



Annex 3 - VDE-Terrestrial specific

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Annex 3 shall contain the general information suitable for- ITU-R M.VDES-0.

Overall Document structure

Annex 1 VDES Operation

Annex 2 (ASM)

Annex 3 (VDE-TER)

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Annex 4 (VDE-SAT-Downlink)

Annex 5 (VDE-SAT-Uplink)

Annex 6 TER-SAT sharing

ParticipantsReview/working group:

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Hans Haugli (EFTA) - Synchronisation (Preamble, postamble?) + Physical Layer Header

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Krysztof Bronk, - scrambling, Synchronisation (Preamble, postamble?) + Physical Layer Header

Schedule:

First followup March 2nd

Input for ENAV16 ready well before ENAV16, date TBD.

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IALA Working Document

Table of Contents

1.1	Structure of the VDE.....	6
1.2	VHF data exchange system channel usage in accordance with RR Appendix 18.....	6
1.2.1	5.1.1 VHF data exchange system data exchange between terrestrial stations.....	6
2	OSI Layer (from Annex 2).....	8
2.1	Transport layer.....	9
2.1.1	Network layer.....	9
2.1.2	Link layer.....	9
2.1.3	Physical layer	9
3	Physical layer (Ship/Shore)	10
3.1	Parameters.....	10
3.2	General.....	10
3.3	Transmission media.....	10
3.4	Multi-channel operation	10
3.4.1	Ship to ship communication uses the VDE1-B spectrum in a simplex mode	10
3.4.2	Ship to shore communication uses the VDE1-A spectrum for transmission and VDE1-B spectrum for reception. Shore to ship communication uses the VDE1-B spectrum for transmission and VDE1-A and VDE1-B spectrum for reception.....	10
3.5	Transceiver characteristics.....	10
3.5.1	Transmit power.....	10
3.5.2	Spectral mask, Emission Assumptions.....	10
3.6	17
3.6.1	Carrier Frequency error.....	17
3.6.2	Symbol timing accuracy	17
3.6.3	Transmitter Timing Jitter.....	17
3.6.4	Slot Transmission Accuracy.....	17
3.7	Bit rates.....	17
3.8	Adaptive modulation and coding scheme mechanisms	17
3.8.1	Training sequence.....	17
3.9	The slot time duration should be the same regardless of the MCS chosen in the particular case. 18	
3.10	Data encoding (Bit-to-symbol mapping).....	18
3.11	Forward error correction -DLR to provide more input	19
3.11.1	Signalling FEC	19
3.11.2	Data packet FEC Turbo for example 3 GPP, CCSDS.....	19
3.11.3	Performance measure, Packet error ratio (1e-1, 1e-2 with ARQ, 1e-3).....	19
3.12	Interleaving (multi-packet) -DLR input and ESA.....	19
3.13	Synchronisation (Preamble, postamble?) + Physical Layer Header.....	19
3.14	Bit scrambling.....	19
3.14.1	Data link sensing.....	20
3.14.2	Transmitter power	20

3.14.3	Shutdown procedure.....	20
3.15	Link budget analysis.....	23
3.15.1	Assumed parameters.....	23
3.15.2	Range vs throughput.....	23
3.17	Framing Structure (similar to AIS + extensions)	24
3.17.1	VDES Slots (Signalling packet size).....	25
3.17.2	Data transfer packet size	26
3.18	Modulation	26
3.18.1	Channel Bandwidth.....	26
3.18.2	Symbol rates	26
4	Link layer.....	28
4.1	MAC layer (Media access control)	28
4.1.1	Base station media access.....	28
4.1.2	Ship-ship media access.....	28
4.1.3	Ship-shore media access	28
4.1.4	Channel access schemes	29
4.1.5	Incremental time division multiple access.....	29
4.1.6	Carrier sense time division multiple access.....	29
4.1.7	Random access time division multiple access	29
4.1.8	Random access time division multiple access algorithm	29
4.1.9	Fixed access time division multiple access.....	29
4.1.10	Fixed access time division multiple access algorithm.....	29
4.1.11	Fixed access time division multiple access parameters	30
4.1.12	Broadcast	30
4.1.13	Assignement (resoure allocation)	30
4.1.14	Slotted ALOHA random access	30
4.1.15	Multipacket transfer	30
4.2	Signalling (control) protocol (VDE Base station) – Hans input.....	30
4.3	Data transfer protocol	30
4.4	Automati Repeat Request	30
5	Link layer – JRC,HANS,Others?	30
5.1	Packet format signalling	30
5.2	Packet format data transfer	30
5.2.1	Cyclic redundancy check.....	30
5.2.2	Encapsulation (e.g Packet ID,)	30
6	Transport layer.....	31
6.1.1	Transmit (minimum) antenna gain (Antenna Pattern).....	35
6.1.2	Range (min and max).....	35
7	1 Introduction	35
8	2 Ship-to-shore application	36
8.1	2.1 Basis for the coverage assessment	36

8.2	2.2 Purpose for use of the Recommendation ITU-R P.1546-4 propagation curve	36
8.3	2.3 Determination of transmitting/base antenna height, h_1	36
8.4	2.4 Determination of the minimum field strength (sensitivity threshold) at the VHF data exchange base receiving site	36
8.5	2.5 Determine the range to the +10.1 dBu (-103 dBm) coverage limit for a seawater propagation path	37
8.6	2.6 Determine the seaward ship-to-shore coverage range from Figure 13	37
8.7	2.7 Determine the received signal strength indication values for various other ranges	37
9	3 Shore-to-ship application	39
9.1	3.1 Basis for the coverage assessment	39
9.1.1	3.1.1 Determination of the minimum field strength (sensitivity threshold) at the VHF data exchange ship receiving site	39
9.1.2	3.1.2 Determine the range to the +21.3 dBu (-98 dBm) coverage limit for a seawater propagation path	39
9.1.3	3.1.3 Determine the seaward shore-to-ship coverage range from Figure 14	40
9.1.4	3.1.4 Determine the received signal strength indication values for various other ranges	40
9.1.5	Receive antenna gain.....	43
9.1.6	Receive noise floor	43
9.1.7	Link C/N0.....	43
9.1.8	Source of Self Interference (assumptions about the interference)	43
9.1.9	Received signal to noise plus Interference level.....	43

Annex 3

Technical characteristics of VDES-terrestrial in the maritime mobile band

— Structure of the VDE

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1.1 VHF data exchange system channel usage in accordance with RR Appendix 19

1.1.1 5.1.1 VHF data exchange system data exchange between terrestrial stations

VDEI-A lower legs (channels 1024, 1084, 1025, 1085) are ship-to-shore VDE.

VDEI-B upper legs (channels 2024, 2084, 2025, 2085) are shore-to-ship and ship-to-ship VDE.

— Ship to ship

2 OSI Layer -(from Annex 2)

The VDES architecture utilizes the open systems interconnection (OSI) model as illustrated in Figure.

-The first four layers (physical, link, network and transport) are described with-in this recommendation. These layers for the VDE, ASM and AIS sub-systems need to be coordinated. AIS should have the highest priority in the VDES, and all other functions should be organized such that the AIS is not adversely affected.

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FIGURE 4

Application Layer	
Presentation Layer	
Session Layer	
Transport Layer	
Network Layer	
VDE1-A	Link Management Entity (LME) Layer
VDE1-B	Link Management Entity (LME) Layer
Link Management Entity (LME) Layer	Data Link Service (DLS) Layer
Data Link Service (DLS) Layer	Medium Access Control (MAC) Layer
Medium Access Control (MAC) Layer	Physical Layer
Physical Layer	RX(ship/shore?) / TX (shore)
RX (shore)/ TX(ship)	Rx: Receiver Tx: Transmitter

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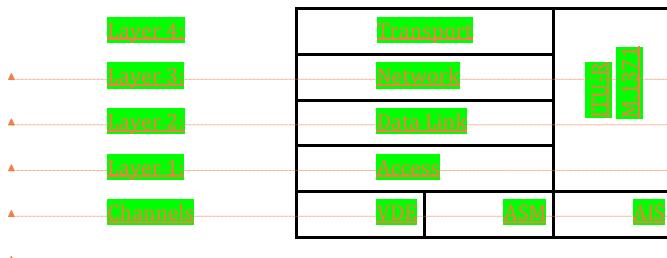
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The VDES architecture should utilize the open systems interconnection layers 1 to 4 (physical layer, link layer, network layer, transport layer) as illustrated in Figure.

FIGURE 1

open systems interconnection layers 1-4



2.1 Transport layer

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

2.1.1 Network layer

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

2.1.2 Link layer

—The link layer orders VDE messages into 8bit bytes for assembly of transmission packets.

1.2.3.2 Data link services

Applies error correction coding, scrambling and interleaving. Calculate CRC and appends to data to complete creation of transmission packets.

1.2.3.3 Media access control

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

2.1.3 Physical layer

Converts binary data into transmission symbols using gray code. Assembles transmission symbols, synchronization, and other overhead symbols to transmission packets. Converts coded transmission packets to appropriate analogue signal for the transmitter according to the selected modulation and channelization scheme.

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3.1 Link Parameters

3.2 General

3.3 Transmission media

Data transmissions are made in the VHF maritime mobile band. Data transmissions are made within the spectrum allocated for VDE1-A and VDE1-B. The spectrum may be used as 25kHz, 50 kHz and 100kHz channels. Additional spectrum may be available for VDE communication on a regional basis.

3.4 Multi-channel operation

3.4.1 Ship to ship communication uses the VDE1-B spectrum in a simplex mode
3.4.2 Ship to shore communication uses the VDE1-A spectrum for transmission

and VDE1-B spectrum for reception
Shore to ship communication uses the VDE1-B spectrum for transmission
and VDE1-A and VDE1-B spectrum for reception

When 25kHz channels are combined to form either a 50kHz or 100kHz bandwidth, the following methodology shall be used ... (bulletin board???)

3.5 Transceiver characteristics

4.1 for the Ship

The maximum peak average power shall not be more than exceed 25W per 100Khz used spectrum at a time. (50 kHz and 100 kHz channel signal may

Insert figures from 1842 or 1371
25kHz as AIS.

Possible Modulation schemes for future considerations

Create table of modulation, and related parameters

GESK

GMSK

Pi/4 DQPSK

QOPSK (Pi/4 QPSK)

QPSK

16APSK 16PSK

64 APSK

4x16QAM

32APSK

32OFDM (multicarrier)

Current Transmission waveforms for VHF data exchange

Bandwidth	25 kHz	25 kHz	50 kHz	100 kHz
Modulation	$\pi/4$ DQPSK	$\pi/8$ DQPSK	16-QAM 3216 multi	16-QAM 32 multi carriers

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			carriers	2.7 kHz spacing
Modulation Category	PSK modulation	PSK modulation	OAM modulation	OAM modulation

3.6

3.6.1 Carrier Frequency error

3ppm (same as AIS, or better)

3.6.2 Symbol timing accuracy

210 ppm

3.6.3 Transmitter Timing Jitter

1% RMS of symbol duration (or may be expressed as 104 microseconds but will need a table based on symbol rate) (may need to be revised)

3.6.4 Slot Transmission Accuracy

UTC Direct operation; 104 Micro sec for a mobile unit

3.7 Bit rates

3.8 Adaptive modulation and coding scheme mechanisms

The VDE terrestrial link should enable the usage of different modulation and coding schemes. This mechanism needs to work in an adaptive and autonomous manner without the necessity of the base station participation in the process.

3.8.1 Training sequence

The particular modulation coding schemes (MCS) should be encoded into the training sequence as follows:

(D ₀ , D ₀ + 1, 0, 1, 1, 0, 1, 1, 1, 0, 0, 0) Modulo 2
(D ₁ , D ₁ + 1, 0, 1, 1, 0, 1, 1, 1, 0, 0, 0) Modulo 2
(D ₂ , D ₂ + 1, 0, 1, 1, 0, 1, 1, 1, 0, 0, 0) Modulo 2
(D ₃ , D ₃ + 1, 0, 1, 1, 0, 1, 1, 1, 0, 0, 0) Modulo 2

Where 1, 0, 1, 1, 0, 1, 1, 0, 0, 0 is a Barker code (length 11) with a very low autocorrelation function (sidelobe level ratio about -20.8 dB). This will maximize the detection probability. [The potential 180 degrees phase error

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may be eliminated for instance with the usage of the start flag (or any known sequence within the header).

Training sequence should be always modulated with the low order

Only the data block should be coded, scrambled and modulated according to the selected MCS scheme. Modulation and coding schemes should be for instance defined according to the given below table.

Commented [PB17]: We need to use this in Annex 2 (no coding on the CRC)

<u>Modulation and coding scheme</u>	<u>D₀, D₁, D₂, D₃ values</u>	<u>CQI value</u>	<u>Total throughput [kbps]*</u>	<u>Total data bitrate (user data + framing overhead) [kbps]</u>
<u>No transmission</u>	<u>0</u>	<u>-</u>	<u>-</u>	<u>-</u>
<u>MCS-1 (GMSK, CR=1/2)</u>	<u>0, 0, 0, 1</u>	<u>1</u>	<u>76,8</u>	<u>38,4</u>
<u>MCS-2 (GMSK, CR=3/4)</u>	<u>0, 0, 1, 0</u>	<u>2</u>	<u>76,8</u>	<u>57,6</u>
<u>MCS-3 (π/4 DQPSK, CR=1/2)</u>	<u>0, 0, 1, 1</u>	<u>3</u>	<u>153,6</u>	<u>76,8</u>
<u>MCS-4 (π/4 DQPSK, CR=3/4)</u>	<u>0, 1, 0, 0</u>	<u>4</u>	<u>153,6</u>	<u>115,2</u>
<u>MCS-5 (8PSK, CR=3/4)</u>	<u>0, 1, 0, 1</u>	<u>5</u>	<u>230,4</u>	<u>172,8</u>
<u>MCS-6 (8PSK, CR=5/6)</u>	<u>0, 1, 1, 0</u>	<u>6</u>	<u>230,4</u>	<u>192</u>
<u>MCS-7 (16QAM SC, CR=3/4)</u>	<u>0, 1, 1, 1</u>	<u>7</u>	<u>307,2</u>	<u>230,4</u>
<u>MCS-8 (16QAM SC, CR=5/6)</u>	<u>1, 0, 0, 0</u>	<u>8</u>	<u>307,2</u>	<u>256</u>
<u>MCS-9 (16QAM 32MC, CR=7/8)</u>	<u>1, 0, 0, 1</u>	<u>9</u>	<u>307,2</u>	<u>268,8</u>
<u>TBD</u>	<u>1, X, X, X</u>	<u>TBD</u>		

*) An assumption: 76,8 ksym/s in 100 kHz bandwidth (Roll-off factor: 0,3)

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Commented [PB19]: This needs to be defined.

CQI (Channel Quality Indicator) values should correspond directly to the combination of the link quality indicators like: BER, MER or even RSSI.

The calculation of the BER should be based on the known sequences within the frame.

CQI calculation may also involve the CRC verification result.

CQI value of the received message should be contained within the ACK/NACK message. This way forsach that the next transmission a-may use a differentnew MCS may be chosen by the link layer (adaptive mechanism). ACK/NACK message need to be alwaysshould be modulated with the low order modulation like GMSK.

The change of the MCS should be initiated by the link layer and the transmission need always toshould start with the MCS 1GMSK. MCS may be dynamically changed during the transmission to maximize the throughput with an assumed target quality level.

3.9 The slot time duration should be the same regardless of the MCS chosen, in the
3.10 Data encoding (Bit-to-symbol mapping)

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26ms(?)

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-Wait for more Krzysztof input

The bit to symbol mapping shall for FSK and GMSK modulations be gray
coded.

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3.11 Forward error correction -DLR to provide more input

The turbo code with the code rate of $\frac{1}{2}$ or lower should be used. Different
code rates will be obtained with the puncturing technique.

Commented [PB22]: Need from Annex 4 and then
harmonized with Annex 2

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3.11.1 Signalling FEC

3.11.2 Data packet FEC for exampleis 3 GPP, CCSDS,

3.11.3 Performance measure. Packet error ratio (1e-1, 1e-2 with ARQ, 1e-3)

3.11.3.1 Channel definition (e.g. AWGN)

Signal to noise ratios thresholds per MODCODS

3.12 Interleaving (multi-packet) -DLR input and ESA

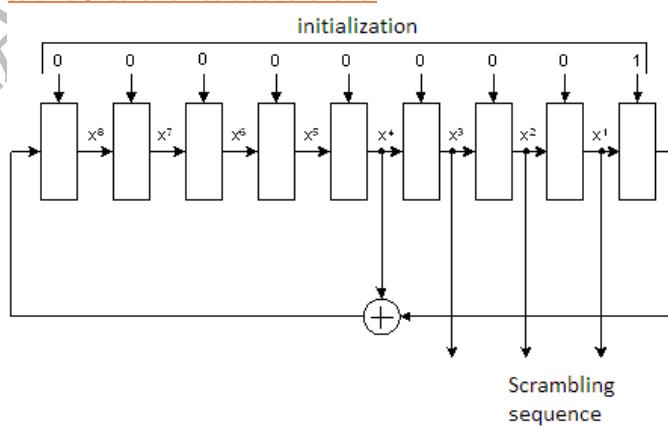
3.13 Synchronisation (Preamble, postamble?) + Pysical Layer Header

-Hans input, Krzysztof input

3.14 Bit scrambling

Scrambling of the user data is required to avoid the power spectral density
to be concentrated in the narrow band.

Scrambler should be based on the linear feedback shift register (LFSR). For
instance it may be defined by the polynomial $x^9 + x^4 + 1$. The scrambling
pseudo-random sequence in this case would be 511 bits long ($2^9 - 1$) and the
scrambler scheme would be as follows:



The scrambling sequence (least significant bits of the register) should be added modulo-two with the data bits obtained after the FEC encoding. The number of bits will depend on the modulation scheme used in the particular case. When the 16QAM modulation is exploited then the last four bits of the register need to be XOR-ed with the four bits creating the 16QAM symbol. For each consecutive symbol the register should be shifted by the number of bits creating the scrambling sequence (i.e. 4 in a case of 16QAM).

Commented [LJ23]: Add table for each modulation scheme that may be defined?

The scrambler should be initialized with the sequence 00000001 for each frame.

3.14.1 Data link sensing

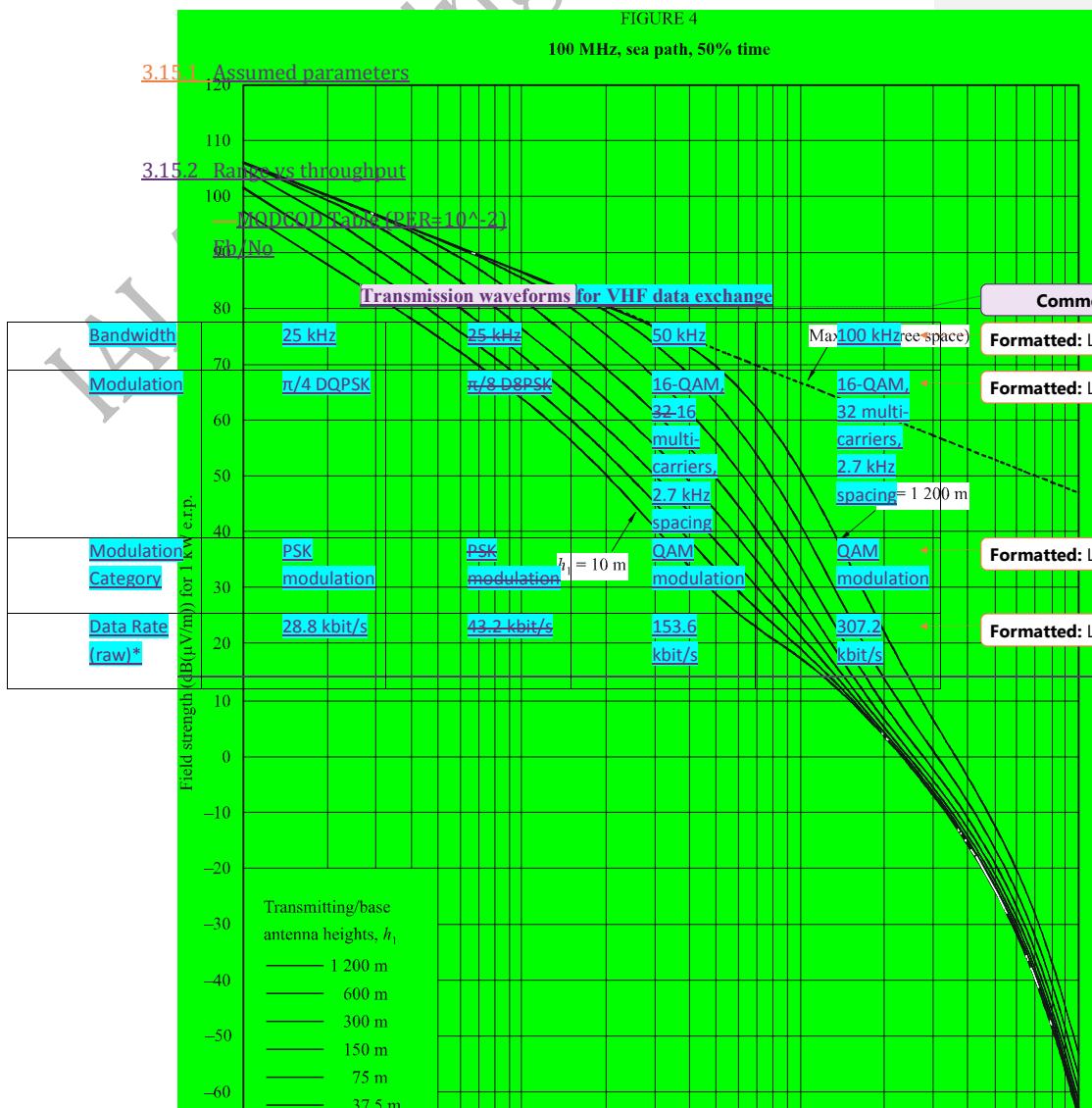
Handled by link layer

3.14.2 Transmitter power

The transmitter may use several power level settings, not to exceed 25W.

3.14.3 Shutdown procedure

The transmitter shall have an automatic shutdown procedure after 1 seconds, to prevent stuck transmitters. The function shall be independent from software control.



Sensitivity**	107 dBm (min) 112 dBm (typical)	107 dBm (min) 112 dBm (typical)	-98 dBm (ships) -103 dBm (base stations)	-98 dBm (ships) -103 dBm (base stations)
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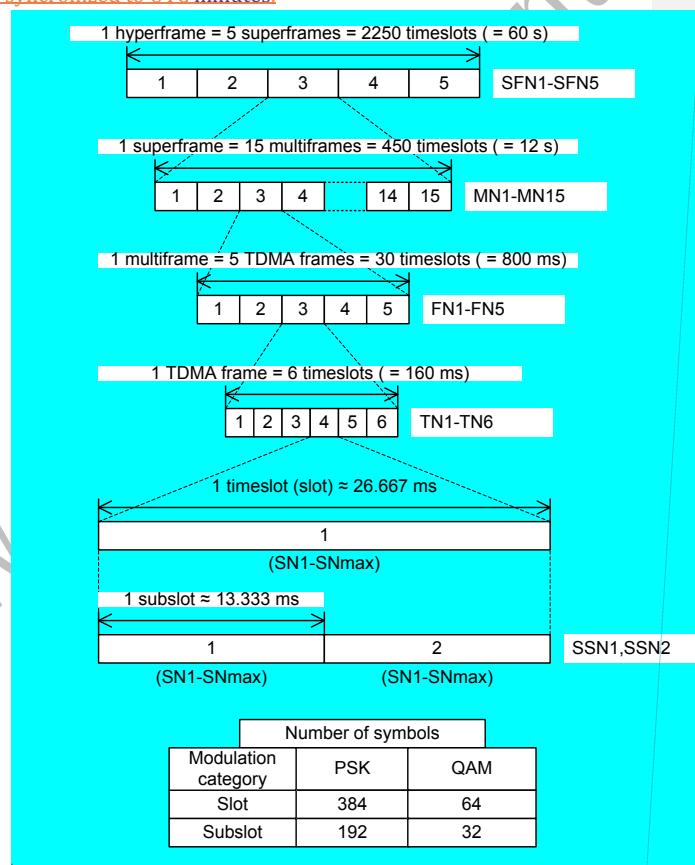
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3.17 **Framing Structure (similar to AIS + extensions)**

VDE communication uses the concept of frames and slots, as defined by R.M.1371, to quantize the communication channel into time segments and should be synchronized to slot boundaries of AIS. A VDE frame is divided into a multitude of 2250 slots. The VDE slot is the minimum addressable time unit of the VDE data link. The VDE frame is in turn part of a VDE superframe, spanning a number of VDE frames. The number of VDE frames shall correspond to the largest addressable VDE Data Link time unit. Each frame is 60s long, synchronized to UTC minutes.

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TDMA frame

Six timeslots should form a TDMA frame. The TDMA frame has duration of 160 ms.

The TDMA frames should be numbered by a Frame Number (FN). The FN should be cyclically numbered from 1 to 5. The FN should be incremented at the end of each TDMA frame.

2.2.2.2 Timeslot numbering

The timeslots within a TDMA frame should be numbered from 1 to 6 and a particular timeslot should be referenced by its Timeslot Number (TN).

Subslot

The timeslots may be divided into 2 subslots. The subslots within a timeslot should be numbered from 1 to 2 and a particular subslot should be referenced by its SubSlot Number (SSN).

2.2.2.4 Multiframe

Five TDMA frames should form a multiframe. The multiframe should have duration of 800 ms.

The multiframe should be numbered by a Multiframe Number (MN). The MN should be cyclically numbered from 1 to 15. The MN should be incremented whenever the TDMA FN returns to 1.

2.2.2.5 Superframe

Fifteen multiframe should form a superframe. The superframe should have duration of 12 s.

The superframes should be numbered by a SuperFrame Number (SFN). The SFN should be cyclically numbered from 1 to 5. The SFN should be incremented whenever the MN returns to 1.

2.2.2.6 Hyperframe

The hyperframe should be the longest recurrent time period of the TDMA structure. Five superframes should form a hyperframe. The hyperframe should have duration of 60 s.

4.9.13.17.1 VDES Slots (Signalling packet size)

The VDE slot is an integer fraction of an AIS slot. The VDE slot size shall therefore be $2/(75 \cdot n)$ seconds, where n is an integer. The slot determines the minimum amount of link load to be occupied by short messages. Short slots allow access to the data link to more actors, and reduces unnecessary large link overhead for short messages. The slot size shall be long enough to fit control channel data amount such as FATDMA reservations and acknowledgements, with the most robust MSC (modulation and coding scheme) available.

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The time slot is a time interval of approximately 26.667 ms ($60000/2250 = 80/3 \approx 26.667$). For PSK modulation, the time slot corresponds to 384 symbol durations, each one with a duration of approximately 69.4 μ s ($(60000000/2250)/384 = 625/9 \approx 69.4$). For QAM modulation, the time slot

is divided into 64 modulation symbol durations, each one with a duration of approximately 416.7 µs ($(60000000/2250)/64 = 1250/3 \approx 416.7$). The timeslots may be subdivided into 2 subslots.

The physical content of a time slot is carried by a burst.

26,67 ms

4.9.23.17.2 Data transfer packet size

The data transfer packet size may vary between depending on the amount of be transmitted. The minimum size is one VDE slot, and the maximum consists of a Fixed at 26,67 ms (UTC synced) or multiple of VDE slots

4.10.0 Krzyżakow has input

3.18.1 Channel Bandwidth

VDE capable systems shall be able to operate on the four 25kHz duplex channels 24.84.25.85, allocated for data communication according to RR Appendix 18.

four 25kHz channels. The 100kHz channel on VDE-B may be divided into two 50kHz channels or four 25kHz channels.

In the case of multiples of 25kHz channels being combined, all spectrum VDE1-A. The corresponding upper set of channels, 2024, 2084, 2025, 2085, are referred to as VDE1-B.

3.18.2 Symbol rateSymbol rates

Bandwidth	25 kHz	50 kHz	100 kHz
Symbol rate			

5.0.0.0

6.0.0 Modulation type

GFSK

GMSK

Pi/4 DQPSK

QPSK (Pi/4 QPSK)

QPSK

16APSK, 16PSK

64 APSK

4x16QAM

32APSK

32OFDM (multicarrier)

Transmission waveforms for VHF data exchange

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404.1 MAC layer (Media access control)

— Media access control
transfers onto the VHF data link (VDL). The method used is a TDMA scheme using a common time reference based on UTC.

4.1.1 Base station media access

Base stations are configured to create fixed FATDMA allocations for periodic transmissions, and will use the control channelling mechanism to pre-allocate additional link access.

4.1.2 Ship-ship media access

4.1.3 Ship-shore media access

To distinguish between ship-to-ship and shore to ship, ship to shore

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schemes (ITDMA, CSTDMA and FATDMA) that are used for VDES are defined in Recommendation ITU-R M.1371-5. This TDMA organization scheme protects the integrity of the AIS and is used in a similar way to organize and synchronize the ASM and VDE transmissions.

To be taken from the existing PDNR version.

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4.1.4 Channel access schemes

The access schemes, as defined below, should coexist and operate simultaneously on the TDMA channel.

4.1.5 Incremental time division multiple access

ITDMA should be used for creation of transmission chains for multi transmission data packets.

4.1.6 Carrier sense time division multiple access

Used for single VDE slot transmissions or as initial transmission when starting ITDMA transmission chain.

4.1.7 Random access time division multiple access

RATDMA is used when a station needs to allocate a slot, which has been pre-announced. This is generally done for the first transmission slot

during data link network entry, or for messages of a non-repeatable character.

4.1.8 Random access time division multiple access algorithm

The RATDMA access scheme should use a probability persistent (p-persistent) algorithm as described in ITU-R M.1371 Annex 7 Section 2.

4.1.9 Fixed access time division multiple access

FATDMA should be used by base stations only. FATDMA allocated slots should be used for repetitive messages, as well to reserve slots for remote targets that has requested to transmit on the VDE1-A channel.

4.1.10 Fixed access time division multiple access algorithm

Access to the data link should be achieved with reference to frame start.

reserving base station. VDE stations (except when using FATDMA) should not use FATDMA reserved slots within this range. FATDMA reservations do not apply beyond 120 nautical miles from the reserving base station. All stations may consider these slots as available.

4.1.11 Fixed access time division multiple access parameters

- Start slot - The first slot (referenced to frame start) to be used by the station
- Increment - Increment to next block of allocated slots.
- Block size - Determines the default number of consecutive slots which are to be reserved at each increment

FATDMA for base station

4.1.13 Assignment (resource allocation)

4.1.14 Slotted ALOHA random access

4.1.15 Multipacket transfer

Commented [PR27]: Rev 1 material, needs user requirement input

4.3 Data transfer protocol

4.4 Automatic Repeat Request

To facilitate control of ship-shore communication - Johan input

410 Packet format signalling

3.1.1 Cyclic redundancy check

5.2 Packet format data transfer

5.2.1 Cyclic redundancy check

Recommended to increase from 16 bits to minimum 20, preferable 32

5.2.2 Encapsulation (e.g. Packet ID.)

44

456 Transport layer

46 Physical layer (to be duplicated for Ship and

INFORMATIVE ANNEX – Link budget

6.1.1 Transmit (minimum) antenna gain (Antenna Pattern)

Since the shipborne antenna is required to receive the VDES satellite downlink at high elevation angles, the 0dBi (2.1dBi) option is selected. To achieve optimum satellite reception, this antenna should be mounted as high as possible, preferably on an extension pole, on the ship to minimize obstructions to the antenna's view of the horizon. For the terrestrial VDES base station, the 6dBi (8dBi) option is selected. These two antennas are used in the propagation range predictions in Annex 2. Figure 7 presents a mask for the receiving antenna gain as a function of elevation that would allow the received signal from satellite to be at constant power level at the receiver input for a wide range of elevation angles, taking into account the PEP constraints imposed on the VDE-SAT downlink (ref. Table 3 of Annex 1). Although this mask may not represent the antenna pattern associated with a commercially available antenna, it could serve as a guide for designing an antenna to enhance the satellite reception. The same mask is also applicable to the design of shipborne antenna for VHF terrestrial link due its high directivity in the horizontal direction. Annex 3 provides further rationale for the selection of this mask.

Antenna type	1 elem	2 eleme nts	3 eleme nts	4 eleme nts
Gain to horizon	2 dBi	3 dBi	6 dBi	9 dBi

For antenna patterns, refer to Annex 4 (VDES-SAT).

6.1.2 Range (min and max)

Propagation range predictions for VHF data exchange system terrestrial links

7.1 Introduction

This is an informative annex. The excellent propagation characteristics of AIS are well established and appreciated. The propagation range predictions for the 100 kHz VDE ship-to-shore and shore-to-ship links follow below.

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8.2 Ship-to-shore application

8.2.1 Basis for the coverage assessment

This coverage assessment is based on Recommendation ITU-R P.1546-4 (assuming no ducting), taking into account the antenna height and the seawater propagation path.

Height of antenna (Base Station): 75 meters (see graph for various heights)

Assumed Transmitter power for ships: 12.5 Watts

Tx ship's antenna minimum gain: 2dBi (10dBi)

Rx shore antenna gain: 8dBi (6dBi)

$P_r = -103\text{dBm}$ (VDE shore station sensitivity)

Commented [PR28]: We may have higher gain antennas

8.2.2 Purpose for use of the Recommendation ITU-R P.1546-4 propagation curve

Recommendation ITU-R P.1546-4 prescribes the use of the propagation curves (§3 from Annex 5 and Figure 4 (Figures 13 and 14 of this Annex) from Annex 1, see below) assuming no ducting and a smooth earth/seabed surface. This analysis may be used as a reference point for field test measurements that usually include some ducting, depending on weather, atmospheric conditions, and other factors.

Commented [PR29]: Will depend on modulation used. Sensitivity should be expressed as noise floor at this point in the link budget calculation. The later analysis of link budget should use this noise floor required Eb/No at prescribed packet/message error rate for each modulation and coding scheme.

8.3.2.3 Determination of transmitting/base antenna height, h_t

Recommendation ITU-R P.1546-4 specifies (§3 of Annex 5) the transmitting/base antenna height, h_t , to be used in calculation depending on the type and length of the path. For sea paths h_t is the height of the antenna above mean sea level; for land paths h_t is the height above average terrain.

8.4.2.4 Determination of the minimum field strength (sensitivity threshold) at the VHF data exchange base receiving site

For ship-to-shore:

Power received (linear formula): $P_r = G_r E_r^2 c^2 / 4\pi d^2$

Rearranged: $E_r = \sqrt{(4\pi d^2)^{-1} P_r / G_r c^2}$, where

E_r = field strength in volts/meter

G_r = gain of receiving antenna = 6.3 = 8dBi

c = speed of light in free space = 3×10^8 meters/second

f = VDE ship-to-shore frequency = 1.57×10^8 (157 MHz)

$P_r = 5 \times 10^{-14}$ watts = -133dBW = -103dBm

Thus,

$E_r = 3.21 \times 10^{-6} = 3.21 \mu\text{V}/\text{m} = +10.1\text{dB}\mu\text{V}/\text{m}$

The logarithmic formula can also be used to calculate P_r (dBm):

$P_r(\text{dBm}) = 42.8 - 20\log f + 20\log E + G$, where

G = antenna gain in dBi = 8dBi

F = frequency in MHz = 157

$P_r(\text{dBm}) = 42.8 - 43.9 - 109.9 + 8 = -103\text{dBm}$ (-133dBW)

Commented [PR30]: Simplify this calculation, this is too detailed

3.5.2.5 Determine the range to the +10.1dB₀(+102dBm) coverage limit for a separate propagation path.

Calculate the effective radiated power:

$$P_e = P_r + G$$

$$P_e = 10 \log(12.5) - 30 = +19\text{dBk} (19\text{dB below } 1\text{ kW})$$

$$G = 2\text{dBi} = +0\text{dBd} (0\text{dB over a dipole})$$

Thus $P_e = 19 + 0 = +19\text{dBk ERF}$

$F = P_e - P_0$ (vertical scale reference for the propagation graph in Figure 4 of Recommendation ITU-R P.1546-1, Figure 13 of this Annex)

$$P_0 = +10.1\text{dBm}$$

$$P_e = +19\text{dBk}$$

$$\text{Thus } F = 10.1 - (-19) = +29.1\text{dB}$$

3.6.2.6 Determining the seaward ship-to-shore coverage range from Figure 13.

The +10.1dB₀(+102dBm) range is 85km, which is 46NM (use $h_t = 75\text{m}$)

3.7.2.7 Determining the received signal strength indication values for various other ranges

The reference point received signal strength indication (RSSI) = +102dBm at a range of 85km (46NM) is determined above. For other ranges, the RSSI value is determined from the propagation curve (Figure 13) for the assumed antenna height of 75m. RSSI values in 10dB increments above the sensitivity threshold are shown in Table 7 below.

TABLE 7

VHF data exchange base station received signal strength indication value vs. distance ship-to-shore

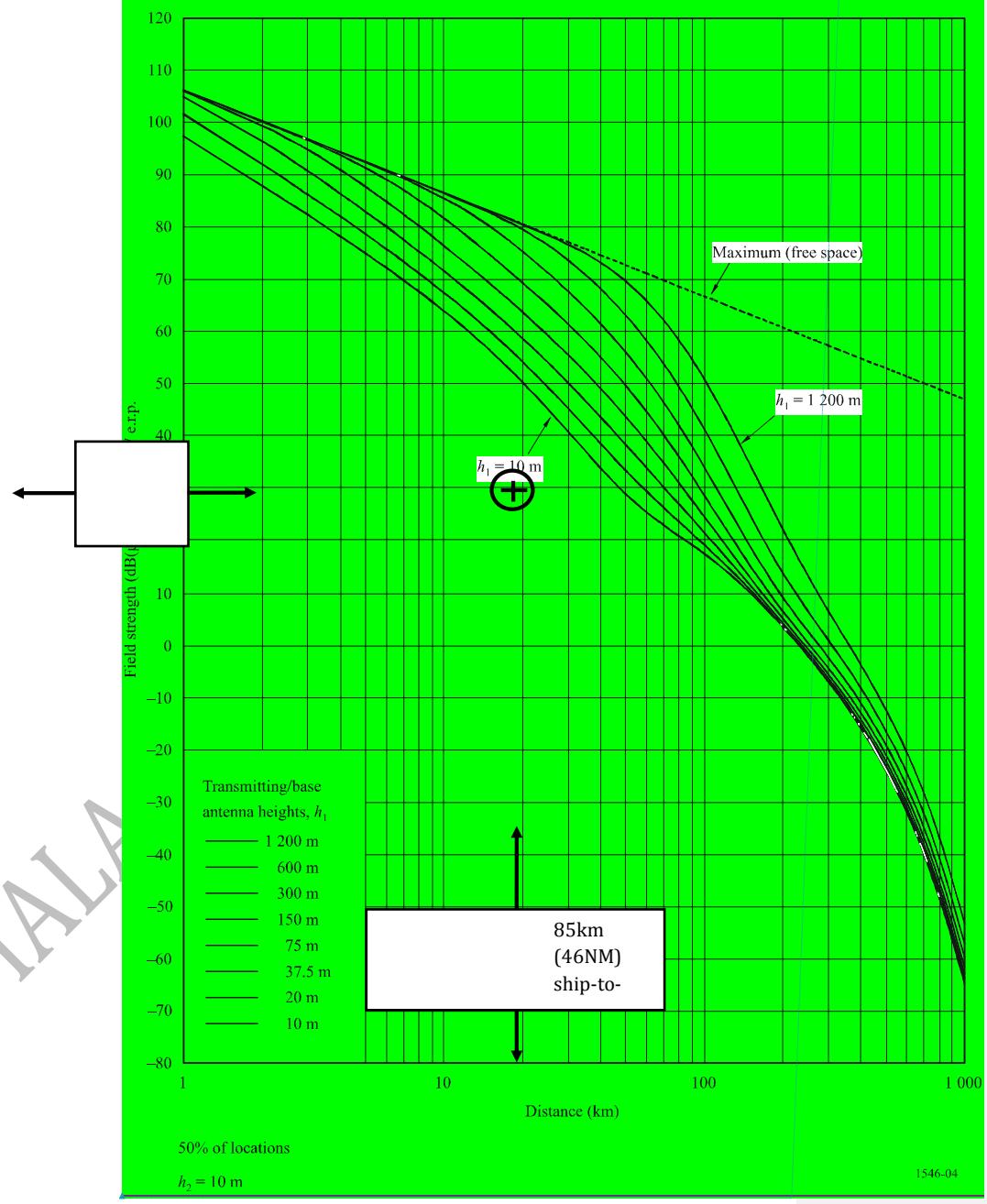
-103 dBm	85 km (46 NM)
-93 dBm	60 km
-83 dBm	40 km
-73 dBm	25 km
-63 dBm	15 km
-53 dBm	9 km
-43 dBm	5.5 km

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FIGURE 4
100 MHz, sea path, 50% time

Field Code Changed



9.3 Shore-to-ship application

9.1.3.1 Basic for the coverage assessment

Referring to section 2 above, consider the reverse direction shore-to-ship signal levels at the ship receiving site, the shore transmitter power of 50 Watts and the shore-to-ship frequency of 162 MHz.

Height of antenna (VDES Base Station): 75 meters (see graph for various heights)

Transmitter power of VDES on shore: 50 Watts (at base of shore antenna)

Tx shore antenna gain: +8 dBi (+6 dBd)

Rx ships antenna gain: +2 dBi (0 dBd)

P_t : -98 dBm (VDE ship station sensitivity)

9.1.1 3.1.1 Determination of the minimum field strength (sensitivity threshold) at the VHF data exchange ship receiving site

For shore-to-ship:

Power received (linear formula): $P_r = G_r E^2 r^2 / 4\pi c^2 t$

Rearranged: $P_r = \sqrt{4\pi c^2 t^2 P_t / (G_r c^2)}$, where

E = field strength in volts/meter

G_r = gain of receiving antenna = 1.63 ± 2.1 dB

c = speed of light in free space = 3×10^8 meters/second

t = VDE shore-to-ship frequency = 1.62×10^9 (162 MHz)

$P_t = 1.58 \times 10^{-11}$ watts = -17.8 dBW = -98 dBm

Thus

$E = 11.61 \times 10^{-6} = 11.61 \mu\text{V}/\text{m} = +21.3 \text{ dB}\mu\text{V}/\text{m}$

The logarithmic formula can also be used to calculate P_r (dBm).

P_r (dBm) = $42.8 - 20\log E + 20\log G_r$, where

G_r = antenna gain in dBi ± 2.1 dB

E = frequency in MHz ± 162

P_r (dBm) = $42.8 - 44.1 - 98.7 + 2.1 = -98 \text{ dBm} (-128 \text{ dBW})$

9.1.2 3.1.2 Determine the range to the +21.3 dBm (-98 dBm) coverage limit for a seawater propagation path

Calculate the effective radiated power:

$P_e = P_t + G_r$

$P_e = 10 \log 50 - 30 = +13 \text{ dBk}$ (+3 dB below 1 kW)

$G_r = 8 \text{ dBi} = +6 \text{ dBd}$ (6 dB over a dipole)

Thus $P_e = 13 + 6 = +7 \text{ dBk}$ ERP

$E_r = E + P_e$ (vertical scale reference for the propagation graph in Figure 4 in Recommendation ITU-R P.1546-4, Figure 2 of this Annex)

$E = +21.3 \text{ dBm}$

$P_e = +7 \text{ dBk}$

Thus $R_s = 21.3 - (-7) = +28.3 \text{ dB}$

Note that since this value of R_s is within 1dB of the value calculated in Section 2.5 because the reduced sensitivity of the ship station is compensated by the higher power and antenna gain of the shore base station.

9.1.3 3.1.3 Determining the seaward shore-to-ship coverage range from Figure 14

The +28.3 dB (+9.8 dBm) range is 85 km, which is 46 NM (use $h = 75 \text{ m}$). This is the same as the ship-to-shore coverage range, an ideal balanced two-way coverage, which confirms the proposed choices of antennas and transmitter power values for the shipborne and shore VDES stations.

9.1.4 3.1.4 Determine the received signal strength indication values for various other ranges

The reference point RSSI = -98 dBm at a range of 85 km (46 NM) is determined in 2.6 above. For other ranges, the RSSI value is determined from the propagation curve (Figure 14) for the assumed antenna height of 75 m. RSSI values in 10 dB steps above and below the -98 dBm threshold sensitivity for the shipborne VDR receiver are shown in below.

TABLE 2
VDP data exchange ship station received signal strength indication values vs. distance shore-to-ship

-118 dBm	170 km
-108 dBm	130 km
-98 dBm	85 km (46 NM)
-88 dBm	60 km
-78 dBm	40 km

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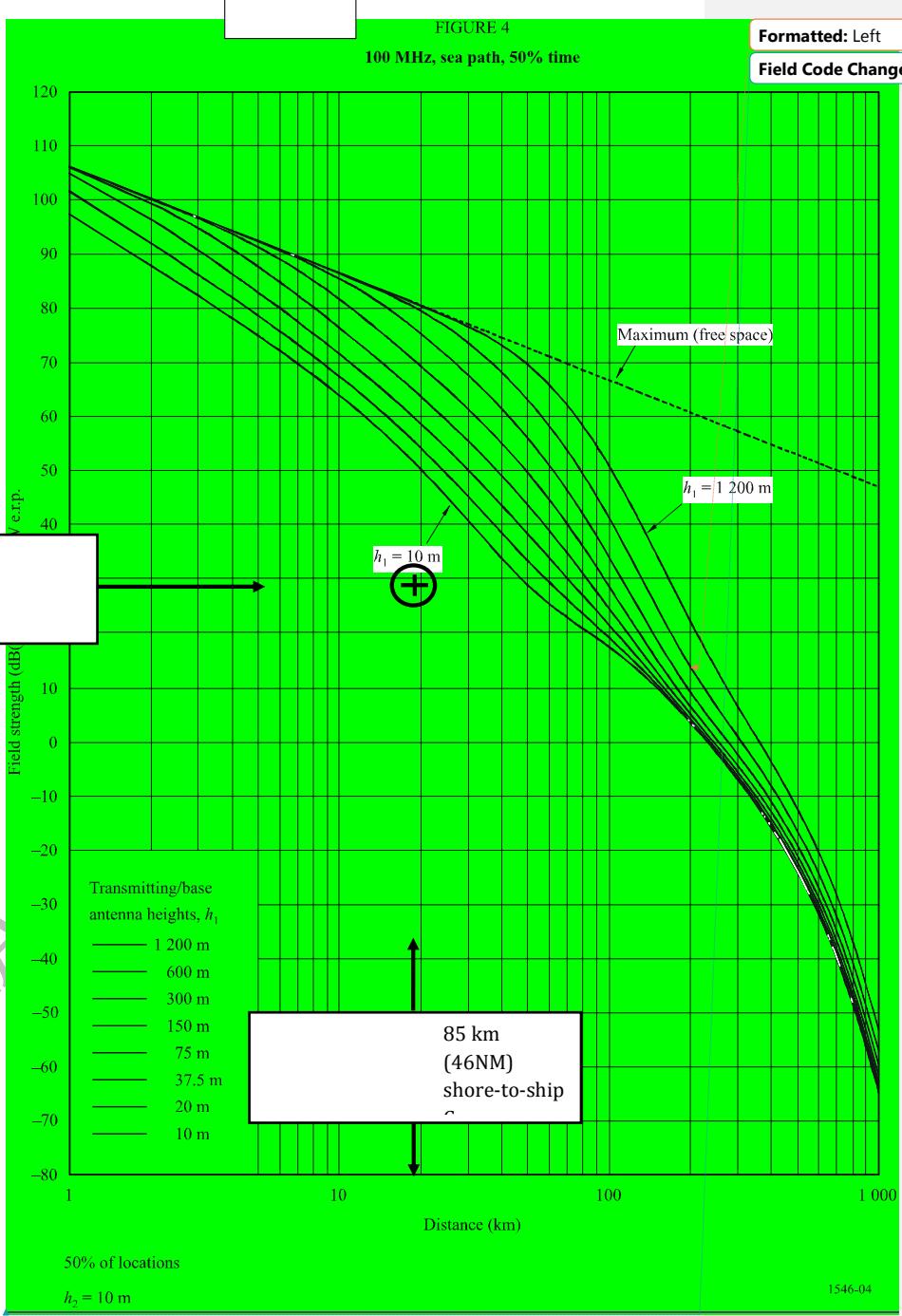
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9.1.4.1 Anomaly Due to Inversion (Delay Tolerance due to the distance up to a few msec)

9.1.5 Receive antenna gain

9.1.6 Receive noise floor

9.1.7 Link C/N0

9.1.8 Source of Self Interference (assumptions about the interference)

9.1.9 Received signal to noise plus Interference level