

# **Recommendation ITU-R M.2092-2**

## **(02/2026)**

M Series: Mobile, radiodetermination, amateur and related satellite services

### **Technical characteristics for VHF data exchange system in the maritime mobile service**

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## RECOMMENDATION ITU-R M.2092-2

**Technical characteristics for VHF data exchange system  
in the maritime mobile service**

(2015-2022-2026)

**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
$C/N$	Carrier to Noise
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 Organisation for Marine Aids to Navigation
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
pdf	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**

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

Recommendation 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

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

Report ITU-R M.2317 – VHF data exchange system channel sounding campaign

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;

g) it is important that VDES has the capability to verify digital signatures and facilitate authentication of AIS messages, based on IMO performance standards,

*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;

15 that VDES should be able to verify digital signatures and facilitate authentication of AIS messages.

## Annex 1

### General description of the VHF data exchange system operating system

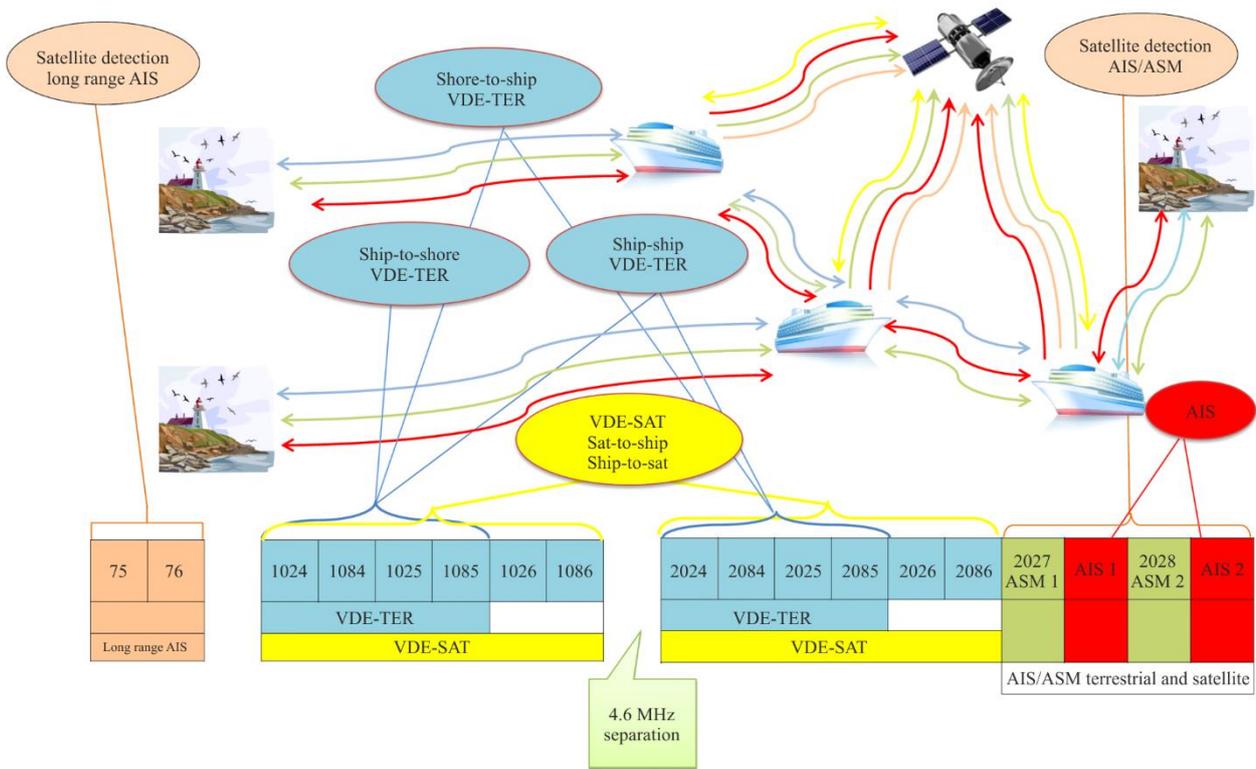
#### TABLE OF CONTENTS

	<i>Page</i>
A1-1 General description of VHF data exchange system.....	6
A1-2 Key technical characteristics .....	6
A1-2.1 Satellite downlink .....	6
A1-2.2 VHF data exchange-terrestrial may operate in either duplex or simplex mode.....	7
A1-2.3 VHF data exchange system channel usage in accordance with Appendix 18 of the Radio Regulations.....	7
A1-2.4 Identification.....	8
A1-2.5 Presentation interface protocol .....	8
A1-2.6 VHF data exchange system communications prioritization .....	8
A1-2.7 Simplified VHF data exchange system.....	8

**A1-1 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  
**VDES**



M.2092-01

**A1-2 Key technical characteristics**

**A1-2.1 Satellite downlink**

To ensure interoperability and compatibility between VDE-TER and VDE-SAT, a pfd-mask is described by the following formula, where  $\theta^\circ$  is the angle between the direction of the earth’s horizon and the direction of the satellite.

$$\begin{aligned}
 \theta^\circ &= \text{earth to satellite elevation angle} \\
 PFD(\theta^\circ)_{(dBW/(m^2 * 4 \text{ kHz}))} &= \begin{cases} -149 + 0.16 * \theta^\circ & 0^\circ \leq \theta < 45^\circ; \\ -142 + 0.53 * (\theta^\circ - 45^\circ) & 45^\circ \leq \theta < 60^\circ; \\ -134 + 0.1 * (\theta^\circ - 60^\circ) & 60^\circ \leq \theta \leq 90^\circ. \end{cases}
 \end{aligned}$$

The values shown above are intended to be what is received by a vertically polarised dipole antenna on ships.



## **A1-2.4 Identification**

### **A1-2.4.1 Station identification**

All VDES stations should be uniquely identified with a maritime mobile service identity (MMSI) according to Recommendation ITU-R M.585, except satellite VDES stations, which should refer to § A5-3.1.9.

### **A1-2.4.2 Source and destination identification**

When the source or destination is a VDES station, an MMSI should be used. For other purposes, numerical identifiers greater than 999999999, but less than  $2^{32}$ , may be used for additional source or destination identifiers.

## **A1-2.5 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.

## **A1-2.6 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 § A3-4.5.3

Priority 3: VDE transmissions – see § A4-4.19

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.

## **A1-2.7 Simplified VHF data exchange system**

Simplified VHF data exchange system (simplified VDES) means a VDES for mobile station which output average power is up to 5 W.

NOTE – The simplified VDES should include the Class B AIS.

**Annex 2**

**Common technical elements of VHF data exchange system**

TABLE OF CONTENTS

	<i>Page</i>
A2-1 Protocol layer.....	9
A2-1.1 Protocol layer overview.....	9
A2-1.2 Physical layer.....	10
A2-1.3 Link layer.....	32

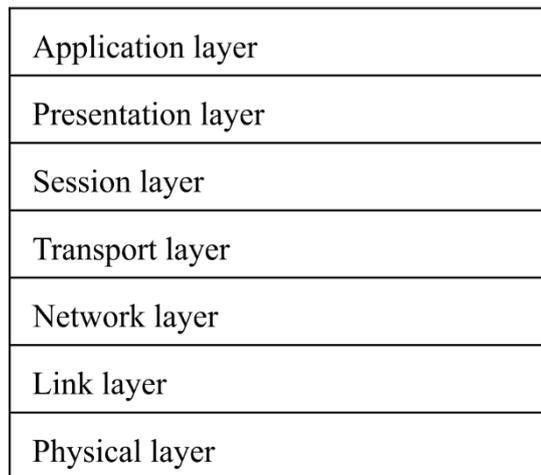
This Annex describes those elements of VDES that may be common across the ASM and VDE Channels.

**A2-1 Protocol layer**

**A2-1.1 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



**A2-1.2 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.

**A2-1.2.1 Transmission accuracy figures**

**A2-1.2.1.1 Symbol timing accuracy (at the output)**

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

**A2-1.2.1.2 Transmitter timing jitter**

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

**A2-1.2.1.3 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.

**A2-1.2.2 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 ( $60\,000 / 2\,250 \approx 26.667$ ). 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

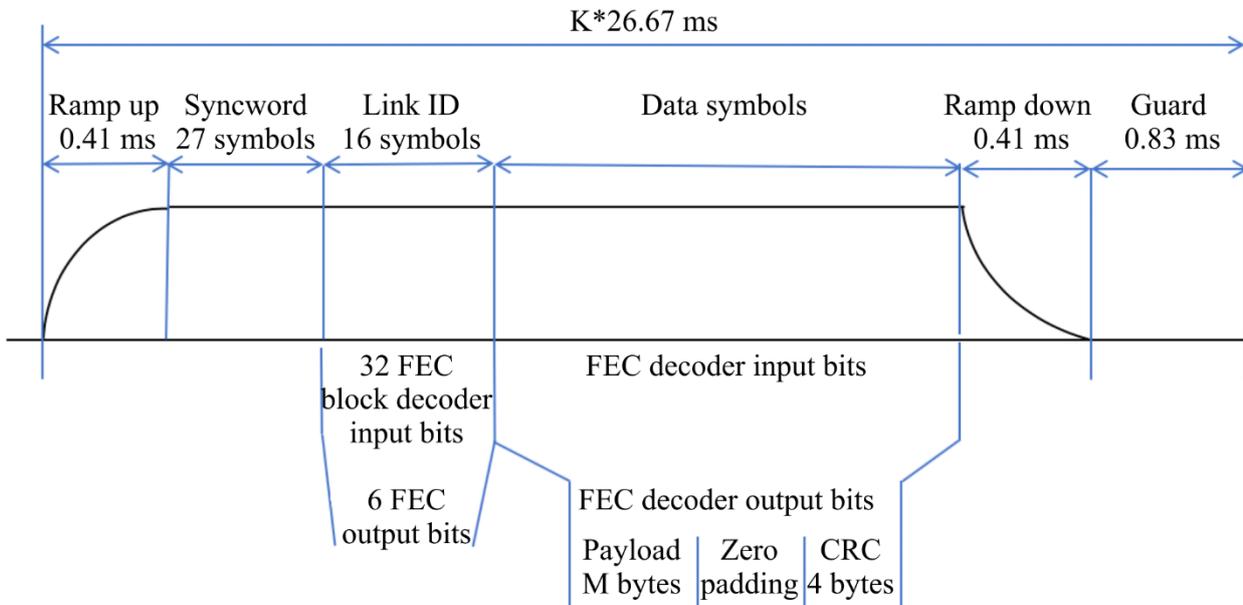
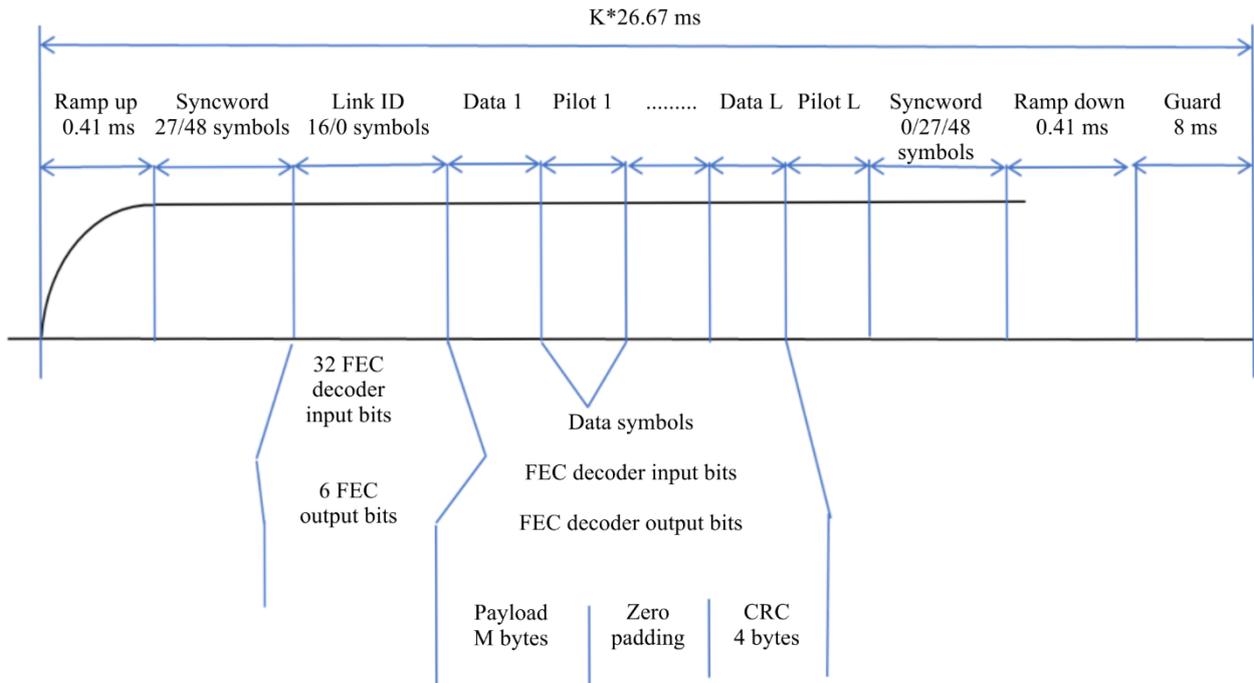


FIGURE 5

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



M.2092-05

**A2-1.2.3 Burst transmission structure**

**A2-1.2.3.1 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  $417 \mu\text{s}$ . 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.

**A2-1.2.3.2 Training sequence**

Table 1 shows the syncwords used for VDES.

TABLE 1  
Syncwords for VHF data exchange system

Usage	Symbol size	Sequence	Type
ASM-TER	27	1 1111100110101 0000011001010	1+ Barker13+ inverted Barker13
VDE-TER			
ASM-SAT	27	010001010010010000000110011	Best autocorrelation for differential detection
VDE-SAT			
VDE-SAT	48	00010001111001101100000101011 1011010110111101000	

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.

### A2-1.2.3.3 Bit mapping for training sequence

For training the following mapping applies:

- 1 maps to  $\pi/4$  quadrature phase shift keying (QPSK) (1 1) (see Fig. 11)
- 0 maps to  $\pi/4$  QPSK (0 0).

For  $\pi/4$  QPSK bit mapping, see § A2-1.2.9.

### A2-1.2.3.4 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  $\pi/4$  QPSK bit mapping (see § A2-1.2.9). 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 (32,6) biorthogonal 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
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.

**A2-1.2.3.5 Data payload with cyclic redundancy check**

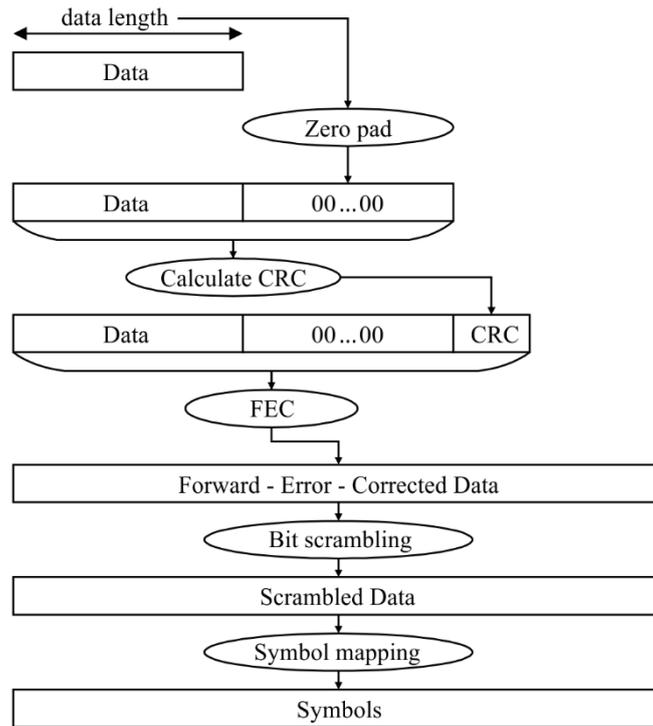
Input data is processed most significant bit (MSB) first.

The data payload with its appended cyclic redundancy check (CRC) (refer to § A2-1.2.5) is interleaved (refer to Table 4) encoded (refer to § A2-1.2.4.1), scrambled (refer to § A2-1.2.6) and bit mapped (refer to § A2-1.2.9).

Unused payload data is padded as specified in the appropriate section.

FIGURE 6

Typical order of operations for symbol data; if cyclic redundancy = 1 and forward error correction is applied



M.2092-06

### A2-1.2.3.6 Bit scrambling

Scrambling of the user data is required to avoid the power spectral density to be concentrated in the narrow band. Refer to § A2-1.2.6 for the detailed definition of the scrambler sequence.

### A2-1.2.3.7 Guard time

The guard time consists of the ramp down time from full power to  $-50$  dBc of less than or equal to  $417 \mu\text{s}$ . The remaining time is for delay and jitter.

## A2-1.2.4 Forward error correction

### A2-1.2.4.1 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<sup>1</sup>.

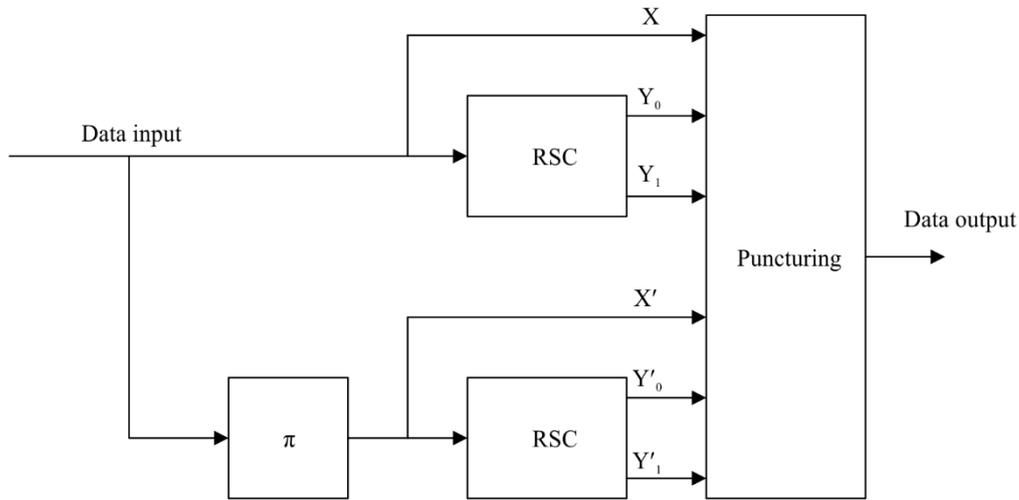
The general encoder structure is depicted in Fig. 7. The encoder consists of two recursive systematic convolutional (RSC) encoders concatenated in parallel. Each encoder produces three output bits per input bit. The first RSC encoder produces the bits  $X$ ,  $Y_0$  and  $Y_1$ , while the second encoder produces the bits  $X'$ ,  $Y'_0$  and  $Y'_1$ . The  $\langle \pi \rangle$  block in Fig. 7 represents the interleaving function as described in § A2-1.2.4.3.

The first encoder gets as input a word  $\mathbf{u}$  of  $k$  bits, with  $k$ , as specified in § A2-1.2.4.3. The second encoder input is denoted by  $\mathbf{u}'$  and it is a permuted version of the vector  $\mathbf{u}$ . The input  $\mathbf{u}$  is the data

<sup>1</sup> 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.

(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)



M.2092-07

**A2-1.2.4.2 Constituent codes**

The constituent codes are specified by the transfer function:

$$G(D) = \left[ 1 \quad \frac{n_0(D)}{d(D)} \quad \frac{n_1(D)}{d(D)} \right]$$

where:

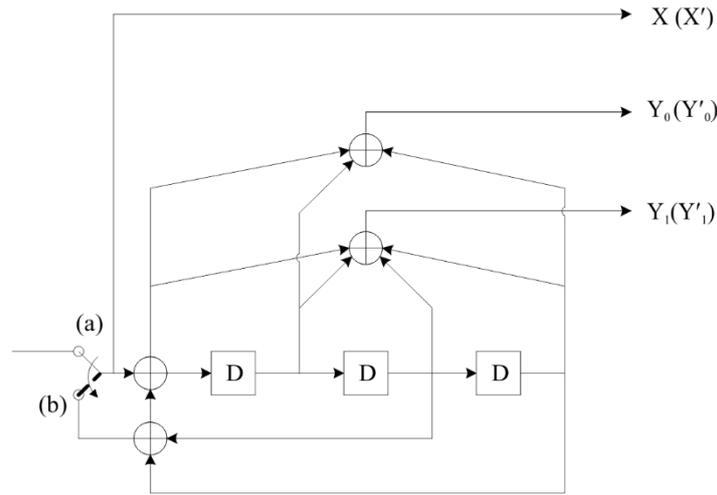
$$n_0(D) = 1 + D + D^3$$

$$n_1(D) = 1 + D + D^2 + D^3$$

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

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<sub>0</sub>, Y<sub>1</sub>, X', Y'<sub>0</sub>, Y'<sub>1</sub>*) with *X* output first.

FIGURE 8  
Recursive systematic convolutional code encoder



M.2092-08

**A2-1.2.4.3 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	$k_1 k_2$	$p_1 p_2 p_3 p_4 p_5 p_6 p_7 p_8$	Puncturing ID	Tail ID
4	3/4	952	4 238	113 31 59 163 29 181 101 11	8	8a
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 <sup>(1)</sup>	1/2	192	2 96	31 37 43 47 53 59 61 67	6	6
9 <sup>(1)</sup>	1/2	448	2 224	31 37 43 47 53 59 61 67	6	6
10 <sup>(1)</sup>	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

TABLE 4 (*end*)

LinkID	Nominal code rate	Information length	k1 k2	p1 p2 p3  p4  p5  p6  p7  p8	Puncturing ID	Tail ID
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	( <sup>2</sup> )

(<sup>1</sup>) No previous definitions or simulations results available, but a default configuration suggested.

(<sup>2</sup>) 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  $p_q$ ,  $q \in (1, \dots, 8)$  as given in Table 4.

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

$$\begin{aligned}
 m &= (s - 1) \bmod 2 \\
 i &= \text{floor}((s - 1) / (2k_2)) \\
 j &= \text{floor}((s - 1) / 2) - ik_2 \\
 t &= (19i + 1) \bmod (k_1/2) \\
 q &= t \bmod 8 + 1 \\
 c &= (p_q j + 21m) \bmod k_2 \\
 \pi(s) &= 2(t + ck_1/2 + 1) - m
 \end{aligned}$$

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

#### A2-1.2.4.4 Rate adaptation

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

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<sup>2</sup>.

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

TABLE 5  
Puncturing patterns for data bit periods

Punc. pattern ID	Code rate	Punc. patern (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:

- 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  $XXX\bar{Y}_0\bar{Y}_1$ , 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  $XXX\bar{Y}_0\bar{Y}_1$ , 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<sup>3</sup>.

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<sup>3</sup>.

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

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	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;2;1;1	0;0;0;2;1;1	0;0;0;2;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	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	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;1	0;0;0;1;1;0	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	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	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;1;1	0;0;0;2;0;0	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	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	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;2;1;0	0;0;0;0;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;1;1	0;0;0;1;0;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	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;1;0	0;0;0;1;0;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	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;1	0;0;0;1;0;0	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	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	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	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;1	0;0;0;1;0;0	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;1	0;0;0;1;0;0	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	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.

#### A2-1.2.4.5 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  $L_p$ .

In the case when  $K$  is not a multiple of  $L_p$  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  $6 \cdot L_p$  as defined in Table 4 and the number of 1's in the Table is exactly  $L_p/r$ .

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

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

#### A2-1.2.5 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<sup>4</sup> for CRC-32 and ETSI EN 301 545<sup>5</sup> 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.

#### A2-1.2.6 Bit scrambling

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

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

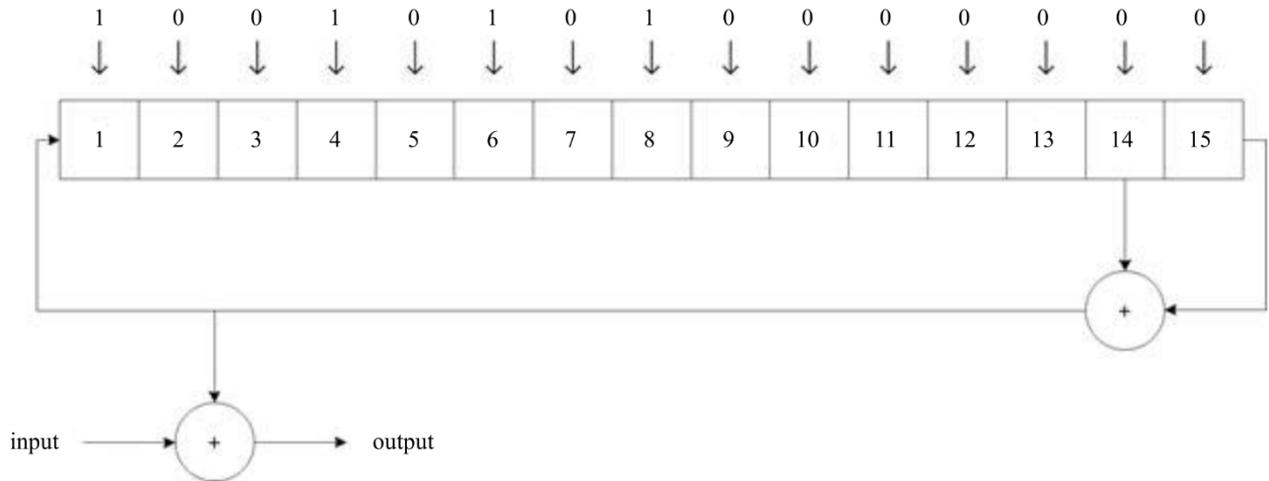
and the initialization sequence as indicated in the top of Fig. 9. For each transmitted packet, the bit scrambler is re-initialized. The MSB shall be the first output bit.

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<sup>4</sup> Series V: Data Communication over the Telephone Network – Error control – Error-correcting procedures for DCEs using asynchronous-synchronous conversions.

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

FIGURE 9  
Bit scrambling



M.2092-09

**A2-1.2.7 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	48 <sup>(1)</sup>	6	7
Channel BW (kHz)	16							
Roll off filtering <sup>(2)</sup>	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)	$\pi/4$ -QPSK (00/11 only)							
Link ID symbols	16							
Link ID modulation	$\pi/4$ -QPSK							

TABLE 7 (end)

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
Net symbols/burst (symbols)	197	453	709	640	197	453	709
Channel bits (bits)	394	906	1418	1280	394	906	1418
Padding+FEC tail <sup>(3)</sup> (bits)	10+0			0+11	0+10		
FEC decoder input symbols (symbols)	192	448	704	634.5 <sup>(4)</sup>	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.	$\pi/4$ -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 § A4-4.6 Data Structures.

(4) Note that the FEC tail plus FEC decoder input results in an integer number of symbols.

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 <sup>(4)</sup>	12 <sup>(1)</sup>	36 <sup>(4)</sup>	13 <sup>(1)</sup>	14 <sup>(1)</sup>	15 <sup>(1)</sup>	16 <sup>(1)</sup>	17	37 <sup>(4)</sup>	18 <sup>(1)</sup>	38 <sup>(4)</sup>	19			
Channel BW (kHz)	25					50					100 <sup>(5)</sup>					
Roll off filtering <sup>(2)</sup>	0.3															
Signal BW (kHz)	25.0					49.9					99.8					
Symbol rate (ksps)	19.2					38.4					76.8					
Modulation	$\pi/4$ -QPSK		8-PSK		16-QAM	$\pi/4$ -QPSK		8-PSK		16-QAM	$\pi/4$ -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	$\pi/4$ -QPSK (00/11 only)															
Link ID size (symbols)	16 (32,6 block code)															
Link ID modulation	$\pi/4$ -QPSK															

TABLE 8 (end)

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
Net symbols/burst (symbols)	437			917			1877		
Channel bits	874	1311	1748	1834	2751	3668	3754	5631	7508
Padding + FEC tail <sup>(3)</sup> (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	972	1296	896	2016	2688	1872	4032	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 § A4-4.6 Data Structures.
- (4) Not for communications, reserved for future radio navigation.
- (5) Equipment should operate in the channel conditions reported in Report ITU-R M.2317 VHF data exchange system channel sounding campaign.

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 <sup>(1)</sup>	24 <sup>(3)</sup>
Channel bandwidth (kHz)	50				
Roll off filtering <sup>(2)</sup>	0.25				
Signal bandwidth (kHz)	42.0				
CDMA chip rate (kcps)	33.6				
Spreading factor (chips)	16	N/A			
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 <sup>(4)</sup>				
Ramp-up/down (ms)	0.41/0.41				
Syncword size (symbols)	48	27			
Syncword modulation	QPSK/CDMA (00/11) <sup>(6)</sup>	$\pi/4$ -QPSK (00/11)			
Link ID size (symbols)	0	16 (32,6 block code)			
Link ID modulation	NA	$\pi/4$ -QPSK			

TABLE 9 (end)

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
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 <sup>(5)</sup> (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 <sup>(7)</sup>
FEC sub-block	1	1		1	2
Modulation	QPSK / CDMA <sup>(6)</sup>	$\pi/4$ -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

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

<sup>(2)</sup> The baseband shall employ a root raised cosine filter.

<sup>(3)</sup> FEC block is split into two sub-blocks in order to avoid very long FEC block.

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

<sup>(5)</sup> Given as padding + FEC tail bits, where the tail bits are according to Table 6, refer to § A4-4.6 Data Structures.

<sup>(6)</sup> The spreading sequence shall be in accordance with § A5-2.5.1.

<sup>(7)</sup> The two FEC blocks contain a non-integer number of bytes (3 788 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   41 <sup>(3)</sup>	29   42 <sup>(3)</sup>
Channel BW (kHz)	50			100	150
Roll off filtering <sup>(1)</sup>	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	

TABLE 10 (end)

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
Total syncword symbols (symbols)	480	945		1536	
Syncword distance (symbols)	1004	2268		2690	4214
Syncword modulation	BPSK/CDMA	$\pi/4$ -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 <sup>(2)</sup> (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	229216	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	$\pi/4$ -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	

(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 § A4-4.6 Data Structures.

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

TABLE 11

**VHF data exchange-satellite downlink identification parameters**

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 <sup>(1)</sup>	0.25		
Signal BW (kHz)	42.0		
CDMA chip rate (kcps)	33.6	N/A	
Spreading factor (chips)	8	N/A	
Symbol rate (kps)	4.2	33.6	
Burst size (slots)	15		
Guard time (ms)	8.238	8	8.625
Burst duration (ms)	392.0		

TABLE 11 (*end*)

PL format	SAT-MCS-0.50-2	SAT-MCS-0.50-3	SAT-MCS-1.50-2
Symbols/burst (symbols)	1 645	13 171	13 150
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	$\pi/4$ -QPSK (00/11)
Pilot distance (symbols)	8	N/A	27
Total pilots symbols (symbols)	180	N/A	480
Burst symbol duration <sup>(2)</sup> (symbols)	1641	13143	13122
Net symbols/burst (symbols)	1269	12855	12480
Channel bits	1269	12855	24960
Padding + FEC tail <sup>(3)</sup> (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	$\pi/4$ -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 § A4-4.6.

### A2-1.2.8 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.

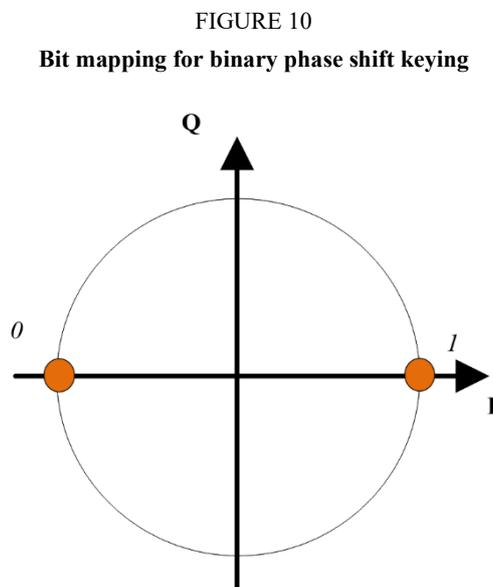
### A2-1.2.9 Bit mapping

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  $\pi/4$ -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  $\pi/4$ -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:

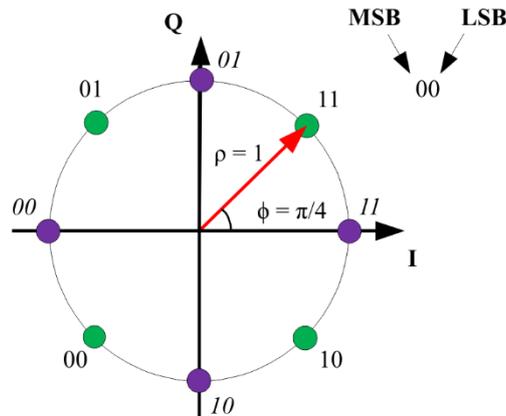
- 1 The root mean square (RMS) error vector in any burst shall be less than 0.15.
- 2 The peak error vector magnitude shall be less than 0.45 for any symbol.



The modulation accuracy requirements for  $\pi/4$ -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  $\pi/4$  quadrature phase shift keying

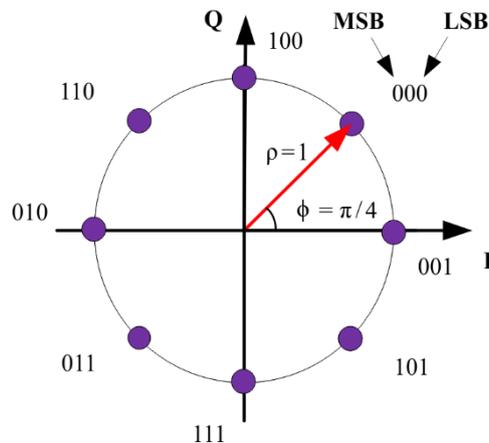


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The modulation accuracy requirements for 8-PSK are:

- 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

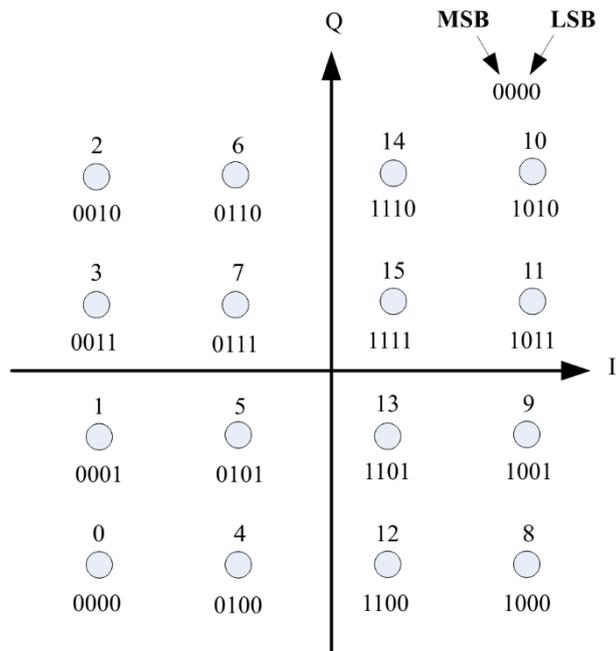


M.2092-12

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



M.2092-13

**A2-1.2.10 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.

**A2-1.2.11 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 <sup>(1)</sup>	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

<sup>(1)</sup> The galactic background antenna noise temperature is 245 K at 160 MHz {RD-4}.

### A2-1.2.12 Transmitter requirements for VHF data exchange system

#### A2-1.2.12.1 Ship Stations transmitter power

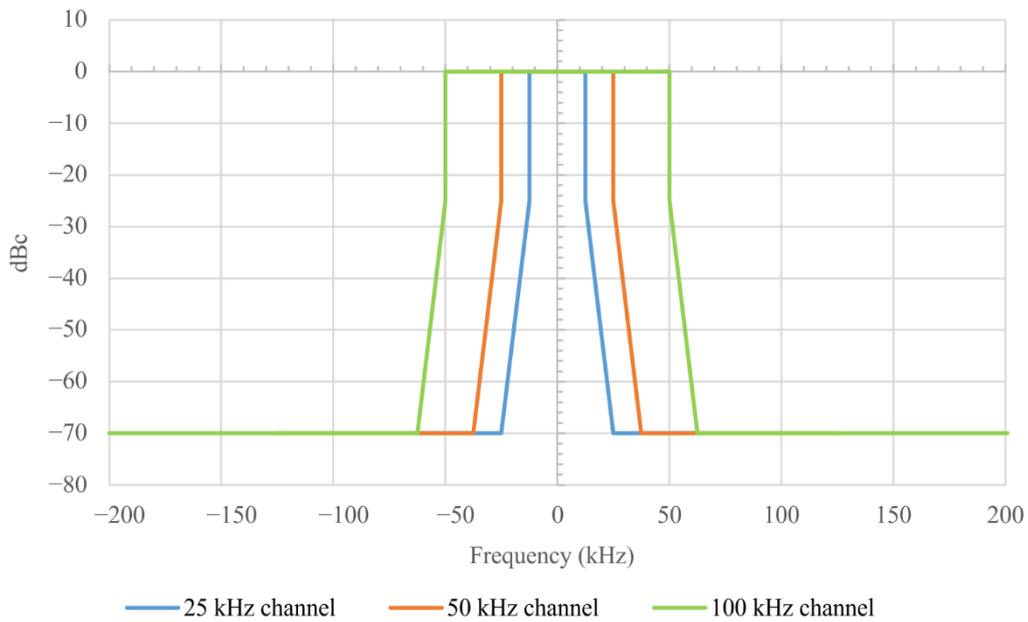
Except for Annex 3, Table 13 defines the requirements for VDES ship station transmitters, for the transmit spectrum mask (see Fig. 14). The resolution bandwidth for the mask measurement is 300 Hz.

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 Tables 8 et 9. The power tolerance is $\pm 1.5$ dB in normal, $+2/-6$ dB in extreme conditions.	Conducted
Maximum adjacent power levels for 25 kHz channel	$\Delta f_c < \pm 12.5$ kHz: 0 dBc <sup>6</sup> $\pm 12.5$ kHz $< \Delta f_c < \pm 25$ kHz: below the straight line between -25 dBc at $\pm 12.5$ kHz and -70 dBc at $\pm 25$ kHz $\pm 25$ kHz $< \Delta f_c < \pm 62.5$ kHz: -70 dBc	
Maximum adjacent power levels for 50 kHz channel	$\Delta f_c < \pm 25$ kHz: 0 dBc $\pm 25$ kHz $< \Delta f_c < \pm 37.5$ kHz: below the straight line between -25 dBc at $\pm 25$ kHz and -70 dBc at $\pm 37.5$ kHz $\pm 37.5$ kHz $< \Delta f_c < \pm 125$ kHz: -70 dBc	
Maximum adjacent power levels for 100 kHz channel	$\Delta f_c < \pm 50$ kHz: 0 dB. $\pm 50$ kHz $< \Delta f_c < \pm 62.5$ kHz: below the straight line between -25 dBc at $\pm 50$ kHz and -70 dBc at $\pm 62.5$ kHz $\pm 62.5$ kHz $< \Delta f_c < \pm 250$ kHz: -70 dBc	
Spurious emissions	-36 dBm -30 dBm	9 kHz to 1 GHz 1 GHz to 4 GHz

<sup>6</sup> Where 0 dBc is average.

FIGURE 14  
Slotted transmission mask (VHF data exchange)



M.2092-14

**A2-1.2.12.2 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

**A2-1.2.12.3 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.

**A2-1.2.12.4 Safety precautions**

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

**A2-1.3 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.

**A2-1.3.1 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.

**A2-1.3.2 Coordinated universal time direct**

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

**A2-1.3.3 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**

## TABLE OF CONTENTS

	<i>Page</i>
A3-1 Introduction .....	34
A3-2 Open systems interconnection layers .....	34
A3-2.1 Physical layer.....	34
A3-2.2 Link layer.....	34
A3-2.3 Network layer .....	34
A3-2.4 Transport layer.....	34

A3-3 Physical layer.....	35
A3-3.1 Parameters.....	35
A3-3.2 Transceiver characteristics.....	35
A3-3.3 Modulation scheme.....	37
A3-3.4 Data transmission bit rate .....	37
A3-3.5 Frame structure .....	37
A3-3.6 Signal information .....	37
A3-3.7 Forward error correction and bit scrambling.....	37
A3-3.8 Transmitter transient response .....	37
A3-3.9 Transmitter power.....	37
A3-4 Link layer.....	38
A3-4.1 Sub-layer 1 – medium access control .....	38
A3-4.2 TDMA synchronization .....	38
A3-4.3 Time division .....	38
A3-4.4 Sub-layer 2 – data link service.....	39
A3-4.5 Sub layer 3 – link management entity .....	40
A3-5 Network layer .....	48
A3-5.1 Multi-channel operations .....	49
A3-5.2 Management of priority assignment for messages .....	49
A3-5.3 Data link congestion prevention .....	49
A3-6 Transport layer.....	50
A3-6.1 Definition of transmission packet.....	50
A3-6.2 Application specific message identifier.....	50
A3-6.3 Transmission packets.....	50
A3-6.4 Multiple incremental time division multiple access .....	51
A3-6.5 Message retransmission .....	52
A3-7 Packet structure.....	54
A3-7.1 Slot transmission structure.....	54
A3-7.2 Message summary .....	55
A3-7.3 Message 0: broadcast automatic identification system application specific message.....	55
A3-7.4 Message 1: Scheduled broadcast message.....	56
A3-7.5 Message 2: Broadcast message.....	57
A3-7.6 Message 3: Scheduled individual addressed message.....	58
A3-7.7 Message 4: Individual addressed message .....	59
A3-7.8 Message 5: Acknowledgment message .....	60
A3-7.9 Message 6: Geographical multicast message.....	60
A3-7.10 Message 7: ASM data link management message .....	61
A3-8 Example of application specific message burst symbol generation .....	65

### **A3-1 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.

### **A3-2 Open systems interconnection layers**

Refer to Annex 2.

#### **A3-2.1 Physical layer**

Convert digital transmission packet to  $\pi/4$ -QPSK signal to modulate transmitter.

#### **A3-2.2 Link layer**

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

##### **A3-2.2.1 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.

##### **A3-2.2.2 Data link services**

This sub layer has the following functions:

- Calculate CRC of the ASM message bits (see § A2-1.2.5)
- Append CRC to ASM message to complete creation of transmission packet contents.
- Complete assembly of transmission packet.

##### **A3-2.2.3 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.

#### **A3-2.3 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.

#### **A3-2.4 Transport layer**

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

### A3-3 Physical layer

#### A3-3.1 Parameters

##### A3-3.1.1 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 15, 16 and 17.

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) <sup>(1)</sup> (kHz)	25	25
ASM 1 <sup>(1)</sup> (MHz)	161.950	161.950
ASM 2 <sup>(1)</sup> (MHz)	162.000	162.000
Average transmit output power (W)	1	12.5

<sup>(1)</sup> See Recommendation ITU-R M.1084, Annex 4.

##### A3-3.1.2 Transmission media

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

##### A3-3.1.3 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.

#### A3-3.2 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.

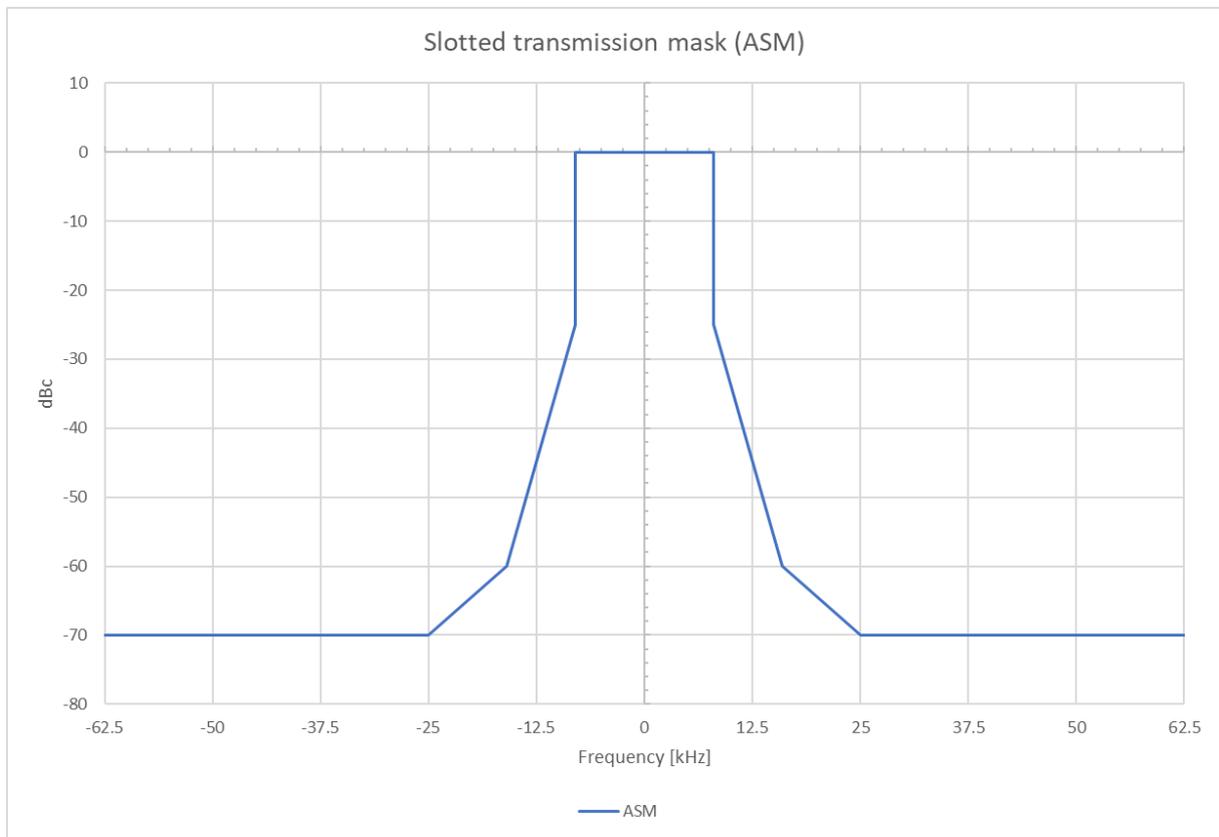
TABLE 16

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	$\Delta f_c < \pm 8$ kHz: 0 dBc <sup>7</sup> $\pm 8$ kHz < $\Delta f_c < \pm 16$ kHz: below the straight line between -25 dBc at ±8 kHz and -60 dBc at ±16 kHz $\pm 16$ kHz < $\Delta f_c < \pm 25$ kHz: below the straight line between -60 dBc at ±16 kHz and -70 dBc at ±25 kHz $\pm 25$ kHz < $\Delta f_c < \pm 62.5$ kHz: -70 dBc
Spurious emissions	-36 dBm: 9 kHz ... 1 GHz -30 dBm: 1 GHz ... 4 GHz

FIGURE 15

Application specific message slotted modulation mask



<sup>7</sup> Where 0 dBc is 12.5 W average power for higher power and 1 W average power for low power.

TABLE 17

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

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

### A3-3.3 Modulation scheme

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

For the modulation bit mapping, see Annex 2.

### A3-3.4 Data transmission bit rate

The transmission bit rate should be 19.2 kbit/s  $\pm 10$  ppm for  $\pi/4$ -QPSK.

### A3-3.5 Frame structure

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

### A3-3.6 Signal information

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

### A3-3.7 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.

### A3-3.8 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 § A2-1.2.3.1). 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.

### A3-3.9 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  $\pm 1.5$  dB.

#### **A3-4 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.

##### **A3-4.1 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.

##### **A3-4.2 TDMA synchronization**

TDMA synchronization is achieved using an algorithm as described in § A2-1.3.1.

##### **A3-4.3 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.

###### **A3-4.3.1 Slot phase and frame synchronization**

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

###### **A3-4.3.2 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.

###### **A3-4.3.3 Frame synchronization**

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

###### **A3-4.3.4 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 § A2-1.2.2.

###### **A3-4.3.6 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”.

**A3-4.4 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.

**A3-4.4.1 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.

**A3-4.4.2 Data transfer**

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

**A3-4.4.3 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.

**A3-4.4.3.1 Summary of the transmission packet**

The data packet is defined in Table 18.

The ASM channel configurations are defined by Link ID table, Table 21.

TABLE 18

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

	<b>Symbols</b>	<b>Description</b>
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: 618.5	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	TER : 5 SAT 5.5	Set to zero when not used.
Ramp Down	4	Distance delay and jitter.
Guard Time	TER: 8 SAT: 77	Distance delay and jitter.
Total	1 slot: 256 2 slot: 512 3 slot: 768	

Note that the data, CRC and FEC termination bits combined results in an integer number of symbols.

**A3-4.4.3.2 Transmission timing**

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

**A3-4.4.3.3 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.

**A3-4.4.4 Error detection and control**

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

**A3-4.4.5 Forward error correction**

Forward error correction should be handled as described in § A2-1.2.4, and specified by the Link ID see Table 21.

**A3-4.5 Sub layer 3 – link management entity**

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

**A3-4.5.1 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.

### A3-4.5.2 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.

### A3-4.5.3 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 § A3-4.3.6.

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.

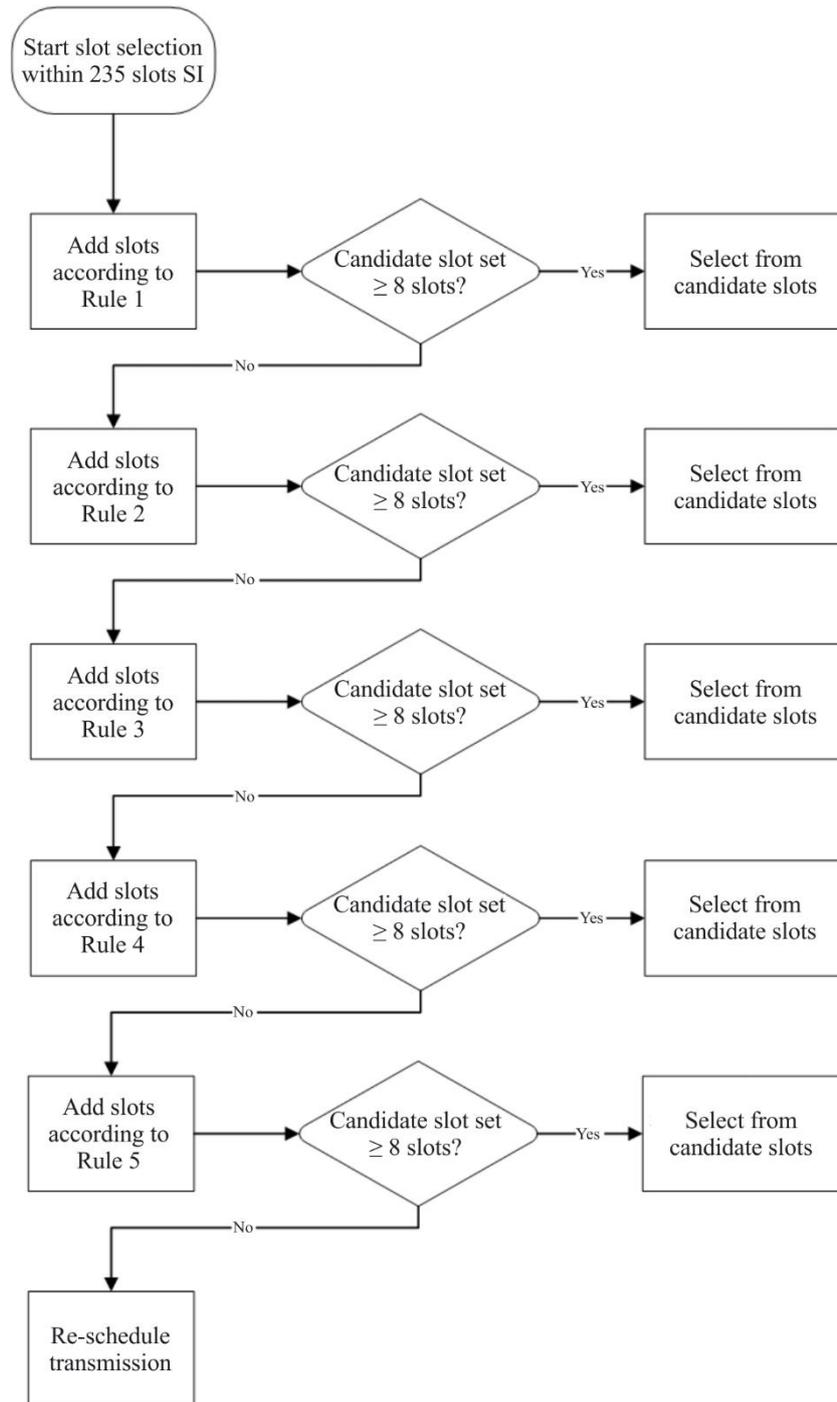
The purpose of maintaining a minimum of eight candidate slots within the same probability of being used for transmission is to provide high probability of access to the link.

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



M.2092-16

**A3-4.5.4 Modes of operation**

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

**A3-4.5.5 Autonomous**

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

### **A3-4.5.6 Designated**

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

### **A3-4.5.7 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.

#### **A3-4.5.7.1 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.

#### **A3-4.5.7.2 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 § A3-6.4.

#### **A3-4.5.7.3 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.

#### **A3-4.5.7.4 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).

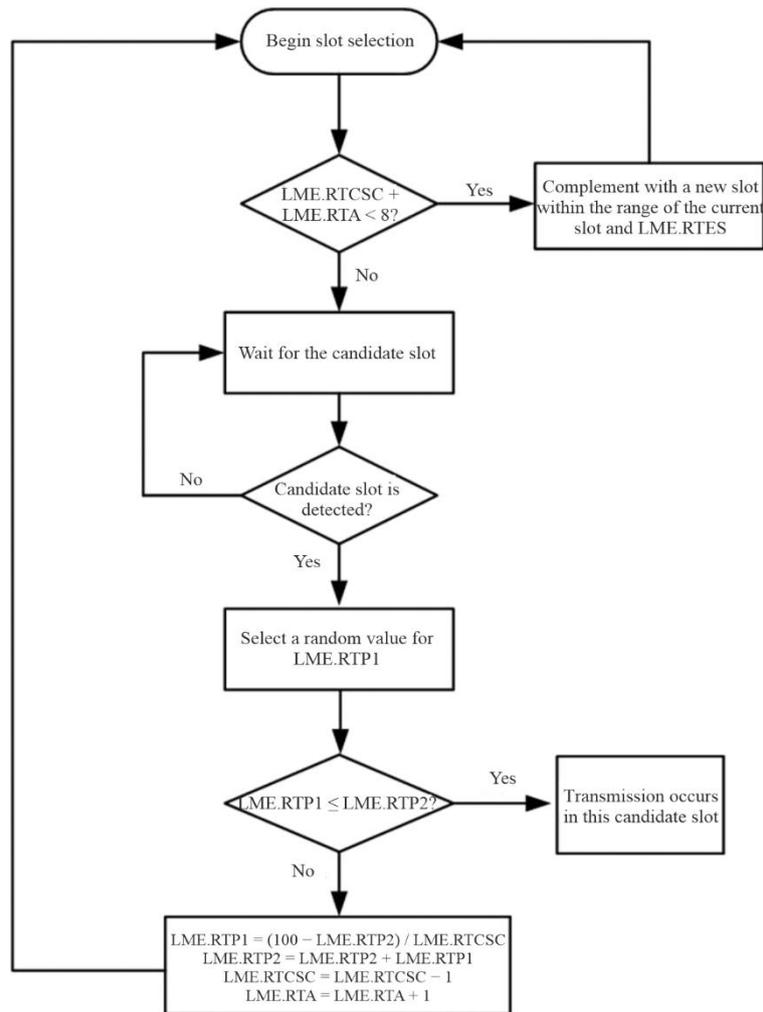
When a candidate slot is selected, the station randomly selects a probability value (LME.RTP1) between 0 and 100. This value should be compared with the current probability for transmission (LME.RTP2). If LME.RTP1 is equal to, or less than LME.RTP2, transmission should occur in the candidate slot. If 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.

FIGURE 17  
RATDMA p-persistent algorithm



M.2092-17

**4.5.7.5 Random access time division multiple access parameters**

The parameters in Table 19 are used to control the RATDMA scheduling.

TABLE 19

**Random access time division multiple access parameters**

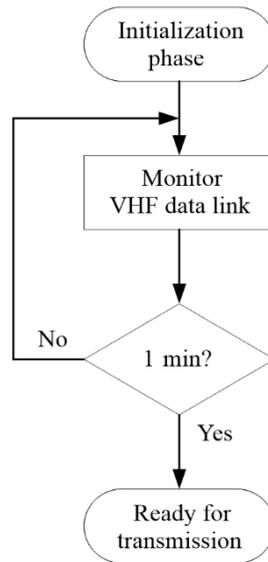
Symbol	Name	Description	Minimum	Maximum
RTCSC	Candidate slot counter	The number of slots currently available in the candidate set. NOTE 1 – The initial value is always 8 or more (see § A3-4.5.3). However, during the cycle of the p-persistent algorithm the value may be reduced below 8.	1	235
RTES	End 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 $\approx 12$ ( $100/8$ ).	0	12
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	234
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	12

**A3-4.5.7.6 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 shore stations, as shown in Fig. 18. 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 18

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



M.2092-18

**A3-4.5.7.7 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.

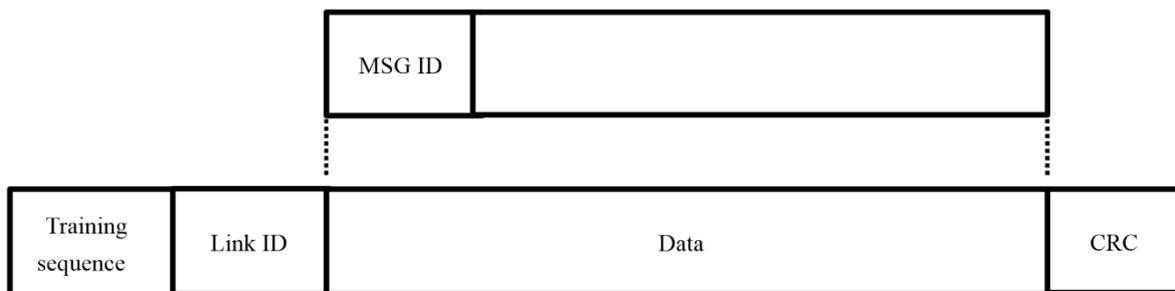
**A3-4.5.7.8 Multiple incremental time division multiple access channel access**

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.

**A3-4.5.8 Message structure**

The messages should have the following structure shown in Fig. 19 inside the data portion of a data packet.

FIGURE 19  
Message structure



M.2092-19

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.

**A3-4.5.8.1 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.

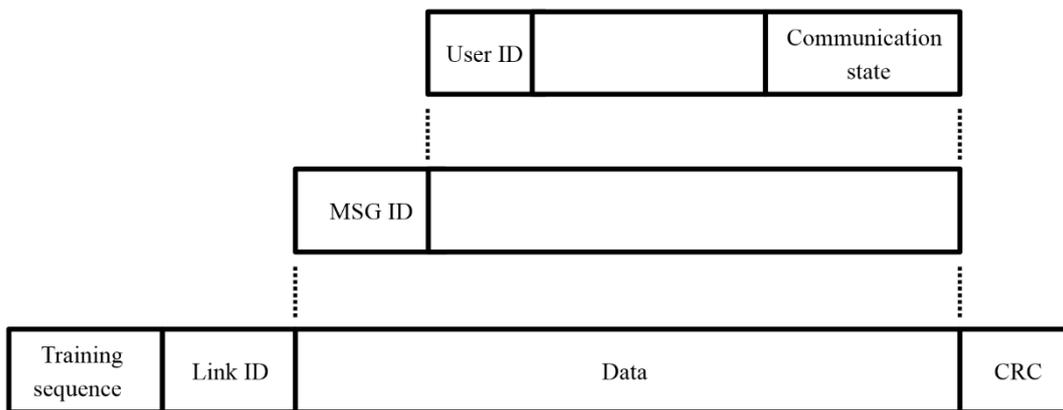
**A3-4.5.8.2 User identification**

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.

**A3-4.5.8.3 Multiple incremental time division multiple access message structure**

The MITDMA message structure is shown in Fig. 20.

FIGURE 20  
MITDMA message structure



M.2092-20

**A3-4.5.8.4 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	An increasing counter used to identify the block of data within the transmit chain uniquely. This identifier also maps to the acknowledgment for addressed messages. A value of 0 indicates this is the first transmission within the chain and corresponds to the bit 0 of the ACK mask.	0	14
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 reservations.	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 reservations.	20	255 13500 <sup>(1)</sup>
Number of Slots 2	2	Indicates the number of consecutive slots, which are allocated, starting at the slot increment. A value of 0 indicates no slot reservations.	1	3
Slot Increment 3	8	Offset to the next slot to be used, referenced to the slot specified by Slot Increment 2. A value of 0 indicates no additional slot reservations.	20	255
Number of Slots 3	2	Indicates the number of consecutive slots, which are allocated, starting at the slot increment. A value of 0 indicates no additional slot reservations.	1	3
Total bits	38			

<sup>(1)</sup> 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.

**A3-5 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.

### **A3-5.1 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.

### **A3-5.2 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.

### **A3-5.3 Data link congestion prevention**

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 percentage of slots in which an ASM transmission is detected by a station on a specific channel shall be adopted by the station as the channel loading on that channel.

Regardless of the channel load, the maximum number of slots used by a mobile station for transmission 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.

#### **A3-5.3.1 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 (see Table 21).

TABLE 21

**Quiet time multiplier**

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

**A3-6 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.

**A3-6.1 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 three consecutive slots. When data does not completely fill the block, then padding bits with the value of 0 should be added to complete the required block size.

**A3-6.2 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 special values for international compatibility, as defined in Recommendation ITU-R M.1371, Annex 5 “Application specific messages”.

**A3-6.3 Transmission packets****A3-6.3.1 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.

### **A3-6.3.2 Broadcast messages**

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

### **A3-6.3.3 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).

### **A3-6.3.4 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.

## **A3-6.4 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 in the last three transmissions as specified in example in § A3-6.4.1.

### **A3-6.4.1 Multiple incremental time division multiple access example**

An MITDMA access example is shown in Fig. 21. 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 met.

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 acknowledgment

(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.

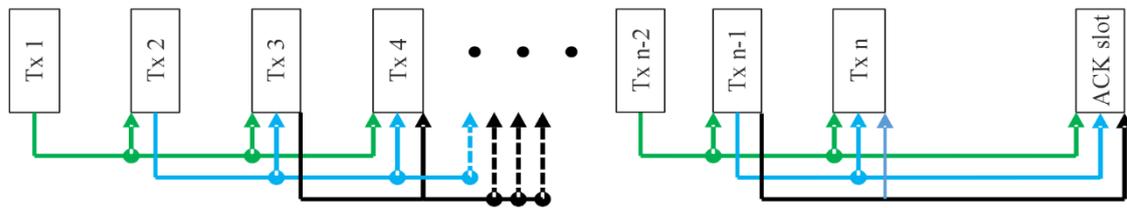
At Tx n-1 a new offset is calculated for the ACK slot. This information is provided in the MITDMA communication state. Slot Increment 1 reserves the Tx n, Slot Increment 2 reserves the ACK slot, and Slot Increment 3 is set to 0.

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 21

#### Multiple incremental time division multiple access example



M.2092-21

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).

### A3-6.5 Message retransmission

In the ASM message, scheduled broadcast message and scheduled addressed message are transmitted via Multiple incremental time division multiple access (MITDMA), enabling a chain up to 15 data block transmissions together. These two types of messages utilize data retransmission mechanisms to achieve efficient data transmission.

#### A3-6.5.1 Scheduled broadcast message retransmission

Scheduled broadcast messages can be transmitted multiple times. Retransmission should be initiated within 3 minutes after the first transmission. For scheduled broadcast messages that are expected to be retransmitted, the Retransmit flag should be set to 1 during the initial transmission, indicating that retransmitted messages may follow. In subsequent retransmissions, the Retransmit flag should remain set to 1, and the Session ID should be kept consistent throughout. Based on the Block Identifier, the receiving station should ascertain whether any previously not received or failed verification blocks are correctly received this time. If so, they should be integrated into the message. If all blocks in the MITDMA chain are complete, they should be output through the PI. After the PI outputs the data, the device should ignore subsequent retransmitted data with the same Session ID. Scheduled broadcast

message retransmission should be completed within 20 minutes referenced from the start of the first block.

**A3-6.5.2 Scheduled addressed message retransmission**

When the source device receives an Acknowledgment Message indicating one or more blocks are not successfully received and need to be retransmitted, it may initiate another MITDMA block chain. The first transmission uses RATDMA and then uses MITDMA to reserve slots for subsequent retransmissions and ACK. In the retransmitted blocks, the Retransmit flag should be set to 1, the Session ID should remain consistent with that in the first transmission, the Block Identifier should match the block number of the MITDMA chain in the first transmission, and the Transmit block counter should only count the number of retransmitted blocks. The schedule mechanism for ACK slots is the same as in the first transmission, as shown in Table 23. Within the ACK message, the bits corresponding to the Block Identifier of the retransmitted blocks should indicate whether the blocks were successfully transmitted, while all other bits should be set to 0.

TABLE 23

**Criteria for retransmission**

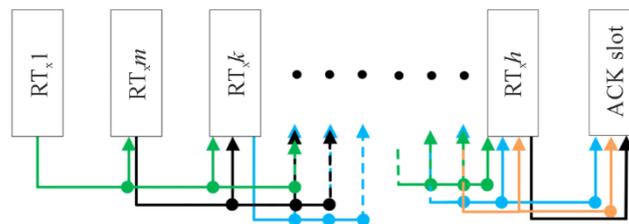
Parameter	Description
Retransmit flag	Set to 1.
Session ID	Maintain consistency with that in the first transmission.
Transmit block counter	Only count the number of retransmitted messages.
Block identifier	Maintain consistency with the blocks in the first transmission of the MITDMA chain.
Slot increment	Reserve slots for subsequent retransmissions or ACK.
Number of slots	

During retransmission, the first block (Block 0) of the message should be transmitted regardless of whether it has been successfully transmitted before.

If the total time slots occupied by the blocks in the current retransmission exceed 22, or if adding the blocks from the current retransmission will result in the total time slots of all retransmitted blocks within one minute time span exceeding 22, the retransmission operation shall not be initiated. Instead, the whole message can be retransmitted in subsequent transmissions with a new session ID.

FIGURE 22

**Multiple incremental time division multiple access example in retransmission**



### A3-7 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.

#### A3-7.1 Slot transmission structure

The generic slot transmission structure is defined in Table 24.

TABLE 24  
Slot transmission structure

Parameter	Number of bits	Descriptions
Ramp up	8	417 $\mu$ s.
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.
Ramp down	8	417 $\mu$ s.
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	

### A3-7.2 Message summary

The defined message types are summarized in Table 25.

TABLE 25  
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	ASM Data link management message	This message is used to broadcast FATDMA reservations for ASM.	RATDMA FATMDA	None

### A3-7.3 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 26.

TABLE 26

**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	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 § A1-2.4.
Data count	11	Size of actual data in Application Data field in bits, excluding padding bits range: from 1 to maximum data count.
Application data (no FEC / FEC)	1 slot: 296 / 200 2 slot: 808 / 584 3 slot: 1320 / 968	Content is encapsulated AIS Messages that are channelled 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.

**A3-7.4 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 as described in § A3-4.5.7.2. Scheduled broadcast message is defined in Table 27.

TABLE 27  
Scheduled broadcast message

Parameter	Number of bits	Description	
Message ID	4	1 – Broadcast message with MITDMA communication state.	
Retransmit flag	1	0 – Indicates there will be no retransmission of data. 1 – Indicates there will be 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 § A1-2.4.	
Data count	11	Size of actual data in Application Data field in bits, excluding padding bits. range: from 1 – Max data count.	
Application data (no FEC / FEC)	1 slot: 256 / 160 2 slot: 768 / 544 3 slot: 1280 / 928	ASM Identifier	The first 16 bits of the Application data are the ASM Identifier, which is described in § A3-6.2. When chaining multiple blocks using MITDMA, the ASM Identifier is only contained in the first transmission.
		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 § A3-6.4.	
Spare bits	2	Spare bits – reserved for the future.	

### A3-7.5 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 28.

TABLE 28  
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 § A1-2.4.	
Data count	11	Size of actual data in Application Data field in bits, excluding padding bits. range: from 1 – Max data count.	
Application data (no FEC / FEC)	1 slot: 296 / 200 2 slot: 808 / 584 3 slot: 1320 / 968 SAT: N/A / 864	ASM Identifier	The first 16 bits of the Application data are the ASM Identifier, which is described in § A3-6.2.
		Application data as specified by the ASM Identifier.	The available length of the binary data is specified by the Link ID.

### A3-7.6 Message 3: Scheduled individual 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 as described in § A3-4.5.7.2.

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 29.

TABLE 29  
Scheduled individual 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 § A1-2.4.
Destination ID	32	The Unique Identifier of the receiving station, as described in § A1-2.4.

TABLE 29 (*end*)

Parameter	Number of bits	Description	
Data count	11	Size of actual data in Application Data field in bits, excluding padding bits. range: from 1 – Max data count.	
Application data (no FEC / FEC)	1 slot: 224 / 128 2 slot: 736 / 512 3 slot: 1248 / 896	ASM Identifier	The first 16 bits of the Application data are the ASM Identifier, which is described in § A3-6.2. When chaining multiple blocks using MITDMA, the ASM Identifier is only contained in the first transmission.
		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 § A3-6.4.	
Spare bits	2	Spare Bits – reserved for the future.	

### A3-7.7 Message 4: Individual 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 30.

TABLE 30

### Individual 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 § A1-2.4.	
Destination ID	32	The Unique Identifier of the receiving station as described in § A1-2.4.	
Data count	11	Size of actual data in Application Data field in bits, excluding padding bits. range: from 1 – Max: data count.	
Application data (no FEC / FEC)	1 slot: 264 / 168 2 slot: 776 / 552 3 slot: 1288 / 936 SAT: N/A / 832	ASM Identifier	The first 16 bits of the Application data are the ASM Identifier, which is described in § A3-6.2.
		Application data as specified by the ASM Identifier.	The available length of the binary data is specified by the Link ID.

### A3-7.8 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 31.

TABLE 31  
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 § A1-2.4.
Destination ID	32	The Unique Identifier of the receiving station as described in § A1-2.4.
ACK/NACK mask	16	Specifies which MITDMA block identifiers failed. Bit map field with the LSB representing Block identifier 0, up to the 15th bit representing Block identifier 14. “1” indicates a packet failed. “0” indicates the packet was received ok. The MSB (16th bit) is not used and should be set to “0”.
Coding rate adaption request	2	0 (reserved for future use).
Channel quality indicator	8	Signal quality.
Zero padding (no FEC / FEC)	1 slot: N/A / 153	Padding bits are added as required to complete the block size. These bits are not available for future use.

### A3-7.9 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 32.

TABLE 32  
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 § A1-2.4.	
Longitude 1	18	Longitude of area to which the group assignment applies; upper right corner (north-east); in 1/10 min ( $\pm 180^\circ$ , 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 ( $\pm 90^\circ$ , 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 ( $\pm 180^\circ$ , 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 ( $\pm 90^\circ$ , North = positive, South = negative).	
Data Count	11	Size of actual data in Application Data field in bits, excluding padding bits. range: from 1 – Max data count.	
Spare bits	2	Spare bits – reserved for the future.	
Application data (no FEC / FEC)	1 slot: 224 / 128	ASM Identifier	The first 16 bits of the Application data are the ASM Identifier, which is described in § A3-6.2.
	2 slot: 736 / 512	Application data as specified by the ASM Identifier.	The available length of the binary data is specified by the Link ID.
3 slot: 1248 / 896			

### A3-7.10 Message 7: ASM data link management message

This ASM message is used by the ASM shore station to broadcast FATDMA reservations. It should be repeated as often as required. Link ID 5 should always be used.

The mobile station, within 120 nautical miles<sup>8</sup> should then reserve the slots as unavailable for its own transmission until time-out occurs. The shore station should refresh the time-out value with each transmission of Message 7 in order to allow mobile stations to terminate their reservation for the use of the slots.

<sup>8</sup> A shore station report (AIS Message 4) in conjunction with a data link management message (ASM Message 7) with the same shore station ID (MMSI) must be received by the mobile station so that it can determine its distance from the transmitting shore station.

The parameters: offset number, number of slots, time-out, and increment should be treated as a unit, meaning that if one parameter is defined all other parameters should be defined within that unit. The parameter offset number should denote the offset from the slot in which Message 7 was received to the first slot to be reserved. The parameter number of slots should denote the number of consecutive slots to be reserved starting with the first reserved slot. This defines a reservation block.

This reservation block should not exceed 15 slots. The parameter increment should denote the number of slots between the starting slot of each reservation block. An increment of zero indicates one reservation block per frame. The following values for increment are allowed: 30, 45, 50, 75, 90, 125, 150, 225, 250, 375, 450, 750 or 1 125. Use of one of these values guarantees symmetric slot reservations throughout each frame. ASM data link management message is described in Table 33.

TABLE 33  
ASM data link management message

Reservation Block	Parameter	Number of bits	Description
	Message ID	4	7 – ASM Data link management.
	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 § A1-2.4.
Reservation Block 1	Channel selection	2	0 = ASM1; 1 = ASM2; 2 = ASM1 and ASM2; 3 = no reservation.
	Offset number	12	Reserved offset number.
	Number of slots	4	Number of reserved consecutive slots: 1-15.
	Time-out	4	Time-out value in minutes.
	Increment	4	Increment to repeat reservation block 1. 0 = one reservation block per frame. 1 = 30, 2 = 45, 3 = 50, 4 = 75, 5 = 90, 6 = 125, 7 = 150, 8 = 225, 9 = 250, 10 = 375, 11 = 450, 12 = 750, 13 = 1125, 14-15 not used.

TABLE 33 (cont.)

Reservation Block	Parameter	Number of bits	Description
Reservation Block 2	Channel selection	2	0 = ASM1; 1 = ASM2; 2 = ASM1 and ASM2; 3 = no reservation.
	Offset number	12	Reserved offset number.
	Number of slots	4	Number of reserved consecutive slots: 1-15.
	Time-out	4	Time-out value in minutes.
	Increment	4	Increment to repeat reservation block 2. 0 = one reservation block per frame. 1 = 30, 2 = 45, 3 = 50, 4 = 75, 5 = 90, 6 = 125, 7 = 150, 8 = 225, 9 = 250, 10 = 375, 11 = 450, 12 = 750, 13 = 1125, 14-15 not used.
Reservation Block 3	Channel selection	2	0 = ASM1; 1 = ASM2; 2 = ASM1 and ASM2; 3 = no reservation.
	Offset number	12	Reserved offset number.
	Number of slots	4	Number of reserved consecutive slots: 1-15.
	Time-out	4	Time-out value in minutes.
	Increment	4	Increment to repeat reservation block 3. 0 = one reservation block per frame. 1 = 30, 2 = 45, 3 = 50, 4 = 75, 5 = 90, 6 = 125, 7 = 150, 8 = 225, 9 = 250, 10 = 375, 11 = 450, 12 = 750, 13 = 1125, 14-15 not used.
Reservation Block 4	Channel selection	2	0 = ASM1; 1 = ASM2; 2 = ASM1 and ASM2; 3 = no reservation.
	Offset number	12	Reserved offset number.
	Number of slots	4	Number of reserved consecutive slots: 1-15.
	Time-out	4	Time-out value in minutes.
	Increment	4	Increment to repeat reservation block 4. 0 = one reservation block per frame. 1 = 30, 2 = 45, 3 = 50, 4 = 75, 5 = 90, 6 = 125, 7 = 150, 8 = 225, 9 = 250, 10 = 375, 11 = 450, 12 = 750, 13 = 1125, 14-15 not used.

TABLE 33 (cont.)

Reservation Block	Parameter	Number of bits	Description
Reservation Block 5	Channel selection	2	0 = ASM1; 1 = ASM2; 2 = ASM1 and ASM2; 3 = no reservation.
	Offset number	12	Reserved offset number.
	Number of slots	4	Number of reserved consecutive slots: 1-15.
	Time-out	4	Time-out value in minutes.
	Increment	4	Increment to repeat reservation block 5. 0 = one reservation block per frame. 1 = 30, 2 = 45, 3 = 50, 4 = 75, 5 = 90, 6 = 125, 7 = 150, 8 = 225, 9 = 250, 10 = 375, 11 = 450, 12 = 750, 13 = 1125, 14-15 not used.
Reservation Block 6	Channel selection	2	0 = ASM1; 1 = ASM2; 2 = ASM1 and ASM2; 3 = no reservation.
	Offset number	12	Reserved offset number.
	Number of slots	4	Number of reserved consecutive slots: 1-15.
	Time-out	4	Time-out value in minutes.
	Increment	4	Increment to repeat reservation block 6. 0 = one reservation block per frame. 1 = 30, 2 = 45, 3 = 50, 4 = 75, 5 = 90, 6 = 125, 7 = 150, 8 = 225, 9 = 250, 10 = 375, 11 = 450, 12 = 750, 13 = 1125, 14-15 not used.
Reservation Block 7	Channel selection	2	0 = ASM1; 1 = ASM2; 2 = ASM1 and ASM2; 3 = no reservation.
	Offset number	12	Reserved offset number.
	Number of slots	4	Number of reserved consecutive slots: 1-15.
	Time-out	4	Time-out value in minutes.
	Increment	4	Increment to repeat reservation block 7. 0 = one reservation block per frame. 1 = 30, 2 = 45, 3 = 50, 4 = 75, 5 = 90, 6 = 125, 7 = 150, 8 = 225, 9 = 250, 10 = 375, 11 = 450, 12 = 750, 13 = 1125, 14-15 not used.

TABLE 33 (end)

Reservation Block	Parameter	Number of bits	Description
Reservation Block 8	Channel selection	2	0 = ASM1; 1 = ASM2; 2 = ASM1 and ASM2; 3 = no reservation.
	Offset number	12	Reserved offset number.
	Number of slots	4	Number of reserved consecutive slots: 1-15.
	Time-out	4	Time-out value in minutes.
	Increment	4	Increment to repeat reservation block 8. 0 = one reservation block per frame. 1 = 30, 2 = 45, 3 = 50, 4 = 75, 5 = 90, 6 = 125, 7 = 150, 8 = 225, 9 = 250, 10 = 375, 11 = 450, 12 = 750, 13 = 1125, 14-15 not used.
	Spare	3	Spare bits – reserved for the future.

**A3-8 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 § A3-7.8**

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
Session ID	6	56	1 1 1 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
<b>Total bits above</b>	<b>103</b>		





A4-3.5 Sensitivity .....	69
A4-3.6 Symbol timing accuracy .....	70
A4-3.7 Transmitter timing jitter.....	70
A4-3.8 Slot transmission accuracy at the output .....	70
A4-3.9 Frame structure .....	70
A4-4 Link layer.....	70
A4-4.1 Time division multiple access hierarchy .....	70
A4-4.2 Link layer definitions.....	71
A4-4.3 Control station service area .....	71
A4-4.4 Resource management .....	72
A4-4.5 Endianness .....	72
A4-4.6 Data structures .....	72
A4-4.7 Adaptive coding and modulation/rate adaption.....	72
A4-4.8 Slot functions .....	73
A4-4.9 VHF data exchange-terrestrial messages.....	75
A4-4.10 Cyclic redundancy check.....	88
A4-4.11 Acknowledgement.....	88
A4-4.12 Logical channels.....	89
A4-4.13 Terrestrial bulletin board .....	89
A4-4.14 VHF data exchange-terrestrial default physical channel and slotmap .....	89
A4-4.15 Digital signature of messages .....	90
A4-4.16 Data transfer protocols .....	91
A4-4.17 Data session transmission and continuation .....	91
A4-4.18 Data frame retry.....	93
A4-4.19 Giving priority to automatic identification system.....	93
A4-4.20 Short data message .....	95
A4-4.21 Random access channel scheme.....	95
A4-4.22 Announcement channel access scheme .....	96
A4-4.23 Logical channel access .....	96
A4-4.24 Logical channel use map .....	96
A4-4.25 Unused logical channel slots as random access channel slots.....	96
A4-4.26 Logical channel assignment .....	97
A4-4.27 Retry mechanism.....	97
A4-4.28 Data transfer protocol detail .....	97
A4-4.29 Segmentation of VHF data exchange payload .....	104
A4-5 Network layer .....	106
A4-6 Transport layer.....	106
A4-7 Presentation interface layer .....	106

**A4-1 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 § A1-2.3. The spectrum may be used as 25 kHz, 50 kHz or 100 kHz channels.

The system should use TDMA techniques in a synchronized manner.

**A4-2 Open systems interconnection layer**

Refer to Annex 2.

**A4-3 Physical layer**

**A4-3.1 Range**

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

**A4-3.2 Transmitter parameter settings**

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

**A4-3.3 Antenna**

Refer to Annex 2.

**A4-3.4 Modulation**

**A4-3.4.1 Waveforms**

The waveforms are defined in Annex 2.

**A4-3.4.2 Bit mapping**

For bit mappings, see Annex 2.

**A4-3.5 Sensitivity**

VDE uses adaptive modulation and coding to maximise spectral efficiency and throughput. Sensitivity for the supported modulation methods are given in Table 34.

TABLE 34  
Sensitivity

Receiver parameters	Requirements					
	LinkID 11	LinkID 13	LinkID 14	LinkID 16	LinkID 17	LinkID 19
Sensitivity	1% PER at -111 dBm	1% PER at -108 dBm	1% PER at -108 dBm	1% PER at -105 dBm	1% PER at -105 dBm	1% PER at -102 dBm

### A4-3.6 Symbol timing accuracy

Refer to Annex 2.

### A4-3.7 Transmitter timing jitter

Refer to Annex 2.

### A4-3.8 Slot transmission accuracy at the output

Refer to Annex 2.

### A4-3.9 Frame structure

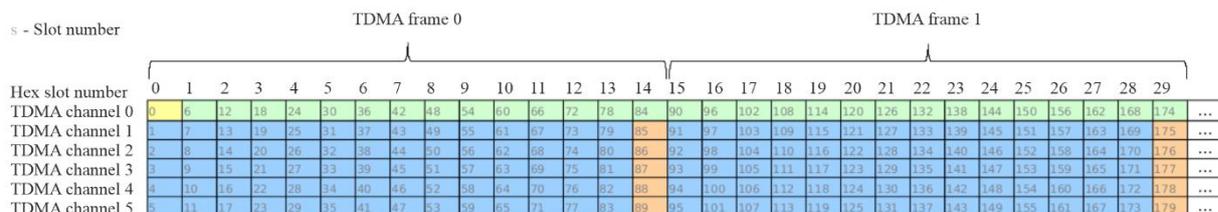
Refer to Annex 2.

## A4-4 Link layer

### A4-4.1 Time division multiple access hierarchy

TDMA hierarchy describes the use of slots in a time interleaved pattern, thus non-continuous in time. Figure 23 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 23  
Time division multiple access hierarchy



M.2092-23

#### A4-4.1.1 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.

#### A4-4.1.2 Time division multiple access channel

A TDMA channel refers to all the slots with the same offset in the hexslot. Every 6<sup>th</sup> slot is part of the same TDMA channel. Six TDMA channels are defined. Figure 23 shows each TDMA channel as a horizontal line of slots.

#### A4-4.1.3 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.

#### **A4-4.1.4 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.

### **A4-4.2 Link layer definitions**

#### **A4-4.2.1 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 § A4-4.12.

#### **A4-4.2.2 Physical channel**

A Physical Channel is defined by a frequency and bandwidth.

#### **A4-4.2.3 VHF data exchange slotmap**

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

#### **A4-4.2.4 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 § A4-4.13.

#### **A4-4.2.5 Short data message**

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

#### **A4-4.2.6 Data session**

A data session refers to the period of data transfer, starting with the first fragment, and ending with a fragment that indicates “End data session”. A data session may span multiple TDMA frames. See § A4-4.17.

#### **A4-4.2.7 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 § A4-4.17.

### **A4-4.3 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 § A4-4.14 unless instructed otherwise.

#### A4-4.4 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 ships originated short data messages or only allow traffic with high priority levels.

#### A4-4.5 Endianness

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

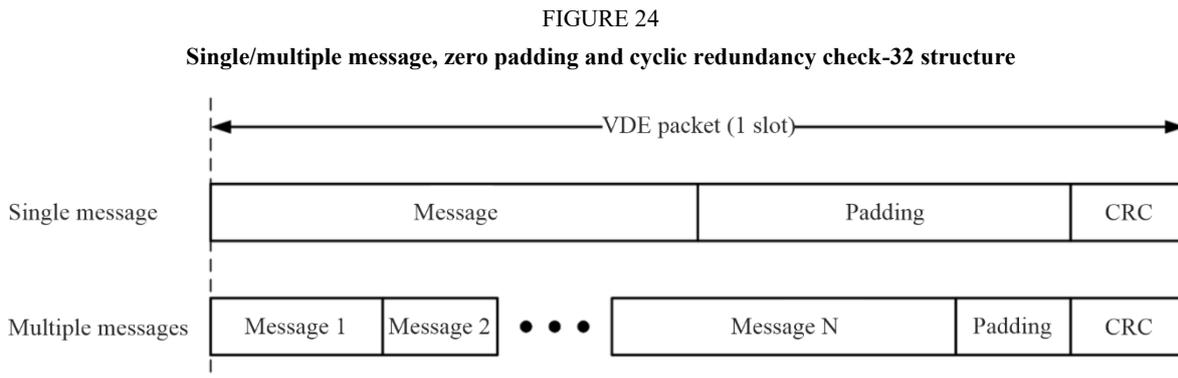
With regards to the message structure, the same endianness is used as in AIS. See Recommendation ITU-R M.1371-5, § 3.3.7, Annex 1.

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.

#### A4-4.6 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. 24.



M.2092-24

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.

#### A4-4.7 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 adaptation mechanism is intentionally undefined.

#### **A4-4.8 Slot functions**

##### **A4-4.8.1 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.

##### **A4-4.8.2 Random access channel**

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

##### **A4-4.8.3 Announcement signalling channel**

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

##### **A4-4.8.4 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.

##### **A4-4.8.5 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.

##### **A4-4.8.6 Ranging channel**

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

##### **A4-4.8.7 VHF data exchange-terrestrial default slot functions**

The default slot functions are defined in Figs 25 and 26.

FIGURE 25

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	6	12	18	24	30	36	42	48	54	60	66	72	78	84
TDMA 1	1	7	13	19	25	31	37	43	49	55	61	67	73	79	85
TDMA 2	2	8	14	20	26	32	38	44	50	56	62	68	74	80	86
TDMA 3	3	9	15	21	27	33	39	45	51	57	63	69	75	81	87
TDMA 4	4	10	16	22	28	34	40	46	52	58	64	70	76	82	88
TDMA 5	5	11	17	23	29	35	41	47	53	59	65	71	77	83	89
TDMA 0	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174
TDMA 1	91	97	103	109	115	121	127	133	139	145	151	157	163	169	175
TDMA 2	92	98	104	110	116	122	128	134	140	146	152	158	164	170	176
TDMA 3	93	99	105	111	117	123	129	135	141	147	153	159	165	171	177
TDMA 4	94	100	106	112	118	124	130	136	142	148	154	160	166	172	178
TDMA 5	95	101	107	113	119	125	131	137	143	149	155	161	167	173	179
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
TDMA 0	2160	2166	2172	2178	2184	2190	2196	2202	2208	2214	2220	2226	2232	2238	2244
TDMA 1	2161	2167	2173	2179	2185	2191	2197	2203	2209	2215	2221	2227	2233	2239	2245
TDMA 2	2162	2168	2174	2180	2186	2192	2198	2204	2210	2216	2222	2228	2234	2240	2246
TDMA 3	2163	2169	2175	2181	2187	2193	2199	2205	2211	2217	2223	2229	2235	2241	2247
TDMA 4	2164	2170	2176	2182	2188	2194	2200	2206	2212	2218	2224	2230	2236	2242	2248
TDMA 5	2165	2171	2177	2183	2189	2195	2201	2207	2213	2219	2225	2231	2237	2243	2249

M.2092-15

FIGURE 26

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	6	12	18	24	30	36	42	48	54	60	66	72	78	84
TDMA 1	1	7	13	19	25	31	37	43	49	55	61	67	73	79	85
TDMA 2	2	8	14	20	26	32	38	44	50	56	62	68	74	80	86
TDMA 3	3	9	15	21	27	33	39	45	51	57	63	69	75	81	87
TDMA 4	4	10	16	22	28	34	40	46	52	58	64	70	76	82	88
TDMA 5	5	11	17	23	29	35	41	47	53	59	65	71	77	83	89
TDMA 0	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174
TDMA 1	91	97	103	109	115	121	127	133	139	145	151	157	163	169	175
TDMA 2	92	98	104	110	116	122	128	134	140	146	152	158	164	170	176
TDMA 3	93	99	105	111	117	123	129	135	141	147	153	159	165	171	177
TDMA 4	94	100	106	112	118	124	130	136	142	148	154	160	166	172	178
TDMA 5	95	101	107	113	119	125	131	137	143	149	155	161	167	173	179
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
TDMA 0	2160	2166	2172	2178	2184	2190	2196	2202	2208	2214	2220	2226	2232	2238	2244
TDMA 1	2161	2167	2173	2179	2185	2191	2197	2203	2209	2215	2221	2227	2233	2239	2245
TDMA 2	2162	2168	2174	2180	2186	2192	2198	2204	2210	2216	2222	2228	2234	2240	2246
TDMA 3	2163	2169	2175	2181	2187	2193	2199	2205	2211	2217	2223	2229	2235	2241	2247
TDMA 4	2164	2170	2176	2182	2188	2194	2200	2206	2212	2218	2224	2230	2236	2242	2248
TDMA 5	2165	2171	2177	2183	2189	2195	2201	2207	2213	2219	2225	2231	2237	2243	2249

M.2092-26

## A4-4.9 VHF data exchange-terrestrial messages

TABLE 35

## VHF data exchange message summary

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

## A4-4.9.1 Media access control

TABLE 36  
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	12: Total size in bytes, fixed at 12 bytes.
3	0 to $2^{32}-1$	4	Source ID	The unique identifier of the transmitting station as described in § A1-2.4.
4	0-255	1	Media Access priority level	Reserved for future use. Always 0.
5	0-511	2	Random access selection interval	The random access scheme selection interval in hexslots. 0 – Default selection interval applies.
6	0-127	1	Short data message limit	Maximum allowed number of short data message transmissions on the RAC during a frame.
7	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.

## A4-4.9.2 Resource allocation

TABLE 37  
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 § A1-2.4.
4	0 to $2^{32}-1$	4	Destination ID	The unique identifier of the station being assigned a logical channel as described in § A1-2.4. Set to 0 for shore-originated broadcast.
5	0-255	1	Logical Channel Tx	Logical channel assigned to the session for transmission. Transmission only applies to data slots: <sup>(1)</sup> 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: <sup>(1)</sup> 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 <sup>(2)(3)</sup> .
9 <sup>(4)</sup>	0	1	Session ID	Session ID.
10	0-255	1	CQI	Received channel quality indicator as defined in § A2-1.2.8.

<sup>(1)</sup> 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.

<sup>(2)</sup> 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.

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

<sup>(4)</sup> The session ID is reserved for future use.

## A4-4.9.3 Acknowledge/NACK

TABLE 38  
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 § A1-2.4.
4	0 to $2^{32}-1$	4	Destination ID	The unique identifier of the receiving station, as described in § A1-2.4.
5 <sup>(1)</sup>	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.
7	0 to $2^{16}-1$	2	ACK/NACK mask 1	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.
8	0 to $2^{16}-1$	2	ACK/NACK mask 2	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.
9	0-255	1	CQI	Received channel quality indicator averaged over the last TDMA frame received as defined in § A2-1.2.8.
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.

<sup>(1)</sup> Session ID is reserved for future use.

## A4-4.9.4 Resource request/transmission announcement

TABLE 39

## 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 § A1-2.4.
4	0 to $2^{32}-1$	4	Node source ID	Unique identifier of the current node transmitting the message, as described in § A1-2.4.
5	0 to $2^{32}-1$	4	Node destination ID	Unique identifier of the current node receiving the message, as described in § A1-2.4. Set to 0 for shore-originated broadcast.
6	0 to $2^{32}-1$	4	Original destination ID	The unique identifier of the receiving station, as described in § A1-2.4. Set to 0 for shore-originated broadcast.
7	0-255	1	Priority	Set to 0. Reserved for future use.
8	0 to $2^{32}-1$	4	Terminal capabilities	Bits 0 – 3 indicate the M.2092 version. Value 0 = M.2092-0, Value 1 = M.2092-1, Value 2 = M.2092-2, Values 3 - 15 reserved for future use Bit 4: Set to 1 for the simplified VDES (refer to § A1-2.7).  Bits 5 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.

**A4-4.9.5 Short data message (with acknowledgement)**

TABLE 40

**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 § A1-2.4.
4 <sup>(1)</sup>	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.

<sup>(1)</sup> Session ID is reserved for future use.

**A4-4.9.6 Short data message (no acknowledgement)**

TABLE 41

**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 § A1-2.4.
4 <sup>(1)</sup>	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 § A1-2.4. 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.

<sup>(1)</sup> Session ID is reserved for future use.

## A4-4.9.7 Bulletin board start fragment message

TABLE 42

## 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 § A1-2.4.
4	0 to 255	1	Control station ID	
5	0 to 255	1	Service capability	TBB Structure as defined: Value 0 = M.2092-0 Value 1 = M.2092-1 Value 2 = M.2092-2 Values 3 – 255 reserved for future use
6	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).
7	0 to 255	1	Number of fragments	Should be a value from 1 to 6 (TBC).
8		Variable	Bulletin board payload	See bulletin board payload definition in Table 43.

TABLE 43

## 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: 3, 5, 15 (default). Only 15 have to be supported.
4		Variable	Physical channel definitions	See physical channel definition in Table 47.

TABLE 43 (*end*)

Field No.	Value (dec)	Size (bytes)	Function	Content
5	0 to 255	1	Modulation, coding and protocol versions supported	Set to zero. May be used to in the future to define 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.
6		9	Control station service area	Parameter (longitude and latitude) defining the control station service area. See Table 44.
7		6	Digital Certificate Fingerprint	See § A4-4.15
8		64	Authentication and integrity sequence	See § A4-4.15

TABLE 44

**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 ( $\pm 180^\circ$ , East = positive, West = negative).
Latitude of point 1	17	Latitude of area to which the assignment applies; upper right corner (North-East); in 1/10 min ( $\pm 90^\circ$ , North = positive, South = negative).
Longitude of point 2	18	Longitude of area to which the assignment applies; lower left corner (South-West); in 1/10 min ( $\pm 180^\circ$ , 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 ( $\pm 90^\circ$ , North = positive, South = negative).
Priority	2	0:very high (default) 1:high 2:medium 3:low

**A4-4.9.8 Bulletin board continuation fragment message**

TABLE 45

**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 § A1-2.4.
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 43.

**A4-4.9.9 Bulletin board end fragment message**

TABLE 46

**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 § A4-1-2.4.
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 43.

TABLE 47

**Physical channel definition**

<b>Name</b>	<b>Value</b>	<b>Field size (bits)</b>	<b>Content</b>
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 Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. 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 48.	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 Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. 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 48	Variable	Defines the logical channel definition of physical channel N.

TABLE 48  
**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	0-1	1	0 – This LC does not repeat in the TDMA channel. 1 – This LC does repeat in the TDMA channel.
LC 0 duration	0-255	8	The duration in slots of this LC in each TDMA frame .
...	...	...	...
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	0-1	1	0 – This LC does not repeat in the TDMA channel. 1 – This LC does repeat in the TDMA channel.
LC N duration	0-255	8	The duration in slots of this LC in each TDMA frame .
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 § A4-4.13 for explanation.

## A4-4.9.10 Start fragment

TABLE 49  
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 § A1-2.4.
4 <sup>(1)</sup>	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 § A1-2.4. Set to 0 for broadcast.
6	0-255	1	Number of fragments	Number of fragments in this TDMA frame. 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 resource usage	0 – Ends data session. 1 – Continue resource usage.
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.

<sup>(1)</sup> Session ID is reserved for future use.

## A4-4.9.11 Continuation fragment

TABLE 50  
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 § A1-2.4.
4 <sup>(1)</sup>	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 § A1-2.4. Set to 0 for broadcast.
6	0-255	1	Number of fragments	Total number of fragments in this TDMA frame. Should be a value from 1 to 14.
7	0-255	1	Fragment number in this TDMA frame	Fragment number in this TDMA frame. Should be a value from 2 to 13.
8	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.
9		Variable	Payload	

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

<sup>(1)</sup> Session ID is reserved for future use.

**A4-4.9.12 End fragment**

TABLE 51  
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 § A1-2.4.
4 <sup>(1)</sup>	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 § A1-2.4. Set to 0 for broadcast.
6	0-255	1	Number of fragments	Total number of fragments in this TDMA frame. 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 resource usage	0 – Ends data session. 1 – Continues resource usage.
9		Variable	Payload	

Note: 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.

<sup>(1)</sup> Session ID is reserved for future use.

**A4-4.9.13 Padding single byte**

TABLE 42  
Padding single byte

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

**A4-4.10 Cyclic redundancy check**

Refer to § A2-1.2.5.

**A4-4.11 Acknowledgement**

Acknowledgement behaviour for the terrestrial link is described in § A4-4.17.

#### **A4-4.12 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.

#### **A4-4.13 Terrestrial bulletin board**

The terrestrial bulletin board (TBB) message defines the slot map for each physical channel (PC). The TBB content is defined in § A4-4.9.7, § A4-4.9.8 and § A4-4.9.9. 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 that repeat as multiple TDMA frames. See Fig. 23.

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, repeat and duration. The slotmap of each TDMA frame is identical as defined by Table 48. 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 § A4-4.14.

A VDES station shall use the most recent valid TBB with the highest priority 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 43).

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.

#### **A4-4.14 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 27 and 28.

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<sup>th</sup> slot (DSCH) is used for ACK/NACK and resource allocation signalling.

FIGURE 27  
VHF data exchange-terrestrial ship to shore default slot to LC mapping (lower leg)

	Bulletin board signalling channel
	Random access signalling channel
	Announcement signalling channel
	Data signalling channel
	Data channel
S	Slot number
L	Logical channel number

TDMA 0	0 0	6 0	12 0	18 1	24 1	30 1	36 1	42 1	48 1	54 1	60 1	66 1	72 1	78 1	84 1
TDMA 1	1 2	7 2	13 2	19 2	25 2	31 2	37 2	43 2	49 2	55 2	61 2	67 2	73 2	79 2	85 3
TDMA 2	3 4	9 4	15 4	21 4	27 4	33 4	39 4	45 4	51 4	57 4	63 4	69 4	75 4	81 4	87 5
TDMA 3	5 6	11 6	17 6	23 6	29 6	35 6	41 6	47 6	53 6	59 6	65 6	71 6	77 6	83 6	89 7
TDMA 4	7 8	13 8	19 8	25 8	31 8	37 8	43 8	49 8	55 8	61 8	67 8	73 8	79 8	85 8	91 9
TDMA 5	9 10	15 10	21 10	27 10	33 10	39 10	45 10	51 10	57 10	63 10	69 10	75 10	81 10	87 10	93 11

TDMA 0	90 0	96 0	102 0	108 1	114 1	120 1	126 1	132 1	138 1	144 1	150 1	156 1	162 1	168 1	174 1	...
TDMA 1	91 2	97 2	103 2	109 2	115 2	121 2	127 2	133 2	139 2	145 2	151 2	157 2	163 2	169 2	175 3	...
TDMA 2	93 4	99 4	105 4	111 4	117 4	123 4	129 4	135 4	141 4	147 4	153 4	159 4	165 4	171 4	177 5	...
TDMA 3	95 6	101 6	107 6	113 6	119 6	125 6	131 6	137 6	143 6	149 6	155 6	161 6	167 6	173 7	...	
TDMA 4	97 8	103 8	109 8	115 8	121 8	127 8	133 8	139 8	145 8	151 8	157 8	163 8	169 8	175 9	...	
TDMA 5	99 10	105 10	111 10	117 10	123 10	129 10	135 10	141 10	147 10	153 10	159 10	165 10	171 10	177 11	...	

...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

TDMA 0	...	2160 0	2166 0	2172 0	2178 1	2184 1	2190 1	2196 1	2202 1	2208 1	2214 1	2220 1	2226 1	2232 1	2238 1	2244 1
TDMA 1	...	2161 2	2167 2	2173 2	2179 2	2185 2	2191 2	2197 2	2203 2	2209 2	2215 2	2221 2	2227 2	2233 2	2239 2	2245 3
TDMA 2	...	2162 4	2168 4	2174 4	2180 4	2186 4	2192 4	2198 4	2204 4	2210 4	2216 4	2222 4	2228 4	2234 4	2240 4	2246 5
TDMA 3	...	2163 6	2169 6	2175 6	2181 6	2187 6	2193 6	2199 6	2205 6	2211 6	2217 6	2223 6	2229 6	2235 6	2241 6	2247 7
TDMA 4	...	2164 8	2170 8	2176 8	2182 8	2188 8	2194 8	2200 8	2206 8	2212 8	2218 8	2224 8	2230 8	2236 8	2242 8	2248 9
TDMA 5	...	2165 10	2171 10	2177 10	2183 10	2189 10	2195 10	2201 10	2207 10	2213 10	2219 10	2225 10	2231 10	2237 10	2243 10	2249 11

M.2092-27

FIGURE 28  
VHF data exchange-terrestrial ship to ship default slot to logical channel mapping (upper leg)

	Bulletin board signalling channel
	Random access signalling channel
	Announcement signalling channel
	Data signalling channel
	Data channel
S	Slot number
L	Logical channel number

TDMA 0	0 12	6 12	12 12	18 13	24 14	30 13	36 14	42 13	48 14	54 13	60 14	66 13	72 14	78 13	84 14
TDMA 1	1 15	7 15	13 15	19 15	25 15	31 15	37 15	43 15	49 15	55 15	61 15	67 15	73 15	79 15	85 16
TDMA 2	3 17	9 17	15 17	21 17	27 17	33 17	39 17	45 17	51 17	57 17	63 17	69 17	75 17	81 17	87 18
TDMA 3	5 19	11 19	17 19	23 19	29 19	35 19	41 19	47 19	53 19	59 19	65 19	71 19	77 19	83 19	89 20
TDMA 4	7 21	13 21	19 21	25 21	31 21	37 21	43 21	49 21	55 21	61 21	67 21	73 21	79 21	85 21	91 22
TDMA 5	9 23	15 23	21 23	27 23	33 23	39 23	45 23	51 23	57 23	63 23	69 23	75 23	81 23	87 23	93 24

TDMA 0	90 12	96 12	102 12	108 13	114 14	120 13	126 14	132 13	138 14	144 13	150 14	156 13	162 14	168 13	174 14	...
TDMA 1	91 15	97 15	103 15	109 15	115 15	121 15	127 15	133 15	139 15	145 15	151 15	157 15	163 15	169 15	175 16	...
TDMA 2	92 17	98 17	104 17	110 17	116 17	122 17	128 17	134 17	140 17	146 17	152 17	158 17	164 17	170 17	176 18	...
TDMA 3	93 19	99 19	105 19	111 19	117 19	123 19	129 19	135 19	141 19	147 19	153 19	159 19	165 19	171 19	177 20	...
TDMA 4	94 21	100 21	106 21	112 21	118 21	124 21	130 21	136 21	142 21	148 21	154 21	160 21	166 21	172 21	178 22	...
TDMA 5	95 23	101 23	107 23	113 23	119 23	125 23	131 23	137 23	143 23	149 23	155 23	161 23	167 23	173 23	179 24	...

...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

TDMA 0	...	2166 12	2166 12	2172 12	2178 13	2184 14	2190 13	2196 14	2202 13	2208 14	2214 13	2220 14	2226 13	2232 14	2238 13	2244 14
TDMA 1	...	2167 15	2167 15	2173 15	2179 15	2185 15	2191 15	2197 15	2203 15	2209 15	2215 15	2221 15	2227 15	2233 15	2239 15	2245 16
TDMA 2	...	2168 17	2168 17	2174 17	2180 17	2186 17	2192 17	2198 17	2204 17	2210 17	2216 17	2222 17	2228 17	2234 17	2240 17	2246 18
TDMA 3	...	2169 19	2169 19	2175 19	2181 19	2187 19	2193 19	2199 19	2205 19	2211 19	2217 19	2223 19	2229 19	2235 19	2241 19	2247 20
TDMA 4	...	2170 21	2170 21	2176 21	2182 21	2188 21	2194 21	2200 21	2206 21	2212 21	2218 21	2224 21	2230 21	2236 21	2242 21	2248 22
TDMA 5	...	2171 23	2171 23	2177 23	2183 23	2189 23	2195 23	2201 23	2207 23	2213 23	2219 23	2225 23	2231 23	2237 23	2243 23	2249 24

M.2092-28

### A4-4.15 Digital signature of messages

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. For VDES the primary purpose is to authenticate messages by attaching a digital signature.

It should be possible to store certificates and certificate revocation lists for the authentication of digital signatures and of new certificates 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 are done by using the VDES unit PI. In case the verification of the signature fails on the VDES mobile station the message cannot be trusted. For Link Layer messages, such as the bulletin board, the system shall act as if it never had received the message.

Cryptographic algorithm for the end-entities digital signatures is the elliptic curve digital signature algorithm. The elliptic curve cryptography public key shall be 256 bits in size. With this key size, the recommendations from Internet Engineering Task Force (IETF) Document RFC 5480<sup>9</sup> states that the minimum bits of security should be 128, the message digest algorithm Secure Hash Algorithm (SHA)-256, using IEEE P1363 Fixed-Field Concatenation format and the curve secp256r1.

A digital certificate fingerprint, consisting of the 48 least significant bits of a certificate's signature Value (see RFC 5480, 4.1.1.3), is used to identify the certificate that should be used to validate the signature.

#### **A4-4.16 Data transfer protocols**

The following 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.

#### **A4-4.17 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 (see Fig. 29). When the two LCs are on different PCs, the session is considered duplex (see Fig. 30).

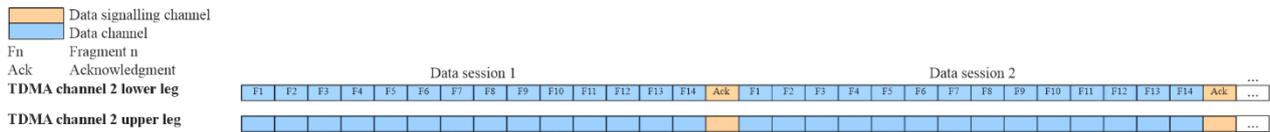
LCs assigned for data transmission sessions should have a DC slot function, while LCs assigned for acknowledgement reception, should have DSCH slot function. See § A4-4.8.

Figures 29 and 30 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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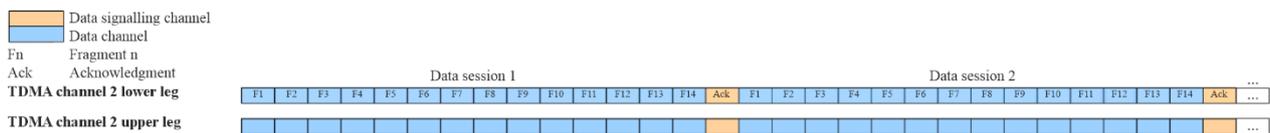
<sup>9</sup> IETF Document RFC 5480: *Elliptic Curve Cryptography Subject Public Key Information*.

FIGURE 29  
Simplex data session



M.2092-29

FIGURE 30  
Duplex data session



M.2092-30

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.

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 resource usage” parameter in the end fragment (#76) message to 1. On successful transmission, the fragments 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.

To continue the data transmission over multiple TDMA frames during a shore to ship data session, the shore station should transmit a Resource Allocation (#4) message in the ASC before the start of the next TDMA frame.

**A4-4.18 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.

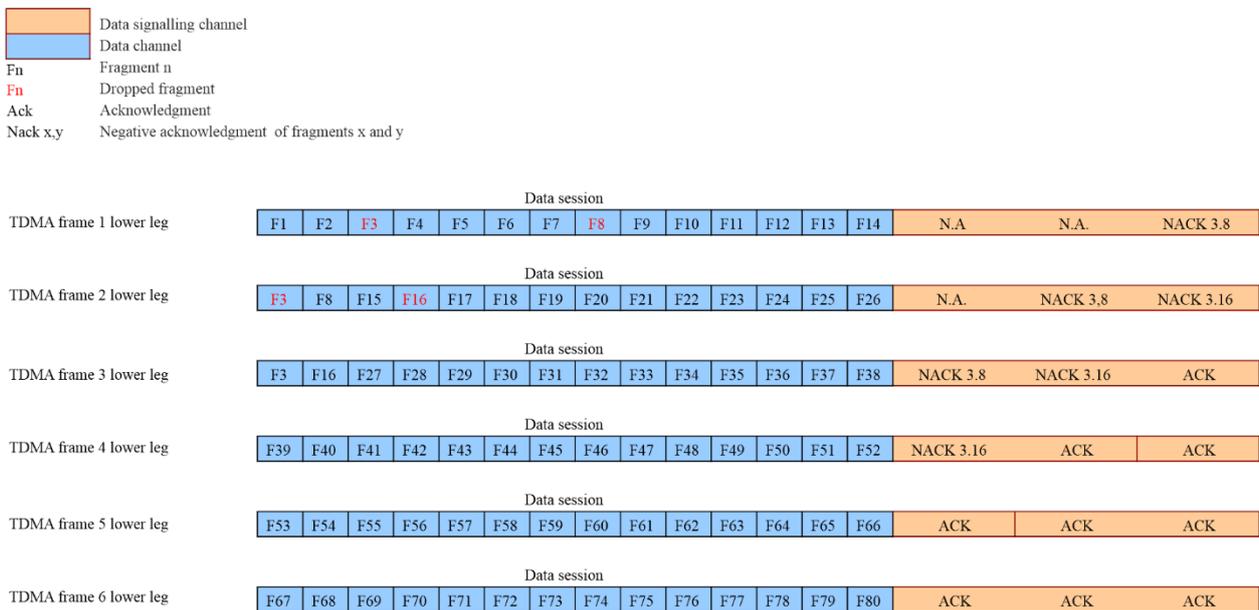
The receiving station shall request retransmission of data fragments for a maximum of three attempts.

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. 31.

FIGURE 31  
Simplex data session retry



M.2092-31

**A4-4.19 Giving priority to automatic identification system**

VDE transmissions should always give preference to AIS transmissions.

**A4-4.19.1 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 § A4-4.21.1.

#### **A4-4.19.2 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.

##### **A4-4.19.2.1 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 shore 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 53.

TABLE 53

#### **Shore station co-site performance**

AIS base station sensitivity as per Rec. ITU-R M.1371 <sup>(1)</sup>	20% PER at -107 dBm
Required margin	-10 dBm
VDE transceiver power	41 dBm rms
Mask sideband noise of VDE at AIS1	-70 dBc (-29 dBm)
Required isolation	82 dB

<sup>(1)</sup> 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.

#### **A4-4.19.2.2 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.

#### **A4-4.20 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.

#### **A4-4.21 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 § A4-4.21.1 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.

##### **A4-4.21.1 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 § A3-4.3.6.

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 § A3-4.3.6) 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.

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

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 a flowchart representation of the selection algorithm.

#### **A4-4.22 Announcement channel access scheme**

Ad hoc messages (messages 4, 90 and 92) shall be transmitted on ASC 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 ASC 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.

#### **A4-4.23 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.

#### **A4-4.24 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.

#### **A4-4.25 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 § A4-4.21.1. 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.

**A4-4.26 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.

**A4-4.27 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.

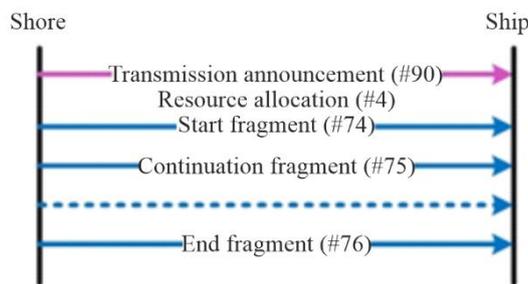
**A4-4.28 Data transfer protocol detail**

**A4-4.28.1 Shore originated broadcast**

The sequence diagram for shore originated broadcast without ACK is shown in Fig. 32. The transfer starts with a resource allocation. The diagram shows a large multi-fragmented data session.

FIGURE 32  
Shore originated broadcast sequence diagram

- Random access channel
- Announcement signalling channel
- Data channel
- Data signalling channel



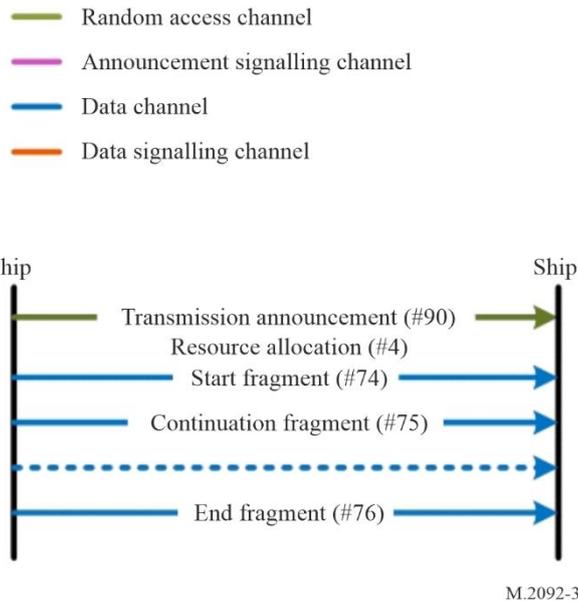
M.2092-32

**A4-4.28.2 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. 33.

FIGURE 33

Ship originated broadcast outside control station service area sequence diagram

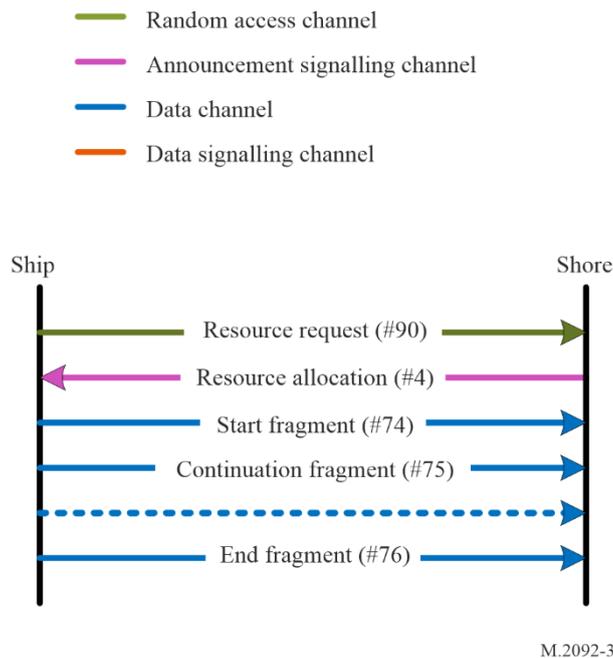


**A4-4.28.3 Ship originated broadcast inside control station service area**

The sequence diagram for ship originated broadcast inside of control station service area is shown in Fig. 34.

FIGURE 34

Ship originated broadcast inside control station service area sequence diagram



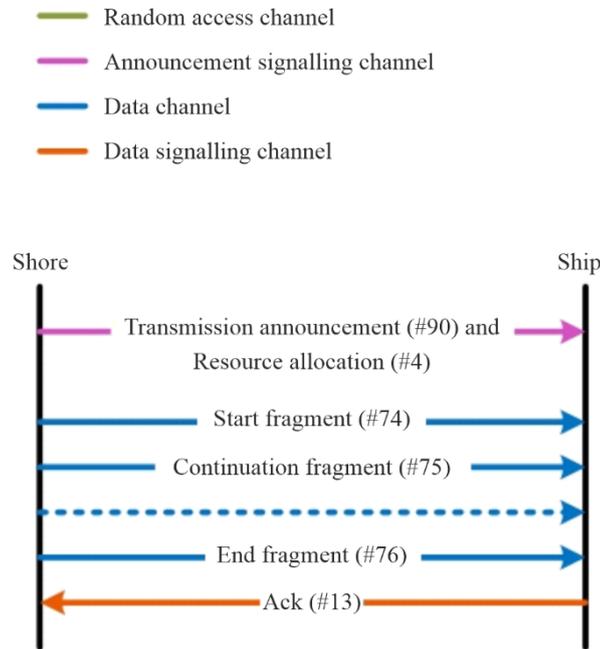
**A4-4.28.4 Shore to ship addressed message**

The sequence diagram for shore to ship addressed message is shown in Fig. 35. 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 35  
Shore to ship addressed message sequence diagram



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**A4-4.28.5 Ship to shore addressed message**

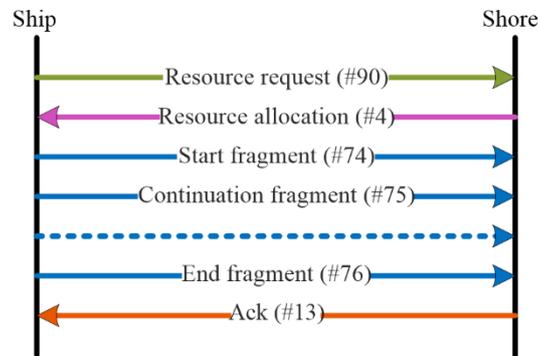
The sequence diagram for ship to shore addressed message is shown in Fig. 36. The transfer starts with a resource request message to request a LC for the data session. The following resource allocation message is transmitted to assign a LC to the data session. The diagram shows a large multi-fragmented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

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

FIGURE 36

**Ship to shore addressed message sequence diagram**

- Random access channel
- Announcement signalling channel
- Data channel
- Data signalling channel



M.2092-36

**A4-4.28.6 Ship to ship addressed message outside control station service area**

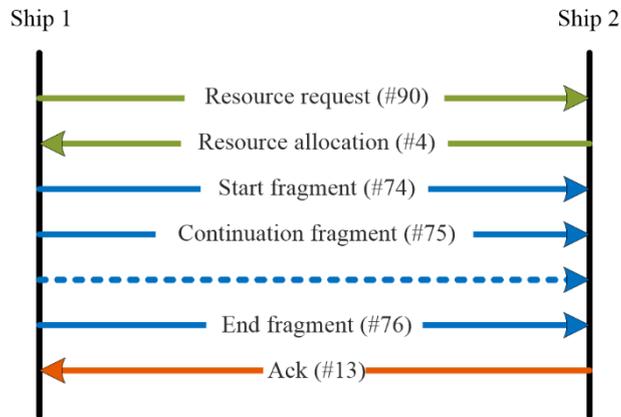
The sequence diagram for ship to ship addressed message outside of control station service area is shown in Fig. 37. The transfer starts with a resource request message to request a LC for the data session. The following resource allocation message is transmitted to assign a LC to the data session. The diagram shows a large multi-fragmented data session.

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

FIGURE 37

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

- Random access channel
- Announcement signalling channel
- Data channel
- Data signalling channel



M.2092-37

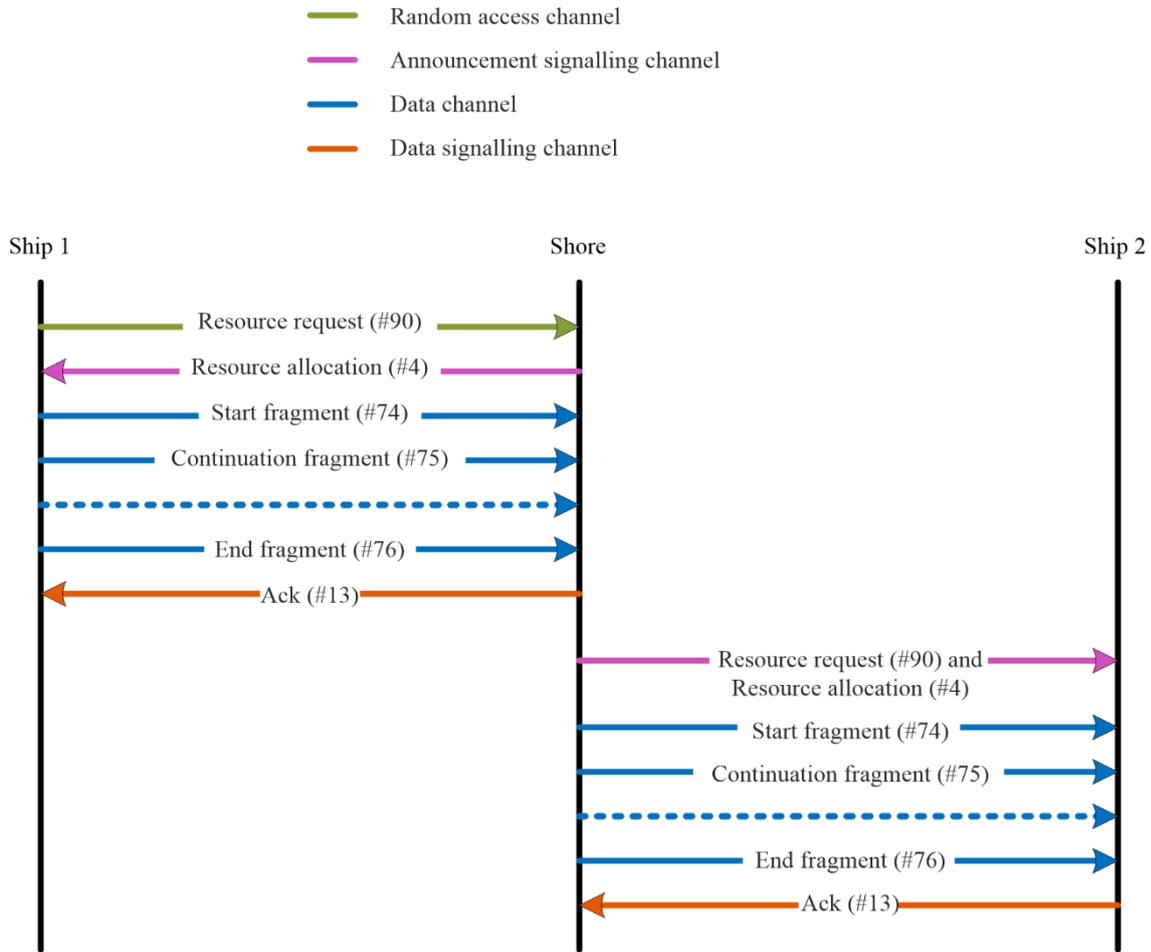
**A4-4.28.7 Ship to ship addressed message inside control station service area**

The sequence diagram for ship to ship addressed message inside of control station service area is shown in Fig. 38. 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 38

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



M.2092-38

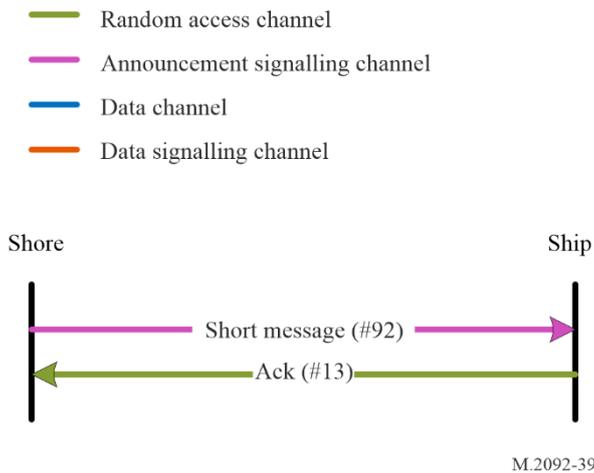
**A4-4.28.8 Shore to ship short data message**

The sequence diagram for shore to ship short data message with ACK is shown in Fig. 39. 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 39

Shore to ship short data message sequence diagram with ACK

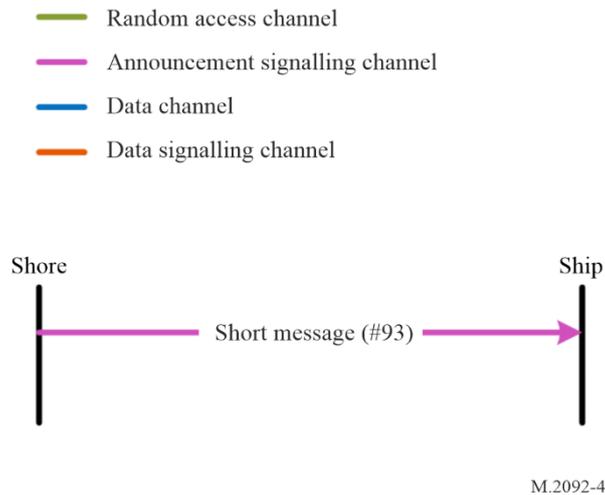


The sequence diagram for shore to ship short data message without ACK is shown in Fig. 40. This protocol is used for short data messages that fit within a single transmission burst.

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

FIGURE 40

Shore to ship short data message sequence diagram without ACK



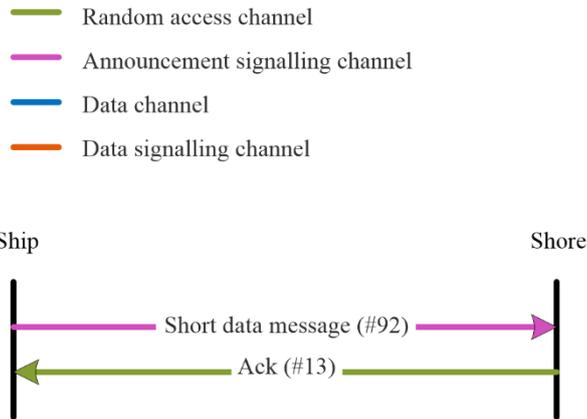
#### A4-4.28.9 Ship to shore short data message

The sequence diagram for ship to shore short data message is shown in Fig. 41. 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 41

**Ship to shore short data message sequence diagram**



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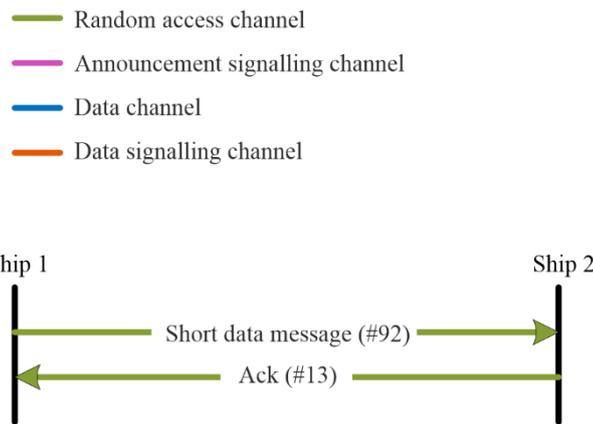
**A4-4.28.10 Ship to ship short data message**

The sequence diagram for ship-to-ship short data message is shown in Fig. 42. 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 42

**Ship to ship short data message sequence diagram**



M.2092-42

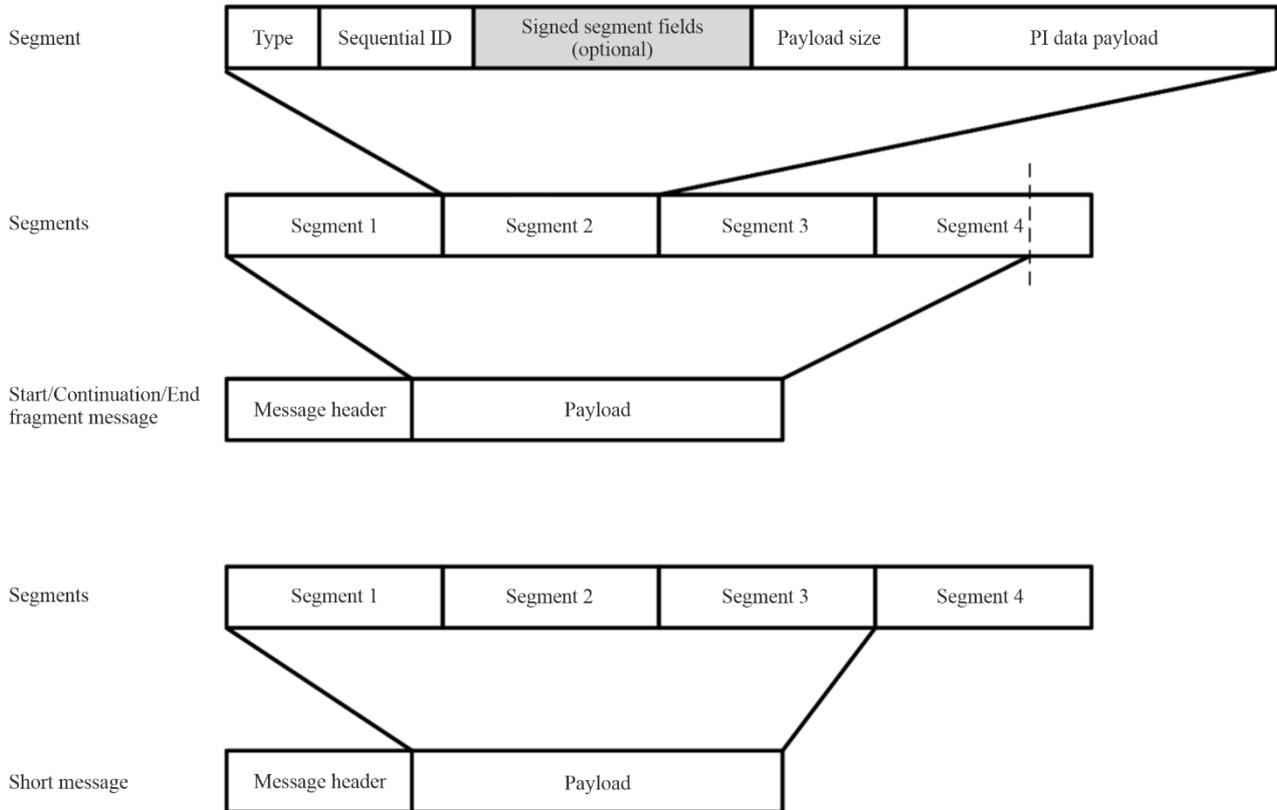
**A4-4.29 Segmentation of VHF data exchange payload**

Data to be transmitted over VDE payload should be input to equipment via the PI by using applicable international standards.

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.

A segment may be signed or unsigned as indicated by the Segment type. When calculating the digital signature, the Source MMSI and Destination MMSI are prepended to the data, but are not transmitted as part of the segment. When receiving a signed segment, the Source MMSI and Destination MMSI should be prepended to the data when verifying the signature.

FIGURE 43  
Segmentation of VHF data exchange payload



M.2092-43

Segments may span multiple fragments, but not multiple data sessions.

#### A4-4.29.1 Segment description

TABLE 54  
Unsigned segment description

Field No.	Value (Dec)	Size (Bits)	Function	Content
1	0 to 3	2	Segment type	0: Unsigned segment: only contains payload.
2	0 to $2^{14}-1$	14	Sequential ID	Sequential ID of matching data transaction.
3	0 to $2^{16}-1$	16	Payload size	Size of the segment payload data only (bytes).
4		Variable	Payload data	Payload data.

TABLE 55

**Signed segment description**

Field No.	Value (Dec)	Size (Bits)	Function	Content
1	0 to 3	2	Segment type	Specifies the type of segment 1: Signed segment: contains authentication fields. 2 & 3: Reserved for future use.
2	0 to $2^{14}-1$	14	Sequential ID	Sequential ID of matching data transaction.
3	0 to 127	7	Signed Segment Format	0: Using elliptic curve cryptography as defined in ITU-R M.2092 Section 4.15
4	0 or 1	1	Valid until field present	0: Valid until field not present 1: Valid until field present
5		0 or 32	Valid until	Unsigned integer number of seconds after the 1st of January 1970 00:00:00 UTC.
6		48	Certificate fingerprint	Fingerprint of the public key certificate that can be used for authenticating the digital signature.
7		512	Digital signature	The Digital Signature shall be calculated over the concatenated sequence of bytes from: <ul style="list-style-type: none"> <li>• Source MMSI</li> <li>• Destination MMSI</li> <li>• Segment Type</li> <li>• Sequential ID</li> <li>• Signed Segment Format</li> <li>• Valid until field present</li> <li>• Valid Until value (not applicable if not present)</li> <li>• Certificate Fingerprint</li> <li>• Payload size</li> <li>• Payload data</li> </ul>
8	0 to $2^{16}-1$	16	Payload size	Size of the segment payload data only (bytes).
9		Variable	Payload data	Payload data.

**A4-5 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.

**A4-6 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.

**A4-7 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

	<i>Page</i>
A5-1 Introduction .....	108
A5-2 Physical layer.....	108
A5-2.1 VHF data exchange-satellite component key parameters.....	108
A5-2.2 Technical characteristics of the VHF data exchange-satellite component downlink .....	112
A5-2.3 Technical characteristics of the VHF data exchange-satellite component uplink .....	114
A5-2.4 Bit mapping .....	115
A5-2.5 Spreading .....	115
A5-2.6 Baseband shaping and quadrature modulation .....	119
A5-2.7 Transmission timing accuracy .....	119
A5-2.8 Half duplex and full duplex satellites .....	119
A5-2.9 Frame structure .....	120
A5-2.10 Pilots and syncword symbol location and modulation .....	120
A5-2.11 Forward error correction and interleaving.....	121
A5-2.12 VHF data exchange-satellite link configuration formats.....	121
A5-2.13 VHF data exchange-satellite downlink block channel interleaver .....	121
A5-3 Link layer.....	122
A5-3.1 Link layer definitions.....	122
A5-3.2 Resource management .....	123
A5-3.3 Endianness .....	124
A5-3.4 Data structures .....	124
A5-3.5 Slot functions .....	124
A5-3.6 Guard slot.....	125
A5-3.7 VHF data exchange-satellite default bulletin board .....	125
A5-3.8 Use of the data acknowledgement signalling channel .....	128
A5-3.9 VHF data exchange-satellite message summary .....	129
A5-3.10 VHF data exchange-satellite message descriptions.....	130
A5-3.11 Downlink retry mechanism .....	147
A5-3.12 Uplink retry mechanism .....	147
A5-3.13 Data transfer protocol details.....	148
A5-3.14 Random access .....	153
A5-3.15 Logical channel assignment .....	154
A5-3.16 Adaptive coding and modulation/rate adaptation.....	154
A5-4 Segmentation of VHF data exchange-satellite payload.....	154
A5-5 Network layer .....	154
A5-6 Transport layer.....	154
A5-7 Presentation Layer .....	154

## **A5-1 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 data message.
- Ship to satellite short data 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.

## **A5-2 Physical layer**

### **A5-2.1 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.

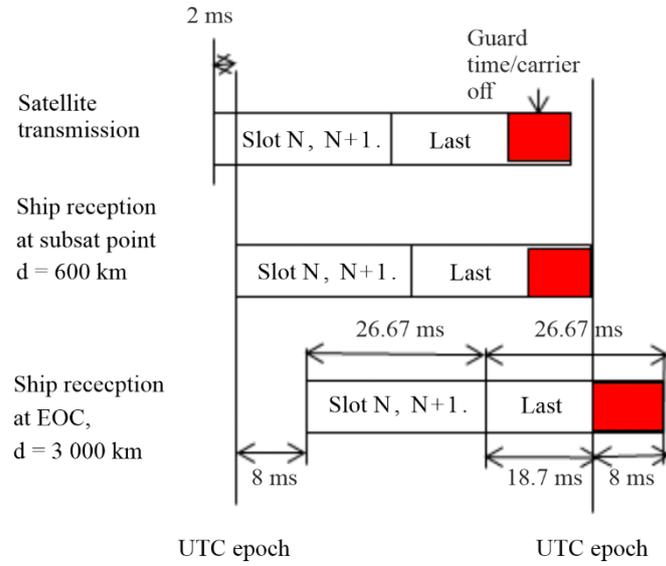
#### **A5-2.1.1 Satellite to surface distance range**

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 44 and 45.

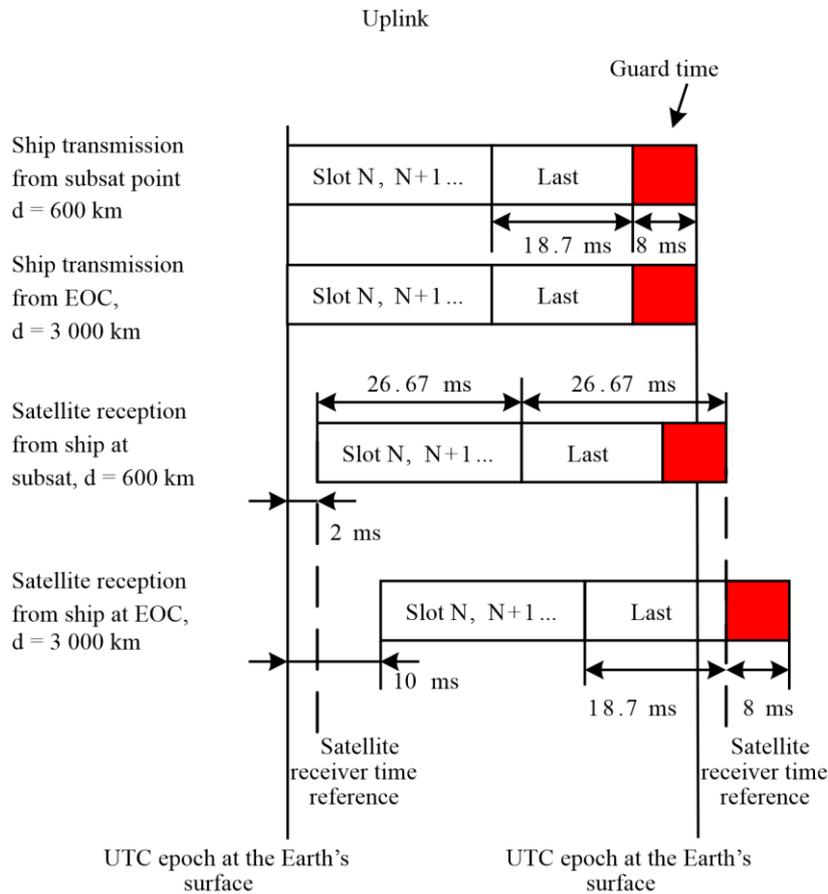
For the VDE-SAT downlink, in addition to the relative delays between signal receptions at a vessel from different satellites, there could be absolute delay due to other sources such as signal processing delay. The satellite service provider should pre-compensate for absolute delay, by transmitting packets 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 44  
VHF data exchange-satellite downlink timing



M.2092-44

FIGURE 45  
VHF data exchange-satellite uplink timing



M.2092-45

**A5-2.1.2 Satellite transmission carrier frequency error**

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

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

**A5-2.1.3 Ship station transmitter requirements**

For ship station transmitter requirements, see Annex 2.

**A5-2.1.4 Ship station antenna gain**

For ship station antenna gain, see Annex 2.

**A5-2.1.5 Ship station noise plus interference level**

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

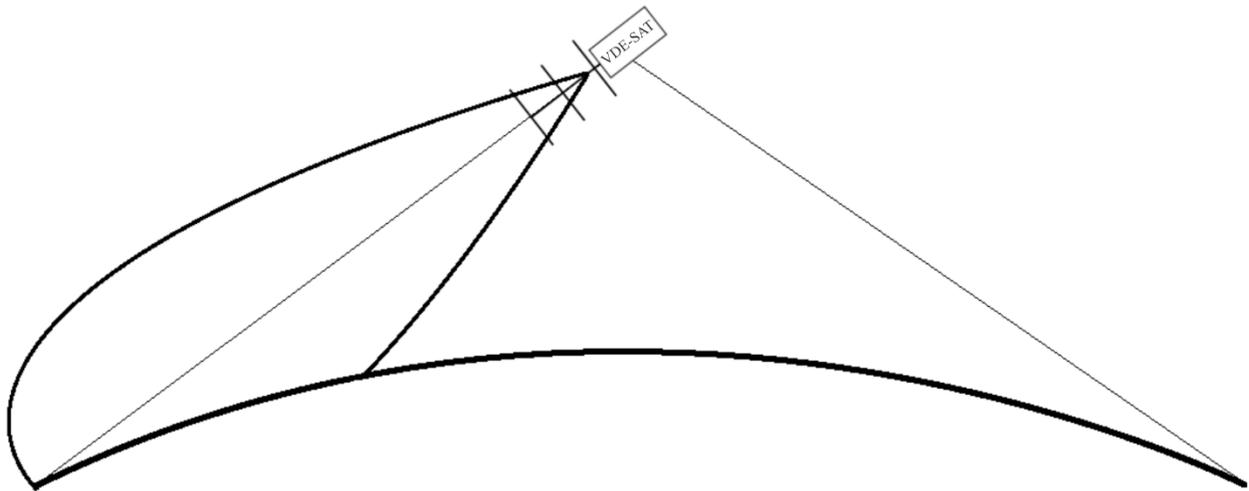
**A5-2.1.6 Satellite antenna characteristics**

A circularly polarized Yagi antenna, comprised of three elements, is used as an example for the satellite antenna. Figure 46 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 56. 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 § A1-2.1 when above areas with VDE-TER coverage.

FIGURE 46

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



M.2092-46

TABLE 56

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

### A5-2.2 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.

#### A5-2.2.1 Satellite downlink equivalent isotropic radiated power

A pfd-mask to ensure interoperability and compatibility between VDE-TER and VDE-SAT is specified in § A1-2.1.

Table 57 shows the theoretical maximum satellite e.i.r.p. as a function of elevation angles for this mask.

TABLE 57

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

Ship elevation angle $\theta$ (degrees)	pfd-mask on ground (dB(W/(m <sup>2</sup> ·4 kHz)))	Satellite range (km)	Inverse squared distance (dB)	pfd-mask at satellite antenna (dB(W/(m <sup>2</sup> ·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 § A5-2.1.6, 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 § A1-2.1. Satellite e.i.r.p. and resulting margin to the pfd-mask as a function of ship elevation is shown in Table 58.

TABLE 58

**Satellite effective isotropic radiated power and margin to the pfd-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

#### **A5-2.2.2 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.

#### **A5-2.2.3 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 59 for the satellite antenna described in § A5-2.1.6. 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 59 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 59

**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

**A5-2.3 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.

**A5-2.3.1 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.

**A5-2.3.1.1 Satellite system noise temperature**

The satellite receiver noise temperature is shown in Table 60. The system noise temperature is 25.7 dBK, assuming no external interference.

TABLE 60

**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

### A5-2.3.1.2 VHF data exchange-satellite component uplink link budget

Table 61 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 § A5-2.1.6. 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 § A5-2.3.1.1. The link budget in Table 61 is theoretical and does not take into account propagation effects such as multi-path, which is documented in § 2.1, Annex 1 to Report ITU-R M.2435-0, or interference from other services operating in the same frequency band.

TABLE 61

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

### A5-2.4 Bit mapping

For bit mappings, see Annex 2.

### A5-2.5 Spreading

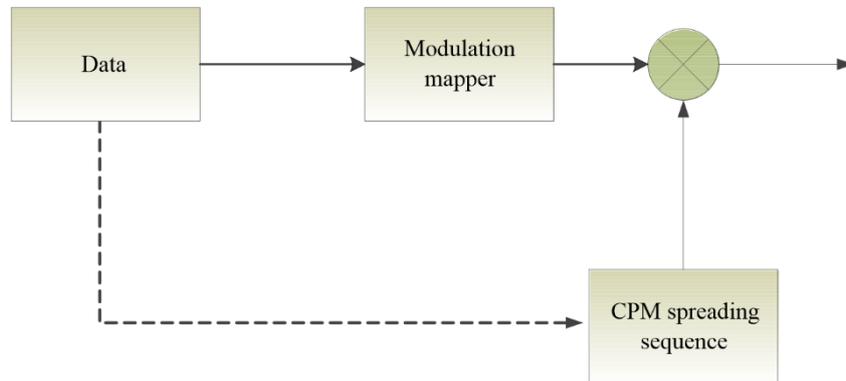
Direct sequence spreading with constant envelope is applied for the PL burst format SAT-MCS-1.50-2, identified by Link ID 20. Spreading for the downlink burst waveforms carrying bulletin boards, Link ID 25 and Link ID 32 are achieved by utilising gold sequences of length 2047. A short direct spreading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

#### A5-2.5.1 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. 47.

FIGURE 47  
Continuous phase modulation spreading principle



M.2092-47

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. 48). The generated constant envelope spreading output sequence  $y(k)$  is given by:

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

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  $\pi/4$ -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 (see Fig. 47). 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  $m = k \% SL = k - SL \cdot [k/SL] = k - SL \cdot n$ , 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

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

and

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

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\_r1.txt”, and the  $cp_e$  table is stored in the file “cpe\_SF16\_NS16\_BL261\_r1.txt”<sup>10</sup>. The table entities within the files are oriented in  $BS/2$  rows and 4 columns. The row number thus directly related to the first dimensional table indexes,  $l_a$  and  $l_e$ . Each of the complex values  $cp()$  can be represented as a phasor with amplitude and angle. The ASCII file contains the angle values (as radian) of the phasor with unity amplitude. The full relationship between a loaded ASCII file table,  $T[l, j]$ , and a signature table  $cp()$  becomes:

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

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

<sup>10</sup> 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 § A5-2.5, are found in the ASCII text files “cpa\_SF16\_NS16\_BL261\_r1.txt” and “cpe\_SF16\_NS16\_BL261\_r1.txt” respectively. These embedded files are not subject to IP restrictions.



CPA\_SF16\_NS16\_BL261\_r1.txt

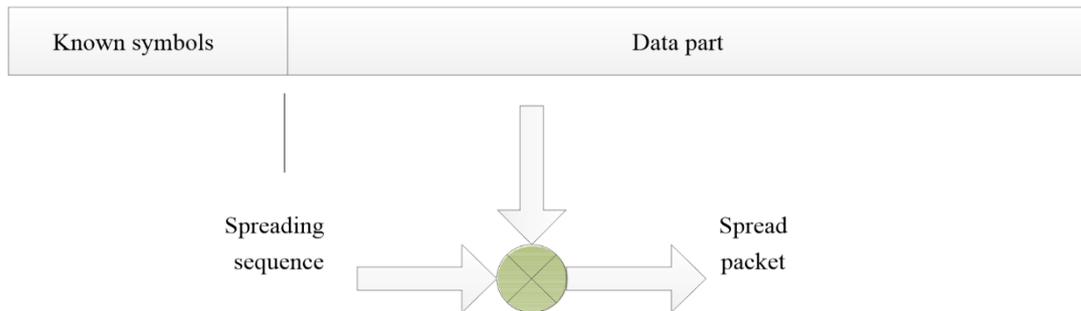


CPE\_SF16\_NS16\_BL261\_r1.txt

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

FIGURE 48

**Proposed spreading in the continuous phase modulation**



M.2092-48

### A5-2.5.2 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 62. 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 62  
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.

#### A5-2.6 Baseband shaping and quadrature modulation

For baseband shaping of symbols, see Annex 2.

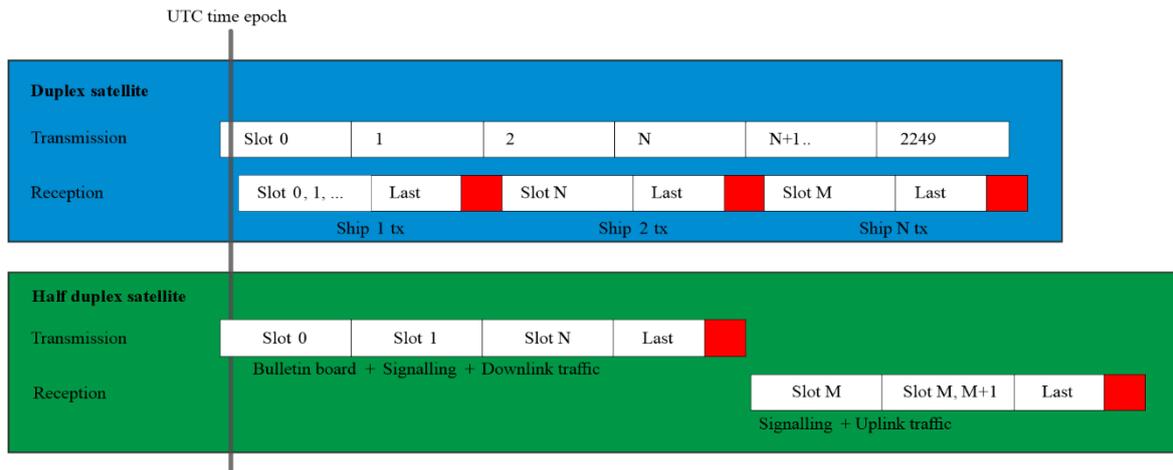
#### A5-2.7 Transmission timing accuracy

For transmission accuracy figures, see Annex 2.

#### A5-2.8 Half duplex and full duplex satellites

The system can be configured for both half and full duplex satellites as shown in Fig. 49.

FIGURE 49  
Half-duplex and full duplex satellite operation



M.2092-49

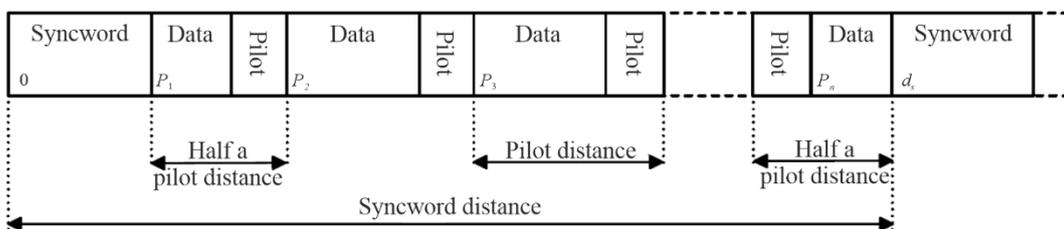
**A5-2.9 Frame structure**

For frame and transmission burst structure, see Annex 2.

**A5-2.10 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  $\frac{(1+j)}{\sqrt{2}}$ . For waveforms utilising direct sequence spreading, the pilot symbols shall have a bit value of “1” before spreading. After spreading, the pilot symbols will utilise the same modulation as the rest of the waveform. A generalized burst structure containing both uniformly repetitive syncword and regularly distributed single pilot symbols is visualised in Fig. 50.

FIGURE 50  
General PL burst structure with repetitive sync word and distributed single pilot symbols



M.2092-50

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 50 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. 50. 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 is 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  $\pi/4$ -QPSK, 8-PSK and 16-QAM modulation, the syncword is  $\pi/4$  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 § A2-1.2.9, 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  $\pi/4$  QPSK modulated PL burst waveforms, single pilot symbols located at odd symbol position indexes are phase offset by  $\pi/4$  from the nominal QPSK symbol constellation points as all other odd symbol positioned symbols in the actual burst.

#### **A5-2.11 Forward error correction and interleaving**

For forward error correction and interleaving, see Annex 2.

#### **A5-2.12 VHF data exchange-satellite link configuration formats**

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

#### **A5-2.13 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  $M \times N$  matrix and read out by column after accomplished first row and then column permutations. The row and column permutations are given by:

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

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

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 63.

TABLE 63

**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

### A5-3 Link layer

#### A5-3.1 Link layer definitions

##### A5-3.1.1 Physical channel

A physical channel is defined by a frequency and bandwidth.

##### A5-3.1.2 Channel pair

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

##### A5-3.1.3 Logical channel

Logical channels define functions for a set of continuous slots.

##### A5-3.1.4 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. 52.

### **A5-3.1.5 Bulletin board**

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

### **A5-3.1.6 Short data message**

The short data message refers to the data transfer protocol used for transmission of the payload in a single burst on RAC or ASC channel.

### **A5-3.1.7 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.

### **A5-3.1.8 Data fragment**

During a data session, the data may be broken into multiple data fragments to be transmitted in separate bursts. The data fragments refer to the start fragment, continuation fragment and end fragment VDE messages. See § A5-3.10.7 to § A5-3.10.9.

### **A5-3.1.9 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 § A5-3.10.2).

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 § A5-3.10.2).

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

### **A5-3.1.10 Paging**

The satellite may utilise paging to query if a ship station is in range and what its terminal capabilities are.

## **A5-3.2 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. When transmitting a short data message (with acknowledgment), neither satellites nor ship stations may initiate a new short data message until an acknowledgment is received or a timeout occurs.

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.

### **A5-3.3 Endianness**

See § A4-4.5.

### **A5-3.4 Data structures**

See § A4-4.6.

### **A5-3.5 Slot functions**

#### **A5-3.5.1 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.

#### **A5-3.5.2 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.

#### **A5-3.5.3 Data acknowledgement signalling channel**

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

#### **A5-3.5.4 Random access channel**

The uplink RAC is used for resource request, paging response and short data messages. Link ID 20 should always be used by default. If the satellite also supports additional Link IDs (as indicated in the Media Access Control message), short data messages may be transmitted with the additional Link IDs.

#### **A5-3.5.5 Data up or down channel**

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

#### **A5-3.5.6 Empty channel**

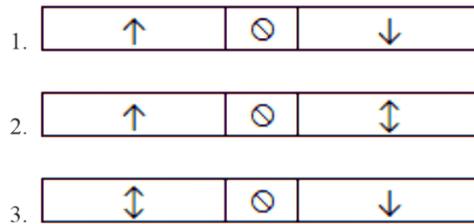
As overlapping bandwidths are feasible, by assigning a channel as not used, it can indicate when a channel should not interfere with other channels.

### A5-3.6 Guard slot

When the satellite switches from uplink to downlink (see § A5-2.1.1), 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. 51.

- 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 51  
Use of guard slot



M.2092-51

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.

### A5-3.7 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 64.

TABLE 64

## 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

## Lower band

## Upper band

Channel No.	1024	1084	1025	1085	1026	1086		2024	2084	2025	2085	2026	2086
Uplink	E		C		A			F		D		B	
Downlink	D				B			C				A	
	F							E					

The VDE slotmap for channel pairs A and B are illustrated in Fig. 52. 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 52

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	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	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	2
Size in slots		90	30	90	90	90	90	30	30	179	1	

M.2092-52

The slotmap for the remaining channel pairs C to F are illustrated in Fig. 53. Note that the first two logical channels are marked as not used, as these would overlap with SBB and resource allocation messages.

FIGURE 53

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

Channel types		Channel direction	
BBSC	Bulletin boarding signalling channel	↓	Downlink
RAC	Random access signalling channel	↑	Uplink
ASC	Announcement signalling channel	↕	Uplink or downlink
DSCH	Data acknowledgment signalling channel	⊘	Do not use
DC	Data up or down channel		
GS	Guard slot		
EMPTY	Empty		

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	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	2
Size in slots	90	30	90	90	90	90	30	30	179	1	

M.2092-53

### A5-3.8 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. 54). 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 54

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

M.2092-54

## A5-3.9 VHF data exchange-satellite message summary

TABLE 65

## VHF data exchange-satellite 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 addressed message acknowledgement	Acknowledgement or negative-acknowledgement of uplink data fragments for addressed messages.	ASC
14	Downlink short data message (with ACK)	Short data message to ship that requires acknowledgement.	ASC
16	Downlink short data message (without ACK)	Short data message to ship with no acknowledgement.	ASC
20	Resource request	Request resource from ship.	RAC
21	Paging response	Paging response.	RAC
23	Uplink short data message (without ACK)	Short data message from ship with no acknowledgement.	RAC
24, 25, 26, 27, 28	Uplink short data message (without ACK)	5 bytes of data to satellite pre-configured destinations.	RAC
29	Downlink addressed message 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
33	Uplink short data message (with ACK)	Short data message from ship with acknowledgement.	RAC
34	Uplink short data message Acknowledgement	Acknowledgement of uplink short data messages.	ASC
35	Padding byte	Byte used for padding.	BBSC, ASC, RAC, DSCH, DC
36	Downlink short data message Acknowledgement	Acknowledgement of downlink short data messages.	RAC

TABLE 65 (*end*)

Type	Name	Description	Slot function
37	Variable length uplink short data message (with ACK)	Short data message from ship with acknowledgement with a variable length payload.	RAC
38	Variable length uplink short data message (without ACK)	Short data message from ship with no acknowledgement with a variable length payload.	RAC

### A5-3.10VHF data exchange-satellite message descriptions

#### A5-3.10.1 Satellite bulletin board

TABLE 66

#### 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. Rec. ITU-R M.2092 version compatibility; Value 1 = M.2092-1; Value 2 = M.2092-2. 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 message 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.
13	6	Digital Certificate Fingerprint	Refer § A4-4.15

TABLE 67

## 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 Rec. ITU-R M.1084. Channel bandwidth is not according to Rec. 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 $15 \times 15=225$ 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.

TABLE 67 (end)

Field No.	Size (bytes)	Function	Content
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.
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 Rec. 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 $15 \times 15 = 225$ 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 68

## 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.

TABLE 68 (end)

Field No.	Size (bytes)	Function	Content
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.
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 $15 \times 15 = 225$ 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, 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 $15 \times 15 = 225$ 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, 2, 3, 5, 5. See "SBB Fragment 2" for more details.

TABLE 69

## 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.
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 $15 \times 15 = 225$ 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, 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.

TABLE 69 (*end*)**Satellite bulletin board (Fragment 4)**

Field No.	Size (bytes)	Function	Content
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 $15 \times 15 = 225$ 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 70

**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 § A4-4.15.

TABLE 71

**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 § A4-4.15.

## A5-3.10.2 Media access control

TABLE 72  
Media access control

Field No.	Size (bytes)	Function	Content
1	1	Type	Type = 10.
2	2	Payload size	Fixed of fields 3 to 12. Payload size = 11.
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 short data messages allowed. 255: No accesses allowed; system busy.
7	1	Random selection interval	In multiple of 15 slots. e.g. = 12 ( $12 \times 15 = 180$ 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 $\times$ 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.
12	1	Additional Link ID on RAC	Additional Link IDs supported by the satellite on RAC, in addition to Link ID 20. Bits are set to enable a Link ID. Bit 0: Link ID 21 Bit 1: Link ID 22 Bit 2: Link ID 23 Bit 3: Link ID 24 Bit 4 to 7: Reserved for future use. Default: 0 (No additional Link ID supported by the satellite)

## A5-3.10.3 Paging

TABLE 73

## 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 § A1-2.4.
4	4	Ship 2 Station ID	The Unique Identifier of the receiving station, as described in § A1-2.4. Set to 0 when empty.
5	4	Ship 3 Station ID	The Unique Identifier of the receiving station, as described in § A1-2.4. Set to 0 when empty.
6	4	Ship 4 Station ID	The Unique Identifier of the receiving station, as described in § A1-2.4. Set to 0 when empty.
7	4	Ship 5 Station ID	The Unique Identifier of the receiving station, as described in § A1-2.4. Set to 0 when empty.
8	4	Ship 6 Station ID	The Unique Identifier of the receiving station, as described in § A1-2.4. Set to 0 when empty.
9	4	Ship 7 Station ID	The Unique Identifier of the receiving station, as described in § A1-2.4. Set to 0 when empty.
10	4	Ship 8 Station ID	The Unique Identifier of the receiving station, as described in § A1-2.4. Set to 0 when empty.

## A5-3.10.4 Paging response

TABLE 74  
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 § A1-2.4.
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 the simplified VDES (refer to § A1-2.7).
4	1	Downlink ASC CQI	Received channel quality indicator averaged over the last VDE-SAT sub-frame received as defined in § A2-1.2.8.

## A5-3.10.5 Resource request

TABLE 75  
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 § A1-2.4.
3	1	Satellite ID	Destination satellite ID. 0-255.
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 § A2-1.2.8.
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.

**A5-3.10.6 Resource allocation**

TABLE 76  
**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 § A1-2.4. 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	Assigned session ID.
7	1	Uplink link CQI 1	Received Channel Quality Indicator as defined in § A2-1.2.8.
8	4	Ship Station ID 2	The Unique Identifier of the ship station, as described in §A1- 2.4. 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 § A2-1.2.8.
13	4	Ship Station ID 3	The Unique Identifier of the ship station, as described in § A1-2.4. 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 § A2-1.2.8.
18	4	Ship Station ID 4	The Unique Identifier of the ship station, as described in § A1-2.4. 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 § A2-1.2.8

**A5-3.10.7 Start fragment**

Data transfers which are not short data messages, use start, continuation and end fragment messages as described in § A5-3.10.7, § A5-3.10.8 and § A5-3.10.9. A start fragment is always sent in a VDE-SAT data session. 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 77

**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 ID	The Unique Identifier of the source station, as described in § A1-2.4, and § A5-3.1.9.
4	1	Satellite ID	Satellite ID. 0-255.
5	1	Session ID	1-255.
6	4	Destination ID	The Unique Identifier of the destination station, as described in § A1-2.4, and § A5-3.1.9. Set to 0 for broadcast.
7	2	Remaining fragments	The number of remaining fragments in this VDE-SAT data session. Valid range 0-65535.
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.

**A5-3.10.8 Continuation fragment**

TABLE 78

**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 ID	The Unique Identifier of the source station, as described in § A1-2.4, and § A5-3.1.9.
4	1	Satellite ID	Satellite ID. 0-255.
5	1	Session ID	1-255
6	4	Destination ID	The Unique Identifier of the destination station, as described in § A1-2.4, and § A5-3.1.9. Set to 0 for broadcast.

TABLE 78 (*end*)

Field No.	Size (bytes)	Function	Content
7	2	Fragment number	Fragment number in this VDE-SAT data session. First continuation fragment should start at 1, increment with any additional fragment. Valid range 1-65534.
8	Variable	Payload	

**A5-3.10.9 End fragment**

TABLE 79

**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 ID	The Unique Identifier of the source station, as described in § A1-2.4, and § A5-3.1.9.
4	1	Satellite ID	Satellite ID. 0-255.
5	1	Session ID	1-255
6	4	Destination ID	The Unique Identifier of the destination station, as described in § A1-2.4, and § A5-3.1.9. Set to 0 for broadcast.
7	2	Fragment number	The last fragment number in this VDE-SAT data session. Valid range 1-65535.
8	Variable	Payload	

**A5-3.10.10 Downlink acknowledgement**

TABLE 80

**Downlink acknowledgement for addressed messages**

Field No.	Size (bytes)	Function	Content
1	1	Type	Type = 29
2	1	Satellite ID	Satellite ID. 0-255.
3	4	Ship station ID	The Unique Identifier of the ship station, as described in § A1-2.4.
4	1	Downlink CQI	Received Channel Quality Indicator averaged over the last VDE-SAT sub-frame received as defined in § A2-1.2.8.

TABLE 80 (*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.

TABLE 81

**Downlink acknowledgement for short data messages**

Field No.	Size (bytes)	Function	Content
1	1	Type	Type = 36
2	1	Satellite ID	Satellite ID. 0-255.
3	4	Ship station ID	The Unique Identifier of the ship station, as described in § A1-2.4.
4	1	Ship NACK flag	Received short data message sets to 0.

## A5-3.10.11 Uplink acknowledgement

TABLE 82

## 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 § A1-2.4.
4	1	Session ID	1-255.
5	1	Resource allocation	re-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 § A2-1.2.8.
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.
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. The mask works like a 200 bits long shift register, with the most significant bit of the first byte representing the oldest allocated burst, and the least significant bit of the last byte the most recent allocated burst. Bits representing bursts before allocation started shall be set to one. 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 83

**Uplink acknowledgement for short data 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 data message sets to 0.
6	4	Ship 2 Station ID	Set to 0 when empty.
7	1	Ship 2 NACK flag	Received short data message sets to 0.
8	4	Ship 3 Station ID	Set to 0 when empty.
9	1	Ship 3 NACK flag	Received short data message sets to 0.
10	4	Ship 4 Station ID	Set to 0 when empty.
11	1	Ship 4 NACK flag	Received short data message sets to 0.
12	4	Ship 5 Station ID	Set to 0 when empty.
13	1	Ship 5 NACK flag	Received short data message sets to 0.
14	4	Ship 6 Station ID	Set to 0 when empty.
15	1	Ship 6 NACK flag	Received short data message sets to 0.

Note: Used for the ACK of uplink short data messages.

**A5-3.10.12 Downlink short data message (with acknowledgement)**

TABLE 84

**Downlink short data 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 § A1-2.4.
6	Variable	Payload	Binary data.

**A5-3.10.13 Downlink short data message (without acknowledgement)**

TABLE 85

**Downlink short data 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 § A1-2.4.
6	Variable	Payload	Binary data.

**A5-3.10.14 Uplink short data message (with acknowledgement)**

TABLE 86

**Uplink short data 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 § A1-2.4.
3	4	Destination ID	The Unique Identifier of the destination station, as described in § A1-2.4.
4	1	Data	Binary data.

**A5-3.10.15 Uplink short data message (without acknowledgement)**

TABLE 87

**Uplink short data 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 § A1-2.4.
3	4	Destination ID	The Unique Identifier of the destination station, as described in § A1-2.4.
4	1	Data	Binary data.

**A5-3.10.16 Uplink short data message (without acknowledgement and destination identification)**

TABLE 88

**Uplink short data 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 § A1-2.4.
3	5	Data	Binary data.

**A5-3.10.17 Padding byte**

TABLE 89

**Padding byte**

Field No.	Size (bytes)	Function	Content
1	1	Type	Type = 35.

Padding byte used to fill the fragment to the required size.

**A5-3.10.18 Variable length uplink short data message (with acknowledgement)**

TABLE 90

**Variable length uplink short data message (with acknowledgement)**

Field No.	Size (bytes)	Function	Content
1	1	Type	Type = 37
2	2	Payload size	Size of fields 3 to 5.
3	4	Ship station ID	The Unique Identifier of the source station, as described in § A1-2.4.
4	4	Destination station ID	The Unique Identifier of the destination station, as described in § A1-2.4.
5	Variable	Payload	

Note: Only to be used when the satellite supports an additional Link ID on RAC.

**A5-3.10.19 Variable length uplink short data message (without acknowledgement)**

TABLE 91

**Variable length uplink short data message (without acknowledgement)**

Field No.	Size (bytes)	Function	Content
1	1	Type	Type = 38
2	2	Payload size	Size of fields 3 to 5.
3	4	Ship station ID	The Unique Identifier of the source station, as described in § A1-2.4.
4	4	Destination station ID	The Unique Identifier of the destination station, as described in § A1-2.4.
5	Variable	Payload	

Note – Only to be used when the satellite supports an additional Link ID on RAC.

**A5-3.11 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.

**A5-3.12 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 bursts, referencing the fragments transmitted during the previous VDE-SAT sub-frames.

Each ACK/NACK bit represents an allocated burst, regardless of if a fragment is transmitted or not. It is the responsibility of the ship station to keep track of what fragment was transmitted in each burst position. The size of each burst depends on the link ID used, so the number of ACK/NACK mask bits per VDE-SAT sub-frame depends on the DC size and link ID used.

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 allocated burst, 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 allocated bursts, the ship station shall retransmit all not-acknowledged fragments as long as uplink resources are allocated to it.

### **A5-3.13 Data transfer protocol details**

Detailed protocol diagrams for VDE-SAT are provided in § A5-3.13.1 through § A5-3.13.8.

Addressed data transfers are from a source ID to a destination 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 ID. The source ID is also used for sending an answer back to it.

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

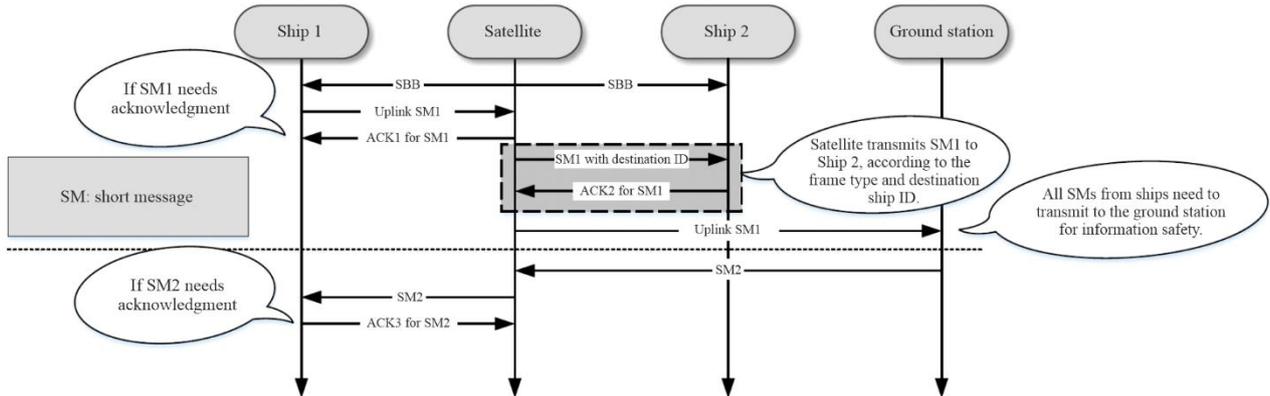
For an uplink addressed transfer from a ship to a destination station, the ship station ID is part of the resource request (see § A5-3.10.5), and the destination ID is given as the destination ID in the start, continuation and end fragments.

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 ID is given as the source ID in the start, continuation and end fragments.

Two examples of a data transfer process are illustrated in Figs 55 and 56. Additional considerations on the two examples are provided in the enumerated list below the two Figures.

FIGURE 55

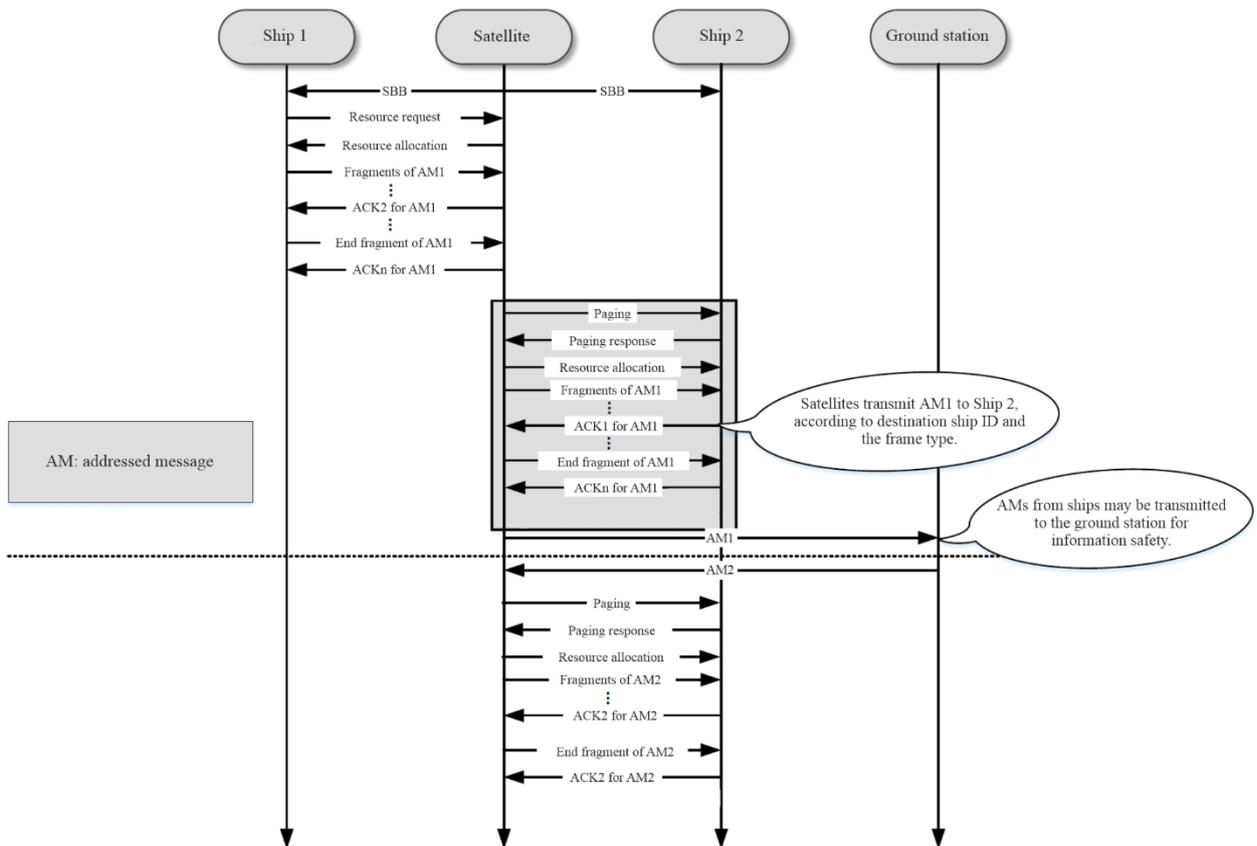
Example of a short data messages transfer process in VHF data exchange system-satellite



M.2092-55

FIGURE 56

Example of an addressed messages transfer process in VHF data exchange system-satellite



M.2092-56

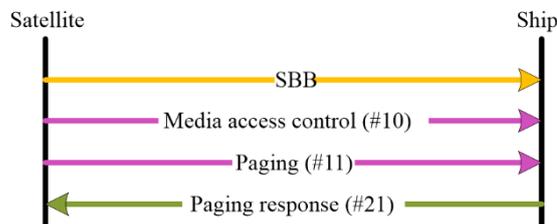
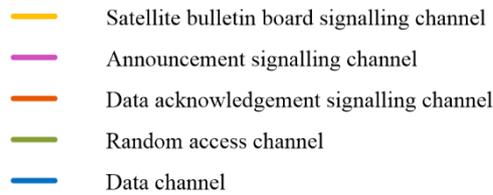
- 1) Short data messages may use ACK or not, while addressed messages always use ACK.
- 2) Short/addressed data messages may support the service from one ship to another via satellite.
- 3) Short/addressed data messages may originate from the ground station.

- 4) All short/addressed data messages from ships may be transmitted to ground stations for information safety.
- 5) Short and addressed messages from one ship to another use two transfer processes, ship to satellite and satellite to ship.
- 6) For addressed messages, there is only one ship and one satellite in every data session.

**A5-3.13.1 Paging**

FIGURE 57

**Paging**

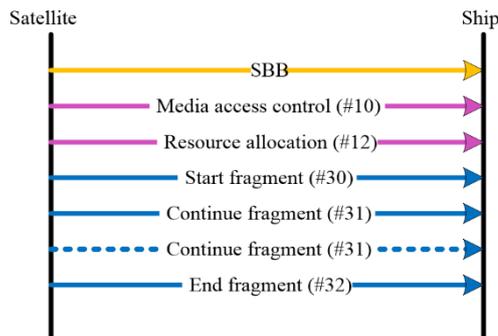
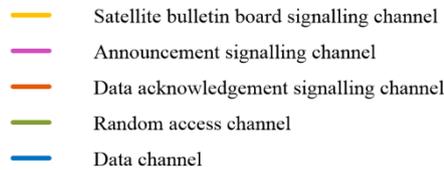


M.2092-57

**A5-3.13.2 Satellite originated broadcast**

FIGURE 58

**Satellite originated broadcast**

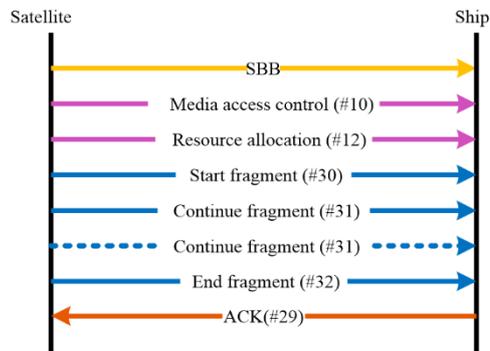


M.2092-58

A5-3.13.3 Satellite to ship addressed message

FIGURE 59  
Satellite to ship addressed message

- Satellite bulletin board signalling channel
- Announcement signalling channel
- Data acknowledgement signalling channel
- Random access channel
- Data channel

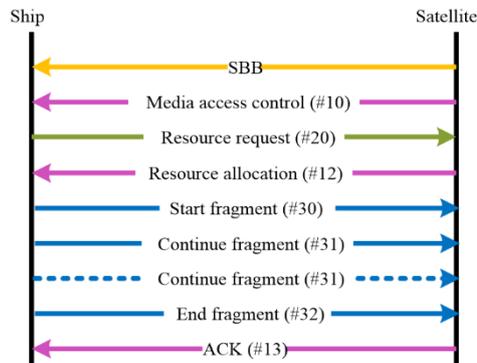


M.2092-59

A5-3.13.4 Ship to satellite addressed message

FIGURE 60  
Ship to satellite addressed message

- Satellite bulletin board signalling channel
- Announcement signalling channel
- Data acknowledgement signalling channel
- Random access channel
- Data channel



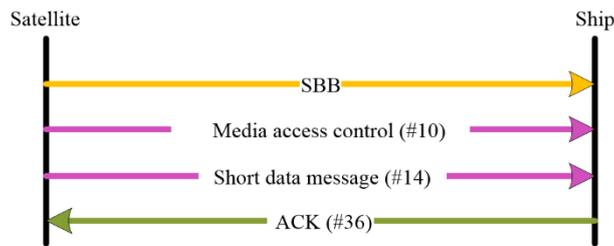
M.2092-60

**A5-3.13.5 Satellite to ship short data message (with acknowledgement)**

FIGURE 61

**Satellite to ship short data message (with acknowledgement)**

- Satellite bulletin board signalling channel
- Announcement signalling channel
- Data acknowledgement signalling channel
- Random access channel
- Data channel



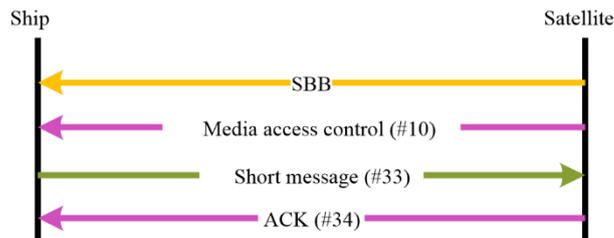
M.2092-61

**A5-3.13.6 Ship to satellite short data message (with acknowledgement)**

FIGURE 62

**Ship to satellite short data message (with acknowledgement)**

- Satellite bulletin board signalling channel
- Announcement signalling channel
- Data acknowledgement signalling channel
- Random access channel
- Data channel

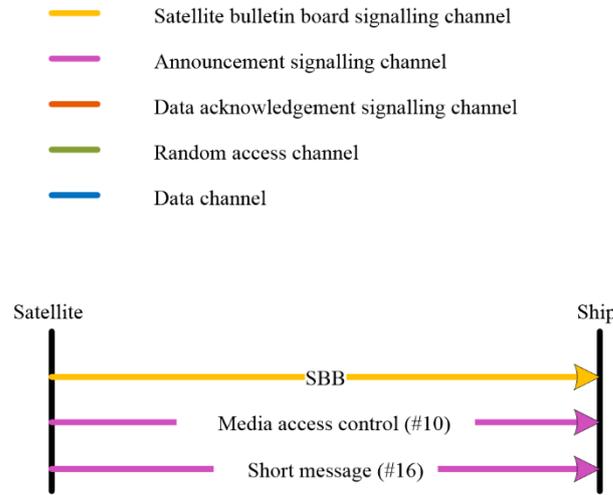


M.2092-62

**A5-3.13.7 Satellite to ship short data message (no acknowledgement)**

FIGURE 63

**Satellite to ship short data message (no acknowledgement)**

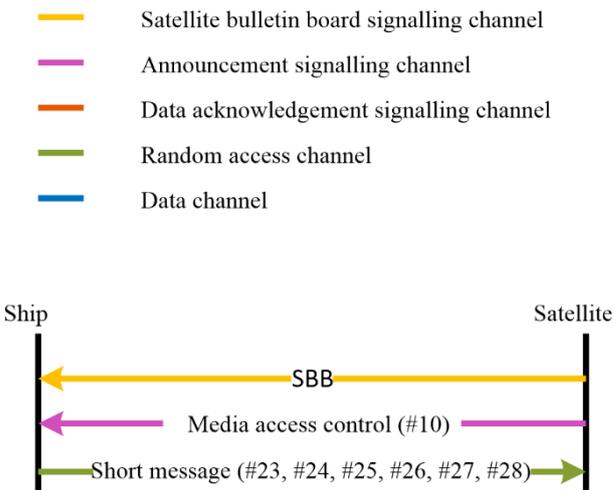


M.2092-63

**A5-3.13.8 Ship to satellite short data message (no acknowledgement)**

FIGURE 64

**Ship to satellite short data message (no acknowledgement)**



M.2092-64

**A5-3.14 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.

#### **A5-3.15 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).

#### **A5-3.16 Adaptive coding and modulation/rate adaptation**

See § A4-5.

#### **A5-4 Segmentation of VHF data exchange-satellite payload**

See § A4-4.30.

#### **A5-5 Network layer**

See § A4-5.

#### **A5-6 Transport layer**

See § A4-6.

#### **A5-7 Presentation Layer**

See § A4-7.

## **Annex 6**

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

#### TABLE OF CONTENTS

	<i>Page</i>
A6-1 Introduction .....	155
A6-2 VHF data exchange system resource sharing principles .....	155

A6-2.1 Automatic identification system priority .....	155
A6-2.2 Coordination between application specific message and VHF data exchange...	155
A6-2.3 Shore station VHF data exchange system control area .....	155
A6-3 VHF data exchange-terrestrial resource sharing between multiple controlling shore stations .....	156
A6-4 VHF data exchange-terrestrial and VHF data exchange-satellite resource sharing .....	156
A6-5 Sharing between different VHF data exchange-satellite systems .....	157

## **A6-1 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.

## **A6-2 VHF data exchange system resource sharing principles**

### **A6-2.1 Automatic identification system priority**

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

### **A6-2.2 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.

### **A6-2.3 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.

### A6-3 VHF data exchange-terrestrial resource sharing between multiple controlling shore stations

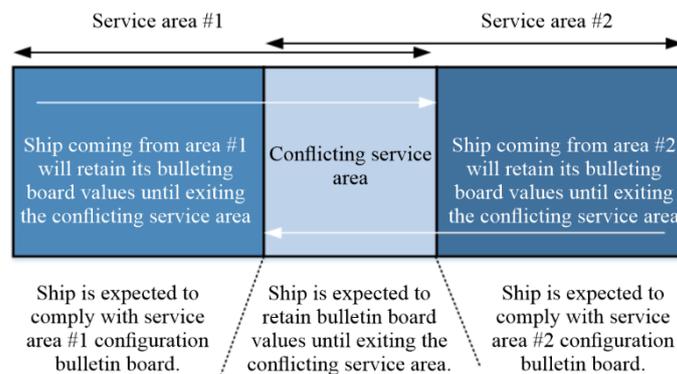
The allocation of frequency and time slots used for the bulletin board announcement should be coordinated between controlling stations. Other resource assignments are managed based on the content of the bulletin board and announcement signalling channels. The assignment may change dynamically (according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

There are dedicated resources that are assigned to the terrestrial bulletin board and announcement signalling 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 signalling 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 area, 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. 65.

FIGURE 65  
Expected behaviour of VHF data exchange system units in conflicting service areas



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### A6-4 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 § A1-2.1.

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 § A1-2.1.

#### **A6-5 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.

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