WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT ITU-R M.[VDES-SAT]

Scope

(… no change …)

Keywords

(… no change …)

Glossary / abbreviations

(… no change …)

Related ITU-R Recommendations and Reports

Recommendations

ITU-R SM.329: Unwanted emissions in the spurious domain

ITU-R P.372: Radio noise

ITU-R F.699: Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the frequency range from 100 MHz to about 70 GHz

ITU-R F.758: System parameters and considerations in the development of criteria for sharing or compatibility between digital fixed wireless systems in the fixed service and systems in other services and other sources of interference

ITU-R RA.769: Protection criteria used for radio astronomical measurements

ITU-R SM.1055: The use of spread spectrum techniques

ITU-R M.1184: Technical characteristics of mobile satellite systems in the frequency bands below 3 GHz for use in developing criteria for sharing between the mobile-satellite service (MSS) and other services

ITU-R F.1336: Reference radiation patterns of omnidirectional, sectoral and other antennas for the fixed and mobile service for use in sharing studies in the frequency range from 400 MHz to about 70 GHz

ITU-R P.1546: Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz

ITU-R M.1802: Characteristics and protection criteria for radars operating in the radiolocation service in the frequency band 30-300 MHz

ITU-R M.1808: Technical and operational characteristics of conventional and trunked land mobile systems operating in the mobile service allocations below 869 MHz to be used in sharing studies

ITU-R M.2092: Technical characteristics for a VHF data exchange system in the VHF maritime mobile band

Reports

ITU-R M.1021: Equipment characteristics for digital transmission in the land mobile services

ITU-R M.2172: Radiolocation service sharing feasibility in the frequency band 154-156 MHz

ITU-R S.2173: Multi-carrier based transmission techniques for satellite systems

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

1 Introduction

(… no change …)

2 VHF data exchange-satellite, the essential supplement to terrestrial VHF data exchange system

(… no change …)

3 Identification of spectrum requirements and rationale for the use of the frequency bands of RR Appendix 18

(… no change …)

4 Technical description of the VHF data exchange-satellite

4.1 VHF data exchange system - satellite key parameters

(… no change …)

4.1.1 Satellite to surface distance range

(… no change …)

4.1.2 Satellite transmission carrier frequency error

(… no change …)

4.1.3 Ship station antenna gain and transmitter requirements

(… no change …)

4.1.4 Satellite antenna gain

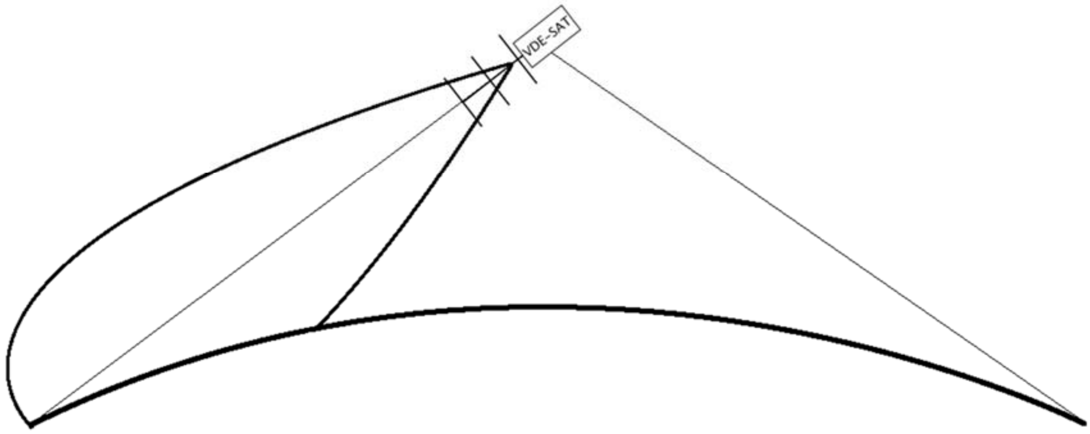
The following two satellite antennas have been analysed and provide acceptable performance for VDE-SAT:

~~*[Editor's note: Additional detail on the operational concept for VDE-SAT should be provided]*~~

1) Yagi Antenna: ~~For t~~This antenna ~~the link budget is optimised for 0 degrees ship elevation angle~~ uses~~ing~~ a three crossed two element circularly polarized ~~crossed two~~ Yagi antennas with the ~~satellite~~ antenna boresight pointed at the horizon. This is illustrated in Figure 9, showing how the Yagi antenna and its main lobe 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. Assuming a peak antenna gain of 8 dBi, satellite antenna gain versus ship elevation angle and nadir offset angle are shown in Table 3. It is the responsibility of the VDE-SAT service provider 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 Table 5.

FIGURE 9

Illustration showing how the Yagi antenna and its main lobe 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.



2) Isoflux antenna: This antenna is designed to point at the nadir direction providing a symmetric radiation pattern around the pointing direction. This is illustrated in Figure 10, showing how the whole field of view, indicated by the thin solid line, is within the communications coverage of the isoflux antenna. Assuming a peak antenna gain of 2 dBi, satellite antenna gain versus ship elevation and nadir offset angle are shown in Table 3.

FIGURE 10

Illustration showing how the whole field of view, indicated by the thin solid line, is within the communications coverage of the isoflux antenna.

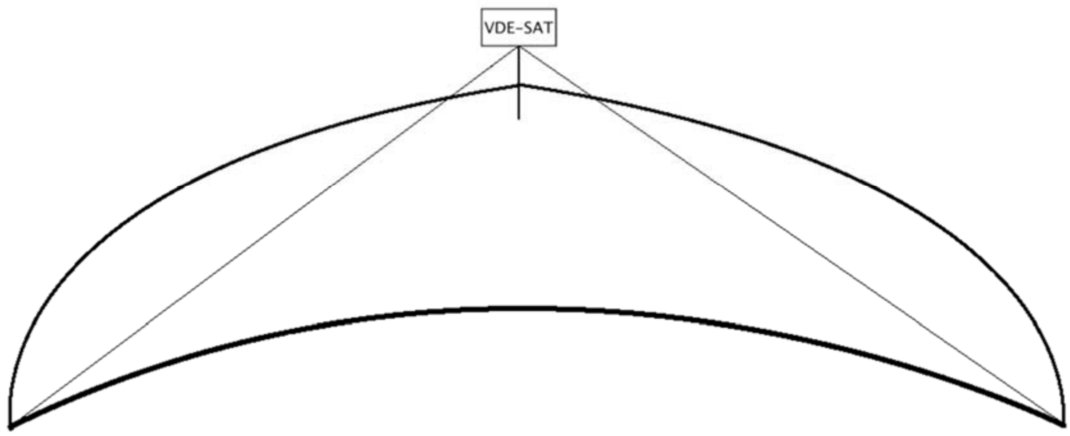


TABLE 3

Satellite Yagi-antenna gain vs. nadir offset angle

Ship elevation angle	**Nadir offset angle**	**Satellite antenna gain**
Degrees	degrees	dBi
0	66.1	8
10	64.2	8
20	59.2	8
30	52.3	7.8
40	44.4	6.9
50	36	5.5
60	27.2	3.6
70	18.2	0.7
80	9.1	–2.2
90	0	–5.5

TABLE 4

Satellite Isoflux-antenna gain vs. nadir offset angle

Ship elevation angle	**Nadir offset angle**	**Satellite antenna gain**
Degrees	degrees	dBi
0	66.1	2
10	64.2	1.5
20	59.2	1
30	52.3	–0.5
40	44.4	–2
50	36	–4
60	27.2	–5
70	18.2	–7
80	9.1	–8
90	0	–8.5

4.2 Technical characteristics of the VHF data exchange -satellite downlink in the VHF maritime mobile frequency band

(… no change …)

4.3 Technical characteristics of the VHF data exchange-satellite uplink in the VHF maritime mobile frequency band

(… no change …)

5 Interoperability and resource sharing with VHF data exchange-terrestrial and between VHF data exchange-satellite systems

(… no change …)

6 Interference to incumbent services and those in adjacent frequency bands

6.1 In-band interference

6.1.1 Fixed services in-band

(… no change …)

6.1.2 Land and aeronautical mobile services in-band

6.1.2.1 Analysis of the interference effect of the VHF data exchange-satellite uplink

(… no change …)

6.1.2.2 Analysis of the interference effect of the VHF data exchange-satellite downlink

There are three views on the interference effect of the VDE-SAT downlink into the land mobile service. The pfd mask contained in view 1 is specified in Recommendation ITU-R M.2092. The pfd masks contained in views 2 and 3 is based on protection criteria defined in Recommendation ITU-R M.1808-6.

6.1.2.2.1 View 1 about power flux density mask

The VDE-SAT downlink is compliant with the pfd mask specified in Recommendation ITU-R M.2092-0 and provided in section 4.2.1. The pfd mask is presented in Table 5.

Given this mask, a study on the compatibility between the VDE-SAT downlink and the land mobile service has been performed. The study evaluates the effect of the interference from the VDE-SAT downlink received by a land mobile base station on the transmission from a mobile station to a base station. Basis for the study is technical characteristics of land mobile systems as provided in Recommendation ITU-R M.1808, including interference criteria and performance criteria, and methods for point-to-area predictions for terrestrial services as provided in Recommendation ITU-R P.1546.

The methodology used to evaluate the compatibility between the VDE-SAT downlink and the land mobile service is based on carrier-to-interference (C/I) considerations and degradation protection, as proposed in Recommendation ITU-R M.1808, section 2.1 of Annex 1.

6.1.2.2.1.1 Characteristics of land mobile systems operating in the 156 to 162 MHz band

Representative technical and operational characteristics of conventional and trunked land mobile systems operating in the mobile service in the frequency band 156-162 MHz are given in Recommendation ITU-R M.1808. Table 28 provides the technical characteristics of base stations and Table 29 provides technical characteristics of mobile stations as they are given in that Recommendation. Recommendation ITU-R P.372 provides additional relevant information regarding interference.

TABLE 28

Technical characteristics for base stations operating in the mobile service in the frequency band 138-174 MHz

Frequency band (MHz)	**138–174**	
Type of emission	**Analogue**	**Digital**
System-wide		

Frequency band (MHz)	**138–174**	
Type of emission	**Analogue**	**Digital**
Channel bandwidth (kHz)	12.5/15/25/30	6.25/7.5/12.5/15
Modulation type	FM	C4FM
Type of operation	Simplex/duplex	Duplex
Typical SINAD (dB) or BER (%)	12 dB	5%
Transmitter		
Output power (W)	5–125 (30) (100)	20–125 (60) (100)
e.r.p. (dBW)	7–26 (19) (24)	13–26 (18) (24)
Necessary bandwidth (kHz)	11/11/16/16	5.5/5.5/8.1/8.1
Coverage radius (km)	1–75 (50)	1–75 (50)
Antenna gain (dBd)	0–9 (6)	0–9 (6)
Antenna height (m) (relative to ground level)	10–150 (60)	10–150 (65)
Radiation pattern	Omnidirectional	Omnidirectional
Antenna polarization	Vertical	Vertical
Total loss (dB)	0–7 (2)	3–9 (6) (2)
Receiver		
Noise figure (dB)	6–12 (7)	6–12 (7)
IF filter bandwidth (kHz)	8/11/12.5/16	5.5/5.5/5.5/5.5
Sensitivity (dBm)	−116 – −121 (−119)	−116 – −121 (−119)
Antenna gain (dBd)	0–9 (6)	0–9 (8)
Antenna height (m) (relative to ground level)	10–150 (60)	10–150 (65)
Radiation pattern	Omnidirectional	Omnidirectional
Antenna polarization	Vertical	Vertical
Total loss (dB)	0–6 (3)	0–6 (3)

NOTE 1 – Simplex systems use the same frequency for both the base station and mobile station to transmit.

NOTE 2 – Frequency division duplex systems have different frequencies for the base station and mobile station which allows simultaneous communications.

NOTE 3 – Typical values are shown in parenthesis. In some instances, more than one typical value is provided.

NOTE 4 – e.r.p. is equal to the output power (dBW) plus antenna gain (dBd) minus total losses (dB).

TABLE 29

Technical characteristics for mobile stations operating in the mobile service in the frequency band 138-174 MHz

Frequency band (MHz)	**138–174**	
Type of emission	**Analogue**	**Digital**
System-wide		
Channel bandwidth (kHz)	12.5/15/25/30	6.25/7.5/12.5/15
Modulation type	FM	C4FM
Type of operation	Simplex/duplex	Duplex
Typical SINAD (dB) or BER (%)	12 dB	5%
Transmitter		
Output power (W)	1–100 (H: 5 V: 30, 50)	1–100 (H: 5 V: 30, 50)
e.r.p. (dBW)	−3–18 (H: −3 V: 14, 16)	−3–18 (H: −3 V: 14, 16)
Necessary bandwidth (kHz)	11/11/16/16	5.5/5.5/8.1/8.1
Antenna gain (dBd)	−10–4 (H: −10, V: 0)	−10–4 (H: −10, V: 0)
Antenna height (m) (relative to ground level)	(2)	(2)
Radiation pattern	Omnidirectional	Omnidirectional
Antenna polarization	Vertical	Vertical
Total loss (dB)	0–1 (H: 0, V: 1)	0–1 (H: 0, V: 1)
Receiver		
Noise figure (dB)	6–12 (7)	6–12 (7)
IF filter bandwidth (kHz)	8/11/12.5/16	5.5/5.5/5.5/5.5
Sensitivity (dBm)	−116 – −121 (−119)	−116 – −121 (−119)
Antenna gain (dBd)	−10–4 (H: −10, V: 0)	−10–4 (H: −10, V: 0)
Antenna height (m) (relative to ground level)	(2)	(2)
Radiation pattern	Omnidirectional	Omnidirectional
Antenna polarization	Vertical	Vertical
Total loss (dB)	0–1 (H: 0, V: 1)	0–1 (H: 0, V: 1)

NOTE 1 – Simplex systems use the same frequency for both the base station and mobile station to transmit.

NOTE 2 – Frequency division duplex (FDD) systems have different frequencies for the base station and mobile station which allows simultaneous communications.

NOTE 3 – Typical values are shown in parenthesis, “H:” represents the value for handheld mobile stations and “V:” represents the value for vehicular mobile stations. In some instances, more than one typical value is provided.

NOTE 4 – e.r.p. is equal to the output power (dBW) plus antenna gain (dBd) minus total losses (dB).

For the studies of the compatibility of the VDE-SAT downlink with the land mobile service the typical values from Table 28 and Table 29 have been used. These technical characteristics and values are summarized in Table 30.

TABLE 30

Typical values for technical characteristics of land mobile service stations used in compatibility study

Station type	**Base station**	**Mobile station**
Necessary bandwidth (kHz)	16	16
Output power (W)	100	50
Output power (dBW)	20	17
Feed loss (dB)	2.0	1.0
Maximum antenna gain (dBd)	6.0	0.0
Maximum antenna gain (dBi)	8.2	2.2
Maximum e.r.p.	24.0	16.0
Maximum e.i.r.p.	26.2	18.2
Antenna height (m)	60	2
Distance to horizon from station (km)	27.7	5.1

Figure 16 shows antenna patterns for typical antennas used in the land mobile service as described in Recommendation ITU-R F.1336-4. Assuming a 6 dBd antenna is used at the base station and a 0 dBd antenna is used at the mobile station, the antenna gain versus elevation angle can be tabulated as in Table 31 and Table 32 for the base station and mobile station respectively. Table 31 and Table 32 also present the resulting e.i.r.p versus elevation angle for the two station types.

FIGURE 16

Antenna patterns for typical antennas used in the land mobile service as described in Recommendation ITU-R F.1336-4

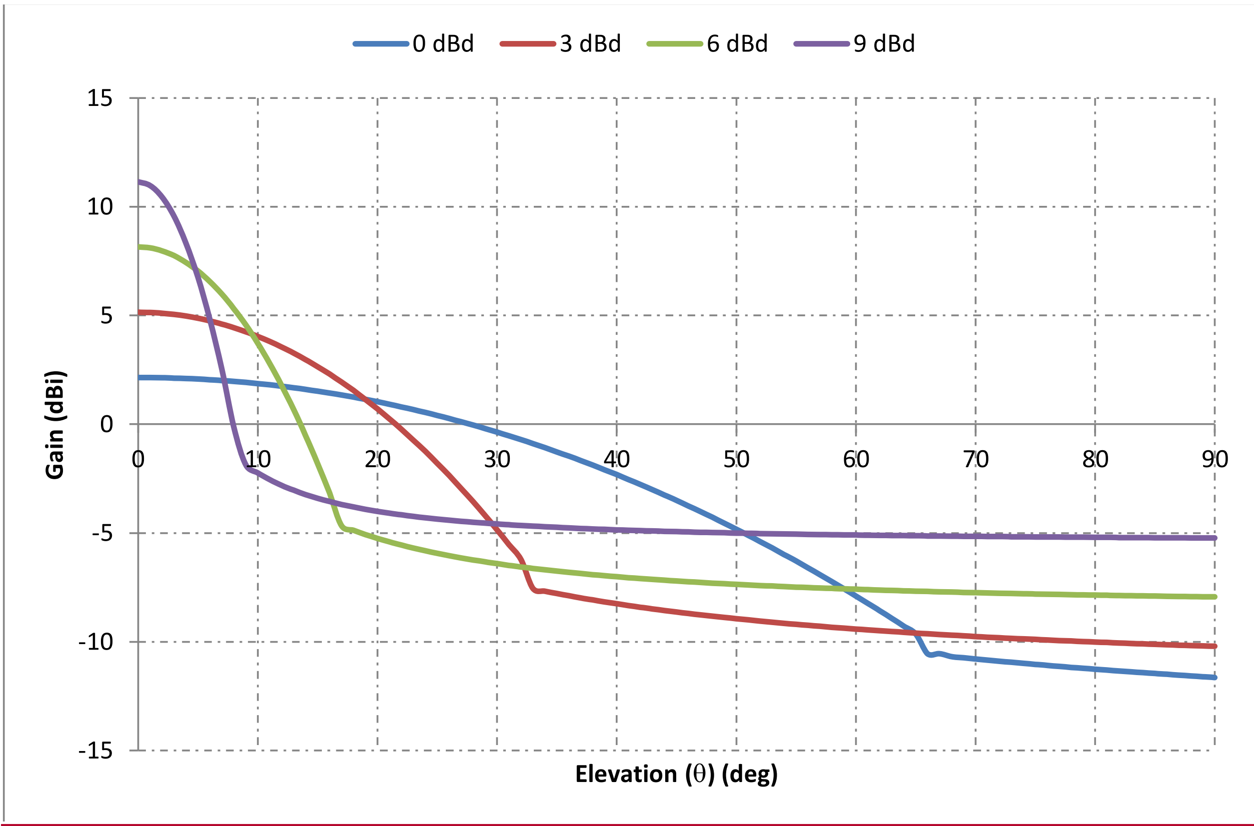


TABLE 31

Base station antenna gain and e.i.r.p versus elevation angle

Elevation angle	**Antenna gain**	**e.i.r.p.**
degrees	dBi	dBW
0	8.2	26.2
10	3.7	21.7
20	−5.2	12.8
30	−6.4	11.6
40	−7.0	11.0
50	−7.4	10.6
60	−7.6	10.4
70	−7.7	10.3
80	−7.9	10.1
90	−7.9	10.1

TABLE 32

Mobile station antenna gain and e.i.r.p versus elevation angle

Elevation angle	**Antenna gain**	**e.i.r.p.**
degrees	dBi	dBW

0	2.2	18.2
10	1.9	17.9
20	1.0	17.0
30	−0.4	15.6
40	−2.3	13.7
50	−4.8	11.2
60	−7.9	8.1
70	−10.8	5.2
80	−11.3	4.7
90	−11.6	4.4

6.1.2.2.1.2 Link budget calculations for transmission from base station to mobile station

Given the typical antenna heights for the land mobile base station and mobile station summarized in Table 30, the distance to the horizon from the base or mobile station can be calculated. Then the mobile station to base station range can be found to be 32.7 km. Based on the mobile station to base station range the transmission free space loss can be calculated to 106.9 dB.

In addition to the free space loss, a land mobile transmission channel will experience additional path loss. Recommendation ITU-R P.1546 provide methods for point-to-area predictions for terrestrial services for the relevant frequency band. Based on tabulated field strengths available from the Radiocommunication Bureau, as discussed in Annex 1 of that recommendation, combined with formulas for interpolation of field strength as function of antenna height, distance and frequency as provided in Annex 5 of that recommendation, the additional path loss can be estimated. The tabulated field strengths exceeded 50 % of the time from Recommendation ITU-R P.1546 assumes a transmit e.r.p of 1 kW, and the values needed to perform the interpolation to the frequency of 162 MHz and the antenna height and mobile station to base station range given in Table 30, are provided in Table 33.

TABLE 33

Tabulated field strength values exceeded 50% of the time from Recommendation ITU-R P.1546 needed to perform the interpolation to the frequency of 162 MHz and the antenna height and mobile station to base station range.

Frequency (MHz)	**Antenna height (m)**	**Distance (km)**	**Field strength value (dB uV/m)**
100	37.5	30	41.3
		35	38.1
	75	30	47.5
		35	44.2
600	37.5	30	37.5
		35	34.2
	75	30	44.2
		35	40.5

Through the use of the interpolation formulas provided in Annex 5 of Recommendation ITU-R P.1546 the estimated field strength can be calculated for the frequency of 162 MHz, antenna height of 60 meters and a distance of 32.7 km. The result is an estimated field strength of 42.7 dB uV/m. The corresponding field strength if only free space loss is considered will be 72.5 dB uV/m. The additional path loss experienced on a land mobile transmission channel is equal to this difference, which is 29.8 dB. The calculation steps are provided in Table 34 for transparency.

TABLE 34

Calculation steps for interpolation of field strength values exceeded 50% of the time from Recommendation ITU-R P.1546 to the frequency of 162 MHz and the antenna height and mobile station to base station range.

	Frequency (MHz)	**Antenna height (m)**	**Distance (km)**	**Field strength value (dB uV/m)**
Free space loss and additional path loss	162	37.5	30	40.3
			35	37.0
		75	30	46.6
			35	43.2
	162	60	30	44.5
			35	41.2
	162	60	32.7	42.7
Free space loss only	100		30	77.4
	162		32.7	72.5
Additional path loss only (dB)	*162*	*60*	*32.7*	*29.8*

The additional terrestrial path loss of 29.8 dB must be taken into considered in the link budget. Taking into account the mobile station EIRP at 0º elevation and the base station antenna gain at 0º elevation this leads to the received carrier power of -112.4 dBW for the mobile station to base station link and -109.4 dBW for the base station to mobile station link. The results are provided in Table 35.

TABLE 35

Link budget calculations for transmissions between mobile stations and base stations

Station type	**Base station**	**Mobile station**
Output power (W)	100	50
Output power (dBW)	20.0	17.0
Feed loss (dB)	2.0	1.0
Maximum antenna gain (dBd)	6.0	0.0
Maximum antenna gain (dBi)	8.2	2.2
Maximum e.r.p.	24.0	16.0
Maximum e.i.r.p.	26.2	18.1
Antenna height (m)	60	2.0

Station type	Base station	Mobile station
Distance to horizon from station (km)	27.7	5.0
Mobile station to base station range (km)	32.7	
Free space loss (dB)	106.9	
Additional terrestrial path loss (dB)	29.8	
Received carrier power *C* (dBW)	-112.4	-109.4

6.1.2.2.1.3 C/I analysis for the interference level from the VDE-SAT downlink into a base station

Recommendation ITU-R M.2092-0 and Section 4.2.1 of this report provide the pfd-mask for the VDE-SAT downlink. Based on the pfd mask, and the base station characteristics given in Table 6-7, a link budget for the interference level from the VDE-SAT downlink into a base station can be calculated. Combining the interference level with the received carrier power for transmissions between mobile stations and base stations from Table 35, the carrier to interference ratio (C/I) can be found. The outcome is presented in Tables 36 and 37.

It should be noted that a practical realization of the VDE-SAT downlink with the Yagi antenna concept as described in Section 4.1.4 will not match the pfd-mask perfectly. As shown in Table 7, there will be margin to the pfd-mask at all elevation angles, except at 30 degrees. When this additional margin is accounted for the C/I will improve further, as shown in Table 36 and 37.

TABLE 36

C/I considerations for transmissions from mobile station to base station with received carrier power, C, of -112.4 dBW and interference from the VDE-SAT downlink according to the pfd-mask specified in Recommendation ITU-R M.2092-0

Ship elevation angle	pfd-mask specified in Rec. ITU-R M.2092-0	pfd per 16 kHz	Base station antenna gain including feed loss	Effective area of base station antenna	*I* per 16 kHz	*C/I*	*C/I* with realizable pfd
degrees	dBW/m^2 per 4 kHz	dBW/m^2 per 16 kHz	dBi	dB(m^2)	dBW	dB	dB
0	-149.0	-143.0	6.2	0.6	-142.4	30.0	33.4
10	-147.4	-141.4	1.7	−3.9	-145.3	32.9	34.6
20	-145.8	-139.8	−7.2	−12.8	-152.6	40.2	40.6
30	-144.2	-138.2	−8.4	−14.0	-152.2	39.8	39.8
40	-142.6	-136.6	−9.0	−14.6	-151.2	38.8	39.6
50	-139.4	-133.4	−9.4	−15.0	-148.4	36.0	40.1
60	-134.0	-128.0	−9.6	−15.2	-143.2	30.8	41.3
70	-133.0	-127.0	−9.7	−15.3	-142.3	29.9	43.6
80	-132.0	-126.0	−9.9	−15.5	-141.5	29.1	46.3
90	-131.0	-125.0	−9.9	−15.5	-140.5	28.1	49.5

TABLE 37

C/I considerations for transmissions from base station to mobile station with received carrier power, C, of -109.4 dBW and interference from the VDE-SAT downlink according to the pfd-mask specified in Recommendation ITU-R M.2092-0

Ship elevation angle	pfd-mask specified in Rec. ITU-R M.2092-0	pfd per 16 kHz	Mobile station antenna gain including feed loss	Effective area of mobile station antenna	*I* per 16 kHz	*C/I*	*C/I* with realizable pfd
degrees	dBW/m^2 per 4 kHz	dBW/m^2 per 16 kHz	dBi	$dB(m^2)$	dBW	dB	dB
0	-149.0	-143.0	1.2	−4.4	-147.4	38.0	41.4
10	-147.4	-141.4	0.9	−4.7	-146.1	36.7	38.4
20	-145.8	-139.8	0.0	−5.6	-145.4	36.0	36.4
30	-144.2	-138.2	−1.4	−7.0	-145.2	35.8	35.8
40	-142.6	-136.6	−3.3	−8.9	-145.5	36.1	36.9
50	-139.4	-133.4	−5.8	−11.4	-144.8	35.4	39.5
60	-134.0	-128.0	−8.9	−14.5	-142.5	33.1	43.6
70	-133.0	-127.0	−11.8	−17.4	-144.4	35.0	48.7
80	-132.0	-126.0	−12.3	−17.9	-143.9	34.5	51.7
90	-131.0	-125.0	−12.6	−18.2	-143.2	33.8	55.2

6.1.2.2.1.4 Conclusions

As shown in Table 36, the carrier to interference ratio (C/I) for the mobile station to base station link with interference from the VDE-SAT downlink will be between 28.1 dB and 40.2 dB. For the base station to mobile station link the C/I with interference from the VDE-SAT downlink will be between 33.1 and 38.0 dB, as shown in Table 37.

Recommendation ITU-R M.1808, section 2.2 of Annex 1, provide SINAD ratio values of 12 dB to 20 dB for establishing degradation protection for land mobile systems. These SINAD values correspond to C/I values of 6 dB to 10 dB. A C/I level of more than 28.1 dB for the mobile station to base station link with interference from the VDE-SAT downlink is negligible relative to the SINAD degradation protection values provided in Recommendation ITU-R M.1808. When, considering the actual realizable pfd level, the situation will improve even further.

Furthermore, Report ITU-R M.1021 provides equipment characteristics for digital transmission in the land mobile service, including a bit energy to noise density ratio (E_b/N_0) reference sensitivity of 12 dB corresponding to a bit error ratio (BER) of 1%. According to Recommendation ITU-R M.1808, digital land mobile systems use C4FM modulation and a BER threshold of 5%. C4FM modulation has two bits per symbol. Given that C/I corresponds to symbol energy to noise density ratio (E_s/N_0), digital land mobile systems have a typical C/(N+I) threshold of 15 dB. A C/I level of more than 28.1 dB for the mobile station to base station link with interference from the VDE-SAT downlink is negligible relative to the reference sensitivity provided in Report ITU-R M.1021. When, considering the actual realizable pfd level, the situation will improve even further.

Therefore, it can be concluded that the land mobile service will not experience harmful interference from the VDE-SAT downlink with the pfd-mask specified in Recommendation ITU-R M.2092-0.

6.1.2.2.2 View 2 about the power flux density mask

(… no change …)

6.1.2.2.3 View 3 about power flux density mask

(… no change …)

6.2 Out-of-band interference

(… no change …)

7 Satellite receiver resilience to harmful interference from incumbent services and those in adjacent frequency band

7.1 Compatibility of VHF data exchange - satellite with the mobile service operating in the frequency band 156-162 MHz

7.1.1 Introduction

(… no change …)

7.1.2 Characteristics of land mobile systems operating in the 156 to 162 MHz band

(… no change …)

7.1.3 Characteristics of the VHF data exchange - satellite uplink

(… no change …)

7.1.4 Estimation of interference level from base and mobile stations operating in the land mobile service in the 156 to 162 MHz band

(… no change …)

7.1.5 Effect on VHF data exchange - satellite uplink link budget from interference from base and mobile stations operating in the land mobile service in the 156 to 162 MHz band

(… no change …)

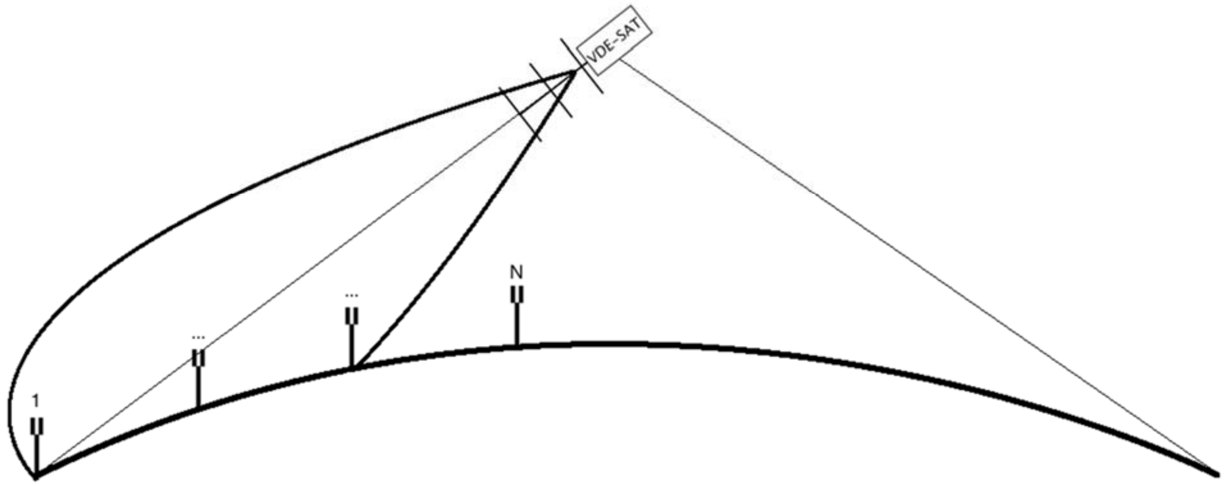
7.1.6 Effect of interference from multiple land mobile stations

As a satellite at all times will cover a large area, there is a chance that the VDE-SAT receiver on-board a satellite will experience simultaneous interference from multiple land mobile stations. To evaluate the effect of simultaneous interference from multiple land mobile stations an interference scenario as illustrated in Figure 18 has been defined.

~~[Editor's note: Figure 18 needs to be updated to ensure clarity]~~

FIGURE 18

Illustration of interference scenario to evaluate the effect of simultaneous interference from multiple land mobile stations.



The land mobile stations are illustrated by the antennas, and are placed along the boresight axis of the Yagi antenna. The number of interfering land mobile stations are given by the separation distance between the stations. Given the coverage radius for land mobile base station provided Table ~~7-1~~35 of typically 50 km. To limit interference between land mobile systems, the separation distance will normally be larger than 250 km.

Figures ~~7-3~~19 to ~~7-5~~21 presents estimated link margin for a range of land mobile base station separation distances. The results are based on interference power calculations performed using the same approach as that used in Tables ~~7-8~~42 and ~~7-10~~44, and summarizing multiple interference sources. For interference from land mobile base stations with a separation distance of 250 km the link margin is positive for a large range of ship elevation angles between about 20 and 44 degrees. The range of elevation angles with positive link margin grows to between 17 and 50 degrees with a land mobile base station separation distance of 300 km and to between about 10 and 57 with a land mobile base station separation distance of 500 km.

FIGURE 19

Estimated link margin for the VHF data exchange - satellite uplink waveform 1 with 8 interfering land mobile stations separated by 250 km.

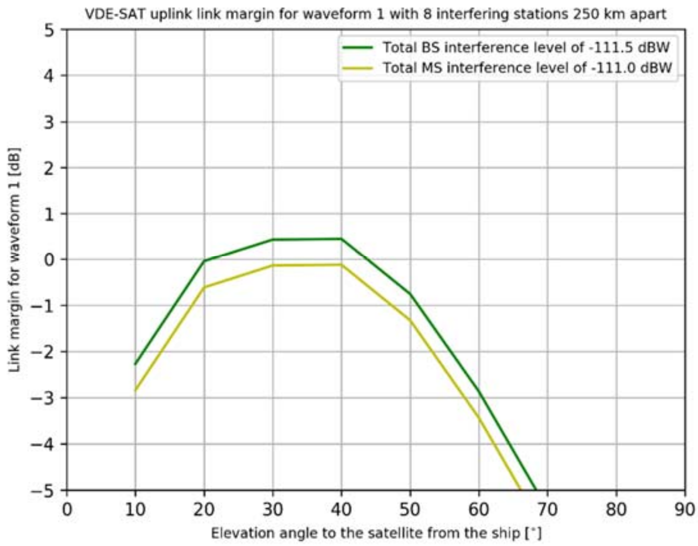


FIGURE 20

Estimated link margin for the VHF data exchange - satellite uplink waveform 1 with 6 interfering land mobile stations separated by 300 km.

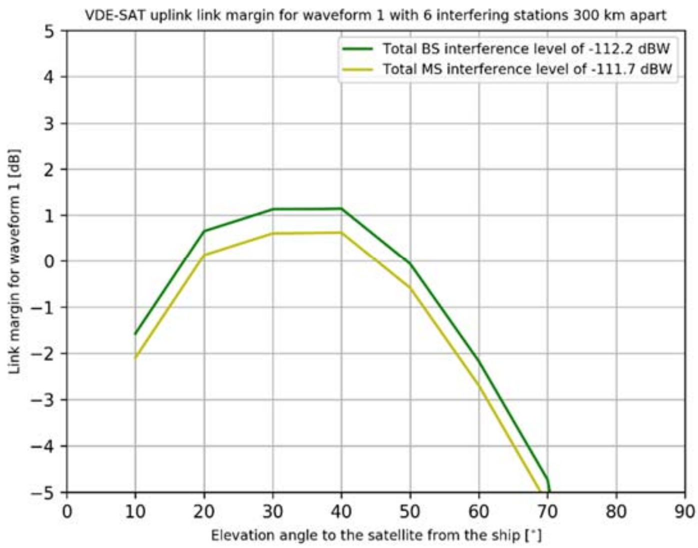
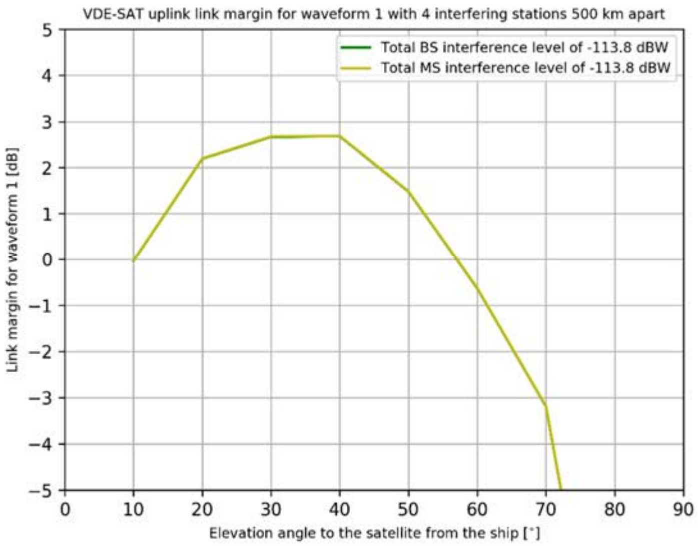


FIGURE 21

Estimated link margin for the VHF data exchange - satellite uplink waveform 1 with 4 interfering land mobile stations separated by 500 km.



A separation distance of 250 km can be assumed to represent a worst case scenario, since the VDE-SAT system is designed for maritime usage and the antenna therefore will be pointed towards sea and ocean areas where there are no land mobile stations. In addition, the discrimination factors and mitigation techniques summarized in Table 49 can be applied.

7.1.7 Conclusions

~~*[Editor's note: The conclusion needs to be revisited pending review of Tables 45 to 48.]*~~

~~Based on t~~The calculations and estimations presented in this section show that the most robust waveform, which provides low data rate operation~~above it is clear that only low data rate operation (at 1.1 kbps with the most robust waveforms defined for the VDE-SAT uplink)~~, is resilient to harmful interference from base and mobile stations operating in the land mobile service in the band 156-162 MHz for all elevation angles between 0 and 60 degrees. The more efficient waveforms, which provide higher data rates,~~High data rate operation (waveforms 2-5)~~ will not be available in presence of harmful interference from base and mobile stations operating in the land mobile service ~~unfeasible~~. Together with the interference mitigation techniques listed in Table 49, the adaptive coding and modulation scheme defined for VDE-SAT will ensure the use of the most efficient waveform with positive link margin.

7.2 Compatibility of VHF data exchange - satellite with the radiolocation service operating in the frequency band 154-156 MHz

7.2.1 Introduction

(… no change …)

7.2.2 Characteristics of space surveillance radars operating in the frequency band 154-156 MHz

(… no change …)

7.2.3 Characteristics of VHF data exchange - satellite uplink (ship-to-satellite)

(… no change …)

7.2.4 Scenario of interference from unwanted emissions by radars operating in the frequency band 154-156 MHz on VHF date exchange system satellite receiver

(… no change …)

7.2.5 Estimation of interference level from unwanted emissions by radars operating in the frequency band 154-156 MHz on VHF data exchange system satellite receiver

(… no change …)

7.2.6 Estimation of link budget for VHF data exchange system up-link with a satellite receiver in a 600 km altitude orbit

(… no change …)

7.2.7 Potential for burnout and blocking of the VHF data exchange-satellite receiver caused by unwanted emissions from the radar

Table 57 and Table 58 show the radar levels at the antenna for both the isoflux and Yagi antennas, with peak output e.i.r.p. from the radar of 71 dBW at 156 MHz. It can be seen that the maximum level is less than -61 dBW. This is more than 30 dB below expected burnout levels. Thus, the VDE-SAT receiver will not be exposed to an interference level from the radar that potentially can be capable of destroying the satellite receiver.

The presence radar signal between 154 and 156 MHz will add a blocking performance requirement for the VDE-SAT receiver. This requirement is not expected to be a concern.

TABLE 57

Maximum signal level of unwanted emissions from radar with Isoflux antenna onboard the satellite

Elevation angle	Radar e.i.r.p.	Polarisation loss	Range	Pathloss	Satellite antenna gain	Received signal level
Degrees	dBW	dB	km	dB	dBi	dBW
0	71.0	3.0	2 830.0	–145.3	2.0	–76.3
10	71.0	3.0	1 932.0	–142.0	1.5	–73.5
20	71.0	3.0	1 392.0	–139.2	1.0	–71.2
30	71.0	3.0	1 075.0	–136.9	–0.5	–70.4
40	71.0	3.0	882.0	–135.2	–2.0	–70.2
50	71.0	3.0	761.0	–133.9	–4.0	–70.9
60	71.0	3.0	683.0	–133.0	–5.0	–71.0
70	71.0	3.0	635.0	–132.4	–7.0	–72.4
80	71.0	3.0	608.0	–132.0	–8.0	–73.0
90	71.0	3.0	600.0	–131.9	–8.5	–73.4

TABLE 58[1]

Maximum signal level of unwanted emissions from radar with Yagi antenna onboard the satellite

Elevation angle	**Radar e.i.r.p.**	**Polarization loss**	**Range**	**Pathloss**	**Satellite antenna gain**	**Received signal level**
deg	dBW	dB	km	dB	dBi	dBW
0.0	71.0	3.0	2 830.0	–145.3	8.0	–70.3
10.0	71.0	3.0	1 932.0	–142.0	8.0	–67.0
20.0	71.0	3.0	1 392.0	–139.2	8.0	–64.2
30.0	71.0	3.0	1 075.0	–136.9	7.8	–62.1
40.0	71.0	3.0	882.0	–135.2	6.9	–61.3
50.0	71.0	3.0	761.0	–133.9	5.5	–61.4
60.0	71.0	3.0	683.0	–133.0	3.6	–62.4
70.0	71.0	3.0	635.0	–132.4	0.7	–64.7
80.0	71.0	3.0	608.0	–132.0	–2.2	–67.2
90.0	71.0	3.0	600.0	–131.9	–5.5	–70.4

7.2.8 Conclusions

~~*[Editorial note: The conclusion is reserved for finalization of the contents of this report and for confirmation in liaison exchanges with appropriate working parties.]*~~

~~*[Editor's note: The conclusion needs to be revisited pending review of Tables 54, 55 and 58.]*~~

~~[~~Based on the calculations and estimations presented above, ~~it is clear all~~ waveforms~~-~~ 1 to 4 defined for the VDE-SAT uplink, see Table 13, ~~excluding waveform 5 is~~are resilient to harmful interference from radars operating in the frequency band 154-156 MHz for all elevation angles up to 60~~-80~~ degrees~~, , without any additional interference discrimination or mitigation techniques~~. Allowing for potential discrimination factors and mitigation techniques discussed ~~above~~in Table 56, ~~even the~~ waveform 5 ~~are~~ is also expected to perform. Together with the interference mitigation techniques listed in Table 56, ~~The~~ the adaptive modulation and coding scheme defined for VDE-SAT will ensure use of the most efficient waveform with positive link margin. ~~can be utilized to ensure the link is closed.~~

Furthermore, ~~T~~the~~se~~ calculations and estimations ~~also~~ show that the interference level from the radar will not harm the onboard satellite VDE-SAT receiver.~~will not be exposed to an interference level from the radar that potentially can be capable of destroying the satellite receiver.]~~

8 Testing, demonstrations and measurements

(… no change …)

9 Future demonstrations and measurements

(… no change …)

[1] Antenna pointing is described in Section 4.1.4.~~requires clarification with subsequent refinement of the table content if necessary.~~

APPENDIX 1

Considerations for the power flux density mask for the VHF data exchange - satellite downlink
(Rec. ITU-R M.2092-0 Annex 4)

(… no change …)