Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

MANAGING THE TRANSITION TO DIGITAL SOUND BROADCASTING IN THE LF/MF BANDS

Athens, February 2008

0 EXECUTIVE SUMMARY

In ITU Regions 1 and 3, the GE75 LF/MF Final Acts provide a Plan for the assignment of frequencies to broadcasting stations, a modification procedure (Article 4) and the technical details to be used for the preparation of the Plan. This Agreement is based on analogue amplitude modulated double-sideband (AM) transmissions.

Digital Radio Mondiale (DRM) as a technology is anticipated to be used alongside AM initially and then supersede it over time. It is a COFDM digital sound broadcasting modulation format which offers a better utilisation of spectrum and provides a considerably improved quality of service for both broadcaster and audience, while still fitting within the same channel bandwidths of existing AM transmissions. Based on work carried out in the ITU it is suggested that for the same interference potential, the total power in a DRM transmission should be 7 dB lower than the carrier power of the original AM assignment. Considerable detail can be found in ITU-R Recommendations BS 1514 and BS 1615 (references (1) and (2)), and on the DRM website www.drm.org.

All the necessary regulatory provisions, in particular the Rules of Procedure associated with the GE75 Agreement, are already in place to allow the deployment of DRM within the existing GE75 Plan and to allow a progressive analogue to digital transition for sound broadcasting in the LF and MF bands. Thanks to these Rules of Procedure, a significant number of DRM transmissions are currently 'on air' as advertised or experimental services Therefore, no action is currently required in this area.

Further work will be needed, however to review the necessary technical parameters, such as minimum usable field strength and protection ratio, for which the current values are partly based on the results of theoretical studies.

Given the improvement in quality available with DRM, there will be pressure to introduce stereo and other potential enhancements, some of which will require a greater transmission bandwidth. The GE 75 Plan has some assignments with bandwidths wider than the standard 9 kHz channel and the DRM standard encompasses similarly wider bandwidth modes. There will be a need for suitable DRM planning parameters for the wider bandwidth modes.

In the longer term, as more and more transmissions migrate to 'digital', the matter of protecting analogue transmission will become less important and the planning environment may need to be reconsidered, based on the experience gained from practical implementation. It may then be possible to enhance the existing regulatory provisions in order to take advantage of wider bandwidth modes and improved planning parameters as they become available. The improved planning parameters can be incorporated into the GE75 Agreement by a Regional Conference but such a Conference is not needed for the foreseeable future.

All concerned broadcasters and Administrations within CEPT are encouraged to consider the transition from analogue to DRM digital transmissions in order to benefit from the improved quality of service which is already available.

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1 INTRODUCTION

AM double sideband broadcasting in the LF, MF bands has been in operation for some 85 years. Broadcasters rely heavily upon the use of these bands because of the ease of providing wide-area coverage with very stable and predictable propagation conditions. The technology is simple to implement for transmitters and receivers and, for at least half of that period of operation, has delivered good quality to listeners. However, growing demand for additional coverage and rising expectations for audio quality means that the services offered in the LF/MF bands have become increasingly unsatisfactory.

The first attempts, from the early 1950s, to counter interference and spectrum congestion involved the transfer or duplication of many service requirements into VHF Band II using FM. Another major factor at the time was to overcome impulsive interference from car spark ignition systems and other man-made noise sources. Although better suppression techniques eventually overcame those problems, broadcasting at LF/MF now faces new challenges from radiated noise caused by PLT systems, together with switched mode power supplies in lighting and electronic equipment, and the large numbers of electronic devices like PCs. Nonetheless, AM broadcasting in the LF/MF bands has retained many advantages in terms of predictable coverage and simple receiver design.

1.1 Alternative modulation techniques in the LF/MF bands

Several schemes have been investigated to make better use of the available spectrum or to improve the listening experience in the LF/MF bands. Single-sideband (SSB) techniques, using both reduced and suppressed carriers were at one time considered to offer the possibility of easing congestion in the LF/MF bands. However, receiver complexity and expense with the available manufacturing technology at that time proved to be major negative factors; also the listening experience was judged to be poor. Perhaps the outcome would have been different if solid state processing and surface wave filters had been available to allow the production of low cost receivers without inductive components. But crucially, SSB did not offer a useful improvement in spectrum availability once the protected bandwidth requirements needed to support the rapid roll-off in the spectrum mask had been factored in.

The next scheme to be considered was AM stereo. A number of systems advanced to the trial stage, some of which, using quadrature frequency and phase shift modulation techniques, did prove that the available bandwidth of LF/MF broadcasting channels could support the transmission of more information. However, the project failed in terms of commercial viability. One interesting conclusion was that basic AM audio quality could be much improved by requiring better linearity in the design and coupling of transmitters and aerials. Also the standard of early solid state receivers left much to be desired. The inherent linearity of a valve superheterodyne receiver was far superior to that of junction transistor designs.

The earlier false starts in improving LF/MF sound broadcasting were nevertheless instrumental in guiding further studies once the advent of digital sound compression techniques and narrow band modulation techniques had reached the stage where re-engineering a delivery system in the LF/MF bands to support digital sound broadcasting could be contemplated.

1.2 Advent of digital sound broadcasting below 30 MHz

The service requirements for a narrow bandwidth digital modulation system to replace analogue modulation in the LF, MF and HF bands were set by Recommendation ITU-R BS.1348 (1998, revised 2001), namely to:

- be capable of providing high-quality monophonic or stereophonic sound to vehicular, portable and fixed receivers;
- provide better spectrum and power efficiency than conventional analogue systems;
- provide significantly improved performance in a multipath environment;
- allow for a trade-off between extent of coverage and service quality for a given emission power;
- be capable of allowing, with a common receiver, the use of all means of programme delivery (e.g. mono, stereo, dual mono);
- be capable of providing facilities for programme-related data;
- be capable of providing additional data services;
- allow the manufacturing of low-cost receivers through mass production.

Subsequently two systems for digital sound broadcasting in the bands below 30 MHz were selected for evaluation in Recommendation ITU-R BS.1514, namely the Digital Radio Mondiale system (DRM) and the IBOC system (In Band, On Channel system. NB: in commercial deployment, IBOC is now referred to as HD Radio). Only the DRM system met all the objectives set throughout the LF, MF and HF bands. Following extensive tests over 5 years, European administrations are now concentrating on taking forward the deployment of DRM.

The DRM system was developed specifically to replace AM broadcasting in the LF, MF and HF bands. The audio signals are compressed into a data stream using Advanced Audio Coding (AAC) techniques, a further development by the Fraunhofer Institute of the MPEG[1] compression algorithms used in the production and distribution of audiovisual works. The system specification includes a choice of three audio codecs, and supports both Single Frequency and Multi-Frequency Network operation (SFN/MFN).

As with other systems for digital broadcasting (e.g. Eureka 147 DAB and Digital Video Broadcasting DVB-T), DRM uses coded orthogonal frequency division multiplexing (COFDM) to transmit the encoded audio data. In the DRM system, 200 sub-carriers are distributed across the 9 or 10 kHz channels used for broadcasting below 30 MHz. Each of the various subcarriers is modulated using quadrature amplitude modulation (QAM) in order to carry the information content.

The system is actually a family of compression modes. In a standard mode, the DRM system can deliver a far superior audio quality within the same bandwidth of a standard AM broadcast, thereby achieving the important goal of improving the utilisation of the radio frequency spectrum. Various enhanced modes are also available which could be used to replace a standard monophonic AM broadcast by stereo or dual language programming. The DRM system has the capability to tailor its transmission characteristics to match the service requirements and variations in radio propagation conditions.

2 TRANSITION TO DRM

The substitution or addition of DRM emissions into bands formally used exclusively by AM double-sideband transmissions poses a number of regulatory and administrative problems. While the protection ratios between DRM emissions are more advantageous in terms of spectrum occupancy than those for AM, and DRM broadcasts can operate at lower power levels than AM, the worst case protection scenario is from DRM to AM emissions. In the HF bands, this was the main problem that had to be resolved in moving over to digital modulation, since previous WRC decisions, notably Resolution 517 (Rev.WRC-03), specifically allow digital modulation in the HF bands allocated to the broadcasting service, under the provisions of the six monthly scheduling Procedure of Article 12. The disparity in protection levels in a mixed environment of analogue and digital broadcasts was overcome by adopting a 7 dB power reduction for a digital broadcast compared to that for a comparable analogue broadcast. The 7 dB factor thus represents a compromise between retaining coverage requirements for digital broadcasts and the protection of analogue services, and also assumes the use of high compression audio processing for a comparable AM transmission. The worst case situation is mixed analogue and digital emissions in the same band – a situation that will persist for some time as the transition to digital modulation progresses. Planning for optimum band utilization will be much easier in an all digital environment.

The key to achieving an all digital environment for sound broadcasting below 30 MHz is a rapid transition to digital broadcasting in the LF and MF bands. This is of crucial interest and importance to the major commercial and public service broadcasting networks in all countries. The objective of a rapid deployment of digital broadcasting in the LF and MF bands does, however, have to be consistent with the long established Plans for LF and MF sound broadcasting around the world.

1 Motion Picture Expert's Group

2.1 Current regulatory situation in the LF/MF frequency bands

The ITU frequency allocations to the broadcasting service in the LF and MF bands are summarised in the following table. The relevant extracts from the Radio Regulations, Article 5 (Frequency Allocations), are given in Annex 4.

ITU Regions and associated Agreements	LF Band	MF Band
Region 1 GE75	148.5-255.0 kHz 255.0-283.5 kHz (shared with aeronautical services)	526.5-1606.5 kHz
Region 2 RJ81 RJ88	- - -	525.0-535 kHz (shared with aeronautical services) 535.0-1 605.0 kHz 1 605.0-1 625.0 kHz 1 625.0-1 705.0 kHz (shared with fixed and mobile services)
Region 3 GE75	- - -	526.5-535 kHz (with mobile services on a secondary basis) 535.0-1 606.5 kHz

ITU frequency allocations - LF and MF bands

For Europe the relevant Plan is that established at the ITU Conference of 1975 in Geneva for countries in ITU Regions 1 & 3 (the GE75 Plan). The GE75 LF/MF Final Acts provide a Plan for the assignment of frequencies to broadcasting stations, a modification procedure (Article 4) and the technical details to be used for the preparation of the Plan.

For ITU Region 2, the operative MF broadcasting plan is that of Rio de Janeiro, 1981 (the RJ81 Plan); there being no LF broadcasting band in Region 2.

GE75 is the latest in a series of Plans that have supported LF/MF broadcasting:

- Geneva 1925 – standardised on 10 kHz channel spacings at MF;
- Brussels 1928 – moved to 9 kHz channel spacings on MF below 1000 kHz;
- Prague 1929 – 9 kHz channel spacings on MF extended to 1400 kHz;
- Madrid/Lucerne 1932 – mostly 9 kHz channel spacings, but not harmonic multiples;
- Montreux 1939 – never implemented due to World War II;
- Copenhagen 1948 – all 9 kHz spacings, but offset from harmonic multiples by 1 kHz at MF and 2 kHz at LF

The GE75 Plan is based on analogue double-sideband transmissions. All channel spacings are 9 kHz and, in order to reduce heterodyning, all assignments now operate on exact multiples of 9 kHz. Note, however, that channel bandwidths are not all fixed at 9 kHz; many assignments operate with 10, 15, 16, 18 or 20 kHz bandwidths. This is irrespective of domestic receiver bandwidths.

A regime of detailed international planning has proved essential for providing and coordinating terrestrial broadcasting in and between countries. Except for the HF bands, the coverage of terrestrial broadcasts is, for the most part, planned on the basis of national coverage. However, with the higher powers used, compared to many other radiocommunication services, the potential for interference can extend well beyond national boundaries. Moreover, many LF/MF stations, particularly from the early years of broadcasting, have been established with the purpose of extending the cultural reach of programming beyond national boundaries.

A crucial element in the broadcasting Plans developed for LF, MF, VHF and UHF terrestrial broadcasting is to define a means of calculating the usable field strength for the Plan entries. The usable field strengths then serve as a reference that can be used to assess the impact on coverage with modifications or additions to the entries in the Plan. A common methodology used to assess the impact of modifications or additions to a broadcasting Plan is to assess whether the effect of the changed interference environment will degrade the usable field strength at the test points, determined in accordance with the GE75 Agreement, by more than 0.5 dB. The "half dB rule" is fundamental to the maintenance of the GE75 Plan for LF/MF Broadcasting in ITU Regions 1 & 3.

2.1.1 Adapting the GE75 Plan for the DRM system

In order to facilitate the rapid deployment of digital broadcasting in the LF and MF bands, but without introducing the additional uncertainties of reviewing the GE75 Plan in all its aspects, a mechanism was developed, with the assistance of the Radio Regulatory Board (RRB), whereby an existing GE75 assignment may be converted to DRM with a power reduction of 7 dB. New DRM assignments may also be considered, under the standard procedures for modifying the Plan, but again with a power reduction of 7 dB relative to that of comparable new broadcasting assignments using analogue double sideband emissions. This power reduction was considered to be effective in maintaining the existing interference environment of the GE75 Plan and was based on the existing practice in the HF bands.

To a first approximation the power needed for a DRM transmission is the same as the sideband power in an AM transmission. There is therefore a considerable power saving through elimination of the carrier component. An exact comparison is, however, difficult because of the widespread use of asymmetric modulation and high compression audio processing in modern AM transmitters. Since the 1980s, most designs now function using pulsed modulation, switched at around a 60 kHz rate, and can deliver 125% modulation in the sideband energy for audio peaks. The fact that the modulation process is, in effect, digitally switched also means that conversion to fully digital modulation is relatively straightforward and DRM transmitters use similar techniques but at the higher switching frequency of 192kHz.

The mechanism for introducing DRM into the GE75 Plan is through Rules of Procedure modifying how the Radiocommunication Bureau handles notifications and examinations made under the regulatory procedures of the GE75 Plan. This was possible because the GE75 Plan had already envisaged the use of other modulation methods at a later date and, unlike the RJ81 Plan, imposes no technological restrictions on modulation methods. In the RJ81 Plan, sound broadcasting transmissions must be receivable using envelope detection.

2.1.2 The Rules of Procedure including the decision of the RRB in December 2002

Two Rules of Procedure have been prepared by the Radiocommunication Bureau of the ITU to complement the GE75 Final Acts in order to permit the use of DRM transmissions in the GE75 LF/MF Plan. In December 2002, the Radio Regulatory Board (RRB) amended these Rules of Procedure, as follows:

- The first Rule of Procedure is related to "Resolution N°8 (Relating to the Use of Bandwidth Saving Modulation Systems) " of the GE75 Final Acts. In order to permit the conversion of existing analogue assignments to digital. this Rule of Procedure records that *"any frequency assignment for AM broadcasting in the Plan may provisionally be used with digital modulation (transmission types DRM A2 or B2), provided the radiation is reduced by at least 7 dB in all directions, compared to the radiation of the AM modulated frequency assignment in the Plan"*. The DRM A2 and B2 modes are optimised for higher data throughput, as opposed to error correction overheads, and therefore provide for better audio quality, but depend on the stable propagation conditions in the LF/MF bands in order to maintain reliability.

  This first Rule of Procedure, as amended by the RRB in December 2002, is shown in Annex 1.

- The second Rule of Procedure is related to "Chapter 4 (Broadcasting Standards) of Annex 2" of the GE75 Final Acts. It is intended to clarify the technical requirements and procedures to permit notification of DRM Mode A2 or B2 assignments into the GE75 Plan. The Rule of Procedure states: *"In the examination of the probability of interference from notices related to assignments using digital modulation, the Bureau shall use a co-channel protection ratio increased by 7 dB, and an adjacent channel protection ratio increased by 1 dB compared to the one applicable to the interfered transmitter"*.

  This second Rule of Procedure, as amended by the RRB in December 2002, is shown in Annex 2.

An additional amendment introduced by the RRB decision to each Rule of Procedure is that *"This Rule of Procedure is of a provisional nature until such time that it is confirmed by a competent conference empowered to deal with the subject matter."* For completeness the full text of the RRB decision adopted in December 2002 is shown in Annex 3.

The RRB noted the comments and support from a number of administrations for the desirability of facilitating the introduction of digital modulation, while preserving the integrity of the Plan.

The RRB also considered comments from other administrations that suggested that issues dealt with in the Rules should be subject to consideration by a Conference. However, the RRB concluded that, given the current schedule of conferences, such a consideration is not envisaged in the foreseeable future. Indeed, until the transition to digital modulation has

progressed to the extent that the remaining analogue stations need no longer constrain the power or coverage requirements of replacement or new digital assignments, there would be no purpose in re-considering the Plan.

2.2 Planning Criteria

Rec. ITU-R BS 1615 "Planning parameters for digital sound broadcasting at frequencies below 30 MHz" forms the basis of all the planning parameters required to plan a DRM service. It contains all the necessary planning parameters (i.e. protections ratios and minimum usable field strengths) and describes their derivation which is partly based on a theoretical approach and will need verification within the broadcast environment of the GE 75 Plan.

Therefore with the expected increase in the number of DRM transmissions, there will be a need for field measurements to confirm the compatibility checks as outlined in the table below.

This should include minimum usable field strength and protection ratio values for the DRM system for the following cases:

Wanted Emission	Unwanted Emission
Analogue	DRM
DRM	Analogue
DRM	DRM

2.3 Further development of the GE75 Plan TO FACILITATE the transition to DRM

An essential component of a broadcasting Plan is the ability to define a reference situation in terms of usable fields strengths, and hence coverage potential, that will support further development of the Plan. Thus, eventually, the GE75 Plan will need to be revised in terms of all digital entries, with remaining analogue assignments having to accept operation within the envelope of a digital assignment, which would be the reverse of the present situation. At the least, this will require moving away from the provisional limitation of DRM operation in the LF/MF bands to the 9 kHz bandwidth modes for GE75. The DRM planning parameters will need to be expanded and confirmed to incorporate the wide bandwidth modes (10, 15, 16, 18 & 20 kHz), allowed for in the Plan, assuming that future receivers are capable of receiving in these wider bandwidths.

At present, the wider bandwidth assignments in the GE75 Plan allow broadcasters greater freedom to provide a higher quality AM services without using the high degree of audio compression and processing assumed in establishing the 7 dB compatibility figure for 9 kHz channel bandwidths. However nearly all analogue receivers filter out the majority of any extra bandwidth for on channel analogue signals, but would suffer adjacent channel interference from a DRM signal wider than the standard 9kHz GE75 channels.

For the future, once analogue is switched off, the wider bandwidth assignments in the GE75 Plan may be able to exploit the full capabilities of the DRM system to provide additional functionality, such as stereo, additional languages or digital data. Moreover, the MF prediction method is being revised in ITU-R SG3 to include "city absorption" etc. It is therefore premature to consider revision to the Plan as a whole or even just the technical part of the associated Agreement until a stable known planning environment is established, and the limitations imposed by co-existence in a predominantly analogue environment have been removed.

2.3.1 Need for a revision of GE75 Agreement and PLAN

To take account of co- and adjacent channel DRM transmissions in their own right, the existing or modified planning parameters need to be incorporated into the GE75 Final Acts. This would involve changes to Annex 2, Chapter 4 of the Agreement, particularly the following sections:

- Class of Emission
- Protection Ratios
- Co-Channel Protection Ratios
- Adjacent Channel Protection Ratios
- Minimum Value of Field Strength
- Usable Field Strength

Furthermore, various issues related to coverage for DRM will need to be addressed, such as:

- How is the DRM coverage defined?
- How is it protected?
- How a protected AM coverage area might change as an assignment changes to DRM?[2]
- How a protected coverage is defined in a plan that encompasses both DRM and AM assignments?
- How a protected coverage might have to change to reflect legitimate changes to the plan and how any subsequent increases or losses in coverage should be treated?

Such revisions to the GE75 Final Acts can only be introduced by a competent Regional Radiocommunications Conference[3]. Although the changes required are substantial, they do not necessarily affect the frequency assignment Plan. It is therefore likely that the changes to the modification procedure could in principle be agreed at a short conference aimed only at the revision of technical parameters and associated procedures.

Administrations already have a possibility to modify and add assignments to the GE75 Plan in order to meet the requirements for digital transmission (DRM). It is expected that over time most, if not all, existing AM services would migrate to DRM. This in itself may yield increased spectrum efficiency (SFN usage) and allow introduction of new services. Furthermore, a substantial experience in the roll-out of DRM transmissions is required to verify and/or improve the planning parameters contained in the current ITU Recommendations and to evaluate the performance of consumer receivers.

Therefore, it is considered that a planning conference to revise the GE75 Agreement and the associated Plan is not needed in the foreseeable future and this question should be revisited at an appropriate time in the future. Convening such a conference while the transition is still in progress would absorb considerable financial and engineering resources and preparations are likely to be time consuming. The overall benefit of having a revised Agreement would be significantly reduced by the increased complexity of the procedures and contentious timescales, most of which will become redundant after the transition is complete.

3 CONCLUSIONS

The switch from AM sound broadcasting to digital transmission (DRM) in the LF/MF bands will bring many benefits to listeners in terms of improved audio quality and the availability of added value options. The subjective experience on an average quality receiver will be much the same as FM and the wider area coverage will provide benefits to broadcasters and society as a whole in reducing the consumption of electrical power.

The current regulatory provisions, in particular the GE75 Agreement and the associated Rules of Procedure, are adequate to allow the deployment of DRM within the existing GE75 Plan and to allow a progressive analogue to digital transition. Therefore, no action is currently required in this area.

However, there are some shortcomings in the current regulatory situation. The current Rules of Procedure are limited to DRM transmissions with spectrum occupancy 2 (9 kHz). There is no provision for increasing spectrum occupancy. Furthermore, these Rules of Procedure are provisional and as a consequence the DRM transmissions introduced using these Rules of Procedure are also provisional.

In the longer term, as more and more transmissions migrate to 'digital', the matter of protecting analogue transmission will become less important and the planning environment may need to be reconsidered, based on the experience gained from practical implementation. It may be possible to enhance the existing regulatory provisions in order to take advantage of wider bandwidth modes and improved planning parameters as they become available. Further work will be needed to review the necessary technical parameters, such as minimum usable field strength and protection ratios, for which the current values are partly based on the results of theoretical studies.

An ITU conference may need to be convened at an appropriate point in the future to revise the GE75 Agreement and the associated Plan. Such a conference should take advantage of wider bandwidth DRM modes and improved planning parameters as they become available and should aim at optimising network coverage so as to make best use of the advantages offered by DRM.

[2] Some coverage implications of the transition to DRM are elaborated in Annex 5 to this Report.
[3] Article 14, No.2, of GE75 states that "The Agreement shall remain in force until it is revised by a competent conference of the Members of the Union in Regions 1 and 3 of the GE75 Agreement"

4 REFERENCES

(1) **Recommendation ITU-R - BS.1514**: System for digital sound broadcasting in the broadcasting bands below 30 MHz.

(2) **Recommendation ITU-R - BS.1615**: Planning parameters for digital sound broadcasting at frequencies below 30 MHz.

(3) **Recommendation ITU-R - BS.1348**: Service requirements for digital sound broadcasting at frequencies below 30MHz.

(4) **Final Acts** of the Regional Administrative Conference, LF/MF broadcasting Conference (Regions 1 and 3) Geneva, 1975:

(5) **ITU Circular letter CCRR/20:** Special study, under No. 13.15 of the Radio Regulations, in relation to the regional agreements GE75, RJ81 and RJ88

ANNEX 1

RULE OF PROCEDURE RELATED TO RESOLUTION N°8 OF THE GE75 AGREEMENT, AS AMENDED BY DECISION OF THE RRB IN DECEMBER 2002

Resolution No. 8 of the Regional Conference, Geneva, 1975, states:

"1. *that broadcasting stations may provisionally use bandwidth saving modulation methods on condition that interference in the same or adjacent channels concerned does not exceed the interference resulting from the application of double sideband modulation with full carrier (A3E)*;

2. *that any administration which envisages using these methods of emission shall seek the agreement of all affected administrations by following the procedure specified in Article 4 of the Agreement*."

After consideration of the relevant ITU-R studies, the Board decided that any frequency assignment for AM broadcasting in the Plan may provisionally be used with digital modulation (transmission types DRM A2 or B2), provided the radiation is reduced by at least 7 dB in all directions, compared to the radiation of the AM modulated frequency assignment in the Plan.

Therefore, when examining the conformity to the GE75 Plan of a notice received under Article 11 of the Radio Regulations, the Bureau shall accept such a notice as being in conformity to the Plan. A note should indicate that the favourable finding is provisional.

This Rule of Procedure is of a provisional nature until such time that it is confirmed by a competent conference empowered to deal with the subject matter.

ANNEX 2

RULE OF PROCEDURE RELATED TO ANNEX 2 TO THE GE75 AGREEMENT, AS AMENDED BY DECISION OF THE RRB IN DECEMBER 2002

Chapter 4 of Annex 2 gives the broadcasting standards applicable to the Agreement. In particular:

4.1 *Class of Emission*: The Plan is established for a system with double sideband amplitude modulation with full carrier (A3E).

4.2 *Power*: The power of a transmitter is the carrier power in the absence of modulation.

4.3 *Radiated Power*: The radiated power is assumed to be the product of the nominal power of the transmitter and the gain of the antenna (relative to a short vertical antenna) without taking into account any losses[*]. It is expressed either by the cymomotive force (c.m.f. in V or in dB relative to 300 V) or by the effective monopole radiated power (e.m.r.p. in kW or in dB relative to 1 kW).

4.4 *Protection Ratios*: In applying the Agreement, the values of the co-channel and adjacent channel protection ratios given below should be used unless otherwise agreed between the administrations concerned. In the case of fluctuating wanted or unwanted signals, the values of the protection ratio apply for at least 50% of the nights of the year at midnight.

However, Resolution No. 8 of the Regional Conference, Geneva, 1975, states:

"*1. that broadcasting stations may provisionally use bandwidth saving modulation methods on condition that interference in the same or adjacent channels concerned does not exceed the interference resulting from the application of double sideband modulation with full carrier (A3E)*;

2. that any administration which envisages using these methods of emission shall seek the agreement of all affected administrations by following the procedure specified in Article 4 of the Agreement."

After consideration of the relevant ITU-R studies, the Board decided that any frequency assignment for AM broadcasting in the Plan may provisionally be used with digital modulation (transmission types DRM A2 or B2), provided the radiation is reduced by at least 7 dB in all directions, compared to the radiation of the AM modulated frequency assignment in the Plan.

The power of the transmitter to be notified in case of digital modulation shall be the total power within the necessary bandwidth.

In the examination of the probability of interference from notices related to assignments using digital modulation, the Bureau shall use a co-channel protection ratio increased by 7 dB, and an adjacent channel protection ratio increased by 1 dB compared to the one applicable to the interfered transmitter.

When the proposed assignment using digital modulation is recorded into the Plan following the application of Article 4, it shall bear a symbol indicating that the recording is provisional. The reference situation shall be determined as if it were an AM transmission using an audio-frequency modulating signal of 4.5 kHz and a high degree of compression.

This Rule of Procedure is of a provisional nature until such time that it is confirmed by a competent conference empowered to deal with the subject matter.

ANNEX 3

DECISION OF THE RRB - DECEMBER 2002

The RRB (Radio Regulatory Board) approved the Rules of Procedure as proposed with the following amendments:

1) Amend the fourth paragraph of the Rule relating to Resolution 8 (Annex 1 to CCRR/20) and the ninth paragraph of the Rule relating to Annex 2 (Annex 2 to CCRR/20) as follows: "After consideration of the relevant ITU-R studies, the Board decided that any frequency assignment for AM broadcasting in the Plan may provisionally be used with digital modulation (transmission types DRM A2 or B2), provided the radiation is reduced by at least 7 dB in all directions, compared to the radiation of the AM modulated frequency assignment in the Plan".

2) Add a new sentence at the end of each rule as follows: "This Rule of Procedure is of a provisional nature until such time that it is confirmed by a competent conference empowered to deal with the subject matter."

The Board noted the comments and support from a number of administrations for the desirability of facilitating the introduction of digital modulation, while preserving the integrity of the Plan. The Board also considered comments from other administrations that suggested that issues dealt with in the Rules should be subject to consideration by a Conference.

The Board concluded that, given the current schedule of conferences, such a consideration is not envisaged in the foreseeable future.

ANNEX 4

EXTRACT FROM THE RADIO REGULATIONS, ARTICLE 5 (FREQUENCY ALLOCATIONS): LF AND MF FREQUENCY BANDS ALLOCATED TO BROADCASTING

110-255 kHz

<table>
<tr><th colspan="3">Allocation to services</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td>110-112
FIXED
MARITIME MOBILE
RADIONAVIGATION

5.64</td><td rowspan="8">110-130
FIXED
MARITIME MOBILE
MARITIME RADIO-
NAVIGATION 5.60

Radiolocation</td><td>110-112
FIXED
MARITIME MOBILE
RADIONAVIGATION 5.60

5.64</td></tr>
<tr><td>112-115
RADIONAVIGATION 5.60</td><td>112-117.6
RADIONAVIGATION 5.60</td></tr>
<tr><td>115-117.6
RADIONAVIGATION 5.60
Fixed
Maritime mobile

5.64 5.66</td><td>Fixed
Maritime mobile

5.64 5.65</td></tr>
<tr><td>117.6-126
FIXED
MARITIME MOBILE
RADIONAVIGATION 5.60
5.64</td><td>117.6-126
FIXED
MARITIME MOBILE
RADIONAVIGATION 5.60
5.64</td></tr>
<tr><td>126-129
RADIONAVIGATION 5.60</td><td>126-129
RADIONAVIGATION 5.60
Fixed
Maritime mobile
5.64 5.65</td></tr>
<tr><td>129-130
FIXED
MARITIME MOBILE
RADIONAVIGATION 5.60

5.64</td><td>129-130
FIXED
MARITIME MOBILE
RADIONAVIGATION 5.60

5.64</td></tr>
<tr><td>130-148.5
FIXED
MARITIME MOBILE
5.64 5.67

148.5-255
BROADCASTING

5.68 5.69 5.70</td><td>130-160
FIXED
MARITIME MOBILE

5.64

160-190
FIXED

190-200
AERONAUTICAL
RADIONAVIGATION</td><td>130-160
FIXED
MARITIME MOBILE
RADIONAVIGATION
5.64

160-190
FIXED
Aeronautical radionavigation</td></tr>
</table>

5.65 *Different category of service:* in Bangladesh, the allocation of the bands 112-117.6 kHz and 126-129 kHz to the fixed and maritime mobile services is on a primary basis (see No. **5.33**). (WRC-2000)

5.66 *Different category of service:* in Germany, the allocation of the band 115-117.6 kHz to the fixed and maritime mobile services is on a primary basis (see No. **5.33**) and to the radionavigation service on a secondary basis (see No. **5.32**).

5.67 *Additional allocation:* in Azerbaijan, Bulgaria, Mongolia, Kyrgyzstan, Romania and Turkmenistan, the band 130-148.5 kHz is also allocated to the radionavigation service on a secondary basis. Within and between these countries this service shall have an equal right to operate. (WRC-2000)

5.68 *Alternative allocation:* in Angola, Burundi, Congo (Rep. of the), Malawi, the Dem. Rep. of the Congo, Rwanda and South Africa, the band 160-200 kHz is allocated to the fixed service on a primary basis. (WRC-03)

5.69 *Additional allocation:* in Somalia, the band 200-255 kHz is also allocated to the aeronautical radionavigation service on a primary basis.

5.70 *Alternative allocation:* in Angola, Botswana, Burundi, Cameroon, the Central African Rep., Congo (Rep. of the), Ethiopia, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Nigeria, Oman, the Dem. Rep. of the Congo, Rwanda, South Africa, Swaziland, Tanzania, Chad, Zambia and Zimbabwe, the band 200-283.5 kHz is allocated to the aeronautical radionavigation service on a primary basis. (WRC-03)

200-495 kHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
255-283.5 BROADCASTING AERONAUTICAL RADIONAVIGATION 5.70 5.71	**200-275** AERONAUTICAL RADIONAVIGATION Aeronautical mobile	**200-285** AERONAUTICAL RADIONAVIGATION Aeronautical mobile
283.5-315 AERONAUTICAL RADIONAVIGATION MARITIME RADIONAVIGATION (radiobeacons) 5.73 5.72 5.74	**275-285** AERONAUTICAL RADIONAVIGATION Aeronautical mobile Maritime radionavigation (radiobeacons) **285-315** AERONAUTICAL RADIONAVIGATION MARITIME RADIONAVIGATION (radiobeacons) 5.73	
315-325 AERONAUTICAL RADIONAVIGATION Maritime radionavigation (radiobeacons) 5.73 5.72 5.75	**315-325** MARITIME RADIONAVIGATION (radiobeacons) 5.73 Aeronautical radionavigation	**315-325** AERONAUTICAL RADIONAVIGATION MARITIME RADIONAVIGATION (radiobeacons) 5.73
325-405 AERONAUTICAL RADIONAVIGATION 5.72	**325-335** AERONAUTICAL RADIONAVIGATION Aeronautical mobile Maritime radionavigation (radiobeacons) **335-405** AERONAUTICAL RADIONAVIGATION Aeronautical mobile	**325-405** AERONAUTICAL RADIONAVIGATION Aeronautical mobile
405-415 RADIONAVIGATION 5.76 5.72	**405-415** RADIONAVIGATION 5.76 Aeronautical mobile	
415-435 MARITIME MOBILE 5.79 AERONAUTICAL RADIONAVIGATION 5.72	**415-495** MARITIME MOBILE 5.79 5.79A Aeronautical radionavigation 5.80	
435-495 MARITIME MOBILE 5.79 5.79A Aeronautical radionavigation		
5.72 5.82	5.77 5.78 5.82	

5.71 *Alternative allocation:* in Tunisia, the band 255-283.5 kHz is allocated to the broadcasting service on a primary basis.

5.72 Norwegian stations of the fixed service situated in northern areas (north of 60° N) subject to auroral disturbances are allowed to continue operation on four frequencies in the bands 283.5-490 kHz and 510-526.5 kHz.

5.73 The band 285-325 kHz (283.5-325 kHz in Region 1) in the maritime radionavigation service may be used to transmit supplementary navigational information using narrow-band techniques, on condition that no harmful interference is caused to radiobeacon stations operating in the radionavigation service. (WRC-97)

5.74 *Additional Allocation:* in Region 1, the frequency band 285.3-285.7 kHz is also allocated to the maritime radionavigation service (other than radiobeacons) on a primary basis.

5.75 *Different category of service:* in Armenia, Azerbaijan, Belarus, the Russian Federation, Georgia, Moldova, Kyrgyzstan, Tajikistan, Turkmenistan, Ukraine and the Black Sea areas of Bulgaria and Romania, the allocation of the band 315-325 kHz to the maritime radionavigation service is on a primary basis under the condition that in the Baltic Sea area, the assignment of frequencies in this band to new stations in the maritime or aeronautical radionavigation services shall be subject to prior consultation between the administrations concerned. (WRC-2000)

5.76 The frequency 410 kHz is designated for radio direction-finding in the maritime radionavigation service. The other radionavigation services to which the band 405-415 kHz is allocated shall not cause harmful interference to radio direction-finding in the band 406.5-413.5 kHz.

5.77 *Different category of service:* in Australia, China, the French Overseas Territories of Region 3, India, Indonesia (until 1 January 2005), Iran (Islamic Republic of), Japan, Pakistan, Papua New Guinea and Sri Lanka, the allocation of the band 415-495 kHz to the aeronautical radionavigation service is on a primary basis. Administrations in these countries shall take all practical steps necessary to ensure that aeronautical radionavigation stations in the band 435-495 kHz do not cause interference to reception by coast stations of ship stations transmitting on frequencies designated for ship stations on a worldwide basis (see No. **52.39**). (WRC-2000)

5.78 *Different category of service:* in Cuba, the United States of America and Mexico, the allocation of the band 415-435 kHz to the aeronautical radionavigation service is on a primary basis.

5.79 The use of the bands 415-495 kHz and 505-526.5 kHz (505-510 kHz in Region 2) by the maritime mobile service is limited to radiotelegraphy.

5.79A When establishing coast stations in the NAVTEX service on the frequencies 490 kHz, 518 kHz and 4 209.5 kHz, administrations are strongly recommended to coordinate the operating characteristics in accordance with the procedures of the International Maritime Organization (IMO) (see Resolution **339 (Rev.WRC-97)**)*. (WRC-97)

5.80 In Region 2, the use of the band 435-495 kHz by the aeronautical radionavigation service is limited to non-directional beacons not employing voice transmission.

5.81 (SUP - WRC-2000)

5.82 In the maritime mobile service, the frequency 490 kHz is, from the date of full implementation of the GMDSS (see Resolution **331 (Rev.WRC-97)**)*, to be used exclusively for the transmission by coast stations of navigational and meteorological warnings and urgent information to ships, by means of narrow-band direct-printing telegraphy. The conditions for use of the frequency 490 kHz are prescribed in Articles **31** and **52**. In using the band 415-495 kHz for the aeronautical radionavigation service, administrations are requested to ensure that no harmful interference is caused to the frequency 490 kHz. (WRC-97)

495-1 800 kHz

Allocation to services		
Region 1	**Region 2**	**Region 3**
495-505		
505-526.5 MARITIME MOBILE 5.79 5.79A 5.84 AERONAUTICAL RADIONAVIGATION	**505-510** MARITIME MOBILE 5.79	**505-526.5** MARITIME MOBILE 5.79 5.79A 5.84 AERONAUTICAL RADIONAVIGATION Aeronautical mobile
	510-525 MOBILE 5.79A 5.84 AERONAUTICAL RADIONAVIGATION	Land mobile
5.72	**525-535**	
526.5-1 606.5 BROADCASTING	BROADCASTING 5.86 AERONAUTICAL RADIONAVIGATION	**526.5-535** BROADCASTING Mobile 5.88
	535-1 605 BROADCASTING	**535-1 606.5** BROADCASTING
5.87 5.87A	**1 605-1 625**	
1 606.5-1 625 FIXED MARITIME MOBILE 5.90 LAND MOBILE	BROADCASTING 5.89	**1 606.5-1 800** FIXED MOBILE RADIOLOCATION RADIONAVIGATION
5.92	5.90	
1 625-1 635 RADIOLOCATION	**1 625-1 705** FIXED MOBILE BROADCASTING 5.89 Radiolocation	
5.93	5.90	
1 635-1 800 FIXED MARITIME MOBILE 5.90 LAND MOBILE	**1 705-1 800** FIXED MOBILE RADIOLOCATION AERONAUTICAL RADIONAVIGATION	
5.92 5.96		5.91

5.83 The frequency 500 kHz is an international distress and calling frequency for Morse radiotelegraphy. The conditions for its use are prescribed in Articles **31** and **52,** and in Appendix **13**.

5.84 The conditions for the use of the frequency 518 kHz by the maritime mobile service are prescribed in Articles **31** and **52** and in Appendix **13**. (WRC-97)

5.85 Not used.

5.86 In Region 2, in the band 525-535 kHz the carrier power of broadcasting stations shall not exceed 1 kW during the day and 250 W at night.

5.87 *Additional allocation:* in Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland and Zimbabwe, the band 526.5-535 kHz is also allocated to the mobile service on a secondary basis. (WRC-03)

5.87A *Additional allocation:* in Uzbekistan, the band 526.5-1 606.5 kHz is also allocated to the radionavigation service on a primary basis. Such use is subject to agreement obtained under No. **9.21** with administrations concerned and limited to ground-based radiobeacons in operation on 27 October 1997 until the end of their lifetime. (WRC-97)

5.88 *Additional allocation:* in China, the band 526.5-535 kHz is also allocated to the aeronautical radionavigation service on a secondary basis.

5.89 In Region 2, the use of the band 1 605-1 705 kHz by stations of the broadcasting service is subject to the Plan established by the Regional Administrative Radio Conference (Rio de Janeiro, 1988).

The examination of frequency assignments to stations of the fixed and mobile services in the band 1 625-1 705 kHz shall take account of the allotments appearing in the Plan established by the Regional Administrative Radio Conference (Rio de Janeiro, 1988).

5.90 In the band 1 605-1 705 kHz, in cases where a broadcasting station of Region 2 is concerned, the service area of the maritime mobile stations in Region 1 shall be limited to that provided by ground-wave propagation.

5.91 *Additional allocation:* in the Philippines and Sri Lanka, the band 1 606.5-1 705 kHz is also allocated to the broadcasting service on a secondary basis. (WRC-97)

5.92 Some countries of Region 1 use radiodetermination systems in the bands 1 606.5-1 625 kHz, 1 635-1 800 kHz, 1 850-2 160 kHz, 2 194-2 300 kHz, 2 502-2 850 kHz and 3 500-3 800 kHz, subject to agreement obtained under No. **9.21**. The radiated mean power of these stations shall not exceed 50 W.

5.93 *Additional allocation:* in Angola, Armenia, Azerbaijan, Belarus, the Russian Federation, Georgia, Hungary, Kazakhstan, Latvia, Lithuania, Moldova, Mongolia, Nigeria, Uzbekistan, Poland, Kyrgyzstan, Slovakia, the Czech Rep., Tajikistan, Chad, Turkmenistan and Ukraine, the bands 1 625-1 635 kHz, 1 800-1 810 kHz and 2 160-2 170 kHz and, in Bulgaria, the bands 1 625-1 635 kHz and 1 800-1 810 kHz, are also allocated to the fixed and land mobile services on a primary basis, subject to agreement obtained under No. **9.21**. (WRC-2000)

5.94 and **5.95** Not used.

5.96 In Germany, Armenia, Austria, Azerbaijan, Belarus, Denmark, Estonia, the Russian Federation, Finland, Georgia, Hungary, Ireland, Iceland, Israel, Kazakhstan, Latvia, Liechtenstein, Lithuania, Malta, Moldova, Norway, Uzbekistan, Poland, Kyrgyzstan, Slovakia, the Czech Rep., the United Kingdom, Sweden, Switzerland, Tajikistan, Turkmenistan and Ukraine, administrations may allocate up to 200 kHz to their amateur service in the bands 1 715-1 800 kHz and 1 850-2 000 kHz. However, when allocating the bands within this range to their amateur service, administrations shall, after prior consultation with administrations of neighbouring countries, take such steps as may be necessary to prevent harmful interference from their amateur service to the fixed and mobile services of other countries. The mean power of any amateur station shall not exceed 10 W. (WRC-03)

ANNEX 5

COVERAGE IMPLICATIONS OF THE TRANSITION TO DRM

The coverage range of transmissions in the LF/MF bands is determined by the electrical properties of the ground along the path from the transmitter to receiver, and the effects of the ionosphere. Propagation at these frequencies is predominately determined by the transmission of a ground wave (or more precisely a surface wave) along the surface of the earth. The range of the ground wave is related to the conductivity of the earth's surface along the path; the longest ranges being achieved over surfaces with good conductivity and consequently low attenuation (e.g., salt water, coastal areas, grass land) and the shortest over surfaces with poor conductivity and consequently high attenuation (e.g., deserts, built-up areas). Eventually the limit of coverage is reached when the signal strength is attenuated to a level that is no longer usable for communication purposes, but it may still be significant in degrading reception of transmissions in adjacent areas.

Propagation by sky wave - reflection from the ionosphere - also plays a part in determining the wanted coverage area and also the extent of interference to other transmissions beyond the reliable coverage area. Reflections from the ionosphere can extend the range of LF/MF transmissions to several times the ground wave limit. The effect is particularly evident during the night when the lowest ionised layer of the ionosphere, the D-layer, rapidly disappears after sunset. The D- layer predominantly acts as an absorber of LF/MF radio waves. Normally, the impact of the ionosphere on LF/MF broadcasting is that strong reflections from the next higher layer of the ionosphere, the E-layer, will take place at night once the effect of absorption in the D-layer disappears at sunset.

The effect is more pronounced at MF, greatly extending the potential range of the transmissions. This can be a negative effect, because of *mutual interference* between stations on the same frequency, and *interference fading* caused by a broadcasting transmitter's own signals arriving at the receiver by different paths from the transmitting station. Alternatively, ionospheric propagation effects can be exploited by planning for extended coverage at night by sky wave. Normally though, action is taken to minimise the interference from sky wave effects through aerial designs that limit high angle radiation, or through making power reductions at night. As the main purpose of the GE75 Plan is to maximise re-use of the LF/MF spectrum for broadcasting, the planned characteristics of the assignments typically include day and night time variations to the aerial configuration and transmitter power.

The treatment of day and night coverage variability will require further consideration before any revision of the Plan for an all digital environment can be contemplated. This is because of the more adverse impact on digital reception quality in areas where a broadcast is received via ground wave and sky wave simultaneously. With analogue modulation, the audible effect of interference fading in the zone where the ground wave and sky wave components overlap is a fairly annoying continuous variation between a low level noisy distorted sound and a louder slushy sound, but programme content remains intelligible. With DRM the effect is heard as a pronounced rhythmic fading pattern, where the signal goes from good to almost total mutual interference/cancellation, which may well be perceived as more objectionable than the AM case.

The night time skywave propagation also means that the co-ordination of high power stations has to be done over a very wide geographical area, as signals can easily reach across a continental scale. It is this very large co-ordination area which would make reconvening any conference to review GE75 a truly monumental task, possibly on a similar scale to the RRC06, but with co-ordination ranges, and the number of countries from which approval would be required per high power transmitter multiplied by a factor of 10 or more. This would be a very time consuming and costly exercise, especially when considering that we already have a set of Rules of Procedure to cover it.

Another planning consideration that will change substantially after the period of mixed analogue and digital broadcasting gives way to predominately digital use is the high level of protection that is required for coordinating stations in the analogue to analogue and digital to analogue cases, compared to digital to digital. This means that coverage from digital broadcasting stations will be subject to limitations during the transition period that can be relaxed after the transition is substantially complete.

To attempt to improve on this situation by revising the GE75 Plan before this point would involve introducing complex coordination procedures to cover all the possible variants in coordinating band use between stations (legacy analogue to analogue, analogue to digital, digital to analogue and digital to digital), all but one of which would become obsolete in due course. In addition to the waste of time and resources involved, the prospect of an impending re-planning conference for the LF/MF bands will create uncertainty as to the outcome and may well dissuade broadcasters from taking the risk of re-engineering their LF/MF networks. The design and construction of LF/MF transmitting stations requires a far greater effort in terms of financial planning, civil engineering and health and safety considerations than VHF FM broadcasting stations.