REPORT ITU-R M.2010

IMPROVED EFFICIENCY IN THE USE OF THE BAND 156 - 174 MHz BY STATIONS IN THE MARITIME MOBILE SERVICE

(Question ITU-R 96/8)

(1993)

1 Introduction

1.1 Recommendation No. 318 (Mob-87) of the World Administrative Radio Conference (Geneva 1987) invites the CCIR to undertake urgently studies to determine the most appropriate means of promoting a more efficient use of the frequency spectrum in the VHF maritime mobile band.

1.2 This Report includes a survey of spectrum conserving technologies and systems, used in or proposed for the private land mobile services, and examines various options for their suitability to the VHF maritime mobile service. A small number were selected as having the greatest potential. These have been examined in more detail to determine the likely improvement in spectrum utilization and to identify related issues, both technical and operational, and areas requiring further study.

2. Survey of technologies and systems

The maritime service must at all times provide an effective communication channel for distress and safety calls, for search and rescue operations, and for navigational information. In addition the service supports Public Correspondence, the broadcast of weather bulletins, port and harbour control communications and intership communications. These factors have to be considered in assessing the suitability of the alternative technologies and systems. It is particularly important that any changes to the current system:

– be implementable within the maritime VHF band as additional spectrum cannot be expected in the foreseeable future;
– provide a significant increase in spectrum capacity; the changes will have to provide enough capacity to satisfy the growth expected over the next ten or more years. However it should be noted that existing terrestrial cellular systems already cover some coastal waters and are relieving some of the pressure from Public Correspondence channels in the maritime VHF band;
– have minimal impact on the existing services, particularly the operation of distress and safety channels;
– take advantage of new technologies available to provide new features, such as encryption to provide added security and privacy.

The alternative technologies and systems reviewed in this study are outlined below.

2.1 Narrow-band modulation

Replacing the current 25 kHz channels with channels of a narrower bandwidth would be a straightforward way of obtaining more channels. In principle halving the bandwidth would provide twice as many. In practice adjacent and co-channel performance is usually reduced with the result that reuse distances are increased and the full potential gain is not always realized.

The following narrow-band technologies have been considered:

– 12.5 kHz channel spacing using analogue FM. Potentially this could provide up to twice as many channels;
– 6.25 kHz channel spacing using digital speech and modulation. Potentially this could provide up to four times as many channels;
– 5 kHz channel spacing using linear modulation (a form of SSB modulation). Potentially this could provide up to five times as many channels.

All three approaches could provide significant capacity gains, are applicable to the VHF band, and would not entail any major changes in the way that current services operate. All are evaluated further in § 3.

2.2 Replacement of speech by data

In applications where standard messages are often used, or the message is one way, the transmission of text instead of voice can save a significant amount of channel time. For example, a 10 s voice message can be sent as text using data transmission at 1 200 bit/s in 2 s, and in less at higher bit rates. This offers a 5 to 1 improvement in channel capacity or better. However the extent to which this can be realized in practice depends on the extent to which text can replace voice.

On the optimistic assumption that half of all Port Operations traffic, but not Public Correspondence or ship-to-ship communications, can be replaced by data transmission the increase in capacity on the international frequencies would be equivalent to an additional six duplex and four simplex channels. Overall capacity would be increased by a factor of 1.2.

2.3 Automatic call set-up

The introduction of automatic call set-up systems provides a small increase in capacity, e.g. 20% assuming an existing manual call set-up time of 0.5 min for an average 2.5 min call.

3 Selected narrow-band modulation options

All the narrow-band technologies considered here are equally applicable to duplex and simplex channels.

3.1 12.5 kHz analogue FM

12.5 kHz FM modulation is already widely used in land mobile radio and could be adopted to give a halving of the channel spacing. The main advantage of this approach is that the technology is available and proven, and that the new equipment would be inter-operable with existing sets (with some reduction in performance). The major disadvantage is the limited gain in capacity relative to alternative narrow-band modulation techniques.

3.1.1 Spectrum/capacity gain

Halving the channel bandwidth would provide double the number of channels. There is, however, an increase in susceptibility to co-channel interference and therefore the minimum reuse distance would be increased. In areas where the reuse distance is anyway greater than this minimum the full gain in capacity of a factor of two would be obtained.

3.1.2 Operational issues and migration

Operationally there would need to be no changes and the new equipment would be interoperable with old equipment. Migration would be straightforward. Initially new channels could be interleaved (with suitable planning e.g. with sufficient geographical or frequency separation), and then progressively changed over to 12.5 kHz. Thus extra channels can be provided first where needed most.

3.1.3 Equipment

Equipment is available and in use for private land mobile today in the VHF bands. Costs would be expected to be about the same as for existing 25 kHz equipment.

3.2 5 kHz or 6.25 kHz linear modulation

Linear modulation based on ACSSB (amplitude compandored single sideband) with Transparent Tone In-Band (TTIB) and Feed Forward Signal Regeneration (FFSR) has been shown to be suitable for land mobile radio use in 6.25 kHz [McGeehan and Bateman, 1983] and 5 kHz [Baden and Jenkins, 1990] channels. The major advantage of this technology is the large gain in spectrum capacity with little or no change to operational procedures. Its main disadvantage is the limited availability of commercial equipment at the present time, although some use is being made of 5 kHz and 6.25 kHz equipment for the land mobile service in the United States and is therefore likely to become more readily available in the future.

3.2.1 Spectrum/capacity gain

5 kHz channelling would provide five times as many channels as are presently available. As with 12.5 kHz analogue FM the susceptibility to co-channel interference, and therefore the minimum reuse distance, is increased. In areas of intense frequency reuse the overall gain in capacity will be less than a factor of 5. [French, 1979], suggests that a factor of 2.5 is likely, although later (unpublished) studies indicate the higher reuse factor can be expected.

3.2.2 Operational issues and migration

Operationally there need be no changes. During the changeover phase, however, extra equipment or dual mode transceivers would be required. Migration would be by interleaving (possibly with two SSB channels between each old channel). Thereafter FM channels have to be taken out and replaced by narrow-band channels.

3.2.3 Equipment

ACSSB equipment is not at present in widespread use. However equipment has been developed and is being used on a limited basis at 220 MHz in the United States.

Initially costs would be expected to be higher than current 25 kHz equipment.

3.3 6.25 kHz channels with digital modulation

A digital speech codec and digital modulation could be used to provide a single speech channel in a 6.25 kHz channel. Such a system could flexibly support both speech and data. A built-in advantage of this system is that of inherent privacy and security, thus alleviating growing problems of this nature.

3.3.1 Spectrum/capacity gain

This approach would increase the number of channels by a factor of 4. The adjacent and co-channel performance of this format is not established, however, but in areas of intense frequency reuse the gain achievable may be less.

3.3.2 Operational issues and migration

Operationally there need be no changes but extra equipment or dual mode transceivers would be required during the changeover phase. Migration to the new system would be similar to 5 kHz ACSSB.

3.3.3 Equipment

There is no known prototype equipment. Initially costs would be expected to be higher than current 25 kHz equipment but would fall with volume production.

4 Reallocation of duplex channels to simplex

4.1 Spectrum/capacity gain

The capacity of each pair of duplex frequencies reallocationed as simplex channels is doubled. However, not all duplex channels could be re-assigned. Public Correspondence channels, for example, would not be suited to simplex working. Making the assumption that all duplex channels exclusive to Port Operations and half those shared with Public Correspondence could be reallocated as two single frequency channels the number of extra channels obtained is 16. This is equivalent to a gain in capacity of a factor of 1.3.

It should be noted that single frequency operation is normally to be avoided at radio stations required to operate on more than one channel at a time. Receiving on one antenna while transmitting on a nearby frequency on an adjacent antenna requires very high levels of filtering and considerably increases the engineering problems and cost of the installation.

4.2 Operational issues and migration

The introduction of additional simplex channels would not require any operational changes. Duplex channels could be changed over individually or in groups. New equipment would be required only where existing equipment was not re-programmable.

4.3 Equipment

There are no technical problems or risks associated with this change.

5 Summary and conclusions

Table 1 summarizes the main characteristics of the selected options.

TABLE 1

Comparison of the selected options

Option	Gain in capacity	Operational implications	Migration	Equipment
12.5 kHz analogue FM	x 1.5 - x 2	None, inter-operable with existing equipment	Interleaving	Used in land mobile radio service
5 kHz or 6.25 kHz linear modulation	x 2.5 - x 5	Extra or dual mode equipment required	Interleaving (with careful planning)	In limited use in land mobile radio service
6.25 kHz channelling with digital modulation	< x 4	Extra or dual mode equipment required	Interleaving (with careful planning)	No commercial equipment available
Reallocation of duplex channels to simplex	x 1.3	None	"Over night" changeover but simple	Minor changes to current equipment

Changing to 12.5 kHz analogue FM or reallocating duplex channels to simplex operation would be the simplest approach to improving spectrum utilization. Both would have minimal impact on current operations and a straightforward migration path. Spectrum utilization would increase by a factor of between 1.5 and 2 with 12.5 kHz analogue FM, and by a factor of 1.3 with re-allocation of duplex channels. By combining both changes the number of duplex channels could be maintained at their present levels and the spectrum utilization gain increased to a factor of approximately 2.5.

Larger gains in spectrum utilization would be achieved with either 5 kHz linear modulation or with 6.25 kHz channels and digital voice. The former would increase utilization by a factor of between 2.5 and 5, the latter by a factor of up to 4 plus inherent security and privacy. The penalty would be the need for dual mode equipment during changeover and the increase in equipment costs. Neither technology is yet in widespread use but 5 kHz linear modulation (ACSSB) is in limited commercial use in the United States. However it should be borne in mind that any change to the channelling arrangement of Appendix 18 to the Radio Regulations will require a decision by a future competent World Radio Conference which could not occur before 1997 at the earliest, by which time use of these technologies by the land mobile service is likely to have reduced the cost significantly.

The estimates of spectrum gain presented in this Report are based on studies of land mobile radio and as such provide only a guide to the performance likely in the VHF maritime band. Before firm conclusions can be drawn further work is required to verify the estimates. In particular the adjacent and co-channel performance and its implications for frequency reuse require further study.

It can be seen that 5 kHz linear modulation or 6.25 kHz channelling with digital voice or data provide the greatest potential for a significant increase in efficiency in the use of the maritime VHF band and should be the prime candidates for further study.

REFERENCES

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