S	Assigned	N/A

F: functional message
S: system management message
N/A: not applicable
ACK: acknowledgement
VTS: vessel traffic services

3.3.8.2 Message descriptions

All positions should be to be transmitted in WGS 84 datum.

3.3.8.2.1 Messages 1, 2, 3: position reports

TABLE 14

Parameter	Number of bits	Description
Message ID	6	Identifier for this message 1, 2 or 3
Data terminal equipment	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 (< 10 m) 0 = low (> 10 m)
Longitude	28	Longitude in 1/10 000 min (180°, East = positive, West = negative)
Latitude	27	Latitude in 1/10 000 min (90°, North = positive, South = negative)
COG	12	Course over ground in 1/10° (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
Communication state	18	See below
Total number of bits	168	

Message ID	Communication state
1	SOTDMA communication state as described in § 3.3.7.2.2.
2	SOTDMA communication state as described in § 3.3.7.2.2.
3	ITDMA communication state 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 15

Parameter	Number 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 (< 10 m) 0 = low (> 10 m)
Longitude	28	Longitude in 1/10 000 min (180°, East = positive, West = negative)
Latitude	27	Latitude in 1/10 000 min (90°, North = positive, South = negative)
Type of navigation sensor	4	
Spare	20	Not used. Should be set to zero
Communication state	18	SOTDMA communication state as described in § 3.3.7.2.2
Total number of bits	168	

3.3.8.2.3 Message 5: Ship static and voyage related data

TABLE 16

Parameter	Number of bits	Description
Message ID	6	Identifier for this message
Spare	2	Not used. Should be set to zero
User ID	30	MMSI number
Spare	2	Not used. Should be set to zero
IMO number	30	Maximum 9 numeric characters
Call sign	36	6×6 bit ASCII characters
Name	120	Maximum 20 characters 6 bit ASCII
Type of ship and cargo type	8	As defined in § 3.3.8.2.3.1
Position of GNSS antenna	30	Also indicates the dimension of ship in metres (see Fig. 15 and § 3.3.8.2.3.2)
Type of navigation sensor	4	
Expected time of arrival	20	MMDDHHMM
Actual draught	8	in 1/10 m, maximum 25.5 m
Destination	120	Maximum 20 characters
Total number of bits	416	

GNSS: global navigation satellite system

Message occupies 2 slots.

3.3.8.2.3.1 Type of ship

TABLE 17

Identifiers to be used by ships to report their type and in the ADDRESS of calls directed to a group of ships	
Identifier 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 the 1949 Geneva Conventions and Additional Protocols)
59	Ships according to Resolution 18 (Mob-83)
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 ship	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

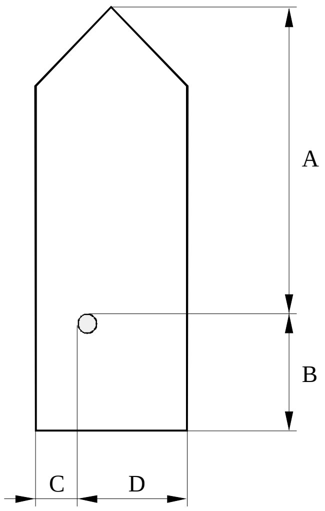
DG: dangerous goods
HS: harmful substances
MP: marine pollutants

NOTE 1 – The identifier should be constructed by selecting the appropriate first and second digits.

3.3.8.2.3.2 Position of GNSS antenna in use

FIGURE 15

Addressed binary and safety related message



	Number of bits	Bit fields	Distance (m)
A	9	0-8	maximum 511
B	9	9-17	maximum 511
C	6	18-23	maximum 63
D	6	19-29	maximum 63

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3.3.8.2.4 Messages 6, 12: Addressed binary and safety related message

TABLE 18

Parameter	Number of bits	Description
Message ID	6	Identifier for messages 6, 12
Spare	2	Not used. Should be zero
Source ID	30	MMSI number
Spare	2	Not used. Should be zero
Destination ID	30	MMSI number
Spare	2	Not used. Should be zero
Data	936	117 bytes maximum
Buffer	184	23 bytes maximum
Total number of bits	1 192	

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

Data = data + buffer – bit stuffing.

3.3.8.2.5 Messages 7, 13: Binary and safety related message acknowledgement

TABLE 19

Parameter	Number of bits	Description
Message ID	6	Identifier for messages 7, 13
Spare	2	Not used. Should be set to zero
Source ID	30	MMSI number
Spare	2	Not used. Should be set to zero
Destination ID	30	MMSI number
Spare	2	Not used. Should be set to zero
Destination ID	30	MMSI number
Spare	2	Not used. Should be set to zero
Destination ID	30	MMSI number
Spare	2	Not used. Should be set to zero
Destination ID	30	MMSI number
Spare	2	Not used. Should be set to zero
Total number of bits	168	Fewer are allowed

3.3.8.2.6 Messages 8, 14, 19, 21: Broadcast binary message

TABLE 20

Parameter	Number of bits	Description
Message ID	6	Identifier for messages 8, 14 ,19, 21
Spare	2	
Source ID	30	MMSI number
Spare	2	Not used. Should be set to zero
Data	968	121 bytes maximum
Buffer	184	23 bytes maximum
Total number of bits	1 192	

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

$$\text{Data} = \text{data} + \text{buffer} - \text{bit stuffing.}$$

3.3.8.2.7 Message 10: UTC time inquiry

TABLE 21

Parameter	Number of bits	Description
Message ID	6	Identifier for message 10
Spare	2	Not used. Should be set to zero
Source ID	30	MMSI number
Spare	2	Not used. Should be set to zero
Destination ID	30	MMSI number
Spare	98	Optional. Should be set to zero, if inserted
Total number of bits	168	

3.3.8.2.8 Message 15: Interrogation

TABLE 22

Parameter	Number of bits	Description
Message ID	6	Identifier for message 15
Spare	2	Not used. Should be set to zero
Source ID	30	MMSI number
Spare	2	Not used. Should 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. Should be set to zero
Total number of bits	168	

3.3.8.2.9 Message 17: Differential GNSS broadcast binary message

TABLE 23

Parameter	Number of bits	Description
Message ID	6	Identifier for message 17
Spare	2	Not used. Should be set to zero
Longitude	18	Longitude in 1/10 min (180°, East = positive, West = negative)
Latitude	17	Latitude in 1/10 min (90°, North = positive, South = negative)
Spare	5	Not used. Should be set to zero
Data	784	Differential correction data (see below)
Total number of bits	832	

The differential correction data section should be organized as listed below:

Parameter	Number of bits	Description
Message type	6	Recommendation ITU-R M.823 message type 1, 2 or 9
Station ID	10	Recommendation ITU-R M.823 station identifier
Z count	13	Time value in 0.6 s (0-3599.4)
Sequence number	3	Message sequence number (cyclic 0-7)
DGNSS data words	5	Number of satellite records
Health	3	Reference station health (specified in Recommendation ITU-R M.823)
DGNSS Data Word	$N \times 24$	Satellite records excluding parity
Total number of bits	784	Assuming $N = 31$

3.3.8.2.10 Message 20: Data link management message

TABLE 24

Parameter	Number of bits	Description
Message ID	6	Identifier for message 20
Spare	2	Not used. Should be set to zero
Source station ID	30	MMSI number
Spare	2	Not used. Should 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. Should be set to zero
Total number of bits	168	

3.3.8.2.11 Message 22: Channel management

TABLE 25

Parameter	Number of bits	Description
Message ID	6	Identifier for message 22
Spare	2	Not used. Should be set to zero
Station ID	30	MMSI number
Spare	2	Not used. Should be set to zero
Channel 1	12	Channel number according to Recommendation ITU-R M.1084, Annex 4
Channel 2	12	Channel number according to Recommendation ITU-R M.1084, Annex 4
Mode	4	0=Tx1/Tx2, Rx1/Rx2 1=Tx1, Rx1/Rx2
Power	1	0 = high, 1 = low
Longitude 1	18	Longitude in 1/10 min (180°, East = positive, West = negative)
Latitude 1	17	Latitude in 1/10 min (90°, North = positive, South = negative)
Longitude 2	18	Longitude in 1/10 min (180°, East = positive, West = negative)
Latitude 2	17	Latitude in 1/10 min (90°, North = positive, South = negative)
Training sequence	1	0 = 24 bits, 1 = 32 bits
Spare	28	Not used. Should be set to zero
Total number of bits	168	

4 Network layer

The network layer is responsible for:

– establishing and maintaining channel connections;

– distribution of transmission packets between channels;

– data link congestion resolution.

4.1 Dual channel operation

Dual channels allow for:

– use by fishing vessels and leisure craft;

– additional communication services (in addition to AIS);

– redundancy (to cope with interference problems).

4.2 Distribution of transmission packets

4.2.1 The user directory

The user directory is internal to the AIS which is a directory of all users that the station receives (transponder IDs, bearing and distance, relative speed, 30 min + history).

4.2.2 Routing of transmission packets

– Position reports should be distributed to the presentation interface.

– Own position should be reported to the presentation interface and transmit it over the VHF data link.

4.3 Reporting rates

4.3.1 Autonomously increased reporting rate (continuous and autonomous mode)

When a ship changes course, a higher update rate should be required. A change of course should be determined by calculating the mean value of the heading for the last 30 s 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 s between reports, should be applied. The increased rate should be maintained until the difference between the mean value of heading and present heading has been less than 5° for more than 20 s.

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 should be used with a reporting rate of 3 min. This function should be selected by an external command via the presentation interface. The type 3 message should be transmitted 3 min after the type 5 message.

4.4 Data link congestion resolution

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

4.4.1 The Robin Hood algorithm

If the link load exceeds 90% of the theoretical maximum, SOTDMA should select 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:

– converting data into transmission packets of correct size;

– sequencing of data packets;

– 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:

– position sensors, such as a GNSS;

– from session layer;

– 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 should convert data, received from the session layer, into transmission packets. If the resulting length of a transmission packet results in a data link message longer than 5 slots, the presentation interface message should 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 should be 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 time-out of 4 s is allowed between retries. The number of retries should be configurable. The result of a transmission should be forwarded to above layers. The acknowledgement should be between transport layers in two stations.

5.4.1.1 Broadcast

In the broadcast mode the packet lacks a destination identifier. Therefore receiving stations should not acknowledge broadcast packets.

5.4.1.2 Sequencing for the presentation interface

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

5.4.2 Binary messages

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

5.5 Presentation interface protocol

5.5.1 The IEC 6 1162 series for digital communication

Applicable parts of IEC 6 1162 should be used as the presentation interface protocol with the following amendments:

– communication is full duplex. Hardware handshaking is not required;

– communication interfaces may use RS232, RS485/422 standards;

– communication should be capable of using a bit rate of 38 400 bps.

5.5.1.1 Message structure

The message structure should use the features of the IEC 6 1162 series. Each message has the general structure shown in Fig. 16:

FIGURE 16

$	PAIS	,	<MSG ID>	,	<DATA>	*	<FCS>	<CR>	<LF>

$: 24$_h$. 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

*: 2A$_h$. 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>: 0D$_h$ and 0A$_h$. Marks the end of a complete message

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ANNEX 3

Channel management and digital selective-calling (DSC) compatibility*

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), (2087)* and

AIS 2 (Channel 88B, 162.025 MHz) (2088)*.

The AIS should default to operation on these channels. Operation on other channels should 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 should 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 should contain two TDMA receivers. Regular scheduled transmissions should alternate between the two channels.

1.3 Regional operating frequencies

Regional operating frequencies should be designated by the four-digit channel numbers specified in Recommendation ITU-R M.1084, Annex 4. This allows for simplex, duplex, 25 kHz and 12.5 kHz channels for regional options, subject to the provisions of RR Appendix S18.

1.4 Regional operating areas

Regional operating areas should be designated by a Mercator projection rectangle with two reference points (WG S84). The first reference point should be the geographical coordinate address of the northeastern corner (to the nearest tenth of a minute) and the second reference point should be the geographical coordinate address of the southwestern corner (to the nearest tenth of a minute) of the rectangle.

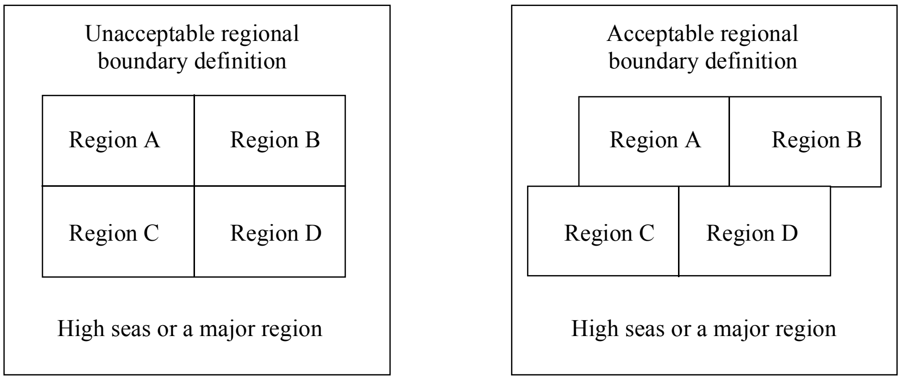
1.5 Transitional mode operations near regional boundaries

The AIS device should 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 should transmit and receive on the primary AIS frequency specified for the occupied region, and it should 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 should 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. The high seas area should be considered to be a region. Regions should 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 in Figs. 17a and 17b.

* See Recommendation ITU-R M.1084, Annex 4.

FIGURE 17a FIGURE 17b



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2 DSC compatibility

2.1 General

The AIS should be capable of performing limited AIS-related DSC operations. These operations should 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 should 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 Nos. 09, 10, 11, 12, and 13 should be added to Table 5 of Recommendation ITU-R M.825 as specified below. The AIS device should be capable of responding to such calls by performing operations in accordance with § 1 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 § 1 to 1.5. A transmission interval of 15 minutes is recommended, and each transmission should be made twice, with a time separation of 500 ms between the two transmissions, in order to insure that reception by AIS transponders is accomplished.

DSC operations performed by the AIS should 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 should be used in accordance with Table 5 of Recommendation ITU-R M.825. Each of these expansion symbols should be followed by two DSC symbols (4 digits) which specify the AIS regional channel(s), as defined by Recommendation ITU-R M.1084, Annex 4. This allows for simplex, duplex, 25 kHz and 12.5 kHz channels for regional options, subject to the provisions of Appendix S18 of the Radio Regulations. Expansion symbol No. 09 should designate the primary regional channel, and expansion symbol No. 10 or 11 should be used to designate the secondary regional channel.

When single-channel operation is required, then only expansion symbol No. 09 should be used. For two-channel operation, either expansion symbol No. 10 should be used to indicate that the secondary channel is to operate in both transmit and receive modes, or expansion symbol No. 11 should 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 should be in accordance with Table 5 of Recommendation ITU-R M.825. Expansion symbol No. 12 should 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 should 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 should provide a two-way interface for equipment which provides for long range communications. This interface should comply with IEC 1162 Standard.