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Contents

Foreword

This Project Team Special Mobile Group (PT SMG) Permanent Document has been produced by SMG11 for the SMG Technical Committee of the European Telecommunications Standards Institute (ETSI).

This PT-PD provides the project schedule for the standardization of the GSM Adaptive Multi-Rate Speech Codec (AMR). The document identifies the key milestones and pending issues of the project. It also lists the necessary amendments to the GSM/DCS phase 2+ specifications for the technical realization of the work item.

This PT-PD is an informative document resulting from ETSI TC-SMG studies, which are not appropriate for European Telecommunication Standard (ETS), Interim European Telecommunication Standard (I-ETS) or ETSI Technical Report (ETR) status.

1 Scope

The purpose of this document is to describe the project schedule, key milestones and open issues for the standardization of the GSM Adaptive Multi-Rate speech codec (AMR). It also lists the new specifications and necessary amendments to the GSM/DCS phase 2+ specifications for the technical realization of the function.

1.1 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] "Adaptive Multi Rate (AMR) Study Phase Report", version 1.0, Tdoc SMG 740/97, ETSI SMG#23 meeting, Budapest, Hungary, 13-17, October 1997.

[2] "AMR, the way forward", Tdoc SMG 860/97, Source: SMG11 Chairman, ETSI SMG#23 meeting, Budapest, Hungary, 13-17, October 1997.

[3] "AMR deliverables", Tdoc SMG11 264/97, Source: SMG11, ETSI SMG11#4 meeting, Bad Aibling, Germany, November 17th - 21st, 1997

[4] AMR permanent document AMR-1, Project Overview, version 0.3, Tdoc SMG11 AMR 109/98, ETSI SMG11#6&AMR#10 meeting, Stockholm, Sweden, 3-12 June, 1998

[5] AMR permanent document AMR-2, Project plan, version 0.1, Tdoc SMG11 AMR 49/98, ETSI SMG11 AMR#9 meeting, Versailles, France, 23-25 March, 1998

[6] AMR permanent document AMR-3b, Performance requirements, version 1.0, Tdoc SMG11 125/98, ETSI SMG11#6bis meeting, Tampere, Finland, 28-30 July, 1998

[7] AMR permanent document AMR-4a, Selection rules for Qualification Phase version 1.0, Tdoc SMG11 AMR 64/98, ETSI SMG11 AMR#9 meeting, Versailles, France, 23-25 March, 1998

[8] AMR permanent document AMR-4b, Selection rules for Selection Phase, version 1.0, Tdoc SMG11 133/98, ETSI SMG11#6bis meeting, Tampere, Finland, 28-30 July, 1998

[9] AMR permanent document AMR-5, Design constraints, version 1.2, Tdoc SMG11 80/98, ETSI SMG11#6 meeting, Stockholm, Sweden, 3-12 June, 1998

[10] AMR permanent document AMR-6, Radio simulator version 0.1, Tdoc SMG11 AMR 57/98, ETSI SMG11 AMR#9 meeting, Versailles, France, 23-25 March, 1998

[11] AMR permanent document AMR-7a, Test plans for Qualification Phase version 1.0, Tdoc SMG11 AMR 73/98, ETSI SMG11 AMR#9 meeting, Versailles, France, 23-25 March, 1998

[12] AMR permanent document AMR-7b, Test plans for Selection Phase, version 1.5, Tdoc SMG11 132/98Rev5, ETSI SMG11#6bis meeting, Tampere, Finland, 28-30 July, 1998

[13] AMR permanent document AMR-8, System simulator for the AMR development, , version 1.0, Tdoc SMG11 126/98, ETSI SMG11#6bis meeting, Tampere, Finland, 28-30 July, 1998

[14] AMR permanent document AMR-9, Complexity and delay assessment, version 1.3, Tdoc SMG11 136/98Rev, ETSI SMG11#6bis meeting, Tampere, Finland, 28-30 July, 1998

[15] AMR permanent document AMR-12a, Qualification deliverables, version 1.2, Tdoc SMG11 AMR 61/98Rev3, ETSI SMG11 AMR#9 meeting, Versailles, France, 23-25 March, 1998

[16] AMR permanent document AMR-12b, Selection deliverables, version 1.0, Tdoc SMG11 134/98Rev3, ETSI SMG11#6bis meeting, Tampere, Finland, 28-30 July, 1998

[17] AMR permanent document AMR-13b, Processing functions for AMR qualification tests, version 0.5, Tdoc SMG11 AMR 51/98Rev3, ETSI SMG11 AMR#9 meeting, Versailles, France, 23-25 March, 1998

[18] AMR permanent document AMR-13b, Processing functions for AMR selection tests, version 1.2, Tdoc SMG11 131/98Rev2, ETSI SMG11#6bis meeting, Tampere, Finland, 28-30 July, 1998

[19] Results of AMR Qualification Phase", Tdoc SMG 368/98, Source: SMG11 and AMR Chairmen, ETSI SMG#26 meeting, Helsinki, Finland, 22-26, June 1998.

[20]: Revision to AMR Performance requirements, Tdoc SMG 369/98, Source: SMG11, ETSI SMG#26 meeting, Helsinki, Finland, 22-26, June 1998.

[21]: Results of AMR Selection Phase, Tdoc SMG 562/98, Source SMG11, ETSI SMG#27 meeting, Prague, Czech Republic, October 12-16, 1998.

1.2 Abbreviations

ACR	Absolute Category Rating
AMR	Adaptive Multi-Rate
C/I	Carrier-to-Interferer ratio
CNG	Comfort Noise Generation
DCR	Degradation Category Rating
DEC	Dynamic Error Condition
DSP	Digital Signal Processor
DTMF	Dual Tone Multi Frequency
DTX	Discontinuous Transmission for power consumption and interference reduction
ECx	Error Condition at x dB C/I
EFR	Enhanced Full Rate
EID	Error Insertion Device
ETSI	European Telecommunications Standards Institute
FR	Full-rate channel or original GSM Full Rate speech codec
FH	Frequency Hopping
G.726	ITU 16kbs/24kbs/32kbs ADPCM codec
G.728	ITU 16kbs LD-CELP codec
G.729	ITU 8kbps speech codec
GSM	Global System for Mobile communications

HR	Half-rate channel or GSM Half Rate speech codec
IRS	Intermediate Reference System, No IRS= rather flat
ITU-T	International Telecommunication Union Telecommunications Standardization Sector
MNRU	Modulated Noise Reference Unit
MOS	Mean Opinion Score
MS	Mobile Station
OVL	Overload point
PCM	Pulse Code Modulation
Q	Speech-to-speech correlated noise power ratio in dB
qdu	quantization distortion unit
RPE-LTP	Regular Pulse Excited codec with Long Term Prediction
SID	Silence Descriptor
SMG	Special Mobile Group
SNR	Signal to Noise Ratio
TCH-HS	Traffic CHannel Half rate Speech
TCH-FS	Traffic CHannel Full rate Speech
TDMA	Time Division Multiple Access
TFO	Tandem Free Operation
UPCM	Uniform or Linear PCM
VAD	Voice Activity Detector

Error Patterns (EP0, EP1, EP2 and EP3):

- EP0 without channel errors;
- EP1 C/I=10 dB; 5 % Gross BER (well inside a cell); TU3, Ideal Frequency Hopping
- EP2 C/I= 7 dB; 8 % Gross BER (at a cell boundary);
- EP3 C/I= 4 dB; 13 % Gross BER (outside a cell).

1.3 Support of specification work

This document is a 'living document' permanently updated by PT SMG & SMG11. Proposals for change shall be forwarded to PT SMG (contact name and mailing information listed on the last page). The latest version of this document can be obtained from the same source. The AMR specification rapporteurs should make sure that this document always reflects the latest status of work.

Specification and Change Request rapporteurs should ensure that the latest versions of their material is made available for review and comment by the following mechanisms:

ETSI FTP Server (docboc.etsi.fr or docbox.etsi.org):

in /Tech-Org/smg/Document/smg11/smg11_amr/

- All new AMR specifications.
- All AMR meeting reports, most input and all output documents from all AMR ad-hoc.

in /Tech-Org/smg/Document/smg11/smg11_amr/CR/

- All change requests to the existing specifications.

Email distribution list:

SMG2SMG11AMR@list.etsi.fr

2 General

Unlike previous GSM speech codecs (FR, EFR, and HR) which operate at a fixed rate and constant error protection level, the AMR speech codec adapts its error protection level to the local radio channel and traffic conditions. AMR selects the optimum channel (half or full rate) and codec mode (speech and channel bit rates) to deliver the best combination of speech quality and system capacity. This flexibility provides a number of important benefits:

- Improved speech quality in both half-rate and full-rate modes by means of codec mode adaptation i.e. by varying the balance between speech and channel coding for the same gross bit-rate;
- The ability to trade speech quality and capacity smoothly and flexibly by a combination of channel and codec mode adaptation; this can be controlled by the network operator on a cell by cell basis;
- Improved robustness to channel errors under marginal radio signal conditions in full-rate mode. This increased robustness to errors and hence to interference may be used to increase capacity by operating a tighter frequency re-use pattern;
- Ability to tailor AMR operation to meet the different needs of operators;
- Potential for improved handover and power control resulting from additional signaling transmitted rapidly in-band.

The AMR codec concept is adaptable not only in terms of its ability to respond to changing radio and traffic conditions but also to be customized to the specific needs of network operators. There are three levels of adaptation of the AMR system:

- Handovers between half-rate and full-rate channels according to traffic demands;
- Variable partitioning between speech and channel coding bit-rates to adapt to the channel conditions and always provide the best speech quality;
- Possibility of channel and codec control algorithms optimization to meet specific operator needs and network conditions.

This allows the codec to be operated in many ways of which three important examples are:

- Full-rate only for maximum robustness to channel errors. This additional robustness may be used to extend the coverage in marginal signal conditions, or to improve the capacity by using a tighter frequency re-use, assuming high AMR MS penetration.
- Half-rate only for maximum capacity advantage; more than 100% capacity increase achievable relative to FR or EFR (i.e. same as existing HR). Significant quality improvements relative to the existing HR will be given for a large proportion of mobiles as a result of the codec mode adaptation to the channel conditions and excellent (wireline like) speech quality in half rate mode for low error conditions.
- Mixed half/full rate operation allowing a trade-off between quality and capacity enhancements according to the radio and traffic conditions and operator priorities.

In the AMR standardization, the complete AMR speech and channel codecs will be defined, in addition to the codec mode adaptation control process, the new link performance metrics and their transmission in-band on the traffic channel. The AMR codec proposals submitted as codec candidates to SMG11 contained all these components. Related features such as VAD, DTX, CNG/Comfort Noise Generation and TFO will also be developed.

The AMR channel mode adaptation will rely on the existing intra-cell handover methods in terms of signaling procedures. However, the channel mode adaptation decision algorithm could be extended and use all available metrics; the existing RxQual and RxLev and possibly the newly defined metrics. This algorithm will be left open to manufacturers to develop and improve with time. The repacking of half-rate radio channels required by the AMR operation will also rely on the existing signaling procedures.

A more complicated AMR standardization phase could be launched later in order to introduce a new mode adaptation control algorithm (Half Rate vs Full Rate) using a new link quality metrics, more advanced handover or enhanced repacking algorithms, etc. The need for the AMR phase 2 will be determined after the completion of the first phase of the AMR standardization.

SMG11 was also mandated to complete the feasibility study of a complementary and optional AMR wideband mode. This AMR wideband coding mode will be developed and selected independently of the narrowband AMR at a later phase, if found feasible. The wideband option would extend the audio bandwidth from the current [300 Hz-4 kHz], to [50 Hz -5 kHz] or [50 Hz 7 kHz].

Finally, SMG#26 approved a new work item for the definition, selection and standardization of a default and optional noise suppresser for the AMR speech codec. This activity will take place once the AMR selection phase has been completed.

3 Requirements

The AMR Performance Requirements are provided by [6]. The first set of performance requirements was approved by SMG#24 (Tdoc SMG 953/97), then revised by SMG#26 after the qualification phase, as defined in Tdoc SMG 369/98 [20]. The final set of performance requirements is included in Annex 1.

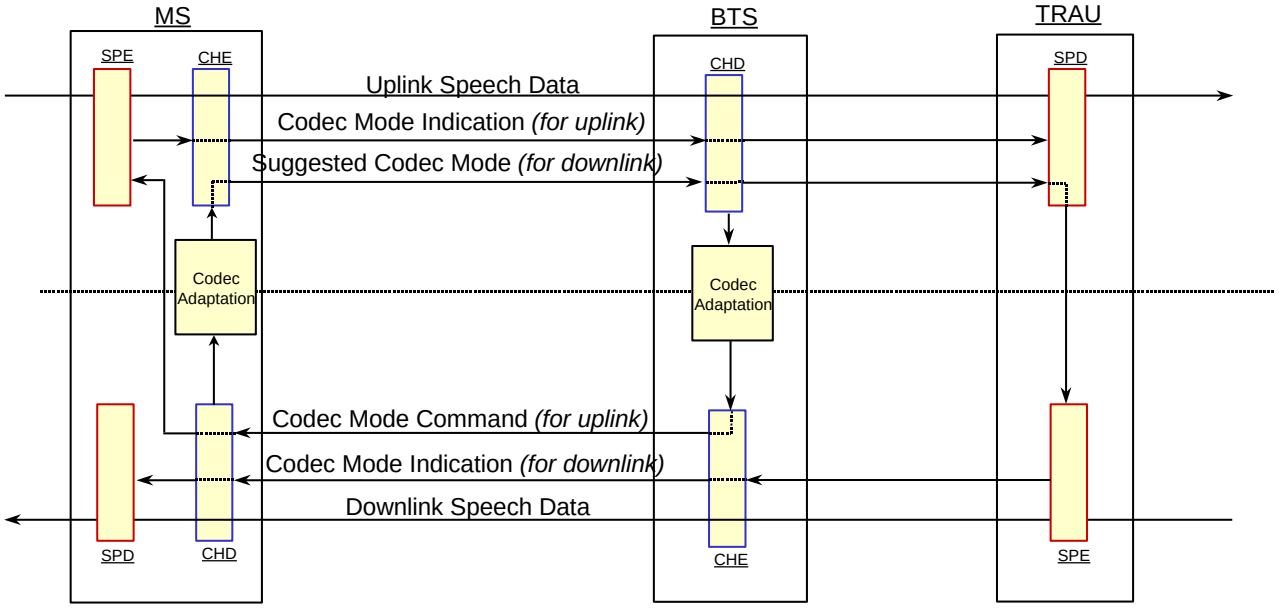
The AMR design constraints were gathered in a dedicated permanent document [9]. They are reproduced in Annex 2.

4 Functional description

The AMR speech codec includes a set of fixed rate speech codecs modes for half rate and full rate operation, with the possibility to switch between the different modes as a function of the propagation error conditions. Each codec mode provides a different level of error protection through a dedicated distribution of the available gross bit rate (22.8 kbps in Full Rate and 11.4 kbps in Half rate) between source coding and channel coding.

The actual speech rate used for each speech frame depends on the existing radio channel conditions. A codec adaptation algorithm selects the optimized speech rate (or codec mode) as a function of the channel quality. The most robust codec mode is selected in bad propagation conditions. The codec mode providing the best quality is selected in good propagation conditions. The codec adaptation relies on channel quality measurements performed in the MS and the network and on in band information sent over the Air Interface together with the speech data.

The following diagram shows the main information flows over the key system interfaces:



CHE: Channel Encoder
CHD: Channel Decoder
SPE: Speech Encoder
SPD: Speech Decoder

In both directions, the speech data frames are associated with a Codec Mode Indication used by the receiving end to select the correct channel and source decoders. In the network, the Codec Mode Indication must also be sent to the Transcoder Units so that the correct source decoding is selected.

For the adaptation of the uplink codec mode, the network must estimate the channel quality, identify the best codec for the existing propagation conditions and send this information to the MS over the Air Interface (Codec Mode Command Data field).

For the downlink codec adaptation, the MS must estimate the downlink channel quality and send to the network a quality information, which can be mapped in the network to a 'suggested' codec mode.

In theory, the codec mode can be changed every speech frame. In practice, because of the propagation delays and necessary filtering in the codec adaptation functions, the codec mode should be adapted at a lower rate.

Each link may use a different codec mode but it is mandatory for both links to use the same channel mode (either full rate or half rate).

The channel mode is selected by the Radio Resource management function in the network. It is done at call set up or after a handover. The channel type can further be changed during a call as a function of the channel conditions.

The key characteristics of the selected AMR solution are:

- 8 codec modes in Full Rate mode including the GSM EFR and IS136 EFR
- 6 codec modes in Half Rate mode (also supported in Full Rate), including the IS136 EFR
- Possibility to operate on a set of up to 4 codec modes selected at call set up or handover
- Codec Mode Indications multiplexed with the Uplink Codec Mode Command and Suggested Downlink Codec Mode every other frame
– In band signaling based on a 2 bits information field sent every other block coded over the Air Interface

The full set of codec modes is listed in the following table:

Channel	Source codec bit-rate
TCH/FS/AMR (TCH/AFS)	12.2 kbit/s (GSM EFR) 10.2 kbit/s 7.95 kbit/s 7.40 kbit/s (IS136 EFR) 6.70 kbit/s 5.90 kbit/s 5.15 kbit/s 4.75 kbit/s
TCH/HS/AMR (TCH/AHS)	7.95 kbit/s 7.40 kbit/s (IS136 EFR) 6.70 kbit/s 5.90 kbit/s 5.15 kbit/s 4.75 kbit/s

5 Technical realization and amendments

This section lists the required new Recommendations and Change Requests for the standardization of AMR.

5.1 New Specifications

The following table lists all new required recommendations for the introduction of the AMR speech codec. All recommendation numbers are provisional. A priority level was allocated to each specification to identify those that must be completed in time for the approval of the GSM release 98 during SMG#28.

Doc Nr.	Title	STC	Prime/Rapporteur	Priority	Status	Info to SMG	Appr.
06.71	Adaptive Multi-Rate speech processing functions: General description	SMG11	Erik Ekudden Ericsson	1	Version 2.0.0 approved by SMG11#9	-	SMG#28
06.73	ANSI-C code for the GSM Adaptive Multi-Rate speech codec	SMG11	Erik Ekudden Ericsson	1	c	-	SMG#28
06.74	Test Sequences for the GSM Adaptive Multi-Rate speech codec (AMR)	SMG11	Rapporteur tbd	2	Preliminary version expected in 1Q99	SMG#29	SMG#29/30
06.75	Performance characterization of the GSM AMR speech codec	SMG11	Rapporteur tbd	2	Draft Test Plan approved by SMG11#9. Tests planned for 1Q99	SMG#29	SMG#30
06.90	Adaptive Multi-Rate speech transcoding	SMG11	Erik Ekudden Ericsson	1	Version 2.0.0 approved by SMG11#9	-	SMG#28
06.91	Substitution and muting of lost frames for Adaptive Multi-Rate speech traffic channels	SMG11	Erik Ekudden Ericsson	1	Version 2.0.0 approved by SMG11#9	-	SMG#28
06.92	Comfort noise aspects for Adaptive Multi-Rate (AMR) speech traffic channels	SMG11	Erik Ekudden Ericsson	1	Version 2.0.0 approved by SMG11#9	-	SMG#28
06.93	Discontinuous Transmission (DTX) for Adaptive Multi-Rate speech traffic channels	SMG11	Erik Ekudden Ericsson	1	Version 2.0.0 approved by SMG11#9	-	SMG#28
06.94	Voice Activity Detection (VAD) for Adaptive Multi-Rate speech traffic channels	SMG11	Jari Hagquist Nokia	1	Version 2.0.0 approved by SMG11#9	-	SMG#28
05.09	Link Adaptation	SMG2 WPB	Erik Ekudden Ericsson	1	Version 2.0.0 approved by SMG2#29	-	SMG#28

5.2 Change Requests

The following table provides a preliminary list of required Change Request for the introduction of AMR. Most Change Requests are targeted for approval at SMG#28 (Priority 1).

Doc Nr.	Title	STC	Required Modification	Prime/Editor	Priority	Status	STC Approval	SMG Approval
04.08	Mobile Radio Interface Layer 3 Specification	SMG2 WPA	Introduction of AMR Support	N. Ting Nortel S. Hamiti Nokia	1	Approved by SMG2	SMG2 WPA#1/99 SMG2#29	SMG#28
04.08	Mobile Radio Interface Layer 3 Specification	SMG3 WPA	Introduction of AMR Support on Bearer Capabilities	Shkumbin Hamiti Nokia	1	Approved by SMG3	SMG3 WPA#1/99 SMG3#1/99	SMG#28
04.53 08.62	Inband Tandem Free Operation of Speech Codecs - Service Description	SMG11 SMG12	Introduction of AMR	tbd	2	First version expected for 1Q99	SMG11#10	SMG#29
05.01	Physical Layer on the Radio Path (General Description)	SMG2 WPB	Introdution of AMR dedicated block structures and channel coding schemes and possibly, the codec adaptation	Alain Ohana GSM North America	1	Approved by SMG2	SMG2 WPB#7 SMG2#29	SMG#28
05.03	Channel Coding	SMG2 WPB	Introduction of AMR dedicated channel coding	Erik Ekudden Ericsson	1	Two versions approved by SMG2, Selection in SMG	SMG2 WPB#7 SMG2#29	SMG#28
05.05	Radio Transmission and Reception	SMG2 WPB	Introduction of AMR related channel performances	Erik Ekudden Ericsson	1	Delayed until selection of Channel Coding Scheme	SMG2 WPB#8 SMG2#30	SMG#29
05.08	Radio Subsystem Link Control	SMG2 WPB	Possible changes for DTX operation of AMR	Erik Ekudden Ericsson	1	Approved by SMG2	SMG2 WPB#7 SMG2#29	SMG#28
08.08	BSC-MSC Layer 3 Secification	SMG2 WPA	Introduction of AMR support	N. Ting Nortel S. Hamiti Nokia	1	Approved by SMG2	SMG2 WPA#1/99 SMG2#29	SMG#28
08.58	BSC-BTS Interface Layer 3 Specification	SMG2 WPA	Introduction of AMR support	N. Ting Nortel S. Hamiti Nokia	1	Approved by SMG2	SMG2 WPA#1/99 SMG2#29	SMG#28
08.60	Inband Control of the Remote Transcoders and Rate Adaptors	SMG2 WPB SMG2 WPA	Introduction of dedicated AMR TRAU Frame and procedure	Karl Hellwig Ericsson	1	Two schemes under discusion in SMG2	SMG2 WPB#8 SMG2#30	SMG#29
08.61	Inband Control of the Remote Transcoders and Rate Adaptors- Half Rate	SMG2 WPB SMG2 WPA	Introduction of dedicated AMR TRAU Frame and procedure - Switching between Full and Half Rate?	Karl Hellwig Ericsson	1	First version expected for 1Q99 for 8 kbps/s multiplexing	SMG2 WPB#8 SMG2#30	SMG#29
11.10	Mobile Station Conformance Specification	SMG7	Introduction of AMR dedicated Tests	tbd	2	First version expected for 1-2Q99?	?	SMG#29?
11.21	GSM Radio Aspects Base Station System Equipment Specification	SMG8	Introduction of AMR dedicated Tests	tbd	2	First version expected for 1-2Q99?	?	SMG#29?
11.24	GSM Transcoding and Rate Adaptation: Base Station Equipment specification	SMG8	Introduction of AMR dedicated Tests	tbd	2	First version expected for 1-2Q99?	?	SMG#29?

6 Approvals Time Frame for AMR

6.1 SMG11 mandate and specification development time scale

The initial mandate from SMG#23 (October 1997) for the AMR codec development is given in [2] and reproduced below:

- SMG11 and SMG2 start narrowband AMR immediately with the target to complete the codec specifications by 12/98 and the systems specifications during 1999.
- The feasibility assessment of wideband will be completed as soon as possible.
- Wideband may be developed with narrowband or, alternatively, be added to AMR as a later option according to the outcome of the wideband feasibility assessment.
- The AMR selection process will allow the submission of wideband candidates. Every proposing party is obliged to describe an evolution path to include wideband.
- The AMR development should aim at one expandable platform.

SMG will review the status and time scale of the program at appropriate intervals.

Initial target dates for the finalized AMR specifications (ready for SMG approval) were given in [3]:

- December 1998: source codec, channel codec, bad frame handling, in-band signaling of codec mode - transmission aspects and definition of parameters, in-band signaling of channel metric and side information - transmission aspects (bit allocation and channel protection)
- December 1998 highly desirable: VAD/DTX/comfort noise generation, definition of channel metric and side information parameters, example of codec mode adaptation, layer 3 signaling
- June 1999: AMR TRAU frames, channel performance tables (GSM 05.05), TFO, test sequences
- December 1999: performance characterization, [minimum performance of adaptation algorithms]

At SMG11#7, the target dates were updated so that most of the AMR specifications could be approved as part of the GSM Release 98 in February 99. The new target dates for the completion of the specifications were set as follows:

February 99: Source codec and channel codec, bad frame handling, in-band signaling of codec mode indication and control and/or quality measurement. VAD/DTX/comfort noise generation, definition of quality reporting, example of codec mode adaptation, layer 3 signaling, AMR TRAU frames, channel performance tables

- March 1999: Performance characterization
- June 1999: TFO, Test sequences, Test specifications
- AMR Wideband mode and Noise Suppresser (tbd)

SMG#28 (2/99) must select the AMR channel coding between two alternatives evaluated by SMG2 and SMG11. Because of this incertitude on the Channel Coding, the definition of the channel performances tables (Update on the 05.05) has been delayed to SMG#29. Likewise, two 16 kbps A-TRAU schemes are under discussion in SMG2. As a result, the final proposal for the 08.60 and 08.61 updates was also delayed to SMG#29.

6.2 Phased Introduction of Capability

The first and only phase of the AMR standard should be completed by February 1999 and approved at SMG#28.

The possibility to start a second phase of the AMR development as described in section 3.0 will be assessed at the end of the first phase of development.

Future optional enhancements to the AMR standard (Wideband mode, Noise suppresser) will be introduced in 1999. The detailed schedule for these enhancements is tbd.

6.3 Development Plan and Status

The development of the AMR speech codec followed a traditional speech codec selection phased approach. Organizations interested in proposing an AMR candidate were first required to present subjective listening test results of their solution according to a previously agreed Qualification Test Plan [15], in addition to preliminary technical information on their proposal [11]. The best candidates were pre-selected by SMG11 to take part in the selection phase. This pre-selection was approved by SMG#26.

After analysis of the selection test results, the candidate providing the best performances was recommended to SMG#27 to serve as the basis for the production of the AMR standard. After the SMG approval, the development process was completed with the optimization and verification phases. The completion of final verification items and characterization tests and the preparation of the TR on the Characterization of the AMR Speech Codec are scheduled for 1-2Q99. Additional information on these tasks is provided below:

1. Qualification Phase: The five most promising codec solutions were qualified to enter the selection phase after analysis of the in-house listening test results and technical information on the proposed solutions. The Qualification Phase was completed in June 1998. The results were presented and approved at SMG#26 [19].

2. Selection Phase: Seven independent listening laboratories performed formal subjective listening tests on the five pre-selected candidates to find the optimum codec solution. The best solution (ENS1 proposal) was selected by SMG11#7 in September 1998 and recommended as the preferred AMR choice to SMG. The selection test results were presented and approved at SMG#28 [21] with the recommendation to select the ENS1 proposal. An extract of the selection test report showing the key AMR performances obtained by the best candidates to the selection phase is included in Annex 3. Following the SMG11 recommendation, SMG also agreed that the selection results did not justify to initiate a long optimization phase, but approved a 3 month optimization essentially restricted to the correction of the bugs identified by the ENS consortium members, proponents of the selected solution.

3. Verification Phase: The verification items were distributed in two phases in SMG11 AMR#12 in October 1998. The first phase included the checking of the bit-exactness of the ENS codec with the executable and C-Code delivered earlier in the development process to ETSI. The second phase included verification items related to the codec performance and compatibility with special operational conditions and input signals (DTMF, announcement tones, language dependency, overload, special inputs, influence of VAD/DTX, etc.). The verification items were allocated to SMG11 members (other than the ENS consortium members) in SMG11 AMR#12. The first part of the verification phase was completed by SMG11#9 in January 1999 without any issue being identified. The second part was partially completed by SMG11#9. Because of the two channel coding alternatives and the two VAD options proposed for standardization to SMG#28, few additional verification will be required especially on the operation of the VAD options and generation of the Comfort Noise in DTX mode. These tasks will be completed for SMG11#10 (4/99). SMG11#9 considered that the preliminary verification results were satisfying enough to proceed with the approval of the specifications in their present status.

4. Optimization Phase: Final corrections were brought to the C-code of the selected solution in the 11/98 to 01/99 time-frame. Performance enhancements were essentially selected based on expert listening tests. The optimization phase leading to the final version of the code was completed for SMG11#8 in November 1998. It was restricted to the ENS consortium members. The code was later modified before it was released to SMG11 members participating to the verification phase. A new set of modifications was identified after the review of the verification phase results and the approval of the AMR specifications in SMG2 and SMG11.

In addition, SMG2#28 proposed to evaluate a modified channel coding scheme restricting the convolutional codes to the existing polynomials. Additional simulation and subjective listening tests were required to assess the respective performance of the different channel coding options. After review of the results, SMG2 and SMG11 decided to propose both alternatives to SMG#28 with a request to adopt only one scheme for the AMR standard.

5. Selection of VAD/DTX: As requested in the design constraints, the selection winner proposed a dedicated AMR Voice Activity Detection and Comfort Noise Generation algorithms and a new Discontinuous Transmission scheme. The corresponding specifications were presented in SMG11#8 in November 1998. The inclusion of the corresponding code in the version delivered for the verification phase was also approved by SMG11#8.

The finalization of the AMR VAD/DTX standard was open to contributions from any SMG11 member as defined in [4]. A second VAD alternative was introduced in SMG11#8 and the corresponding specification presented in the Ad Hoc SMG11#8Bis meeting (12/98). After a review of the new scheme, SMG11#9 decided to include this VAD as a second option in the AMR standard with a strong desire to remove one option by SMG#29, after the completion of the remaining verification items.

6. Edition of new Recommendations and Change Requests to new recommendations: The new recommendations and available change requests were approved in January 1999 by SMG2#29 and SMG11#9. They are presented to SMG#28 for approval. Change Requests on 05.05, 08.60, 08.61, 08.62 and the 11 series are expected for approval by SMG#29.

7. Characterization Phase: The performances of the AMR codec will be evaluated in multiple environmental conditions and with a diversity of input signals. The ETSI Technical Report (ETR) on the Performance Characterization of the AMR codec will be prepared for SMG#29 (6/99). The characterization test plan was approved at SMG11#9. The tests are scheduled for 1Q99.

8. Wideband AMR mode development Phase: The selection and possible standardization of a wideband mode could take place after the completion of a dedicated feasibility study. The corresponding report is expected for SMG#29 (6/99).

9. Noise Suppression development Phase: The evaluation and possible selection and standardization of a noise suppresser has been initiated in SMG#27 after the completion of the AMR narrowband selection. The corresponding selection tests are scheduled for mid-99.

10. Future development phases: To be defined

6.4 Road Map for the approval of the AMR standard

SMG#28 – February 8-12, 1999: Approval of AMR as part of the GSM Release 98

SMG11#10 - April 1999: Review of the results of the remaining verification items and characterization tests

SMG2#30 - April 12-16, 1999 Approval of CRs on 05.05, 08.60 & 08.61

SMG11#11 - May 1999 Review and approval of the ETR on the AMR Characterization Performances
Approval of the AMR wideband mode feasibility study report

SMG#29 – June 21-25, 1999: Review and approval of the remaining items of the development process (CRs on 05.05, 08.60&08.61, TFO, Characterization test results, Test sequences and Test specifications)

7 Work item history and status

This section provides the project history after SMG#23 and lists the open issues.

7.1 SMG2

7.1.1 History

SMG2 WPB#2	Bonn, Germany, November 3-7, 1997: Preparation of the qualification phase (static and dynamic error patterns, system simulator, TRAU Frame, Use of stealing flags)
SMG2 WPB#3	Nuremberg, Germany, January 12-16 , 1998: Preparation of the qualification phase (definition of the system simulator for the preparation of the error patterns, maximum acceptable data rates on Abis/Ater and preliminary solutions for the TRAU Frame, DTX operation)
March 1998	Approbation and release of the system simulator and Error Patterns by Correspondence
SMG2 WPB#4	Kuusamo, Finland, April 20-24 , 1998: Review of the system simulator performances and characteristics of the Error patterns
SMG2 WPB#5	Høje Taastrup, Denmark, August 31-September 3, 1998: Review of the Liaison Statement from SMG11, Discussion on Fast Power control
SMG2 WPB#6	Milan, Italy November 2-6, 1998: General review of the project status. Review of the proposed channel coding for the selected

	solution, in addition to the technical options for the completion of the standard (Radio channel performances, specification of the codec adaptation performances). Initial review of impact on Ater/Abis TRAU frames
SMG2 WPA9811	Bois d'Arcy, France November 2-6, 1998: General review of the project status. Review of the technical option for the standardization of the AMR Layer 3 signaling.
SMG2#28	Dresden, Germany November 16-20, 1998: Review of new a proposal for the support of a second set of polynomials for the AMR Channel Coding
Joint SMG2/SMG11	Sophia-Antipolis, France January 11, 1999: Review of the test results on the evaluation of the different channel coding alternatives. Agreement to send two alternatives to SMG#28 for decision Review of the draft 05.09, available Change Requests and proposals for the AMR TRAU frames for the 16 kbit/s A-bis/A-ter sub-multiplexing scheme
SMG2 WPA#1/99	Sophia-Antipolis, France January 12-15, 1999: Review and approval of all Layer 3 signaling Change Requests for the introduction of AMR (CRs on 04.08, 08.08 and 08.58)
SMG2 WPB#7	Sophia-Antipolis, France January 12-15, 1999: Review and approval of 05.09 and available Change Requests on 05 serie
SMG2#29	Sophia-Antipolis, France January 22-29, 1999: Review and approval of the new recommendation and available change requests Ad Hoc for the review of the proposed TRAU frames

7.1.2 Future

Review and approval of the remaining CRs on 05.05 (channel performance tables), 08.60 and 08.61 (TRAU frames).

7.1.3 Upcoming meetings

April 12-16, 1999	Joint SMG2 WPA/WPB/Plenary

7.2 SMG3

7.2.1 History

SMG3#1/99	Sophia-Antipolis, France January 22-29, 1999: Review and Approval of AMR related Change Request

7.2.2 Future

None required

7.2.3 Upcoming meetings

January 25-29, 1999	SMG3 WPA followed by SMG3 Plenary

7.3 SMG11

7.3.1 History

SMG11#4	Bad-Aibling, Germany, November 17-21, 1998: Preparation of the qualification phase Preliminary definition of the design constraints
AMR#8 SMG11#4Bis	Dresden, Germany, January 19-23, 1998: Preparation of the qualification phase Preliminary agreement on the qualification rules
SMG11#5	Milan, Italy, February 16-20, 1998: Preparation of the qualification phase Agreement of the design constraints and qualification rules
AMR#9	Versailles, France, March 23-25, 1998: Final approval of Qualification Permanent documents Release of System Simulator and Error Patterns
AMR#10	Stockholm, Sweden June 3-5, 1998: Review of the Qualification test results
SMG11#6	Stockholm, Sweden, June 6-12, 1998: Approval of the Qualification test results. Recommendation to SMG on list of qualified candidates
AMR#11 SMG11#6Bis	Tampere, Finland, July 28-30, 1998: Preparation of the selection tests Agreement on selection deliverables and selection rules
SMG11#7	St-Laurent-du Var, France, September 28-October 2, 1998: Review of the selection test results. Selection of an AMR solution for standardization
AMR#12	Tampere, Finland, October 12-16, 1998: Identification and Allocation of Verification items, Schedule of remaining tasks for the completion of the AMR specification. Review of updated draft AMR specifications.
SMG11#8	Miami, Florida, November 23-27, 1998: Review and approval of the results of the optimization phase Completion of the first part of the verification phase (Partial) Review of updated draft AMR specifications including the VAD/DTX/CNG specifications Approval of the optimized version of the code to be released for the second part of the verification phase including the ENS proposed VAD/DTX/CNG Compromised agreement to evaluate alternative channel coding schemes as proposed by SMG2 and possibility for SMG11 members to finalized alternative VAD proposals by SMG11#8Bis
SMG11#8Bis	London-Heathrow, UK, December 17, 1998: Review of the results of the evaluation of alternative channel coding scheme Submission of alternative VAD specification and related test results
SMG11#9	Helsinki, Finland, January 18-22, 1999: Review of the available results of the second part of the verification phase

	Approval of the Characterization Test Plan Approval of the AMR specifications of the 06 series Agreement to include two VAD options in the standard with a strong desire to remove one option by SMG#29 if feasible

7.3.2 Future

Execution of the Characterization Tests in 1Q99.

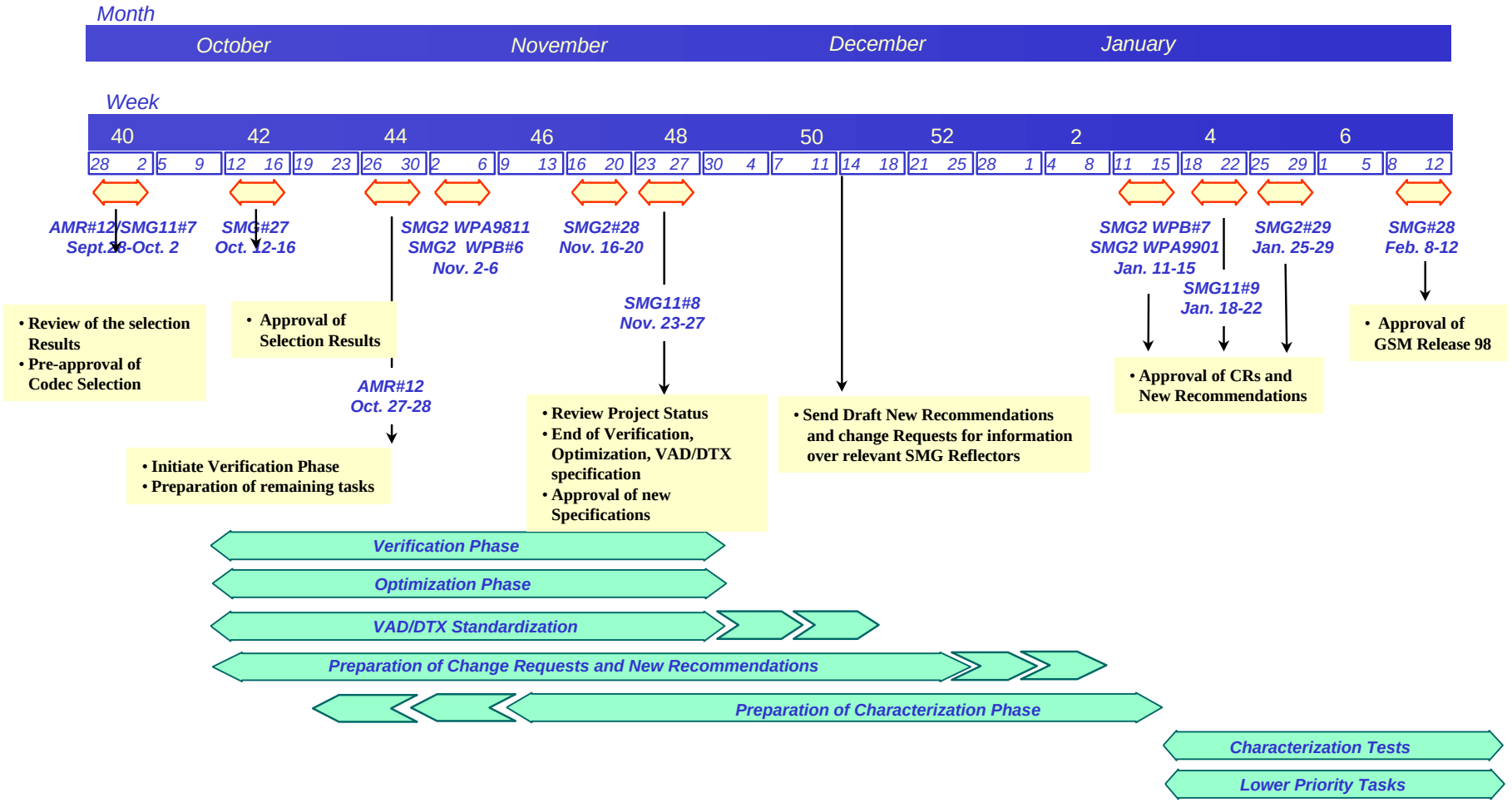
Completion of remaining activities (TFO, Characterization, Test Sequences and Test specifications) for approval at SMG#29.

7.3.3 Upcoming meetings

April, 1999	SMG11#10
May, 1999	SMG11#11

7.4 Project Schedule

The key remaining project milestones are shown in the following diagram:



7.5 Open Issues

Action	To be completed by:
AP1: Identification of Editors for the AMR recommendations and CRs	Closed
AP2: AMR TRAU Frames A sub-group must be set up for the definition of the AMR TRAU Frames and the preparation of the AMR CRs. A preliminary discussion took place in TFO#18 during SMG11#8 to address the TFO requirement for the AMR TRAU frame. It was also agreed during an informal meeting to try to finalize the 16 kbit/s sub-multiplexing option before SMG#28 while leaving the 8 kbit/s option to be finalized for SMG#29. During the joint SMG2/SMG11 meeting in 01/99 two alternative TRAU frame structures were proposed by Ericsson and Alcatel/Nortel. No decision was reached on either solution during the joint SMG2/SMG11 meeting. Two other opportunities to discuss this subject were identified: during the SMG11#9 meeting on week 3/99 and during the SMG2#29 plenary on week 4/99. The dedicated TFO requirements were discussed again in an informal meeting during SMG11#9. The two proposed alternatives were once again analyzed and finalized in an Ad-Hoc meeting during SMG2#29. A final decision is now pending the definition of TFO operation for AMR	**SMG2**
AP3: Synchronization required between AMR TRAU Frames and radio TDMA Frames	Closed
AP4: Definition of Codec adaptation performances	Closed
AP5: Radio Channel Performances Volunteer organizations required to prepare simulation on Radio Performances. Radio Performances simulation still not available, but expected for week 5/99 with inputs from Siemens (on speech channels), Ericssson (on In band signaling) and Nokia (on SID related frames) Change Request on 05.05 to be approved for SMG#29 after selection of a channel coding scheme	**SMG2**
AP6: Definition of layer 3 Signaling	Closed
AP7: VAD: Analysis and consideration to be given to VAD/DTX proposals coming from outside the selection winning consortium. SMG11#8 agreed that organizations interested in contributing to the AMR VAD specification would be awarded the same two weeks allowed for the investigation of the alternative channel coding schemes, to provide additional information on their VAD solution. Motorola provided over the Email reflector additional test results and a draft specification proposal before SMG11#8bis. Due to a lack of time, this alternative VAD proposal was not discussed in SMG11#8bis. It was only reviewed in SMG11#9. SMG11#9 decided to include the Motorola VAD proposal as a second VAD option in the relevant specification with a strong desire to delete one option by SMG#29 if feasible.	**SMG11**
AP8: Agreement on NDAs for the release of the C-Code originated from ENS	Closed
AP9: Characterization Phase Funding: Detailed Test and Budget Plan prepared by SMG 11 and provided to the GSM MoU by end of November 1999. Partial funding (300 kECU) accepted by the GSM Association in December 1998 Pending agreement on required funding complement	**SMG11**
AP10: Modification of AMR Channel Coding SMG2 proposed to specify an alternative Channel Coding scheme using the existing GSM polynomials (as defined in GSM 05.03 version 6.1.1). This proposal was discussed in SMG11#8 and it was decided to investigate the speech quality impact of the proposed restriction. The results of this investigation were first provided over the Email reflector (12/13/98), then reviewed in an ad-hoc SMG11#8Bis meeting on 12/17/98. The investigation results were provided to SMG2 and discussed during the joint SMG2/SMG11 meeting in week 2/99. It was not possible to reach an agreement on one single solution during this meeting. As a result, it was decided to send a liaison statement to SMG with two versions of the AMR CR on 05.03 corresponding to the two channel coding scheme alternatives. The liaison statement is asking SMG to select one option for standardization.	**SMG**
AP11: Completion of the Verification items Motorola must release the C-Code for the second VAD option in a format exploitable for the completion of the verification items with both VAD options SMG11 members participating to the verification phase must finalize their commitment with the two VAD options if applicable and the channel coding scheme selected by SMG if necessary	**SMG11**

8 Backwards compatibility

The additions and changes caused by the AMR work item shall not cause backward compatibility problems with exiting GSM equipment.

9 IPR Declarations

List of organizations having declared having AMR related IPRs:

To be completed

Additional information on the AMR related IPRs can be obtained from the ETSI Legal Department at the following address:

ETSI Legal Department
Att. Mr. Stephane Trochon
06921 Sophia Antipolis Cedex
FRANCE
Tel: 33 (0) 4 92 94 42 00
Fax: 33 (0) 4 93 65 47 16

10 Funding

The in-house listening tests executed as part of the qualification phase were funded by the codec proponents.

The five candidates participating to the selection phase provided the required funding to perform the planned subjective listening tests and the verification of the complexity figures.

SMG11 has indicated that the characterization phase would require an additional funding estimated to 300 kECU. This funding was provisionally agreed by the GSM MoU plenary in October 1998 and the endorsement confirmed by the Association Executive Committee in December 1998.

11 Annex 1: AMR Performance Requirements

11.1 Static conditions

This document presents performance requirements and objectives for the speech quality of the GSM AMR system under static test conditions.

The half-rate and full-rate channels will be assessed separately. For each channel the speech quality of the codec modes associated with that channel will be assessed over a range of C/I and background noise conditions to provide a 'family' of performance curves.

Separate requirements and objectives are specified for clean speech and background noise. The type of the background noise, e.g. babble or vehicle, and signal-to-noise ratio (SNR) are specified in the associated subjective test plan.

The requirements and objectives for the full-rate and half-rate traffic channels under static test conditions are specified in Table 1. The following notes apply:

Note 1: 'Ideal case performance' assumes that optimum mode selection has occurred for the given channel, and is defined as the performance of the codec mode which provides the *best* subjective performance under the specified C/I and background noise condition.

Note 2: 'Worst case performance' assumes that the mode selection algorithm has made the poorest choice for the given channel, and is defined as the performance of the codec mode which provides the *worst* subjective performance under the specified C/I and background noise condition.

Note 3: Unless otherwise stated, the requirement shall be assumed to be 'not worse than', interpreted statistically at the 95% confidence level. In the case where two reference codecs are specified, the candidate codec must meet the stated requirement for both reference codecs.

	Full-Rate Channel		Half-Rate Channel	
C/I	**Ideal case performance (requirement)**	**Worst case performance (objective)**	**Ideal case performance (requirement)**	**Worst case performance (objective)**
No errors	EFR no errors	G.728 no errors	G.728 no errors	FR no errors
19 dB	EFR no errors	G.728 no errors	G.728 no errors	FR no errors
16 dB	EFR no errors	G.728 no errors	G.728 no errors	FR at 10 dB
13 dB	EFR no errors	G.728 no errors	FR at 13 dB	FR at 7 dB
10 dB	G.728 no errors	EFR at 10 dB	FR at 10 dB	FR at 4 dB
7 dB	G.728 no errors	EFR at 7 dB	FR at 7 dB	
4 dB	EFR at 10 dB	EFR at 4 dB	FR at 4 dB	

Table 1a: Clean speech requirements and objectives under static test conditions.

	Full-Rate Channel		Half-Rate Channel	
C/I	**Ideal case performance (requirement)**	**Worst case performance (objective)**	**Ideal case performance (requirement)**	**Worst case performance (objective)**
No errors	EFR no errors	G.729 and FR no errors	EFR no errors	G.729 and FR no errors
19 dB	EFR no errors	G.729 and FR no errors	G.729 and FR no errors	G.729 and FR no errors
16 dB	EFR no errors	G.729 and FR no errors	G.729 and FR no errors	FR at 10 dB
13 dB	EFR no errors	G.729 and FR no errors	FR at 13 dB	FR at 7 dB
10 dB	G.729 and FR no errors	FR at 10 dB	FR at 10 dB	FR at 4 dB
7 dB	G.729 and FR no errors	FR at 7 dB	FR at 7 dB	
4 dB	FR at 10 dB	FR at 4 dB	FR at 4 dB	

Table 1b: Background noise requirements and objectives under static test conditions:

11.2 Dynamic conditions

Full-Rate Channel	
Requirement	Same or better than the EFR under the same conditions, and also the same or better than all the AMR full rate tested modes under the same conditions
Objective 1	Same or better than the EFR using the error pattern + 3 dB
Objective 2	Same or better than the EFR using the error pattern + 6 dB

Table 2a: Requirements and objectives under dynamic test conditions for the full-rate channel

Half-Rate Channel	
Requirement	Same or better than the FR under the same conditions, and also the same or better than all the AMR half rate tested modes under the same conditions
Objective 1	Same or better than the FR on a full rate channel using the error pattern + 3 dB
Objective 2	Same or better than the FR on a full rate channel using the error pattern + 6 dB

Table 2b: Requirements and objectives under dynamic test conditions for the half-rate channel

Note 1: It is not yet agreed, whether mixed FR/HR case is needed in the qualification phase. Should it be needed, requirements are left for further study.

Note 2: The above requirements are for clean conditions. AMR#7 agreed that dynamic performance requirements need not be set for background noise case since background noise performance will be already assessed in the static tests in qualification tests. However, it is noted that to cover codec algorithms where mode adaptation is based on the background noise content of the source signal, it could be useful to define requirements also for dynamic conditions under background noise.

Note 3: 4-6 error patterns are needed for each channel. In order to initialize the system, a [5]-second preamble will be used. Each profile having duration of 2 minutes.

11.3 Additional speech codec performance requirements and objectives

In addition to the static and dynamic performance requirements and objectives, there are a number of other performance criteria which must be specified for the AMR speech codec. The reference speech codecs for the performance under tandeming and talker, level and language dependency are specified in Table 3. The performance requirements and objectives for DTMF, information tones and idle noise are specified in Table 4.

Tandeming performance and level dependency will be evaluated in the qualification phase. It is anticipated that the other additional requirements will be evaluated in the characterization phase.

	Full-Rate Channel		Half-Rate Channel	
Condition	**Reference for highest bit-rate (requirement)**	**Reference for lowest bit-rate (objective)**	**Reference for highest bit-rate (requirement)**	**Reference for lowest bit-rate (objective)**
Tandeming	EFR	G.729 and FR	G.729 and FR	G.729 and FR
Talker dependency	EFR	G.729 and FR	G.729 and FR	G.729 and FR
Level dependency	EFR	G.729 and FR	G.729 and FR	G.729 and FR
Language dependency	EFR	G.729 and FR	G.729 and FR	G.729 and FR

Table 3: Reference codecs for additional speech signal performance requirements.

The following notes apply to Table 3:

Note 1: The bit-rates tested will be those normally used within the given channel, i.e. excluding 'special' modes such as TFO. In the case of a discrepancy, 'highest bit-rate' shall be defined as the bit rate that gives the best performance for the given condition, 'lowest bit-rate' refers to the bit-rate that demonstrates the worst performance, i.e. all bit-rates will be tested for the given channel.

Note 2: Unless otherwise stated the performance criterion shall be assumed to be 'not worse than'. In the case where two reference codecs are specified, the candidate codec must meet the stated requirement for both reference codecs. The method of comparison will be defined in the appropriate test plan.

Note 3: In the tandeming case, each AMR codec mode will be tested in tandem with itself (i.e. both codecs in the tandem chain will operate at the same rate).

Note 4: The level dependency shall be measured over -16dBov (-10dBmO), -26dBov and -36dBov.

Note 5: All requirements are defined under error free conditions.

Condition	Requirement	Objective
DTMF		Transparent transmission of DTMF.
Information tones	Recognizable as given information tone.	
Output noise with idle input.	No annoying artifacts.	

Table 4: Requirements and objectives for speech codec performance with non-speech inputs.

12 Annex 2: AMR Design Constraints

Development constraints	Open issues
Complexity requirements: The complexity requirements are valid for all phases of the AMR development and are separate for channel coding, speech coding and DTX algorithms. *Channel coding including control loop management algorithms:* **A. wMOPS(*AMR-HR ch. codec*) ≤ 3.0 wMOPS** ≈ 1.1 × wMOPS(*HR ch. codec*) **B. wMOPS(*AMR-FR ch. codec*) ≤ 5.7 wMOPS** ≈ 2.1 × wMOPS(*HR ch. codec*) **C. RAM(*AMR-HR ch. Codec*) ≤ 3.5 kwords** ≈ 1.1 × RAM(*HR ch. Codec*) **D. RAM(*AMR-FR ch. Codec*) ≤ 6.6 kwords** ≈ 2.1 × RAM(*HR ch. Codec*) **E. ROM(*AMR ch. Codec*) ≤ 5.0 kwords** ≈ 5.6 × ROM(*HR ch. codec*) **F. FOM(*AMR HR ch. Codec*) ≤ 4.1** ≈ 1.0 × FOM(*HR ch. codec*) **G. FOM(*AMR FR ch. Codec*) ≤ 8.2** ≈ 2.0 × FOM(*HR ch. codec*) **H. Program ROM(*AMR ch. Codec.*) ≤ 4 × Program ROM(*HR channel. Codec.*)** *Speech coding (excluding VAD/DTX):* **I. wMOPS(*AMR speech codec*) ≤ 24 wMOPS** ≈ 8.1 × wMOPS(*FR speech codec*) ≈ 1.6 × wMOPS(*EFR sp. Codec*) **J. RAM(*AMR speech codec*) ≤ 10 kwords** ≈ 2.1 × RAM(*EFR speech codec*) **K. ROM(*AMR speech codec*) ≤ 17 kwords** ≈ 3.2 × ROM(*EFR speech codec*) **L. FOM(*AMR speech codec*) ≤ 27.5** = 8.0 × FOM(*FR speech codec*) ≈ 1.6 × FOM(*EFR speech codec)* **M. Program ROM(*AMR sp. Codec*) ≤ 3 × Program ROM(*EFR speech. Codec.*)** *Additional complexity for VAD/DTX operation:* **N. wMOPS(*AMR VAD/DTX*) ≤ 0.2 wMOPS** ≈ 2 × wMOPS(*EFR VAD/DTX*) **O. RAM(*AMR VAD/DTX*) ≤ 0.6 kwords** ≈ 0.1 × RAM(*AMR speech codec*) **P. ROM(*AMR VAD/DTX*) ≤ 0.5 kwords** ≈ 4 × ROM(*EFR VAD/DTX*) *Notes*: • FOM = Figure of merit, as described in doc. AMR-9 • Program ROM is computed as the number of basic instructions • The control loop management algorithms are intended to include all the additional algorithms beyond speech and channel codec that are needed for codec mode adaptation: channel metric estimation, adaptation algorithm, coding and decoding of the inband signaling. **Complexity calculation rules:** The same complexity evaluation methodology as used in the past for GSM HR and EFR codecs (based on ETSI fixed-point basic operations) will be used for complexity evaluation of the AMR codec. Detailed procedure for each phase is the following: • **Qualification**: Complexity evaluation may be based on floating point code. The results should nevertheless be presented as ETSI FOM, wMOPS, and memory figures even though they are allowed to be estimated from a floating point code. Requirements shall be checked according to the assessment methodology given in document AMR-9 (Complexity and delay assessment). • **Selection**: ETSI methodology based on fixed point code (Basic op. Counters, i.e. Worst observed case) • **Verification/characterization**: ETSI methodology based on fixed point code (Theoretical worst case) **Arithmetic used in codec proposals:** • **Qualification**: Fixed point or floating point code • **Selection**: Fixed point code (using ETSI set of basic operations) • **Verification/characterization**: Fixed point code (using ETSI set of basic operations).	• A few new arithmetic operators could be added to the ETSI set of basic operators but only to be applied after selection. The detailed definition of these operators is left to the complexity subgroup of AMR. **Deadline for provision is 4 weeks after selection.**
A-ter submultiplexing: At least one codec mode at HR should be consistent with 8 kbit/s sub multiplexing on the A-ter interface. This implies the constraint of providing at least one codec mode in HR mode operating at a source codec bit-rate below 6.85 kbit/s. No constraint is applied on the upper limit of the source codec bit-rate in HR mode.	

The AMR codec shall support A-ter sub-multiplexing at 16 kbit/s. The maximum source coding rate for FR channel modes is limited by the constraint of the maximum allowed rate to achieve 16 kbit/s submultiplexing. This implies a maximum source coding rate for FR codec modes of 14.4 kbit/s. These figures do not take into account the probable need of in-band signaling for TFO operation.	
Codec mode: • Codec mode signaling: transmitted in-band on the radio interface • Channel measurement signaling: transmitted in-band on the radio interface • Signaling can be different on the up and down links. • Adaptation may operate independently on the up- and down-links. • The working assumption should be not to use the stealing flags for in-band signaling. This assumption can be reverted only it is proved that the stealing flags may be used without degrading the FACCH detection performance as specified in 05.05. Decision to revert the working assumption has to be taken by SMG2. • In the static conditions of qualification tests, four codec modes (for each of the two channel modes) are tested although the codec candidates may include more modes. The codec proponent may select up to 4 codec modes to the qualification test as he wishes, but the chosen codec modes must be the same throughout all the static tests. Also the same codec modes shall be used in the dynamic tests.	
Channel mode: Channel mode handovers will be executed in the same way as existing intra-cell handovers. However, the algorithm used to determine when and whether to perform an AMR handover will be new and specific to the BSS manufacturer. • Channel mode signaling: transmitted out of band on the radio interface • The up- and downlink(of the same air-interface) shall use the same channel mode. • Channel mode control is located in the network.	
Tandem Free Operation (TFO): The AMR codec shall support Tandem Free Operation. TFO shall not decrease the capacity gain achievable using the AMR codec. TFO mode can be operated only if both terminals (e.g. up-link MS-A to network and downlink, network to MS-B) use the same speech coding bit-rate and algorithm. (In principle this does not imply that the same channel mode has to be used, but TFO can be achieved only if the AMR coder is capable of operating at the same source rates for both FR and HR channel modes.) It is not mandatory to have a common speech codec rate in FR and HR modes. In order to support TFO, AMR must be designed such that all HR codec contained in the proposal can be supported over a full rate channel. The in band signaling in full rate channel must be designed such that it is possible to signal the operation of all HR and FR speech codecs. It is possible to use an escape mechanism between the FR and HR mode and enter a new mode of operation of the in band signaling to switch between the HR codec modes in the full rate channel. The escape mechanism is only allowed when entering or leaving the TFO operation mode, and not while operating in TFO. The channel coding and in band signaling complexity corresponding to the support of all HR codecs in a full rate channel must be included in the FR channel coding complexity figures. The channel coding required for the support of the HR codec in the full rate channel should be defined as part of the proposal. The corresponding code does not need to be included in the executable to be delivered prior the selection tests. It must be included in the C-Code to be delivered for the evaluation of the channel coding complexity.	
Discontinuous Transmission (DTX): The AMR codec shall support DTX operation. The increase in radio channel activity in terms of average transmission power during speech inactivity shall not significantly affect the gain of DTX operation i.e. the interference reduction and the battery saving should be similar to that of current DTX operation. The VAD algorithm and Comfort Noise generation algorithm are part of the specification of the AMR codec. To limit the impact of in-band signaling on the DTX gain, the increase of the radio channel activity in terms of average transmission power should not exceed 8 % compared to today's GSM codecs and assuming the same VAD activity. Under the assumption the TX power could not be modified for DTX operation, the signaling needed during speech pauses for DTX operation as well as codec mode adaptation shall use no more than 16	• The assumption of reducing the TX power of in-band signaling frames will not be considered until a confirmation of feasibility is received from SMG2-WPB.

burst in FR and 12 burst in HR per multiframe. Since VAD/DTX is developed only after the selection phase, the codec proponents shall commit to provide it. The qualification rules will not apply to the test conditions with reversed link in DTX mode.	

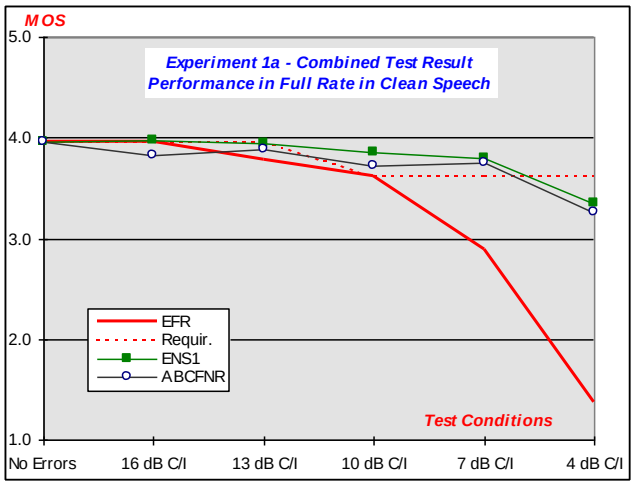
(continued)

(concluded)

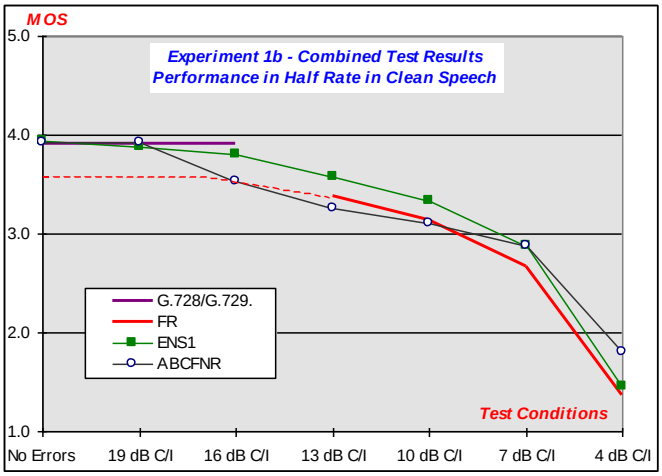
Development constraints	Open issues
Radio interface: The AMR codec and its control will operate without any changes to the air-interface channel multiplexing, with the possible exception of the interleave depth. Conventional TCH-F and TCH-H channels will be used for FR and HR channel modes of the codec.	
Power control: It shall be possible to operate power control independently of the AMR adaptation. However, operators may choose to optimize the AMR control according to the power control settings. Fast power control may also be introduced provided that the measurement reports are transmitted in-band for AMR codec adaptation control.	
Codec mode control: • Codec mode control relating to capacity or radio link quality should be located in the network (BSS) • MS can autonomously select the codec mode of the up-link on the basis of speech source content (e.g. background noise); however, the network should have the option to e.g. override the MS preferred selection or restrict the range of selectable modes. • It shall be possible to upgrade the adaptation algorithm from the network.	
Active noise suppression in the qualification/selection phase: In order to compare all solutions in the same conditions, and select the candidate with the best intrinsic quality, it was decided that noise suppressers would not be included during the qualification and selection phases, or that any noise suppresser integrated to a source codec should be turned off for these tests. The selection and possible standardization of a noise suppresser will then be addressed in a separate phase	
Transmission delay: The algorithmic round trip delay for HR codec modes shall be less than or equal to the algorithmic round trip delay of the HR GSM codec increased by 10 ms. The algorithmic round trip delay for FR codec modes shall be less than or equal to the algorithmic round trip delay of the EFR GSM codec increased by 10 ms. This has to be ensured in all operating conditions including codec mode switching. The transmission delay shall be evaluated according to the rules described in doc. AMR-9.	
Error concealment: Error concealment techniques of AMR codec candidates shall only rely on soft-output information from the equalizer. This does not preclude any future exploitation of other radio channel parameters in the final AMR system.	
Frame size: The frame size is constrained to be one of the possible values: 5ms, 10ms or 20 ms.	
Codec expandability: In addition to the signaling needed to support TFO, the AMR in-band signaling shall be expandable (prepared) to signal the use of future AMR modes including signaling the use of the existing GSM FR, GSM HR and GSM EFR speech coders, one or two wideband modes. Switching between AMR codecs and extended codecs shall be possible although not tested in qualification and selection phases and the constraint relates to the switching capabilities and not to the quality performance.	

13 Annex 3: AMR Selection Results Performance Diagrams of ENS1 and ABCFNR candidates

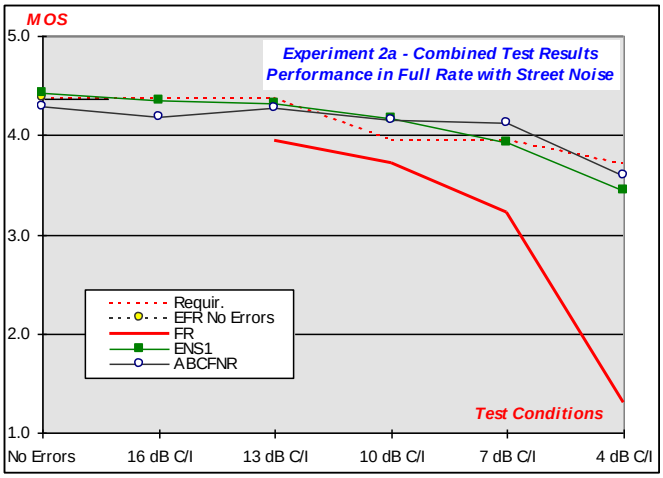
Experiment 1a: Performances in Full Rate, Clean Speech and Static C/I without Codec adaptation



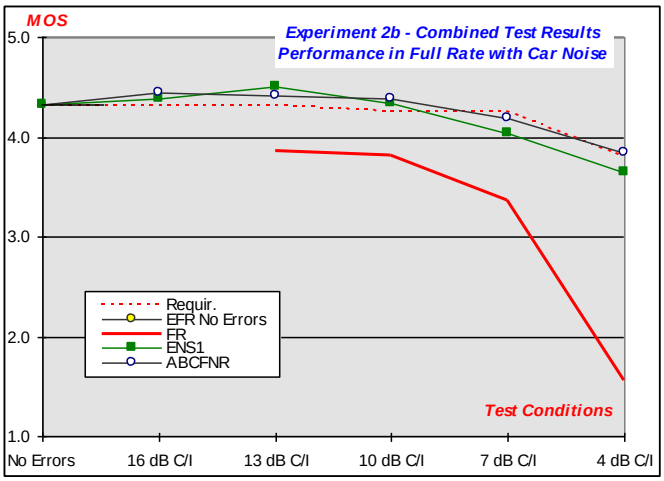
Experiment 1b: Performances in Half Rate, Clean Speech and Static C/I without Codec adaptation



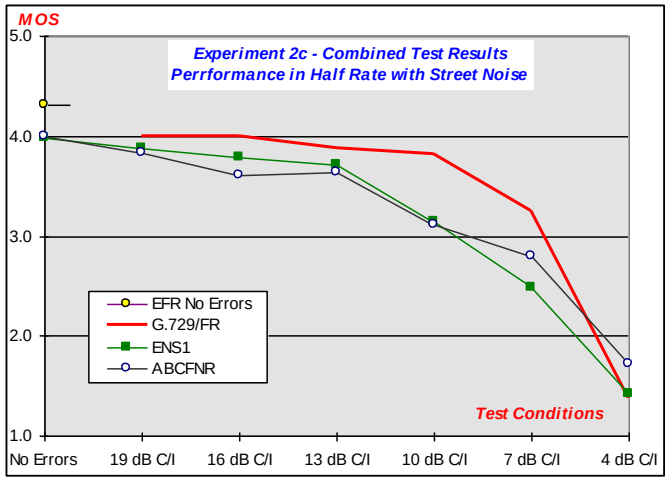
Experiment 2a: Performances in Full Rate, with Street Noise and Static C/I without Codec adaptation



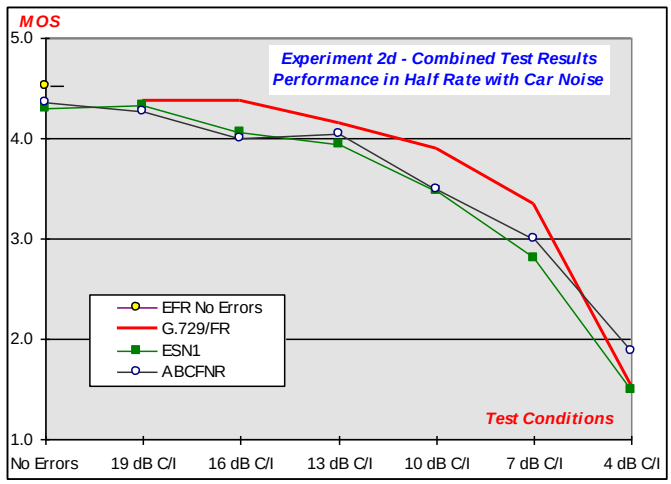
Experiment 2b: Performances in Full Rate, with Car Noise and Static C/I without Codec adaptation



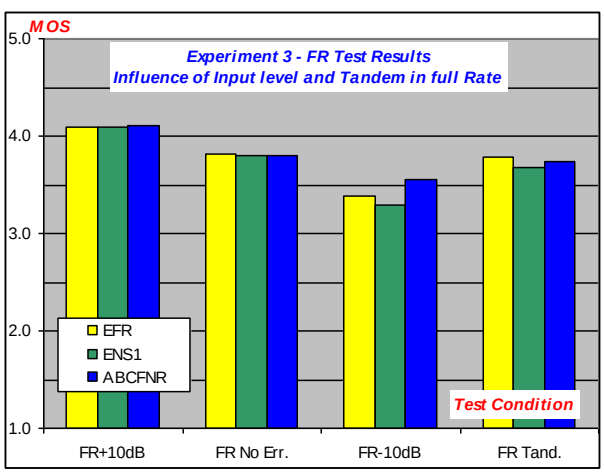
Experiment 2c: Performances in Half Rate, with Street Noise and Static C/I without Codec adaptation

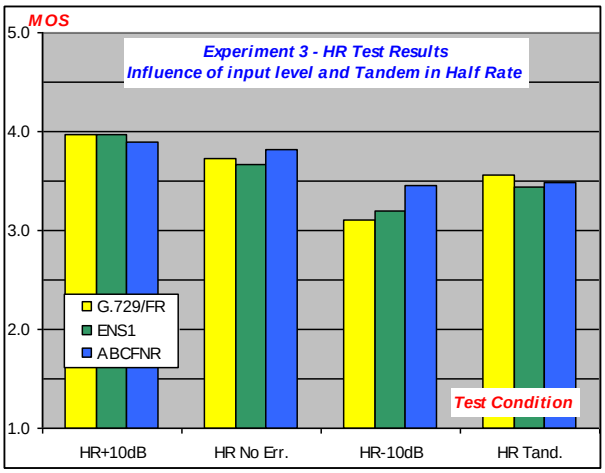


Experiment 2d: Performances in Half Rate, with Car Noise and Static C/I without Codec adaptation

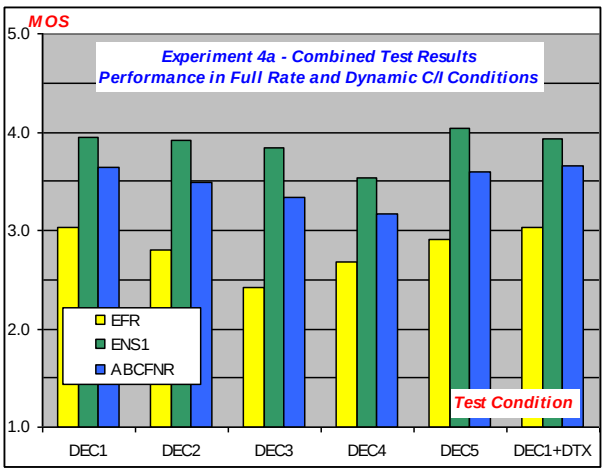


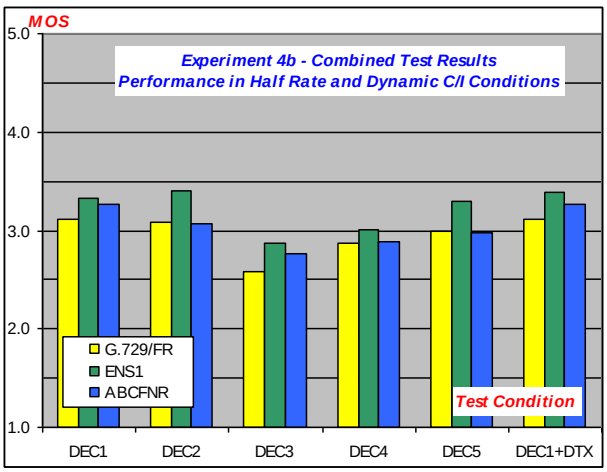
Experiment 3: Influence of Input level and Tandeming in Full Rate and Half Rate (No Errors)



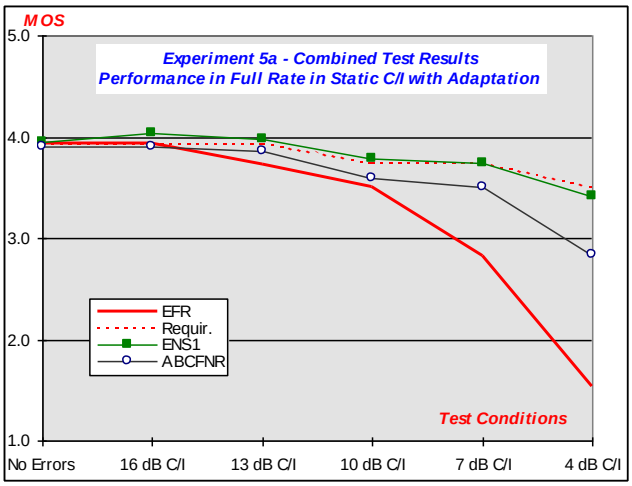


Experiment 4a & 4b: Performances in Full Rate (4a) and Half Rate (4b), Clean Speech and Dynamic C/I with Codec adaptation

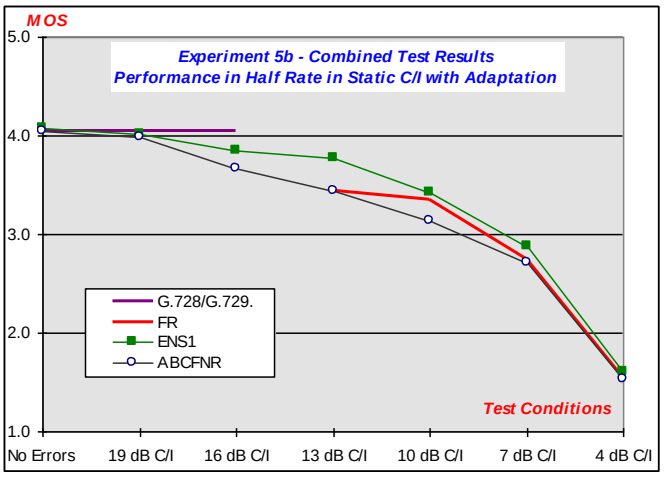




Experiment 5a: Performances in Full Rate, Clean Speech and Static C/I with Codec adaptation



Experiment 5b: Performances in Half Rate, Clean Speech and Static C/I with Codec adaptation


MOS
5.0
4.0
3.0
2.0
1.0
Experiment 5b - Combined Test Results
Performance in Half Rate in Static C/I with Adaptation
G.728/G.729.
FR
ENS1
ABCFNR
Test Conditions
No Errors
19 dB C/I
16 dB C/I
13 dB C/I
10 dB C/I
7 dB C/I
4 dB C/I

History

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October 30, 1998	Draft Version 0.0.2 Update with editorial corrections agreed in SMG11 AMR#12
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