International Telecommunication Union

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Radiocommunication Sector of ITU

Recommendation ITU-R M.2092-1

(02/2022)

Technical characteristics for a VHF data exchange system in the VHF maritime mobile band

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RECOMMENDATION ITU-R M.2092-1

Technical characteristics for a VHF data exchange system in the VHF maritime mobile band

(2015-2022)

Scope

This Recommendation provides the technical characteristics of a VHF data exchange system (VDES) which integrates the functions of VHF data exchange (VDE) comprising both terrestrial and satellite components, application specific messages (ASM) and the automatic identification system (AIS) operating in the frequency bands listed in Appendix **18** of the Radio Regulations (RR).

Keywords

Maritime, VHF, VDES, ASM, data exchange

Abbreviations/Glossary

ACK	Acknowledgement
ACM	Adaptive coding and modulation
AIS	Automatic identification system
ARQ	Automatic repeat request
ASC	Announcement signalling channel
ASM	Application-specific messages
AWGN	Additive white Gaussian noise
BB	Bulletin board
BBSC	Bulletin board signalling channel
BER	Bit error rate
BPSK	Binary phase shift keying
BW	Bandwidth
CA	Certificate authority
CDMA	Code division multiple access
CPM	Continuous phase modulation
CQI	Channel quality indicator
CRC	Cyclic redundancy check
DAC	Designated area code
DC	Data channel
DLS	Data link service
DSCH	Data signalling channel
EDN	End delivery notification
e.i.r.p.	Equivalent isotropic radiated power
ETSI	European Technical Standards Institute
FATDMA	Fixed access time-division multiple access
FEC	Forward error correction

GNSS	Global navigation satellite system
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ID	Identification
IEC	International Electrotechnical Commission
IMO	International Maritime Organization
IP	Internet protocol
ITU	International Telecommunication Union
LC	Logical channel
LCID	Link config ID
LEO	Low-earth orbiting
LME	Link management entity
LNA	Low noise amplifier
LSB	Least significant bit
MAC	Media access control
MCS	Modulation and coding scheme
MITDMA	Multiple incremental time division multiple access
MMSI	Maritime mobile service identity
MSB	Most significant bit
NM	Nautical mile
OSI	Open systems interconnection
PAPR	Peak to average power ratio
PC	Physical channels
PCN	Physical channel number
pfd	Power flux-density
PKI	Public key infrastructure
PI	Presentation interface
PL	Physical layer
ppm	parts per million
PSK	Phase shift keying
QAM	Quadrature amplitude modulation
QPSK	Quadrature phase shift keying
RA	Random access
RAC	Random access channel
RATDMA	Random access time-division multiple access
RC	Ranging channel
RF	Radio frequency
RMS	Root mean square
RR	Radio Regulations
RSC	Recursive systematic convolutional
SI	Selection interval
SINR	signal to interference-plus-noise ratio
SYNC	Synchronization

TBB	Terrestrial bulletin board
TDMA	Time division multiple access
UTC	Coordinated universal time
VDE	VHF data exchange
VDES	VHF data exchange system
VDE-SAT	VHF data exchange-satellite
VDE-TER	VHF data exchange-terrestrial
VDL	VHF data link
VHF	Very high frequency

Related ITU Recommendations, Reports

Recommendations

ITU-R M.585 – Assignment and use of identities in the maritime mobile service

ITU-R M.1084 – Interim solutions for improved efficiency in the use of the band 156-174 MHz by stations in the maritime mobile service

ITU-R M.1371 – Technical characteristics for an automatic identification system using time-division multiple access in the VHF maritime mobile band

Report

ITU-R M.2435 – Technical studies on the satellite component of the VHF data exchange system

The ITU Radiocommunication Assembly,

considering

a) that the International Maritime Organization (IMO) has a continuing requirement for a universal shipborne automatic identification system (AIS);

b) that the use of a universal shipborne AIS allows efficient exchange of navigational data between ships and between ships and shore stations, thereby improving safety of navigation;

c) that the VHF data exchange system (VDES) should use appropriate access schemes that ensure the protection of AIS while making efficient use of the spectrum and accommodate all users;

d) that while AIS is used primarily for surveillance and safety of navigation purposes in ship-to-ship use, ship reporting and vessel traffic services applications, a growing need for other maritime safety related communications has developed;

e) that the VDES gives priority to AIS, and also accommodate future expansion in the number of users and diversification of data communications applications, including vessels which are not subject to IMO AIS carriage requirements, aids to navigation and search and rescue;

f) that the VDES has data communications capacity and technical characteristics that support the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment,

recognizing

that the implementation of VDES ensures that the functions of digital selective calling, AIS and voice distress, safety and calling communication (Channel 16), are not impaired, *recommends*

1 that general elements of VDES should be designed in accordance with Annex 1;

2 that technical elements common to VHF data exchange (VDE) and application specific messages (ASM) should be designed in accordance with Annex 2;

3 that technical characteristics of the ASM channel should be designed in accordance with Annex 3;

4 that technical characteristics of the VDE-terrestrial (VDE-TER) channel should be designed in accordance with Annex 4;

5 that technical characteristics of the satellite component of VDE-satellite (VDE-SAT) should be designed in accordance with Annex 5;

6 that characteristics necessary for each component of VDES to share the available spectrum such that impact between applications is minimized and AIS is respected should be designed in accordance with Annex 6;

7 that applications of the VDES which make use of ASM designed for AIS, as defined in Recommendation ITU-R M.1371 should also take into account the international application identifier branch, as specified in IMO SN.1/Circ. 289, maintained and published by IMO;

8 that the design and installation of VDES should also consider relevant technical requirements, recommendations and guidelines published by IMO, IEC and IALA;

9 that VDES should give its highest priority to the AIS position reporting and safety related information;

10 that VDES should be capable of transmitting additional safety information on request;

11 that VDES installation should be able to operate continuously while under way, moored or at anchor;

12 that VDES should be capable of various modes of operation, including the autonomous, assigned and polled modes;

13 that VDES should provide flexibility for the users in order to prioritize some applications and, consequently, adapt some parameters of the transmission (robustness or capacity) while minimizing system complexity;

14 that VDES shipborne stations should have one multi-function transmitter and a multi-channel and multi-function receiver capable of simultaneously supporting the functions AIS, ASM, VDE-TER and VDE-SAT.

Annex 1

General description of the VHF data exchange system operating system

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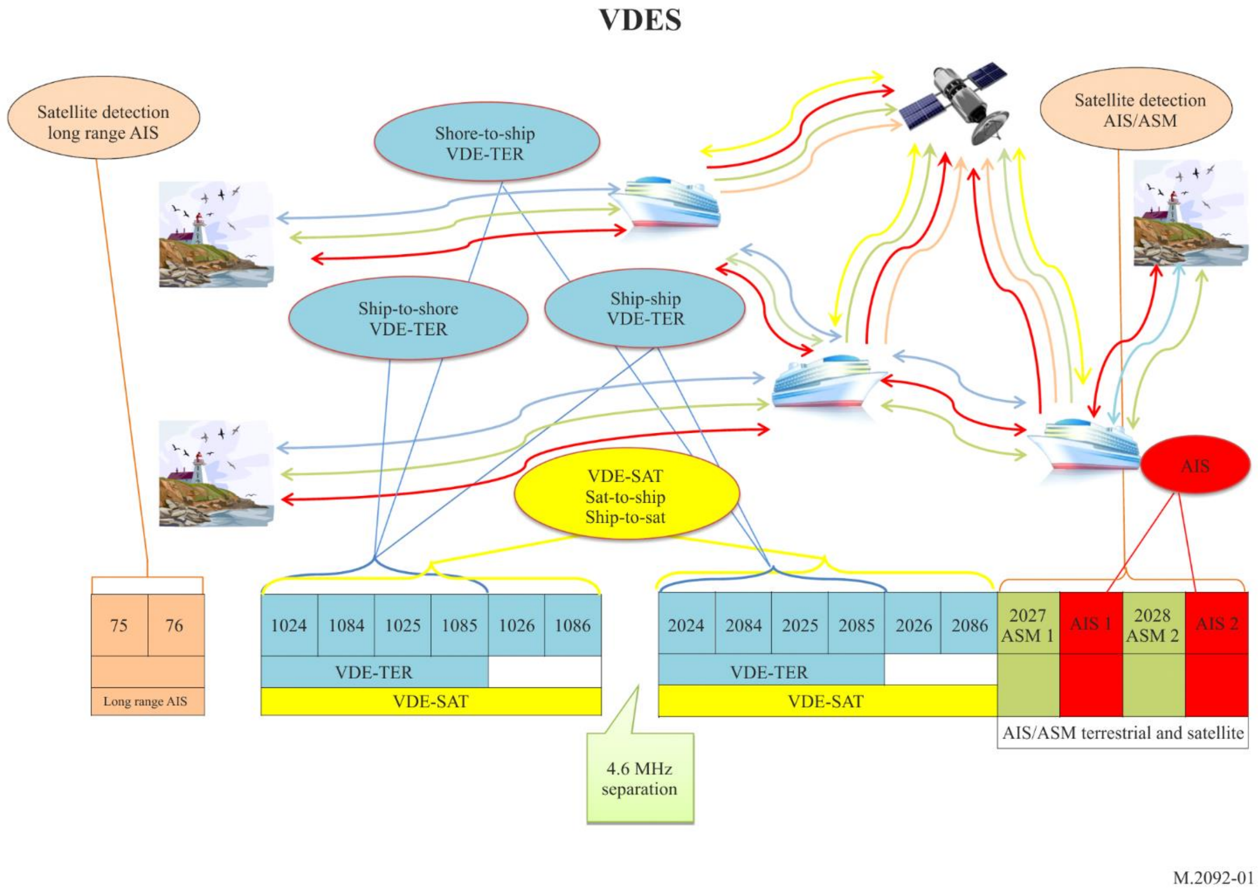
1 General description of VHF data exchange system

In essence, the VDES provides a variety of means for the exchange of data between maritime stations, ship-to-ship, ship-to-shore, shore-to ship, ship-to-satellite and satellite-to-ship. The VDES is a multi-component system comprising of VDE, ASM and the AIS in the VHF maritime mobile band (156.025-162.025 MHz). The VDES has a terrestrial component VDE-TER and a satellite component VDE-SAT. The VDES functions are illustrated pictorially in Fig. 1.

FIGURE 1

VHF data exchange system functions illustrated



2 Key technical characteristics

2.1 Satellite downlink

To ensure interoperability and compatibility between VDE-TER and VDE-SAT, a pfd-mask is described by the following formula, where θ° is the angle between the direction of the earth's horizon and the direction of the satellite.

$$\theta° = earth\ to\ satellite\ elevation\ angle$$

$$PFD(\theta°)_{\ (\mathrm{dBW/(m^2*4\ kHz)})} = \begin{cases} -149 + 0.16 * \theta° & 0° \leq \theta < 45°; \\ -142 + 0.53 * (\theta° - 45°) & 45° \leq \theta < 60°; \\ -134 + 0.1 * (\theta° - 60°) & 60° \leq \theta \leq 90°. \end{cases}$$

2.2 VHF data exchange-terrestrial may operate in either duplex or simplex mode

VDE-TER may operate in duplex mode by using the lower leg channels for ship-to-shore and the upper leg channels for shore-to-ship and ship-to-ship digital messaging.

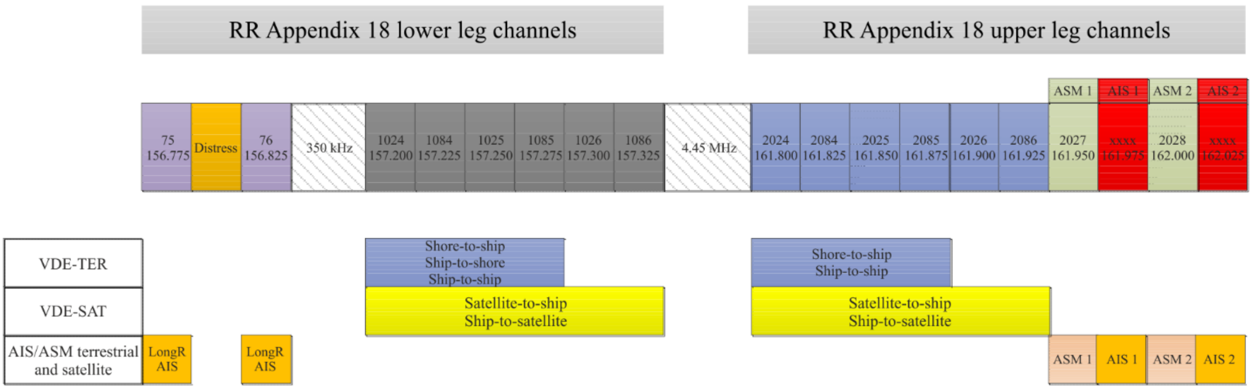
VDE-TER may operate in simplex mode by using the lower leg channels for ship-to-shore, shore-to-ship and ship-to-ship digital messaging.

2.3 VHF data exchange system channel usage in accordance with Appendix 18 of the Radio Regulations

This section provides information on channel usage between terrestrial stations and between satellite and terrestrial stations. The VDES frequency usage is illustrated in Fig. 2.

FIGURE 2

VHF data exchange system frequency usage



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AIS 1 and AIS 2, which are AIS channels, are used in accordance with Recommendation ITU-R M.1371, and are also used for receiving AIS messages by satellite.

Long Range AIS using channel 75 and channel 76 are used in accordance with Recommendation ITU-R M.1371 for receiving AIS messages by satellite.

ASM 1 and ASM 2 are ASM channels used in accordance with this recommendation for ASM, and are also used for receiving ASM by satellite.

Channels 1024, 1084, 1025 and 1085 are the VDE channels used in accordance with this Recommendation and identified for ship-to-shore, shore-to-ship and ship-to-ship VDE, but may be used for VDE-SAT without imposing constraints on VDE-TER.

Channels 2024, 2084, 2025 and 2085 are the VDE channels used in accordance with this Recommendation and are identified for shore-to-ship and ship-to-ship VDE, but may be used for VDE-SAT without imposing constraints on VDE-TER.

Channels 1026, 1086, 2026 and 2086 are VDE channels used in accordance with this Recommendation and are identified for ship-to-satellite and satellite-to-ship VDE and are not used by the terrestrial component of VDE.

2.4 Station identification

Identification and location of all active maritime stations is provided automatically by means of the AIS. All VDES stations should be uniquely identified. For the purpose of identification, a unique numerical identifier is used as defined by the following:

If the unique identifier has a range which is less than or equal to 999999999, then this number is defined by the most recent version of Recommendation ITU-R M.585.

If the unique identifier has a range which is greater than 999999999, then this number is free form.

2.5 Presentation interface protocol

For VDES transceivers:

– data may be input via the presentation interface to be transmitted by the VDES station;
– data received by the VDES station should be output through the presentation interface.

2.6 VHF data exchange system communications prioritization

Since transmissions by own equipment may impair reception by own equipment on own ship, the priority and timing of ship station transmissions shall be in accordance with the following service priorities:

Highest Priority 1: AIS transmissions

Priority 2: ASM transmissions – see § 4.5.3, Annex 3

Priority 3: VDE transmissions – see § 4.19, Annex 4

The references given above are specifically addressing how priority is given to AIS by each VDES function.

The ship station VDES receivers should always be active.

Annex 2

Common technical elements of VHF data exchange system

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This Annex describes those elements of VDES that may be common across the ASM and VDE Channels.

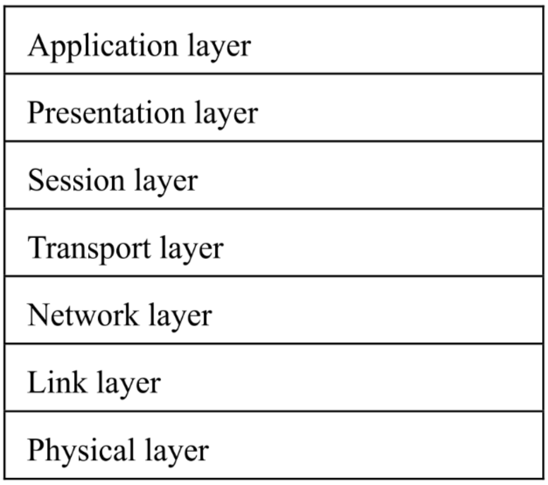
1 Protocol layer

1.1 Protocol layer overview

The VDES architecture should utilize the open systems interconnection layers 1 to 4 (physical layer (PL), link layer, network layer, transport layer) as illustrated in Fig. 3.

FIGURE 3

Seven-layer open systems interconnection model



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1.2 Physical layer

This layer provides transmission and reception of raw bit streams over a physical medium including signal modulation, filtering/shaping upon transmission, and amplification, filtering, time and frequency synchronization, demodulation, and decoding upon reception.

1.2.1 Transmission accuracy figures

1.2.1.1 Symbol timing accuracy (at the output)

The timing accuracy of the transmit signal should be better than 5 ppm.

1.2.1.2 Transmitter timing jitter

The timing jitter should be better than 5% of the symbol interval (peak value).

1.2.1.3 Slot transmission accuracy at the output

The slot transmission accuracy should be better than 100 μs peak relative to coordinated universal time (UTC) reference for ship stations.

1.2.2 Frame structure

The system uses the Recommendation ITU-R M.1371 concept of a frame. A frame equals one (1) minute and is divided into 2 250 slots. The slot is a time interval of approximately 26.667 ms (60 000 / 2 250 ≈ 26.667). Access to the data link is, by default, given at the start of a slot. The VDES frame structure is identical and synchronized in time to UTC (as in AIS). The general slot formats are shown in Figs 4 and 5.

FIGURE 4

Application specific message – terrestrial and VHF data exchange-terrestrial general slot format

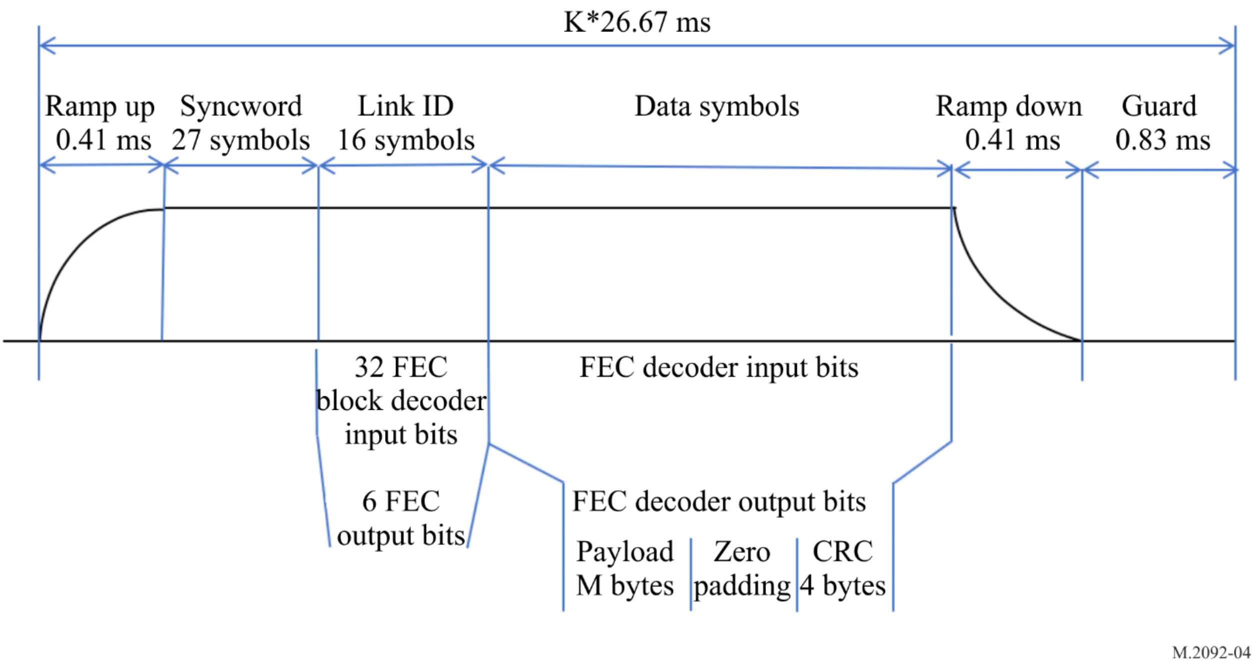
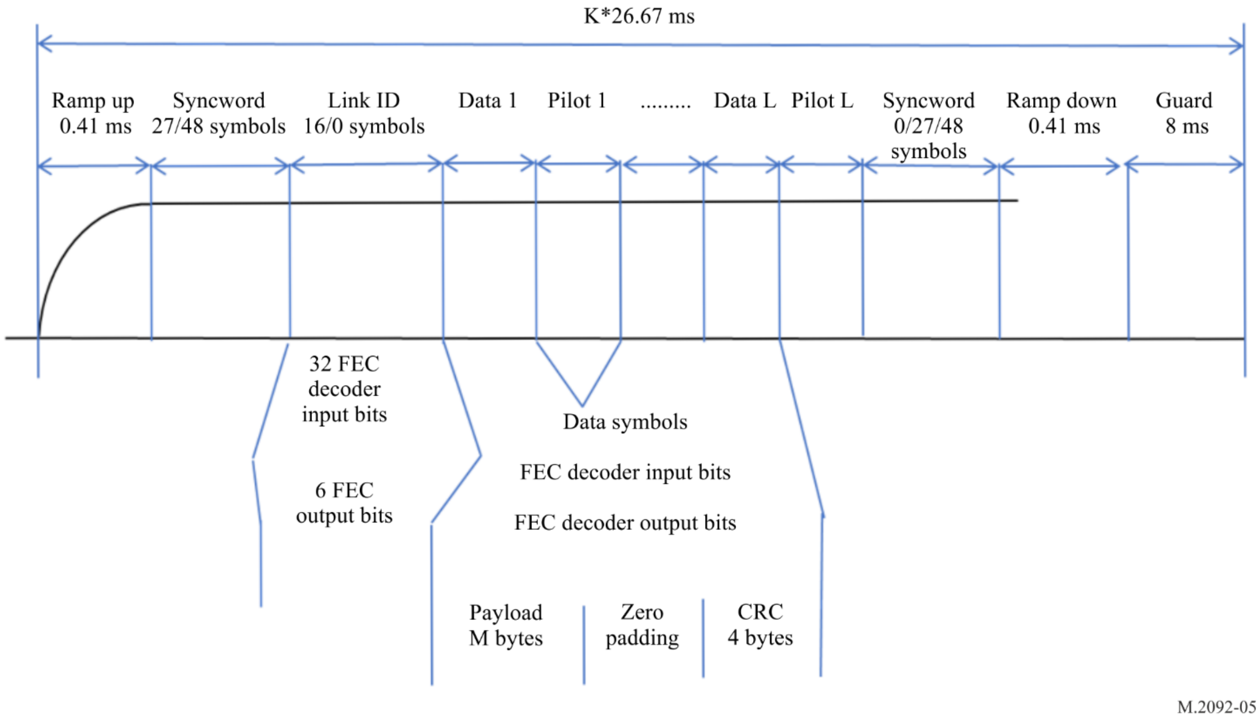


FIGURE 5

Application specific message – satellite and VHF data exchange-satellite general slot format



1.2.3 Burst transmission structure

1.2.3.1 Ramp up

The ramp up from −50 dBc to −1.5 dBc of the power shall have a controlled rise time and occur in approximately 417 µs. 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 modulation during ramp up is not specified.

1.2.3.2 Training sequence

Table 1 shows the syncwords used for VDES.

TABLE 1

Syncwords for VHF data exchange system

<table>
<tr><th>Usage</th><th>Symbol size</th><th>Sequence</th><th>Type</th></tr>
<tr><td>ASM-TER</td><td rowspan="2">27</td><td rowspan="2">1 1111100110101 0000011001010</td><td rowspan="2">1+ Barker13+ inverted Barker13</td></tr>
<tr><td>VDE-TER</td></tr>
<tr><td>ASM-SAT</td><td rowspan="2">27</td><td rowspan="2">010001010010010000000110011</td><td rowspan="3">Best autocorrelation for differential detection</td></tr>
<tr><td>VDE-SAT</td></tr>
<tr><td>VDE-SAT</td><td>48</td><td>0001000111100110110000010101 1101101011011110100</td></tr>
</table>

The Double Barker sequence used for ASM-TER and VDE-TER allows for detection of the two correlation peaks and the 13-bit known noise in-between. Furthermore, the correlation peak size indicates frequency offset.

1.2.3.3 Bit mapping for training sequence

For training the following mapping applies:

1 maps to π/4 quadrature phase shift keying (QPSK) (1 1) (see Fig. 11)

0 maps to π/4 QPSK (0 0).

For π/4 QPSK bit mapping, see § 1.2.9.

1.2.3.4 Link identification

The Link ID defines the channel configurations. The Link ID is used to index the table of channel configurations (see Tables 7, 8, 9, 10 and 11).

The Link ID follows the training sequence for transmissions (see Figs 4 and 5), and uses π/4 QPSK bit mapping (see § 1.2.9). Note that not all burst transmission structures utilize the Link ID (refer to Tables 7, 8, 9, 10 and 11).

The Link ID consists of 6 bits (D0, D1, D2, D3, D4, D5) encoded into a sequence of 32 bits using biorthogonal (32,6) code. The code is a first order Reed-Muller code with generator matrix:

TABLE 2

Reed-Muller generator matrix

Generator matrix
10 00 00 10 11 10 10 01 11 10 10 01 10 01 01 10
01 00 00 01 11 01 01 01 11 01 01 01 01 01 01 01
00 10 00 11 10 11 00 11 00 11 00 11 00 11 00 11
00 01 00 11 00 00 11 11 10 00 11 11 00 00 11 11
00 00 10 00 01 11 11 11 00 00 00 00 11 11 11 11
00 00 01 00 00 00 00 00 01 11 11 11 11 11 11 11

The code shall be bit scrambled using the scrambling word 11000010111000101000111001001111. This results in the Link ID coding of Table 3.

TABLE 3

Link identification code words for VHF data exchange system

Link ID	Bit-scrambled code word	Link ID	Bit-scrambled code word
0	11 00 00 10 11 10 00 10 10 00 11 10 01 00 11 11	32	01 00 00 00 00 00 10 11 01 10 01 11 11 01 10 01
1	11 00 01 10 11 10 00 10 11 11 00 01 10 11 00 00	33	01 00 01 00 00 00 10 11 00 01 10 00 00 10 01 10
2	11 00 10 10 10 01 11 01 10 00 11 10 10 11 00 00	34	01 00 10 00 01 11 01 00 01 10 01 11 00 10 01 10
3	11 00 11 10 10 01 11 01 11 11 00 01 01 00 11 11	35	01 00 11 00 01 11 01 00 00 01 10 00 11 01 10 01
4	11 01 00 01 11 10 11 01 00 00 00 01 01 00 00 00	36	01 01 00 11 00 00 01 00 11 10 10 00 11 01 01 10
5	11 01 01 01 11 10 11 01 01 11 11 10 10 11 11 11	37	01 01 01 11 00 00 01 00 10 01 01 11 00 10 10 01
6	11 01 10 01 10 01 00 10 00 00 00 01 10 11 11 11	38	01 01 10 11 01 11 10 11 11 10 10 00 00 10 10 01
7	11 01 11 01 10 01 00 10 01 11 11 10 01 00 00 00	39	01 01 11 11 01 11 10 11 10 01 01 11 11 01 01 10
8	11 10 00 01 01 01 00 01 10 11 11 01 01 11 11 00	40	01 10 00 11 10 11 10 00 01 01 01 00 11 10 10 10
9	11 10 01 01 01 01 00 01 11 00 00 10 10 00 00 11	41	01 10 01 11 10 11 10 00 00 10 10 11 00 01 01 01
10	11 10 10 01 00 10 11 10 10 11 11 01 10 00 00 11	42	01 10 10 11 11 00 01 11 01 01 01 00 00 01 01 01
11	11 10 11 01 00 10 11 10 11 00 00 10 01 11 11 00	43	01 10 11 11 11 00 01 11 00 10 10 11 11 10 10 10
12	11 11 00 10 01 01 11 10 00 11 00 10 01 11 00 11	44	01 11 00 00 10 11 01 11 11 01 10 11 11 10 01 01
13	11 11 01 10 01 01 11 10 01 00 11 01 10 00 11 00	45	01 11 01 00 10 11 01 11 10 10 01 00 00 01 10 10
14	11 11 10 10 00 10 00 01 00 11 00 10 10 00 11 00	46	01 11 10 00 11 00 10 00 11 01 10 11 00 01 10 10
15	11 11 11 10 00 10 00 01 01 00 11 01 01 11 00 11	47	01 11 11 00 11 00 10 00 10 10 01 00 11 10 01 01
16	10 00 00 11 00 11 01 11 01 01 10 11 00 01 10 10	48	00 00 00 01 11 01 11 10 10 11 00 10 10 00 11 00
17	10 00 01 11 00 11 01 11 00 10 01 00 11 10 01 01	49	00 00 01 01 11 01 11 10 11 00 11 01 01 11 00 11
18	10 00 10 11 01 00 10 00 01 01 10 11 11 10 01 01	50	00 00 10 01 10 10 00 01 10 11 00 10 01 11 00 11
19	10 00 11 11 01 00 10 00 00 10 01 00 00 01 10 10	51	00 00 11 01 10 10 00 01 11 00 11 01 10 00 11 00
20	10 01 00 00 00 11 10 00 11 01 01 00 00 01 01 01	52	00 01 00 10 11 01 00 01 00 11 11 01 10 00 00 11
21	10 01 01 00 00 11 10 00 10 10 10 11 11 10 10 10	53	00 01 01 10 11 01 00 01 01 00 00 10 01 11 11 00
22	10 01 10 00 01 00 01 11 11 01 01 00 11 10 10 10	54	00 01 10 10 10 10 11 10 00 11 11 01 01 11 11 00
23	10 01 11 00 01 00 01 11 10 10 10 11 00 01 01 01	55	00 01 11 10 10 10 11 10 01 00 00 10 10 00 00 11
24	10 10 00 00 10 00 01 00 01 10 10 00 00 10 10 01	56	00 10 00 10 01 10 11 01 10 00 00 01 10 11 11 11
25	10 10 01 00 10 00 01 00 00 01 01 11 11 01 01 10	57	00 10 01 10 01 10 11 01 11 11 11 10 01 00 00 00
26	10 10 10 00 11 11 10 11 01 10 10 00 11 01 01 10	58	00 10 10 10 00 01 00 10 10 00 00 01 01 00 00 00

TABLE 3 (*end*)

Link ID	Bit-scrambled code word	Link ID	Bit-scrambled code word
27	10 10 11 00 11 11 10 11 00 01 01 11 00 10 10 01	59	00 10 11 10 00 01 00 10 11 11 11 10 10 11 11 11
28	10 11 00 11 10 00 10 11 11 10 01 11 00 10 01 10	60	00 11 00 01 01 10 00 10 00 00 11 10 10 11 00 00
29	10 11 01 11 10 00 10 11 10 01 10 00 11 01 10 01	61	00 11 01 01 01 10 00 10 01 11 00 01 01 00 11 11
30	10 11 10 11 11 11 01 00 11 10 01 11 11 01 10 01	62	00 11 10 01 00 01 11 01 00 00 11 10 01 00 11 11
31	10 11 11 11 11 11 01 00 10 01 10 00 00 10 01 10	63	00 11 11 01 00 01 11 01 01 11 00 01 10 11 00 00

The Link ID is not used by the satellite link.

1.2.3.5 Data payload with cyclic redundancy check

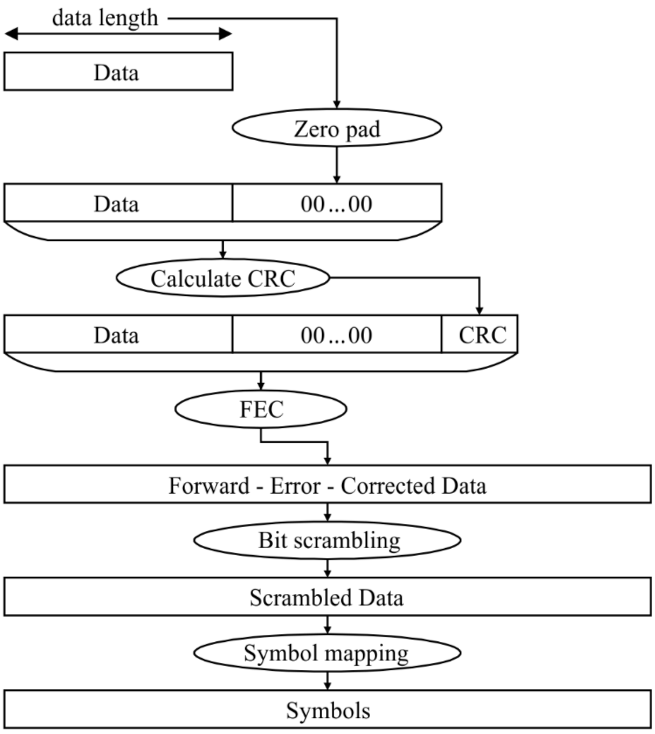
Input data is processed most significant bit (MSB) first.

The data payload with its appended cyclic redundancy check (CRC) (refer to § 1.2.5) is interleaved (refer to Table 4) encoded (refer to § 1.2.4.1), scrambled (refer to § 1.2.6) and bit mapped (refer to § 1.2.9).

Unused payload data is zero-filled.

FIGURE 6

Typical order of operations for symbol data; if cyclic redundancy=1 and forward error correction is not applied



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1.2.3.6 Bit scrambling

Scrambling of the user data is required to avoid the power spectral density to be concentrated in the narrow band. Refer to § 1.2.6 for the detailed definition of the scrambler sequence.

1.2.3.7 Guard time

The guard time consists of the ramp down time from full power to −50 dBc of less than or equal to 417 μs. The remaining time is for delay and jitter.

1.2.4 Forward error correction

1.2.4.1 Encoder structure

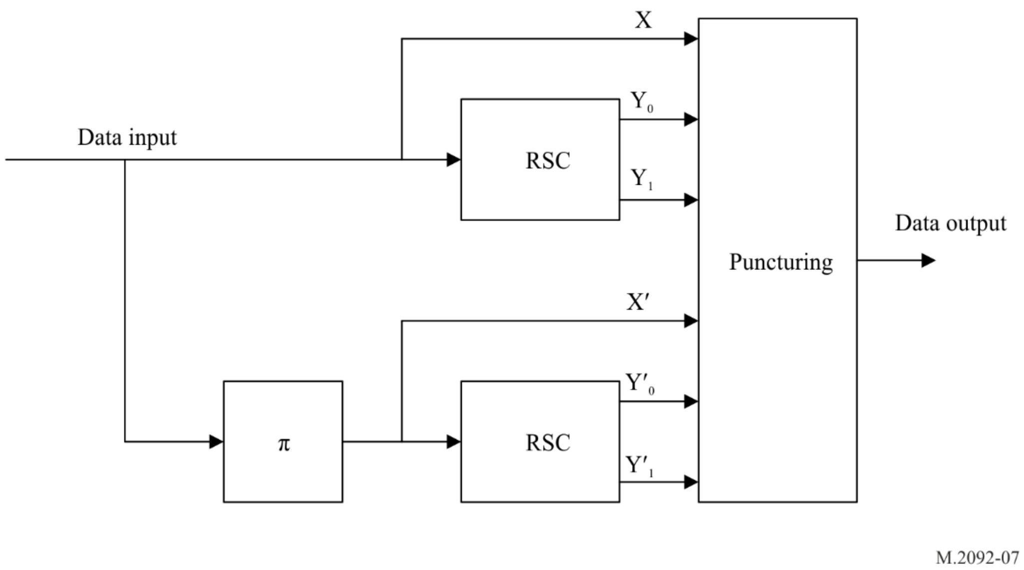
This paragraph defines the general structure of the forward error correction encoder to be used on the satellite and the terrestrial component of the VDES. The overall structure follows the specification in the European Technical Standards Institute standard (ETSI) EN 302 583[1].

The general encoder structure is depicted in Fig. 7. The encoder consists of two recursive systematic convolutional (RSC) encoders concatenated in parallel. Each encoder produces three output bits per input bit. The first RSC encoder produces the bits X, Y_0 and Y_1, while the second encoder produces the bits X', Y'_0 and Y'_1. The <pi> block in Fig. 7 represents the interleaving function as described in § 1.2.4.3.

The first encoder gets as input a word **u** of k bits, with k, as specified in § 1.2.4.3. The second encoder input is denoted by **u**' and it is a permuted version of the vector **u**. The input **u** is the data (including padding and CRC), with MSB of each byte first. For example, if the data is 0x7F, 0xA5, … **u** will be 01111111 10100101 ….

FIGURE 7

Turbo encoder structure (high-level)



1.2.4.2 Constituent codes

The constituent codes are specified by the transfer function:

$$G(D) = \begin{bmatrix} 1 & \frac{n_0(D)}{d(D)} & \frac{n_1(D)}{d(D)} \end{bmatrix}$$

1 ETSI EN 302 583 (V1.2.1) – Digital Video Broadcasting (DVB); Framing Structure, channel coding and modulation for Satellite Services to Handheld devices (SH) below 3 GHz.

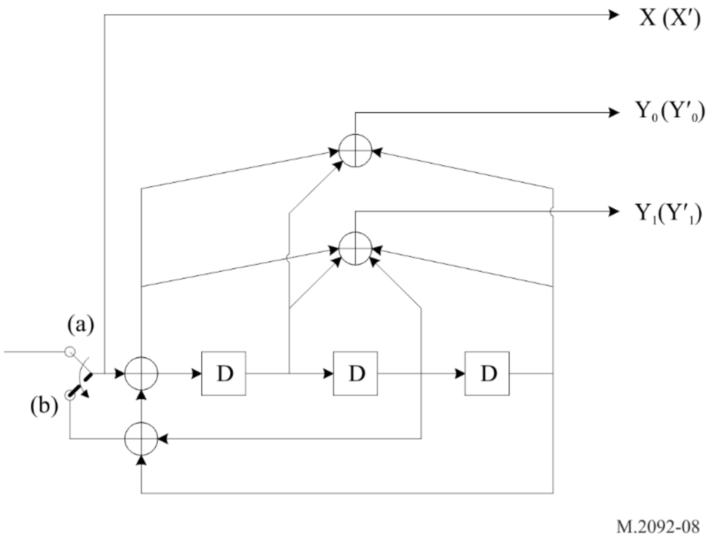
where:

$$n_0(D) = 1 + D + D^3$$
$$n_1(D) = 1 + D + D^2 + D^3$$
$$d(D) = 1 + D^2 + D^3.$$

The constituted encoder definition is provided in Fig. 8. For the first k clocks the switch is in position (a), i.e. information is fed into the encoder. For the subsequent six clocks, the switch is moved to position (b) to handle the RSC trellis termination. In the first three termination clocks, only the RSC 1 (upper branch) is output, while in the subsequent three termination clocks, only the output of RSC 2 (lower branch) is provided. The termination is thus given by the sequence of six termination bits (X, Y_0, Y_1, X', Y'_0, Y'_1) with X output first.

FIGURE 8

Recursive systematic convolutional code encoder



1.2.4.3 Interleaver definition

The interleaver specification follows that prescribed in the Consultative Committee for Space Data systems, Recommendation for Space Data System Standards, "*TM Synchronization and Channel Coding*". CCSDS 131.0-B-2. Blue Book. Issue 2. Washington, D.C.: August 2011.

First factorize $k = k_1 k_2$, where the parameters k_1 and k_2 depend on the choice of the respective code, where k is the information block length. Then select prime numbers and puncturing parameters values as given in Table 4.

TABLE 4

Interleaver and puncturing parameters for different information lengths / code rates

LinkID	Nominal code rate	Information length	k1|k2	p1|p2|p3| p4| p5| p6| p7| p8	Puncturing ID	Tail ID
4	3/4	952	4|240	113|31|59|163|29|181|101|11	8	8
5	3/4	288	2|144	47|17|233|127|239|139|199|163	8	8b
6	3/4	672	2|336	37|101|191|149|79|131|229|31	8	8b
7	3/4	1056	4|264	23|31|167|223|59|113|47|211	8	8b
8*	1/2	192	2|96	31|37|43|47|53|59|61|67	6	6
9*	1/2	448	2|224	31|37|43|47|53|59|61|67	6	6
10*	1/2	704	2|352	31|37|43|47|53|59|61|67	6	6
11	1/2	432	2|216	127|191|241|5|83|109|107|179	6	6a
12	3/4	972	2|486	31|37|43|47|53|59|61|67	8	8
13	3/4	1296	2|648	31|37|43|47|53|59|61|67	8	8
14	1/2	896	2|448	31|37|43|47|53|59|61|67	6	6
15	3/4	2016	4|504	31|37|43|47|53|59|61|67	8	8
16	3/4	2688	4|672	31|37|43|47|53|59|61|67	8	8
17	1/2	1872	6|312	211|61|227|239|181|79|73|193	6	6a
18	3/4	4032	4|1008	31|37|43|47|53|59|61|67	8	8
19	3/4	5616	16|351	137|101|223|41|67|131|61|47	8	8
20	1/4	96	2|48	37|83|211|61|107|101|149|167	2	2a
21	2/3	736	2|368	139|17|241| 47|109|11|29|163	7a	7a
22	2/3	3120	16|195	89|47|239|17|127|59|43|31	7a	7b
23	2/3	4544	4|1136	31|37|43|47|53|59|61|67	7b	7b
24	5/6	3788*2	4|947	127|251|227|173|139|149|101|7	9	9
25	1/2	4776	12|398	31|37|43|47|53|59|61|67	6	6a
26	1/4	5456*7	16|341	37|41|43|47|53|59|61|67	2	2a
27	1/2	6032*19	16|377	31|37|43|47|53|59|61|67	6	6b
28	1/4	5280*4	16|330	31|37|43|47|53|59|61|67	2	2b
29	1/4	5552*6	16|347	31|37|43|47|53|59|61|67	2	2c
30	1/4	5320*13	14|380	31|37|43|47|53|59|61|67	2	2c
31	1/4	5328*22	16|333	31|41|43|47|53|59|61|67	2	2d
32	1/4	312	2|156	37|79|29|139|151|97|181|157	2	2e
33	1/3	4280	8|535	59|37|157|167|239|83|163|29	4	4a
34	1/3	4160*2	16|260	163|157|149|137|197|47|241|251	4	**

* No previous definitions or simulations results available, but a default configuration suggested.

** No tail bits.

Table 4 will be extended as different information block lengths are defined.

This forward error correction (FEC) will be calculated by first choosing prime numbers p_q, $q \in (1, ..., 8)$ as given in Table 4.

The following operations shall be performed for $s \in (1, ..., k)$ to obtain the permutation numbers $\pi(s)$:

$$m = (s-1)\ mod\ 2$$

$$i = floor\ ((s-1)\ /(2k_2))$$

$$j = floor\ ((s-1)\ /2)) - ik_2$$
$$t = (19i + 1)\ mod\ (k_1/2)$$
$$q = t\ mod\ 8 + 1$$
$$c = \left(p_q j + 21m\right) mod\ k_2$$
$$\pi(s) = 2(t + ck_1/2 + 1) - m$$

The permutation numbers shall be interpreted such that the s^{th} bit read out after interleaving is the $\pi(s)^{th}$ bit of the input information block.

1.2.4.4 Rate adaptation

Rate adaptation is obtained by puncturing the encoder output as in § 5.3.1 of ETSI EN 302 583[2], as recalled in Table 5 for the first k clocks, and as in ETSI EN 302 583[2].

The puncturing table for the termination part is given in Table 6. The last two rows of Table 6 are not part of ETSI EN 302 583[2].

TABLE 5

Puncturing patterns for data bit periods

Punc. pattern ID	**Code rate**	**Punc. pattern (X; Y0; Y1; X'; Y'0; Y'1 | X; Y0; Y1; X'; Y'0; Y'1 | …)**
0	1/5	1;1;1;0;1;1
1	2/9	1;0;1;0;1;1 | 1;1;1;0;1;1 | 1;1;1;0;0;1 | 1;1;1;0;1;1
2	1/4	1;1;1;0;0;1 | 1;1;0;0;1;1
3	2/7	1;0;1;0;0;1 | 1;0;1;0;1;1 | 1;0;1;0;0;1 | 1;1;1;0;0;1
4	1/3	1;1;0;0;1;0
5	2/5	1;0;0;0;0;0 | 1;0;1;0;0;1 | 0;0;1;0;0;1 | 1;0;1;0;0;1 | 1;0;1;0;0;1 | 0;0;1;0;0;1 | 1;0;1;0;0;1 | 1;0;1;0;0;1 | 0;0;1;0;0;1 | 1;0;1;0;0;1 | 1;0;1;0;0;1 | 0;0;1;0;0;1
6	1/2	1;1;0;0;0;0 | 1;0;0;0;1;0
7	2/3	1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;1;0;0;1
7a	2/3	1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;1;0;0;1;0
7b	2/3	1;0;0;0;0;0 | 1;1;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;1;0
8	3/4	1;0;1;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;1
9	5/6	1;0;0;0;0;0 | 1;1;0;0;0;0 | 1;0;0;0;1;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0

Note: For each rate, the puncturing table shall be read first from left to right and then from top to bottom.

Within a puncturing pattern, a '0' means that the symbol shall be deleted and a '1' means that a symbol shall be passed. A '2' or a '3' means that two or three copies of the symbol shall be passed. This is relevant for the termination periods. In particular:

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2 Digital Video Broadcasting (DVB); Framing Structure, channel coding and modulation for Satellite Services to Handheld devices (SH) below 3 GHz.

For the rate 1/5 turbo code (Punct_Pat_ID=0), the tail output symbols for each of the first three tail bit periods shall be $XXXY_0Y_1$, and the tail output symbols for each of the last three tail bit periods shall be $X'X'X'Y'_0Y'_1$.

For the rate 2/9 turbo code (Punct_Pat_ID=1), the tail output symbols for the first and the second output period shall be $XXXY_0Y_1$, for the third output period XXY_0Y_1, for the fourth and fifth output period $X'X'Y'_0Y'_1$, and for the sixth (last) output period $X'X'X'Y'_0Y'_1$.

For the rate 1/4 turbo code (Punct_Pat_ID=2), the tail output symbols for each of the first three tail bit periods shall be XXY_0Y_1, and the tail output symbols for each of the last three tail bit periods shall be $X'X'\ Y'_0Y'_1$.

All other code rates shall be processed similar to the given examples above with the exact puncturing patterns to be derived from ETSI EN 302 583[3].

The puncturing table for the termination part is given in Table 6. The last rows of the Table are introduced in this Recommendation to obtain higher rates, and are not part of ETSI EN 302 583[3].

TABLE 6

Puncturing and repetition patterns for tail bit periods (last 6 clocks)

Punct. pattern ID	**Code rate**	**Punct. / Rep. pattern (X; Y0; Y1; X'; Y'0; Y'1 | X; Y0; Y1; X'; Y'0; Y'1 | …)**
0	1/5	3;1;1;0;0;0 | 3;1;1;0;0;0 | 3;1;1;0;0;0 | 0;0;0;3;1;1 | 0;0;0;3;1;1 | 0;0;0;3;1;1
1	2/9	3;1;1;0;0;0 | 3;1;1;0;0;0 | 2;1;1;0;0;0 | 0;0;0;2;1;1 | 0;0;0;2;1;1 | 0;0;0;3;1;1
2	1/4	2;1;1;0;0;0 | 2;1;1;0;0;0 | 2;1;1;0;0;0 | 0;0;0;2;1;1 | 0;0;0;2;1;1 | 0;0;0;2;1;1
2a	1/4	1;1;1;0;0;0 | 1;1;1;0;0;0 | 1;1;1;0;0;0 | 0;0;0;1;1;1 | 0;0;0;1;1;1 | 0;0;0;1;1;1
2b	1/4	1;1;1;0;0;0 | 1;1;1;0;0;0 | 1;1;0;0;0;0 | 0;0;0;1;1;1 | 0;0;0;1;1;1 | 0;0;0;1;1;0
2c	1/4	1;1;0;0;0;0 | 1;1;0;0;0;0 | 1;1;0;0;0;0 | 0;0;0;1;1;0 | 0;0;0;1;1;0 | 0;0;0;1;1;0
2d	1/4	1;1;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 0;0;0;1;1;0 | 0;0;0;1;0;0 | 0;0;0;1;0;0
2e	1/4	2;1;1;0;0;0 | 2;1;1;0;0;0 | 2;1;0;0;0;0 | 0;0;0;2;1;1 | 0;0;0;2;1;1 | 0;0;0;2;0;0
3	2/7	1;1;1;0;0;0 | 2;1;1;0;0;0 | 2;1;1;0;0;0 | 0;0;0;2;1;1 | 0;0;0;1;1;1 | 0;0;0;1;1;1
4	1/3	2;1;0;0;0;0 | 2;1;0;0;0;0 | 2;1;0;0;0;0 | 0;0;0;2;1;0 | 0;0;0;2;1;0 | 0;0;0;2;1;0
4a	1/3	2;1;0;0;0;0 | 2;1;0;0;0;0 | 2;0;0;0;0;0 | 0;0;0;2;1;0 | 0;0;0;2;1;0 | 0;0;0;0;1;0
5	2/5	1;1;1;0;0;0 | 1;1;1;0;0;0 | 1;0;1;0;0;0 | 0;0;0;1;1;1 | 0;0;0;1;1;1 | 0;0;0;1;0;1
6	1/2	1;1;0;0;0;0 | 1;1;0;0;0;0 | 1;1;0;0;0;0 | 0;0;0;1;1;0 | 0;0;0;1;1;0 | 0;0;0;1;1;0
6a	1/2	1;1;0;0;0;0 | 1;1;0;0;0;0 | 1;0;0;0;0;0 | 0;0;0;1;1;0 | 0;0;0;1;1;0 | 0;0;0;1;0;0
6b	1/2	1;1;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 0;0;0;1;1;0 | 0;0;0;1;0;0 | 0;0;0;1;0;0
7	2/3	1;0;0;0;0;0 | 1;0;1;0;0;0 | 1;0;1;0;0;0 | 0;0;0;1;0;0 | 0;0;0;1;0;1 | 0;0;0;1;0;0
7a	2/3	1;1;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 0;0;0;1;1;0 | 0;0;0;1;0;0 | 0;0;0;1;0;0
7b	2/3	1;1;0;0;0;0 | 1;1;0;0;0;0 | 1;1;0;0;0;0 | 0;0;0;1;1;0 | 0;0;0;1;1;0 | 0;0;0;1;1;0
8	3/4	1;0;1;0;0;0 | 1;0;1;0;0;0 | 1;0;1;0;0;0 | 0;0;0;1;0;1 | 0;0;0;1;0;1 | 0;0;0;1;0;1
8a	3/4	1;0;1;0;0;0 | 1;0;1;0;0;0 | 1;0;1;0;0;0 | 0;0;0;1;0;1 | 0;0;0;1;0;1 | 0;0;0;1;0;0
8b	3/4	1;0;1;0;0;0 | 1;0;1;0;0;0 | 1;0;0;0;0;0 | 0;0;0;1;0;1 | 0;0;0;1;0;1 | 0;0;0;1;0;0
9	5/6	1;1;0;0;0;0 | 1;0;0;0;0;0 | 1;0;0;0;0;0 | 0;0;0;1;1;0 | 0;0;0;1;0;0 | 0;0;0;1;0;0

For each rate, the puncturing table shall be read first from left to right and then from top to bottom.

3 Digital Video Broadcasting (DVB); Framing Structure, channel coding and modulation for Satellite Services to Handheld devices (SH) below 3 GHz.

1.2.4.5 Determine the number of forward error correction decoder input bits

Typically, the number of FEC decoder input bits is equal to the FEC decoder output bits divided by the FEC rate. However, one or more of the last bits as given by the puncturing pattern in Table 4 is not received when the number of FEC decoder output bits divided by the puncturing length is not an integer number. In the following, the number of FEC decoder input and output bits are denoted N and *K* respectively, and the FEC rate is denoted *r*.

At the transmitter side, the Turbo encoder typically encodes a block of *K* bits into a codeword of *N* bits, given by $N = (1/r)\cdot K$. Since the output of the Turbo code is punctured, this equality is however only valid when the block length *K* is a multiple of the puncturing length *Lp*.

In the case when *K* is not a multiple of *Lp* one should determine the actual number of output bits by examining the puncturing table *P* since the exact number of output bits then depends on how the puncturing table is defined.

The Turbo code puncturing table *P* has size 6·*Lp* as defined in Table 4 and the number of 1's in the Table is exactly *Lp*/*r*.

The number of output bits from the Turbo encoder, excluding tail bits, is then given as:

$$I = \lfloor K/L_p \rfloor$$
$$R = K \bmod L_p$$
$$N = I\left(L_p/r\right) + \sum_{j=1}^{R} \sum_{i=1}^{6} P(i,j)$$

1.2.5 Cyclic redundancy check

A generated CRC check sequence is appended to the last segment of the datagram. A 32-bit CRC-32 check sequence is applied for all waveforms except for the satellite waveform SAT-MCS-1.50-2 (Link ID 20) which applies a 16 bits CRC-16 check sequence. The CRC-32 is calculated with the generator polynomial

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^{8} + x^{7} + x^{5} + x^{4} + x^{2} + x + 1$$

and the CRC-16 with the generator polynomial $x^{16} + x^{15} + x^{2} + 1$. CRC check sequence generation shall be equivalent to that defined in ITU-T H.222.0, Annex A of Recommendation ITU-T V.42[4] for CRC-32 and ETSI EN 301 545[5] for CRC-16. The CRC check sequence is the remainder of the division of the initial value + datagram by the generator polynomial and can be effectively calculated by applying a linear feedback shift register. The 32 bits shift register for generating CRC-32 should be set to the initial value 0xFFFF FFFF, and the 16 bits shift register for generating CRC-16 to the initial value 0x0000 (all zero).

The CRC check sequence is calculated over all fragments of the datagram (including any zero padding) with MSB of each byte processed first, and the resulting CRC check sequence is appended MSB first. In the receiver, the CRC check sequence can be verified by obtaining an all zero result in the linear feedback shift register after processing over the entire data+padding+CRC datagram.

1.2.6 Bit scrambling

The bit scrambler shown in Fig. 9 uses the polynomial:

$$F(x)=1 + x^{-14} + x^{-15}$$

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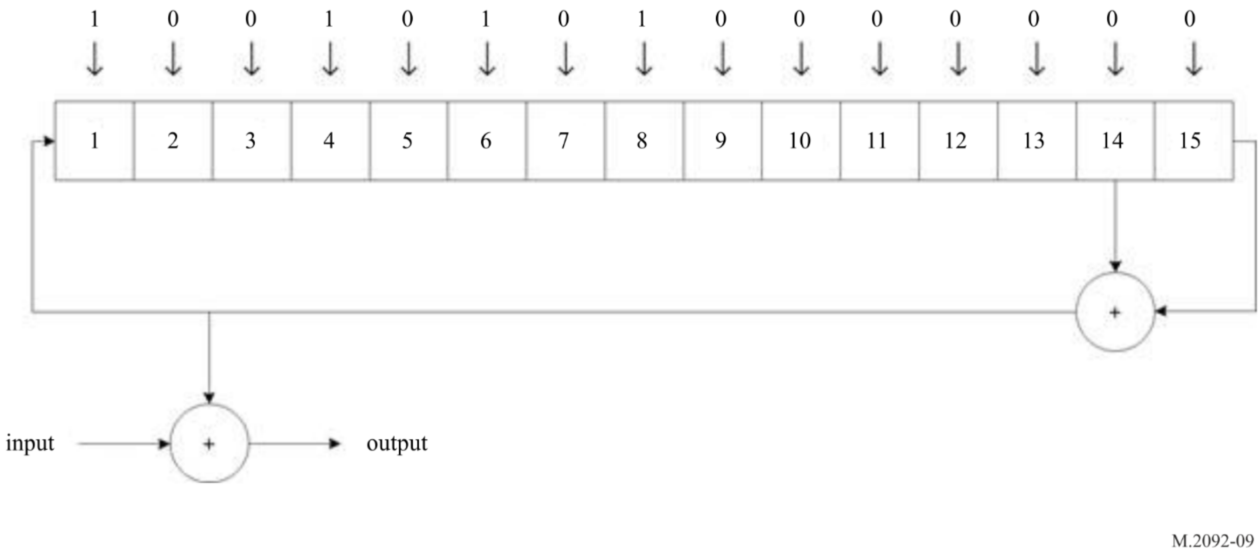
[4] Series V: Data Communication over the Telephone Network – Error control – Error-correcting procedures for DCEs using asynchronous-synchronous conversions.

[5] Digital Video Broadcasting (DVB); Second Generation DVB – Interactive Satellite System (DVB-RCS2); Part 2: Lower Layers for Satellite standard.

and the initialization sequence as indicated in the top of Fig. 9. For each transmitted packet, the bit scrambler is re-initialized. The MSB shall be the first output bit.

FIGURE 9

Bit scrambling



1.2.7 Modulation coding schemes

All modulation coding scheme (MCS) formats are defined in the Link ID in Tables 7, 8, 9, 10 and 11 (refer to Figs 4 and 5). The channel quality indicator (CQI) value is used by the adaptive coding and modulation (ACM) mechanism.

TABLE 7

Application specific message link identification parameters

PL format #	**ASM-MCS-1.16-1**	**ASM-MCS-1.16-2**	**ASM-MCS-1.16-3**	**ASM-MCS-1.16-4**	**ASM-MCS-1.16-5**	**ASM-MCS-1.16-6**	**ASM-MCS-1.16-7**			
Link ID	1	2	3	4 (SAT)	5	6	7	8[(1)]	9[(1)]	10[(1)]
Channel BW (kHz)	16									
Roll off filtering[(2)]	0.35									
Signal BW (kHz)	13.0									
Symbol rate (ksps)	9.6									
PAPR (example) (dB)	3.35									
Output average power (W)	12.5									
Burst size (slots)	1	2	3	3	1	2	3			
Guard time (ms)	0.83			8	0.83					
Burst duration (ms)	25.8	52.5	79.2	72.0	25.8	52.5	79.2			
Symbols/ burst (symbols)	248	504	760	691	248	504	760			
Ramp-up/down (symbols)	4/4									
Ramp-up/down (ms)	0.41/0.41									
Syncword size (symbols)	27									
Syncword modul. (symbols)	π/4-QPSK (00/11 only)									
Link ID symbols	16									
Link ID modul. (symbols)	π/4-QPSK									
Net symbols/burst (bits)	197	453	709	640	197	453	709			
Channel bits (bits)	394	906	1418	1280	394	906	1418			
Padding+FEC tail [(3)] (symbols)	10+0			0+11	0+10					
FEC decoder input symbols (bits)	192	448	704	634.5	192	448	704			
FEC decoder input bits (bits)	384	896	1408	1269	384	896	1408			
FEC output bits	384	896	1408	952	288	672	1056			
FEC output (bytes)	48	112	176	119	36	84	132			
Modul.	π/4-QPSK									
Bits / symbol	2									
FEC rate	1			3/4						
E_s/N_0 on AWGN (dB)	11.0	11.0	11.0	4.5	5.3	5	4.8			
$C/(N_0 + I_0)$ threshold (dB/Hz)	50.8	50.8	50.8	44.3	45.1	44.8	44.6			

(1) This link configuration is defined for future use. It is optional and not subject to testing.

(2) The baseband shall employ a root raised cosine filter.

(3) Given as padding + FEC tail bits, where the tail bits are according to Table 6, refer to § 4.6, Annex 4 Data Structures.

TABLE 8

VHF data exchange-terrestrial link identification parameters

PL format #	TER-MCS-1.25		TER-MCS-3.25		TER-MCS-5.25	TER-MCS-1.50	TER-MCS-3.50	TER-MCS-5.50	TER-MCS-1.100		TER-MCS-3.100		TER-MCS-5.100
Link ID	11	35 [4]	12 [1]	36 [4]	13 [1]	14 [1]	15 [1]	16 [1]	17	37 [4]	18 [1]	38 [4]	19
Channel BW (kHz)	25					50			100				
Roll off filtering [2]	0.3												
Signal BW (kHz)	25.0					49.9			99.8				
Symbol rate (ksps)	19.2					38.4			76.8				
Modulation	π/4-QPSK		8-PSK		16-QAM	π/4-QPSK	8-PSK	16-QAM	π/4-QPSK		8-PSK		16-QAM
PAPR (example) (dB)	3.82		4.4		6.7	3.82	4.4	6.7	3.82		4.4		6.7
Output average power (W)	12.5		11		6.5	12.5	11	6.5	12.5		11		6.5
Burst size (slots)	1												
Guard time (ms)	0.83												
Burst duration (ms)	25.8												
Symbols/burst (symbols)	496					992			1984				
Ramp-up/down (symbols)	8/8					16/16			32/32				
Ramp-up/down (ms)	0.41/0.41												
Syncword size (symbols)	27												
Syncword modulation	π/4-QPSK (00/11 only)												
Link ID size (symbols)	16 (32,6 block code)												
Link ID modulation	π/4-QPSK												
Net symbols/burst (symbols)	437					917			1877				
Channel bits	874		1311		1748	1834	2751	3668	3754		5631		7508
Padding + FEC tail [3] (bits)	0+10		3+12		8+12	30+12	51+12	72+12	0+10		243+12		8+12
FEC decoder input symbols (symbols)	432		432		432	896			1872		1792		1872
FEC decoder input bits	864		1296		1728	1792	2688	3584	3744		5376		7488
FEC output bits	432	N/A	972	N/A	1296	896	2016	2688	1872	N/A	4032	N/A	5616
FEC output bytes	54		121		162	112	252	336	234		504		702
FEC rate	1/2		3/4		3/4	1/2	3/4	3/4	1/2		3/4		3/4
E_s/N_0 on AWGN (dB)	1.0		7.9		10.2	1.0	7.9	10.2	1.0		7.9		10.2
$C/(N_0+I_0)$ threshold (dB/Hz)	43.8		50.7		53.0	46.8	53.7	56.0	49.9		56.8		59.1

(1) This link configuration is defined for future use. It is optional and not subject to testing.

(2) The baseband shall employ a root raised cosine filter.

(3) Given as padding + FEC tail bits, where the tail bits are according to Table 6, refer to § 4.6, Annex 4 Data Structures.

(4) Not for communications, reserved for future radio navigation.

TABLE 9

VHF data exchange-satellite uplink identification parameters

PL format	SAT-MCS-1.50-2	SAT-MCS-1.50-3	SAT-MCS-1.50-4	SAT-MCS-3.50-2	SAT-MCS-5.50
Link ID	20	21	22	23[(1)]	24[(3)]
Channel bandwidth (kHz)	50				
Roll off filtering [(2)]	0.25				
Signal bandwidth (kHz)	42.0				
CDMA chip rate (kcps)	33.6	N/A			
Spreading factor (chips)	16				
Symbol rate (ksps)	2.1	33.6			
PAPR (example) (dB)	0	4.35		4.9	7.1
Output average power (W)	12.5	11		10	6
Burst size (slots)	5	1	3		
Guard time (ms)	8				
Burst duration (ms)	125.3	18.7	72.0		
Symbols/burst (symbols)	263	627	2419		
Ramp-up/down (symbols)	14/14 [(4)]				
Ramp-up/down (ms)	0.41/0.41				
Syncword size (symbols)	48	27			
Syncword modulation	QPSK/CDMA (00/11)[(6)]	π/4-QPSK (00/11)			
Link ID size (symbols)	0	16 (32,6 block code)			
Link ID modulation	NA	π/4-QPSK			
Pilot symbol distance (symbols)	17	N/A		33	
Total pilot symbols (symbols)	12	0		71	
Net symbols/burst (symbols)	201	556	2348	2277	2277
Channel bits	402	1112	4696	6831	9108
Padding + FEC tail [(5)] (bits)	0+18	0+8	4+12	3+12	2*(0+8)
FEC decoder input symbols (symbols)	192	552	2340	2272	2273
FEC decoder input bits	384	1104	4680	6816	4546*2
FEC output bits	96	736	3120	4544	3788*2
FEC output bytes	12	92	390	568	947[(7)]
FEC sub-block	1	1		1	2
Modulation	QPSK / CDMA[(6)]	π/4-QPSK		8-PSK	16-QAM
FEC rate	1/4	2/3			5/6
E_s/N_0 on AWGN (dB)	-0.9	3.9	3.9	8.0	12.2
$C/(N_0+I_0)$ threshold (dB/Hz)	32.3	49.2	49.2	53.3	57.5

(1) This link configuration is defined for future use. It is optional and not subject to testing.

(2) The baseband shall employ a root raised cosine filter.

(3 FEC block is split into two sub-blocks in order to avoid very long FEC block.

(4) For spread sequence it is 14/14 chips.

(5) Given as padding + FEC tail bits, where the tail bits are according to Table 6, refer to § 4.6, Annex 4 Data Structures.

(6) The spreading sequence shall be in accordance with § 2.5.1, Annex 5.

(7) The two FEC blocks contain a non-integer number of bytes (3788 bits per FEC block).

TABLE 10

VHF data exchange-satellite downlink identification parameters

PL format	SAT-MCS-0.50-1	SAT-MCS-1.50-1	SAT-MCS-3.50-1	SAT-MCS-0.100	SAT-MCS-0.150
Link ID	25	26	27	28	29
Channel BW (kHz)	50			100	150
Roll off filtering(1)	0.25				
Signal BW (kHz)	42.0			90.0	141.0
CDMA chip rate (kcps)	33.6	N/A		72.0	112.8
Spreading factor (chips)	8			2	
Symbol rate (ksps)	4.2	33.6		36.0	56.4
Burst size (slots)	90				
Guard time (ms)	8				
Burst duration (ms)	2392.0				
Symbols/burst (symbols)	10046	80371		86112	134908
Ramp-up/down (symbols / chips)	14/14			30/30	47/47
Ramp-up/down (ms)	0.41/0.41				
Syncword size (symbols)	48	27		48	
Number of syncwords	10	35		32	
Total syncword symbols (symbols)	480	945		1536	
Syncword distance (symbols)	1004	2268		2690	4214
Syncword modulation	BPSK/ CDMA	π/4-QPSK (00 /11)		BPSK/CDMA	
Link ID size (symbols)	0 (N/A)				
Link ID modulation	N/A	N/A		N/A	
Pilot distance (symbols)	N/A	27		N/A	
Total pilots symbols (symbols)	N/A	2940		N/A	
Net symbols/burst (symbols)	9562	76458	76458	84546	133325
Burst stuffing bits	0	1	6	2	5
Channel bits	9562	152915	229368	84544	133320
Padding + FEC tail*** (bits)	0+10	7*(3+18)	(0+8)*19	4*(0+16)	6*(0+12)
FEC decoder input symbols (symbols)	9552	76384	76406	84480	133248
FEC decoder input bits*	9552	152768	229218	84480	133248
FEC output bits	4776	7*5456	19*6032	4*5280	6*5552
FEC output bytes	597	7*682	19*754	4*660	6*694
FEC sub-blocks	1	7	19	4	6
Modulation	BPSK/ CDMA	π/4-QPSK	8-PSK	BPSK/CDMA	
FEC rate	1/2	1/4	1/2	1/4	
E_s/N_0 on AWGN (dB)	−2.0	−2.4	5.0	−2.0	
$C/(N_0+I_0)$ threshold (dB/Hz)	34.2	42.9	50.3	40.6	42.5

(1) The baseband shall employ a root raised cosine filter.

(2) Given as padding + FEC tail bits, where the tail bits are according to Table 6, refer to § 4.6, Annex 4 Data Structures.

TABLE 11

VHF data exchange-satellite downlink identification parameters (*continued*)

PL format	SAT-MCS-0.50-2	SAT-MCS-0.50-3	SAT-MCS-1.50-2
Link ID	32	33	34
Channel BW (kHz)	50		
Roll off filtering[(1)]	0.25		
Signal BW (kHz)	42.0		
CDMA chip rate (kcps)	33.6	N/A	
Spreading factor (chips)	8		
Symbol rate (ksps)	4.2	33.6	
Burst size (slots)	15		
Guard time (ms)	8		
Burst duration (ms)	392.0		
Symbols/burst (symbols)	1646	13171	
Ramp-up/down (symbols/chips)	14/14		
Ramp-up/down (ms)	0.41/0.41		
Syncword size (symbols)	48	48	27
Number of syncwords (symbols)	4	6	6
Total syncword symbols (symbols)	192	288	162
Syncword distance (symbols)	531	2619	2619
Syncword modulation	BPSK / CDMA	BPSK	π/4-QPSK (00/11)
Padding (symbols)	32 for future use (not used), set to 0,1,0,1 …		
Pilot distance (symbols)	8	N/A	27
Total pilots symbols (symbols)	180	N/A	480
Burst symbol duration[(2)] (symbols)	1641	13143	13122
Net symbols/burst (symbols)	1269	12855	12480
Channel bits	1269	12855	24960
Padding + FEC tail[(3)] (bits)	0+21	0+15	0+0
FEC decoder input symbols (symbols)	1248	12840	12480
FEC decoder input bits	1248	12840	2*12480
FEC output bits	312	4280	2*4160
FEC output bytes	39	535	1040
FEC sub-blocks	1	1	2
Modulation	BPSK/CDMA	BPSK	π/4-QPSK
FEC rate	1/4	1/3	1/3
E_s/N_0 on AWGN (dB)	−4.5	−3.6	−0.6
$C/(N_0+I_0)$ threshold (dB/Hz)	31.6	41.7	44.7

(1) The baseband shall employ a root raised cosine filter.

(2) Burst symbol duration is the number of net symbols/burst plus pilot and syncword symbols.

(3) Given as padding + FEC tail bits, where the tail bits are according to Table 6, refer to § 4.6 in Annex 4.

1.2.8 Channel quality indicator

A receiving station will report a CQI in the relevant response messages to provide feedback on the quality of received transmissions. The receiving station shall estimate the CQI parameters based on a signal to noise plus interference ratio estimate, signal to interference-plus-noise ratio (SINR), given in dB. The *SINR* is equivalent to E_s/N_0 on AWGN, when no interference. The *CQI* parameter is a positive integer value that occupies one byte, ranging from 0 to 255. The relationship between the estimated *SINR* and the *CQI* is given by:

$$CQI = 4\cdot(10 + SINR) = 40 + 4\cdot SINR$$

The SINR estimate and hence the CQI parameter is independent of the channel BW, and the carrier to noise plus interference ratio estimate, $C/(N_0 + I_0)$, as given in Annex 2, is related to *SINR* by:

$$C/(N_0 + I_0) = SINR + 10\log_{10}(R_s)$$

where R_s denotes the symbol rate. An estimated *SINR* value less than −10.0 dB shall result in a minimum *CQI* value of 0, and a SINR larger 53.75 dB shall result in $CQI = 255$. The precision of the CQI parameter is 0.25 dB, but the actual accuracy is also dependent on the variance of the SINR estimate. The CQI accuracy will thus depend on the SINR working point, the length of the burst waveform, type of modulation and estimation method.

The SINR can be estimated based on averaging the noise power of demodulated symbol, found by squaring the deviating distance from nominal symbol locations. The signal power is known in advance, provided that an automatic gain control loop is implemented. Such an estimation approach can be performed on known symbols (syncwords and pilot symbols), but also on unknown symbols based on symbol location decision. Another possible method for estimating the SINR can be based on bit error rate (BER), counting the error corrected by the FEC Turbo coder.

When a response message relates to multiple received transmissions, the average CQI will be calculated and reported.

1.2.9 Bit mapping

The bit mappings used throughout the Annexes are shown in Figs 10, 11, 12 and 13.

The first output from the bit scrambler is mapped to the MSB of the first symbol, the second bit to the next bit in the symbol, and so on until the least significant bit (LSB) of the symbol has been filled, then mapping continues in the next symbol. If more bits are needed to complete the last symbol, 0 shall be used. The initial state of the alternating π/4-QPSK bit mapping is defined such that the first symbol of the training sequence is mapped to the constellation defined by points $\{(1+j)/\sqrt{2},\ (-1+j)/\sqrt{2},\ (-1-j)/\sqrt{2},\ (1-j)/\sqrt{2}\}$ (shown in green in Fig. 11); the next symbol is mapped to the constellation defined by points $\{1+0j, 0+j, -1+0j, 0-j\}$ (shown in purple in Fig. 11); the third symbol is mapped to the same constellation as the first symbol; and so on. If the modulation of the following transmission is also π/4-QPSK, then the first symbol should be mapped to the constellation defined by points $\{1+0j, 0+j, -1+0j, 0-j\}$ (shown in purple in Fig. 11).

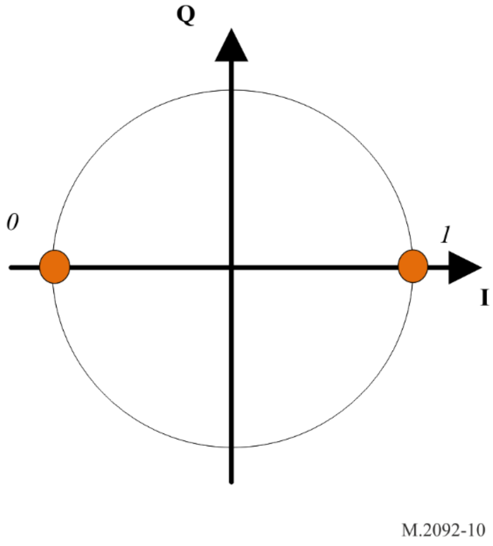
The modulation accuracy requirements for binary phase shift keying (BPSK) are:

1 The root mean square (RMS) error vector in any burst shall be less than 0.15.

2 The peak error vector magnitude shall be less than 0.45 for any symbol.

FIGURE 10

Bit mapping for binary phase shift keying



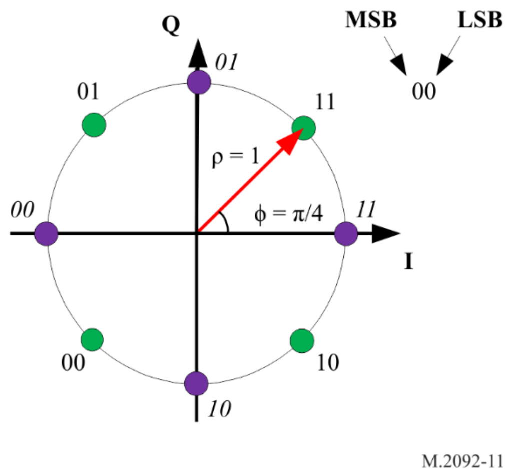
The modulation accuracy requirements for π/4-QPSK are:

1 The RMS error vector in any burst shall be less than 0.1.

2 The peak error vector magnitude shall be less than 0.3 for any symbol.

FIGURE 11

Bit mapping for π/4 quadrature phase shift keying



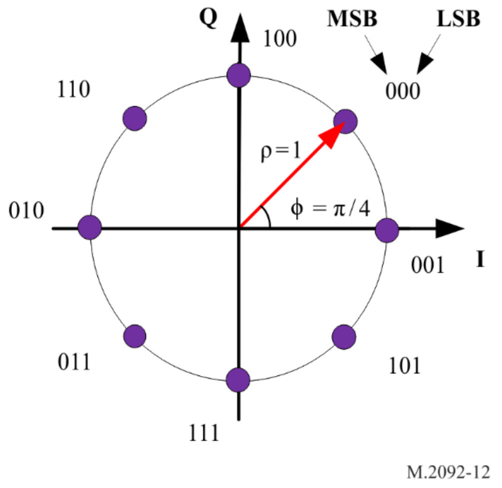
The modulation accuracy requirements for 8-PSK are:

1 The RMS error vector in any burst shall be less than 0.07.

2 The peak error vector magnitude shall be less than 0.22 for any symbol.

FIGURE 12

8 phase shift keying symbol to bit mapping



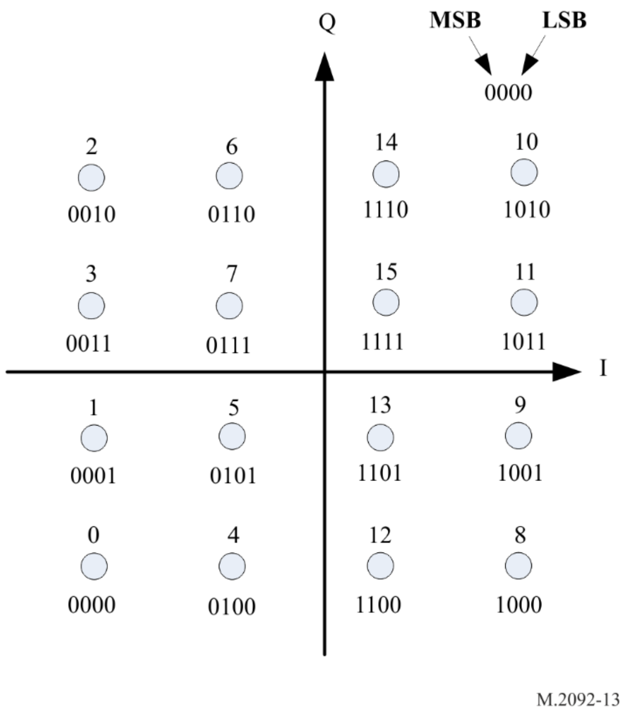
The modulation accuracy requirements for 16-QAM are:

1 The RMS error vector in any burst shall be less than 0.04.

2 The peak error vector magnitude shall be less than 0.1 for any symbol.

FIGURE 13

Bit mapping for 16 quadrature amplitude modulation



1.2.10 Antenna gain for VHF data exchange system ship stations

Existing ship AIS antennas may be used for VDES. An antenna with a gain of 2 dBi at zero degrees elevation is assumed.

1.2.11 Noise and interference level

The noise floor is a function of many sources such as vessel electronics, other radio equipment, power supplies, etc., and sensitivity is also reduced by RF cabling losses and the low noise amplifier (LNA) noise figure. Table 12 presents assumed representative values for the receiver noise figure.

TABLE 12

Ship receiver noise figure calculations

Antenna noise temperature*	245.0	K
LNA noise figure	6.0	dB
LNA noise temperature	813.8	K
Feed loss noise temp at LNA	0.0	K
Antenna noise temp at LNA	245.0	K
System noise temp at LNA	1058.8	K
System noise temp at LNA	30.2	dBK

* The galactic background antenna noise temperature is 245 K at 160 MHz {RD-4}.

1.2.12 Transmitter requirements for VHF data exchange system

1.2.12.1 Ship Stations transmitter power

Except for Annex 3, Table 13 defines the requirements for VDES ship station transmitters, for the transmit spectrum mask (see Fig. 14). The resolution bandwidth for the mask measurement is 300 Hz.

TABLE 13

Transmitter parameters

Transmitter parameters	Requirements	Condition
Frequency error	1.5 ppm	normal
Frequency error	3 ppm	extreme
Average transmit power capability	The minimum average power should be according to Table 8, Table 9. The power tolerance is ±1.5 dB in normal, +2/−6 dB in extreme conditions.	Conducted
Maximum adjacent power levels for 25 kHz channel	Δfc < ±12.5 kHz: 0 dBc[6] ±12.5 kHz < Δfc < ±25 kHz: below the straight line between −25 dBc at ±12.5 kHz and –70 dBc at ±25 kHz ±25 kHz < Δfc < ±62.5 kHz: −70 dBc	

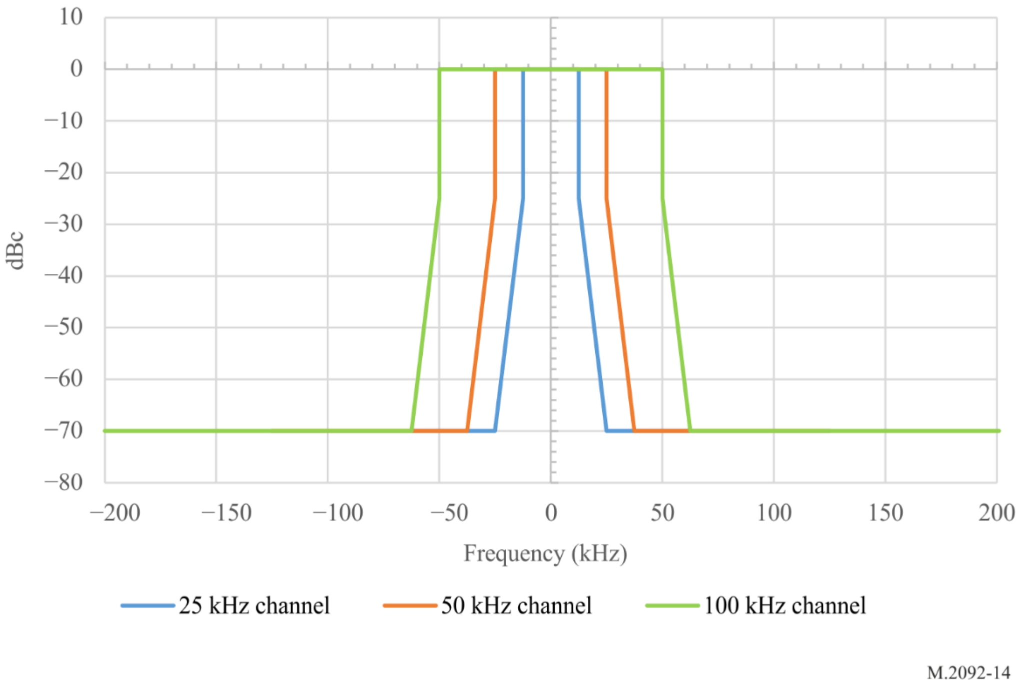
6 Where 0 dBc is average.

TABLE 13 (*end*)

Transmitter parameters	Requirements	Condition
Maximum adjacent power levels for 50 kHz channel	Δ*fc* < ±25 kHz: 0 dBc ±25 kHz < Δ*fc* < ±37.5 kHz: below the straight line between −25 dBc at ±25 kHz and –70 dBc at ±37.5 kHz ±37.5 kHz < Δ*fc* < ±125 kHz: −70 dBc	
Maximum adjacent power levels for 100 kHz channel	Δ*fc* < ±50 kHz: 0 dBc ±50 kHz < Δ*fc* < ±62.5 kHz: below the straight line between −25 dBc at ±50 kHz and –70 dBc at ±62.5 kHz ±62.5 kHz < Δ*fc* < ±250 kHz: −70 dBc	
Spurious emissions	−36 dBm −30 dBm	9 kHz to 1 GHz 1 GHz to 4 GHz

FIGURE 14

Slotted transmission mask (VHF data exchange)



1.2.12.2 Ship effective isotropic radiated power vs. elevation angle

The minimum ship effective isotropic radiated power (e.i.r.p.), vs elevation angle is shown in Table 14. There are no minimum e.i.r.p. requirements above 80 degrees elevation. Table 14 is based on a linear transmitter meeting the maximum Adjacent Channel Interference levels defined in Table 13. For saturated operation, the e.i.r.p. shall be 3 dB higher.

TABLE 14

Minimum ship e.i.r.p. vs elevation angle

Ship elevation angle (degrees)	Ship antenna gain (dBi)	Minimum ship e.i.r.p. with 6 W transmitter (dBW)
0	3	10.8
10	3	10.8
20	2.5	10.3
30	1	8.8
40	0	7.8
50	−1.5	6.3
60	−3	4.8
70	−4	3.8
80	−10	−2.2
90	−20	−12.2

1.2.12.3 Shutdown procedure

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.

1.2.12.4 Safety precautions

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

1.3 Link layer

This layer ensures reliable transmission of data between ships, ship and shore, and ship and satellite. This layer will further be responsible for packing data into messages and providing access to the data transfer medium using time division multiple access (TDMA) techniques.

1.3.1 Time division multiple access synchronization

TDMA synchronization is achieved using an algorithm as described below.

The TDMA receiving process should not depend on slot boundaries.

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

1.3.2 Coordinated universal time direct

A station, which may acquire timing directly from UTC source having the required accuracy.

1.3.3 Coordinated universal time indirect

A station, which is unable to get direct access to UTC, but has access to the AIS system timing, should get its synchronization from the AIS system.

Annex 3

Technical characteristics of the application specific message channels for the VHF data exchange system in the VHF maritime band

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1 Introduction

This section describes those elements of the ASM that are unique to ASM operation. It contains a description of the different protocols according to the open systems interconnection (OSI) layer model and recommends implementation details for each layer. For those elements that are common, the cross reference into Annex 2 is provided.

The system should use TDMA techniques in a synchronized manner.

This Annex describes the characteristics of the TDMA access schemes which include random access TDMA (RATDMA), Multiple Incremental TDMA (MITDMA), fixed access TDMA (FATDMA), techniques. Slot carrier sense TDMA may be implemented as an option. The behaviour should be in accordance with Recommendation ITU-R M.1371-5, Annex 7.

2 Open systems interconnection layers

Refer to Annex 2.

2.1 Physical layer

Convert digital transmission packet to π/4-QPSK signal to modulate transmitter.

2.2 Link layer

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

2.2.1 Link management entity

This sub layer has the following functions:

Assemble ASM message bits

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

2.2.2 Data link services

This sub layer has the following functions:

Calculate CRC of the ASM message bits (see § 1.2.5, Annex 2)

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

Complete assembly of transmission packet.

2.2.3 Media access control

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.

2.3 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.

2.4 Transport layer

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

3 Physical layer

3.1 Parameters

3.1.1 General

The PL is responsible for the transfer of a bit-stream from an originator, out on to the data link. The performance requirements for the PL are summarized in Tables 22, 23 and 24.

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

TABLE 15

Minimum required time division multiple access transmitter characteristics

Parameter name	Low setting	High setting
Channel spacing (encoded according to RR Appendix **18** with footnotes)(1) (kHz)	25	25
ASM 1(1) (MHz)	161.950	161.950
ASM 2(1) (MHz)	162.000	162.000
Average transmit output power (W)	1	12.5

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

3.1.2 Transmission media

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

3.1.3 Multi-channel operation

The ASM station 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 may be used to enable TDMA transmissions on one or two independent frequency channels.

ASM transmission should alternate between the two ASM channels

MITDMA linked transmissions should be on the same channel.

3.2 Transceiver characteristics

The transceiver should perform in accordance with the characteristics set forth herein, see Table 16 and Fig. 15. The resolution bandwidth for the mask measurement is 300 Hz.

TABLE 16

Minimum required time division multiple access transmitter characteristics

	Requirements
Carrier power error	±1.5 dB
Carrier frequency error (normal)	1.5 ppm
Carrier frequency error (extreme)	3.0 ppm
Slotted modulation mask	Δfc < ±8 kHz: 0 dBc[7] ±8 kHz < Δfc < ±16 kHz: below the straight line between −25 dBc at ±8 kHz and –60 dBc at ±16 kHz ±16 kHz < Δfc < ±25 kHz: below the straight line between −60 dBc at ±16 kHz and –70 dBc at ±25 kHz ±25 kHz < Δfc < ±62.5 kHz: −70 dBc
Spurious emissions	−36 dBm: 9 kHz ... 1 GHz −30 dBm: 1 GHz ... 4 GHz

[7] Where 0 dBc is 12.5 W average power for higher power and 1W average power for low power.

FIGURE 15

Application specific message slotted modulation mask

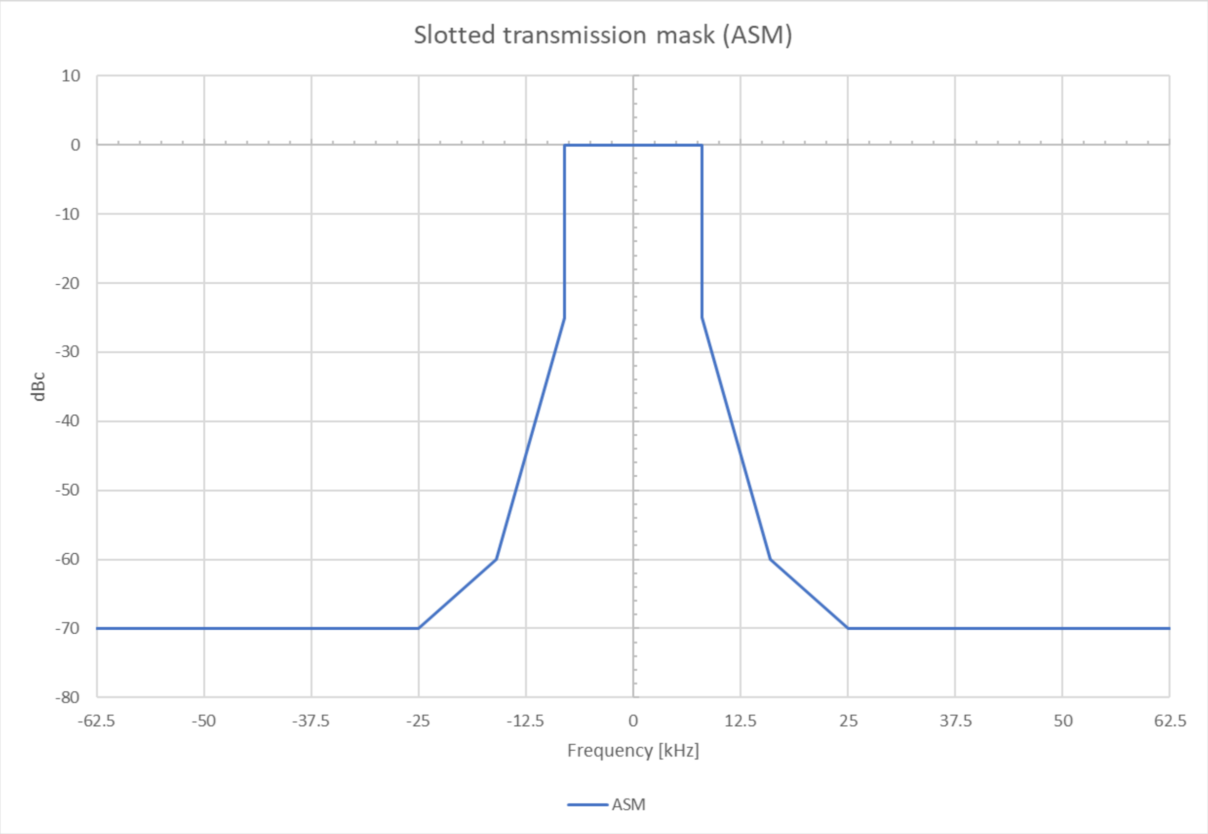


TABLE 17

Minimum required time division multiple access receiver characteristics without forward error correction

Receiver parameters	Requirements
Sensitivity	20% PER @ −107 dBm
Error behaviour at high input levels	1% PER @ −77 dBm 1% PER @ −7 dBm
Adjacent channel selectivity	20% PER @ 70 dB
Spurious response rejection	20% PER @ 70 dB
Intermodulation response rejection	20% PER @ 71 dB
Spurious emissions	−57 dBm (9 kHz to 1 GHz) −47 dBm (1 GHz to 4 GHz)
Blocking	20% PER @ 86 dB

3.3 Modulation scheme

The base modulation is defined by the Link ID, see Table 7.

For the modulation bit mapping, see Annex 2.

3.4 Data transmission bit rate

The transmission bit rate should be 19.2 kbit/s ±10 ppm for π/4-QPSK.

3.5 Frame structure

For the generic definition of the frame structure, see Annex 2.

3.6 Signal information

Signal information selects the modulation scheme and coding according to the Link ID defined in Table 7.

3.7 Forward error correction and bit scrambling

When forward error correction is used, it will be used as defined in Annex 2. Interleaving and bit scrambling are used, as defined by the FEC designated in the signal information. In the event of no FEC, bit scrambling according to Annex 2 shall be implemented.

3.8 Transmitter transient response

The time taken to switch from transmit to receive conditions, and receive to transmit conditions, should not exceed the transmit ramp up and ramp down (see § 1.2.3.1, Annex 2). 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.

3.9 Transmitter power

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

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.

The nominal levels for the two power settings should be 1 W (average power) and 12.5 W (average power); tolerance should be within ±1.5 dB.

4 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 sub-layers.

4.1 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 access scheme is TDMA using a common time reference.

4.2 TDMA synchronization

TDMA synchronization is achieved using an algorithm as described in § 1.3.1, Annex 2.

4.3 Time division

The slot and frame are as defined in Annex 2. 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.

4.3.1 Slot phase and frame synchronization

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

4.3.2 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.

4.3.3 Frame synchronization

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

4.3.4 Slot identification

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

4.3.5 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 should occur within the slots allocated for own transmission. The slot access is performed as described in § 1.2.2, Annex 2.

4.3.6 Slot state

Each slot on an ASM or VDE channel can be in one of the following states:

Unavailable:

If any of the conditions below are met, the corresponding slot should be considered as unavailable on all VDE and ASM channels:

(1) slot is internally allocated by own station for the purpose of own transmission on any channel;

(2) when the same slot on an AIS channel is externally allocated by an AIS station and meets the following conditions (*):

  (2.1) SOTDMA slot timeout = 0;

  (2.2) the slot is an FATDMA allocated slot to an AIS station within 120 NM;

(3) slot is allocated for addressed message to own station on any channel;

(4) slot is allocated for own station VDE reception; or

(5) slot is reserved for VDE-TER or VDE-SAT bulletin board reception.

(*) only when co-locating with AIS.

Allocated:

A slot that is not Unavailable, and externally allocated by an ASM station or VDE station on the channel is considered Allocated.

Free:

A slot that is not Unavailable or Allocated is considered Free on the channel.

NOTE: For AIS channels, slots are considered “allocated” when matching the requirements defined for “available” in Recommendation ITU-R M.1371 section on “Intentional slot reuse by the own station”

4.4 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.

4.4.1 Data link activation and release

Based on the MAC sub layer the DLS will listen, activate or release the data link. A slot, marked as free or externally allocated, indicates that own equipment should be in receive mode and listen for other data link users.

4.4.2 Data transfer

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

4.4.3 Packet format

Data is transferred using the generic transmission packet as defined in Figs 4 and 5.

The packet should be sent from left to right. The training sequence is being used to synchronize the VDES receiver.

4.4.3.1 Summary of the transmission packet

The data packet is defined in Table 18.

The ASM channel configurations are defined by Link ID table, Table 7.

TABLE 18

Packet symbol structure for $\pi/4$ quadrature phase shift keying modulation scheme

	Symbols	Description
Ramp up	4	
Training sequence	27	Necessary for synchronization
Link ID	16	Decoded from (32,6) biorthogonal code; ASM channel configurations as defined in Link ID table; Note that the Link ID will identify how many slots make up the message.
Data	1 slot: 176 2 slot: 432 3 slot: 688 SAT: 616	The symbol count and the information bits varies according to coding rate as defined by the Link ID field
CRC	16	The CRC only includes the data field
FEC termination bits	6	Set to zero when not used
Ramp Down	4	Distance delay and jitter
Guard Time	TER: 7 SAT: 79	Distance delay and jitter
Total	1 slot: 256 2 slot: 512 3 slot: 768	

4.4.3.2 Transmission timing

The modulation may be applied during the ramp up period, but it shall not be considered as part of the training sequence

4.4.3.3 Long transmission packets

A station may occupy a maximum of three consecutive slots, as defined by the Link ID, for one (1) continuous transmission. Only a single application of the overhead (ramp up, training sequence, CRC, guard time) is required for a long transmission packet.

4.4.4 Error detection and control

Error detection is accomplished using a CRC polynomial as described in Annex 2.

4.4.5 Forward error correction

Forward error correction should be handled as described in § 1.2.4, Annex 2, and specified by the Link ID see Table 7.

4.5 Sub layer 3 – link management entity

The LME controls the operation of the DLS, MAC and the PL.

4.5.1 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 MITDMA, RATDMA, and FATDMA.

4.5.2 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 system should give priority to the AIS system when accessing the physical data link.

4.5.3 Candidate slots

For ASM shore stations, a shore authority may decide to make FATDMA reservations on the AIS channels to account for ASM transmissions in FATDMA mode ensuring that no AIS data is lost to the shore station when sending ASM data. All shore stations should also be capable of using the rules below for candidate slot selection if FATDMA is not configured in the station.

The definitions of slot states applied in the selection rules below are defined in § 4.3.6.

Slots, used for transmission, are selected from *candidate slots* in the selection interval (SI) which is defined as 235 slots. The ASM transmit channel should be selected before initiating the slot selection process.

The selection process uses received data from AIS, ASM and VDE channels where these functions are co-located. Functions not part of a co-located station, or not in use by the station, are not considered by the candidate slot selection process of the station.

There should be, at minimum, a set of eight candidate slots to choose from.

Only candidate slots that are free on the transmit ASM channel shall be considered using the rule set below in consecutive order.

Rule 1: The candidate slots are initially selected from slots that are Free on all VDES channels.

If the candidate slot set contains less than eight slots, additional candidate slots can be obtained by using the following rules and order (rule 2 followed by rule 3 and then rule 4 and then rule 5):

Rule 2: Free on AIS and ASM channels, Free or Allocated on VDE channel(s).

Rule 3: Free on AIS channels, Free or Allocated on the other ASM channel or the VDE channel(s).

Rule 4: Free on one AIS channel and Available on the other, Free or Allocated on the other ASM channel or the VDE channel(s).

Rule 5: Available on both AIS channels, Free or Allocated on the other ASM channel or the VDE channel(s).

When selecting candidates for messages longer than one (1) slot, i.e. a multi-slot message, a candidate slot should be the first slot in a consecutive block of slots that conform to the selection criteria stated above, i.e. all slots selected for the multi-slot message should meet one of the rules above.

If the station cannot find a sufficient number of candidate slots, the station should not transmit and should re-schedule the transmission.

The candidate slot selection process also has to consider time periods reserved for the reception of the VDE-TER and VDE-SAT bulletin board.

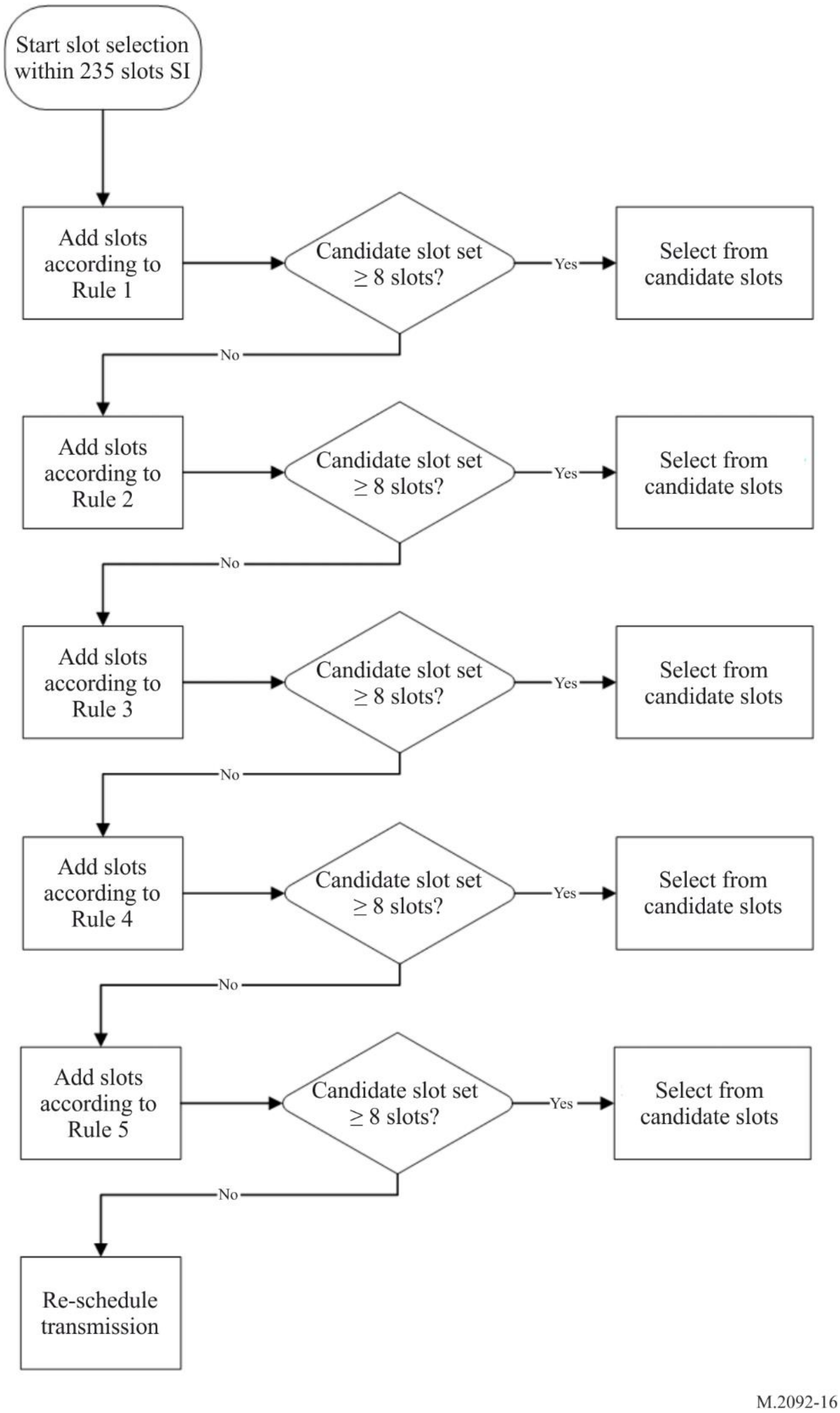
The purpose of maintaining a minimum of eight candidate slots within the same probability of being used for transmission is to provide high probability of access to the link.

Note that individual VDES services need only to be considered in the candidate slot selection process when they are in use and there is not sufficient isolation ensure that the individual services will meet its receiver performance requirements.

Figure 16 shows a flowchart representation of the selection algorithm.

FIGURE 16

Application specific message candidate slot selection algorithm



4.5.4 Modes of operation

There should be two modes of operation, autonomous and designated. The default mode should be autonomous.

4.5.5 Autonomous

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

4.5.6 Designated

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

4.5.7 Channel access schemes

The access schemes, as defined below, should coexist and operate simultaneously on the TDMA channel. The access scheme FATDMA is as defined in Recommendation ITU-R M.1371.

4.5.7.1 Multiple incremental time division multiple access

The MITDMA access schemes allows a station to pre-announce transmission slots that the station will use in the future. A single MITDMA transmission may be used to schedule up to three future transmissions with each transmission occupying up to three slots.

4.5.7.2 Multiple incremental time division multiple access algorithm

MITDMA is a method of chaining slot allocations together for the purpose of transmitting messages. The first transmission within a MITDMA chain will be a single slot transmission using RATDMA access. Further transmissions will be allocated by the MITDMA communication state.

Receiving stations should mark these slot allocations as unavailable.

MITDMA may chain up to 15 transmissions together in a single frame. See § 6.4.

4.5.7.3 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 for the first transmission slot during MITDMA chain, or for messages of a non-repeatable character.

4.5.7.4 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 19).

When a candidate slot is selected, the station randomly selects 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.

The SI for RATDMA should be 235 time slots, which is equivalent to 6.3 s. The candidate slot set should be chosen within the SI, so that the transmission occurs within 6.3 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 < 8 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.

4.5.7.5 Random access time division multiple access parameters

The following parameters (Table 19) are used to control the RATDMA scheduling:

TABLE 19

Random access time division multiple access parameters

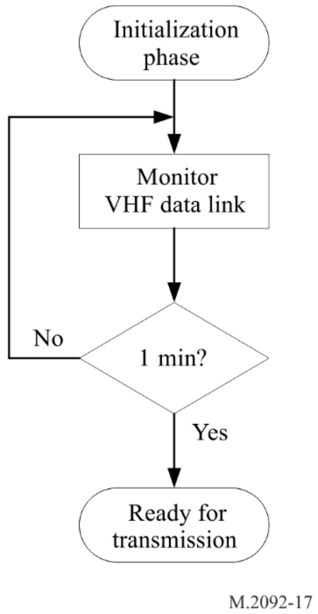
Symbol	Name	Description	Minimum	Maximum
RTCSC	Candidate slot counter	The number of slots currently available in the candidate set. NOTE 1 – The initial value is always 8 or more (see § 4.5.3). However, during the cycle of the p-persistent algorithm the value may be reduced below 8	1	235
RTES	End Slot	Defined as the slot number of the last slot in the initial SI, which is 235 slots ahead	0	2249
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 6 or more initially. Therefore LME.RTPS has a maximum value of −16 (100/6)	0	16
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
RTP2	Current probability	The current probability that a transmission will occur in the next candidate slot	RTPS	100
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	224
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	16

4.5.7.6 Network access and entry of a new data stream

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 reported positions of other users, and possible existence of base stations, as shown in Fig. 17. During this time, a dynamic directory of all members 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.

FIGURE 17

Network access for multiple incremental time division multiple access and random access time division multiple access



4.5.7.7 Random access time division multiple access channel access

When the ASM station needs to transmit a single ASM message which is not repeated periodically, it should use RATDMA access.

4.5.7.8 Multiple incremental time division multiple access channel access

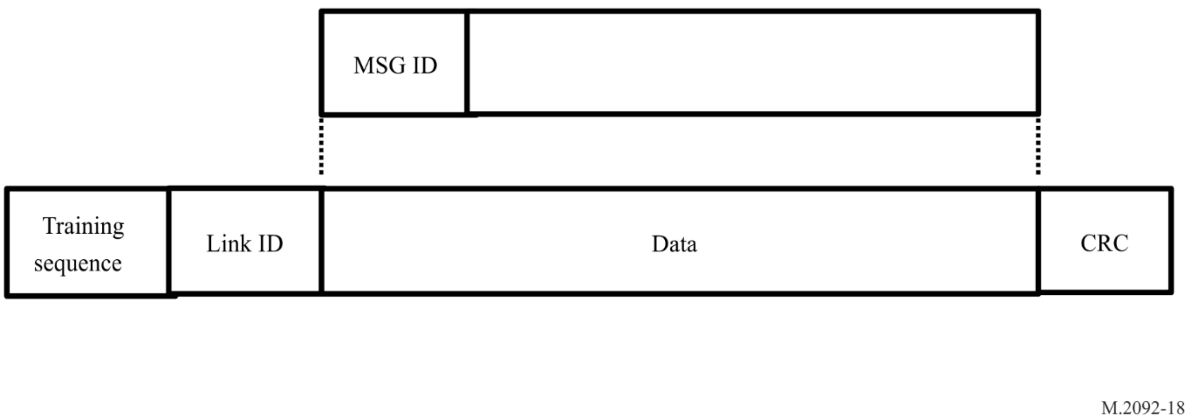
When the ASM station needs to transmit a block of ASM messages, or if it needs to transmit ASM message periodically, it should use MITDMA access.

4.5.8 Message structure

The messages should have the following structure shown in Fig. 18 inside the data portion of a data packet.

FIGURE 18

Message structure



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.

4.5.8.1 Message identification

The message ID should be 4 bits long and should have a range of 0 – 15. The message ID should identify the message type.

4.5.8.2 User identification

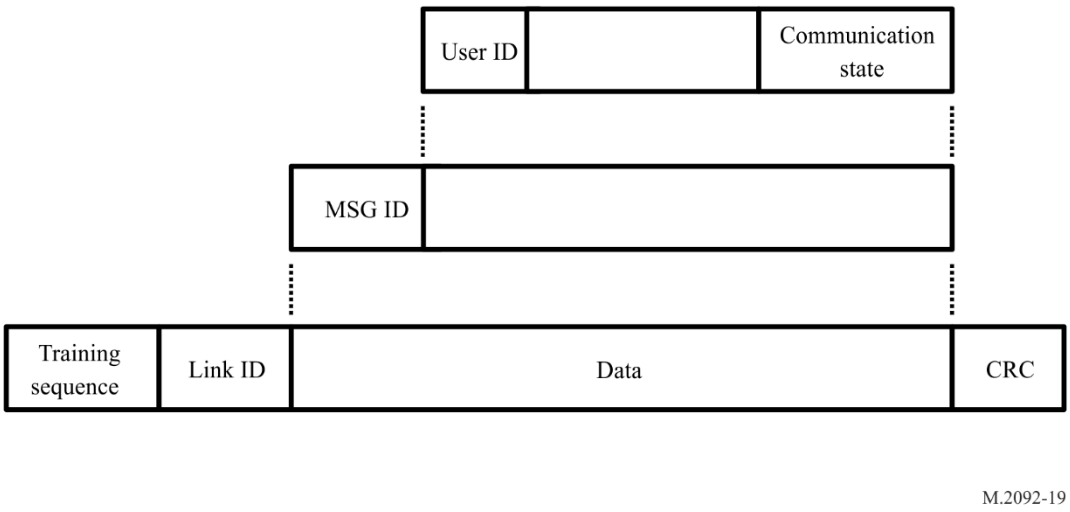
The user ID should be a unique identifier and is 32 bits long. All ASM messages will contain the user identifier to identify the source of the transmission.

4.5.8.3 Multiple incremental time division multiple access message structure

The MITDMA message structure is shown in Fig. 19.

FIGURE 19

MITDMA message structure



4.5.8.4 Multiple incremental time division multiple access communication state

The communication state provides the information used by the slot allocation algorithm in the MITDMA concept.

The MITDMA communication state is structured as shown in Table 20.

TABLE 20

Multiple incremental time division multiple access communication state parameters

Parameter	Number of bits	Description	Minimum	Maximum
Transmit block counter	4	A decrementing counter used to indicate how many transmissions are left to transmit within the chain A value of 1 indicates this is the last transmission within the chain A value of 0 indicates a recurring transmission.	0	15
Block Identifier	4	This identifier uniquely identifies the block of data within the transmit chain. This identifier also maps to the acknowledgment for addressed messages.	0	15
Slot Increment 1	8	Offset to the next slot to be used, referenced to the current transmission start slot. A value of 0 indicates no additional slot allocations	20	255
Number of Slots 1	2	Indicates the number of consecutive slots, which are allocated, starting at the slot increment A value of 0 indicates the 8 bits from Slot Increment 1 become the MSB for the Slot Increment 2	0	3
Slot Increment 2	8	Offset to the next slot to be used, referenced to the slot specified by slot increment 1 (or current transmission slot if the number of slots 1 is set to 0) A value of 0 indicates no additional slot allocations	20	255 13500*
Number of Slots 2	2	Indicates the number of consecutive slots, which are allocated, starting at the slot increment	1	3
Slot Increment 3	8	Offset to the next slot to be used, referenced to the slot specified by Slot Increment 2	20	255
Number of Slots 3	2	Indicates the number of consecutive slots, which are allocated, starting at the slot increment	1	3
Total bits	38			

* When combining Slot Increment 1 and Slot Increment 2 as a 16-bit field. This value should not exceed 6 frames. The combining of these values should only be done for recurring period broadcast transmissions.

5 Network layer

The network layer should be used for:

- Establishing and maintaining channel connections
- Management and priority assignments of messages
- Distribution of transmission packets between channels
- Data link congestion resolution.

5.1 Multi-channel operations

Two frequencies have been designated in RR Appendix **18** for ASM transmissions. These frequencies are:

ASM1 (161.950 MHz)

ASM2 (162.000 MHz)

Channel access is performed independently on each of the two channels. Generally, ASM transmission should alternate between the two channels when available.

Terrestrial transmissions of acknowledgements to addressed messages should be done on the channel as the initial message was received.

Chained transmissions using MITDMA shall all be done on the same channel.

5.2 Management of priority assignment for messages

ASM messages support message priority. The priority of the message is determined by the PI interface. The messages are serviced in order of priority. Messages with the same priority are dealt with in a first in first out order.

5.3 Data link congestion resolution

As the data link becomes loaded, the availability of transmission slots will reduce. When the data link is loaded to such a level as reception of ASM messages is jeopardized, measures should be taken to reduce the loading.

ASM channel loading shall be measured independently per channel over a window of the past 2 250 slots (1 Minute).

The amount of ASM transmissions on a specific channel shall be adopted to the channel loading on that channel.

The maximum number of slots allocated by one station on one channel shall not exceed 50 slots over a period of one minute (2.2% duty cycle), excluding up to 22 slots available for use for retransmission of addressed data. No more than three re-transmission attempts of the same data shall be made.

5.3.1 Mandatory quiet times

After the completion of a singular Non-MITDMA ASM channel transmission or a complete MITDMA transmission block chain, the ASM station shall wait for a specific time before additional transmission can be scheduled. This time is referred to as quiet time. The selection interval for finding candidate transmission slots starts after the quiet time.

For a singular transmission, quiet time shall per default be one second per timeslot.

For an MITDMA linked transmission chain, the quiet time is a function of the number of transmission slots within that chain. The quiet time shall be increased by one second per time slot used in the transmission chain.

The quiet time shall be increased with a multiplier, depending on channel load (Table 21).

TABLE 21

Quiet time multiplier

Channel load	<10%	10%-30%	30%<
Multiplier	1	2	3
Quiet Time [seconds] = Transmission slots * Multiplier			

6 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.

6.1 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. Transmission packets are fixed block sizes on slot boundaries with a maximum of 3 consecutive slots. When data does completely fill the block, then padding bits with the value of 0 should be added to complete the required block size.

6.2 Application specific message identifier

Addressed and broadcast binary messages should contain a 16-bit application identifier (Table 22).

TABLE 22

Application specific message identifier parameters

Bit	Description
15-6	Designated area code (DAC). This code is based on the maritime identification digits (MID). Exceptions are 0 (test) and 1 (international). Although the length is 10 bits, the DAC codes equal to or above 1 000 are reserved for future use
5-0	Function identifier. The meaning should be determined by the authority which is responsible for the area given in the designated area code

Whereas the application identifier allows for regional applications, the application identifier should have the following special values for international compatibility.

6.3 Transmission packets

6.3.1 Addressed messages

Addressed messages are point to point communications between VDES stations. Addressed messages may require an acknowledgment. When an acknowledgement is required and not received, the VDES stations may retransmit the message up to three times.

6.3.2 Broadcast messages

A broadcast message lacks a destination identifier ID. Therefore, receiving stations should not acknowledge a broadcast message.

6.3.3 Conversion to presentation interface messages

Each received transmission packet should be converted to a corresponding presentation interface message and presented in the order they were received regardless of message category. Applications utilizing the presentation interface should be responsible for their own sequencing numbering scheme, as required. For a mobile station, addressed messages should not be output to the presentation interface, if Destination ID (unique identifier) is different to the ID of own station (own unique identifier).

6.3.4 Conversion of data into transmission packets

The transport layer should convert data, received from the presentation interface into transmission packets. If the data exceeds the maximum limit, then a negative acknowledgement should be returned on the PI.

6.4 Multiple incremental time division multiple access

When the length of the data requires more than three consecutive slots, then the data should be divided up into sub-groups of three slot packets and MITDMA should be used to chain the transmissions together. A total of 15 MITDMA transmissions may be chained together. If the data provided by the PI exceeds this limit, a negative acknowledgment should be provided on the PI.

If data transmissions are repetitive in nature, and have a transmit interval less than two frames (4 500 slots), then MITDMA should be used to maintain the link.

If multiple messages are queued for transmission, then MITDMA should be used to allocate slots for the additional messages.

When using MITDMA for addressed messages, the MITDMA will provide the return slot for the message acknowledgment as specified in Slot Increment 3 during block identifier 2, 1 or 0.

6.4.1 Multiple incremental time division multiple access example

An MITDMA access example is shown in Fig. 20. The first transmission (Tx 1) of a MITDMA chain is always a single slot transmission.

Determine the candidate slots for the Tx 1. Apply the RATDMA algorithm until the transmit criteria is meet.

Before transmitting at Tx 1, determine the candidate slots for up to three additional transmissions. Randomly select the transmit slots from the candidate slot lists. Calculate the offsets for these future transmissions. This information is provided in the MITDMA communication state. Slot Increment 1 reserves Tx 2, Slot Increment 2 reserves Tx 3, and Slot Increment 3 reserves Tx 4.

Before transmitting at Tx 2, determine the candidate slots for the next transmission, e.g. Tx 5. Randomly select a transmit slot from the candidate slot list. This information is provided in the MITDMA communication state. Slot Increment 1 reserves Tx 3, Slot Increment 2 reserves Tx 4, and Slot Increment 3 reserves Tx 5.

If this is a broadcast message, then starting at Tx n-2, the unused Slot Increments are set to 0. If this is an addressed message, then the following process happens.

At Tx n-2, determine the candidate slots for the acknowledgment message. Randomly select the acknowledgment slot from the candidate slot list. Calculate the offset for the acknowledgement (ACK) slot. This information is provided in the MITDMA communication state. Slot Increment 1 reserves the Tx n-1, Slot Increment 2 reserves the Tx n, and Slot Increment 3 reserves the ACK slot.

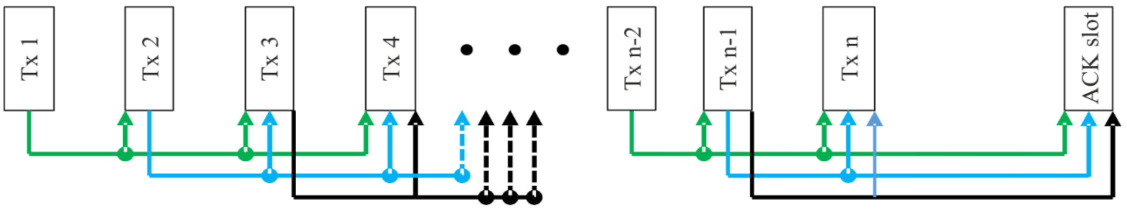
At Tx n-1 a new offset is calculated for the ACK slot. This information is provided in the MITDMA communication state. Slot Increment 1 reserves the Tx n, Slot Increment 2 reserves the ACK slot, and Slot Increment 3 is set to 0.

At Tx n a new offset is calculated for the ACK slot. This information is provided in the MITDMA communication state. Slot Increment 1 reserves the ACK slot, Slot Increment 2 and 3 are set to 0.

At the ACK slot, the receiving station transmits the acknowledgment message with the ACK/NACK Mask field set to indicate the success or failure of the MITDMA transmission chain. If one or more of the blocks failed during the transmission of the chain, then the transmitting station should re-transmit the failed block(s). When starting the re-transmission of the failed MITDMA block(s), Block 1 (the single slot RATDMA transmission) is always sent first.

FIGURE 20

Multiple incremental time division multiple access example



To use MITDMA to transmit a periodic broadcast, the "Transmit Block Counter" field of the MITDMA communication state is set to 0. The "Number Slot 1" field of the MITDMA communication state is set to 0 to allow "Slot Increment 1" and "Slot Increment 2" fields to be combined into a 16-bit value. A slot increment can now be set to a value which has a maximum range of 360 seconds (6 minutes).

7 Packet structure

The ASM transmission packets are used to transport data from one ASM station to another. There are multiple types of packet definitions which use different address modes and channel access schemes. The packet structures are defined by the message identifier.

7.1 slot transmission structure

The generic slot transmission structure is defined in Table 23.

TABLE 23

Slot transmission structure

Parameter	Number of bits	Descriptions
Ramp up	8	417 µs
Training sequence	54	Necessary for synchronization
Link ID	32	Six information bits decoded from (32,6) biorthogonal code ASM channel configurations as defined in Link ID, see Table 7 Note that the Link ID will identify how many slots make up the message.
Data payload including padding (no FEC / FEC)	1 slot: 352 / 256 2 slot: 864 / 640 3 slot: 1376 / 1024 SAT: N/A / 920	The symbol count and the information bits vary according to coding rate as defined by the Link ID field
CRC	32	The CRC is calculated over the data payload including padding
FEC	TER: 10 SAT: 11	Set to zero when not used

TABLE 23 (*end*)

Parameter	Number of bits	Descriptions
Ramp down	8	417 µs
Guard time	TER: 16 SAT: 154	Distance delay TER .083 ms Distance delay SAT 8.02 ms
Total	1 slot: 512 2 slot: 1024 3 slot: 1536	

7.2 Message summary

The defined message types are summarized Table 24.

TABLE 24

Message summary

Message ID	Name	Description	Access scheme	Communication state
0	Broadcast AIS ASM Message	Encapsulated AIS ASM messages.	RATDMA	None
1	Scheduled Broadcast Message	Broadcast data using communication state.	FATDMA RATDMA MITDMA	MITDMA
2	Broadcast Message	Broadcast data with no communication state.	FATDMA RATDMA	None
3	Scheduled Individual Addressed Message	Individual addressed data with communication state. Requires acknowledgement.	FATDMA RATDMA MITDMA	MITDMA
4	Individual Addressed Message	Individual addressed data with no communication state. Requires acknowledgement.	FATDMA RATDMA	None
5	Acknowledgment Message	This message is used to provide and acknowledgment for one or more addressed messages.	FATMDA RATDMA MITDMA	None
6	Geographical Multicast Message	Addressed to a group of stations defined by their geographical location with no communication state. No acknowledgment required.	FATDMA RATDMA	None

7.3 Message 0: broadcast automatic identification system application specific message

ASM Message 0 may contain encapsulated AIS Messages 6, 8, 12, 14, 21, 25 or 26. Acknowledgement is not supported for addressed messages. This message type is for terrestrial use only.

The encapsulated message may or may not be transmitted on AIS1 or AIS2 channels.

If the encapsulation repeats a Message that was transmitted on AIS1 or AIS2 channel, the encapsulation and transmission of messages shall be performed as soon as possible, according to configuration, after receiving the relevant messages which are required to be retransmitted.

The communication state of the encapsulated message shall always be set to zero at encapsulation.

The receiving station shall output all received encapsulated AIS Messages at the PI immediately after reception. Scheduled broadcast message is defined in Table 25.

TABLE 25

Broadcast automatic identification system application specific message

Parameter	**Number of bits**	**Description**
Message ID	4	0 – Selected AIS messages that are output at receiving mobile station PI by using VDM sentence with no communication state
Retransmit flag	1	0 (reserved for future use)
Repeat indicator	2	If the encapsulation repeats a message that was transmitted on AIS1 or AIS2 channel, this is used to indicate how many times a message has been repeated. Encapsulation represents one repeat. Possible values: 0 – 3: 0 = default, shall be used in case where the message is sent only on ASM channel(s); 1: also transmitted on AIS channel(s); 2, 3 = also transmitted on AIS channel(s) and repeated as counted by the repeat indicator on ASM channel.
Session ID	6	The Session ID associates the VDL transmission with a specific PI transaction
Source ID	32	The Unique Identifier of the transmitting station as described in § 2.4, Annex 1.
Data count	11	Size of actual data in Binary Data and ASM Identifier field in bits, excluding padding bits range: from 1 to maximum data count
Binary data (no FEC / FEC)	1 slot: 296 / 200 2 slot: 808 / 584 3 slot: 1320 / 968	Content is encapsulated AIS Messages that are channeled through ASM Channels. Receiver is expected to be ASM-capable mobile station where the ASM-box would relay the encapsulated AIS messages to local presentation interface. The encapsulated AIS Messages would then be output at the PI using VDM sentence. The arrangement would thus be compliant with existing nav presentations. Application data as specified by the ASM Identifier. The available length of the binary data is specified by the Link Id.

7.4 Message 1: Scheduled broadcast message

This ASM message is used to broadcast data to all stations, and utilizes MITDMA communication state. Multiple messages, or periodically broadcasted messages may be chained together using the MITDMA communication state. The first transmission in the chain will use RATDMA to access the link, and all additional transmission will use slots allocated by the MITDMA communication state. Scheduled broadcast message is defined in Table 26.

TABLE 26

Scheduled broadcast message

Parameter	Number of bits	Description
Message ID	4	1 – Broadcast message with MITDMA communication state
Retransmit flag	1	0 (reserved for future use)
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 – 3; 0 = default; 3 = do not repeat any more
Session ID	6	The Session ID associates the VDL transmission with a specific PI transaction
Source ID	32	The Unique Identifier of the transmitting station as described in § 2.4, Annex 1.
Data count	11	1 – Max data count
ASM identifier	16	Application identifier and described in § 6.2
Binary data (no FEC / FEC)	1 slot: 240 / 144 2 slot: 752 / 528 3 slot: 1264 / 912 SAT: N/A / 808	Application data as specified by the ASM Identifier. The available length of the binary data is specified by the Link Id. Unused payload data is zero-filled
Communication state	38	MITDMA communication state as described in § 6.4
Spare bits	2	Spare bits – reserved for the future

7.5 Message 2: Broadcast message

This ASM message is used to broadcast data to all stations and does not contain a communication state. These broadcast messages are used for non-periodic transmission of data, and access the link using RATDMA. Broadcast message is defined in Table 27.

TABLE 27

Broadcast message

Parameter	Number of bits	Description
Message ID	4	2 – Broadcast message with no communication state
Retransmit flag	1	0 (reserved for future use)
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 – 3; 0 = default; 3 = do not repeat any more
Session ID	6	The Session ID associates the VDL transmission with a specific PI transaction
Source ID	32	The Unique Identifier of the transmitting station as described in § 2.4, Annex 1.
Data count	11	1 – Max data count
ASM identifier	16	Application identifier and described in § 6.2
Binary data (no FEC / FEC)	1 slot: 280 / 184 2 slot: 792 / 568 3 slot: 1304 / 952 SAT: N/A / 848	Application data as specified by the ASM Identifier. The available length of the binary data is specified by the Link Id.

7.6 Message 3: Scheduled addressed message

This ASM message is used to send data to an individual station, and utilizes MITDMA communication state. Multiple transmission of messages, or periodically transmissions of messages may be chained together using the MITDMA communication state. The first transmission in the chain will use RATDMA access the link, and all additional transmission will use slots allocated by the MITDMA communication state.

These transmissions require the destination station to return a message acknowledgment (Message 5). This addressed message supplies the return slot for the message acknowledgment. Scheduled addressed message is defined in Table 28.

TABLE 28

Scheduled addressed message

Parameter	Number of bits	Description
Message ID	4	3 – Individually addressed message with MITDMA communication state
Retransmit flag	1	Indicates that this is a retransmission of data
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 – 3; 0 = default; 3 = do not repeat any more
Session ID	6	The Session ID associates the VDL transmission with a specific PI transaction
Source ID	32	The Unique Identifier of the transmitting station, as described in § 2.4, Annex 1.
Destination ID	32	The Unique Identifier of the receiving station, as described in § 2.4, Annex 1.
Data count	11	1 – Max data count
ASM identifier	16	Application identifier and described in § 6.2
Binary data (no FEC / FEC)	1 slot: 208 / 112 2 slot: 720 / 496 3 slot: 1232 / 880 SAT: N/A / 776	Application data as specified by the ASM Identifier. The available length of the binary data is specified by the Link Id.
Communication state	38	MITDMA communication state as described in § 6.4
Spare bits	2	Spare Bits – reserved for the future

7.7 Message 4: Addressed message

This ASM message is used to send data to an individual station and does not contain a communication state. This message is used for non-periodic transmission of data, and access the link using RATDMA.

These transmissions require the destination station to return a message acknowledgment (Message 5). The destination station will use RATDMA to send the message acknowledgment. Addressed message is defined in Table 29.

TABLE 29

Addressed message

Parameter	Number of bits	Description
Message ID	4	4 – Individually addressed message with no communication state
Retransmit flag	1	Indicates that this is a retransmission of data
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 – 3; 0 = default; 3 = do not repeat any more
Session ID	6	The Session ID associates the VDL transmission with a specific PI transaction
Source ID	32	The Unique Identifier of the transmitting station as described in § 2.4, Annex 1.
Destination ID	32	The Unique Identifier of the receiving station as described in § 2.4, Annex 1
Data count	11	1 – Max: data count
ASM identifier	16	Application identifier and described in § 6.2
Binary data (no FEC / FEC)	1 slot: 248 / 152 2 slot: 760 / 536 3 slot: 1272 / 920 SAT: N/A / 816	Application data as specified by the ASM Identifier. The available length of the binary data is specified by the Link Id.

7.8 Message 5: Acknowledgment message

This ASM message is used to return message acknowledgments to one or more addressed messages. Note that this message should always use Link ID of 5 (3/4 coding rate). Acknowledgement message is defined in Table 30.

TABLE 30

Acknowledgment message

Parameter	Number of bits	Description
Message ID	4	5 – Multiple acknowledgment message with no communication state
Retransmit flag	1	0 (reserved for future use)
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 – 3; 0 = default; 3 = do not repeat any more
Session ID	6	The Session ID associates the VDL transmission with a specific PI transaction
Source ID	32	The Unique Identifier of the transmitting station as described in § 2.4, Annex 1.
Destination ID	32	The Unique Identifier of the receiving station as described in § 2.4, Annex 1.
ACK/NACK mask	16	Specifies which MITDMA block IDs failed. Bit map field with the LSB representing Block ID 0, the MSB representing Block ID 15. “1” indicates a packet failed “0” indicates the packet was received ok

TABLE 30 (*end*)

Parameter	Number of bits	Description
Coding rate adaption request	2	0 (reserved for future use)
Channel quality indicator	8	Signal quality
Zero padding (no FEC / FEC)	1 slot: 249 / 153 SAT: N/A / 817 As required	Padding bits are added as required to complete the block size. These bits are not available for future use.

7.9 Message 6: Geographical multicast message

This ASM message is used to broadcast data to a group of stations as defined by the specified geographical area. The broadcast message does not contain a communication state. These broadcast messages are used for non-periodic transmission of data, and access the link using RATDMA. Geographical multicast message is defined in Table 31.

TABLE 31

Geographical multicast message

Parameter	Number of bits	Description
Message ID	4	6 – Geographical addressed message with no communication state
Retransmit flag	1	Indicates that this is a retransmission of data
Repeat Indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 – 3; 0 = default; 3 = do not repeat any more
Session ID	6	The Session ID associates the VDL transmission with a specific PI transaction
Source ID	32	The Unique Identifier of the transmitting station as described in § 2.4, Annex 1.
Longitude 1	18	Longitude of area to which the group assignment applies; upper right corner (north-east); in 1/10 min (±180°, East = positive, West = negative)
Latitude 1	17	Latitude of area to which the group assignment applies; upper right corner (north-east); in 1/10 min (±90°, North = positive, South = negative)
Longitude 2	18	Longitude of area to which the group assignment applies; lower left corner (south-west); in 1/10 min (±180°, East = positive, West = negative)
Latitude 2	17	Latitude of area to which the group assignment applies; lower left corner (south-west); in 1/10 min (±90°, North = positive, South = negative)
Data Count	11	1 – Max data count
Spare bits	2	Spare bits – reserved for the future
ASM identifier	16	Application identifier and described in § 6.2
Binary data (no FEC / FEC)	1 slot: 208 / 112 2 slot: 720 / 496 3 slot: 1232 / 880 SAT: N/A / 776	Application data as specified by the ASM Identifier. The available length of the binary data is specified by the Link Id.

8 Example of application specific message burst symbol generation

The following shows an example of generating one VDES burst, using Link Config ID #5. An ASM acknowledgement message is used as a simple example.

This is done by (a) Generating the ASM message structure (b) bit packing the message, (b) appending CRC32, (c) performing FEC encoding with flushing bits, (d) bit-scrambling and (e) adding Syncword and Link ID + symbol-mapping:

(a) Input message structure (using ASM acknowledgement message as an example) – See § 7.8

Parameter	Number of bits	Value	Bits
Message ID	4	5	0 1 0 1
Retransmit flag	1	0	0
Repeat indicator	2	0	0 0
Source ID	32	123456789	0 0 0 0 0 1 1 1 0 1 0 1 1 0 1 1 1 1 0 0 1 1 0 1 0 0 0 1 0 1 0 1
Destination ID	32	987654321	0 0 1 1 1 0 1 0 1 1 0 1 1 1 1 0 0 1 1 0 1 0 0 0 1 0 1 1 0 0 0 1
ACK/NACK mask	16	0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Coding rate adaption request	2	0	0 0
Signal quality indicator	8	100	0 1 1 0 0 1 0 0
Total bits above	**97**		
Zero padding	159 (256 – 97)	0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

(b) Bit packed ASM acknowledgement message, using LinkID#5 (256 bits)

0 1 0 1 0 0 0 0 0 0 0 0 0 1 1 1 0 1 0 1 1 0 1 1 1 1 0 0 1 1 0 1 0 0 0 1 0 1 0 1 0 0 1 1 1 0 1 0 1 1 0 1 1 1 1 0 0 1 1
0 1 0 0 0 1 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

(c) Input for turbo encoder (256 bits payload + 32 bits CRC = 288 bits)

0 1 0 1 0 0 0 0 0 0 0 0 0 1 1 1 0 1 0 1 1 0 1 1 1 1 0 0 1 1 0 1 0 0 0 1 0 1 0 1 0 0 1 1 1 0 1 0 1 1 0 1 1 1 1 0 0 1 1
0 1 0 0 0 1 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 **0 0 0 1 1 0 1 1 1 1 0 0 0 1 1 0 0 0 0 0 1 1 1 0 1 1 0 1 0 1 0 1**

(d) Turbo encoded data with flushing (288 bits / ¾ FEC rate + 10 FEC tail bits = 394 bits)

0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 1 1 1 1 0 1 1 1 1 1 0 0 0 1 1 0 0 1 0 0 0 0 1 0 1 1 1 0 1 0 0 1 1 1 0
1 0 1 0 1 1 1 1 0 1 1 1 1 0 0 1 0 1 1 0 1 0 0 0 0 0 1 0 1 0 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0
0 0 0 1 1 0 1 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1
0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 1
0 1 1 0 1 1 1 0 0 0 1 0 1 0 0 0 0 0 0 1 1 0 1 1 0 1 1 0 0 1 1 0 1 0 1 1 **0 0 1 1 0 1 0 0 0 1**

(e) Scrambled data (394 bits)

0 0 1 0 1 0 1 1 1 1 1 1 0 1 1 0 1 0 1 1 1 1 0 1 1 1 0 1 1 0 1 1 1 0 1 1 1 1 0 0 0 0 1 1 1 1 0 1 0 1 1 1 0 0 0 0 0 0
1 1 1 0 0 0 0 0 0 1 0 1 1 1 0 0 1 1 0 0 1 0 1 0 1 1 1 1 0 1 1 1 1 1 0 1 1 0 1 0 1 1 0 0 1 1 0 1 1 0 1 0 0 0 1 1 1 0
1 0 1 1 0 1 0 1 0 0 0 1 1 0 1 1 1 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0 0 1 0 1 1 1 0 0 1 0 0 0 0 1 0 1 1 0 1 1 0 1 1 1 0 0
0 0 0 1 0 1 1 0 1 0 1 1 1 0 0 0 0 1 1 1 0 1 1 1 1 1 1 1 0 0 0 1 0 0 1 0 0 0 0 0 0 1 1 1 0 1 1 0 1 0 1 1 0 0 0 0 1 0
0 1 0 1 1 1 1 0 0 1 0 0 1 0 1 0 1 1 0 0 0 0 1 1 0 0 1 1 1 0 0 1 1 1 0 0 1 1 0 0 1 1 0 1 0 0 1 1 0 1 1 0 1 0 1 1 0 1
1 0 1 0 1 1 1 0 1 1 1 0 1 1 0 1 1 1 1 1 1 1 0 0 0 1 1 0 1 0 0 1 0 0 0 1 0 1 0 0 0 1 1 0 1 0 0 1 0 1 1 0 0 0 1 1 1 0
1 0 1 0 1 0 1 1 0 1 1 0 0 1 0 0 1 0 0 0 0 1 0 0 1 1 0 0 1 1 0 1 1 1 1 1 0 0 1 0 1 0 1 1 1 1

(f) Symbol mapped with QPSK (27 symbols syncword + 16 symbols Link ID + 197 symbols data = 240 symbols total)

-- Syncword symbols:

(+0.7,+0.7),(+1.0,+0.0),(+0.7,+0.7),(+1.0,+0.0),(+0.7,+0.7),(+1.0,+0.0),(-0.7,-0.7),(-1.0,+0.0),(+0.7,+0.7),(+1.0,+0.0),(-0.7,-0.7),(+1.0,+0.0),(-0.7,-0.7),(+1.0,+0.0),

(-0.7,-0.7),(-1.0,+0.0),(-0.7,-0.7),(-1.0,+0.0),(-0.7,-0.7),(+1.0,+0.0),(+0.7,+0.7),(-1.0,+0.0),(-0.7,-0.7),(+1.0,+0.0),(-0.7,-0.7),(+1.0,+0.0),(-0.7,-0.7),

-- Link ID symbols:

(+1.0,+0.0),(-0.7,+0.7),(+0.0,+1.0),(-0.7,+0.7),(+1.0,+0.0),(+0.7,-0.7),(+1.0,+0.0),(-0.7,+0.7),(+0.0,+1.0),(+0.7,+0.7),(+1.0,+0.0),(+0.7,-0.7),(+0.0,-1.0),

(+0.7,+0.7),(+1.0,+0.0),(+0.7,+0.7),

-- Data symbols:

(-1.0,+0.0),(+0.7,-0.7),(+0.0,-1.0),(+0.7,+0.7),(+1.0,+0.0),(+0.7,+0.7),(+0.0,+1.0),(+0.7,-0.7),(+0.0,-1.0),(+0.7,+0.7),(+1.0,+0.0),(-0.7,+0.7),(+1.0,+0.0),(-0.7,+0.7),

(+0.0,-1.0),(+0.7,+0.7),(+0.0,-1.0),(+0.7,+0.7),(+1.0,+0.0),(-0.7,-0.7),(-1.0,+0.0),(+0.7,+0.7),(+1.0,+0.0),(-0.7,+0.7),(+0.0,+1.0),(+0.7,+0.7),(-1.0,+0.0),(-0.7,-0.7),

(-1.0,+0.0),(+0.7,+0.7),(+0.0,-1.0),(-0.7,-0.7),(-1.0,+0.0),(-0.7,+0.7),(+0.0,+1.0),(+0.7,+0.7),(-1.0,+0.0),(+0.7,+0.7),(-1.0,+0.0),(+0.7,-0.7),(+0.0,-1.0),(+0.7,+0.7),

(+1.0,+0.0),(-0.7,+0.7),(+1.0,+0.0),(+0.7,+0.7),(+0.0,+1.0),(+0.7,-0.7),(+0.0,-1.0),(+0.7,+0.7),(-1.0,+0.0),(+0.7,+0.7),(+0.0,+1.0),(+0.7,-0.7),(+0.0,-1.0),(-0.7,-0.7),

(+1.0,+0.0),(+0.7,-0.7),(+0.0,-1.0),(+0.7,+0.7),(+0.0,+1.0),(-0.7,+0.7),(-1.0,+0.0),(-0.7,+0.7),(+0.0,-1.0),(+0.7,+0.7),(+1.0,+0.0),(+0.7,+0.7),(-1.0,+0.0),(+0.7,+0.7),

(+1.0,+0.0),(-0.7,-0.7),(-1.0,+0.0),(-0.7,-0.7),(+0.0,+1.0),(-0.7,+0.7),(+1.0,+0.0),(-0.7,-0.7),(+0.0,-1.0),(-0.7,-0.7),(+0.0,+1.0),(-0.7,+0.7),(+0.0,-1.0),(+0.7,+0.7),

(+0.0,+1.0),(+0.7,+0.7),(-1.0,+0.0),(-0.7,-0.7),(+0.0,+1.0),(-0.7,+0.7),(+0.0,-1.0),(+0.7,-0.7),(+1.0,+0.0),(+0.7,-0.7),(-1.0,+0.0),(-0.7,+0.7),(+1.0,+0.0),(-0.7,+0.7),

(+1.0,+0.0),(+0.7,+0.7),(+1.0,+0.0),(-0.7,-0.7),(+0.0,+1.0),(-0.7,-0.7),(+0.0,-1.0),(-0.7,-0.7),(-1.0,+0.0),(-0.7,+0.7),(+1.0,+0.0),(-0.7,+0.7),(+0.0,-1.0),(+0.7,-0.7),

(+1.0,+0.0),(-0.7,-0.7),(-1.0,+0.0),(+0.7,-0.7),(+0.0,+1.0),(-0.7,+0.7),(+1.0,+0.0),(+0.7,-0.7),(+0.0,+1.0),(-0.7,-0.7),(+0.0,-1.0),(+0.7,-0.7),(+1.0,+0.0),(-0.7,-0.7),

(-1.0,+0.0),(+0.7,+0.7),(-1.0,+0.0),(+0.7,+0.7),(+0.0,-1.0),(-0.7,+0.7),(+1.0,+0.0),(-0.7,-0.7),(+1.0,+0.0),(-0.7,-0.7),(+1.0,+0.0),(-0.7,+0.7),(-1.0,+0.0),(+0.7,+0.7),

(+0.0,+1.0),(+0.7,-0.7),(+0.0,-1.0),(+0.7,+0.7),(+0.0,+1.0),(+0.7,-0.7),(+0.0,-1.0),(+0.7,+0.7),(+0.0,-

1.0),(+0.7,+0.7),(+0.0,-1.0),(+0.7,+0.7),(+0.0,+1.0),(+0.7,+0.7),
(+1.0,+0.0),(+0.7,+0.7),(-1.0,+0.0),(-0.7,+0.7),(+0.0,-1.0),(+0.7,-0.7),(+0.0,+1.0),(-0.7,-0.7),(+0.0,+1.0),(-0.7,+0.7),(-1.0,+0.0),(-0.7,+0.7),(+0.0,-1.0),(+0.7,-0.7),
(+0.0,+1.0),(-0.7,+0.7),(+0.0,-1.0),(-0.7,-0.7),(+1.0,+0.0),(+0.7,-0.7),(+0.0,-1.0),(+0.7,-0.7),(+0.0,-1.0),(+0.7,+0.7),(+0.0,+1.0),(+0.7,-0.7),(+0.0,+1.0),(-0.7,-0.7),
(+0.0,-1.0),(-0.7,-0.7),(+0.0,+1.0),(-0.7,-0.7),(+1.0,+0.0),(-0.7,-0.7),(+1.0,+0.0),(-0.7,+0.7),(+1.0,+0.0),(+0.7,+0.7),(-1.0,+0.0),(+0.7,-0.7),(+0.0,-1.0),(+0.7,+0.7),(+1.0,+0.0),

Annex 4

Technical characteristics of VHF data exchange-terrestrial in the maritime mobile band

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Page

1 Introduction

This section describes those elements of the VDE-TER that are unique to VDE-TER operation. For those elements that are common, the cross reference into Annex 2 is provided. It contains a description of the different protocols according to the OSI layer model and recommends implementation details for each layer.

Data transmission is made in the VHF maritime mobile band within the spectrum identified in § 2.3, Annex 1. The spectrum may be used as 25 kHz, 50 kHz or 100 kHz channels.

The system should use TDMA techniques in a synchronized manner.

2 Open systems interconnection layer

Refer to Annex 2.

3 Physical layer

3.1 Range

The communication range of terrestrial VDE is typically 20−50 NM.

3.2 Transmitter parameter settings

Refer to Annex 2 for transmitter parameter settings for mobile stations.

3.3 Antenna

Refer to Annex 2.

3.4 Modulation

3.4.1 Waveforms

The waveforms are defined in Annex 2.

3.4.2 Bit mapping

For bit mappings, see Annex 2.

3.5 Sensitivity

VDE uses adaptive modulation and coding to maximise spectral efficiency and throughput. Sensitivity for the supported modulation methods are given in Table 32.

TABLE 32

Sensitivity

Receiver parameters	**Requirements**					
	LinkID 11	**LinkID 13**	**LinkID 14**	**LinkID 16**	**LinkID 17**	**LinkID 19**
Sensitivity	1% PER @ −111 dBm	1% PER @ −108 dBm	1% PER @ −108 dBm	1% PER @ −105 dBm	1% PER @ −105 dBm	1% PER @ −102 dBm

3.6 Symbol timing accuracy

Refer to Annex 2.

3.7 Transmitter timing jitter

Refer to Annex 2.

3.8 Slot transmission accuracy at the output

Refer to Annex 2.

3.9 Frame structure

Refer to Annex 2.

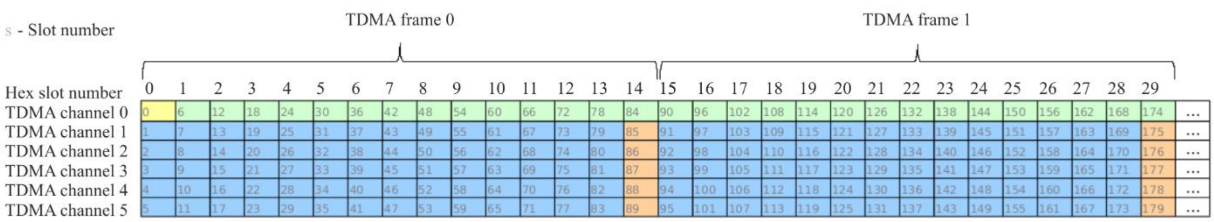
4 Link layer

4.1 Time division multiple access hierarchy

TDMA hierarchy describes the use of slots in a time interleaved pattern, thus non-continuous in time. Figure 21 details the TDMA layout. Note that the numbers inside each block indicate the slot number. Time runs from top to bottom from left to right.

FIGURE 21

Time division multiple access hierarchy



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4.1.1 Hexslot

Six slots numbered from 0 to 5 form a hexslot. The hexslot has duration of 160 ms with each slot having a duration of 26.7 ms. The hexslot should be incremented after every 6 slots.

4.1.2 Time division multiple access channel

A TDMA channel refers to all the slots with the same offset in the hexslot. Every 6th slot is part of the same TDMA channel. Six TDMA channels are defined. Figure 21 shows each TDMA channel as a horizontal line of slots.

4.1.3 Time division multiple access frame

A TDMA channel is divided into TDMA frames. The default total time duration of a TDMA frame is defined as 15 hexslots within a TDMA channel. TDMA frames are numbered from 0 to 24.

The functionality to configure a TDMA frame length by a shore station exists, but is reserved for future use. The frame length would be changed by increasing or decreasing the number of hexslots in a frame.

4.1.4 Time division multiple access slot

A TDMA slot defines the slot number within a TDMA frame. With the TDMA frame length of 15 slots, the TDMA slots will be cyclically numbered from 0 to 14.

4.2 Link layer definitions

4.2.1 Logical channel

Logical channels (LC) define functions for a set of continuous slots within a TDMA channel and may repeat in a TDMA channel. See § 4.12.

4.2.2 Physical channel

A Physical Channel is defined by a frequency and bandwidth.

4.2.3 VHF data exchange slotmap

Each physical channel is associated with one VDE slotmap to map LC to slots for one frame.

4.2.4 Bulletin board

The bulletin board message is sent by a control station to define the physical channels with their VDE slotmap for a control station service area. See § 4.13.

4.2.5 Short data message

The short data message refers to the data transfer protocol used for transmission of payload in one slot only.

4.2.6 Data session

A data session refers to the data transfer protocol used for transmission of payload in a TDMA frame. See § 4.17.

4.2.7 Multisession data transfer

Multisession data transfer, refers to multiple data sessions chained together to be able to transmit arbitrary payloads. See § 4.17.

4.2.8 Data fragment

During a data session, the data may be broken into multiple data fragments to be transmitted in separate slots. The data fragments refer to the start fragment, continuation fragment and end fragment VDE messages. See § 4.17.

4.3 Control station service area

Control stations may transmit a bulletin board message with its control station service area on logical channel 0. The bulletin board content only applies to vessels inside the control station service area. While vessels are inside a control station service area, all data session transmissions between ships should take place via the control station.

Ships outside the control station service area may communicate directly. In this case AIS receptions may be used to determine if a ship is within range.

Coordination is required between control stations to establish mutually exclusive service areas and to ensure that LC are shared appropriately between them, in particular the timing of the broadcast of the bulletin board on logical channel 0.

If a VDE vessel unit detects that it is not within any controlling station service area, it should start using the default bulletin board to communicate, as defined in § 4.14 unless instructed otherwise.

4.4 Resource management

The connection between ship and shore is session oriented with a logical channel being reserved, upon request, for a particular ship for a given time by the control station.

Ship originated short data messages can be sent on the random access channels without resource allocation.

During heavy network loading, the network control may introduce time dispersion for resource requests, modify the maximum allowed number of ship originated short data messages or only allow traffic with high priority levels.

4.5 Endianness

The order of bytes within a binary representation of a number is referred to as the endianness.

With regards to the message structure, the same endianness is used as in AIS. See Recommendation ITU-R M.1371-5, § 3.3.7, Annex 1.

When a message is constructed it should be grouped in bytes of 8 bits from top to bottom of the table associated with each message. Multi-byte words are packed most significant byte first in the message.

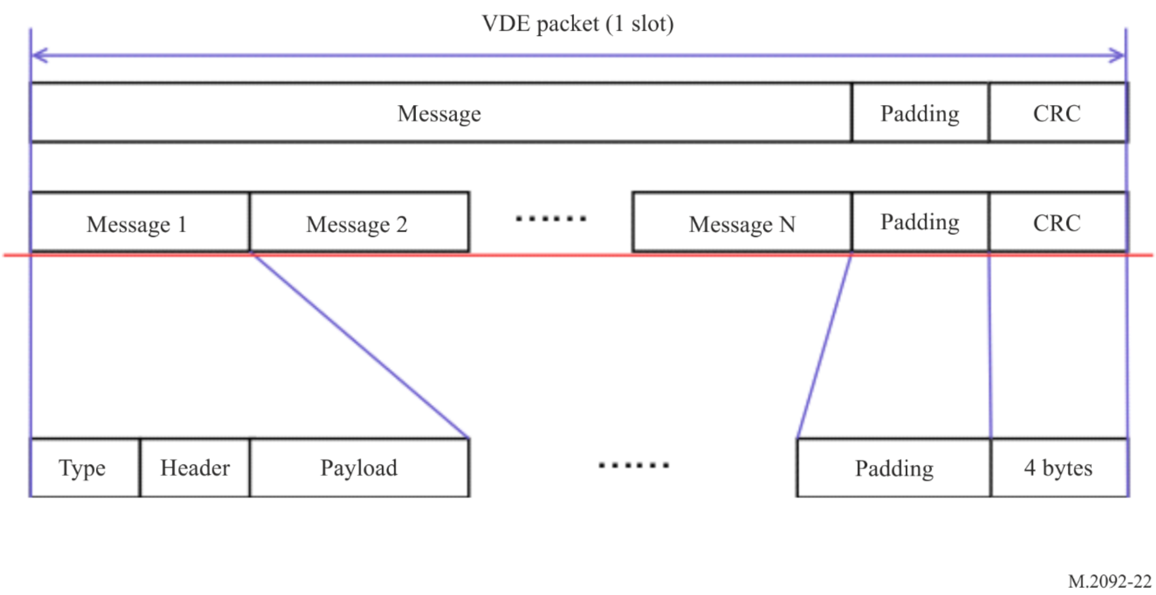
4.6 Data structures

VDE packet transmissions shall always fit into one slot. The number of bits transmitted per VDE packet shall be fixed, depending on the Link ID used. A packet shall consist of one or multiple VDE messages, zero padding and a CRC.

An example is shown in Fig. 22.

FIGURE 22

Single/multiple message, zero padding and cyclic redundancy check-32 structure



Note that the padding is defined as a separate message. The CRC is always at the end of the packet. Preamble and FEC tail bits are not shown.

4.7 Adaptive coding and modulation/rate adaption

The signal and interference environment are expected to change with time and location. The control station may use the reported CQI as well as measure the channel quality of the received ship signal and request the ship to adjust the Link ID to maximize throughput. The Physical Channel may not be changed dynamically according to the environment, thus the physical channel in use determines the Link ID's available for selection as determined by the physical channel bandwidth.

Should the Link ID be changed then re-fragmentation of the data payload is required. Re-fragmentation should start at the first fragment that has not been successfully transmitted. This is because the overall data payload is fragmented based on the Link ID used during a data transfer and the fragmentation cannot be re-adjusted for individual fragments in a data transfer.

During ship-to-ship communication outside of control station service area, the Link ID can be controlled by the resource allocating ship. The details for rate adaptation are not defined in this document.

The link adaption mechanism is intentionally undefined.

4.8 Slot functions

4.8.1 Bulletin board signalling channel

Bulletin board signalling channel (BBSC) slots are reserved for bulletin board message transmissions. All transactions in the BBSC shall use Link ID 11.

4.8.2 Random access channel

Random access channel (RAC) slots are reserved for requests, resource allocations or short data message transmissions by mobile stations.

4.8.3 Announcement signalling channel

Announcement signalling channel (ASC) slots are reserved for requests, assignments or ad-hoc one-slot data transmissions by the control station.

4.8.4 Data channel

Data channel (DC) slots are reserved for data transmission messages. The Link ID used in the DC is defined by message 4, Resource allocation and may be changed with message 13, ACK/NACK.

4.8.5 Data signalling channel

Data signalling channel (DSCH) slots are reserved for acknowledgements, resource allocation and resource de-allocations for the DC within the same TDMA channel. The link ID used in the DSCH is defined by message 4, Resource allocation and may be changed with message 13, ACK/NACK.

4.8.6 Ranging channel

The ranging channel (RC) is reserved for future radio navigation applications.

4.8.7 VHF data exchange-terrestrial default slot functions

The default slot functions are defined in Figs 23 and 24.

FIGURE 23

VHF data exchange-terrestrial ship to shore default slot functions (lower leg)

BBSC	Bulletin board signalling channel
RAC	Random access signalling channel
ASC	Announcement signalling channel
DSCH	Data signalling channel
	Data channel
s	Slot number

TDMA 0	0 BBSC	6 BBSC	12 BBSC	18 RAC	24 RAC	30 RAC	36 RAC	42 RAC	48 RAC	54 RAC	60 RAC	66 RAC	72 RAC	78 RAC	84 RAC
TDMA 1	1	7	13	19	25	31	37	43	49	55	61	67	73	79	85 DSCH
TDMA 2	2	8	14	20	26	32	38	44	50	56	62	68	74	80	86 DSCH
TDMA 3	3	9	15	21	27	33	39	45	51	57	63	69	75	81	87 DSCH
TDMA 4	4	10	16	22	28	34	40	46	52	58	64	70	76	82	88 DSCH
TDMA 5	5	11	17	23	29	35	41	47	53	59	65	71	77	83	89 DSCH

TDMA 0	90 BBSC	96 BBSC	102 BBSC	108 RAC	114 RAC	120 RAC	126 RAC	132 RAC	138 RAC	144 RAC	150 RAC	156 RAC	162 RAC	168 RAC	174 RAC	…
TDMA 1	91	97	103	109	115	121	127	133	139	145	151	157	163	169	175 DSCH	…
TDMA 2	92	98	104	110	116	122	128	134	140	146	152	158	164	170	176 DSCH	…
TDMA 3	93	99	105	111	117	123	129	135	141	147	153	159	165	171	177 DSCH	…
TDMA 4	94	100	106	112	118	124	130	136	142	148	154	160	166	172	178 DSCH	…
TDMA 5	95	101	107	113	119	125	131	137	143	149	155	161	167	173	179 DSCH	…

…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…

TDMA 0	…	2160 BBSC	2166 BBSC	2172 BBSC	2178 RAC	2184 RAC	2190 RAC	2196 RAC	2202 RAC	2208 RAC	2214 RAC	2220 RAC	2226 RAC	2232 RAC	2238 RAC	2244 RAC
TDMA 1	…	2161	2167	2173	2179	2185	2191	2197	2203	2209	2215	2221	2227	2233	2239	2245 DSCH
TDMA 2	…	2162	2168	2174	2180	2186	2192	2198	2204	2210	2216	2222	2228	2234	2240	2246 DSCH
TDMA 3	…	2163	2169	2175	2181	2187	2193	2199	2205	2211	2217	2223	2229	2235	2241	2247 DSCH
TDMA 4	…	2164	2170	2176	2182	2188	2194	2200	2206	2212	2218	2224	2230	2236	2242	2248 DSCH
TDMA 5	…	2165	2171	2177	2183	2189	2195	2201	2207	2213	2219	2225	2231	2237	2243	2249 DSCH

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FIGURE 24

VHF data exchange-terrestrial ship to ship and shore to ship default slot functions (upper leg)

BBSC	Bulletin board signalling channel
RAC	Random access signalling channel
ASC	Announcement signalling channel
DSCH	Data signalling channel
	Data channel
s	Slot number

TDMA 0	0 BBSC	6 BBSC	12 BBSC	18 RAC	24 ASC	30 RAC	36 ASC	42 RAC	48 ASC	54 RAC	60 ASC	66 RAC	72 ASC	78 RAC	84 ASC
TDMA 1	1	7	13	19	25	31	37	43	49	55	61	67	73	79	85 DSCH
TDMA 2	2	8	14	20	26	32	38	44	50	56	62	68	74	80	86 DSCH
TDMA 3	3	9	15	21	27	33	39	45	51	57	63	69	75	81	87 DSCH
TDMA 4	4	10	16	22	28	34	40	46	52	58	64	70	76	82	88 DSCH
TDMA 5	5	11	17	23	29	35	41	47	53	59	65	71	77	83	89 DSCH

TDMA 0	90 BBSC	96 BBSC	102 BBSC	108 RAC	114 ASC	120 RAC	126 ASC	132 RAC	138 ASC	144 RAC	150 ASC	156 RAC	162 ASC	168 RAC	174 ASC	…
TDMA 1	91	97	103	109	115	121	127	133	139	145	151	157	163	169	175 DSCH	…
TDMA 2	92	98	104	110	116	122	128	134	140	146	152	158	164	170	176 DSCH	…
TDMA 3	93	99	105	111	117	123	129	135	141	147	153	159	165	171	177 DSCH	…
TDMA 4	94	100	106	112	118	124	130	136	142	148	154	160	166	172	178 DSCH	…
TDMA 5	95	101	107	113	119	125	131	137	143	149	155	161	167	173	179 DSCH	…

…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…

TDMA 0	…	2160 BBSC	2166 BBSC	2172 BBSC	2178 RAC	2184 ASC	2190 RAC	2196 ASC	2202 RAC	2208 ASC	2214 RAC	2220 ASC	2226 RAC	2232 ASC	2238 RAC	2244 ASC
TDMA 1	…	2161	2167	2173	2179	2185	2191	2197	2203	2209	2215	2221	2227	2233	2239	2245 DSCH
TDMA 2	…	2162	2168	2174	2180	2186	2192	2198	2204	2210	2216	2222	2228	2234	2240	2246 DSCH
TDMA 3	…	2163	2169	2175	2181	2187	2193	2199	2205	2211	2217	2223	2229	2235	2241	2247 DSCH
TDMA 4	…	2164	2170	2176	2182	2188	2194	2200	2206	2212	2218	2224	2230	2236	2242	2248 DSCH
TDMA 5	…	2165	2171	2177	2183	2189	2195	2201	2207	2213	2219	2225	2231	2237	2243	2249 DSCH

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4.9 VHF data exchange-terrestrial messages

TABLE 33

VHF data exchange message summary

Type	Name	Description	Slot function
0	Media access control	Changes random access selection interval	BB, AC
4	Resource allocation	Allocated LC resource to data session	AC, RAC, DSCH
13	ACK/NACK	Acknowledgement or negative-acknowledgement	AC, RAC, DSCH
20	Bulletin board message start fragment	Start fragment of bulletin board message used for control station service area configuration	BB
21	Bulletin board message continuation fragment	Middle fragment of bulletin board message used for control station service area configuration	BB
22	Bulletin board message end fragment	Last fragment of bulletin board message used for control station service area configuration	BB
74	Start fragment	Start data fragment of data session	DC
75	Continuation fragment	Middle data fragment of data session	DC
76	End fragment	Last data fragment of data session	DC
81	Padding byte	Byte used for padding	BB, AC, RAC, DSCH
90	Resource request / Transmission announcement	Request resource from station or announce transmission to follow	AC, RAC
92	Short data message (with ACK)	Short data message. ACK is required	AC, RAC
93	Short data message (no ACK)	Short message that does not require an ACK. May be used for broadcasting	AC, RAC

4.9.1 Media access control

TABLE 34

Media access control

Media access control				
Field no.	**Value (dec)**	**Size (bytes)**	**Function**	**Content**
1	000	1	Type	
2	0 to 2^{16}-1	2	Length	8: Total size in bytes, fixed at 8 bytes
3	0-255	1	Media Access priority level	Reserved for future use. Always 0
4	0-511	2	Random access selection interval	The random access scheme selection interval in hexslots. 0 – Default selection interval applies
5	0-127	1	Short data message limit	Maximum allowed number of short data message transmissions on the RAC during a frame
6	0-255	1	System status	0: Normal 10: Busy 20: Temporarily out of service 30: Scheduled out of service

Note:

Provides methods for granting data transfer access.

When a mobile station receives a MAC message, this message takes preference over the BB message parameters and the mobile station should apply the random access selection interval for a duration selected randomly between 4 and 8 minutes. After the expiry of the duration, the random access selection interval should revert back to the parameters specified by the BB.

If the random access selection interval is set to 0, then the BB random access selection interval applies.

4.9.2 Resource allocation

TABLE 35

Resource allocation

Field no.	Value (dec)	Size (bytes)	Function	Content
1	004	1	Type	
2	0 to 2^{16}-1	2	Length	Total size in bytes, variable
3	0 to 2^{32}-1	4	Source ID	The unique identifier of the transmitting station as described in § 2.4, Annex 1
4	0 to 2^{32}-1	4	Destination ID	The unique identifier of the ship being assigned a logical channel as described in § 2.4, Annex 1
5	0-255	1	Logical Channel Tx	Logical channel assigned to the session for transmission. Transmission only applies to data slots.(1) LC of 255 indicates no resource
6	0-255	1	Logical Channel Rx	Logical channel assigned to the session for reception. Reception only applies to data signalling slots.(1) LC of 255 indicates no resource
7	0-255	1	Link ID	The link ID that should be used in the TDMA channel. This will apply to Messages 74, 75, 76 and 13
8	1-255	1	TDMA frame delay	The number of TDMA frames to delay before the resource may be used. Resource may only be assigned from the start of the next TDMA frame. Default 1 (2) (3)
9 (4)	0	1	Session ID	Session ID
10	0-255	1	CQI	Received channel quality indicator as defined in § 1.2.8, Annex 2

(1) The resource allocation message will always be sent on the signalling channel when being sent in response to a resource request (#90) message and will always be sent in the assigned TDMA channel when sent in response to an end fragment (#76). When the resource allocation message is being sent in the assigned TDMA channel, then the message should be transmitted in the same VDE packet as the ACK (#13) message. See fragment continuation for more details.

(2) When assigning a logical channel, then both the logical channel Tx and the logical channel Rx should have identical TDMA channel numbers. The assigned LCs may have the same physical channels for simplex communication and different physical channels for duplex communication.

(3) The TDMA frame delay allows for the efficient transferal of LC from one vessel to another with as little as possible wasting of slots.

(4) The session ID is reserved for future use.

4.9.3 Acknowledge/NACK

TABLE 36

Acknowledge/NACK

Field no.	Value (dec)	Size (bytes)	Function	Content
1	013	1	Type	
2	0 to 2^{16}-1	2	Length	Total size in bytes.
3	0 to 2^{32}-1	4	Source ID	The unique identifier of the transmitting station, as described in § 2.4, Annex 1.
4	0 to 2^{32}-1	4	Destination ID	The unique identifier of the receiving station, as described in § 2.4, Annex 1.
5[(1)]	0	1	Session ID	Session ID of data session.
6	0 to 2^{16}-1	2	ACK/NACK mask 0	When a packet was not received, then its corresponding bit should be set to one to not acknowledge the packet. Each ACK/NACK mask corresponds to a data transfer session that started with a Start Fragment and ended with an end fragment. If the start fragment is not received, then the least significant bit is set. The first continuation fragment corresponds with the next bit, and so on, with the end fragment being represented by the last bit. If there were 10 fragments and the end fragment was not received, then the ACK/NACK mask should be logically or-ed with 0x0200. ACK/NACK mask 2 represents the latest TDMA frame received directly before this message response. ACK/NACK mask 1 represents the second to last TDMA frame received. ACK/NACK mask 0 represents the third to last TDMA frame received.
7	0 to 2^{16}-1	2	ACK/NACK mask 1	
8	0 to 2^{16}-1	2	ACK/NACK mask 2	
9	0-255	1	CQI	Received channel quality indicator averaged over the last TDMA frame received as defined in § 1.2.8, Annex 2.
10	0-255	1	ACM or EDN	0: Maintain link ID. 1: Increment link ID (higher rate) 2: Decrease link ID. 3: End delivery notification. The link ID may only be changed if all the fragments have been successfully received and the ACK/NACK mask is set to 0. Changing the link ID should not change the channel bandwidth.
11	0-255	1	Power setting	0: Maintain power level 1: Increase power level (reserved for future use). 2: Decrease power level (reserved for future use).

Notes:

The ACK/NACK message will be transmitted in the data signalling channels on the same logical channel as defined by the "logical channel Rx" assigned by the resource allocation (#4).

During short addressed message transmissions, the ACK/NACK message will be transmitted on the RAC.

(1) Session ID is reserved for future use.

4.9.4 Resource request/transmission announcement

TABLE 37

Resource request / transmission announcement

Field no.	Value (dec)	Size (bytes)	Function	Content
1	90	1	Type	
2	0 to 2^{16}-1	2	Length	Total packet size in bytes.
3	0 to 2^{32}-1	4	Original source ID	The unique identifier of the transmitting station, as described in § 2.4, Annex 1.
4	0 to 2^{32}-1	4	Node source ID	Unique identifier of the current node transmitting the message, as described in § 2.4, Annex 1.
5	0 to 2^{32}-1	4	Node destination ID	Unique identifier of the current node receiving the message, as described in § 2.4, Annex 1.
6	0 to 2^{32}-1	4	Original destination ID	The unique identifier of the receiving station, as described in § 2.4, Annex 1.
7	0-255	1	Priority	Set to 0. Reserved for future use.
8	0 to 2^{32}-1	4	Terminal capabilities	This field is a 32-bit bitmask with each bit set to indicate capabilities/restrictions of a unit: Bit 0: All bandwidths and modulation schemes as per VDE v1.0 supported. Bit 1: Unit has only 1 VDE receiver. Bits 2 to 31: Reserved for future use. Should be set to zero.

Note: The Resource request message will be transmitted on the RAC by ships and ASC by shore stations.

The four maritime mobile service identity (MMSI) numbers could allow for multiple hops of data messages between many stations. This functionality is reserved for future use. The original source and original destination IDs are the end points of the communication while the node source and node destination IDs are the immediate stations communicating with each other during the current hop.

4.9.5 Short data message (with acknowledgement)

TABLE 38

Short data message (with acknowledgement)

Field no.	Value (dec)	Size (bytes)	Function	Content
1	92	1	Type	
2	0 to 2^{16}-1	2	Length	Total size in bytes, variable.
3	0 to 2^{32}-1	4	Source ID	The unique identifier of the transmitting station, as described in § 2.4, Annex 1.
4(1)	0	1	Session ID	Session ID of data session.
5	0 to 2^{32}-1	4	Destination ID	Destination MMSI may not be set to zero (broadcast address).
6	0 to 255	1	Retransmission no	Starts with value 0 and increments with every retransmission. Handles lost ACKs Value of 255 indicates no ACK is requested.
7		Variable	Payload	

Notes:

Should always be transmitted on the RAC by ship and ASC by shore station. The short data message ACK message should be transmitted on the RAC by ship and ASC by shore.

(1) Session ID is reserved for future use.

4.9.6 Short data message (no acknowledgement)

TABLE 39

Short data message (no acknowledgement)

Field no.	Value (dec)	Size (bytes)	Function	Content
1	93	1	Type	
2	0 to 2^{16}-1	2	Length	Total size in bytes, variable.
3	0 to 2^{32}-1	4	Source ID	The unique identifier of the transmitting station, as described in § 2.4, Annex 1.
4(1)	0	1	Session ID	Session ID.
5	0 to 2^{32}-1	4	Destination ID	The unique identifier of the receiving station, as described in § 2.4, Annex 1. Set to 0 for broadcast.
6		Variable	Payload	

Notes:

May be used on the RC in conjunction with link IDs 35, 36, 37 and 38 in order to enable future radio navigation applications.

(1) Session ID is reserved for future use.

4.9.7 Bulletin board start fragment message

TABLE 40

Bulletin board start fragment message

Field no.	Value (dec)	Size (bytes)	Function	Content
1	020	1	Type	
2	0 to 2^{16}-1	2	Length	Total size in bytes, variable
3	0 to 2^{32}-1	4	Source ID	The unique identifier of the transmitting station, as described in § 2.4, Annex 1.
4	0 to 255	1	Control station ID	
5	0 to 2^{16}-1	2	Bulletin board version	Version number of this bulletin board All valid versions are stored in the ship terminal (includes configuration message)
6	0 to 255	1	Number of fragments	Should be a value from 1 to 6 (TBC)
7		Variable	Bulletin board payload	See bulletin board payload definition in Table 41

TABLE 41

Bulletin board payload

Field no.	Value (dec)	Size (bytes)	Function	Content
1	0 to 2^{32}-1	4	Start time for this version	UTC start time for this version of the bulletin board in number of seconds since 1 January 2000 00:00:00 UTC
2	0 to 2^{16}-1	2	Validity of this version	Lifetime of this version in number of 1 minute frames Up to 45 days
3	0 to 255	1	TDMA frame size	The size of TDMA frames in hexslots. May have the following values: 2, 3, 5, 6, 9, 10, 15 (default) Only 15 have to be supported.
4		Variable	Physical channel definitions	See physical channel definition in Table 45.
5	0 to 255	1	Modulation, coding and protocol versions supported	Reserved for future use. Set to zero. Defines a mandatory base set and optional more capable versions. Network ID segmentation could be used to distinguish different network types. ASM reception flag one of the parameters for satellite. Reserved for future use. Should be set to 0.

TABLE 41 (*end*)

Field no.	Value (dec)	Size (bytes)	Function	Content
6		9	Control station service area point 1	Parameter (longitude and latitude) defining the control station service area North East corner. GNSS rectangle longitude and latitude as defined in Recommendation ITU-R M.1371. See Table 42 – control station service area.
7		64	Authentication and integrity sequence	Reserved for future use. Set to zero.

TABLE 42

Control station service area

Name	Field size (bits)	Content
Longitude of point 1	18	Longitude of area to which the assignment applies; upper right corner (North-East); in 1/10 min, or 18 MSBs of addressed station ID 1 (±180°, East = positive, West = negative) 181 = not available
Latitude of point 1	17	Latitude of area to which the assignment applies; upper right corner (North-East); in 1/10 min, or 12 LSBs of addressed station ID 1, followed by 5 zero bits (±90°, North = positive, South = negative) 91° = not available
Longitude of point 2	18	Longitude of area to which the assignment applies; lower left corner (South-West); in 1/10 min, or 18 MSBs of addressed station ID 2 (±180°, East = positive, West = negative)
Latitude of point 2	17	Latitude of area to which the assignment applies; lower left corner (South-West); in 1/10 min, or 12 LSBs of addressed station ID 2, followed by 5 zero bits (±90°, North = positive, South = negative)
Padding	2	Padding bits for byte alignment. Set to zero.

4.9.8 Bulletin board continuation fragment message

TABLE 43

Bulletin board continuation fragment message

Field no.	Value (dec)	Size (bytes)	Function	Content
1	021	1	Type	
2	0 to 2^{16}-1	2	Length	Total size in byte, variable.
3	0 to 2^{32}-1	4	Source ID	The unique identifier of the transmitting station, as described in § 2.4, Annex 1.
4	0 to 255	1	Control station ID	
5	0 to 2^{16}-1	2	Bulletin board version	Version number of this bulletin board All valid versions are stored in the ship terminal (includes configuration message)
6	0 to 255	1	Fragment number	
7		Variable	Bulletin board payload	See bulletin board payload definition, Table 41

4.9.9 Bulletin board end fragment message

TABLE 44

Bulletin board end fragment message

Field no.	Value (dec)	Size (bytes)	Function	Content
1	022	1	Type	
2	0 to 2^{16}-1	2	Length	Total size in bytes, variable
3	0 to 2^{32}-1	4	Source ID	The unique identifier of the transmitting station, as described in § 2.4, Annex 1.
4	0 to 255	1	Control station ID	
5	0 to 2^{16}-1	2	Bulletin board version	Version number of this Bulletin Board All valid versions are stored in the ship terminal (includes configuration message)
6	0 to 255	1	Fragment number	
7		Variable	Bulletin board payload	See bulletin board payload definition, Table 41.

TABLE 45

Physical channel definition

Name	Value	Field size (bits)	Content
Number of physical channels N	0-255	8	Number of physical channels defined in control station service area.
Physical channel 0 (PC0) number	0-255	8	Defines the first physical channel number.
PC0 channel frequency	As defined in Rec. ITU-R M.1084	12	Identification of centre frequency use channel numbering scheme defined in Recommendation ITU-R M.1084. Channel bandwidth is not according to Recommendation ITU-R M.1084 and is defined in PC0 bandwidth field below. Default: 1284: 157.2375 MHz
Reserved		1	Reserved for future use.
PC0 bandwidth	0-2	2	0 – 25 kHz 1 – 50 kHz (reserved for future use) 2 – 100 kHz (default)
PC0 Tx flag	0 or 1	1	0 – mobile may not transmit on this PC 1 – mobile may transmit on this PC
PC0 RA selection interval	0-511	9	The Random Access scheme selection interval in hexslots. 0 for default.
PC0 short data message limit	0-127	7	Maximum allowed number of short data message transmissions on the RAC during a frame.
PC0 logical channel definition	See logical channel definition, Table 46.	Variable	Defines the logical channel definition of physical channel 0
…	…	…	...
Physical channel N (PCN) number	0-255	8	Defines the last physical channel number.
PCN channel frequency	As defined in ITU-R M.1084	12	Identification of centre frequency use channel numbering scheme defined in Recommendation ITU-R M.1084. Channel bandwidth is not according to Recommendation ITU-R M.1084 and is defined in PCN bandwidth field below. Default: 2284: 161.8375 MHz
Reserved		1	Reserved for future use.
PCN bandwidth	0-2	2	0 – 25 kHz 1 – 50 kHz (reserved for future use) 2 – 100 kHz (default)
PCN Tx flag	0 or 1	1	0 – mobile may not transmit on this PC 1 – mobile may transmit on this PC
PCN RA selection interval	0-511	9	The random access scheme selection interval in hexslots. 0 for default.
PCN short data message limit	0-127	7	Maximum allowed number of short data message transmissions on the RAC during a frame.
PCN logical channel definition	See logical channel definition, Table 46	Variable	Defines the logical channel definition of physical channel N.

TABLE 46

Logical channel definition terrestrial

Name	Value	Field size (bits)	Content
TDMA 0 LC count	0-63	6	Number of LCs defined inside TDMA channel 0.
TDMA 1 LC count	0-63	6	Number of LCs defined inside TDMA channel 1.
TDMA 2 LC count	0-63	6	Number of LCs defined inside TDMA channel 2.
TDMA 3 LC count	0-63	6	Number of LCs defined inside TDMA channel 3.
TDMA 4 LC count	0-63	6	Number of LCs defined inside TDMA channel 4.
TDMA 5 LC count	0-63	6	Number of LCs defined inside TDMA channel 5.
LC 0 function	0-5	3	Slot function 0 – Bulletin board 1 – Random access 2 – Announcement signalling 3 – Data 4 – Data signalling 5 – Ranging
LC 0 repeat	0-511	9	Slot duration of function. When set to 0, the slot function is set to a duration of 1 slot and does not repeat.
…	…	…	...
LC N function	0-5	3	Slot function 0 – Bulletin board 1 – Random access 2 – Announcement signalling 3 – Data 4 – Data signalling 5 – Ranging
LC N repeat	0-511	9	Slot duration of function. When set to 0, the slot function is set to a duration of 1 slot and does not repeat.
Padding	0	4 if total number of LC definition pairs are even. 0 if total number of LC definition pairs are odd.	Padded with 0 valued bits to ensure byte alignment of logical channel definition.

Note: See § 4.13 for explanation.

4.9.10 Start fragment

TABLE 47

Start fragment

Field no.	Value (dec)	Size (bytes)	Function	Content
1	074	1	Type	
2	0 to 2^{16}-1	2	Length	Total size in bytes, variable
3	0 to 2^{32}-1	4	Source ID	The unique identifier of the current node transmitting this message, as described in § 2.4, Annex 1.
4	0	1	Session ID	Session ID
5[(1)]	0 to 2^{32}-1	4	Destination ID	The unique identifier of the current node receiving this message, as described in § 2.4, Annex 1. Set to 0 for broadcast.
6	0-255	1	Number of fragments	Number of fragments in this session. Should be a value from 1 to 14.
7	0-255	1	Fragment number	Fragment number of the payload in this message. First fragment should start at 0, increment with any additional fragment and wrap at 255.
8	0-255	1	Continue data session	0 – Ends data session 1 – Continue data session with new
9		Variable	Payload	

Notes:

Should always be transmitted on the TDMA channel (derived from the logical channel) as assigned by a resource allocation.

Will always be transmitted to carry payload of first data fragment.

(1) Session ID is reserved for future use.

4.9.11 Continuation fragment

TABLE 48

Continuation fragment

Field no.	Value (dec)	Size (bytes)	Function	Content
1	075	1	Type	
2	0 to 2^{16}-1	2	Length	Total size in bytes, variable.
3	0 to 2^{32}-1	4	Source ID	The unique identifier of the transmitting station, as described in § 2.4, Annex 1.
4[(1)]	0	1	Session ID	Session ID.
5	0 to 2^{32}-1	4	Destination ID	The unique identifier of the current node receiving this message, as described in § 2.4, Annex 1. Set to 0 for broadcast.
6	0-255	1	Number of fragments	Total number of fragments in this session. Should be a value from 1 to 14
7	0-255	1	Fragment number in this session	Fragment number in this session. Should be a value from 2 to 13.
8	0-255	1	Fragment number in this message	Fragment number of the payload in this message. First fragment should start at 0, increment with any additional fragment and wrap at 255.
9		Variable	Payload	

Note: Should always be transmitted on the data channel (derived from the logical channel) as assigned by a resource allocation.

(1) Session ID is reserved for future use.

4.9.12 End fragment

TABLE 49

End fragment

Field no.	Value (dec)	Size (bytes)	Function	Content
1	076	1	Type	
2	0 to 2^{16}-1	2	Length	Total size in bytes, variable.
3	0 to 2^{32}-1	4	Source ID	The unique identifier of the transmitting station, as described in § 2.4, Annex 1.
4(1)	0	1	Session ID	Session ID.
5	0 to 2^{32}-1	4	Destination ID	The unique identifier of the current node receiving this message, as described in § 2.4, Annex 1. Set to 0 for broadcast.
6	0-255	1	Number of fragments	Total number of fragments in this session. Should be a value from 1 to 14.
7	0-255	1	Fragment number in this message	Fragment number of the payload in this message. First fragment should start at 0, increment with any additional fragment and wrap at 255.
8	0-255	1	Continue data session	0 – Ends data session. 1 – Continues data session with new session ID.
9		Variable	Payload	

Note: The resource allocation broadcast by the base station repeatedly broadcasts during the TDMA Frame length.

Should always be transmitted on the data channel (derived from the Logical Channel) as assigned by a resource allocation.

Will always be transmitted on last fragment signalling the end of Logical Channel use, unless only one fragment will be transmitted. When only one fragment will be transmitted, then only a Start Fragment will be transmitted.

(1) Session ID is reserved for future use.

4.9.13 Padding single byte

TABLE 50

Padding single byte

Field no.	Value (dec)	Size (bytes)	Function	Content
1	081	1	Type	1 byte padding

4.10 Cyclic redundancy check

Refer to § 1.2.5, Annex 2.

4.11 Acknowledgement

Acknowledgement behaviour for the terrestrial link is described in § 4.17.

4.12 Logical channels

A LC defines a grouping of slots that can be uniquely identified and assigned for a specific use.

LC map slots to slot functions. LC numbers are used to assign resources to data sessions.

4.13 Terrestrial bulletin board

The terrestrial bulletin board (TBB) message defines the slot map for each physical channel (PC). The TBB content is defined in § 4.9.7, § 4.9.8 and § 4.9.9. A TBB message defines a list of PC. For VDE-TER each PC definition contains six TDMA Channels, each TDMA channel can contain one or more LCs.

A LC definition starts by announcing the number of LC definitions per TDMA channel. Each TDMA Channel, in turn, gets its number of LCs defined by function and duration item pairs. The complete TDMA channel slotmap is built up by repeating each TDMA channel's LC definition from the first Hexslot up to the end of a frame. The LCs should be sized to ensure the repeating pattern aligns with a full frame.

The relationship between LC and PL for ship to shore, shore to ship and ship to ship mappings are shown in § 4.14.

A VDES station shall always use the latest valid TBB that is received. The TBB shall be used in the frame immediately following the frame in which it is valid. The validity is found by use of the TBB start time and Lifetime fields in the TBB payload (Table 41).

The TBB may be transmitted in either the upper or the lower leg in channels 1024 or 2024 respectively. The mobile station should therefore always listen for the bulletin board announcement in both upper leg (channel 2024) and lower leg (channel 1024).

Coast stations should coordinate the timing of the transmissions where multiple station coverage is the case.

4.14 VHF data exchange-terrestrial default physical channel and slotmap

A slotmap defines the LC of all the slots in a frame. Each physical channel in a VDES system will have a valid slotmap defined. By monitoring the terrestrial bulletin board, ships will determine if they are within a control station service area and adopt the physical channel and slotmap from the bulletin board. In the absence of a bulletin board, the default physical channel and slotmap will be applied.

The default physical channel centre frequency is located in the middle of each VDE1 upper (161.837 5 MHz) and lower VDE leg (157.237 5 MHz) and the default bandwidth is set to 100 kHz.

Default LC for VDE lower and upper legs are defined as shown in Figs 25 and 26.

Signalling only takes place in RA, ASC and DSCH slots. For VDE-TER, the default slot map keeps all signalling in TDMA 0 channel and at the DSCH slot at the end of every TDMA frame.

TDMA 1-5 channels are broken into TDMA frames of 15 slots where data transfer can take place on the first 14 (DC) slots while the 15^{th} slot (DSCH) is used for ACK/NACK and resource allocation signalling.

FIGURE 25

VHF data exchange-terrestrial ship to shore default slot to LC mapping (lower leg)

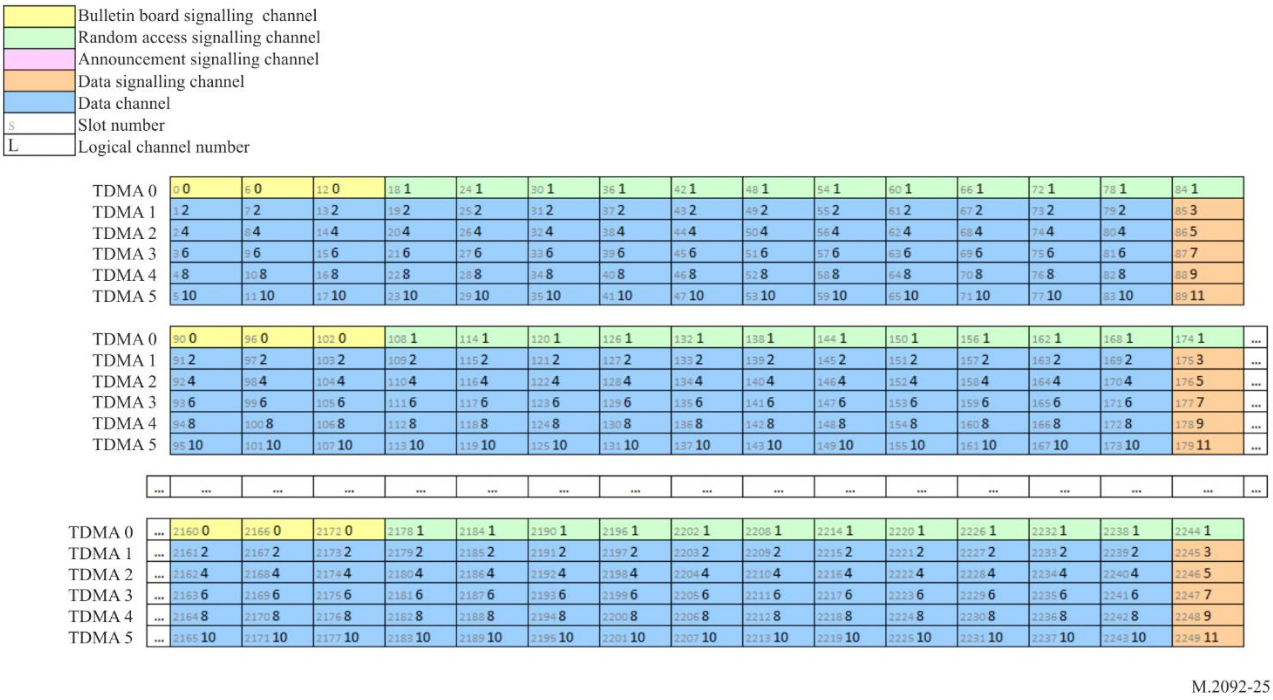
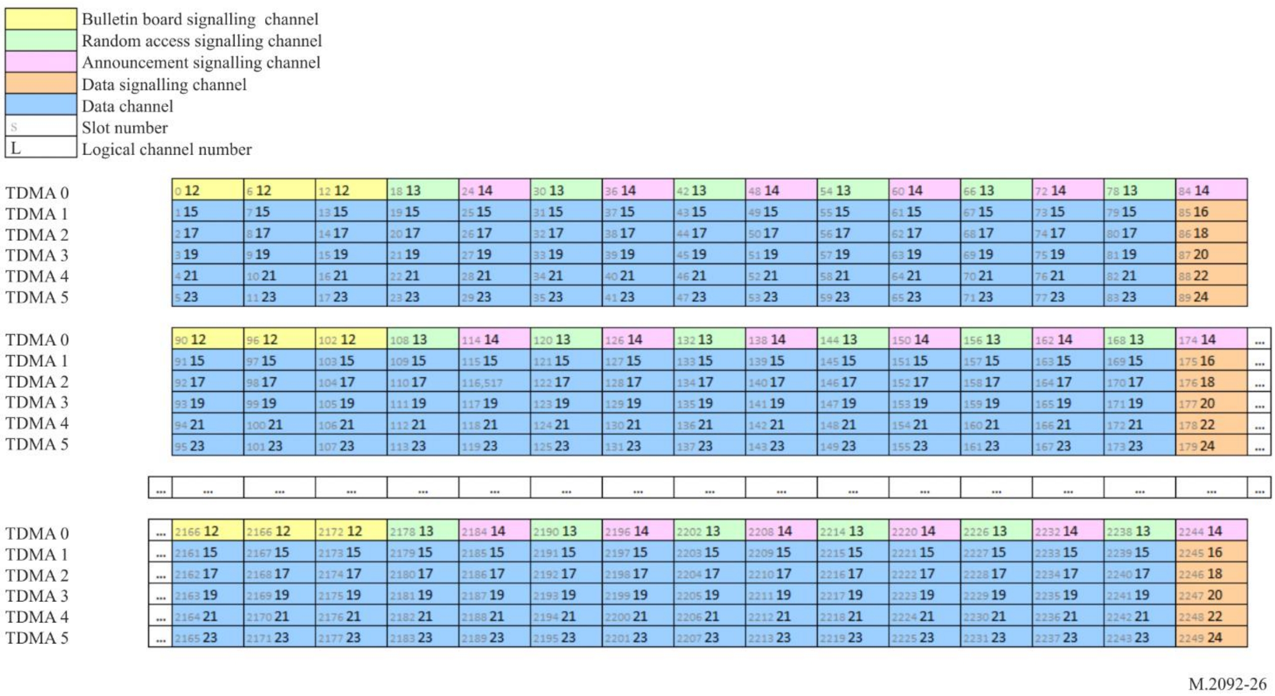


FIGURE 26

VHF data exchange-terrestrial ship to ship default slot to logical channel mapping (upper leg)



4.15 Digital signature of bulletin board

It is assumed that a public key infrastructure (PKI) is established with an international organization capable of acting as certificate authority (CA), and that Recommendation ITU-T X.509 (10/2016) is used for public key certificates and the PKI implementation. The PKI will serve several systems and among these VDES. For VDES the primary purpose is to attach a digital signature to the bulletin board (BB) issued by a VDES control station to authenticate the control station transmitting the BB.

It should be possible to store certificate validation data in the VDES unit to refer to when a network connection is not available to the CA. Both certificate validation data storage and real-time network access to the CA are done by using the VDES unit PI. In case the verification of the signature fails on the VDES mobile station this shall be flagged to the user. The system shall continue its operation as if the signature was verified.

Cryptographic algorithm for the end-entities digital signatures is the elliptic curve digital signature algorithm. The elliptic curve cryptography public key shall therefore be 256 bits. With this key size, the recommendations from Internet Engineering Task Force (IETF) Document RFC 5480[8] states that the minimum bits of security should be 128, the message digest algorithm Secure Hash Algorithm (SHA)-256, and the curve secp256r1. The lifetime of the selected key material is three years.

4.16 Data transfer protocols

The following downlink protocols shall be supported:

Shore originated broadcast

Ship originated broadcast inside/outside control station service area

Shore to ship addressed message

Ship to shore addressed message

Ship to ship addressed message inside/outside control station service area

Shore to ship short data message

Ship to shore short data message

Ship to ship short data message.

4.17 Data session transmission and continuation

For each data session between two stations, each station will be assigned one LC for data transmission and one LC for acknowledgement reception. The two logical channels should have identical TDMA channel numbers but do not have to be on the same PC. This ensures adequate processing time between message transmissions. When both LCs are on the same PC, the session is considered simplex (Fig. 27). When the two LCs are on different PCs, the session is considered duplex (Fig. 28).

LCs assigned for data transmission sessions should have a DC slot function, while LCs assigned for acknowledgement reception, should have DSCH slot function. See § 4.8.

Figures 27 and 28 show examples of the required slot use during simplex and duplex data session transmissions when 14 fragments are transmitted during each TDMA frame. Two TDMA channels are shown from different physical channels.

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[8] IETF Document RFC 5480: *Elliptic Curve Cryptography Subject Public Key Information*.

FIGURE 27

Simplex data session

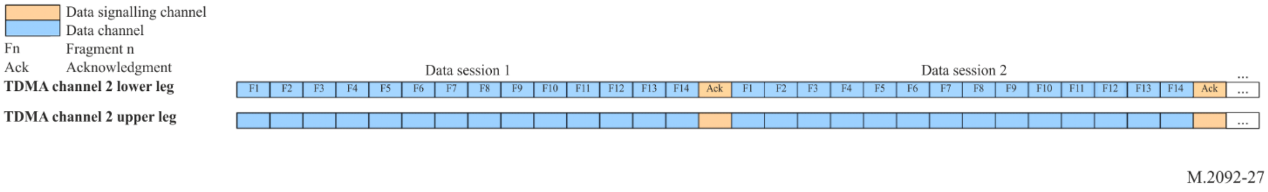
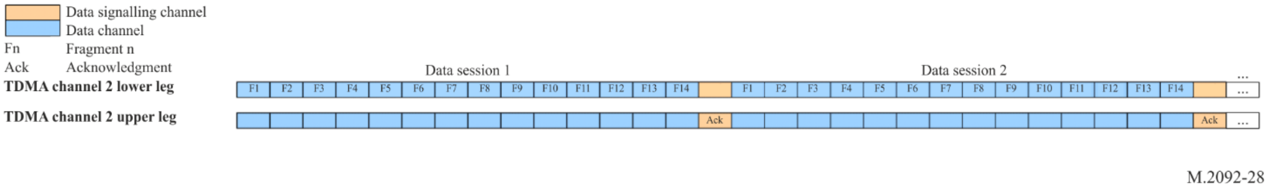


FIGURE 28

Duplex data session



All data fragments will be transmitted on DC slots on the assigned LC only. ACK/NACK messages will be transmitted on the DSCH slots as assigned.

When data exceeds the data packet payload capacity, then data should be broken up and transmitted in fragments. During successful data session transmission, each session will fit into a TDMA frame. This will result in a maximum of 14 fragments per data session (one in each DC slot), before reaching a DSCH slot used for the ACK/NACK.

The first data fragment starts with a start fragment (#74) message, continues with continuation fragment (#75) messages onwards and ends with an end fragment (#76) message.

When only one fragment is transmitted, the one fragment should be a start fragment (#74).

When two fragments are transmitted, then transmission order will be:

1 Start fragment (#74)

2 End fragment (#76).

When three fragments are transmitted, then transmission order will be:

1 Start fragment (#74)

2 Continuation fragment (#75)

3 End fragment (#76), etc.

If the maximum number of fragments (14) are being used and there are data left for transmission, then the data transmission can be continued by setting the “continue data session” parameter in the end fragment (#76) message to 1. On successful transmission, the data transmission session will be acknowledged with an ACK/NACK (#13) message and a logical channel will be immediately assigned by means of a Resource Allocation (#4) message. Both messages ACK/NACK (#13) and resource allocation (#4) will be transmitted in the same data signalling slot. If no more LC resources are available, then an ACK/NACK (#13) message may be transmitted with the ACM or end delivery notification (EDN) parameter set to 3.

4.18 Data frame retry

During data frame transmission, it is expected that data fragments can be lost occasionally. When some data fragments are not received, the receiving station shall transmit a NACK message (#13) and flag the lost fragments in the ACK/NACK mask parameter.

The transmitting station shall retry transmission of each individual fragment for a maximum of three times before giving up.

The receiving station shall request retransmission of data fragments for a maximum of three attempts.

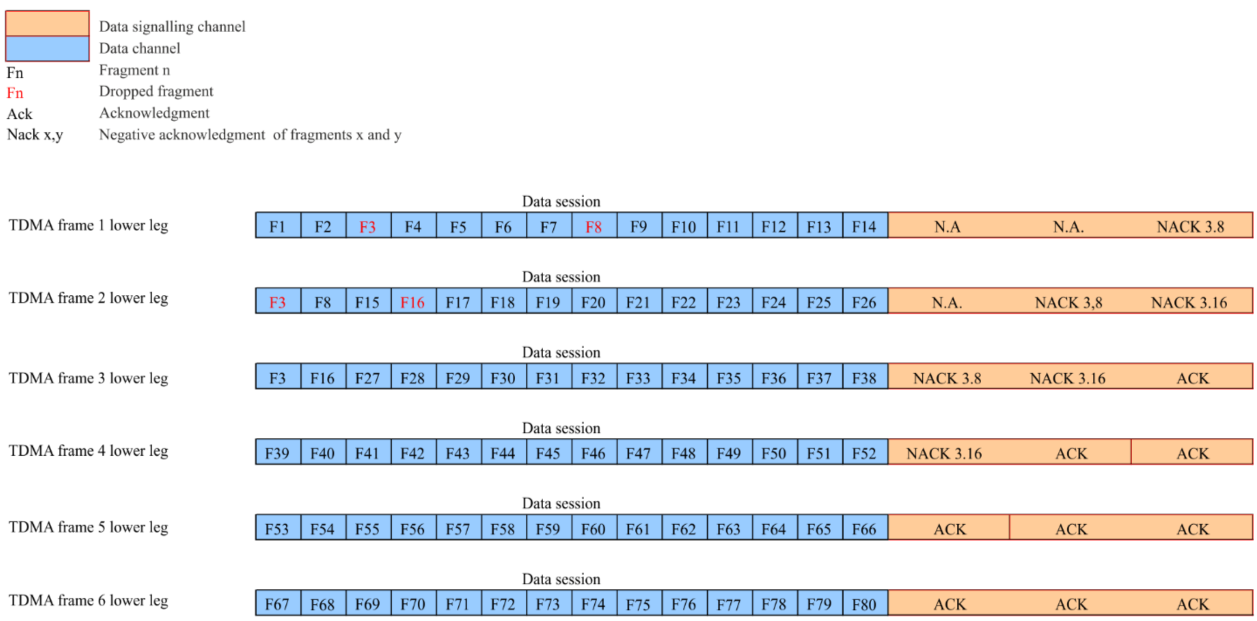
It is also possible that the NACK message (#13) is not received by the transmitting station. It is for this reason that the NACK message (#13) contains redundancy with three ACK/NACK masks, referencing the previous three TDMA frames.

When the transmitting station does not receive an ACK/NACK, it shall continue as if all the fragments has been acknowledged. If there were any errors, then the transmitting station will see this when it receives the next ACK/NACK message. If no ACK is received within three TDMA frames, then the transmitter shall stop transmitting immediately.

An example of this process is shown in Fig. 29.

FIGURE 29

Simplex data session retry



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4.19 Giving priority to automatic identification system

VDE transmissions should always give preference to AIS transmissions.

4.19.1 Ship side

Because of the limited physical antenna separation available on a ship, and the possibility that ships use integrated VDES units (containing VDE-TER, VDE-SAT, ASM and AIS), it is best to assume that whatever VDE-TER configuration is used (simplex or duplex), any VDE-TER or ASM transmission will interfere with AIS and *vice versa*.

It is not required to implement any measure to prevent an own ship AIS transmission from interfering with an ASM or VDE (terrestrial or satellite) reception. The VDE data session acknowledgment and retry mechanism should be able to handle the short interference in this case.

For the more problematic case of VDE or ASM transmission interfering with AIS reception, the first mitigation measure is that a single VDE ship transceiver should not use more than one logical channel simultaneously. This measure in itself will limit VDE interference on AIS channels to a very worst case of 1/6 duty-cycle during the VDE transmission, if the AIS channels are loaded to 100%, which is considered impossible. This measure is not an absolute requirement, but it is a ship-side responsibility to ensure that own VDE transmissions do not overly affect the AIS function primary purpose of collision avoidance. For example, in areas where it is detected that there is no or few AIS stations within close proximity of own ship, a ship may use more than one VDE logical channels simultaneously to transfer larger amounts of data for short periods of time.

A VDES unit may greatly decrease the amount of AIS message transmission conflicts by monitoring the future slots in the current TDMA frame for own AIS transmissions. During the transmission of the Start Fragment (#74) message, the number of fragments used (up to 14) will be announced. The announced number of fragments can be decremented by one for every own AIS message transmission conflict.

For example, if the transmitting station wants to transmit start fragment (#74) with an announcement of 14 fragments but detects one own AIS message transmission conflict with one of the VDE data fragments, then the transmitting station may transmit start fragment (#74) with an announcement of 13 fragments. This way the transmitting station will avoid the data session retry from happening and slowing down the data transfer.

In addition to the general limits explained above, access to VDE RAC is subject to rules for slot selection that have been designed to protect the AIS function. Please see § 4.21.1.

4.19.2 Shore side

Shore-side interference mitigation is a complex matter that can be solved in a number of different ways by subject matter experts. This section aims to highlight the intent of this standard to protect the AIS function from interference. The discussion below should not be interpreted as a specification per se but rather as a reference for achieving acceptable protection of the AIS function within VDES.

4.19.2.1 Duplex configuration

On the shore side, unless sufficient isolation can be achieved, VDE should not be co-located with AIS to prevent wideband noise desensitization of the AIS receiver and loss of situational awareness.

Unless AIS coverage is available from other base stations, providing the desired situational awareness to the shore authority, the recommended isolation between VDE transceiver and AIS receiver is 82 dB as per Table 51.

TABLE 51

Base station co-site performance

AIS base station sensitivity as per Rec. ITU-R M.1371*	20% PER @ −107 dBm
Required margin	−10 dBm
VDE transceiver power	41 dBm rms
Mask sideband noise of VDE @ AIS1	−70 dBc (−29 dBm)
Required isolation	82 dB

* Different AIS deployments may have different sensitivity requirements.

For co-location of VDE and AIS without the recommended isolation, shore authorities should be aware that the local AIS reception will be degraded whenever the VDE control station transmits. Trying to synchronise VDE transmissions with AIS and ASM services so as to minimize the interference runs the risk of greatly reducing the throughput of VDE and should be carefully considered. Increasing the number of AIS receivers in the area to offer coverage redundancy would be preferable if feasible.

This is why sufficient isolation is recommended when operating VDES in duplex mode co-located with AIS.

4.19.2.2 Simplex configuration

The simplex configuration simplifies the isolation between co-located VDE transceiver and AIS receiver to a point where co-location using an affordable duplexer is possible without any interference on AIS. That being said, the simplex configuration reduces the global capacity of VDE-TER, especially in very busy areas where lots of transmissions are expected simultaneously.

4.20 Short data message

Vessels may transmit short data messages in RAC slots as long as the vessel adheres to the selection interval and short data message transmission limits while inside the control station service area. When vessels are not inside a control station service area, then the default selection interval and short data message transmission limits apply.

4.21 Random access channel scheme

When a message is scheduled for immediate RAC transmission, then all transmission candidate slots should be gathered over the selection interval. The default selection interval is 235 slots, but may be set via a control station. Only slots with slot function set as RAC may be considered as candidate slots. As AIS and ASM functions form part of the VDES system, their transmission schedules should also be considered. AIS and ASM will always have priority over VDE transmissions.

The candidate slot selection process for RAC on VDE follows the rules explained in § 4.21.1 below. One candidate slot will be randomly selected from all the available candidate slots. If no candidate slot is available or if for some reason, the VDE message could not be transmitted (AIS messages could be scheduled after the VDE schedule), then the VDE transmission will fail and the normal retry mechanism will follow. The retry mechanism will allow up to 3 retries of the RAC transmission.

4.21.1 Slot selection algorithm for the VHF data exchange random access channel

The definitions of free, allocated and unavailable slots are the same as with ASM function and defined in § 4.3.6, Annex 3.

Slots, used for transmission, are selected from candidate slots in the selection interval (SI) which is defined as 235 slots.

The selection process uses received data from AIS, ASM and VDE channels where these functions are co-located. Functions not part of a co-located station, or not in use by the station, are not considered by the candidate slot selection process of the station.

There should be, at minimum, a set of eight candidate slots to choose from.

The conditions for slot state (see § 4.3.6, Annex 3) will determine if the slot is unavailable for VDE RAC.

Rule 1: The candidate slots are initially selected from slots that are free on all VDES channels.

If the candidate slot set contains less than eight slots, additional candidate slots can be obtained by using the following rules and order (rule 2 followed by rule 3 and then rule 4 and then rule 5):

Rule 2: Free on all AIS and VDE channels, allocated on one ASM channel and free on the other.

Rule 3: Free slot on all AIS and VDE channels, allocated on both ASM channels.

Rule 4: Free on one AIS channel and available on the other, free or allocated on both ASM channels and free on the VDE channel.

Rule 5: Available on both AIS channel, free or allocated on both ASM channels and free on the VDE channel.

If the station cannot find a sufficient number of candidate slots, the station should not transmit and should re-schedule the transmission.

The purpose of maintaining a minimum of eight candidate slots within the same probability of being used for transmission is to provide high probability of access to the link.

Note that individual VDES functions need only to be considered in the candidate slot selection process when they are in use and there is not sufficient isolation ensure that the AIS station will meet its receiver performance requirements.

Figure 16 shows (see Annex 3) a flowchart representation of the selection algorithm.

4.22 Announcement channel access scheme

Ad hoc messages (messages 4, 90 and 92) shall be transmitted on AC by the control station and transmitted on RAC by a mobile station to avoid any conflicts between control station and mobile stations.

When scheduling a message for AC transmission, then the first available announcement slot may be selected for transmission. A control station may choose to use RAC slots for the transmission of ad hoc messages during high congestion but should always use the RAC scheme when accessing the RAC.

4.23 Logical channel access

A resource assignment message assigns two LCs. One LC for data transmission and one LC for receiving signalling information. In addition, the LC pair is assigned with a TDMA frame delay. As the frame delay has a minimum value of 1, transmission cannot start in the current TDMA frame at the time of assignment. The LC assignment goes into effect at the beginning of the next frame, after the TDMA frame delay expires.

Only DC slots may be used for transmission and only DSCH slot may be used for the reception of ACK/NACK and resource re-assignment or de-assignment messages.

4.24 Logical channel use map

Each station should continuously monitor all ASC and DSCH slots for LC resource assignment messages. A station should keep a map of all LCs and mark if they are reserved or free. When an LC remains in use, it will be assigned again at every DSCH slot. If no LC assignment has been received for three consecutive TDMA frames, the LC can be marked as free. Whenever a LC is used for own station transmission or reception, then a LC should be marked as internally assigned for the current TDMA frame and for the following three TDMA frames.

4.25 Unused logical channel slots as random access channel slots

As an LC can only be assigned from the start of the next TDMA frame, an LC that is marked as free in the current TDMA frame shall remain free for the remainder of the current TDMA frame. As these slots will remain unutilised in the current frame, they may be used as RAC slots. These slots may form part of the random access candidate slots, if they also comply with the rules in § 4.21.1. Free slots from the next TDMA frame may not be added to the list of candidate slots, until such time that the TDMA frame has arrived and the slots are still free.

4.26 Logical channel assignment

When a ship is outside of the control station service area, the receiving ship should be capable of assigning a LC to another ship after reception of a resource request message. The LC assignment should be made by randomly selecting a free LC from the logical channel use map.

4.27 Retry mechanism

All individual message transmissions and receptions will in general be retried three times before the session will fail and be removed. Because of different selection intervals of different access schemes, the rules for the general retry mechanism will not hold for all the situations and all the special rules and cases will be shown in the state diagrams.

The retry timeouts will also be modified as the selection interval gets changed via the control station.

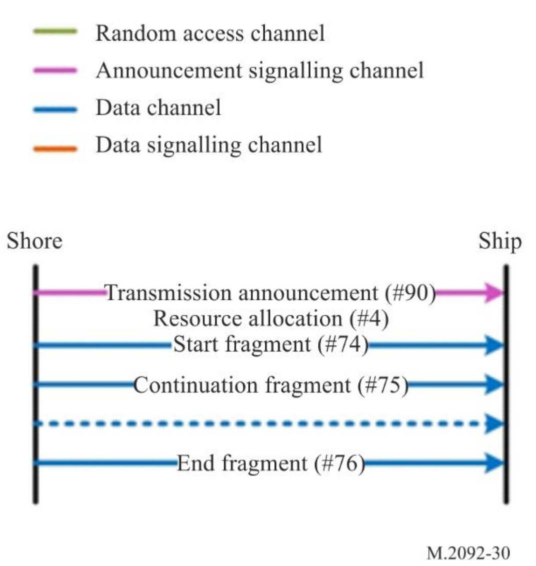
4.28 Data transfer protocol detail

4.28.1 Shore originated broadcast

The sequence diagram for shore originated broadcast without ACK is shown in Fig. 30. The transfer starts with a resource allocation. The diagram shows a large multi-fragmented data session.

FIGURE 30

Shore originated broadcast sequence diagram

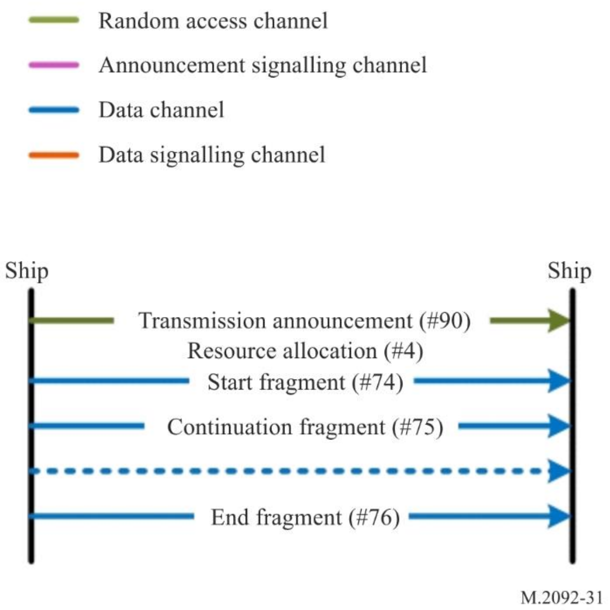


4.28.2 Ship originated broadcast outside control station service area

The sequence diagram for ship originated broadcast outside of control station service area is shown in Fig. 31.

FIGURE 31

Ship originated broadcast outside control station service area sequence diagram

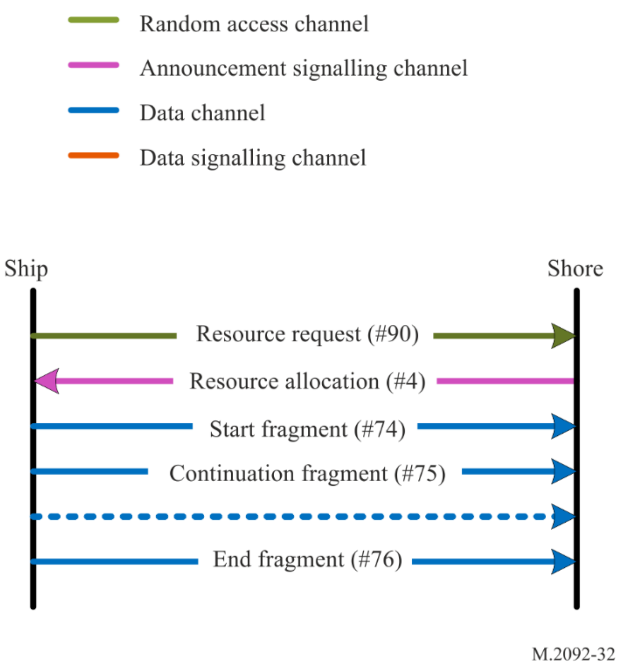


4.28.3 Ship originated broadcast inside control station service area

The sequence diagram for ship originated broadcast inside of control station service area is shown in Fig. 32.

FIGURE 32

Ship originated broadcast inside control station service area sequence diagram



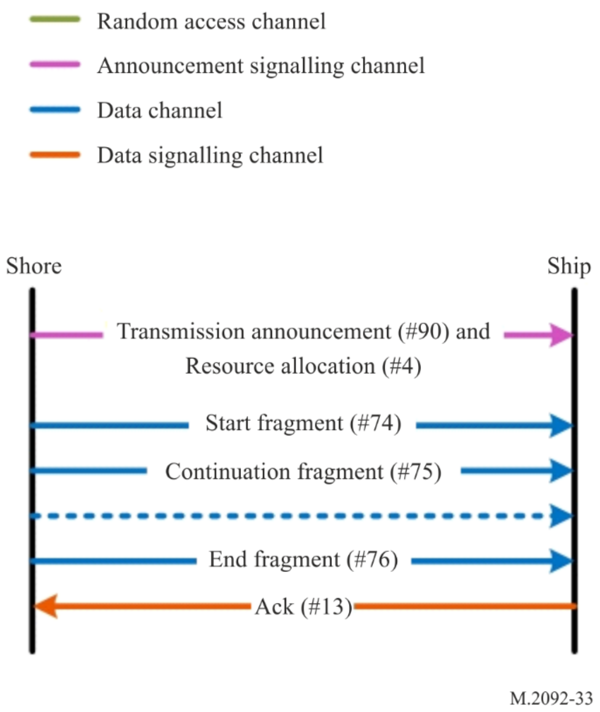
4.28.4 Shore to ship addressed message

The sequence diagram for shore to ship addressed message is shown in Fig. 33. The transfer starts with a resource request/transmission announcement message to announce the source and destinations of the data session. In the same slot, a resource allocation message is transmitted to assign a LC to the data session. The diagram shows a large multi-fragmented data session. Up to 14 fragments are sent before the ship sends a selective NACK indicating which fragments have to be resent. The LC is kept allocated until all fragments have been received by the ship and an ACK has been received or a retry limit has been exceeded.

The datagram payload has source, destination and format encapsulated for routing and presentation purposes.

FIGURE 33

Shore to ship addressed message sequence diagram



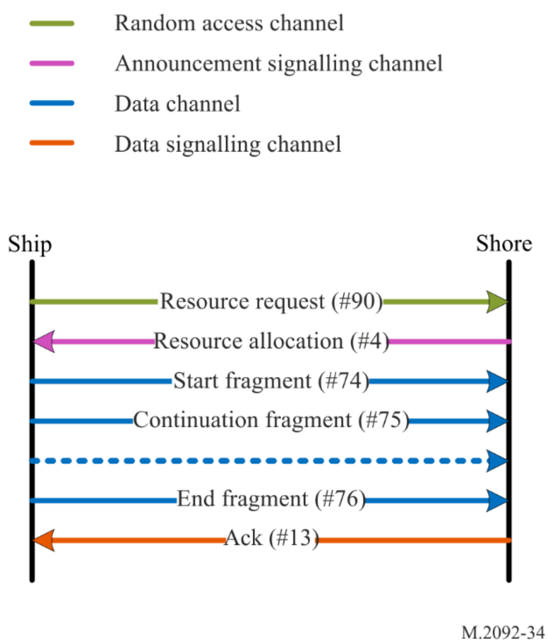
4.28.5 Ship to shore addressed message

The sequence diagram for ship to shore addressed message is shown in Fig. 34. The transfer starts with a resource request message to request a LC for the data session. The following resource allocation message is transmitted to assign a LC to the data session. The diagram shows a large multi-fragmented data session.

The datagram payload has source, destination and format encapsulated for routing and presentation purposes.

FIGURE 34

Ship to shore addressed message sequence diagram



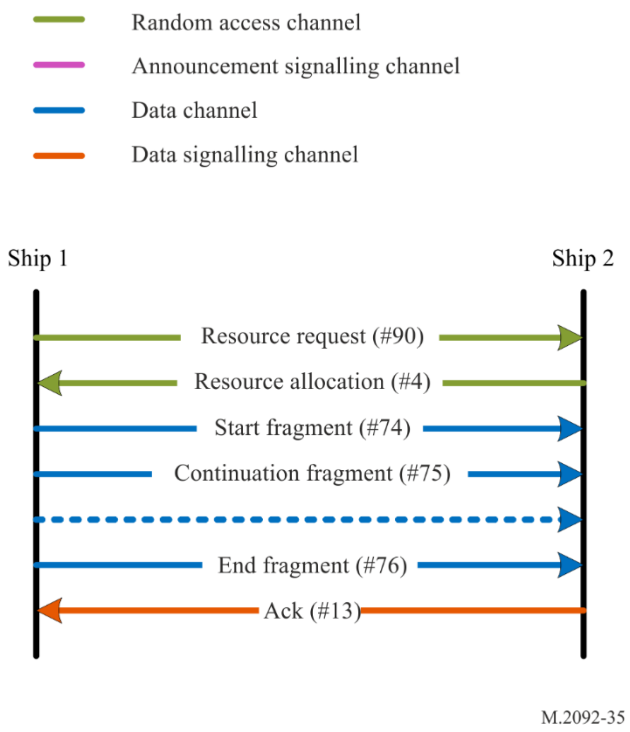
4.28.6 Ship to ship addressed message outside control station service area

The sequence diagram for ship to ship addressed message outside of control station service area is shown in Fig. 35. The transfer starts with a resource request message to request a LC for the data session. The following resource allocation message is transmitted to assign a LC to the data session. The diagram shows a large multi-fragmented data session.

The datagram payload has source, destination and format encapsulated for routing and presentation purposes.

FIGURE 35

Ship to ship addressed message outside control station service area sequence diagram



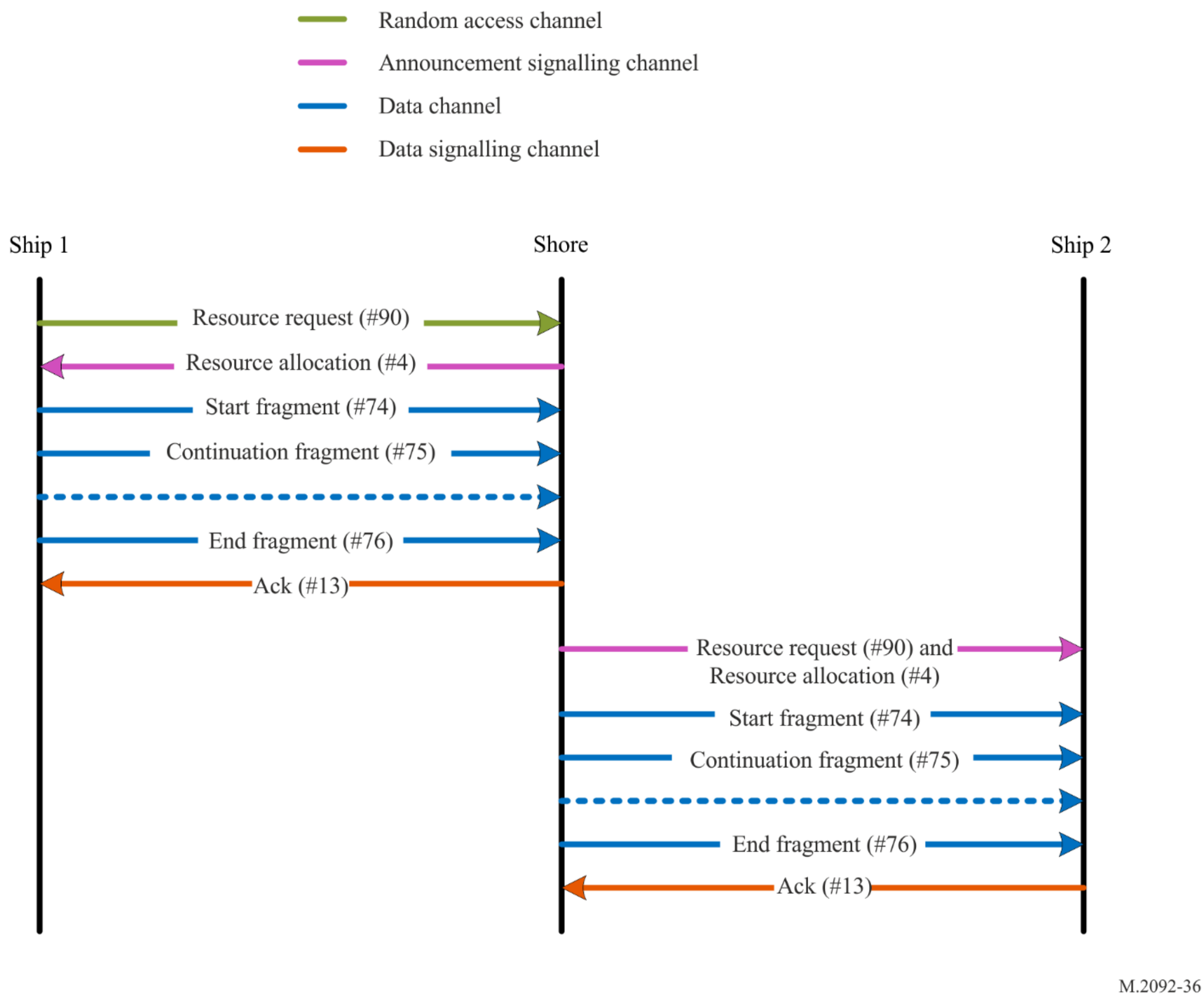
4.28.7 Ship to ship addressed message inside control station service area

The sequence diagram for ship to ship addressed message inside of control station service area is shown in Fig. 36. The transfer starts with a resource request message to request a LC for the data session. The following resource allocation message is transmitted to assign a LC to the data session. The diagram shows a large multi-fragmented data session.

The datagram payload has source, destination and format encapsulated for routing and presentation purposes.

FIGURE 36

Ship to ship addressed message inside control station service area sequence diagram



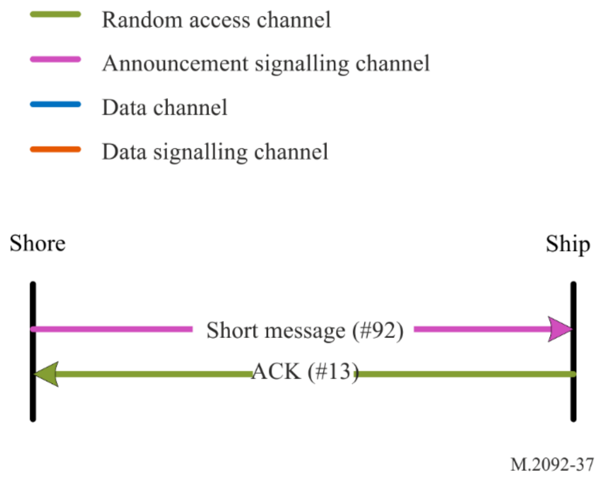
4.28.8 Shore to ship short data message

The sequence diagram for shore to ship short data message with ACK is shown in Fig. 37. This protocol is used for short data messages that fit within a single transmission burst.

The ship sends an ACK when the message is received correctly, otherwise the shore may automatically retry until the retry limit is reached.

FIGURE 37

Shore to ship short data message sequence diagram

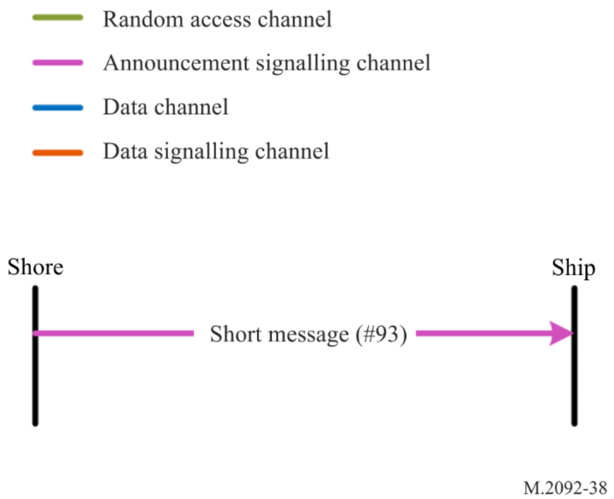


The sequence diagram for shore to ship short data message without ACK is shown in Fig. 38. This protocol is used for short data messages that fit within a single transmission burst.

The destination ID of this message may be set to zero to use it as a short, efficient broadcast message.

FIGURE 38

Shore to ship short data message sequence diagram



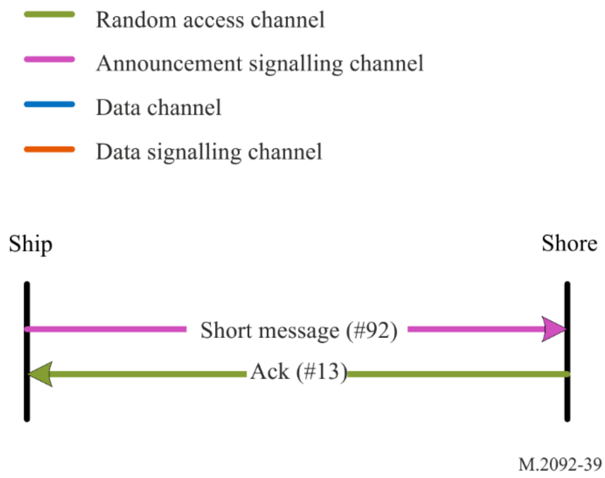
4.28.9 Ship to shore short data message

The sequence diagram for ship to shore short data message is shown in Fig. 39. This protocol is used for short data messages that fit within a single transmission burst. A random slot in the randomizing interval given in the MAC signalling is used for the transmission.

The shore sends an ACK when the message is received correctly, otherwise the ship may automatically retry until the retry limit is reached.

FIGURE 39

Ship to shore short data message sequence diagram



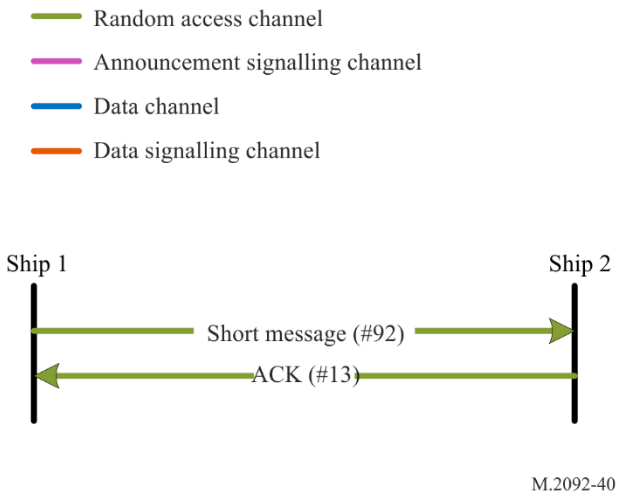
4.28.10 Ship to ship short data message

The sequence diagram for ship-to-ship short data message is shown in Fig. 40. This protocol is used for short data messages that fit within a single transmission burst. A random slot in the randomizing interval given in the MAC signalling is used for the transmission.

The receiving ship sends an ACK when the message is received correctly, otherwise the transmitting ship may automatically retry until the retry limit is reached.

FIGURE 40

Ship to ship short data message sequence diagram



4.29 Data transfer protocol state diagrams

4.29.1 Ship to ship addressed message outside control station service area

The state diagrams in Figs 41 and 42 shows an example of an implementation for the default PC and LC.

FIGURE 41

Example addressed ship to ship transmit state diagram

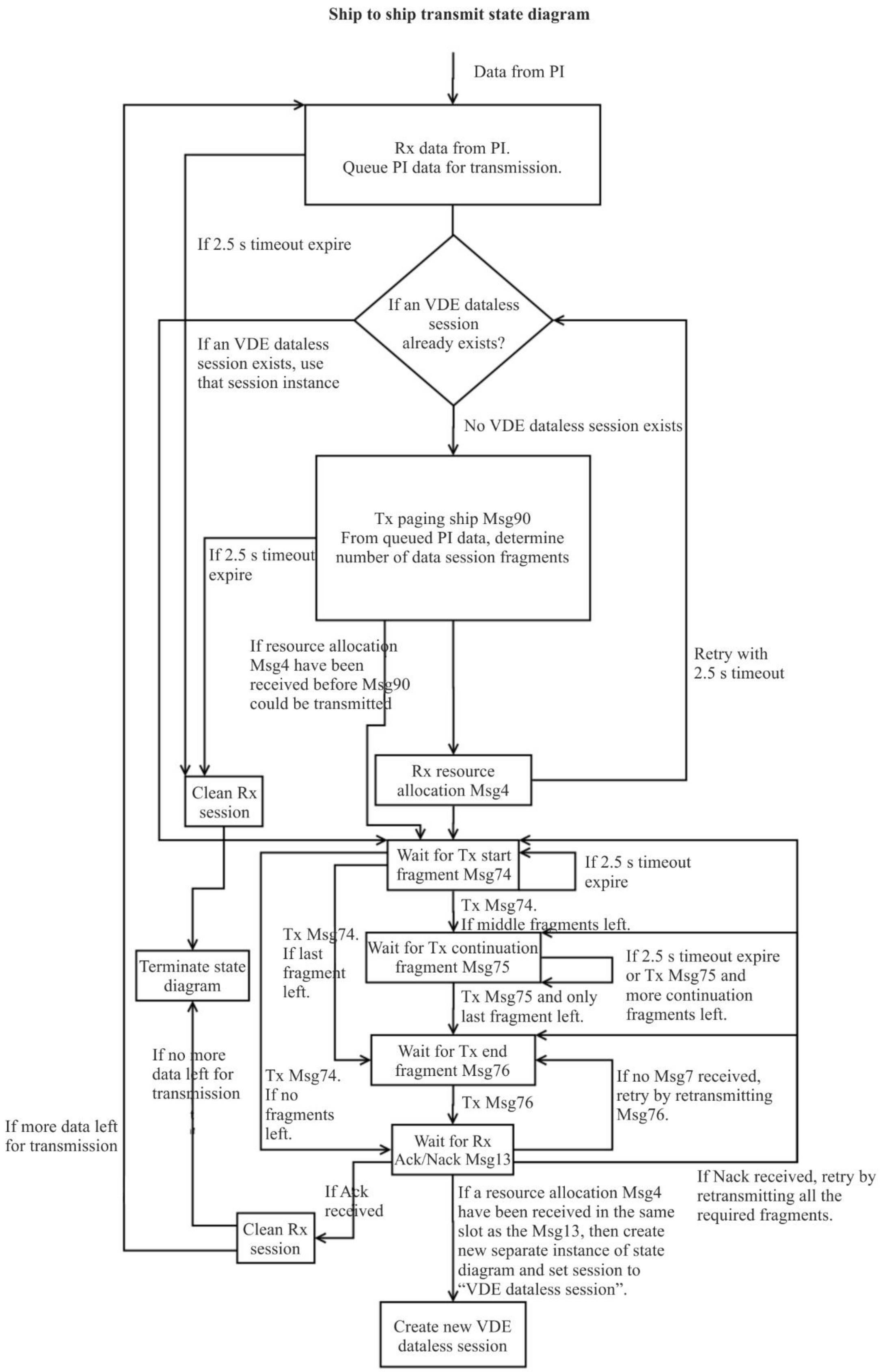


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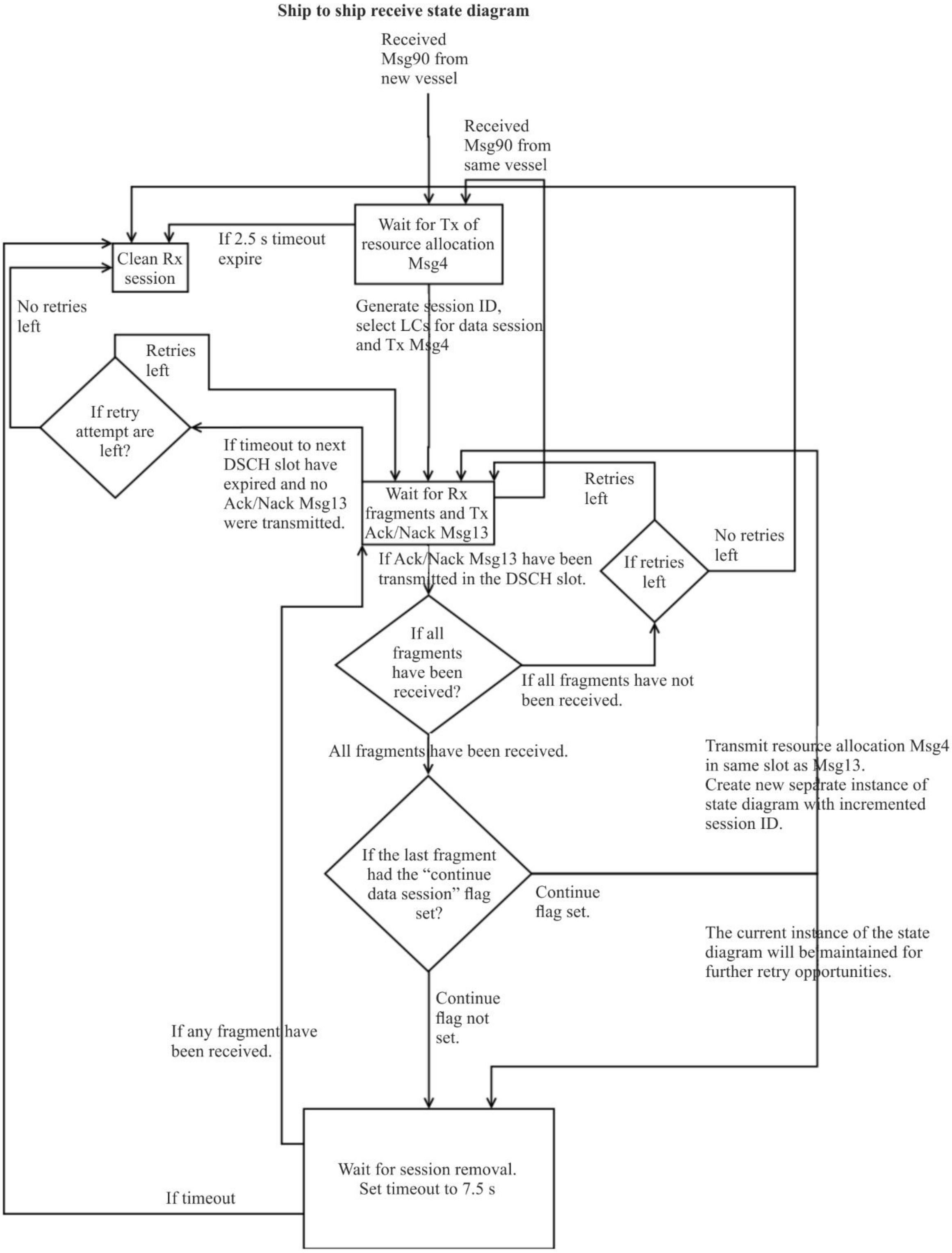
FIGURE 42

Example addressed ship to ship receive state diagram



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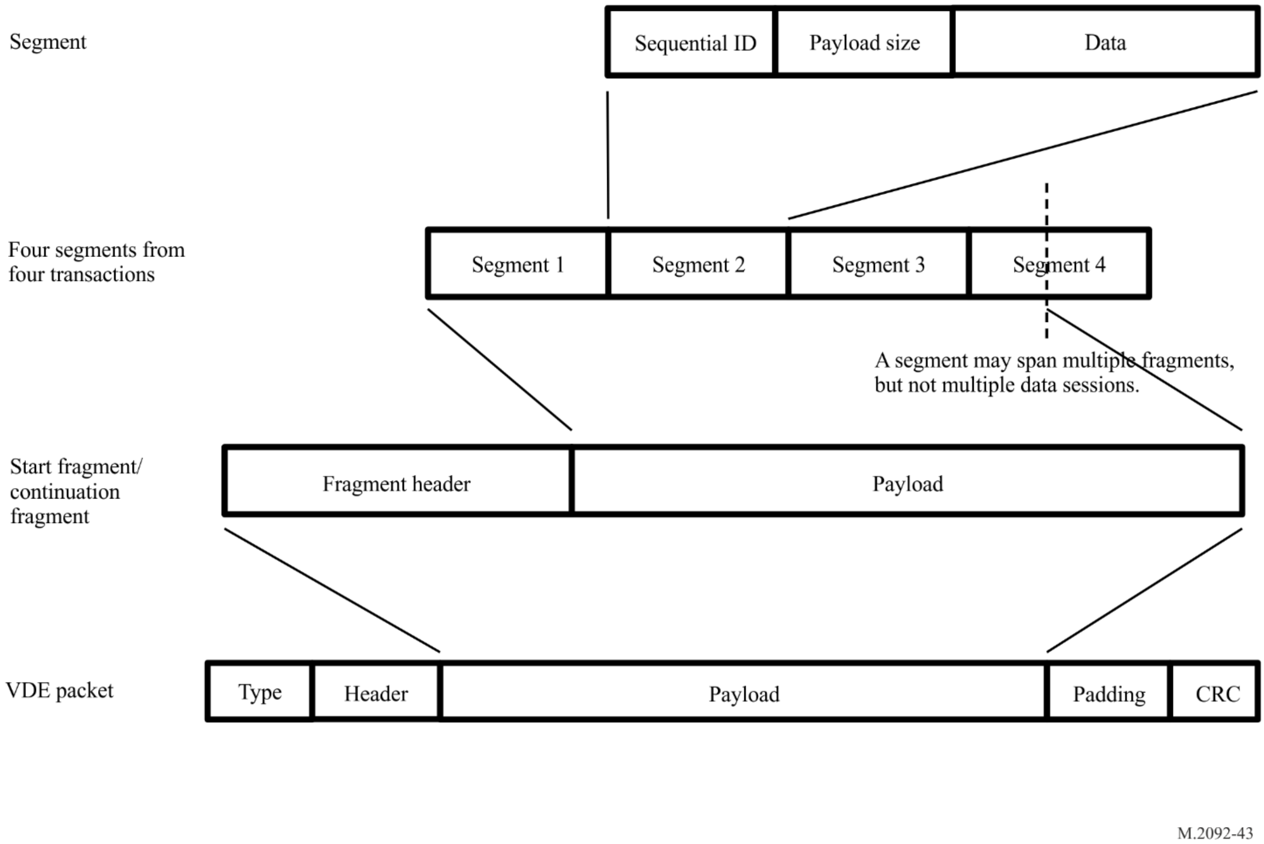
4.30 Segmentation of VHF data exchange payload

Data to be transmitted over VDE payload should be input to equipment via the PI by using applicable international standards. If the PI input results in need of executing multiple simultaneous transactions over VDL, the equipment should process them as described in this section.

VDE payload segments get packed inside the fragment as shown in Fig. 43. Each segment denotes a part of data within a transaction. Transactions under simultaneous processing are identified by different sequential IDs included in the segment header.

FIGURE 43

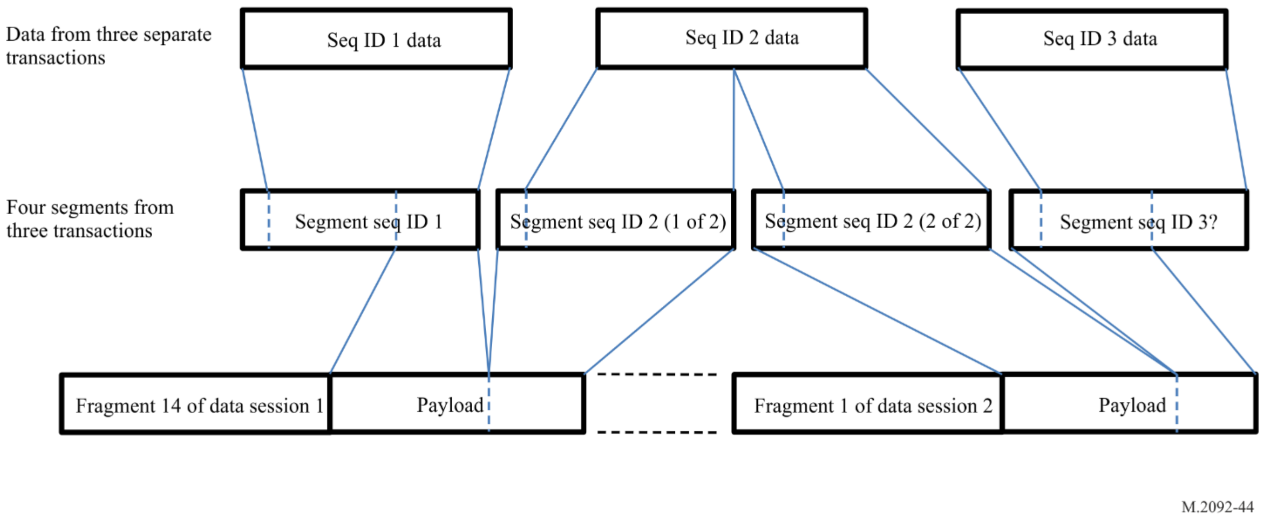
Segmentation of VHF data exchange payload



Segments may span multiple fragments, but not multiple data sessions. Only when a segment is found to span multiple data sessions, may the segment be split into multiple segments to align segments on data session boundaries. See Fig. 44.

FIGURE 44

Segmentation across data session boundaries



4.30.1 Segment description

TABLE 52

Segment description

Field no.	Value (Dec)	Size (Bits)	Function	Content
1	0 to 2^{16}-1	16	Sequential ID	Sequential ID of matching data transaction
2	0 to 2^{16}-1	16	Payload size	Size of the segment payload data only (bytes)
3		Variable	Payload data	Payload data.

5 Network layer

The priority assignment, distribution of transmission packets and data link congestion resolution requires close integration with the link layer. The responsibility of the network layer was therefore moved to the link layer.

6 Transport layer

The reliable transmission of data segments, segmentation, acknowledgement and multiplexing requires close integration with the link layer. The responsibility of the transport layer was therefore moved to the link layer.

7 Presentation interface layer

VDES supports a presentation interface to be specified in detail by the applicable international standards.

Annex 5

Technical characteristics of VHF data exchange-satellite operating in the VHF maritime mobile satellite band

TABLE OF CONTENTS

Page

1 Introduction

This Annex describes those elements of the VDE-SAT that are unique to VDE-SAT operation. For those elements that are common, the cross reference into Annex 2 is provided. In this context, the following types of functionality are envisaged:

Paging

Satellite to ship broadcast multi-packet data transfer

Satellite to ship addressed multi-packet data transfer

Ship to satellite addressed multi-packet data transfer

Satellite to ship short message

Ship to satellite short message

In this Annex, low earth orbit (LEO) satellites with 600 km altitude are considered to present typical examples of VDE satellite solutions. It should be noted that other orbital selections are also possible according to the overall system design consideration.

The focus of this Annex is to describe the PL of the OSI model as defined in Annex 2. The overall description of the link, network and the transport layers is provided in Annex 2.

2 Physical layer

2.1 VHF data exchange-satellite component key parameters

This section outlines key parameters regarding the VDE-SAT system that are common to for the uplink and downlink.

2.1.1 Satellite to surface distance range

The orbit height determines the satellite range variations. For example, for a 600 km LEO the maximum range is 2 830 km. For timing purposes, a maximum range of 3 000 km will be used.

The minimum range is equal to the orbit height. For a LEO satellite at 600 km altitude the minimum range will be 600 km. This value is used to determine the minimum propagation delay time.

Considering these exemplary values for the minimum and maximum ranges, the path delay will vary from 2 ms to 10 ms, a variation of 8 ms as shown in Figs 45 and 46.

For the VDE-SAT downlink, in addition to the relative delays between signal receptions at a vessel from different satellites, there could be absolute delay due to other sources such as signal processing delay. The satellite service provider should pre-compensate for absolute delay, by transmitting packets 2 ms before UTC epoch and receive packets 2 to 8 ms after UTC epoch. This will cause half-duplex satellites to lose one slot when switching from receive to transmit.

FIGURE 45

VHF data exchange-satellite downlink timing

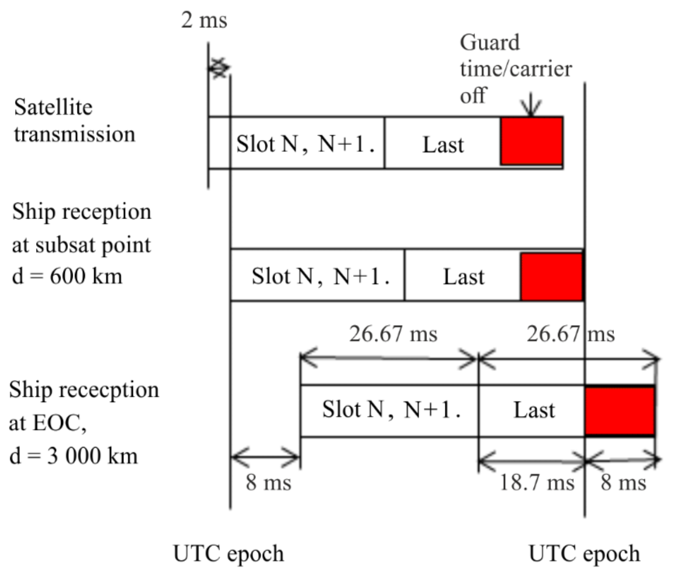


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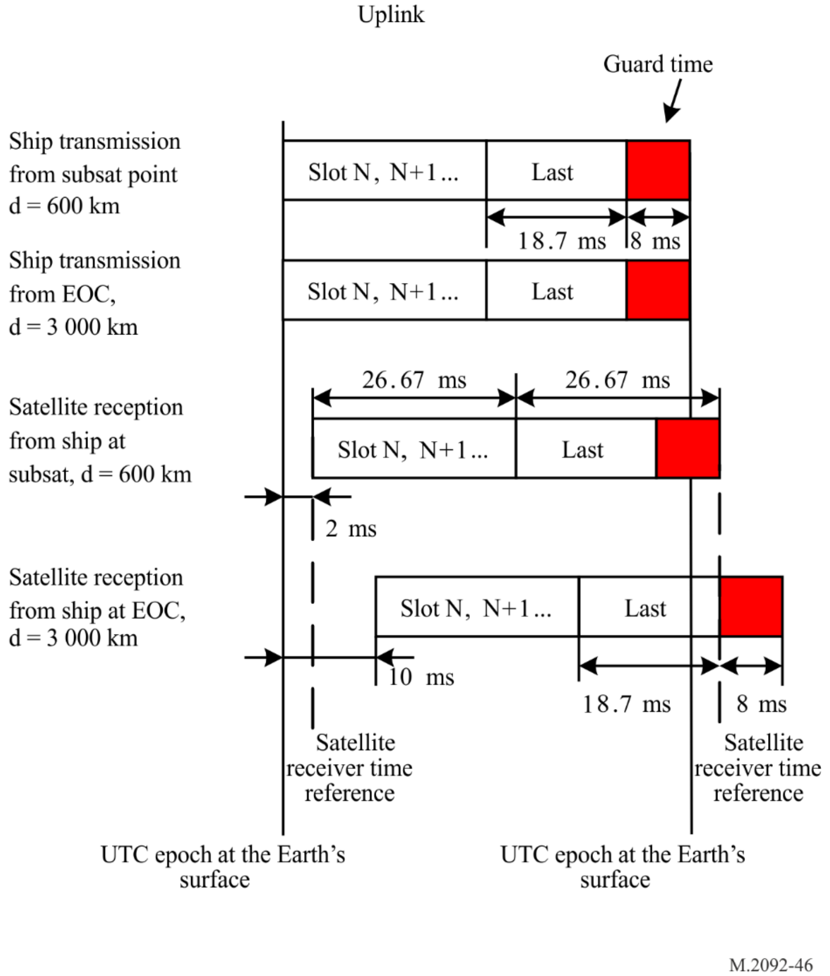
FIGURE 46

VHF data exchange-satellite uplink timing



2.1.2 Satellite transmission carrier frequency error

The transmit carrier frequency error at the satellite shall be less than 1 ppm, i.e. ±160 Hz.

A LEO satellite will move at a speed of about 8 km/s and this will cause a maximum Doppler of ±4 kHz at VHF.

2.1.3 Ship station transmitter requirements

For ship station transmitter requirements, see Annex 2.

2.1.4 Ship station antenna gain

For ship station antenna gain, see Annex 2.

2.1.5 Ship station noise plus interference level

For noise plus interference level of ship station, see Annex 2.

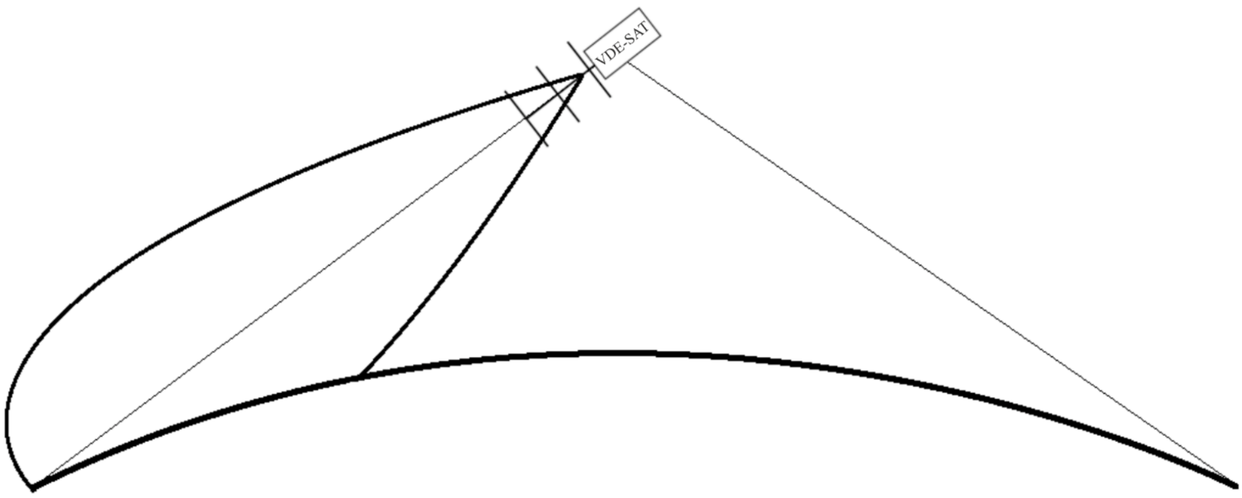
2.1.6 Satellite antenna characteristics

A circularly polarized Yagi antenna, comprised of three elements, is used as an example for the satellite antenna. Figure 47 shows how the main lobe of Yagi antenna is pointed towards the horizon of the earth. The thin solid line indicates the field of view from the satellite, but the communications coverage area will be limited to the area within the main lobe of the Yagi antenna.

Most of the satellite coverage area and visibility time will be at low elevation angles, and high elevation angle coverage may be sacrificed without significant system capacity loss. Assuming a peak antenna gain of 8 dBi, satellite antenna gain versus ship elevation angle and nadir offset angle are shown in Table 53. It is the responsibility of the VDE-SAT satellite operator to ensure that the pointing of the antenna and the e.i.r.p. are set in a manner which keeps the VDE-SAT downlink emissions within the pfd-mask limit specified in § 2.1, Annex 1 when above areas with VDE-TER coverage.

FIGURE 47

Illustration showing how the Yagi antenna and its main lobe is pointed towards the horizon of the earth



M.2092-47

TABLE 53

Satellite antenna gain versus ship elevation angle, nadir offset angle and boresight offset angle

Ship elevation angle (degree)	Nadir offset angle (degree)	Boresight offset angle (degree)	Satellite antenna gain (dBi)
0	66.1	0	8
10	64.2	1.9	8
20	59.2	6.9	8
30	52.3	13.8	7.8
40	44.4	21.7	6.9
50	36	30.1	5.5
60	27.2	38.9	3.6
70	18.2	47.9	0.7
80	9.1	57	−2.2
90	0	66.1	−5.5

2.2 Technical characteristics of the VHF data exchange-satellite component downlink

This section outlines the technical characteristics, key parameters and typical link budgets for the VDE-SAT downlink.

2.2.1 Satellite downlink equivalent isotropic radiated power

A pfd-mask to ensure interoperability and compatibility between VDE-TER and VDE-SAT is specified in § 2.1, Annex 1.

Table 54 shows the theoretical maximum satellite e.i.r.p. as a function of elevation angles for this mask.

TABLE 54

Maximum satellite maximum effective isotropic radiated power as a function of elevation angle

Ship elevation angle θ (degrees)	pfd-mask on ground (dB(W/(m²· 4 kHz)))	Satellite range (km)	Inverse squared distance (dB)	pfd-mask at satellite antenna (dB(W/(m²· 4 kHz)))	Maximum satellite e.i.r.p.			
					dBW/4 kHz	dBW/50 kHz	dBW/100 kHz	dBW/150 kHz
0	−149.0	2 829	−129.0	−20.0	−9.0	2.0	5.0	6.8
10	−147.4	1 932	−125.7	−21.7	−10.7	0.3	3.3	5.1
20	−145.8	1 392	−122.9	−22.9	−11.9	−1.0	2.0	3.8
30	−144.2	1 075	−120.6	−23.6	−12.6	−1.6	1.4	3.2
40	−142.6	882	−118.9	−23.7	−12.7	−1.7	1.3	3.0
50	−139.4	761	−117.6	−21.7	−10.7	0.2	3.2	5.0
60	−134.0	683	−116.7	−17.3	−6.3	4.7	7.7	9.4
70	−133.0	635	−116.1	−16.9	−6.0	5.0	8.0	9.8
80	−132.0	608	−115.7	−16.3	−5.3	5.6	8.7	10.4
90	−131.0	600	−115.6	−15.4	−4.4	6.5	9.5	11.3

The maximum achievable satellite e.i.r.p. depends on the antenna on-board the satellite, and how well the antenna pattern can be made to fit the theoretical maximum satellite e.i.r.p. mask.

With the satellite antenna described in § 2.1.6, which has a peak antenna gain of 8 dBi, a transmit RF power of −9.4 dBW in 50 kHz will ensure compliance with the pfd-mask in defined in § 2.1, Annex 1. Satellite e.i.r.p. and resulting margin to the pfd-mask as a function of ship elevation is shown in Table 55.

TABLE 55

Satellite effective isotropic radiated power and margin to the power flux-density mask as a function of vs elevation angle

Ship elevation angle (degrees)	Satellite antenna gain (dBi)	Satellite e.i.r.p. in circular polarization (dBW/50 kHz)	Margin to maximum satellite e.i.r.p. i.e. margin to the pfd mask (dB)
0	8	−1.4	3.4
10	8	−1.4	1.7
20	8	−1.4	0.4
30	7.8	−1.6	0.0
40	6.9	−2.5	0.8
50	5.5	−3.9	4.1
60	3.6	−5.8	10.5
70	0.7	−8.7	13.7
80	−2.2	−11.6	17.2
90	−5.5	−14.9	21.4

2.2.2 VHF data exchange-satellite component downlink receiver thresholds

The VDES maximizes frequency efficiency by using adaptive coding and modulation based on the actual link quality. Initial system access is done using a combination of spread spectrum, low bit rate and powerful FEC. The VDE-SAT uses the waveforms defined in Annex 2. The thresholds C/N_0 on a Gaussian channel have been estimated.

2.2.3 VHF data exchange-satellite component downlink link budget

The nominal signal level C/N_0 and $C/(N_0 + I_0)$ for the VDE-SAT downlink as a function of elevation angle for a 50 kHz channel are provided in Table 56 for the satellite antenna described in § 2.1.6. In a 50 kHz channel a signal bandwidth of 42 kHz can be used, which allow a satellite transmitter RF output power of −10.2 dBW. A transmission frequency of 161.912 5 MHz is used in the calculation of path loss. The ship antenna maximum gain is 3 dBi and the system noise temperature is 30.2 dBK as shown in Annex 2. The noise density level (N_0) will then be −168.4 dBm/Hz. On board ships there can be additional noise and interference sources which can raise the noise plus interference level (N+I) up to −114.0 dBm in a 50 kHz channel, as documented in IEC 61993. This corresponds to a noise plus interference density level (N_0+I_0) of −161 dBm/Hz.

The link budget shown in Table 56 is theoretical and does not take into account propagation effects such as multi-path which is documented in § 3.1 of Report ITU-R M.2435-0.

TABLE 56

VHF data exchange-satellite component downlink budget as function of elevation angle

Ship elevation angle (degrees)	Satellite e.i.r.p. in circular polarization (dBW)	Satellite range (km)	Path loss (dB)	Polarization loss (dB)	Ship antenna gain (dBi)	Carrier level at LNA (dBm in 50 kHz)	C/N_0 (dBHz)	$C/(N_0+I_0)$ (dBHz)
0	−2.2	2 829	145.7	3	3	−117.8	50.5	43.2
10	−2.2	1 932	142.4	3	3	−114.5	53.8	46.5
20	−2.2	1 392	139.5	3	2.5	−112.2	56.2	48.8
30	−2.4	1 075	137.3	3	1	−111.6	56.7	49.4
40	−3.3	882	135.5	3	0	−111.8	56.5	49.2
50	−4.7	761	134.3	3	−1.5	−113.4	54.9	47.6
60	−6.6	683	133.3	3	−3	−115.9	52.5	45.1
70	−9.5	635	132.7	3	−4	−119.1	49.2	41.8
80	−12.4	608	132.3	3	−10	−127.7	40.7	33.3
90	−15.7	600	132.2	3	−20	−140.9	27.5	20.1

2.3 Technical characteristics of the VHF data exchange-satellite component uplink

This section outlines the technical characteristics, key parameters and typical link budgets for the VDE-SAT uplink.

2.3.1 VHF data exchange-satellite component uplink receiver thresholds

The VDES maximizes frequency efficiency by using adaptive coding and modulation based on the actual link quality. Initial system access is done using a combination of spread spectrum, low bitrate and powerful FEC. The VDE-SAT uses the waveforms defined in Annex 2. The thresholds C/N_0 and $C/(N+I)$ on a Gaussian channel have been estimated.

2.3.1.1 Satellite system noise temperature

The satellite receiver noise temperature is shown in Table 57. The system noise temperature is 25.7 dBK, assuming no external interference.

TABLE 57

Satellite receiver system noise temperature

Antenna noise temperature	200.0	K
Feed losses	1.0	dB
LNA noise figure	2.0	dB
LNA noise temperature	159.7	K
Feedloss noise temp. at LNA	56.1	K
Antenna noise temp. at LNA	158.9	K
System noise temp. at LNA	374.7	K
System noise temp. at LNA	25.7	dBK
Intrinsic noise power density	−202.9	dBW/Hz

2.3.1.2 VHF data exchange-satellite component uplink link budget

Table 58 provide a link budget for the VDE-SAT uplink as a function of elevation angle for a 50 kHz channel with the satellite antenna described in § 2.1.6. In a 50 kHz channel a signal bandwidth of 42 kHz can be used. The ship antenna maximum gain is 3 dBi and the ship terminal output power is 6 W, as provided in Annex 2. Note that the different link configurations available for the VDE-SAT uplink have an average ship terminal output power levels ranging from 6 W to 12.5 W. A transmission frequency of 161.9125 MHz is used in the calculation of path loss. The satellite receiver noise level is −202.9 dBW/Hz as provided in § 2.3.2. The link budget in Table 58 is theoretical and does not take into account propagation effects such as multi-path, which is documented in § 2.1, Annex 1 of Report ITU-R M.2435-0, or interference from other services operating in the same frequency band.

TABLE 58

VHF data exchange-satellite component uplink link budget

Ship elevation angle (degree)	Ship antenna gain (dBi)	Ship e.i.r.p. (dBW)	Polarization loss (dB)	Path length (km)	Path loss (dB)	Satellite antenna gain (dBi)	Carrier level at LNA, including feed loss (dBW)	C/N_0 (dBHz)
0.0	3.0	10.8	3.0	2 829	145.7	8.0	–130.9	72.0
10.0	3.0	10.8	3.0	1 932	142.4	8.0	–127.6	75.3
20.0	2.5	10.3	3.0	1 392	139.5	8.0	–125.2	77.6
30.0	1.0	8.8	3.0	1 075	137.3	7.8	–124.7	78.2
40.0	0.0	7.8	3.0	882	135.5	6.9	–124.9	78.0
50.0	–1.5	6.3	3.0	761	134.3	5.5	–126.5	76.4
60.0	–3.0	4.8	3.0	683	133.3	3.6	–128.9	73.9
70.0	–4.0	3.8	3.0	635	132.7	0.7	–132.2	70.7
80.0	–10.0	–2.2	3.0	608	132.3	–2.2	–140.7	62.1
90.0	–20.0	–12.2	3.0	600	132.2	–5.5	–153.9	48.9

2.4 Bit mapping

For bit mappings, see Annex 2.

2.5 Spreading

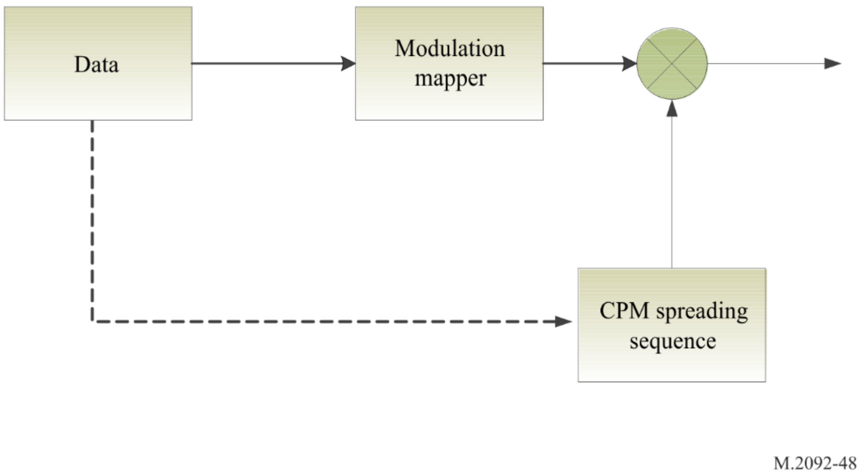
Direct sequence spreading with constant envelope is applied for the PL burst format SAT-MCS-1.50-2, identified by Link ID 20. Spreading for the downlink burst waveforms carrying bulletin boards, Link ID 25 and Link ID 32 are achieved by utilising gold sequences of length 2047. A short direct spreading sequence of length four is applied for the downlink burst waveforms defined by Link ID 28 and 29.

2.5.1 Spread spectrum with constant envelope

Direct sequence spreading with constant envelope can be implemented according to the spreading strategy contained in R. Mueller, *On Random CDMA with Constant Envelope*, IS IT 2011. This provides a way to generate constant envelope signals whilst allowing the use of linear modulations (i.e. BPSK, or QPSK for data modulation). In this approach, the continuous phase modulation (CPM) spreading sequences are selected such that the spread symbols maintain quasi continuous phase even at the transition from one symbol to the next. The CPM spreading principle is provided in Fig. 48.

FIGURE 48

Continuous phase modulation spreading principle



In order to avoid phase discontinuity at the data symbol transitions, the proposed solution is to adapt the spreading sequence according to the modulating data. In other words, the CPM spreading sequence at the edge of each symbol is adapted according to the new input modulating symbol value to avoid, or minimize any phase discontinuity. Such a solution produces a small loss at the receiver as the receiver does not know the edge symbol part of the used CPM spreading sequence. For a spreading factor (SF) of 16 or higher, the resulting correlation loss experienced by the receiver due to this issue is less than 0.25 dB. Performance losses with respect to conventional spreading is thus quite negligible provided that SF = 16 or larger is used.

The CPM spreading sequences are computed and optimized off-line and then stored in the memory of the terminals and receivers. A single spreading code is sufficient for all the users in the system. There is thus no need for storing multiple spreading sequences but just a single spreading sequence.

The stored spreading sequence is then applied starting from the first preamble syncword symbol and continuing in the data part (as shown in Fig. 49). The generated constant envelope spreading output sequence $y(k)$ is given by:

$$y(k) = \begin{cases} x(n) \cdot cp_a\big(l_a, p_a(n)\big), & \text{for } m < SL/2 \\ x(n) \cdot cp_e\big(l_e, p_e(n)\big), & \text{otherwise} \end{cases}$$

where $x(n)$ represents the QPSK modulated input signal of length BL symbols. Thus, $n \in [0, BL-1]$. Bit mapping for QPSK modulation is defined by the green points that appear in Fig. 11 showing the π/4-QPSK constellation. It should be noted that the generated spreading sequence $y(k)$ is actually partly dependent on the modulation symbols in order to ensure continuity of the signal phase when the modulation symbol changes (Fig. 48). The spreading sequence to be generated is oversampled by a factor NS relative to the chip rate. The total number of constant envelope output samples then becomes $BS = BL \cdot SF \cdot NS$, where one single input QPSK symbol is spread to $SL = SF \cdot NS$ output samples. The output sample index k is ranging from 0 to $BS - 1$, and the input symbol index n as function of the output sample index k is related by $n = \lfloor k/SL \rfloor$. Here the floor operator $\lfloor u \rfloor$ rounds u down to the nearest integer towards minus infinity. Furthermore, two predefined two-dimensional complex valued tables, cp_a and cp_e, containing optimised constant envelope spreading signature sequences are utilised in the constant envelope spreading process. The table cp_a is applied for generating the spreading sequence for the first half of an input symbol, while cp_e is used for the second half, where a half symbol period consists of $SL/2$ output samples. The present table to use, either cp_a or cp_e, is decided by the modulus index value given by $m = k \,\%\, SL = k - SL \cdot \lfloor k/SL \rfloor = k - SL \cdot n$, where % defines a modulus operator. The first dimensional, representing sample time, table indexes l_a and l_e are given by $l_a = (m + n \cdot SL/2) \,\%\, TL = (k - n \cdot SL/2) \,\%\, TL$ and $l_e = (m + (n-1) \cdot SL/2) \,\%\, TL = (k - (n+1) \cdot SL/2) \,\%\, TL$, where TL is the first dimensional size of the cp_a and cp_e tables. In this case, the spreading sequence is designed as maximum length, i.e. $TL = BS/2$, $l_a \in [0, BS/2 - 1]$ and $l_e \in [0, BS/2 - 1]$. The modulus TL in the timing index expressions is not needed. The second dimensional table indexes, $p_a(n)$ and $p_e(n)$, depend on $x(n)$ and are based on differential QPSK symbol quadrant computation. Given the applied Gray-coded QPSK bits-to-symbol mapping definition, the belonging quadrant is given by:

$$q = \begin{cases} 0, \text{ for QPSK input bits equal to 11} \\ 1, \text{ for QPSK input bits equal to 01} \\ 2, \text{ for QPSK input bits equal to 00} \\ 3, \text{ for QPSK input bits equal to 10} \end{cases}$$

and the second dimensional table indexes

$$p_a(n) = \begin{cases} 0, & \text{for } n = 0 \\ \big(q(n) - q(n-1)\big) \,\%\, 4, & \text{for } n > 0 \end{cases}$$

and

$$p_e(n) = \begin{cases} \big(q(n+1) - q(n)\big) \,\%\, 4, & \text{for } n < BL - 1 \\ 0, & \text{for } n = BL - 1 \end{cases}$$

As the differential phase table indexes $p_a(n)$ and $p_e(n) \in [0, 3]$, the overall size of the cp_a and the cp_e tables becomes $BS/2 \times 4$, thus containing $2 \cdot BS$ complex valued constant envelope values.

The specified constant envelope spreading scheme is at present only applicable for the SAT-MCS-1.50-2 PL burst format, with Link ID equal to 20, for which $BL = 261$ and $SF = 16$. The signature spreading sequences are optimised for an oversampling factor NS=16, and the cp_a signature table is stored in the ASCII file “cpa_SF16_NS16_BL261.txt”, and the cp_e table is stored in the file “cpe_SF16_NS16_BL261.txt” [9]. The table entities within the files are oriented in $BS/2$ rows and 8 columns. The row number thus directly related to the first dimensional table indexes, l_a and l_e. The first, third, fifth and seventh columns contain the real part of the complex valued entities, while the second, fourth, sixth and eighth columns hold the imaginary part. The full relationship between a loaded ASCII file table, *T[ ]*, and a signature table *cp ( )* becomes:

$$cp(l, p) = T[l + 1, 2p + 1] + j \cdot T[l + 1, 2p + 2]$$

where $j = \sqrt{-1}$ and the row and column of *T[ ]* are assumed counted from one.

Even if the signature sequences are optimised for NS=16, appropriate constant envelope spreading sequences for NS=8 and NS=4 can be generated by decimating the signature spreading tables in

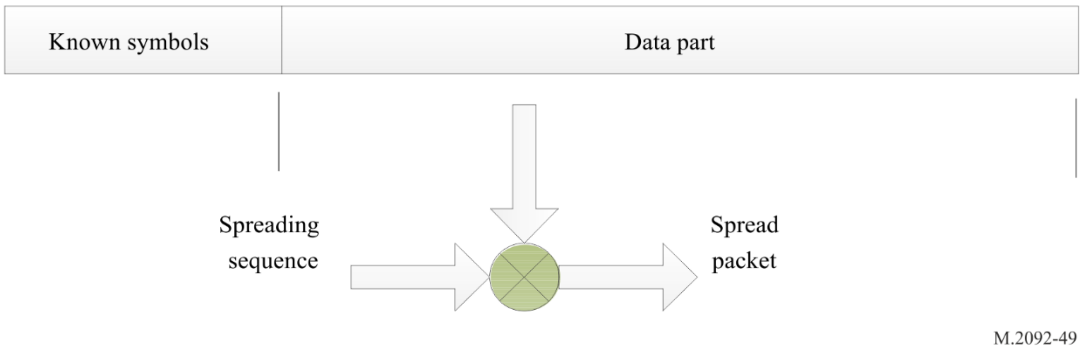
---

9 Signature spreading sequences are utilised such that quasi continuous phase is obtained for the generated direct sequence spreading signal. These signature spreading sequences, referred to as the cp_a and cp_e in § 2.5, are found in the ASCII text files “cpa_SF16_NS16_BL261.txt” and cpe_SF16_NS16_BL261.txt” respectively. These embedded files are not subject to IP restrictions.

cpa_SF16_NS16_BL261.txt cpe_SF16_NS16_BL261.txt time, i.e. along the first dimensional table index, by a decimation factor equal to 2 or 4 correspondingly.

FIGURE 49

Proposed spreading in the continuous phase modulation



2.5.2 Direct sequence spreading for downlink waveforms

The waveform used for the bulletin board should allow for detection of overlapping signals received from two satellites. Two Gold spreading code sequences named SS0 and SS1 are selected to reduce the cross-correlation between delayed and frequency shifted versions of the overlapping waveforms. SS0 and SS1 is shown as byte oriented hexadecimal text strings in Table 59. The first byte, bit sequence "00000100" for spreading sequence SS0, is used to spread the very first syncword bit of the burst into 8 chips. The MSB of the bit sequence is to be transmitted first. The next byte, bit sequence "01100001" for SS0, is then used to spread the second bit of the burst. The spreading process making the chip sequence to transmit is further achieved by XORing between each burst bit and the 8 by 8 spreading sequence bits. As the length of the Gold spreading sequences is limited to 2047, only the 7 MSBs of the last Gold spreading sequence byte is utilised, i.e. "0101101" for byte 0x5A and "0001111" for byte 0x1E. Furthermore, spreading is based on periodic repetition of the spreading sequence, such that when reaching the end of the actual Gold sequence, the 8 bits sequence to utilise for spreading will consist of the 7 MSBs of the last Gold sequence byte appending the MSB of the first byte. Due to this bit shift, the 8 by 8 bits spreading sequences obtained after repetition will not be equal to the original 8 by 8 spreading sequences.

The chip bit sequence is mapped into values by ordinary BPSK bit to symbol mapping.

TABLE 59

Gold spreading sequences

Name	Spreading sequence
SS0	04-61-4F-29-8E-A3-63-13-B4-81-44-3D-35-C9-BC-DF-06-05-D3-3E-A3-13-DE-DA-C9-37-F6-C0-2D-5A-81-B7-ED-4B-43-77-31-0D-DF-99-1C-49-E1-71-31-C1-12-30-58-9E-80-9E-AC-E7-83-AB-D8-9A-AD-24-56-89-BB-C2-37-EA-DB-49-F8-4D-80-B9-2C-E3-F1-98-1C-86-06-45-4C-31-25-68-6A-3F-1F-9B-62-CC-2D-42-4B-E1-9F-2C-0F-F0-84-4F-31-3C-B4-40-05-B6-FD-D2-D4-E8-63-A9-56-62-B6-08-80-DA-DD-07-AA-37-76-C7-8A-81-81-BD-95-31-79-E4-0D-EB-92-8C-A4-D1-A6-FF-45-47-C7-F9-09-D1-D2-2C-46-02-B1-B5-B2-83-6B-57-D0-BF-C3-4C-D6-2A-26-0A-EB-C1-D8-58-49-0A-FB-CF-DA-62-FD-41-60-FD-F7-0F-A2-8E-A4-90-B0-AD-37-FD-2E-E4-2B-75-E6-46-63-AB-FA-55-24-3D-93-CF-4E-72-CE-02-38-B7-77-95-97-30-86-7E-24-2E-80-81-C2-97-26-32-2A-71-90-CB-36-79-17-A5-D4-49-36-04-21-5F-1E-54-A2-88-D6-62-AD-E0-47-61-A7-89-ED-81-34-88-1A-D0-BE-5A

SS1	41-0B-57-66-A0-D1-94-36-C2-94-8C-60-10-FF-81-06-51-84-E3-80-EB-FE-B5-C2-26-5D-AE-A7-12-22-D2-94-18-CF-31-C0-3C-6A-C0-F5-47-EF-46-F6-02-BE-C2-22-53-DA-4A-62-8D-73-7B-48-B5-41-FB-E5-EE-62-D3-1B-40-7F-E3-72-E2-A3-AA-69-1E-FC-BD-D7-B2-A4-D3-75-72-29-EA-16-3A-DD-72-E0-70-27-05-B3-2D-7E-03-11-96-8F-14-75-2B-72-DA-BA-A7-B3-BF-DB-91-62-17-DD-E2-AE-49-E8-8C-DD-5E-36-54-F7-CE-8C-A6-72-66-32-A3-4C-88-A2-86-7F-2A-47-D8-00-54-38-7E-3D-15-CA-56-15-C8-A2-50-CB-0C-5C-FB-0E-9C-12-9A-B3-84-E7-F6-DE-42-B4-23-7C-91-55-EE-6D-A4-8B-90-CE-FE-C0-D0-13-9D-F7-81-9B-4C-D9-9D-1E-58-27-38-AD-C6-BE-BA-83-99-E9-93-2C-B7-C6-11-7E-40-D4-49-91-03-4D-F5-84-DD-BC-91-F7-11-92-E9-38-29-5F-BB-6F-2F-53-A5-97-33-FB-66-D3-41-D1-49-34-5F-6F-C0-20-56-6C-38-88-05-E1-47-C1-E3-A3-7D-9B-3A-CE-F1-78-1F-1E

The direct spreading sequence "0010" is applied for the downlink burst waveforms identified by link ID 28 and 29. This sequence has excellent auto-correlation property. The first bit of the burst is spread by "00", the second by "10", and then the third again by "00" as the spreading sequence are periodically repeated. XORing is performed between burst bits and 2 by 2 spreading sequence bits, and the resulting chip sequence is mapped into values by ordinary BPSK bit to symbol mapping.

2.6 Baseband shaping and quadrature modulation

For baseband shaping of symbols, see Annex 2.

2.7 Transmission timing accuracy

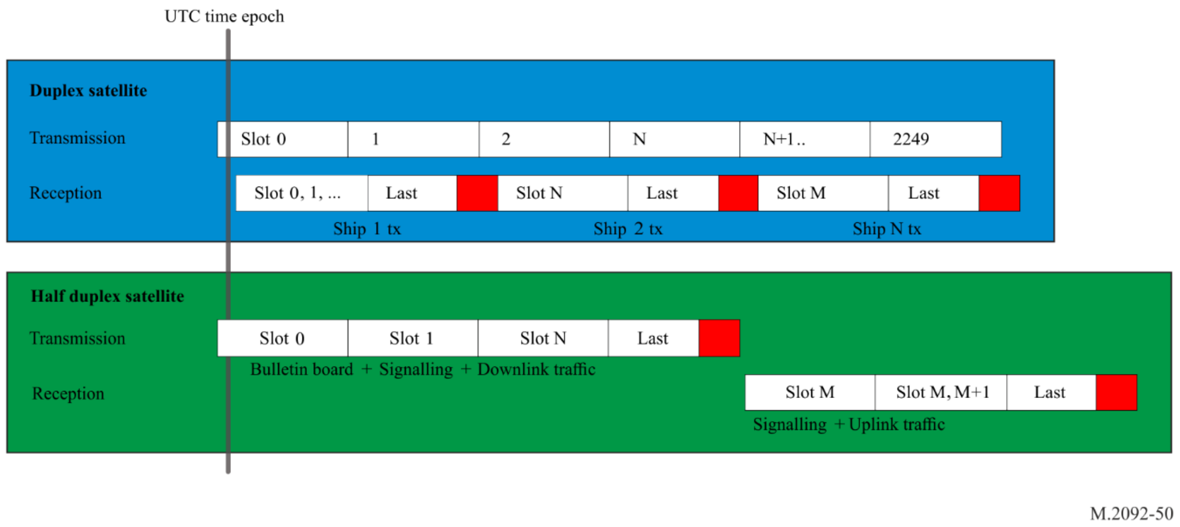
For transmission accuracy figures, see Annex 2.

2.8 Half duplex and full duplex satellites

The system can be configured for both half and full duplex satellites as shown in Fig. 50.

FIGURE 50

Half-duplex and full duplex satellite operation



2.9 Frame structure

For frame and transmission burst structure, see Annex 2.

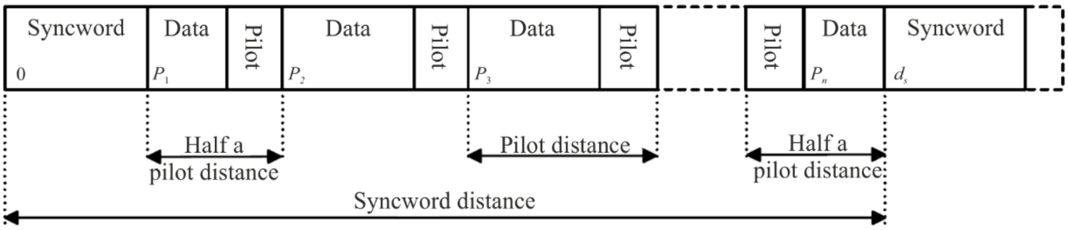
2.10 Pilots and syncword symbol location and modulation

Pilot symbols are utilised for some of the VDE-SAT uplink and downlink PL burst waveforms. A pilot symbol is a single symbol with unity power mapped to the constellation point $\frac{(1+j)}{\sqrt{2}}$.

A generalized burst structure containing both uniformly repetitive syncword and regularly distributed single pilot symbols is visualised in Fig. 51.

FIGURE 51

General PL burst structure with repetitive sync word and distributed single pilot symbols



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Single pilot symbols are regularly distributed over the burst, and the position of each pilot symbol is defined by the pilot distance, denoted by d_p. When d_p is an even number, $(1 + d_p)/2$ is rounded down to the nearest integer, towards minus infinity. The very first pilot symbol in the burst is located $(1 + d_p)/2$ symbols after the last symbol of the preceding training sequence (syncword). P_1 in Fig. 51 is the first symbol position of data following a preamble syncword, which equals the syncword size denoted by S_s. The first pilot symbol is located at ($P_2 - 1$), which equals ($S_s + (d_p - 1)/2$). And the next pilot symbol at position ($P_3 - 1$), which equals ($S_s + (3d_p - 1)/2$). For VDE-SAT downlink, uniformly repeated syncwords are utilised for synchronisation purpose as shown in Fig. 51. The bit pattern sequence of a repeated syncword is equal to the preamble training sequence, as defined for VDE-SAT in Table 1. The location of the uniformly repeated syncwords are given by the syncword distance, defined as the distance between the first symbol of two subsequently syncwords, denoted by d_s. Counting from zero, the first symbol of the preamble syncword and the first repeated syncword in such a burst waveform is thus located at position 0 and d_s, correspondingly. The last pilot symbol preceding the first repeated syncword is located at ($P_n - 1$), which equals ($d_s - (1 + d_p)/2$). Varying number of symbols are following the last syncword and the last single pilot symbol for different PL formats. Some PL burst waveform formats have no symbols after the last syncword.

For the VDE-SAT downlink PL format SAT-MCS-1.50-1 and SAT-MCS-3.50-1, both the syncword size and the pilot distance is 27 symbols, and the syncword distance is 2268 symbols. The last preamble syncword symbol is thus located at position 26, the first pilot symbol at position 40, and the next pilot symbol at position 67. The location of the last pilot symbol preceding the first repeated syncword becomes 2254, and the first repeated syncword symbol is located at position 2268. For both these PL burst waveform formats, the last syncword is followed by 3204 symbols, including single pilot symbols. The last single pilot symbol is followed by 31 symbols.

For PL burst waveform applying π/4-QPSK, 8-PSK and 16-QAM modulation, the syncword is π/4 QPSK modulated. Odd symbol position indexes are then mapped to symbol constellation points that are phase offset by +45 degree from the nominal QPSK symbol constellation points used for even symbol position indexes. This even and odd position indexes toggling rule, as described in § 1.2.9, Annex 2 and visualised in Fig. 11, shall also be applied for the uniformly repeated syncword. This rule results in two different syncword modulation signal patterns for these particular PL burst waveforms when the syncword distance is an even number of symbols.

For π/4 QPSK modulated PL burst waveforms, single pilot symbols located at odd symbol position indexes are phase offset by π/4 from the nominal QPSK symbol constellation points as all other odd symbol positioned symbols in the actual burst.

2.11 Forward error correction and interleaving

For forward error correction and interleaving, see Annex 2.

2.12 VHF data exchange-satellite link configuration formats

For link configurations available for the VDE-SAT uplink and downlink, see Annex 2.

2.13 VHF data exchange-satellite downlink block channel interleaver

A block channel interleaver is required on the VDE-SAT downlink to reduce the impact of short blockage on the channel (for example due to the AIS transmission from the vessel or fast fading events). The channel interleaver at the transmitter side is applied to the coded and scrambled data bits at the output of the bit scrambler, before possible adding of burst stuffing bits.

The channel interleaver is essentially randomly rearranging the scrambled bits. At the receiver side, the channel de-interleaver is performing the reverse operation. In the following, the channel interleaver is specified.

Blocks of scrambled data bits of length L are written by row into a M × N matrix and read out by column after accomplished first row and then column permutations. The row and column permutations are given by:

$p_r(m) = 1 + (A_r \cdot m + C_r(n)) \bmod M$, for $m = 1$ to M, where $C_r(n) = (B_r \cdot n - 1) \bmod M$, for $n = 1$ to N

$p_c(n) = 1 + (A_c \cdot n + C_c(m)) \bmod N$, for $n = 1$ to N, where $C_c(m) = (B_c \cdot m - 1) \bmod N$, for $m = 1$ to M.

The interleaver is relocating the bit appearing at row $p_r(m)$ to row m, and a bit appearing at column $p_c(n)$ is relocated to column n.

As the burst length and the total number of bits to interleave are large for the burst waveforms identified by link config ID (LCID) 26-29, interleaving for these waveforms is split in either four or five smaller interleaver blocks, IB. The interleaver length L times the number of interleaver blocks IB match the number of 'channel bits' as given in Table 9 and Table 10 (located in {RD2}).

The permutation parameters A_r, B_r, A_c and B_c and other interleaver parameters for the VDE-SAT downlink burst waveforms are specified in Table 60.

TABLE 60

Channel interleaver parameters for VHF data exchange-satellite downlink burst waveforms

PL format	SAT-MCS-0.50-1	SAT-MCS-1.50-1	SAT-MCS-3.50-1	SAT-MCS-0.100	SAT-MCS-0.150	SAT-MCS-0.50-2	SAT-MCS-0.50-3	SAT-MCS-1.50-2
LCID	25	26	27	28	29	32	33	34
M	14	257	503	16	132	27	857	128
N	683	119	114	1321	202	47	15	195
L	9562	30583	57342	21136	26664	1269	12855	24960
IB	1	5	4	4	5	1	1	1
A_r	5	127	251	7	61	13	421	51
B_r	3	107	223	13	31	17	367	89
A_c	337	59	53	659	97	23	7	97
B_c	71	41	11	59	59	13	3	19

3 Link layer

3.1 Link layer definitions

3.1.1 Physical channel

A physical channel is defined by a frequency and bandwidth.

3.1.2 Channel pair

A channel pair is a combination of two physical channels that are used together.

3.1.3 Logical channel

Logical channels define functions for a set of continuous slots.

3.1.4 VHF data exchange slotmap

A VDE slotmap is defined for each channel pair, defining the logical channel configuration over a 2250 slot frame.

A VDE-SAT sub-frame is defined as one set of logical channels, see Fig. 53.

3.1.5 Bulletin board

The bulletin board message is sent by the satellite to define six channels pairs, each with its associated VDE slotmap.

3.1.6 Short data message

See § 4.2.5, Annex 4.

3.1.7 Data session

A VDE-SAT data session is a managed data transfer using assigned resources. A data session is uniquely identified by a source, destination MMSI combination and Session ID.

A VDE-SAT data session starts with a start fragment and ends with the last transmitted fragment; the last fragment normally is the end fragment; however, retransmissions and applicable timeouts can make any retransmitted fragment the last fragment; a session can span over multiple, and changing DC assignments, and over multiple VDE-SAT sub-frames.

3.1.8 Data fragment

See § 4.2.8, Annex 4.

3.1.9 Satellite identification and network identifications

Each satellite has a unique satellite ID.

Multiple satellites can be associated as a network of satellites. Each VDE-SAT network, associated with an operator, is assigned a primary network ID (see § 3.10.2).

NOTE – This allows VDE-SAT terminals to choose using satellites from one or multiple specific primary network IDs.

Multiple satellite networks can be combined to represent a roaming network. Each roaming network is assigned a roaming network ID (see § 3.10.2).

NOTE – This allows VDE-SAT terminals to choose using satellites from one or multiple specific roaming network IDs.

3.2 Resource management

The downlink data session connection between ship and satellite is session oriented with one or multiple a data LCs and the corresponding DSCH LC being assigned to a station in the ASC resource allocation message at the beginning of each VDE-SAT sub-frame.

To request an uplink data session, a ship station sends a resource request message to the satellite on the RAC, which is answered by the satellite with a resource allocation message on the ASC, giving the ship station permission to transmit uplink fragments for that session in one or multiple uplink LCs. This resource allocation to a ship station is valid for the current VDE-SAT sub-frame. The satellite indicates the ongoing reservation of subsequent uplink resources to the ship by using the resource reallocation field of the uplink ACK message, or a new resource allocation for this session. The ship shall stop transmission if the resource reallocation is zero, or the LC resources are allocated to another session and/or ship.

Ship originated short data messages can be sent on the RAC without resource allocation.

Satellite originated short data messages can be sent on the ASC without resource allocations.

During heavy network loading, the satellite may increase the selection interval for random access or modify the maximum allowed number of ships originated short data messages. This is done using the MAC message.

3.3 Endianness

See § 4.5, Annex 4.

3.4 Data structures

See § 4.6, Annex 4.

3.5 Slot functions

3.5.1 Satellite bulletin board signalling channel

The downlink satellite BBSC is used for resource configuration of satellite information, frequencies, timeslots and logical channels. All ships should always listen to all BBSC channels. Link ID 32 should always be used.

3.5.2 Announcement signalling channel

The downlink ASC is used for media access control, paging, resource allocation, data broadcast. All ships should listen to all ASC channels. Link ID 32 should always be used.

3.5.3 Data acknowledgement signalling channel

The DSCH is used for acknowledgments of downlink data. Link ID 20 should always be used on this uplink channel.

3.5.4 Random access channel

The uplink RAC is used for resource request, paging response and short messages. Link ID 20 should always be used.

3.5.5 Data up or down channel

The DC is used for data uplink or downlink. The Link ID is assigned by the resource allocation message.

3.5.6 Empty channel

As overlapping bandwidths are feasible, by assigning a channel as not used, it can indicate when a channel should not interfere with other channels.

3.6 Guard slot

When the satellite switches from uplink to downlink (see § 2.1.1), one slot is lost before the change-over. During the bulletin board logical channel slot size assignment, one additional guard slot should automatically be added to the Slotmap by each ship under any of the following conditions, as illustrated in Fig. 52:

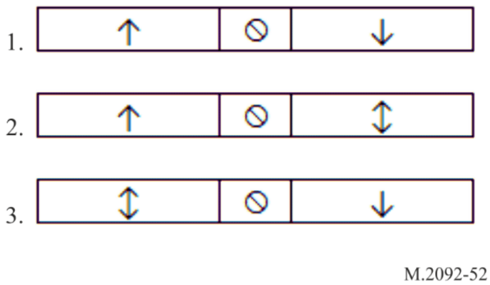
1 When a slot function change from uplink to downlink.

2 When a slot function changes from uplink to a slot function that can be used for both uplink or downlink.

3 When a slot function changes from a slot function that can be used for both uplink or downlink to downlink.

FIGURE 52

Use of guard slot



If any of the above conditions are met, one guard slot should be added to the logical channel slot size before the change-over condition. For each guard slot added, a slot should be removed from another logical channel to allow all the slots to fit into a frame of 2 250 slots. Remove slots as follows:

– If the slot function before the change-over event is RAC, remove the last slot from that RAC logical channel.

– Otherwise remove the slot from the next RAC logical channel.

To minimise the required amount of guard slots, any slot functions used for both uplink and downlink should always be used for downlink first, before switching over to uplink. This rule will ensure that if a slot is lost due to the Satellite switching from uplink to downlink, then the lost slot will always fall inside a guard slot and not inside the logical channel.

3.7 VHF data exchange-satellite default bulletin board

The default VDE-SAT bulletin board defines six channel pairs, labelled A to F, each with an associated VDE slotmap. The default channel pairs have been defined to support the frequencies and bandwidths allocated for VDE-SAT services, as detailed in Table 61.

TABLE 61

Default VHF data exchange-satellite channel pairs

Channel pair	Uplink			Downlink		
	Channel	**Frequency (MHz)**	**Bandwidth (kHz)**	**Channel**	**Frequency (MHz)**	**Bandwidth (kHz)**
A	1226: (1026 + 1086)	157.3125	50	2226: (2026 + 2086)	161.9125	50
B	2226: (2026 + 2086)	161.9125	50	1226: (1026 + 1086)	157.3125	50
C	1225: (1025 + 1085)	157.2625	50	2284: (2024 + 2084 + 2025 + 2085)	161.8375	100
D	2225: (2025 + 2085)	161.8625	50	1284: (1024 + 1084 + 1025 + 1085)	157.2375	100
E	1224: (1024 + 1084)	157.2125	50	2225: (2024 + 2084 + 2025 + 2085 + 2026 + 2086)	161.8625	150
F	2224: (2024 + 2084)	161.8125	50	1225: (1024 + 1084 + 1025 + 1085 + 1026 + 1086)	157.2625	150

<table>
<tr><td></td><td colspan="6">Lower band</td><td></td><td colspan="6">Upper band</td></tr>
<tr><td>Channel No.</td><td>1024</td><td>1084</td><td>1025</td><td>1085</td><td>1026</td><td>1086</td><td></td><td>2024</td><td>2084</td><td>2025</td><td>2085</td><td>2026</td><td>2086</td></tr>
<tr><td>Uplink</td><td colspan="2">E</td><td colspan="2">C</td><td colspan="2">A</td><td></td><td colspan="2">F</td><td colspan="2">D</td><td colspan="2">B</td></tr>
<tr><td rowspan="2">Downlink</td><td colspan="4">D</td><td colspan="2">B</td><td></td><td colspan="4">C</td><td colspan="2">A</td></tr>
<tr><td colspan="6">F</td><td></td><td colspan="6">E</td></tr>
</table>

The VDE slotmap for channel pairs A and B are illustrated in Fig. 53. These slot maps contain the BBSC and ASC channels, as the channel pair is assigned to the 50 kHz physical channels, 2026 / 2086 or 1026 / 1086.

FIGURE 53

VHF data exchange-satellite slotmap for channel pair A and B

Channel types	
BBSC	Bulletin boarding signalling channel
RAC	Random access signalling channel
ASC	Announcement signalling channel
DSCH	Data acknowledgment signalling channel
DC	Data up or down channel
GS	Guard slot
EMPTY	Empty

Channel direction	
↓	Downlink
↑	Uplink
↕	Uplink or downlink
⦸	Do not use

Channel pair	Logical channels										
A	0	1	2	3	4	5	6	7	8	9	
B	12	13	14	15	16	17	18	19	20	21	
	Slot functions										
	↓ BBSC	↓ ASC	↕ DC 0	↕ DC 1	↕ DC 2	↕ DC 3	↕ DC 4	↕ DC 5	↑ DSCH	↑ RAC	⦸ GS
Slot offset in frame	0	90	180	210	300	390	480	570	600	630	809
VDE-SAT subframe	0	0	0	0	0	0	0	0	0	0	0
Size in slots	90	90	30	90	90	90	90	30	30	179	1
		↓ ASC	↕ DC 0	↕ DC 1	↕ DC 2	↕ DC 3	↕ DC 4	↕ DC 5	↑ DSCH	↑ RAC	⦸ GS
Slot offset in frame		810	900	930	1 020	1 110	1 200	1 290	1 320	1 350	1 529
VDE-SAT subframe		1	1	1	1	1	1	1	1	1	1
Size in slots		90	30	90	90	90	90	30	30	179	1
		↓ ASC	↕ DC 0	↕ DC 1	↕ DC 2	↕ DC 3	↕ DC 4	↕ DC 5	↑ DSCH	↑ RAC	⦸ GS
Slot offset in frame		1 530	1 620	1 650	1 740	1 830	1 920	2 010	2 040	2 070	2 249
VDE-SAT subframe		2	2	2	2	2	2	2	2	2	2
Size in slots		90	30	90	90	90	90	30	30	179	1

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The slotmap for the remaining channel pairs C to F are illustrated in Fig. 54. Note that the first two logical channels are marked as not used, as these would overlap with SBB and resource allocation messages.

FIGURE 54

VHF data exchange-satellite slotmap for channel pair C to F

Channel types	
BBSC	Bulletin boarding signalling channel
RAC	Random access signalling channel
ASC	Announcement signalling channel
DSCH	Data acknowledgment signalling channel
DC	Data up or down channel
GS	Guard slot
EMPTY	Empty

Channel direction	
↓	Downlink
↑	Uplink
↕	Uplink or downlink
⦸	Do not use

Channel pair	Logical channels										
C	24	25	26	27	28	29	30	31	32	33	
D	36	37	38	39	40	41	42	43	44	45	
E	48	49	50	51	52	53	54	55	56	57	
F	60	61	62	63	64	65	66	67	68	69	

	Slot functions										
	⦸ EMPTY	⦸ EMPTY	↕ DC 0	↕ DC 1	↕ DC 2	↕ DC 3	↕ DC 4	↕ DC 5	↑ DSCH	↑ RAC	⦸ GS
Slot offset in frame	0	90	180	210	300	390	480	570	600	630	809
VDE-SAT subframe	0	0	0	0	0	0	0	0	0	0	0
Size in slots	90	90	30	90	90	90	90	30	30	179	1
		⦸ EMPTY	↕ DC 0	↕ DC 1	↕ DC 2	↕ DC 3	↕ DC 4	↕ DC 5	↑ DSCH	↑ RAC	⦸ GS
Slot offset in frame		810	900	930	1 020	1 110	1 200	1 290	1 320	1 350	1 529
VDE-SAT subframe		1	1	1	1	1	1	1	1	1	1
Size in slots		90	30	90	90	90	90	30	30	179	1
		⦸ EMPTY	↕ DC 0	↕ DC 1	↕ DC 2	↕ DC 3	↕ DC 4	↕ DC 5	↑ DSCH	↑ RAC	⦸ GS
Slot offset in frame		1 530	1 620	1 650	1 740	1 830	1 920	2 010	2 040	2 070	2 249
VDE-SAT subframe		2	2	2	2	2	2	2	2	2	2
Size in slots		90	30	90	90	90	90	30	30	179	1

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3.8 Use of the data acknowledgement signalling channel

The DSCH is divided into sub-channels, where each sub-channel supports the acknowledgement of a specific DC (see Fig. 55). When the satellite transmits large data messages to a ship on an assigned DC, these are divided into fragments that are selectively acknowledged on a dedicated uplink DSCH sub-channel. There is one DSCH sub-channel for each downlink DC. For the default SBB, 30 slots are allocated to this every 20 s. The ACK for DC 0 is transmitted in the first five slots (starting at slot 600 using the 5 slot link ID 20), the ACK for DC 1 to 5 are transmitted in the consecutive DSCH sub-channels.

Note that the number of available DSCH sub-channel should always match the number of DC. DC direction is given in the assignment message, uplink data transfers use the upper DC (e.g. DC 5) to group downlink and uplink DCs to minimise the number of guard slots.

FIGURE 55

Mapping of DSCH sub-channels

	↓ BBSC	↓ ASC	↕ DC 0	↕ DC 1	↕ DC 2	↕ DC 3	↕ DC 4	↕ DC 5	↑ DSCH	↑ RAC	⦸ GS
Slot offset in frame	0	90	180	210	300	390	480	570	600	630	809
Size in slots	90	90	30	90	90	90	90	30	30	179	1
DSCH sub-channel						1	2	3	4	5	6
Slot offset in frame						600	605	610	615	620	625
Size in slots						5	5	5	5	5	5

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3.9 VHF data exchange-satellite message summary

TABLE 62

VHF data exchange-SAT message summary

Type	Name	Description	Slot function
1	Satellite Bulletin Board 1	Satellite bulletin board fragment 1	BBSC
2	Satellite Bulletin Board 2	Satellite bulletin board fragment 2	BBSC
3	Satellite Bulletin Board 3	Satellite bulletin board fragment 3	BBSC
4	Satellite Bulletin Board 4	Satellite bulletin board fragment 4	BBSC
5	Satellite Bulletin Board 5	Satellite bulletin board fragment 5	BBSC
6	Satellite Bulletin Board 6	Satellite bulletin board fragment 6	BBSC
10	Media access control	Changes random access selection interval, max ARQ retries.	BBSC, ASC
11	Paging	Pages a ship.	ASC
12	Resource allocation	Allocated LC resource to data session.	ASC
13	Uplink acknowledgement	Acknowledgement or negative-acknowledgement of uplink data fragments.	ASC
14	Downlink short message (with ACK)	Short data message to ship that requires acknowledgement	ASC
16	Downlink short message (without ACK)	Short data message to ship with no acknowledgement.	ASC
18	End delivery notification to ship	Message from application layer to acknowledge that the session was finished.	ASC
20	Resource request	Request resource from ship.	RAC
21	Paging response	Paging response.	RAC
22	End Delivery Notification from ship	ACK to short downlink message/message from ship application that a message (session) was received.	RAC
33	Uplink short message (with ACK)	Short data message from ship with acknowledgement.	RAC
23	Uplink short message (without ACK)	Short data message from ship with no acknowledgement.	RAC
24, 25, 26, 27, 28	Uplink short message (without ACK)	5 bytes of data to satellite pre-configured destinations.	RAC
29	Downlink acknowledgement	Selective acknowledgement of downlink data fragments.	DSCH
30	Start fragment	Start data fragment of data session.	DC
31	Continuation fragment	Middle data fragment of data session.	DC
32	End fragment	Last data fragment of data session.	DC
34	Padding byte	Byte used for padding.	BBSC, ASC, RAC, DSCH, DC

3.10 VHF data exchange-satellite message descriptions

3.10.1 Satellite bulletin board

TABLE 63

Satellite bulletin board (Fragment 1)

Field no.	Size (bytes)	Function	Content
1	1	Type	Bulletin Board start fragment 1, network info Type = 1
2	1	Satellite ID	0-255
3	1	Primary Network ID	0-255
4	1	Roaming Network ID	0-255
5	2	SBB Version	Version number of this Bulletin Board All valid versions are stored in the ship terminal.
6	4	Start time	UTC start time for this version of the Bulletin Board in number of seconds since 1 January 2000, 00:00:00 UTC
7	2	Validity duration	Lifetime of this version in number of 1-minute frames Up to 45 days
8	1	Service capabilities	4 MSB Bitmap Rec. ITU-R M.2092 version compatibility; 1 = M.2092-1 4 LSB service capabilities bitmap Bit3: Reserved for future use. Default = 0. Bit2: Reserved for future use. Default = 0. Bit1: Reserved for future use. Default = 0. Bit0: Reserved for future use. Default = 0.
9	2	SBB backup frequency	As defined in Rec. ITU-R M.1084
10	2	Max uplink msg size	Maximum message uplink size allowed in kilo Bytes [kB].
11	1	Reserved for future use	Default 0.
12	2	Total message size of all fragments including overflow	SBB total size in bytes

TABLE 64

Satellite bulletin board (Fragment 2)

Field no.	Size (bytes)	Function	Content
1	1	Type	Logical Channels 0-23 definition, frequency pairs A and B. Type = 2
2	2	Downlink centre frequency A	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. ITU-R M.1084 and is defined in Field no. 4 Default: 2226: 161.9125 MHz
3	2	Uplink centre frequency A	Identification of centre frequency use channel numbering scheme defined in Recommendation ITU-R M.1084. Channel bandwidth is not according to Recommendation ITU-R M.1084 and is defined in Field no. 4 Default: 1226: 157.3125 MHz
4	1	Downlink and uplink bandwidth A	First 4 bits defines downlink bandwidth. 1: 50 kHz (default) 2: 100 kHz 3: 150 kHz Last 4 bits define uplink bandwidth 1: 50 kHz (default) 2: 100 kHz 3: 150 kHz
5	6	Logical channel slot sizes A	Up to 12 LCs on a frequency pair 1, multiple of 15 slots, 4 bits per LC (max size 15 × 15=225 slots) Default SBB slot sizes. 90, 90, 30, 90, 90, 90, 90, 30, 30, 180, 0, 0. The slot sizes except SBB are repeated until frame is full (2250 slots)
6	6	Logical channel function A	4 bits per LCs 0: BBSC 1: ASC 2: DSCH 3: RAC 4: DC, Data up or down (Dynamic, given in Resource Allocation message) 5: Empty Default: 0, 1, 4, 4, 4, 4, 4, 4, 2, 3, 5, 5
7	2	Downlink centre frequency B	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. ITU-R M.1084 and is defined in Field no. 9. Default: 1226: 157.3125 MHz

TABLE 64 (*end*)

Field no.	Size (bytes)	Function	Content
8	2	Uplink centre frequency B	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Re. ITU-R M.1084 and is defined in Field no. 9. Default: 2226: 161.9125 MHz
9	1	Downlink and uplink bandwidth B	First 4 bits defines downlink bandwidth. 1: 50 kHz (default) 2: 100 kHz 3: 150 kHz Last 4 bits define uplink bandwidth 1: 50 kHz (default) 2: 100 kHz 3: 150 kHz
10	6	Logical channel slot sizes B	Up to 12 LCs on a frequency pair 1, multiple of 15 slots, 4 bits per LC (max size 15 × 15 = 225 slots) Default SBB slot sizes. 90, 90, 30, 90, 90, 90, 90, 30, 30, 180, 0, 0. The slot sizes except SBB are repeated until frame is full (2250 slots)
11	6	Logical channel function B	4 bits per LCs Default: 0, 1, 4, 4, 4, 4, 4, 4, 2, 3, 5, 5 See “SBB Fragment 2” for more details.

TABLE 65

Satellite bulletin board (Fragment 3)

Field no.	Size (bytes)	Function	Content
1	1	Type	Logical Channels 24-47 definition, frequency pairs C and D Type = 3
2	2	Downlink centre frequency C	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. ITU-R M.1084 and is defined in Field no. 4. Default: 2284: 161.8375 MHz
3	2	Uplink centre frequency C	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. ITU-R M.1084 and is defined in Field no. 4. Default: 1225: 157.2625 MHz
4	1	Downlink and uplink bandwidth C	First 4 bits defines downlink bandwidth. 2: 100 kHz (default) Last 4 bits define uplink bandwidth 1: 50 kHz (default) See “SBB Fragment 2” for more details.

TABLE 65 (*end*)

Field no.	Size (bytes)	Function	Content
5	6	Logical channel slot sizes C	Up to 12 LCs on a frequency pair 1, multiple of 15 slots, 4 bits per LC (max size 15 × 15 = 225 slots) Default SBB slot sizes. 90, 90, 30, 90, 90, 90, 90, 30, 30, 180, 0, 0. The slot sizes except SBB are repeated until frame is full (2250 slots)
6	6	Logical Channel function C	4 bits per LCs Default: 5, 5, 4, 4, 4, 4, 4, 4, 2, 3, 5, 5 See "SBB Fragment 2" for more details.
7	2	Downlink centre frequency D	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. ITU-R M.1084 and is defined in Field no. 9. Default: 1284: 157.2375 MHz
8	2	Uplink centre frequency D	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. ITU-R M.1084 and is defined in Field no. 9. Default: 2225: 161.8625 MHz
9	1	Downlink and uplink bandwidth D	First 4 bits defines downlink bandwidth. 2: 100 kHz (default) Last 4 bits define uplink bandwidth 1: 50 kHz (default)
10	6	Logical channel slot sizes D	Up to 12 LCs on a frequency pair 1, multiple of 15 slots, 4 bits per LC (max size 15 × 15 =225 slots) Default SBB slot sizes. 90, 90, 30, 90, 90, 90, 90, 30, 30, 180, 0, 0. The slot sizes except SBB are repeated until frame is full (2250 slots)
11	6	Logical Channel function D	4 bits per LCs Default: 5, 5, 4, 4, 4, 4, 4, 4, 2, 3, 5, 5 See "SBB Fragment 2" for more details.

TABLE 66

Satellite bulletin board (Fragment 4)

Field no.	Size (bytes)	Function	Content
1	1	Type	Logical Channels 48-71 definition, frequency pairs E and F Type = 4
2	2	Downlink centre frequency E	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. ITU-R M.1084 and is defined in Field no. 4. Default: 2225: 161.8625 MHz

TABLE 66 (*end*)

Satellite bulletin board (Fragment 4)

Field no.	Size (bytes)	Function	Content
3	2	Uplink centre frequency E	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. ITU-R M.1084 and is defined in Field no. 4. Default: 1224: 157.2625 MHz
4	1	Downlink and uplink bandwidth E	First 4 bits defines downlink bandwidth. 3: 150 kHz (default) Last 4 bits define uplink bandwidth 1: 50 kHz (default) See “SBB Fragment 2” for more details.
5	6	Logical channel slot sizes E	Up to 12 LCs on a frequency pair 1, multiple of 15 slots, 4 bits per LC (max size 15 × 15 = 225 slots) Default SBB slot sizes. 90, 90, 30, 90, 90, 90, 90, 30, 30, 180, 0, 0. The slot sizes except SBB are repeated until frame is full (2250 slots)
6	6	Logical Channel function E	4 bits per LCs Default: 5, 5, 4, 4, 4, 4, 4, 4, 2, 3, 5, 5 See “SBB Fragment 2” for more details.
7	2	Downlink centre frequency F	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. ITU-R M.1084 and is defined in Field no. 9. Default: 1225: 157.2625 MHz
8	2	Uplink centre frequency F	Identification of centre frequency use channel numbering scheme defined in Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. ITU-R M.1084 and is defined in Field no. 9. Default: 2224: 161.8125 MHz
9	1	Downlink and uplink bandwidth F	First 4 bits defines downlink bandwidth. 3: 150 kHz (default) Last 4 bits define uplink bandwidth 1: 50 kHz (default) See “SBB Fragment 2” for more details.
10	6	Logical Channel slot sizes F	Up to 12 LCs on a frequency pair 1, multiple of 15 slots, 4 bits per LC (max size 15 × 15 = 225 slots) Default SBB slot sizes. 90, 90, 30, 90, 90, 90, 90, 30, 30, 180, 0, 0. The slot sizes except SBB are repeated until frame is full (2250 slots)
11	6	Logical Channel function F	4 bits per LC Default: 5, 5, 4, 4, 4, 4, 4, 4, 2, 3, 5, 5 See “SBB Fragment 2” for more details.

TABLE 67

Satellite bulletin board (Fragment 5)

Field no.	Size (bytes)	Function	Content
1	1	Type	SBB digital signature part 1. Type = 5
2	32	Digital signature part 1	Refer § 4.15, Annex 4.

TABLE 68

Satellite bulletin board (Fragment 6)

Field no.	Size (bytes)	Function	Content
1	1	Type	SBB digital signature part 2. Type = 6
2	32	Digital signature part 2	Refer § 4.15, Annex 4.

3.10.2 Media access control

TABLE 69

Media access control

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 10
2	2	Payload size	Fixed of fields 3 to 11. Payload size = 10
3	1	Satellite ID	0-255
4	1	Primary Network ID	0-255
5	1	Roaming Network ID	0-255
6	1	Media Access Priority	0: All accesses allowed 1: All accesses except short data message allowed 2: Only resource request/response allowed 255: No accesses allowed; system busy

TABLE 69 (*end*)

Field no.	Size (bytes)	Function	Content
7	1	Random selection interval	In multiple of 15 slots Default = 12 (12 × 15 = 180 slots) For transmitting a message on the RAC, the ship terminal determines a transmission start slot offset relative to the next RAC slot in time by calculating a uniformly distributed random number from the discrete set 0, …, random selection interval × 15 (Default 0, 5, 10, …, 180). The transmission shall start in the RAC slot defined by that random number. Note: the transmission needs to stay entirely inside the reserved slots for RAC, therefore, the random transmission start slot offset may map the start of transmission to RAC slots beyond the current VDE-SAT sub-frame’s RAC interval into future VDE-SAT sub-frame’s RAC intervals.
8	1	RAC Message access limit	Maximum number of allowed messages sent by a ship terminal on the Random Access Channel during a 15-minute interval. Default: 3
9	1	Network status	0: Operational 1: Reduced availability 2: Network down
10	1	ARQ/timeout limits	4 MSB Number of fragment retries Default: 3 retries for a fragment. 4 LSB: Timeout timer setting Reserved for future use. Default = 0.
11	2	Bulletin Version number	Maps to SBB version number.

3.10.3 Paging

TABLE 70

Paging

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 11
2	2	Payload size	Size of fields 3 to 10. Payload size = 32
3	4	Ship 1 Station ID	The Unique Identifier of the receiving station, as described in § 2.4, Annex 1.
4	4	Ship 2 Station ID	The Unique Identifier of the receiving station, as described in § 2.4, Annex 1. Set to 0 when empty.
5	4	Ship 3 Station ID	The Unique Identifier of the receiving station, as described in § 2.4, Annex 1. Set to 0 when empty.

TABLE 70 (*end*)

Field no.	Size (bytes)	Function	Content
6	4	Ship 4 Station ID	The Unique Identifier of the receiving station, as described in § 2.4, Annex 1. Set to 0 when empty.
7	4	Ship 5 Station ID	The Unique Identifier of the receiving station, as described in § 2.4, Annex 1. Set to 0 when empty.
8	4	Ship 6 Station ID	The Unique Identifier of the receiving station, as described in § 2.4, Annex 1. Set to 0 when empty.
9	4	Ship 7 Station ID	The Unique Identifier of the receiving station, as described in § 2.4, Annex 1. Set to 0 when empty.
10	4	Ship 8 Station ID	The Unique Identifier of the receiving station, as described in § 2.4, Annex 1. Set to 0 when empty.

3.10.4 Paging response

TABLE 71

Paging response

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 21
2	4	Ship Station ID	The Unique Identifier of station where the message originated from, as described in § 2.4, Annex 1.
3	1	Terminal capabilities	Bitmask: 4 MSB: Set for versions of 2092 4 LSB: Bit 3: Reserved for future use. Default = 0. Bit 2: Reserved for future use. Default = 0. Bit 1: Reserved for future use. Default = 0. Bit 0: Set to 1 for low-power terminal < 2W.
4	1	Downlink ASC CQI	Received channel quality indicator averaged over the last VDE-SAT sub-frame received as defined in § 1.2.8, Annex 2

3.10.5 Resource request

TABLE 72

Resource request

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 20
2	4	Ship Station ID	The Unique Identifier of station where the message originated from, as described in § 2.4, Annex 1.
3	1	Satellite ID	Destination satellite ID.
4	1	Priority and message size	Bits 7-4, Priority 0: Normal 15: Highest Bits 3-0, Message size Message size = size of message transmitted/maximum uplink message size (in SBB fragment 1)*15
5	1	Terminal capabilities	See field 3 in Paging Response Message.
6	1	Downlink ASC CQI	Received Channel Quality Indicator averaged over the last VDE-SAT sub-frame received as defined in § 1.2.8, Annex 2
7	1	TBD	Set to 0. Reserved for future use.

Note: The message will be transmitted on the RAC by ships during a resource request.

3.10.6 Resource allocation

TABLE 73

Resource allocation

Field no	Size (bytes)	Function	Content
1	1	Type	Type = 12
2	2	Payload size	Size of fields 3 to 22. Payload size = 32
3	4	Ship Station ID 1	The Unique Identifier of the ship station, as described in § 2.4, Annex 1. 0 for broadcast.
4	1	Logical Channel 1	Logical Channel assigned for data transmission. Only applies to data slots. LC of 255 indicates no resource.
5	1	Link ID 1	Link ID that should be used in Logical Channel 1. Transmission direction can be inferred from link ID.
6	1	Session ID 1	Satellite assigned session ID, range 1-255. 0 used for short message
7	1	Uplink link CQI 1	Received Channel Quality Indicator as defined in § 1.2.8, Annex 2.

TABLE 73 (*end*)

Field no	Size (bytes)	Function	Content
8	4	Ship Station ID 2	The Unique Identifier of the ship station, as described in § 2.4, Annex 1. 0 for broadcast.
9	1	Logical Channel 2	Logical Channel assigned for data transmission. Only applies to data slots. LC of 255 indicates no resource.
10	1	Link ID 2	Link ID that should be used in Logical Channel 2. Transmission direction can be inferred from link ID.
11	1	Session ID 2	Assigned session ID.
12	1	Uplink link CQI 2	Received Channel Quality Indicator as defined in §1.2.8, Annex 2.
13	4	Ship Station ID 3	The Unique Identifier of the ship station, as described in § 2.4, Annex 1. 0 for broadcast.
14	1	Logical Channel 3	Logical Channel assigned for data transmission. Only applies to data slots. LC of 255 indicates no resource.
15	1	Link ID 3	Link ID that should be used in Logical Channel 3. Transmission direction can be inferred from link ID.
16	1	Session ID 3	Assigned session ID.
17	1	Uplink link CQI 3	Received Channel Quality Indicator as defined in § 1.2.8, Annex 2.
18	4	Ship Station ID 4	The Unique Identifier of the ship station, as described in § 2.4, Annex 1. 0 for broadcast.
19	1	Logical Channel 4	Logical Channel assigned for data transmission. Only applies to data slots. LC of 255 indicates no resource.
20	1	Link ID 4	Link ID that should be used in Logical Channel 4. Transmission direction can be inferred from link ID.
21	1	Session ID 4	Assigned session ID.
22	1	Uplink link CQI 4	Received Channel Quality Indicator as defined in § 1.2.8, Annex 2.

3.10.7 Start fragment

The last fragment defines end of a message, thus message length is not needed in the start fragment Message for the given session.

Note: Transfers that are not short messages, use these fragment messages described in § 3.10.7, § 3.10.8 and § 3.10.9. There is always sent a start fragment. Several cases apply:

a) In case the complete payload of a session transfer fits into the start fragment, only a start fragment is sent.

b) In case the complete payload does fit into a start and end fragment, no continuation fragment is sent.

c) In case the complete payload does not fit into a start, or start and end fragment alone, continuation fragments are used to carry payload as well.

TABLE 74

Start fragment

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 30
2	2	Payload size	Size of fields 3 to 8.
3	4	Source Station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1, and § 3.12.
4	1	Satellite ID	Satellite ID.
5	1	Session ID	1-255
6	4	Destination Station ID	The Unique Identifier of the destination station, as described in § 2.4, Annex 1, and § 3.12.
7	2	Fragment number	Fragment number of the payload in this VDE-SAT data session. First fragment should start at 0, increment with any additional fragment and wrap at 65535.
8	Variable	Payload	

Note: Used for uplink and downlink data. The data transfer direction can be inferred from the used link ID. For uplink data, the source station is the ship station; for downlink data, the destination station is the ship station.

3.10.8 Continuation fragment

TABLE 75

Continuation fragment

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 31
2	2	Payload size	Size of fields 3 to 8.
3	4	Source Station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1, and § 3.12.
4	1	Satellite ID	Satellite ID.
5	1	Session ID	1-255
6	4	Destination Station ID	The Unique Identifier of the destination station, as described in § 2.4, Annex 1, and § 3.12.
7	2	Fragment number	Fragment number of the payload in this VDE-SAT data session. First fragment should start at 0, increment with any additional fragment and wrap at 65535.
8	Variable	Payload	

3.10.9 End fragment

TABLE 76

End fragment

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 32
2	2	Payload size	Size of fields 3 to 8.
3	4	Source Station ID	The Unique Identifier of the ship station, as described in § 3.4, Annex 1, and § 3.12.
4	1	Satellite ID	Satellite ID.
5	1	Session ID	1-255
6	4	Destination Station ID	The Unique Identifier of the destination station, as described in § 2.4, Annex 1, and § 3.12.
7	2	Fragment number	Fragment number of the payload in this VDE-SAT data session. First fragment should start at 0, increment with any additional fragment and wrap at 65535.
8	Variable	Payload	

3.10.10 End delivery notification to ship

TABLE 77

End delivery notification to ship

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 18
2	2	Payload size	Size of fields 3 to 14. Payload size = 5 - 30
3	1	Satellite ID	0-255
4	4	Ship 1 Station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1.
5	1	Session ID ship 1	Set to 0 for short uplink messages.
6	4	Ship 2 Station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1. Set to 0 when empty.
7	1	Session ID ship 2	Set to 0 for short uplink messages.
8	4	Ship 3 Station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1. Set to 0 when empty.
9	1	Session ID ship 3	Set to 0 for short uplink messages.
10	4	Ship 4 Station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1. Set to 0 when empty.

TABLE 77 (*end*)

Field no.	Size (bytes)	Function	Content
11	1	Session ID ship 4	Set to 0 for short uplink messages.
12	4	Ship 5 Station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1. Set to 0 when empty.
13	1	Session ID ship 5	Set to 0 for short uplink messages.
14	4	Ship 6 Station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1. Set to 0 when empty.
15	1	Session ID ship 6	Set to 0 for short uplink messages.

3.10.11 End delivery notification from ship

TABLE 78

End delivery notification from ship

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 22
2	4	Ship Station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1.
3	1	Satellite ID	
4	4	Destination Station ID	The Unique Identifier of the destination station, as described in § 2.4, Annex 1.
5	1	Session ID	Set to 0 for short message ACK.

This message may be used by the application on a vessel to confirm reception a downlink message.

3.10.12 Downlink acknowledgement

TABLE 79

Downlink acknowledgement

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 29
2	1	Satellite ID	Satellite ID
3	4	Ship station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1.
4	1	Downlink CQI	Received Channel Quality Indicator averaged over the last VDE-SAT sub-frame received as defined in § 1.2.8, Annex 2.

TABLE 79 (*end*)

Field no.	Size (bytes)	Function	Content
5	1	ACK/NACK mask 0	When a burst was not received, then its corresponding bit should be set to one to Not Acknowledge the packet. Each ACK/NACK mask corresponds to one VDE-SAT sub-frame. If the first fragment of a VDE-SAT sub-frame is not received, then the least significant bit is set. The second fragment corresponds with the next bit, and so on. E.g. if there were five fragments and the last fragment was not received, then the ACK/NACK mask should be logically or-ed with 0×10. NACK mask 2 represents the latest VDE-SAT sub-frame received directly before this message response. NACK mask 1 represents the second to last VDE-SAT sub-frame received. NACK mask 0 represents the third to last VDE-SAT sub-frame received.
6	1	ACK/NACK mask 1	
7	1	ACK/NACK mask 2	

Note: Used for the ACK of downlink addressed messages and short messages.

3.10.13 Uplink acknowledgement

TABLE 80

Uplink acknowledgement for addressed messages

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 13
2	1	Satellite ID	0-255
3	4	Ship Station ID	The Unique Identifier of the ship station, as described in § 2.4, Annex 1.
4	1	Session ID	1-255
5	1	Resource re-allocation	Number of subsequently allocated VDE-SAT sub-frames of the logical channel this acknowledgment message refers to. If the transmitting station is provided with a new resource allocation for this session, or in order to cancel the current allocation, this field is set to 0.
6	1	Uplink CQI	Received Channel Quality Indicator averaged over the last TDMA frame received as defined in § 1.2.8, Annex 2.
7	1	Adaptive coding and modulation control	4 MSB 0: Maintain Link ID 1: Select Link ID with next higher CQI 2: Select Link ID with next lower CQI 4 LSB 0: Use default power level for current Link ID 1: Reduce Power level 10 dB 2: Reduce power level 3 dB 3: Increase power level 3 dB

TABLE 80 (*end*)

Field no.	**Size (bytes)**	**Function**	**Content**
8	25	ACK/NACK mask	When a burst was not received, then its corresponding bit should be set to one to Not Acknowledge the packet. The mask indicates ACK/NACK for the previous 200 bursts as historically allocated for this uplink session in the previous VDE-SAT sub-frames. If the uplink Link ID changes, the mask is reset and the ship station retransmits all non-acknowledged data.

Note: Used for the ACK of uplink addressed messages.

TABLE 81

Uplink acknowledgement for short messages

Field no.	**Size (bytes)**	**Function**	**Content**
1	1	Type	Type = 34
2	2	Payload Size	Size of fields 3 to 15.
3	1	Satellite ID	0-255
4	4	Ship 1 Station ID	Set to 0 when empty.
5	1	Ship 1 NACK flag	Received short message sets to 0.
6	4	Ship 2 Station ID	Set to 0 when empty.
7	1	Ship 2 NACK flag	Received short message sets to 0.
8	4	Ship 3 Station ID	Set to 0 when empty.
9	1	Ship 3 NACK flag	Received short message sets to 0.
10	4	Ship 4 Station ID	Set to 0 when empty.
11	1	Ship 4 NACK flag	Received short message sets to 0.
12	4	Ship 5 Station ID	Set to 0 when empty.
13	1	Ship 5 NACK flag	Received short message sets to 0.
14	4	Ship 6 Station ID	Set to 0 when empty.
15	1	Ship 6 NACK flag	Received short message sets to 0.

Note: Used for the ACK of uplink short messages.

3.10.14 Downlink short message (with acknowledgement)

TABLE 82

Downlink short message (with acknowledgement)

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 14
2	2	Payload size	Size of fields 3 to 6.
3	1	Satellite ID	0-255
4	4	Source ID	
5	4	Ship Station ID	The Unique Identifier of the destination station, as described in § 2.4, Annex 1.
6	Variable	Payload	Binary data.

3.10.15 Downlink short message (without acknowledgement)

TABLE 83

Downlink short message (without acknowledgement)

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 16
2	2	Payload size	Size of fields 3 to 6.
3	1	Satellite ID	0-255
4	4	Source ID	
5	4	Ship Station ID	The Unique Identifier of the destination station, as described in § 2.4, Annex 1.
6	Variable	Payload	Binary data.

3.10.16 Uplink short message (with acknowledgement)

TABLE 84

Uplink short message (with acknowledgement)

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 33
2	4	Ship Station ID	The Unique Identifier of the source station, as described in § 2.4, Annex 1.
3	4	Destination Station ID	The Unique Identifier of the destination station, as described in § 2.4, Annex 1.
4	1	Data	Binary data

3.10.17 Uplink short message (without acknowledgement)

TABLE 85

Uplink short message (without acknowledgement)

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 23
2	4	Ship Station ID	The Unique Identifier of the source station, as described in § 2.4, Annex 1.
3	4	Destination Station ID	The Unique Identifier of the destination station, as described in § 2.4, Annex 1.
4	1	Data	Binary data.

3.10.18 Uplink short message (without acknowledgement and destination identification)

TABLE 86

Uplink short message (without acknowledgement and destination identification)

Field no.	Size (bytes)	Function	Content
1	1	Type	Type = 24 - 28
2	4	Ship Station ID	The Unique Identifier of the source station, as described in § 2.4, Annex 1.
3	5	Data	Binary data.

3.11 Downlink retry mechanism

During data transmission, it is expected that data fragments can be lost occasionally. The ship station shall flag the received and lost fragments in the ACK/NACK masks of the downlink acknowledgment message (#29), sent by the ship station to the satellite for each VDE-SAT sub-frame and assigned DC.

The satellite shall retry transmission of each individual fragment for a maximum of N consecutive VDE-SAT sub-frames before giving up, excluding the original fragment transmission in a data channel.

The ship station shall request retransmission of data fragments for a maximum of N attempts. N is given in the MAC message field 10.

It is also possible that the ACK/NACK message (#29) is not received by the satellite. It is for this reason that the ACK/NACK message (#29) contains redundancy for three ACK/NACK masks, referencing the fragments transmitted during the previous three VDE-SAT sub-frames.

When the satellite does not receive an ACK/NACK message, it shall continue as if all the fragments have been acknowledged. If there were any errors, then the satellite will see this when it receives the next ACK/NACK message in the following VDE-SAT sub-frame. If no ACK/NACK message is received within N consecutive VDE-SAT sub-frames, then the transmitter shall stop that session immediately.

3.12 Uplink retry mechanism

During uplink data transmission, it is expected that data fragments can be lost occasionally. The satellite shall flag the received and lost fragments in the ACK/NACK masks of the uplink acknowledgment message (#13), sent by the satellite to the ship station for each uplink session and VDE-SAT sub-frame.

The ship station shall retransmit each individual lost fragment for a maximum of N consecutive VDE-SAT sub-frames before giving up, excluding the original fragment transmission in a data channel.

The satellite shall request retransmission of data fragments for a maximum of N attempts. N is given in the MAC message field 10.

It is also possible that the uplink acknowledgment message (#13) is not received by the ship station. It is for this reason that the uplink acknowledgment message (#13) contains ACK/NACK bits for 200 fragments, referencing the fragments transmitted during the previous VDE-SAT sub-frames.

When the ship station does not receive uplink acknowledgment messages, it shall continue as if all the fragments have been acknowledged, up to 200 fragments from the last acknowledged fragment, given that the ship station still has an uplink resource allocation. If there were any lost fragments, then the ship station will see this when it receives the next uplink acknowledgment message (#13). If no uplink acknowledgment message (#13) is received for 200 transmitted fragments, the ship station shall retransmit all not-acknowledged fragments as long as uplink resources are allocated to it.

3.13 Data transfer protocol details

Detailed protocol diagrams for VDE-SAT are provided in § 3.13.1 through § 3.13.10.

Addressed data transfers are from a source station ID to a destination station ID, where it is the VDE-SAT networks responsibility to route transfer data from start to end between the two stations.

The source station identifies the station that is originally transmitting the data, to be identified by the receiving destination station ID. The source station ID is also used for sending an answer back to it.

Transfers using resource request and Allocation mechanism, the source and destination station IDs are identified as follows:

For an uplink addressed transfer from a ship to a destination station, the ship station ID is part of the resource request (see § 3.10.5), and the destination station ID is given as the destination station ID in the start, continuation and end fragments.

For a downlink addressed transfer that passes through the satellite to a ship station, the ship station ID is part of the resource allocation, whereas the source station ID is given as the destination station ID in the start, continuation and end fragments.

Two examples of a data transfer process are illustrated in Figs 56 and 57. Additional considerations on the two examples are provided in the enumerated list below the two Figures.

FIGURE 56

Short messages transfer process in VHF data exchange system-satellite

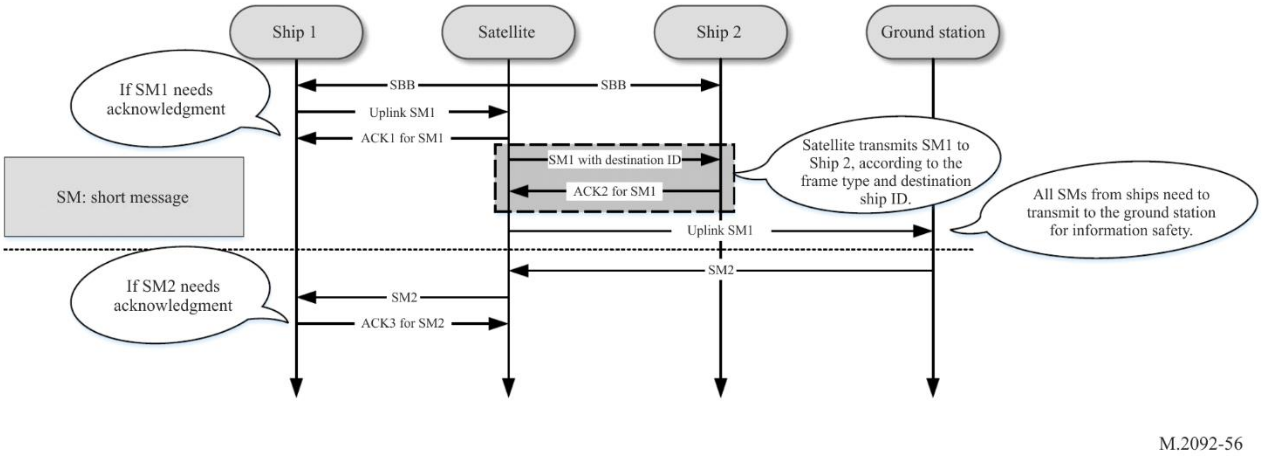
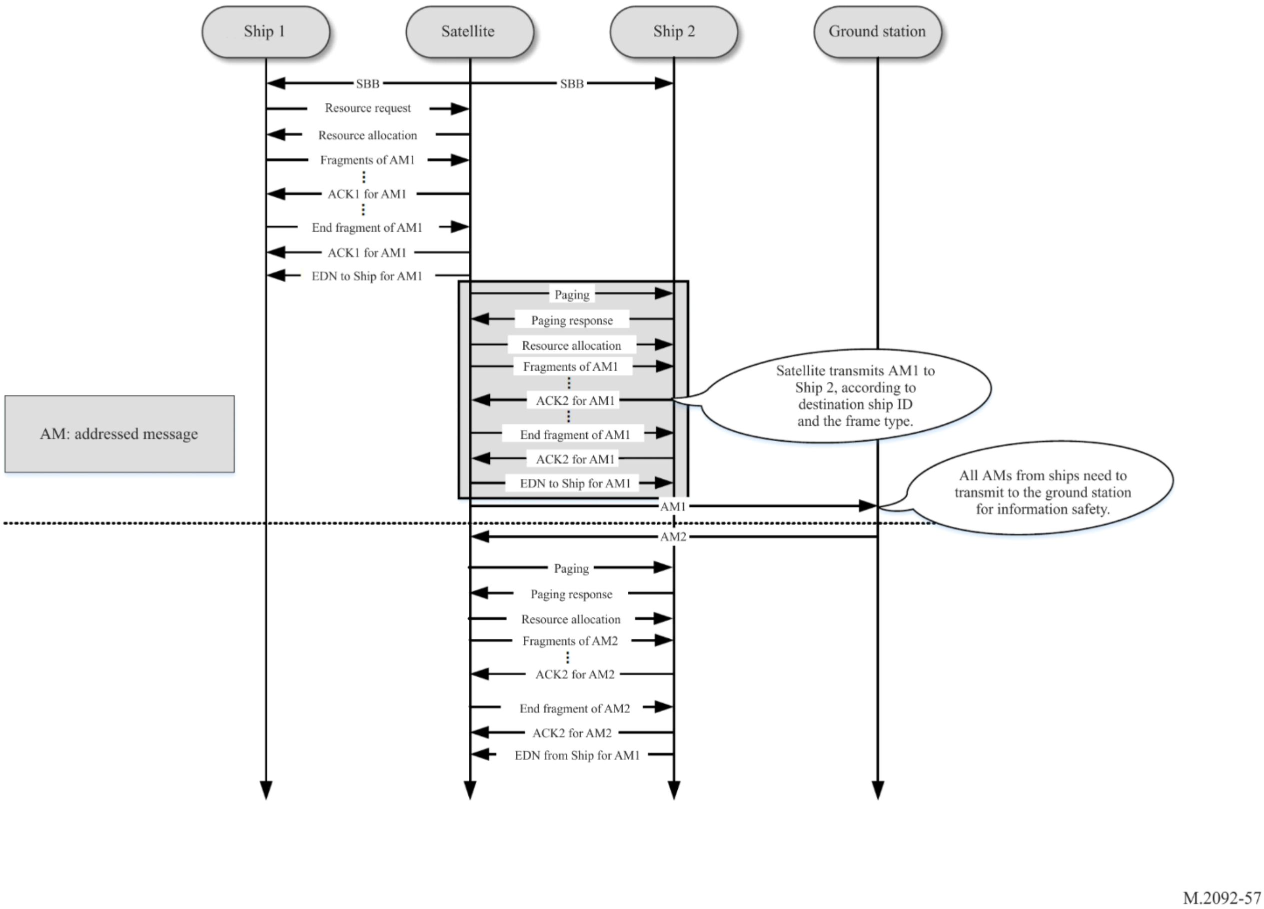


FIGURE 57

Addressed messages transfer process in VHF data exchange system-satellite



1) Short messages can need ACK and none ACK, while addressed message should need ACK.

2) Short/addressed messages support the service from one ship to another via satellite.

3) Short/addressed messages can be from ground station.

4) All short/addressed messages from ships should be transmitted to ground stations for information safety.

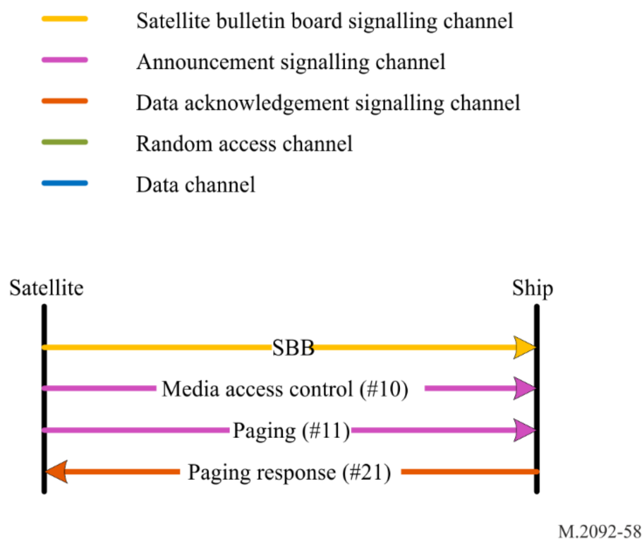
5) For the service (short and addressed messages) from one ship to another, the process should be separated to two transfer processes, ship to satellite and satellite to ship.

6) For addressed messages, there is only one ship and one satellite in every transfer process except broadcast addressed messages, thus EDN (to ship and from ship) is to end its corresponding transfer process or session.

3.13.1 Paging

FIGURE 58

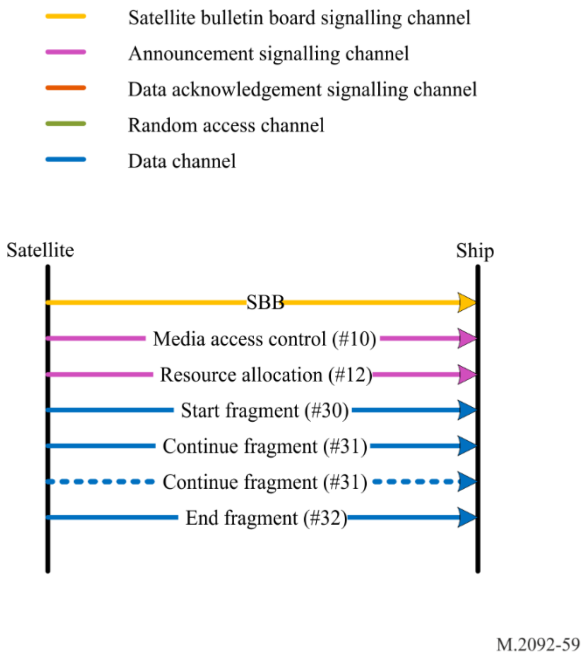
Paging



3.13.2 Satellite originated broadcast

FIGURE 59

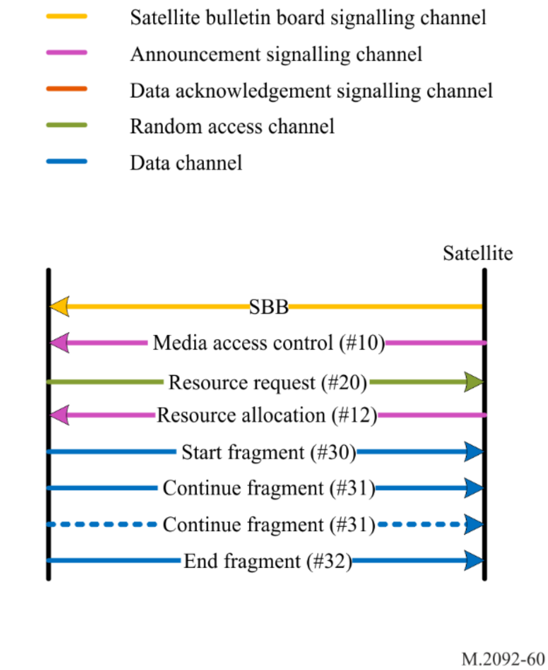
Satellite originated broadcast



3.13.3 Ship transmission without acknowledgement

FIGURE 60

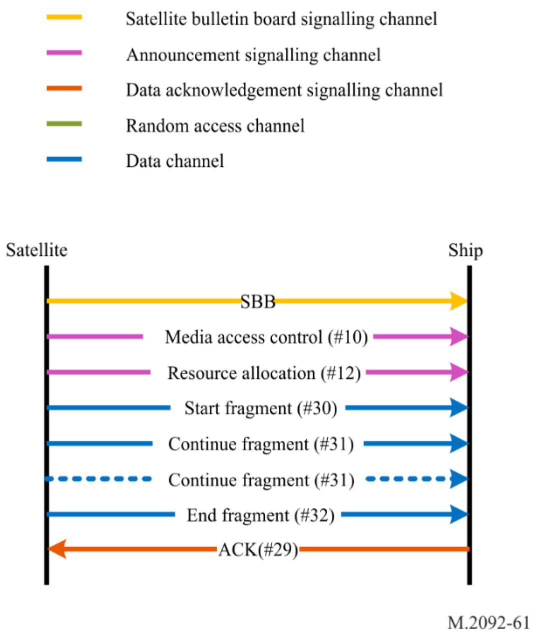
Ship transmission without acknowledgement



3.13.4 Satellite to ship addressed message

FIGURE 61

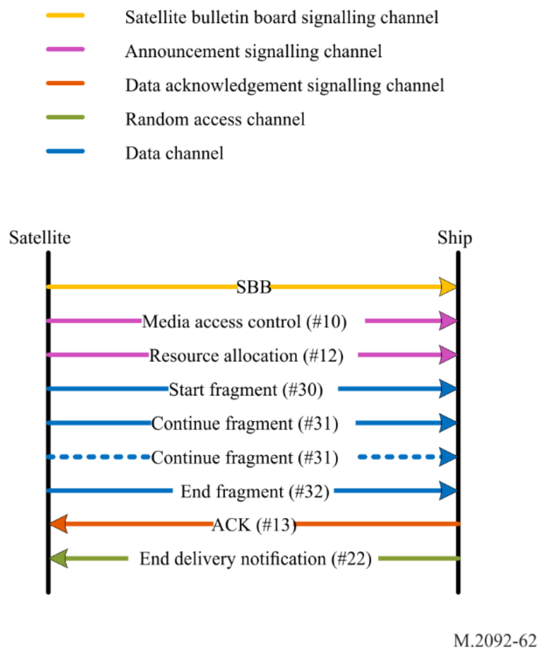
Satellite to ship addressed message



3.13.5 Satellite to ship addressed message with end delivery notification

FIGURE 62

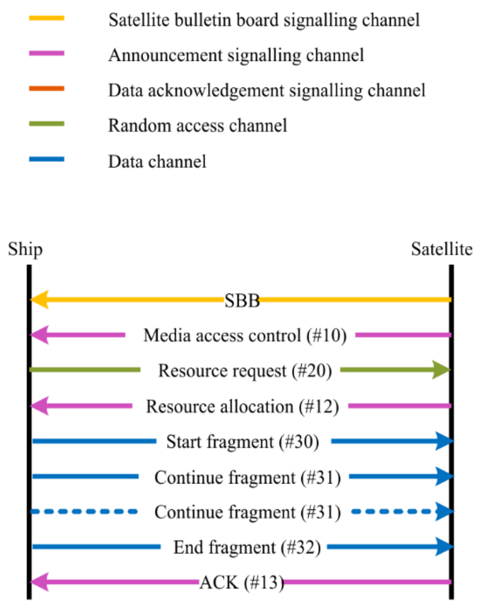
Satellite to ship addressed message with end delivery notification



3.13.6 Ship to satellite addressed message

FIGURE 63

Ship to satellite addressed message

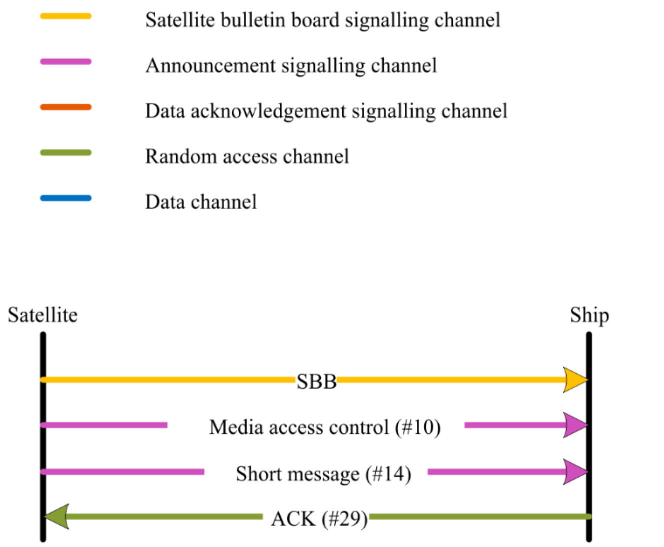


M.2092-63

3.13.7 Satellite to ship short data message (with acknowledgement)

FIGURE 64

Satellite to ship short data message (with acknowledgement)

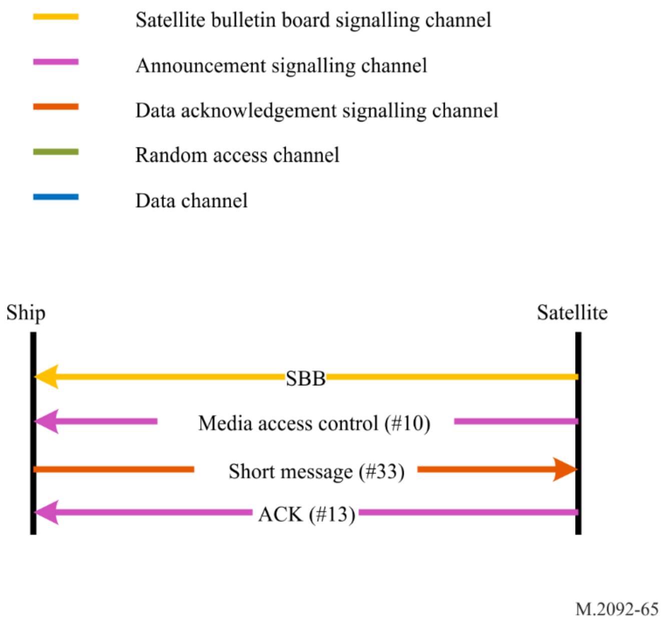


M.2092-64

3.13.8 Ship to satellite short data message (with acknowledgement)

FIGURE 65

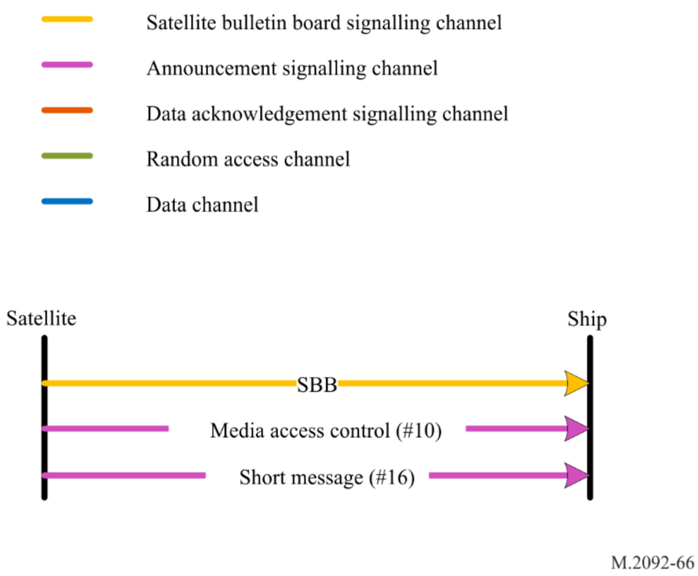
Ship to satellite short data message (with acknowledgement)



3.13.9 Satellite to ship short data message (no acknowledgement)

FIGURE 66

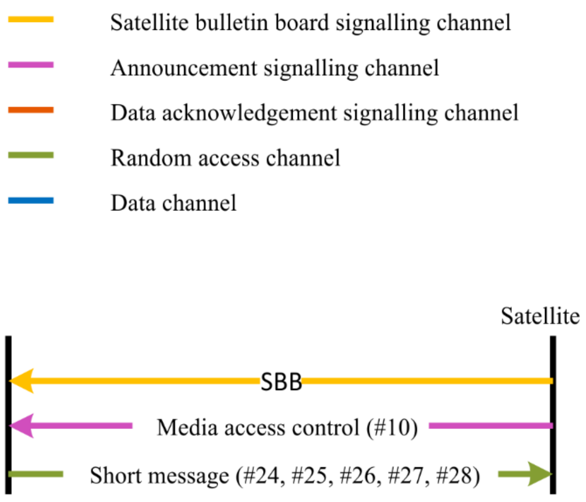
Satellite to ship short data message (no acknowledgement)



3.13.10 Ship to satellite short data message (no acknowledgement)

FIGURE 67

Ship to satellite short data message (no acknowledgement)



M.2092-67

3.14 Random access

A ship accesses the system by requesting a resource or sending a short data message on the random access channel.

When a message is scheduled for immediate RAC transmission, then all transmission candidate slots should be gathered over the selection interval. The default selection interval is 180 slots (minus 1 last guard slot), but may be set via a Media Access Control message, received from a Satellite. Only slots with slot function set as RAC may be considered as candidate slots. As an AIS transceiver forms part of the VDES system, the AIS transmission schedules should also be considered. AIS will always have priority over VDE-SAT transmissions.

One candidate slot will be randomly selected from all the available candidate slots. If no candidate slot is available or if for some reason, the VDE message could not be transmitted (AIS messages could be scheduled after the VDE-SAT schedule), then the VDE transmission will fail and the normal retry mechanism will follow. The retry mechanism will allow up to three retries of the RAC transmission.

3.15 Logical channel assignment

For data transfers two logical DC are assigned until the transfer is complete, has timed out (fragment loss) or is terminated by the satellite for other reasons (e.g. priority or capacity limits).

3.16 Adaptive coding and modulation/rate adaptation

See § 5, Annex 4.

4 Segmentation of VHF data exchange-satellite payload

See § 4.7, Annex 4.

5 Network layer

See § 5, Annex 4.

6 Transport layer

See § 6, Annex 4.

7 Presentation Layer

See § 7, Annex 4.

Annex 6

Resource sharing method for VHF data exchange system terrestrial and satellite services

TABLE OF CONTENTS

Page

1 Introduction

This annex describes how resource sharing (i.e. in time and frequency) for utilizing the VHF spectrum available between different VDES services and stations should be accomplished.

A ship may be within range of multiple controlling shore stations. This annex describes a method for coordinating time and frequency resources between multiple controlling shore stations, particularly the use of bulletin boards and announcement signalling channels, as defined in Annexes 4 and 5.

The VDE-SAT is an effective means to extend the VDES to areas outside of coastal VHF coverage. However, due to the large footprint of satellite, the VDE-SAT downlink signal may interfere with VDE-TER in the coastal areas when satellite is in visibility. Similarly, the terrestrial ship-to-shore VDE signals can interfere with the satellite reception of VDE-SAT uplink when a VDE Satellite is in the field of view. The method described in this annex for resource sharing is derived based on the characteristics of VDE-TER and VDE-SAT, particularly the use of bulletin board and announcement signalling channels, as defined in Annexes 4 and 5.

2 VHF data exchange system resource sharing principles

2.1 Automatic identification system priority

Care should be taken to respect the AIS transmission and reception as the highest priority.

2.2 Coordination between application specific message and VHF data exchange

VDE ship transmissions should be coordinated with transmissions on the ASM channels to ensure that ASM messages with new safety and navigational related information can be received.

2.3 Shore station VHF data exchange system control area

The VDES resource assignments in the proximity of a shore station is monitored and controlled by a shore station. Shore stations utilize TBB to coordinate the resource assignment within the control area.

There are dedicated slots and frequency bands for TBB that are reserved to communicate the required information to each vessel in the control area of a shore station.

3 VHF data exchange-terrestrial resource sharing between multiple controlling shore stations

The allocation of frequency and time slots used for the bulletin board announcement should be coordinated between controlling stations. Other resource assignments are managed based on the content of the bulletin board and announcement signalling channels. The assignment may change dynamically (according to temporal demands).

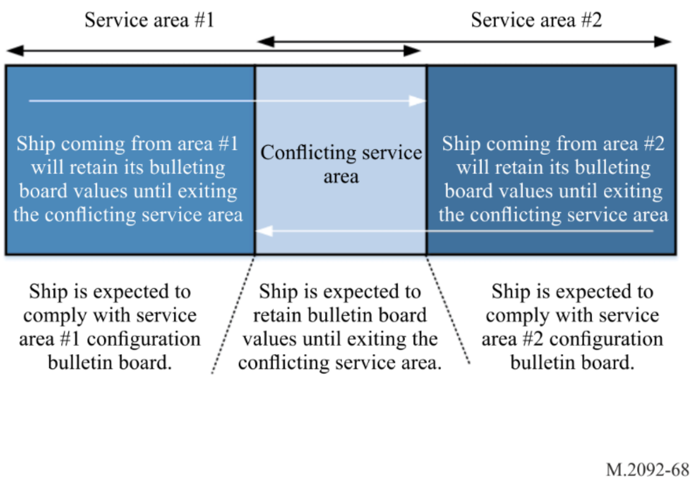
There are dedicated resources that are assigned to the terrestrial bulletin board and announcement channels, as described in Annexes 4 and 5.

Channels 2024, 2084, 2025 and 2085 are shared between multiple controlling stations. The resource sharing should be coordinated between shore station operators. This coordination can be done either directly between the operators or rely on the bulletin board and announcement channels of the shore stations, depending on the shore control areas, the resource assignment may vary. As an initial configuration for resource sharing, the controlling shore stations should adopt a static assignment in time and frequency.

A VDES unit receiving conflicting bulletin boards for the same service area should maintain the bulletin board it was already using until it exits the conflicting service area. Upon exiting the conflicting service are, it can start using the different bulletin board received for the remainder of the area. An example of the desired behaviour is given in Fig. 68.

FIGURE 68

Expected behaviour of VHF data exchange system units in conflicting service areas



4 VHF data exchange-terrestrial and VHF data exchange-satellite resource sharing

Shore stations utilize the TBB, as described in Annex 4, to coordinate the resource assignment within the control area. There are dedicated time slots and frequency bands for TBB that are reserved to communicate the required information to each vessel in the control area of a shore station. The frequency bands and time slots that are assigned to the TBB should not be used for VDE-SAT communications.

Each satellite shall use satellite bulletin board SBB, as defined in Annex 5, to communicate the VDE-SAT resource assignments, both for downlink and uplink, to vessels in the coverage area. There are dedicated slots and frequency bands for the SBB that are reserved to communicate the required information to each vessel in the field of view of a satellite.

Within the service area of a VDE-TER shore station the resource assignments provided in the TBB from that VDE-TER shore station shall be respected and given priority over the resource assignments provided in the SBB from a VDE-SAT satellite. When VDE-SAT uplink transmissions occur, care should be taken to respect the VDE-TER transmission and reception as the higher priority.

Channels 1026, 1086, 2026 and 2086 are identified to VDE-SAT communications, and are managed by the SBB. These channels are not used for VDE-TER communications. Therefore, on these channels no resources are shared between VDE-TER and VDE-SAT and no sharing scheme is required.

Channels 1024, 1084, 1025, 1085, 2024, 2084, 2025 and 2085 are identified for VDE-TER and VDE-SAT communications. With respect to ship stations within VDE-TER shore station coverage, the use of these channels should not cause harmful interference to VDE-TER operation, as described in § 2.1, Annex 1.

For areas not controlled by a VDE-TER shore station, VDE-TER ship-to-ship communications should be according to the default TBB. VDE-SAT communications on channels 1024, 1084, 1025, 1085, 2024, 2084, 2025 and 2085 is managed by the SBB, and should not cause harmful interference to VDE-TER operation, as described in § 2.1, Annex 1.

5 Sharing between different VHF data exchange-satellite systems

The sharing between two or more satellite systems is co-operated between the satellite operators and organized through the bulletin board, delivered by satellites in VDE-SAT downlink bands, as described in Annexes 2 and 5. Ships use the satellite bulletin boards for channel and resource configuration.

The waveform used for the bulletin board should allow for detection of overlapping signals received from multiple satellites. The use of direct sequence spreading as defined in Annex 5, allows for detection of up to four overlapping satellite signals, depending on SAT-MCS.