

Technical characteristics of the Application Specific Messages (ASM) for the VDES in the VHF maritime mobile band

1.7 Structure of the application specific messages

For the VDES, to mitigate AIS VDL loading effects, ASM should conform to the data structure specified in Recommendation ITU-R M.1371 and may use the two channels designated for ASM in Table 1 (ASM 1 and ASM 2) instead of AIS 1 and AIS 2. Transmission method should be according to Section 0. This Annex describes the characteristics of the TDMA access schemes which include random access TDMA (RATDMA), incremental TDMA (ITDMA), fixed access TDMA (FATDMA) techniques.

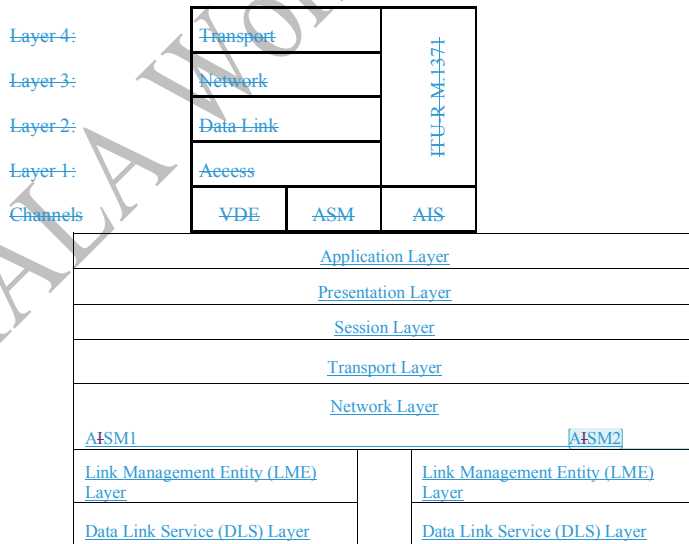
1.18 Application specific messages layer module Protocol layer overview

This recommendation covers layers 1 to 4 (physical layer, link layer, network layer and transport layer) of the open system interconnection (OSI) model.

Figure 1 illustrates the layer model of the ASM station (physical layer to transport layer) and the layers of the applications (session layer to applications layer). The VDES architecture should utilize the open systems interconnection layers 1 to 4 (physical layer, link layer, network layer, transport layer) as illustrated in Figure 3.

FIGURE 1

OPEN SYSTEMS INTERCONNECTION LAYERS 1-4



Commented [PB1]: Convert all reference to timing defined by bits to actual time;

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| | | |
|-----------------------------------|--------------|-----------------------------------|
| Medium Access Control (MAC) Layer | | Medium Access Control (MAC) Layer |
| Physical Layer | | Physical Layer |
| RX ASM1 | TX ASM1/ASM2 | RX ASM2 |
| Rx: Receiver Tx: Transmitter | | |

Commented [AM3]: The labeling here is confusing – is it necessary?

1.2 For the VDES, to mitigate AIS VDL loading effects, ASM should conform to the data structure specified in Recommendation ITU-R M.1371 and may use the two channels designated for ASM in Table 1 (ASM 1 and ASM 2) instead of AIS 1 and AIS 2. Transmission method should be according to Section 0 Responsibilities of layers for preparing ASM data for transmission

1.2.1 Transport layer

The transport layer is responsible for converting data into transmission packets of correct size and sequencing of data packets.

1.2.2 Network layer

The network layer is responsible for the management of priority assignments of messages, distribution of transmission packets between channels, and data link congestion resolution.

1.2.3 Link layer

The link layer is divided into three sub-layers with the following tasks:

1.2.3.1 Link management entity

Assemble ASM message bits.

Order ASM message bits into 8-bit bytes for assembly of transmission packet.

1.2.3.2 Data link services

Calculate frame check sequence (FCS) for ASM message bits.

Append FCS to ASM message to complete creation of transmission packet contents.

Complete assembly of transmission packet.

1.2.3.3 Media access control

Provides a method for granting access to the data transfer to the VHF data link (VDL). The method used is a TDMA scheme using a common time reference.

1.2.4 Physical layer

~~Non return to zero inverted (NRZI) encode assembled transmission packet.~~

Convert digital ~~[NRZI coded]~~ transmission packet to $\pi/4$ ~~Differential~~ Quadrature Phase-Shift Keying (DQPSK) to modulate transmitter.

Commented [AM4]: We had discussed removal of differential encoding due to inefficiency of transmission, and due to modern receiver architectures not requiring differential encode at the last intersessional meeting. I recall we agreed to drop differential encoding?

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2 Physical layer

2.1 Parameters

2.1.1 General

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 1 to 5.

The low setting and the high setting for each parameter is independent of the other parameters.

TABLE 1

| Symbol | Parameter name | Units | Low setting | High setting |
|---------|---|--------|-------------|--------------|
| PH.CHS | Channel spacing (encoded according to RR Appendix 18 with footnotes) ⁽¹⁾ | kHz | 25 | 25 |
| PH.ASM1 | ASM 1 (2027) ⁽¹⁾ | MHz | 161.950 | 161.950 |
| PH.ASM2 | ASM 2 (2028) ⁽¹⁾ | MHz | 162.000 | 162.000 |
| PH.BR | Bit rate | kbit/s | 19.2 | 19.2 |
| PH.TS | Training sequence | Bits | 24 | 24 |
| PH.TXRO | Transmit roll off factor | | 0.35 | 0.35 |
| PH.RXRO | Receive roll off factor | | 0.35 | 0.35 |
| PH.TXP | Transmit output power | W | 11 | 12.5 |

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

2.1.2 Constants

TABLE 2

| Symbol | Parameter name | Value |
|--------|--------------------------|--------------------|
| PH.DE | Data encoding | Not used TBD |
| PH.FEC | Forward error correction | Turbo (selectable) |
| PH.IL | Interleaving | Not used |
| PH.BS | Bit scrambling | Not used TBD |
| PH.MOD | Modulation | $\pi/4$ -DQPSK |

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Commented [JS5]: We should be able to use or not use FEC depending on the environment. This can be encoded into the training sequence.

Commented [AM6]: Alternative is an encoded message type field, such as used for VDES sat downlink format.

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Commented [AM7]: Recommend change to TBD, all FEC schemes benefit from interleaving. Interleaver design is based on knowledge of channel/fading characteristics of the ASM channel. There will be more than one model, space and ground link as a minimum, may vary versus mast height and sea state.

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Commented [AM8]: Recommend trade was between $\pi/4$ and offset QPSK, without differential encoding.

2.1.3 Transmission media

Data transmissions are made in the VHF maritime mobile band. Data transmissions should use ASM 1 and ASM 2 channels.

2.1.4 Multi-channel operation

The ASM should be capable of receiving on two parallel channels and transmitting on two independent channels. Two separate TDMA receiving processes should be used to simultaneously

receive on two independent frequency channels. One TDMA transmitter ~~should~~ may be used to TDMA transmissions on two independent frequency channels.

2.2 Transceiver characteristics

The transceiver should perform in accordance with the characteristics set forth herein.

TABLE 3
Minimum required time division multiple access transmitter characteristics

| Transmitter parameters | Requirements |
|---|--|
| Carrier power error | ±1.5 dB |
| Carrier frequency error | ± 500 Hz |
| Slotted modulation mask | $\Delta f_c < \pm 10$ kHz: 0 dBc ± 10 kHz < $\Delta f_c < \pm 25$ kHz: below the straight line between -25 dBc at ± 10 kHz and -70 dBc at ± 25 kHz ± 25 kHz < $\Delta f_c < \pm 62.5$ kHz: -70 dBc |
| Transmitter test sequence and modulation accuracy | TBD |
| Transmitter output power versus time | Power within mask shown in figure 2 and timing in table 4 |
| Spurious emissions | -36 dBm 9 kHz ... 1 GHz -30 dBm 1 GHz ... 4 GHz |
| Intermodulation attenuation (base station only) | TBD |

Commented [AM9]: Fairly high, a spec of +/- 250 Hz should be economically achievable.

Commented [AM10]: In test standard, can set a specification such as less than 0.5 dB modem loss due total transmitter modulation error.

TABLE 4
Definitions of timing for Figure 2

| Reference | Bits | Time (ms) | Definition |
|---------------------------------|----------|-----------|--|
| T_0 | 0 | 0 | Start of transmission slot. Power should NOT exceed -50 dB of P_{ss} before T_0 |
| T_1 | 0 | 0-0.625 | Power exceeds -50 dB of P_{ss} |
| T_B | T_{B1} | 12 | Power should be within +1.5 or -3 dB of P_{ss} |
| | T_{B2} | 16 | Power should be within +1.5 or -1 dB of P_{ss} (start of training sequence) |
| T_E (includes 1 stuffing bit) | 466 | 24.271 | Power should remain within +1.5 or -1 dB of P_{ss} during the period T_{B2} to T_E |
| T_F (includes 1 stuffing bit) | 482 | 25.104 | Power should be -50 dB of P_{ss} and stay below this |
| T_G | 512 | 26.667 | Start of next transmission time period |

Commented [AM11]: As discussed at intersessional, stuffing bits should not be required.

TABLE 5
Minimum required time division multiple access receiver characteristics⁽¹⁾

| Receiver parameters | Requirements |
|---------------------|-----------------------|
| Sensitivity | [-20% PER @ -107 dBm] |

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| Receiver parameters | Requirements |
|--------------------------------------|--|
| Error behaviour at high input levels | [1% PER @ -77 dBm] [1% PER @ -7 dBm] |
| Adjacent channel selectivity | [20% PER @ 70 dB] |
| Co-channel selectivity | [20% PER @ 19 dB] |
| Spurious response rejection | [20% PER @ 70 dB] |
| Intermodulation response rejection | [20% PER @ 74 dB] |
| Spurious emissions | [-57 dBm (9 kHz to 1 GHz)] [-47 dBm (1 GHz to 4 GHz)] |
| Blocking | [20% PER @ 86 dB] |

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Commented [AM12]: Are these from 1371 AIS? If so, I would suggest TBC beside the numbers, once modulation and bit rate/coding are selected, the requisite numbers for equivalent performance may change.

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2.3 Modulation scheme

The modulation scheme is $\pi/4$ ~~Differential~~ Quadrature Phase-Shift Keying (DQPSK).

Commented [AM13]: As above, $\pi/4$ or offset (to be selected based on analysis/test, and no need for differential encoding).

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2.3.1 $\pi/4$ DQPSK

2.3.1.1 The encoded data should be $\pi/4$ DQPSK coded before modulating the transmitter.

2.3.1.2 The modulator transmitter roll off used for transmission of data should be maximum 0.35 (highest nominal value).

2.3.1.3 The demodulator used for receiving of data should be designed for a receiver roll off of maximum 0.35 (highest nominal value).

2.3.2 Phase modulation

The coded data should modulate the VHF transmitter.

2.3.3 Frequency stability

The frequency stability of the VHF radio transmitter/receiver should be ± 500 ~~TBD~~ Hz or better.

Commented [AM14]: As per comment earlier.

2.4 Data transmission bit rate

The transmission bit rate should be max 19.2 kbit/s ± 1025 ppm.

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2.5 Training sequence/synchronisation header

Data transmission should begin with a 24-bit demodulator synchronisation header training sequence (preamble) consisting of one segment synchronization. This segment should consist of [1111100110101 01111110 xx www 1101 0000 1110 1001 1101 0000].

Commented [JS15]: We should consider a training sequence which implements Barker codes and allows for multiple waveforms and coding rates. I would suggest using a combination the 13 bit Barker Code and a start flag: 1111100110101 01111110 xx www. xx selects the FEC coding:
000 – not coding
001 – 1/2 coding
010 – 3/4 coding
011 – 5/6 coding

www – selects waveform
000 - $\pi/4$ DQPSK

Commented [AM16]: Some form of encoding on the waveform/coding selection bits to increase Hamming distance desired, as per discussions on VDES sat downlink modulation / waveforms.

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000 – no coding

001 – 1/2 coding

010 – 3/4 coding

011 – 5/6 coding

www – selects waveform

000 - $\pi/4$ QPSK

2.6 Data encoding

~~FDD~~Not used.

2.7 Forward error correction

Forward error correction is ~~not used~~. Forward error correction will be performed using turbo and defined in the synchronisation header.

Commented [AM17]: Inconsistent with earlier text.

2.8 Interleaving

Interleaving is not ~~used~~.

Commented [AM18]: Should be investigated, and used if forward error correction coding is employed.

2.9 Bit scrambling

~~FDD~~Bit scrambling is not used. ~~Scrambling of the user data may be required to avoid the power~~

2.10 Data link sensing

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

2.11 Transmitter transient response

The attack, settling and decay characteristics of the RF transmitter should comply with the mask defined in Table 4.

2.11.1 Switching time

FIGURE 2

The channel switching time should be less than 25 ms (see Fig. x).

The time taken to switch from transmit to receive conditions, and vice versa and receive to transmit should not exceed the transmit attack or release time. It should be possible to receive a message from the slot directly after or before own transmission.

The equipment should not be able to transmit during channel switching operation.

The equipment is not required to transmit on the other ASM channel or AIS channels in the adjacent time slot.

Commented [AM20]: What is the switching time as used here? Earlier requirement specified full-time reception of channels ASM1 and ASM2 by suitable receiver. Transmit switching time is another matter, and depends on how other AIS frequencies and ASMs behave for transmissions. If this is transmit/receive switching time, it is longer than desired, this would imply lost reception in slot before and after an ASM message is transmitted?

2.12 Transmitter power

The power level is determined by the link management entity (LME) of the link layer.

2.12.1 Provision should be made for two levels of nominal power (high power, low power) as required by some applications. The default operation of the ASM station should be on the high nominal power level. Changes to the power level should only be by assignment by the approved

2.12.2 The nominal levels for the two power settings should be ~~1~~ W and ~~12.5~~ W. Tolerance be within ± 1.5 dB.

Commented [AM21]: I would recommend 2 W as a minimum for space detection. Some units could be compliant to standard at 1 W to save battery life. Spec could read 1 or 2 W (low power).

2.13 Shutdown procedure

2.13.1 An automatic transmitter hardware shutdown procedure and indication should be provided in case a transmitter continues to transmit for more than 2 s. This shutdown procedure should be independent of software control.

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2.14 Safety precautions

The ASM installation, when operating, should not be damaged by the effects of open circuited or short circuited antenna terminals.

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) sub-layers.

3.1 Sub-layer 1: medium access control

The medium access control (MAC) sub layer provides a method for granting access to the data transfer medium, i.e. the VHF data link. The method used access scheme is a TDMA scheme using a 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 ITDMA communication state, indicates the synchronization state of a station.

The TDMA receiving process should not be synchronized to slot boundaries.

Synchronization other than UTC direct may be provided by the AIS system.

If there is no synchronization available the unit stops transmitting VDE and ASM messages.

A station, which has direct access to coordinated universal time (UTC) timing with the required accuracy should indicate this by setting its synchronization state to UTC direct.

3.1.1.2 Coordinated universal time indirect

A station, which is unable to get direct access to UTC, but has access to the AIS system, may get its synchronization from the AIS system. It should then change its synchronization state to indicate the type of synchronization which is being provided by the AIS system.

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 unavailable the AIS system may provide the frame synchronization.

3.1.3 Slot phase and frame synchronization

Slot phase synchronization and frame synchronization is done by using information from UTC or from the AIS System.

3.1.3.1 Slot phase synchronization

Slot phase synchronization is the method whereby the slot boundary is synchronized with a high level of synchronization stability, thereby ensuring no message boundary overlapping or corruption of messages.

3.1.3.2 Frame synchronization

Frame synchronization is the method whereby the current slot number for the frame is known.

3.1.3.2.1 Coordinated universal time available

A station, which has direct access to UTC, should continuously re-synchronize its transmissions based on UTC source. A station, which has indirect access to UTC should continuously resynchronize its transmissions based on those UTC sources (see § xxx).

Commented [AM22]: The way I would explain it, the medium access control is SOTDMA, RATDMA, etc., TDMA is just the multiple access scheme, not the method itself.

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Commented [AM24]: These assume synchronization similar to AIS – we can limit the cases from those available for AIS, or widen them – the key issue will be how we expect transponders to behave on the AIS channels.

Commented [AM25]: Introducing definitions for super frames or other structures from other annexes may provide future flexibility, for example in specifying behavior of infrequent transmitters (at minutes, 10s minutes or longer intervals in a day). Benefits to hardware can include power savings for battery operated devices with long, well defined sleep cycles.

3.1.3.2.2 Coordinated universal time not available

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 should continuously slot phase synchronize.

3.1.3.2.3 Synchronization sources

The primary source for synchronization should be the internal UTC source (UTC direct). If this source should be unavailable the synchronization should be derived from remote AIS

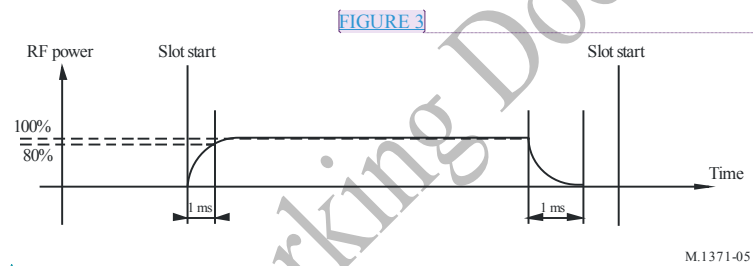
3.1.4 Slot identification

Each slot is identified by its index (0-2249). Slot zero (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 (1) slot. The slot access is performed as shown in Fig. 3:



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3.1.6 Slot state

Each slot can be in one of the following states:

- Free: meaning that the slot is unused within the receiving range of the own station. Externally allocated slots that have not been used during the preceding three frames are also Free slots. This slot may be considered as a candidate slot for use by own station.
- Internal allocation available: meaning that the slot is allocated by own station and can be used for transmission of ASM messages.
- Internal allocation unavailable: meaning that the slot is allocated by own station for the purpose of AIS or ASM transmissions and cannot be a candidate for slot reuse.
- External allocation: meaning that the slot is allocated for transmission by another station and cannot be a candidate for slot reuse.
- Available: meaning that the slot is externally allocated by a station and is a possible candidate for slot reuse.
- Unavailable: meaning that the slot is externally allocated by a station and cannot be a candidate for slot reuse.
- Garbled: meaning that there is significant energy within the slot and no packet received and therefore should not be a candidate for slot reuse.

Commented [JS27]: May be message type dependent

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3.2 Sub layer 2: data link service

The data link service (DLS) sub layer provides methods for:

- data link activation and release;
- data transfer; or
- error detection, correction and control.

3.2.1 Data link activation and release

Based on the MAC sub layer the DLS will listen, activate or release the data link. Activation and free or externally allocated, indicates that own equipment should be in receive mode and listen for other data link users. This should also be the case with slots, marked as available and not to be used by own station for transmission.

3.2.2 Data transfer

Data transfer should use a bit-oriented protocol and should be in accordance with this standard.

3.2.2.1 Packet format

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

FIGURE 4



Commented [PB28]: Training sequence needs to be updated;

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The packet should be sent from left to right. The training sequence should be used in order to synchronize the VHF receiver. The total length of the default packet is 512 bits. This is equivalent to one (1) slot.

3.2.2.3 Ramp-up

The ramp-up portion of the waveform provides for a gradual transition to transmission state from transmitter off state. A gradual ramp-up period provides important spectral shaping to reduce energy spread outside the desired signal modulation bandwidth, and reduces interference to other users of the current and adjacent channel. The signal modulation during ramp up period can be

Training sequence Synchronisation Header

The training sequence synchronisation header should be a bit pattern consisting of 1111100110101 www of [1101 0000 1110 1001 1101 0000] (ref 2.5). The training sequence synchronisation header

3.2.2.4 Data

The data portion is 384 bits long in the default transmission packet. The content of data is undefined at the DLS. Transmission of data, which occupy more than 384 bits, is described in § xxx.

3.2.2.5 Frame check sequence

The FCS uses the cyclic redundancy check (CRC) 32-bit polynomial to calculate the checksum as defined in ISO/IEC 13239:2002. The CRC bits should be pre-set to one (1) at the beginning of a CRC calculation. Only the data portion The synchronisation header and data should be included in

3.2.2.6 End flag

The end flag should be 8 bits long. It is used in order to detect the end of a transmission packet. The end flag consists of a bit pattern, 8 bits long: 01111110 (7E_h). The CRC is used to ensure the proper end flag has been found.

3.2.2.7 Buffer

The buffer is normally 4840 bits long and should be used as follows:

- bit stuffing: 8 bits (normally, for all messages except safety related messages and
- distance delay: 28 bits
- synchronization jitter: 12 bits

3.2.2.7.1 Distance delay¹

A buffer value of 28 bits is reserved for distance delay. This is equivalent to 235.9 nautical miles (NM). This distance delay provides protection for a propagation range of over 120 NM. For messages intended for satellite reception a buffer value of 196 bits is reserved for distance delay.

3.2.2.7.1 Synchronization jitter

For synchronization jitter refer to Recommendation ITU-R M.1371 Annex 2-(Class A)

¹ 1 Nautical mile = 1 852 metres

235.9 Nautical miles = 436 886.8 metres; 120 Nautical miles = 222 240 metres

Commented [AM29]: Default packet can be shorter, to minimize space-based interference between packets on adjacent slots. Using code of less than rate 1/2 will still provide substantial message 'payload' data volume (prior to coding).

Commented [JS30]: We should consider a training sequence which implements Barker codes and allows for multiple waveforms and coding rates. I would suggest using a combination the 13 bit Barker Code and a start flag: 1111100110101 01111110 xx www. xx selects the FEC coding:

000 – not coding
001 – 1/2 coding
010 – 3/4 coding
011 – 5/6 coding

www – selects waveform
000 – π/4 DQPSK

Commented [PB31]: Add header numbering

Commented [AM32]: Should also specify data during the 'ramp-up' portion of the waveform (bit sequence used) – as part of this signal will be transmitted with some significant power level, knowing the bit sequence can assist with packet frequency, timing acquisition and hence detection.

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Commented [PB33]: Add reference when defined

Commented [AM34]: Not necessarily required, per discussions for sat to ship VDES downlink. Predefined length of message with given coding rate should suffice (as bit stuffing is not recommend as well).

Commented [PB35]: Should reference time rather than bits

Commented [PB37]: Should be the same as AIS

Commented [PB38]: Should reference time

Commented [AM39]: Can expand this definition for space reception case - ?

3.2.2.8 Summary of the default transmission packet

The data packet is summarized as shown in Table 6:

TABLE 6

| | | |
|-------------------|----------|---|
| Ramp up | 16 bits | T0 to TTS in Fig. 8 |
| Training sequence | 24 bits | Necessary for synchronization |
| Data | 384 bits | Default |
| CRC | 32 bits | Only the data field is included in the CRC |
| End flag | 8 bits | Fixed value of 7E _h |
| Buffer | 48 bits | Bit stuffing distance delays, repeater delay and jitter |
| Total | 512 bits | |

Commented [PB40]: Need to try to make this generic to accommodate different modulation techniques;

Commented [PB41]: How likely is it that turbo coding could create an invalid end flag?

3.2.2.9 Transmission timing

Figure 6 shows the timing events of the default transmission packet (one slot). 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 termination of transmission. This prevents undesired interference, due to false locking of receiver modems, with the succeeding transmission in the next slot. There should be no modulation during the ramp down period.

Commented [AM42]: That is a good idea

3.2.2.10 Long transmission packets

A station may occupy at maximum 5 consecutive slots for one (1) continuous transmission. Only a single application of the overhead (ramp up, training sequence, flags, FCS, buffer) is required for a long transmission packet. The length of a long transmission packet should not be longer than necessary to transfer the data; i.e. the ASM should not add filler.

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3.2.3 Error detection and control

Error detection and control should be handled using the CRC polynomial as described in § 3.2.2.5. CRC errors should result in no further action by the ASM.

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3.2.4 Forward Error correction

Turbo Coding – selectable rate

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3.3 Sub layer 3 – link management entity

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

3.3.1 Access to the data link

There should be different access schemes for controlling access to the data transfer medium. The application and mode of operation determine the access scheme to be used. The access schemes are ITDMA, RATDMA, SOTDMA, and FATDMA.

Commented [PB43]: Verify that 1371 describes RATDMA such that multiple slots entry is supported;

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3.3.1.1 Cooperation on the data link

The access schemes operate continuously, and in parallel, on the same physical data link. They all conform to the rules set up by the TDMA. The ASM and VDE systems must give priority to the AIS system when accessing the physical data link.

Commented [PB44]: Must VDE give priority to ASM or vice-versa?

3.3.1.2 Candidate slots

Slots, used for transmission, are selected from *candidate slots* in the selection interval (SI) which is defined as 150 slots for an ASM transmission. The selection process uses received data. There should be at minimum four candidate slots to choose. When selecting candidates for messages longer than one (1) slot, a candidate slot should be the first slot in a consecutive block of free. The candidate slots are selected from free slots. No intentional re-use of a slot is allowed. If the station

Commented [AM45]: Why 150 candidate slots? Is this from 2,250?

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When selecting among candidate slots for transmission in one channel, the slot usage of other
The own station is unable to transmit on an adjacent slot on the two parallel channels because of the
used for transmission is to provide high probability of access to the link. To further provide high
probability of access, time-out characteristics are applied to the use of the slots so that slots will
continuously become available for new use.

Commented [AM47]: What is meant by 'parallel' channels?

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.

3.3.2.1 Autonomous and continuous

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

3.3.2.2 Assigned

A station operating in the assigned mode takes into account the transmission schedule of the assigning message when determining when it should transmit.

3.3.2.3 Polled

A station operating in polled mode should automatically respond to interrogation messages. Operation in the polled mode should not conflict with operation in the other two modes. The response should be transmitted on the channel where the interrogation message was received.

3.3.3 Initialization

At power on, a station should monitor the TDMA channels for one (1) minute to determine channel activity, other participating member IDs, current slot assignments, 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 one (1) minute has elapsed, the station may be available to transmit ASM messages according to its own schedule.

3.3.4 Channel access schemes

The access schemes, as defined below, should coexist and operate simultaneously on the TDMA channel. For all access schemes there should be a minimal interval of x slots between transmissions, and the unit should not be rude.

Commented [PB48]: Replace with reference to 1371 provided RATDMA as described in 1371 is adequate for multi-slot; Also include FATMDA (missing here)

Commented [PB49]: The minimal interval should be tied to the channel load rather than a fixed interval (look into repeater standard for threshold), and should consider AIS activity as well

3.3.4.1 Incremental time division multiple access

The ITDMA access scheme allows a station to pre-announce additional transmission slots.

3.3.4.1.1 Incremental time division multiple access algorithm

Commented [PB50]: Taken directly from 1371

A station can begin its ITDMA transmission by allocating a new, unannounced slot, using RATDMA.

Prior to transmitting in the first ITDMA slot, the station may randomly select the next following ITDMA slot and calculate the relative offset to that location. This offset should be inserted into the ITDMA communication state. Receiving stations will be able to mark the slot, indicated by this offset, as externally allocated. The communication state is transmitted as a part of the ITDMA transmission. The process of allocating slots continues as long as required. In the last ITDMA slot, the relative offset is set to zero and no new slots are allocated.

3.3.4.1.2 Incremental time division multiple access parameters

The parameters of Table 7 control ITDMA scheduling:

TABLE 7

| <u>Symbol</u> | <u>Name</u> | <u>Description</u> | <u>Minimum</u> | <u>Maximum</u> |
|---------------|-----------------|--|----------------|----------------|
| 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 | Number of 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 present slot(s) should be reserved in the next frame also. The keep flag is set to FALSE when the allocated slot should be freed immediately after transmission | False = 0 | True = 1 |

3.3.4.2 Random access time division multiple access

RATDMA is used when a station needs to allocate a slot, which has not been pre-announced. This is generally done as the first transmission slot for a message group, or for messages that cannot be pre-announced by a previous transmission.

3.3.4.2.1 Random access time division multiple access algorithm

The RATDMA access scheme should use a probability persistent (p-persistent) algorithm as described in this paragraph (see Table 8).

An ASM station should avoid using RATDMA when possible. A previously scheduled message should be used to announce a future transmission when possible to avoid RATDMA transmissions.

Messages, which use the RATDMA access scheme, are stored in a priority first-in first-out (FIFO). When a candidate slot 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.RTP1) and the station should wait for the next candidate slot in the frame.

The SI for RATDMA should be 150 time slots, which is equivalent to 4 s. The candidate slot set should be chosen within the SI, so that the transmission occurs within 4 s.

Each time that a candidate slot is entered, the p-persistent algorithm is applied. If the algorithm determines that a transmission shall be inhibited, then the parameter LME.RTCSC is decremented by one and LME.RTA is incremented by one.

LME.RTCSC can also be decremented as a result of another station allocating a slot in the candidate set. If $LME.RTCSC + LME.RTA < 4$ then the candidate set shall be complemented with a new slot within the range of the current slot and LME.RTES following the slot selection criteria.

3.3.4.2.2 Random access time division multiple access parameters

The parameters of Table 8 control RATDMA scheduling:

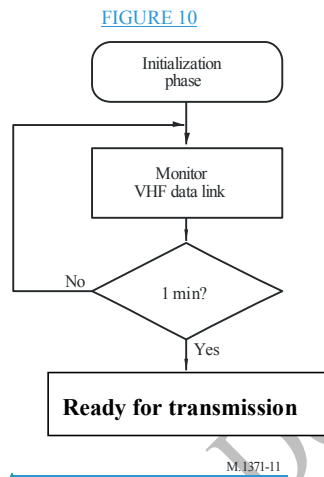
TABLE 8

| Symbol | Name | Description | Minimum | Maximum |
|-----------|------------------------|---|----------|---------|
| LME.RTCSC | Candidate slot counter | The number of slots currently available in the candidate set. NOTE 1 – The initial value is always 4 or more (see § 3.3.1.2). However, during the cycle of the p-persistent algorithm the value may be reduced below 4 | 1 | 150 |
| LME.RTES | End slot | Defined as the slot number of the last slot in the initial SI, which is 150 slots ahead | 0 | 2 249 |
| LME.RTPRI | Priority | The priority that the transmission has when queuing messages. The priority is highest when LME.RTPRI is lowest. Safety related messages should have highest service priority (refer to § 4.2.3) | 1 | 0 |
| LME.RTPS | Start probability | Each time a new message is due for transmission, LME.RTP2 should be set equal to LME.RTPS. LME.RTPS shall be equal to $100/LME.RTCSC$. NOTE 2 – LME.RTCSC is set to 4 or more initially. Therefore LME.RTPS has a maximum value of ≈ 25 ($100/4$) | 0 | 25 |
| 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.RTA | Number of attempts | Initial value set to 0. This value is incremented by one each time the p-persistent algorithm determines that a transmission shall not occur | 0 | 149 |
| LME.RTPI | Probability increment | Each time the algorithm determines that transmission should not occur, LME.RTP2 should be incremented with LME.RTPI. LME.RTPI shall be equal to $(100 - LME.RTP2)/LME.RTCSC$ | 1 | 25 |

Commented [AM51]: This implies very fast transmission rate on the average per device – there may be many cases where much more infrequent operation is adequate, and sharing of the channel should ideally also be efficient in such a scenario.

3.3.4.4 Initialization phase

The initialization phase is described using the flowchart shown in Fig. 10.



Monitor VHF data link

At power on, a station should monitor the TDMA channel for one (1) min interval 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.

Network access and entry of a new data stream

- Initial network entry using RATDMA
- Entry of new data stream using previously allocations by ITDMA
- For periodic transmissions using ITDMA schedule
- Single message transmission using RATDMA or scheduled ITDMA
- Dynamic allocation of additional slots using existing ITDMA
- Priority of transmissions
- Limits how many slots
- Required intervals between transmission, adaptive to the channel load;
- Respect for AIS channel activity (both for transmission and reception);

Assigned operation

A controlling station may:

- Assign slots to a mobile station

Field Code Changed

Commented [AM52]: Is such a slot or frame map similar to Class-A, and subject to license fee if used for lower tier transponders? If so, should a slot-map free variation be also available?

Commented [PB53]: We need to define in a stand-alone section what we mean by "respect AIS" similar to the slot reuse description;

- Exclude slots for autonomous use by other stations
- Limit the amount of slots for a specific station or in an area
- The controlling station needs to support authentication

Entering assigned mode

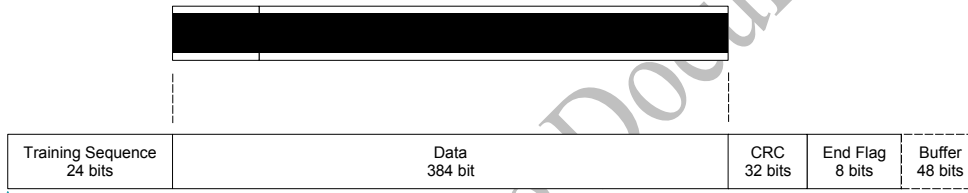
Operating in the assigned mode

Returning to autonomous and continuous mode

Message structure

Messages, which are part of the access schemes, should have the following structure shown in Fig. 1611 inside the data portion of a data packet: TBD

FIGURE 11



Commented [PB54]: Make this clear that the message length here is the maximum for a single slot, however the message can be up to 5 slots; variable length field

Field Code Changed

Each message is described using a table with parameter fields listed from top to bottom.

Each parameter field is defined with the most significant bit first.

Parameter fields containing sub-fields (e.g. communication state) are defined in separate tables with sub-fields listed top to bottom, with the most significant bit first within each sub-field.

Character strings are presented left to right most significant bit first. All unused characters should be represented by the @ symbol, and they should be placed at the end of the string.

When data is output on the VHF data link it should be grouped in bytes of 8 bits from top to bottom of the table associated with each message in accordance with ISO/IEC 13239:2002. Each byte should be output with least significant bit first. ~~During the output process, data should be subject to~~

Unused bits in the last byte should be set to zero in order to preserve byte boundary.

[Generic example for a message table:](#)

TABLE 11

| <u>Parameter</u> | <u>Symbol</u> | <u>Number of bits</u> | <u>Description</u> |
|------------------|---------------|-----------------------|--------------------|
| <u>P1</u> | <u>I</u> | <u>6</u> | <u>Parameter 1</u> |
| <u>P2</u> | <u>D</u> | <u>1</u> | <u>Parameter 2</u> |
| <u>P3</u> | <u>I</u> | <u>1</u> | <u>Parameter 3</u> |
| <u>P4</u> | <u>M</u> | <u>27</u> | <u>Parameter 4</u> |
| <u>P5</u> | <u>N</u> | <u>2</u> | <u>Parameter 5</u> |
| <u>Unused</u> | <u>0</u> | <u>3</u> | <u>Unused bits</u> |

[Logical view of data as described in § 3.3.7:](#)

| | | | | | |
|-------------------|-----------------|----------------|----------------|----------------|-----------------|
| <u>Bit order</u> | <u>M----L--</u> | <u>M-----</u> | <u>-----</u> | <u>-----</u> | <u>--LML000</u> |
| <u>Symbol</u> | <u>TTTTTDI</u> | <u>MMMMMMM</u> | <u>MMMMMMM</u> | <u>MMMMMMM</u> | <u>MMNN000</u> |
| <u>Byte order</u> | <u>1</u> | <u>2</u> | <u>3</u> | <u>4</u> | <u>5</u> |

[Output order to VHF data link \(bit-stuffing is disregarded in the example\):](#)

| | | | | | |
|-------------------|-----------------|----------------|----------------|----------------|-----------------|
| <u>Bit order</u> | <u>--L----M</u> | <u>-----M</u> | <u>-----</u> | <u>-----</u> | <u>000LML--</u> |
| <u>Symbol</u> | <u>IDTTTTT</u> | <u>MMMMMMM</u> | <u>MMMMMMM</u> | <u>MMMMMMM</u> | <u>000NNMM</u> |
| <u>Byte order</u> | <u>1</u> | <u>2</u> | <u>3</u> | <u>4</u> | <u>5</u> |

Message identification

[The message ID should be \[6\] bits long and should range between \[0 and 63\]. The message ID should identify the message type.](#)

[The message ID should be 6 bits long and should respect the current definitions of message IDs as defined for AIS in ITU-R M.1371.](#)

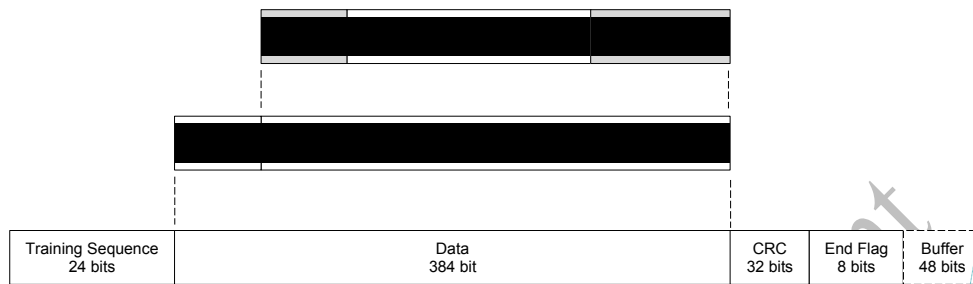
Incremental time division multiple access message structure

[The ITDMA message structure supplies the necessary information in order to operate in accordance with § xxx. The message structure is shown in Fig. 12:](#)

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FIGURE 12



User identification

The user ID should be a unique identifier and is [30] bits long.

Incremental time division multiple access communication state

The communication state provides the following functions:

- it contains information used by the slot allocation algorithm in the ITDMA concept;
- it also indicates the synchronization state.

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

TABLE 12

| <u>Parameter</u> | <u>Number of bits</u> | <u>Description</u> |
|------------------------|-----------------------|--|
| <u>Sync state</u> | 2 | 0 UTC direct (see § 3.1.1.1) 1 UTC indirect (see § 3.1.1.2) |
| <u>Slot increment</u> | 13 | Offset to next slot to be used, or zero (0) if no more transmissions |
| <u>Number of slots</u> | 3 | Number of consecutive slots to allocate. 0 = 1 slot, 1 = 2 slots, 2 = 3 slots, 3 = 4 slots, 4 = 5 slots, 5 = 1 slot; offset = slot increment + 8 192, 6 = 2 slots; offset = slot increment + 8 192, 7 = 3 slots; offset = slot increment + 8 192. Use of 5 to 7 removes the need for RATDMA broadcast for scheduled transmissions up to 6 min intervals |
| <u>Keep flag</u> | 1 | Set to TRUE = 1 if the slot remains allocated for one additional frame (see Table 13) |

The ITDMA communication state should apply only to the slot in the channel where the relevant transmission occurs. ASM 1 and ASM 2 are independent channels.

3.3.7.4 Random access time division multiple access message structure

Long-range applications may be provided by VDES equipment. **It also may provide, by dedicated equipment, for long-range application.**

4.1 General

The medium access control (MAC) sub layer 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.

4.1 Long-range applications by broadcast

Long-range ASM receiving systems may receive long-range ASM broadcast messages, provided these messages are appropriately structured and transmitted to suit the receiving systems.

4.2 Packet bit structure for long-range broadcast message

Long-range ASM receiving systems require suitable guard period and buffering in order to preserve the integrity of the ASM message in the ASM slot boundaries. Table ** shows an example of a modified packet bit structure that is designed to support reception of ASM messages by satellites with orbital altitudes up to 600 km.

TABLE **

Modified packet bit structure for long-range ASM message reception

| Slot composition | Bits | Notes |
|--|------|--|
| Guard period | 100 | Propagation time delay difference = 144 bits Propagation time delay difference of the other ASM messages = 28 bits Ramp up = 16 bits Note - Propagation time delay difference may be changed in accordance with the target satellite orbital altitude |
| Ramp up | 16 | Standard |
| Training sequence | 24 | Standard |
| Data field | 170 | Data field is 384 bits for other single-slot ASM messages. This field is shortened by 194 bits to support the long-range receiving system Message ID = 6 bits User ID = 30 bits Spare = 6 bits Binary data = 128 bits Note - Binary data length may be changed in accordance with the target satellite orbital altitude |
| CRC | 32 | Standard |
| End flag | 8 | Standard |
| Long-range ASM receiving system buffer | 162 | Bit stuffing = 8 bits Synch jitter (mobile station) = 6 bits Synch jitter (mobile/satellite) = 2 bits Propagation time delay difference = 144 bits Spare = 2 bits Note - Propagation time delay difference may be changed in accordance with the target satellite orbital altitude |

Commented [PB56]: Bit stuffing will not be used this needs to be adjusted as appropriate

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| | | |
|-------|-----|----------|
| Total | 512 | Standard |
|-------|-----|----------|

4.2.1 Long-range automatic identification system broadcast message

The long-range ASM broadcast message data field is shown in Table **.

This message should be transmitted by shipborne mobile station.

TABLE **

Long-range ASM broadcast message data field

| <u>Parameter</u> | <u>Number of bits</u> | <u>Description</u> |
|-------------------------|------------------------------|--|
| Message ID | 6 | Identifier for this message; always ** |
| User ID | 30 | MMSI number |
| Binary data | 138 | |
| Spare | 16 | Set to zero, to preserve byte boundaries |
| Total number of bits | 190 | |

4.3 Transmission method for the long-range automatic identification system broadcast message

The long-range ASM broadcast message may be transmitted using an arbitrary ASM channel at the current power setting as a transmit-only function.

4.3.1 Access scheme

There should be different access schemes for controlling access to the data transfer medium. The application and mode of operation determine the access scheme to be used.

The access schemes for the long-range ASM are ITDMA, RATDMA and CSTDMA. The ITDMA and RATDMA should be used in accordance with § 3.3.

4.3.2 Carrier sense time division multiple access

The CSTDMA access scheme may be selected by the long-range ASM message application as an optional.

4.3.2.1 Carrier sense detection method

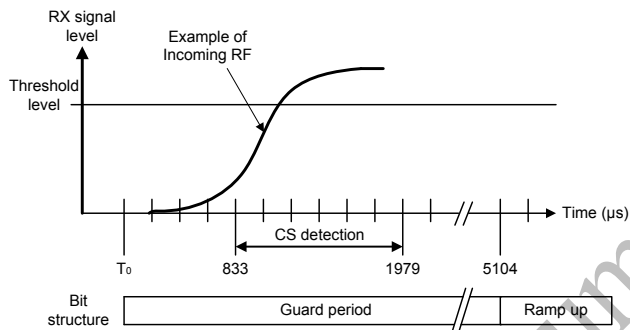
Within a time window of 1 146 μ s starting at 833 μ s and ending at 1 979 μ s after the start of the time period intended for transmission (T_0) ASM equipment using CSTDMA should detect if that time period is used (CS detection window).

NOTE 1 – Signals within the first 16 bits (833 μ s) of the time period are excluded from the decision (to allow for propagation delays and ramp down periods of other units).

ASM equipment using CSTDMA should not transmit on any time period in which, during the CS detection window, a signal level greater than the “CS detection threshold” (§ 4.3.2.2) is detected.

The transmission of a CSTDMA packet should commence 90 bits (4 688 μ s + T_0) after the nominal start of the time period (see Fig. 35).

FIGURE **
Carrier sense timing



Field Code Changed

4.3.2.2 Carrier sense detection threshold

The carrier sense (CS) detection threshold should be determined over a rolling 60 s interval on each Rx channel separately. The threshold should be determined by measuring the minimum energy level (representing the background noise) plus an offset of 10 dB. The minimum CS detection threshold should be -107 dBm and background noise should be tracked for a range of at least 30 dB (which results in a maximum threshold level of -7 dBm)².

4.3.2.3 Multi-channel operation

If ASM uses only for long-range application with only CSTDMA access scheme. The ASM should be capable of receiving on two independent channels and transmitting on two independent channels. At least one TDMA receiving process should be used to receive on two independent frequency channels. One TDMA transmitter should be used to alternate TDMA transmissions on two independent frequency channels.

4.4 Transmitting the long-range broadcast message

The long-range ASM broadcast message should be transmitted only on ASM channels and not on the AIS channels (channels 75, 76, AIS 1, AIS 2 or regional channels).

² The following example is compliant with the requirement:

Sample the RF signal strength at a rate >1 kHz, average the samples over a sliding 20 ms period and over a 4 s interval determine the minimum period value. Maintain a history of 15 such intervals. The minimum of all 15 intervals is the background level. Add a fixed 10 dB offset to give the CS detection threshold.