

REPORT ITU-R M.2122

**EMC assessment of shore-based electronic navigation (eNAV)*
infrastructure and new draft Standards for data exchange
in the VHF maritime mobile band (156-174 MHz)**

(2007)

1 The emergence of modern shore-based eNAV infrastructure

The 1997 ITU World Radio Conference (WRC-97), by request from International Maritime Organization (IMO) (NAV 43; 1997), designated two upper legs of the duplex VHF public correspondence (VPC) channels, channels 87B and 88B, for the AIS globally. Following that frequency designation and the request for a technical standard for the AIS from IMO/NAV43, the ITU-R commenced drafting the AIS technical standard ITU-R M.1371 which also designated the Appendix 18 of the Radio Regulations (RR) channels 87B and 88B as the global ship-to-ship default channels for use on the high seas and globally unless otherwise designated by administrations within their territorial waters. The AIS designation by IMO and ITU affects the VPC, because the globally-designated AIS simplex frequencies were interleaved at the upper end of the block of duplex channels designated for the VPC. Consequentially, administrations should consider the needs of both the Marine Safety Authority (MSA) and the VPC provider to insure the safe and efficient operation of both the VPC and the AIS. An EMC (electro-magnetic compatibility) analysis should be considered to support the development of the eNAV that accounts for the technical characteristics of the radiocommunications systems that are used by the eNAV to ensure compatible operations.

The Reference Example of a 225 kHz wideband system based on the European Technical Standards Institute (ETSI) Standard in Section 3¹ requires a new channel usage plan in which digital VPC services would use a contiguous 225 kHz block of VPC channels, excluding channels 27 and 28. Channels 27 and 28 are adjacent to, and interleaved with, the AIS channels. This system poses potential compatibility issues amongst the maritime services in RR Appendix 18. A technical analysis of the prospective shore-based eNAV infrastructure is needed in order to insure the safe interoperability of the eNAV and SOLAS. This assessment should consider the need to protect all maritime systems.

2 Rationale for the EMC assessment of eNAV infrastructure**2.1 Compatibility of various eNAV infrastructure on adjacent RR Appendix 18 channels**

It is particularly important to address the possibility of interference from other maritime stations that use the channels adjacent to AIS for VPC voice radiocommunications, since this system could raise a constant CW carrier transmitter for the entire duration of the transmission. For example, VPC stations receive on the A-side of the duplex channels (e.g. channel 27A = 157.350 MHz, and

* eNAV – “E-Navigation is the harmonised creation, collection, integration, exchange and presentation of maritime information onboard 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”.

¹ The Reference Example in § 3 is based on Standard ETSI ETS300113-1v.1.5.1.

channel 28A = 157.400 MHz) and transmit on the B-side (e.g. channel 27B = 161.950 MHz, and channel 28B = 162.000 MHz), while the AIS both transmits and receives on the B-side (channel 87B = 161.975 MHz, and channel 88B = 162.025 MHz). Because of the frequency separation (± 0.025 MHz), these VPC voice shore transmitters could potentially interfere with AIS shore station receivers if they are located in close geographical proximity to each other, but the AIS transmitters have a large frequency separation (+4.625 MHz) from the VPC voice receivers and thus pose little interference threat to those stations. Additional study is required.

2.2 Compatibility of the transmitter emissions used for the eNAV

Transmitter emissions should be evaluated to assess the EMC between the shore-based eNAV:

- Voice radiocommunications,
- Data exchange, and
- AIS.

Transmitter emissions for AIS base stations are now defined by International Standard IEC 62320-1 Ed.1. The IEC also has emissions mask requirements for radio transmitters operating in RR Appendix 18, and these requirements have been considered for the AIS. Presumably, voice radiocommunications also consider the IEC emissions mask requirements, but the Reference Example for a 225 kHz wideband VHF data exchange system based on ETS300113-1v.1.5.1 does not consider the need to meet these requirements.

3 Maritime radiocommunications in Appendix 18 with the eNAV and the AIS requires EMC assessment

3.1 Channels for voice and data exchange

The interleaved adjacent channels within RR Appendix 18 present concerns to all maritime systems applications (voice, data exchange and AIS). A comprehensive EMC analysis based on the technical characteristics of the systems has not been performed within ITU-R and is required.

There may be some question whether a digital VPC application could be impaired on the ship station side by the ship-borne AIS on the internationally-designated AIS channels. No suitable off-the-shelf solution has been identified that solves this interference problem, although technology is currently available to develop a solution.

Thus, it may seem logical to conclude that VPC voice communications could be introduced on channels 27 and 28 (the VPC channels adjacent to and interleaved with AIS) in order to provide an immediate commercial application that was invulnerable to AIS and to reserve the channels farther removed from the AIS (and therefore less vulnerable to degradation from the AIS) for the new digital application. This argument may be supported by the rationale that a multi-channel bandwidth may be needed for the data exchange application that would necessitate combining contiguous VPC channels that could not include those interleaved and adjacent to the AIS. The Reference Example for a 225 kHz wideband data exchange system accommodates this rationale for multi-channel bandwidth; however, it does not clearly address the potential EMC issues to the VHF maritime mobile, including the AIS.

3.2 The impact of providing for a 225 kHz wideband VHF data system in RR Appendix 18

The Reference Example would necessarily be implemented in two parts. The first part concerns the consequential impacts on RR Appendix 18 in order to support the wideband 225 kHz VHF data system Reference Example and the second part describes the maritime application of the

ETS300113-1v.1.5.1 standard (the Reference Example) for a VHF data network. The second part describes the technical details of the digital radiocommunications system and the characteristics of the system.

A condensed summary of the wideband Reference Example follows:

- a) The consequential impact to RR Appendix 18:
RR Appendix 18 could require revision to provide more capacity to meet the increasing spectrum demand and in particular respond to the needs of data communications if the Reference Example were implemented. A possible digital maritime VHF technology to replace the existing analogue voice communications should be accepted only after completion of a full study. Such commonly acceptable technology for data is not likely to be available in the immediate future. For digital data in the VHF bands, such technology is being evaluated on an experimental basis by some administrations.
- b) Summary of technical and operational studies and relevant ITU-R Recommendations:
The diminished demand for public correspondence coast stations is apparent. The further introduction of digital radio telephony systems into this band could adopt suitably modified land mobile technology into a worldwide interoperable standard. When such radio telephony technology is available, RR Appendix 18 could consequentially be impacted be needed in the future if technologies such as the Reference Example were implemented. Concerning new digital data systems in the maritime VHF band, such technology is now available. A draft new ITU-R Recommendation will need to be prepared to support this application. This technology would introduce the use of a continuous band, i.e. up to 225 kHz bandwidth.

3.2.1 Inter-system EMC issues with the 225 kHz bandwidth VHF data exchange system

This Reference Example system has potential harmful effects on RR Appendix 18 and the other important services it supports, including the AIS which is now an IMO global carriage requirement for SOLAS vessels. Administrations are obligated to support the AIS, and many administrations are in the process of implementing AIS shore infrastructure that could prospectively be negatively impacted if the proposed wideband VHF data system is implemented with its shore infrastructure. Careful consideration should be given to technologies that can more efficiently provide this much-needed VHF data exchange that do not consequentially impact RR Appendix 18 and that have better EMC with the other existing systems.

Alternative technologies are available that could more efficiently provide a more efficient “VHF radio system and equipment for the exchange of data and e-mail on maritime RR Appendix 18 channels” without harmful interference to the VTS radiocommunications and the AIS and disruption to RR Appendix 18 and the applications it supports, including the International Convention for the Safety of Life at Sea (SOLAS).

The Reference Example would occupy a 225 kHz block of duplex spectrum (just below channels 27 and 28) by consolidating nine contiguous 25 kHz channels designated for VPC. This was to support a prospective wideband digital maritime VPC data exchange system. Concerns about this Reference Example are as follows:

- a) There is not an agreed need for a data rate as high as the proposed data rate of 133 kbit/s.
- b) Technology is available that is more spectrum-efficient that can also provide a high data rate on 25 kHz channels (e.g. ETSI TETRA-TEDS) provides up to 54 kbit/s in a 25 kHz channel bandwidth, and Radio Technical Commission for Maritime Services Special Committee 123 (RTCM SC123) is considering this for a new marine VHF digital small messaging service.
– This would not require consolidating the 25 kHz marine VHF channels.

- This would provide 3.65 times more data throughput ($9 \times 54 \text{ kbit/s} = 486 \text{ kbit/s}$ vs. 133 kbit/s) in the same spectrum.
 - This would provide a means to simultaneously serve multiple customers rather than one at a time, which further increases the efficiency of service.
- c) The 225 kHz transmitter spectral mask for the system (see Fig. 1) is so wide that it is an interference source for the adjacent 25 kHz channels, extending as far as the AIS channels.
- d) Since some administrations do not have all of the proposed nine (9) contiguous channels available in the maritime VPC, this poses an international interoperability problem for the new system.

An alternative approach could analyse the notion of having each channel independently available for any functional use, which would not require the upper interleaved VPC channels to be the only channels designated for voice radiocommunications in order to keep the lower VPC channels available as one contiguous block for the proposed new digital service. This could allow the voice services to be implemented on any of the channels currently available in RR Appendix 18 for VPC voice service thus alleviating the pressure on channels 27 and 28 to accommodate all voice traffic.

Note also that the ETSI TETRA-TEDS 54 kbit/s^2 system would provide a generous data rate allotment for forward error correction (FEC) and interleaving to mitigate any potential co-site interference problems imposed by the ship-borne AIS and still provide a high data throughput for the data exchange system.

3.2.2 Technical assessment of the 225 kHz bandwidth Reference Example

3.2.2.1 Technical assessment by the IALA eNAV Committee

The International Association of Maritime Aids to Navigation and Lighthouse Authorities (IALA) AIS Technical Working Group of the IALA eNAV Committee considered the Reference Example system at their 15-19 January 2007 meeting and drafted a liaison paper based on their expert assessment of this for submittal to ITU-R. IALA requested that ITU-R consider the potential impact on the systems operating in RR Appendix 18, especially the AIS.

3.2.2.2 Detailed technical analysis of the effects of the Reference Example on RR Appendix 18

3.2.2.2.1 The consequential impact of the Reference Example on RR Appendix 18

The consequential impact of the Reference Example on RR Appendix 18 is shown in Tables 1a) and 1b). Note that this calls for the consolidation of the 9 duplex (shore-ship) channels in the Upper Part (Table 1b)) designated for VHF Public Correspondence with footnote o), channels 23-26 and 82-86, into one 225 kHz wideband duplex (shore-ship) channel. Note also that the remaining VPC channels, including the adjacent channels to the AIS, channels 27 and 28, are proposed to be designated for VPC voice radiocommunications.

² ETSI – European Technical Standards Institute

TETRA – Terrestrial Trunked Radio

TEDS – TETRA Enhanced Data Service

TABLE 1

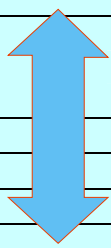
Consequential Impact of the Reference Example on RR Appendix 18

a) Lower part of RR Appendix 18

Channel designator	Notes	Transmitting frequencies (MHz)		Intership	Port operations and ship movement		Public correspondence
		Ship stations	Coast stations		Single frequency	Two frequency	
01	60 m), o)	156.025 156.050	160.625 160.650			x x	x x
	61 m), o)	156.075	160.675		x	x	x
02	62 m), o)	156.100 156.125	160.700 160.725		x x	x x	x x
03	63 m), o)	156.150 156.175	160.750 160.775		x x	x x	x x
04	64 m), o)	156.200 156.225	160.800 160.825		x x	x x	x x
05	65 m), o)	156.250 156.275	160.850 160.875		x x	x x	x x
06	f)	156.300	160.900	x			
07	66 m), o)	156.325 156.350	160.925 160.950				x x
	67 h)	156.375	156.375	x	x	x	
08		156.400		x			
09	68 i)	156.425 156.450	156.425 156.450	x	x x	x x	
10	69 h)	156.475 156.500	156.475 156.500	x	x x	x x	
	70 j)	156.525	156.525	Digital selective calling for distress, safety and calling			
11		156.550	156.550		x	x	
	71	156.575	156.575		x	x	
12		156.600	156.600		x	x	
	72 i)	156.625		x			
13	k)	156.650	156.650	x	x	x	
	73 h), i)	156.675	156.675	x	x	x	
14		156.700	156.700		x	x	
	74	156.725	156.725		x	x	
15	g)	156.750	156.750	x	x	x	
	75 n)	156.775			x	x	

TABLE 1 (end)

b) Upper part of RR Appendix 18

Channel designator	Notes	Transmitting frequencies (MHz)		Intership	Port operations and ship movement		Public correspondence
		Ship stations	Coast stations		Single frequency	Two frequency	
16		156.800	156.800	DISTRESS, SAFETY AND CALLING			
76	n)	156.825			x		
17	g)	156.850	156.850	x	x		
77		156.875		x			
18	m)	156.900	161.500		x	x	x
78	m)	156.925	161.525			x	x
19	m)	156.950	161.550			x	x
79	m)	156.975	161.575			x	x
20	m)	157.000	161.600			x	x
80	m)	157.025	161.625			x	x
21	m)	157.050	161.650			x	x
81	m)	157.075	161.675			x	x
22	m)	157.100	161.700		x	x	x
82	m), o)	157.125	161.725		x	x	x
23	m), o)	157.150	161.750		x	x	x
83	m), o)	157.175	161.775		x	x	x
24	m), o)	157.200	161.800		x	x	x
84	m), o)	157.225	161.825		x	x	x
25	m), o)	157.250	161.850		x	x	x
85	m), o)	157.275	161.875		x	x	x
26	m), o)	157.300	161.900		x	x	x
86	m), o)	157.325	161.925		x	x	x
27		157.350	161.950			x	x
87		157.375			x		
28		157.400	162.000			x	x
88		157.425			x		
AIS 1	l)	161.975	161.975				
AIS 2	l)	162.025	162.025				

	Public correspondence (Voice)
	VHF Data
	Ship to ship communication
	VTS, harbor and pilots
	AIS

An EMC analysis is needed to assess the impact of the Reference Example on the other applications provided by RR Appendix 18. The impact assessment should include:

- The characteristics of the wideband transmitter; and
- EMC analysis of the effects of the designation of channels 27 and 28 for VPC voice radiocommunications.

3.2.2.2.2 Analysis of the transmitter characteristics (based on ETSI Standard ETS300113)

Types of radios

The system operates in full duplex mode where bursts of data are transmitted over the RF channel. All data radios used are required to be capable of full-duplex operation.

Though base and mobile data radios are used in the system, the RF performance of both types shall meet the same requirements. For the purpose of this document only one wideband data radio type is assumed. Whenever a referred standard defines different parameter limits for different radio types, the limit value pertinent to base stations shall be applied.

Channel spacing

The wideband system is assumed to operate in a pair of 225 kHz channels created by joining 9 standard 25 kHz channel. The duplex spacing is assumed to be 4.6 MHz.

Emission designator

200KF1DAN

Modulation symbol rate

The modulation symbol rate shall be 133 000 symbols/s, which corresponds to raw data bit-rate of 133 kbit/s.

Test conditions, power sources and ambient temperatures

For definition of normal and extreme test conditions and for requirements on the test power sources see ETS300113-1 v.1.5.1 clause 6.

Transmitter frequency error

The frequency error of the transmitter is the difference between the measured carrier frequency in the absence of modulation (or with modulation, provided that the presence of modulation allows sufficiently accurate measurement of the carrier frequency) and the nominal frequency of the transmitter.

The transmitter frequency error shall not exceed 3 kHz under any combination of allowable operating conditions. For method of measurement see ETS300113-1 v 1.5.1., clause 8.1.2.

Transmitter carrier power

The transmitter carrier power is the mean power delivered to the artificial antenna during a radio frequency cycle.

The rated output power is the carrier power (conducted) of the equipment declared by the manufacturer.

The transmitter carrier power shall stay within +2.0 dB and –3.0 dB from the rated power under any combination of allowable operating conditions. For method of measurement see ETS300113-1 v 1.5.1., clause 8.2.2.1.

Transmitter spectral mask based on the 225 kHz data channel (refer to Fig. 1)

The emissions spectrum for the 225 kHz wideband data channel is measured by a spectrum analyser using 10 kHz read bandwidth, the zero reference level equals to the unmodulated carrier power.