

# D1.14

## Draft IEC Technical Specification for VDES

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# 1 Abbreviations and Acronyms

AIS	Automatic Identification System
ASM	Application Specific Message
EUT	Equipment Under Test
EVM	Error Vector Magnitude
FEC	Forward Error Correction
GPS	Global Positioning System
LTE	Long Term Evolution
MKD	Minimum Keyboard and Display
MMI	Man, Machine Interface
PC	Performance Check
PER	Packet Error Rate
PI	Presentation Interface
PSU	Power Supply Unit
PT	Performance Test
RX	Receiver
SDR	Software Defined Radio
TBC	To Be Confirmed
TBD	To Be Done
TX	Transmitter
EUT	Equipment Under Test
VDE	VHF Data Exchange
VDES	VHF Data Exchange System
VHF	Very High Frequency
VTB	VDES Test Bed

## 2 Scope

This document is provided with intent of being used as a baseline for developing an IEC specification that may be used for VDES certification.

## 3 Reference Documents

- [1] IEC 61993-2 Ed.2: Class A shipborne equipment of the universal automatic identification system (AIS) – Operational and performance requirements, methods of test and required test results.
- [2] IEC 60945 Ed.4: Maritime navigation and radiocommunication equipment and systems –General requirements –Methods of testing and required test results.
- [3] IEC 62320-1: AIS Base Station Test spec. (also covered by IEC61993-2).

## 4 Test Conditions

### 4.1 Normal and extreme test conditions

The normal and extreme test conditions are summarized in Table 1.

Parameter	Min	Max	Unit
Temperature	+15	+35	°C
Humidity	20	75	%
Power Supply (Normal) <sup>1</sup>	23	25	VDC
Power Supply (Extreme) <sup>2</sup>	21.6	31.2	VDC

<sup>1</sup> IEC 61993, clause 9.1.1.2 Power supply refers to IEC 60945. IEC 60945, clause 5.2.1 specifies 3% on nominal power supply voltage (24VDC?)

<sup>2</sup> IEC 60945, clause 5.2.2 specifies +30% / -10% of nominal supply voltage.

## 4.2 Standard test environment

The EUT is tested in an environment using test equipment to simulate and log VDL messages. The environment will consist of at least 10 simulated targets. The simulated targets shall include an appropriate number of targets of:

1. Class A Mobile
2. Class B "CS" Mobile
3. Class B "SO" Mobile
4. Base station
5. AIS AtoN Station
6. SAR Aircraft
7. AIS SART
8. VDE Mobile
9. ASM Mobile
10. VDE Base Station
11. ASM Base Station

The signal input level at the RF input port of the EUT for any simulated target shall be at least -100 dBm.

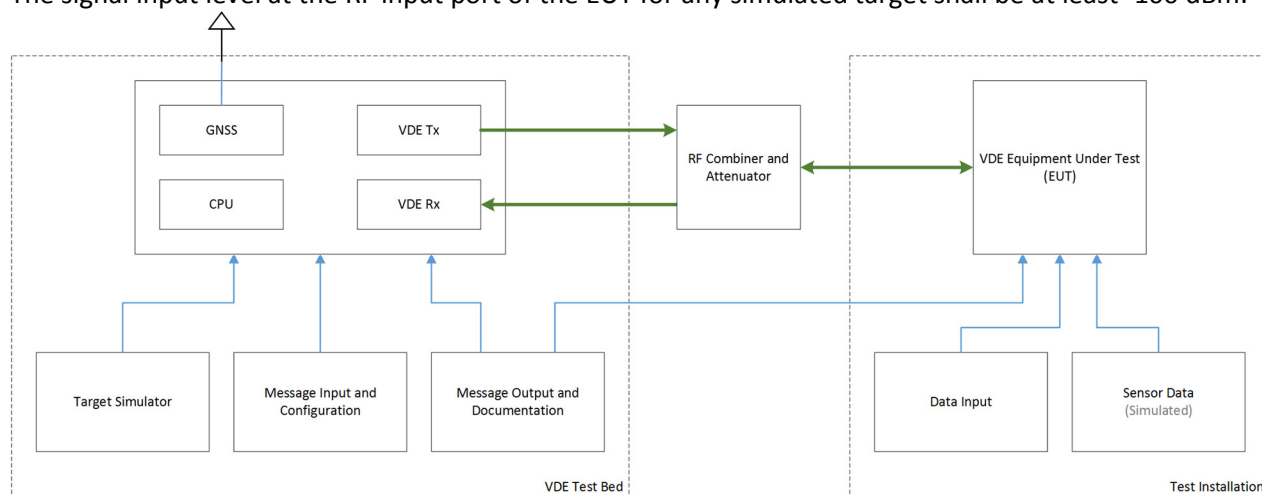


Figure 1 - Block Diagram of standard test environment

The ASM and VDE Test Bed (VTB) is a calibrated and tested SDR environment that is able to generate and measure all of the required signals and messages to complete the range of tests required to certify the ASM and VDE EUT as being compliant to the referred specifications.

All messages in and out of the Presentation Interface (PI) will comply with IEC 61162. Where proprietary IEC61162 messages are used, these should be declared.

Where an external application is required to interface with the ASM and VDE, this should be included.

## 4.3 Common test conditions for protection from invalid controls

In all functional tests using Messages 4, 16, 17, 20, 22, 23 and DSC channel management telecommands, the messages or telecommands sender station shall use a valid base station MMSI format (see 6.12) to verify that the EUT operates as described in the required results.

The tests shall be repeated using an invalid base station MMSI format for the messages or DSC telecommands sender station to verify that the EUT ignores these messages or telecommands.

## 4.4 Test signals

In addition to the test signals 1 to 5 defined in IEC 61993-2 10.1 to 10.5, the following test signals are defined for testing ASM and VDE.

### 4.4.1 Standard test signal number 6

ASM message, using QPSK encoding in 25 kHz band (only band supported by ASM) with no coding.

### 4.4.2 Standard test signal number 7

VDES message, using QPSK encoding and no FEC. Signal can be in 25 kHz, 50 kHz or 100 kHz bandwidth.

### 4.4.3 Standard test signal number 8

VDES message, using 8PSK encoding and no FEC. Signal can be in 25 kHz, 50 kHz or 100 kHz bandwidth.

### 4.4.4 Standard test signal number 9

VDES message, using 16QAM encoding and no FEC. Signal can be in 25 kHz, 50 kHz or 100 kHz bandwidth.

## 5 Methods for test

From IEC 60945: “Confirmation of technical performance is required at two or more levels. The level required to confirm compliance with selective parameters of the equipment standard is a performance test. The levels required only to confirm that the equipment operates are performance checks. Performance Checks (PC) are generally less comprehensive and less time-consuming than the Performance Test (PT). For some equipment, a single performance check definition will suffice, but for others it may be preferable for technical reasons to define different checks for the various types of test defined in this standard.

Performance tests and checks, and the appropriate check for each test shall be fully defined in the equipment standard. If no equipment standard exists or if the performance test is not specified in the equipment standard, the performance test shall be as defined in the test plan and described in the test report.”

## 5.1 Performance Test

### 5.1.1 Purpose

The performance test is of the ASM and VDE UUT.

### 5.1.2 Method of test

The UUT shall be connected to a test setup that is capable of sending and receiving ASM and VDE messages. The UUT shall also be able to receive GNSS signals in order to get a GPS position fix.

The unit shall be configured to send GNSS sentences on the PI so that the operation of the GNSS receiver can be monitored.

The test equipment shall be configured to periodically send message 1 to the unit over the ASM and VDE interface. The UUT shall output the received message on the PI using a VDM sentence.

Periodically send an ABM sentence on the PI and check that its contents are correctly transmitted on the VDE interface.

### 5.1.3 Required result

1. The unit shall obtain a GPS lock and send the position information over the PI.
2. The unit shall correctly receive all messages received on the VDE interface and correctly output a VDM sentence on the PI.
3. The unit shall correctly parse all sentence received on the PI and correctly output the corresponding ASM and VDE messages.

## 6 Power supply, special purpose and safety tests

Tests for power supplies, special purposes and safety shall be performed as specified in IEC 60945, Clauses 7, 11 and 12. Waivers as indicated in IEC 60945 shall apply.

*Note: The following subsections extract the information from IEC 60945, as specified above.*

### 6.1 Extreme power supply

This test is in accordance with IEC 60945, 7.1.

Tests and performance checks at extreme power supply conditions shall be performed under the environmental conditions indicated in Table 2.

Environment	Normal Power Supply	Extreme power supply
Dry heat	PT	PC
Damp heat	PC	-
Low temperature	PT	PC
Normal temperature	PT	PT

Table 2 - Power supply test schedule

### 6.2 Excessive conditions

This test is in accordance with IEC 60945, 7.2.

Apply -24 VDC to the unit for 5 minutes. After completion, apply nominal supply power and perform a PC.

Perform a PC while operating the unit at the minimum extreme power supply voltage, and then the maximum extreme power supply voltage.

### 6.3 Power supply short-term variation

This test is in accordance with IEC 60945, 7.3.

This test is not applicable to the VDES reference design because it is DC powered. The test only applies to AC powered equipment.

### 6.4 Power supply failure

This test is in accordance with IEC 60945, 7.4.

Subject the EUT to three breaks in power supply of duration 60 s each.

Perform a PC after the test to ensure that the unit is still operating correctly with no corruption or loss of software or essential data.

## 6.5 Compass Safe Distance

This test is in accordance with IEC60945, 11.2

## 6.6 Additional PSU tests

Brown out: Slowly change PSU input voltage.

Voltage spike: 20 ms; 200% of input voltage [48 V]; Low impedance.

# 7 Environmental tests

The ASM and VDE test complies to the “Protected” environmental specification from IEC 60945 clause 8.1, as listed in Table 3.

Parameter	Value
Dry Heat	+55 °C
Damp Heat	+40 °C @ 93 % relative humidity
Low temperature	-15 °C
Normal temperature	+25 °C
Vibration	2Hz – 13.2 Hz at $\pm 1\text{mm}$ 13.2 Hz – 100 Hz at $7\text{m/s}^2$ 2 hours on each resonance, otherwise 2 hours at 30 Hz in all three axes.
Corrosion	For periods of seven days at 40 °C with 90 % - 95 % relative humidity after 2 hour salt spray.

Table 3 - Environmental test conditions

The following environmental tests are not applicable to the ASM and VDE test:

1. Thermal shock.
2. Drop onto hard surface.
3. Drop into water.
4. Rain and spray.
5. Water immersion.
6. Solar radiation.
7. Oil resistance.

Dry Heat, Damp Heat, Low temperature and Normal temperature tests are already performed in clause 6.1.

A PC must be done after the Vibration and Corrosion tests.

# 8 EMC tests

Tests for EMC emissions shall be performed as specified in IEC 60945, 9.

Tests for EMC immunity shall be performed as specified in IEC 60945, 10. The ASM and VDE tests shall use the “Protected” category in Table 6. The exclusion band for the receiver will be 148.21 MHz to 165.31 MHz and 152.58 MHz to 170.14 MHz.

# 9 Operational tests

Perform operational tests as per IEC61993, 14.



The following tests shall follow IEC61993:

1. 14.5.2 Transceiver protection (need to physically remove the antenna).
2. 14.6.1 Loss of power supply (need to disconnect the power supply and verify relay status).
3. 14.6.2.1 TX malfunction (needs a physically failing TX).
4. 14.6.2.2 Antenna VSWR (need to physically mismatch the antenna).
5. 14.6.2.3 Rx malfunction (need to provide documentation describing this – no testing).

Tests that cannot be performed by VDE:

1. 14.7.1 Data input/output facilities (no MKD).
2. 14.7.5 Display of targets (no MKD).
3. 14.7.7 Display of targets if optional filter is implemented (no MKD).
4. 14.7.8 Display of received safety related messages (no MKD).
5. 14.7.9 Presentation of navigation information (no MKD).

## 10 Physical tests

### 10.1 TDMA transmitter

The transmitter shall be tested as specified by IEC 61993, 15.1. Additional testing is done for ASM and VDE (R-REC-M.2092). Table 4 lists the transmitter tests that are performed with the clause in the IEC 61993 document that applies to the test. If additional testing is done for ASM and VDE, then the ASM and VDE Additions column in Table 4 specifies the clause number in this document that describes the additions for the test. If there is no deviation from the IEC 61993 requirement, then a dash is placed in the VDE Additions column.

Test Description	IEC 61993	VDE Additions	ASM Additions
Frequency error	15.1.1	-	
Carrier power	15.1.2	10.1.1	??
Slotted transmission spectrum	15.1.3	10.1.2	??
Modulation accuracy	15.1.4	10.1.3	??
Transmitter output power characteristics	15.1.5	10.1.4	??

Table 4 - Transmitter tests for VDE Reference Design

#### 10.1.1 Carrier power

The carrier power test shall be performed as specified in IEC 61993, 15.1.2. The following modulation schemes shall be used in addition to using GMSK modulation in a 25 kHz band (AIS):

1. Test Signal 6, described in 4.4.1.
2. Test Signal 7, described in 4.4.2.
3. Test Signal 8, described in 4.4.3.
4. Test Signal 9, described in 4.4.4.

Both high power (41 dBm / 12.5 W) and low power (30 dBm / 1 W) shall be verified in the specified bandwidths.

#### 10.1.2 Slotted transmission spectrum

The new proposed transmission mask from R-REC-M.2092 shall be used for ASM and VDE messages, as described in Table 5 and Figure 2.

Transmit parameters	Requirements	Condition
Maximum adjacent power levels for 25 kHz	0 dBc	$\Delta f_c < \pm 12.5$ kHz

channel	-25 dBc -60 dBc	$\pm 12.5 \text{ kHz} < \Delta f_c < \pm 25 \text{ kHz}$ $\pm 25 \text{ kHz} < \Delta f_c < \pm 75 \text{ kHz}$
Maximum adjacent power levels for 50 kHz channel	0 dBc -25 dBc -60 dBc	$\Delta f_c < \pm 25 \text{ kHz}$ $\pm 25 \text{ kHz} < \Delta f_c < \pm 50 \text{ kHz}$ $\pm 50 \text{ kHz} < \Delta f_c < \pm 100 \text{ kHz}$
Maximum adjacent power levels for 100 kHz channel	0 dBc -25 dBc -60 dBc	$\Delta f_c < \pm 50 \text{ kHz}$ $\pm 50 \text{ kHz} < \Delta f_c < \pm 100 \text{ kHz}$ $\pm 100 \text{ kHz} < \Delta f_c < \pm 150 \text{ kHz}$

Table 5 - Slotted transmission spectrum for VDES

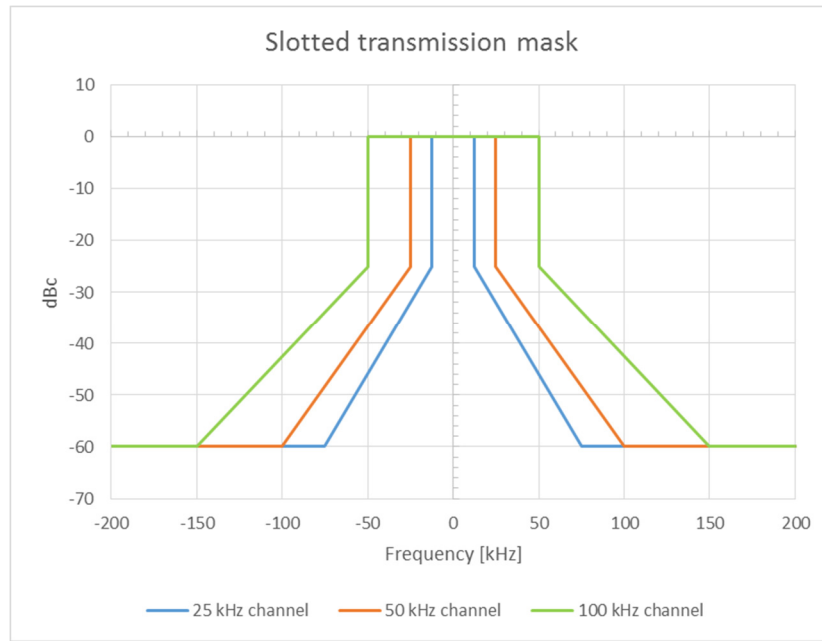


Figure 2 - Slotted transmission spectrum for VDES

### 10.1.3 Modulation accuracy

The Modulation accuracy test for GMSK shall be performed as specified in IEC 61993, 15.1.4. The following test signals shall be used in addition to using GMSK:

1. Test Signal 6, described in 4.4.1.
2. Test Signal 7, described in 4.4.2.
3. Test Signal 8, described in 4.4.3.
4. Test Signal 9, described in 4.4.4.

An Error Vector Magnitude (EVM) measurement shall be used to verify the VDE modulation performance. The required results are listed in Table 6.

Test Signal	Maximum EVM [%]
Test Signal 6.	5
Test Signal 7.	5
Test Signal 8.	5
Test Signal 9.	5

Table 6 - Required VDE Modulation accuracy results

### 10.1.4 Transmitter output power characteristics

The transmitter output power characteristics test for GMSK shall be performed as specified in IEC 61993, 15.1.5. The additional VDE test signals described in 10.1.3 shall also be used.

## 10.2 TDMA receiver

The receiver shall be tested as specified by IEC 61993, 15.2. Additional testing is done for VDE (R-REC-M.2092).

Table 7 lists the receiver tests that are performed with the clause in the IEC 61993 document that applies to the test. If additional testing is done for ASM and VDE, then the VDE Additions column in Table 7 specifies the section number in this document that describes the additions for the test. If there is no deviation from the IEC 61993 requirement, then a dash is placed in the VDE Additions column.

Test Description	IEC 61993	VDE Additions
Sensitivity	15.2.1	10.2.1
Error behaviour at high input levels	15.2.2	10.2.2
Co-channel rejection	15.2.3	10.2.3
Adjacent channel selectivity	15.2.4	10.2.4
Spurious response rejection	15.2.5	-
Intermodulation response rejection and blocking	15.2.6	50/100/150kHz options
Transmit to receive switching time <sup>3</sup>	15.2.7	-
Immunity to out-of-band energy	15.2.8	-
Forward Error Correction	-	10.2.4

Table 7 - Receiver tests for VDE Reference Design

### 10.2.1 Sensitivity

Follow the method described in IEC 61993, 15.2.1.2 with the additional signals and properties specified in Table 8.

Test Signal	Channel	BW	Level [dBm]	Conditions	Max PER [%]
6	2027 and 2028	25	-107	Normal	20
			-101	Extreme	
7	1024 and 2024	25	-110	Normal	20
	1024-1084, 2024-2084	50 50	-107		
	1024-1085, 2024-2085	100 100	-104		
8	1084 and 2084	25	-104	Normal	20
	1024-1084, 2024-2084	50 50	-101		
	1024-1085, 2024-2085	100 100	-98		
9	1085 and 2085	25	-102	Normal	20
	1024-1084, 2024-2084	50 50	-99		
	1024-1085, 2024-2085	100 100	-96		

Table 8 - Parameters used for VDE sensitivity tests

<sup>3</sup> An external signal must be made available for this test.

## 10.2.2 Error behaviour at high input levels

Follow the method described in IEC 61993, 15.2.2.2 with the additional signals and properties specified in Table 9.

Test Signal	Channel	BW	Level [dBm]	Conditions	Max PER [%]
6 <sup>4</sup>	2027 and 2028	25	-7, -77	Normal	1
				Extreme	
7 <sup>5</sup>	1024, 2024	25		Normal	1
	1024-1084, 2024-2084	50 50			
	1024-1085, 2024-2085	100 100			
8 <sup>6</sup>	1084, 2084	25		Normal	1
	1024-1084, 2024-2084	50 50			
	1024-1085, 2024-2085	100 100			
9 <sup>7</sup>	1085, 2085	25		Normal	1
	1024-1084, 2024-2084	50 50			
	1024-1085, 2024-2085	100 100			

Table 9 - Parameters used for VDE high input level tests

## 10.2.3 Co-channel rejection

Follow the method described in IEC 61993, 15.2.3.2 with additional combinations of signals used by generator A and B specified by Table 10.

*Note: The use of signal 6 and 6b is to indicate that the two signals use the same modulation scheme, but the data is not correlated.*

Generator A Test Signal	Generator B Test Signal
6	6b
7	7b
8	8b
9	9b

Table 10 Additional channel combinations used for co-channel rejection tests

## 10.2.4 Adjacent channel selectivity

Follow the method described in IEC 61993, 15.2.4.2 with additional combinations of signals used by generator A and B specified by Table 11.

Generator A Test Signal	Generator B Test Signal
7, 100 kHz	6, 25 kHz

Table 11 - Adjacent channel selectivity tests

## 10.2.5 Forward Error Correction

Execute the same tests as specified in section 10.2.1 but with FEC switched on. There should be an improvement in the PER.

<sup>4</sup> ASM, QPSK, 25 kHz, no coding.

<sup>5</sup> QPSK, no coding.

<sup>6</sup> 8PSK, no coding.

<sup>7</sup> 16QAM, no coding.

## 10.3 Conducted spurious emissions

The tests shall be performed as specified by IEC 61993, 15.3.

The transmitter spurious emissions specifications are identical in ITU-R M.2092, Annex 2 and Annex 3.

The receiver spurious emissions specifications are identical in ITU-R M.2092, Annex 2. It is not specified in Annex 3, but is assumed to also be the same.

## 11 Specific tests of link layer

Follow the method described in IEC 61993, 16. The various tests, with exceptions relating to ASM and VDE is listed in Table 12.

Test Description	IEC 61993	VDE Additions	ASM Additions
TDMA synchronization	16.1	-	??
Time division (frame format)	16.2	-	??
Synchronisation and jitter accuracy	16.3	-	??
Data encoding (bit stuffing)	16.4	11.1	??
Frame check sequence	16.5	11.4	??
Slot allocation	16.6		??
Message formats	16.7	-	??

Table 12 - Link layer tests for VDE

### 11.1 Bulletin Board

R-REC-M.2092 (VDE) introduces the Terrestrial Bulletin Board (TBB) that indicates the Modulation and Coding Scheme (MCS) being used. MCS1, MCSx and MCSy should be tested to ensure that the correct MCS as indicated in the TBB is used.

[TBB test to be defined]

### 11.2 Link Layer messages

A number of Terrestrial Link Layer (TLL) messages have been defined for R-REC-M.2092 (ASM and VDE).

Each of the following TLL need to be tested for correct functionality:

Test Description	Test input and result
Terrestrial Link Layer message 1	
Terrestrial Link Layer message 2	
Terrestrial Link Layer message 3	
Terrestrial Link Layer message 4	
Terrestrial Link Layer message 5	
Terrestrial Link Layer message 6	

Table 13 Terrestrial link layer messages

### 11.3 Data encoding (FEC)

R-REC-M.2092 (ASM and VDE) introduces Forward Error Correction (FEC) as an encoding method. Use the test method described in IEC 61993, 16.4.1, but use MCS-1, MCS-3 and MCS-5 encoded messages as described in ITU-R M.2092-0 Table A3-2.

## 11.4 Frame check sequence

R-REC-M.2092 uses a 32-bit CRC for the frame check sequence. Use the test modulation described in IEC 61993, 16.5.1 but use MCS-1, MCS-3 and MCS-5 encoded messages as described in ITU-R M.2092-0 Table A3-2.

## 12 Specific tests of network layer

Follow the method described in IEC 61993, 17. The various tests, with exceptions relating to VDE is listed in Table 13.

Test Description	IEC 61993	VDE Additions
Dual channel operation	17.1	See concurrent tests
Regional area designation by VDL message	17.2	-
Regional area designation by serial message	17.3	-
Regional area designation with lost position	17.4	-
Power setting	17.5	-
Message priority handling	17.6	-
Slot reuse and FATDMA reservations	17.7	-
Management of received regional operating settings	17.8	-
Continuation of autonomous mode reporting interval		

Table 14 - Network layer tests

## 13 Specific tests of transport layer

Follow the method described in IEC 61993, 18. The various tests, with exceptions relating to ASM and VDE is listed in Table 14.

Test Description	IEC 61993	VDE Additions
Addressed messages	18.1	-
Interrogation responses	18.2	-
Periodic transmission of Message 26	18.3	-

Table 15 - Transport layer tests

## 14 Specific Presentation Interface tests

Follow the method described in IEC 61993, 19. The various tests, with exceptions relating to ASM and VDE is listed in Table 15.

Test Description	IEC 61993	VDE Additions
General	-	-
Check for manufacturer's documentation	-	-
Electrical test	19.3	-
Test of input sensor interface performance	19.4	-
Test of sensor input	19.5	-
Test of high speed output	19.6	-
High speed output interface performance	19.7	-
Output of undefined VDL messages	19.8	-
Test of high speed input	19.9	-

Table 16 - Transport layer tests for VDE

# 15 Long-range functionality tests

Follow the method described in IEC 61993, 20. The various tests, with exceptions relating to ASM and VDE is listed in Table 16.

Test Description	IEC 61993	VDE Additions
Long-range application by two-way interface	21.1	-
Long-range application by broadcast	20.2	

Table 17 - Transport layer tests for VDE

## 16 Concurrent Mode tests

Check that Rx operation is functional when fully loaded with 100% traffic loading on all Rx channels:

1. AIS 1
2. AIS 2
3. ASM 1
4. ASM 2
5. VDE 25 / 50 / 100

Check that an AIS Tx will always pre-empt an ASM or VDE transmission.

*Note: Msg27 Tx on channels 75 and 76 needs to be considered*