Technical Specification Group Services and System Aspects **TSGS#2(99)xxx**

Meeting #2, Fort Lauderdale, 2-4 March 1999

Source:	**TSG-S4 (Codec Working Group)**
Title:	**Mandatory Speech Codec**
Document for:	**Decision**
Agenda Item:	**9.4**

The definition of the narrowband telephony speech service for 3G systems requires to select and specify a speech codec to be mandatory supported by all 3G terminals and network equipment.

TSG-SA WG4 has approved a dedicated Work Item to complete the corresponding specifications on time for the approval of the 3GPP Release 99. TSG-SA WG4 believes that in order to meet this deadline, the mandatory speech codec must be identified as soon as possible. The baseline specifications (Transcoding functions essentially) should be available by April 1999 in order to complete and approve the standard by December 1999. Once the codec has been selected, a considerable amount of work will be required to fully specify and characterise the operation of the speech codec over the 3G radio channels (W-CDMA or TD/CDMA).

This document provides some background information on the work accomplished on this issue by the 3GPP partners.

Based on the results of the evaluation of multiple candidate speech codecs (see reference section), TSG-SA WG4 recommends that TSG-SA approves the selection of the GSM AMR as the mandatory speech codec. This proposal is based on the following key considerations:

- The GSM AMR includes multiple (8) codec modes providing the required flexibility to offer a toll quality speech service without compromising the system capacity;
- The GSM AMR includes the GSM EFR (at 12.2 kbps) and the IS136 EFR (at 7.4 kbps) offering a high level of compatibility with key 2G systems;
- No other candidate codec provides better performances than the GSM EFR (highest mode of GSM AMR). The GSM EFR was found to provide the best performances with respect to the requirements set by ARIB for the Mandatory Speech codec, often exceeding the required performance level;
- At equivalent source rate, the internal codec modes of AMR always provide equivalent or better performances than the other candidate speech codecs. For example the AMR codec modes at 7.95 kbit/s (and 7.4 kbit/s) were found equivalent or better than the IS127 EVRC (8.55 kbit/s mode) or the G.729 (8 kbit/s);
- The AMR speech codec specifications were recently approved by SMG. The corresponding C-Code has been released as part of the specifications. The completion of the 3GPP mandatory speech codec specifications in the time frame presented above would not be achievable if the selected codec specifications and C-Code was not already publicly available.

Background Work in 3GPP Partners

In ETSI SMG11, the definition of the speech codec for the narrowband speech service for UMTS has been discussed for the past two years. The compatibility with existing GSM speech services and the requirement to provide a quality of service at least as good as in 2G systems have been the main targets. Since mid-1998, TC SMG has considered that the GSM AMR should be the working assumption for the future 3G speech codec. AMR was found to provide the required flexibility, compatibility and high quality suited for 3G systems.

Preliminary results of AMR codec modes operating on WCDMA channels were presented and discussed in SMG11 and ARIB. They clearly showed the benefits of the multi-rate speech codec to provide a high level speech quality in a wide range of propagation conditions. In addition, the possibility to dispose of multiple source rates provides the required flexibility to preserve the 3G system capacity.

ARIB Codec Working Group has been working in the past year on the evaluation of candidate speech codecs for the 3G narrowband telephony speech service. ARIB has only considered existing and already standardised speech codecs in this evaluation process. The following speech codecs were pre-selected by ARIB: GSM AMR, IS127 EVRC, G729 Annex E and MPEG-4. A comprehensive set of subjective tests was developed to compare the performances of the proposed candidates in representative conditions [8]. The corresponding specification included tests with and without background noise, with channel errors (using Error Patterns specifically developed by ARIB for this project), in tandeming and with music on hold. A number of organisations performed the required subjective tests with the proposed candidate speech codecs. TSG-SA WG4 reviewed the available test results during the TSGS4#2 meeting in February 1999 (see reference section).

Candidate Codecs Evaluation

A summary of the test results of the evaluation of the candidate speech codecs is provided in Annex 1.

The main conclusions drawn from these test results are:

- The GSM EFR (highest mode of GSM AMR) provides the best performances of all tested candidates. The GSM EFR passes all requirements set by ARIB for the mandatory speech codec to the exception of one test in background noise in Japanese Language and the tests with Music on Hold. No other candidate codec provides better performance than the GSM EFR in any test where the codec performances have been directly compared;
- The performances of the IS127 EVRC, ITU G.729 and AMR Codec modes at 7.95 bit/s and 7.4 kbit/s were found essentially equivalent, justifying that the lower bit rates of the GSM AMR still provide the best in class performance level;
- These results were found consistent with the extensive tests already performed by other standardisation committees (ETSI, TIA) on the GSM AMR and its internal modes and the other candidate speech codecs (IS127 EVRC and G.729).

Test results of an evolution of the MPEG-4 speech codec were also reviewed by TSG-SA WG4, but the corresponding tests did not include any other candidate codec making it difficult to compare the performance of this codec with the GSM AMR, IS 127 EVRC and G.729. It appeared however, that the highest mode of this codec failed a slightly higher number of test conditions than the GSM EFR. It was also noted that the code for this codec was only available in a proprietary floating point implementation at this point making it more challenging to complete the 3G mandatory speech codec standard in the required time frame.

Conclusion

Based on the previous analysis, it appears that the GSM AMR provides the best possible performances and the required flexibility for an optimized implementation in 3G systems. As a result, TSG-SA WG4 recommends the adoption of the GSM AMR speech codec as the mandatory default 3G speech codec.

References

This section provides a list of subjective test results considered relevant for the evaluation of the candidate speech codec performances:

[1]: GSM 06.55 (ETR 305): “Digital cellular telecommunications system; Performance characterisation of the GSM Enhanced Full Rate (EFR) speech codec”

[2]: COMSAT Final report CTD-95/067-1, Nokia Speech Codec listening test dated June 15, 1995. GSM EFR Related

[3]: COMSAT Final Report CTD-95/111-1, Nokia Speech Codec listening test dated November 10, 1995. IS136 EFR Related

[4]: GSM AMR Selection Test Results. ETSI SMG11 Tdoc 182/98

[5]: 3GPP TSGS4#2(99)027. GSM AMR Speech Codec Subjective Performance based on the Draft COMSAT Final Report CTD-99/XXX-X on the evaluation of the ARIB Mandatory speech codec for Ericsson/Nokia

[6]: 3GG TSG-S4#2(99)030. Subjective Test Results of the GSM AMR. from NTT DoCoMo

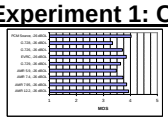
[7]: 3GG TSG-S4#2(99)034. Subjective Test Results of MPEG-4 Narrowband CELP for ARIB Mandatory Sppech

[8]: Subjcetive Test Plan for Mandatory Speech Codec. ARIB Codec WG dated January 13, 1999

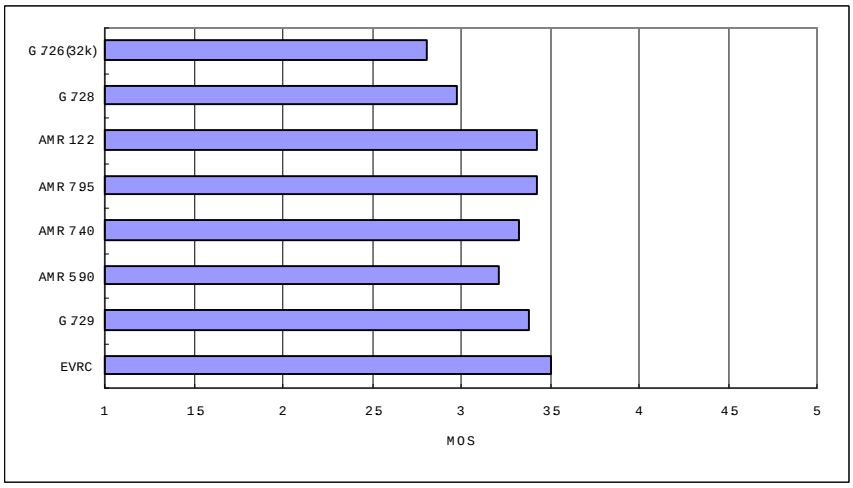
Annex 1: Summary of the Test Results presented at TSG-S4#2

The following diagrams present a subset of results of the subjective tests performed by COMSAT (in English) and NTT DoCoMo (in Japanese) as part of the evaluation of multiple mandatory speech codecs, following the test plan defined by ARIB Codec Working Codec (reference [8]).

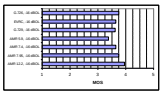
Test Results of Experiment 1: Clear performance, Input level and tandem assessment



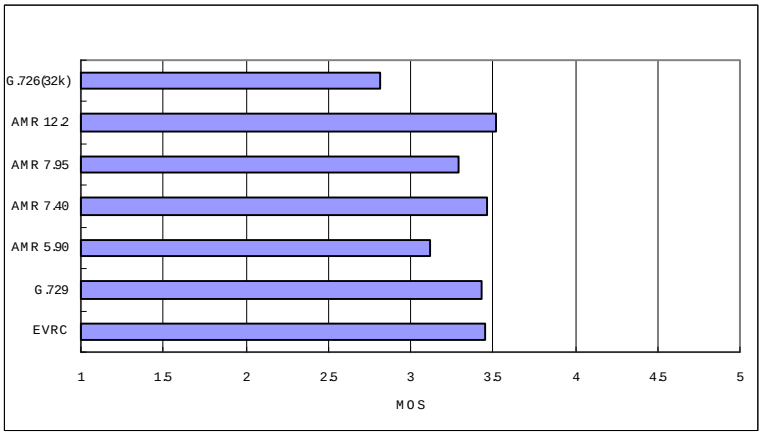
Nominal level: COMSAT Test Result



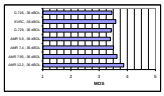
Nominal level: NTT DoCoMo Test Result



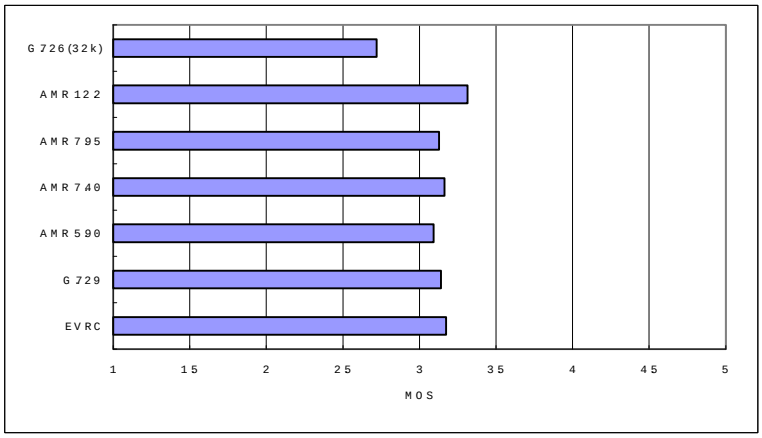
Nominal +10dB: COMSAT Test Result



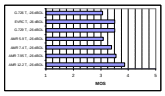
Nominal +10 dB: NTT DoCoMo Test Result



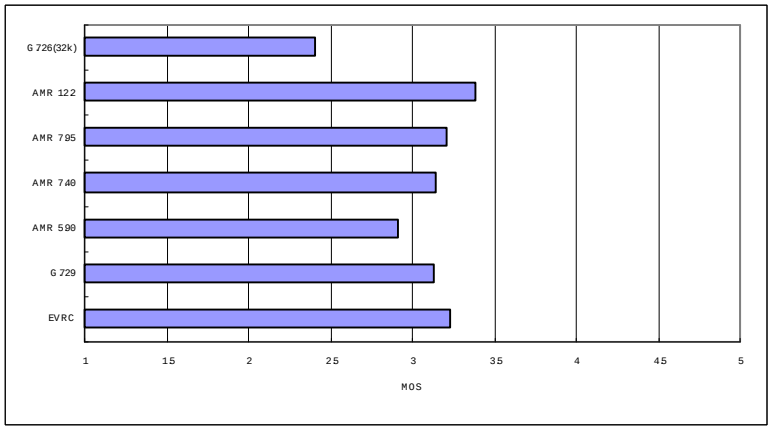
Nominal -10 dB: COMSAT Test Result



Nominal -10 dB: NTT DoCoMo Test Result

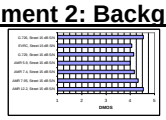


Tandeming: COMSAT Test Result

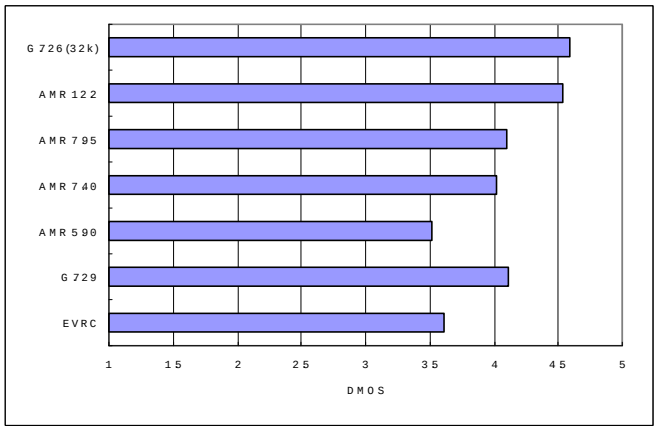


Tandeming: NTT DoCoMo Test Result

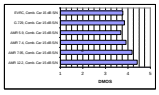
Test Results of Experiment 2: Background Noise Assessment



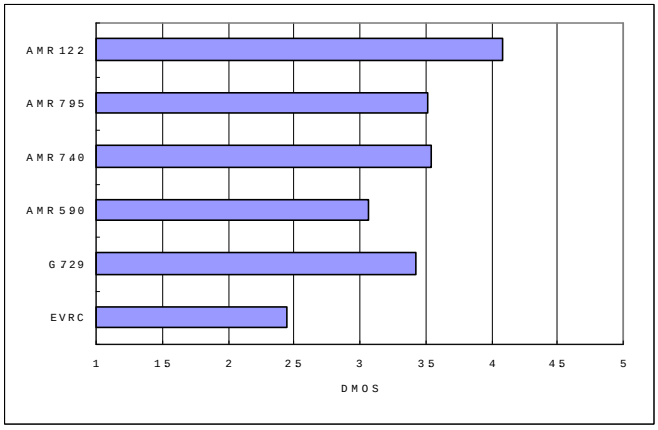
Street 15 dB: COMSAT Test Result



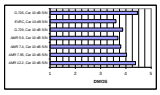
Street 15 dB: NTT DoCoMo Test Result



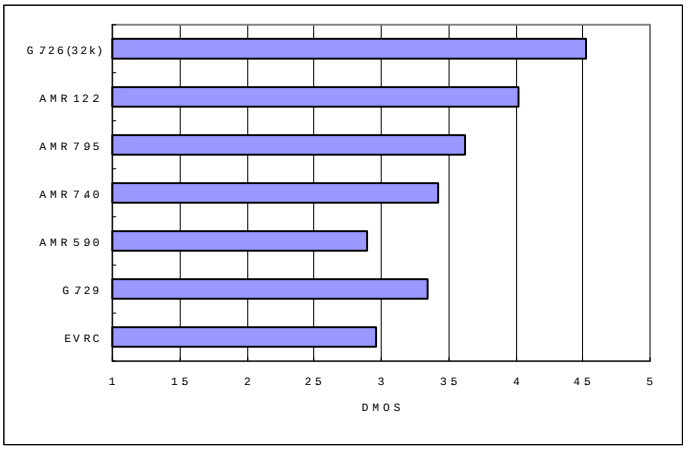
Combined Car 15 dB + 10^{-3} BER: COMSAT Test Result



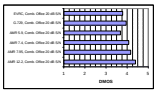
Combined Car 15 dB + 10^{-3} BER: NTT DoCoMo Test Result



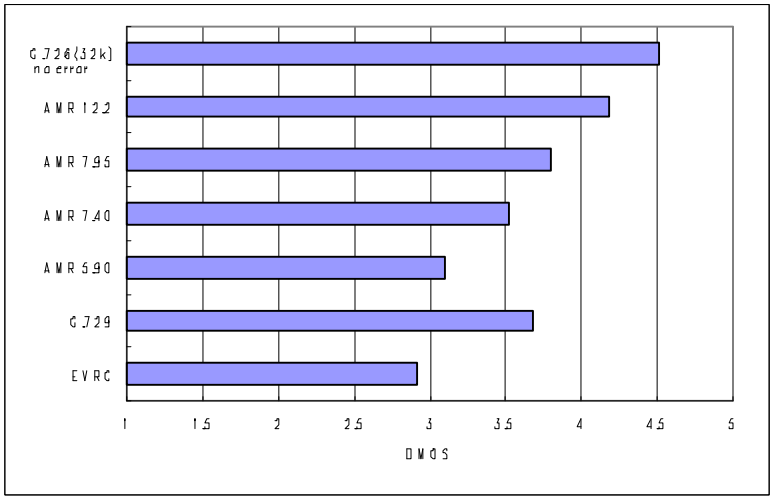
Car 10 dB: COMSAT Test Result



Car 10 dB: NTT DoCoMo Test Result

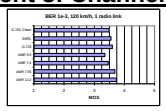


Combined Office 20 dB + 10^{-3} BER: COMSAT Test Result

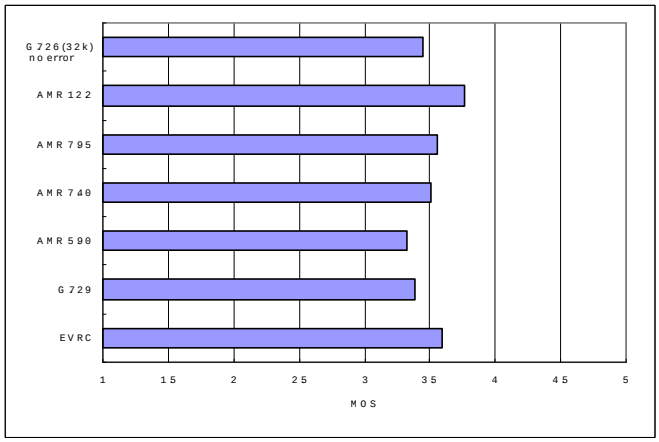


Combined Office 20 dB + 10^{-3} BER: NTT DoCoMo Test Result

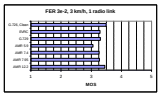
Test Results of Experiment 3: Channel Impairment Assessment



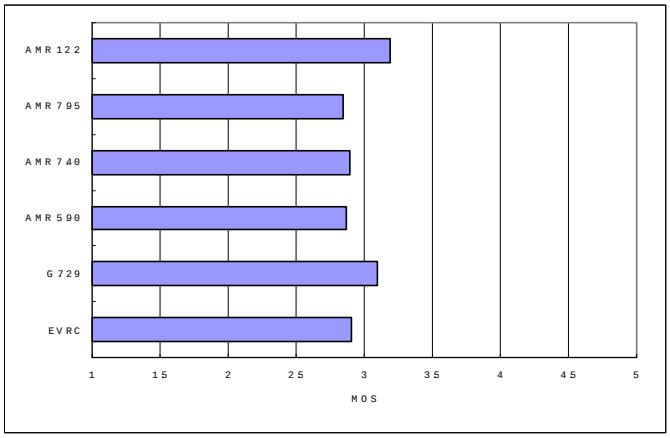
BER 10^{-3}, 120 km/h: COMSAT Test Result



BER 10^{-3}, 120 km/h: NTT DoCoMo Test Result

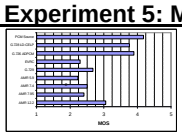


FER 3.10^{-2}, 3 km/h: COMSAT Test Result

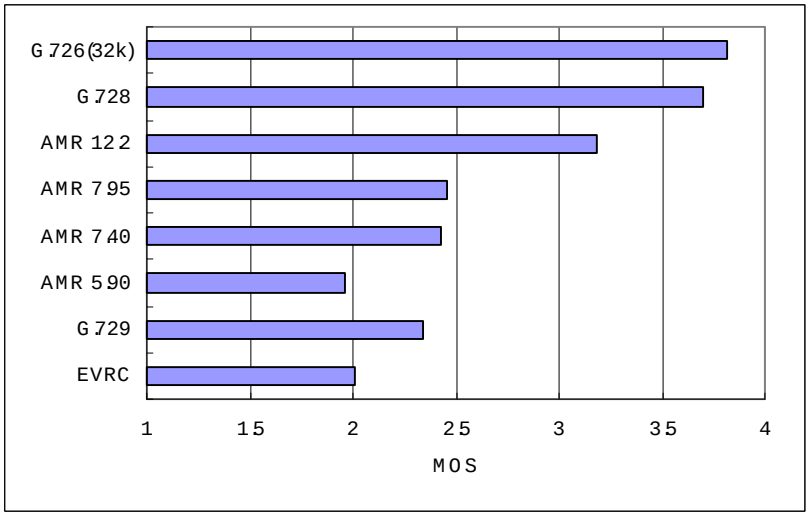


FER 3.10^{-2}, 3 km/h: NTT DoCoMo Test Result

Test Results of Experiment 5: Music On Hold



BER 10^{-3}, 120 km/h: COMSAT Test Result



BER 10^{-3}, 120 km/h: NTT DoCoMo Test Result