



International Telecommunication Union

# ITU-T Study Group 12

## The E-Model and its Applications for Transmission Planning

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Workshop on QoS and user-perceived transmission quality in evolving networks  
Dakar (Senegal), 18 - 19 October 2001



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# Transmission Planning (TP): First Step (1)

Nowadays, transmission planning is a different task and for each reference connection one needs to identify the following:

- o traditional parameter values characterizing a connection such as
  - loudness rating, delay, noise

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## Transmission Planning: First Step (2)

- o Impacts due to modern equipment as low bit-rate codecs or packet based transmission systems which can be characterized by parameters such as
  - type of codec
  - impairments due to bad radio coverage
  - percentage of packet loss

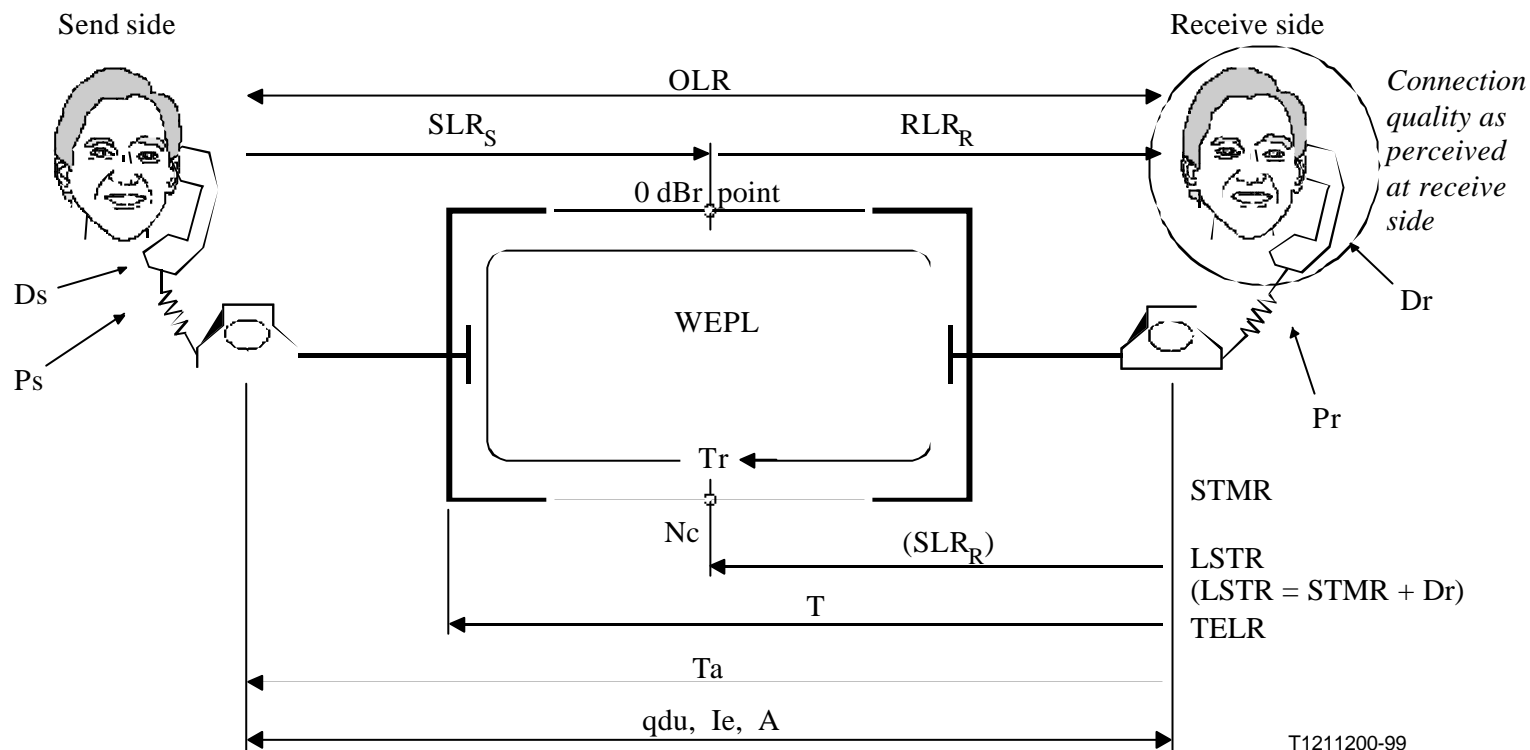
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# Basic Reference Configuration



(Figure 17/G.108)



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# The Common ITU-T Transmission Rating Model

With the E-Model (Rec. G.107) a method is provided which enables the planner to combine, by calculation, all transmission impairments present in the given connection to a total value of impairment.

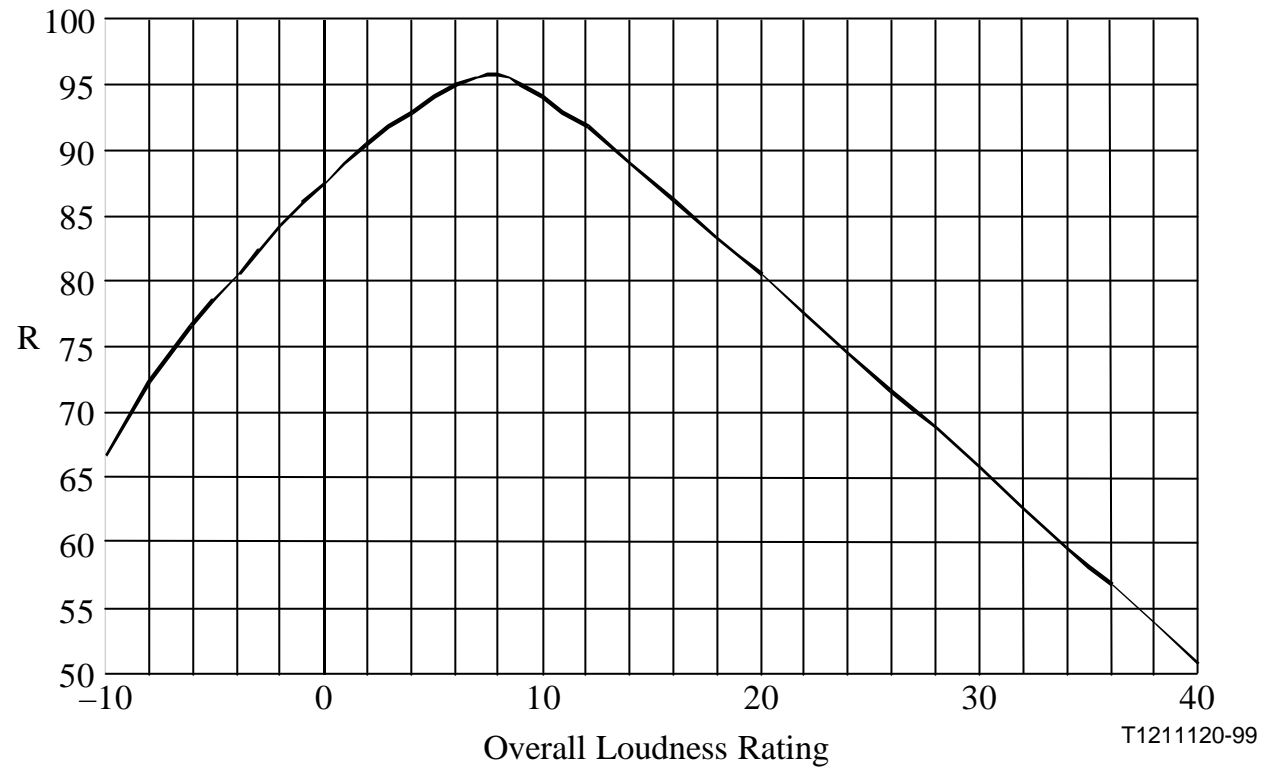
- o This calculation is performed by using an algorithm based on auditive testing.



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# OLR vs. E-Model Rating R



(Figure 9/G.108)

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## Consideration of Combination Effects

In telephone connections consisting of a variety of network elements, different transmission parameters may contribute simultaneously to the total impairment.

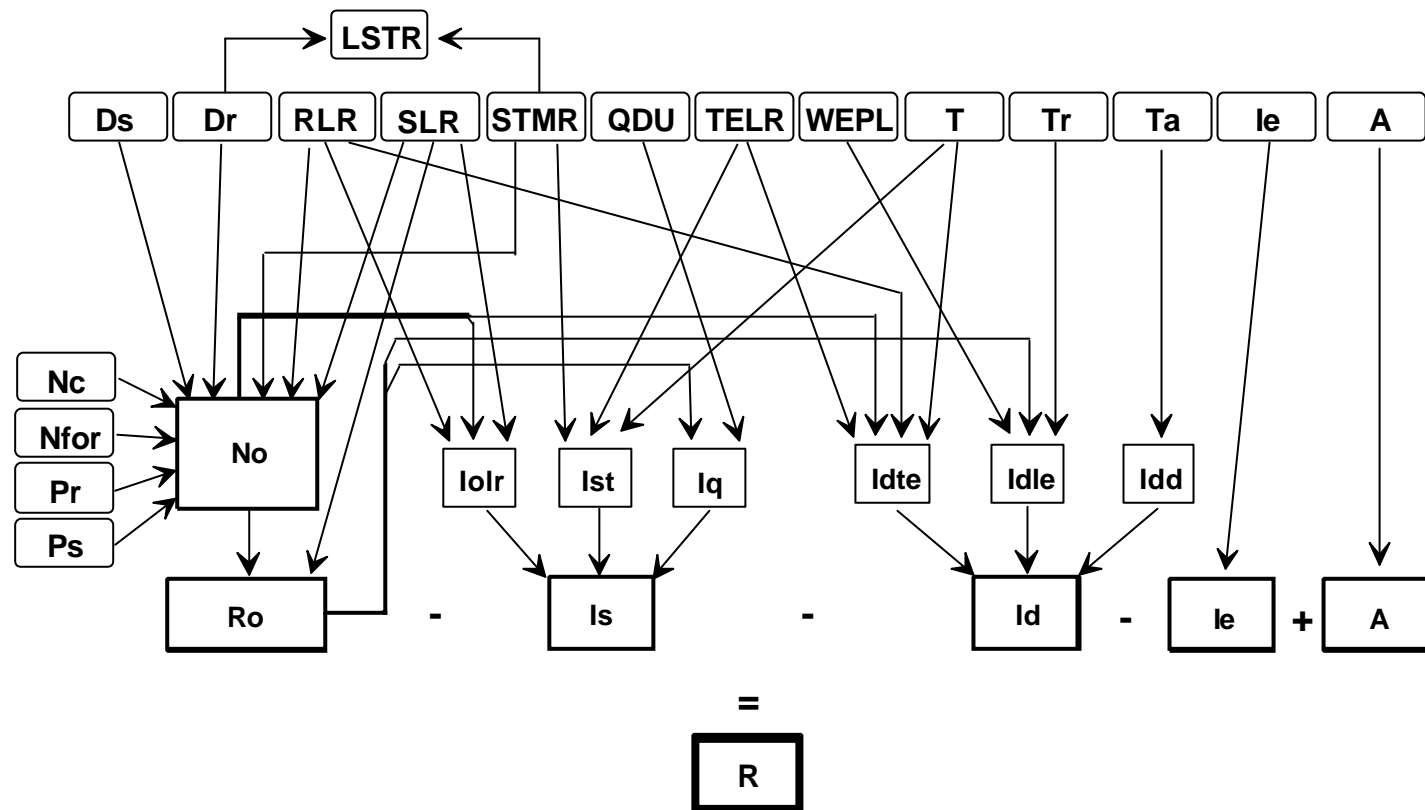
- o The E-Model also incorporates combination effects.



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# Influence of the Different Input Parameters







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## **End-to-End = Mouth-to-Ear**

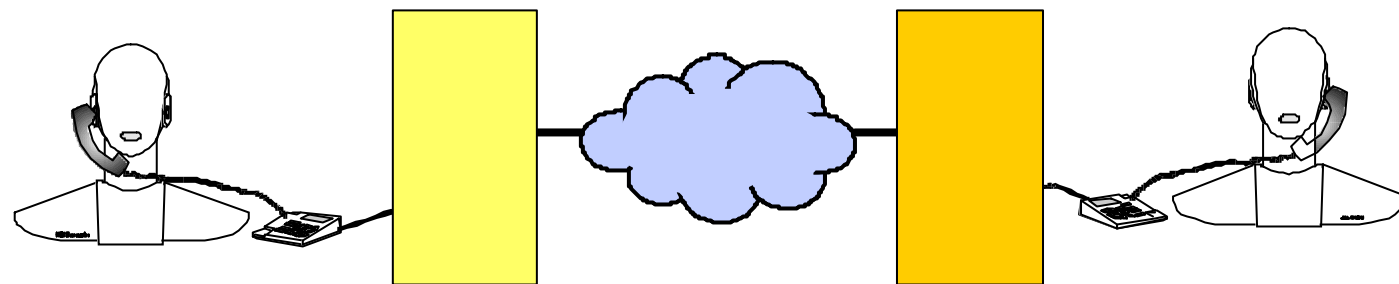
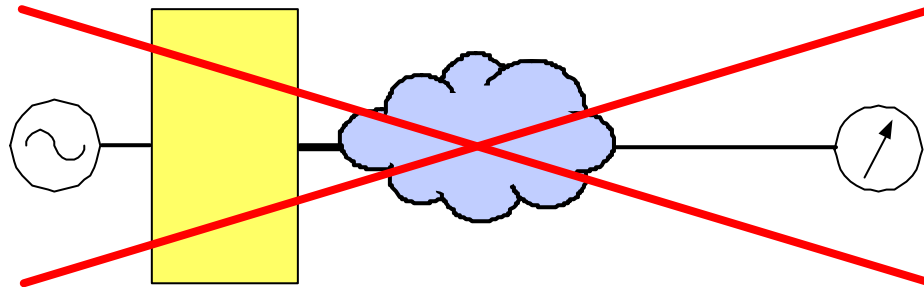
The planning of speech transmission quality should be based on an end-to-end consideration rather than on a specification of individual objective parameter limits.



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# End-to-End = Mouth-to-Ear





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## MOS ≠ MOS

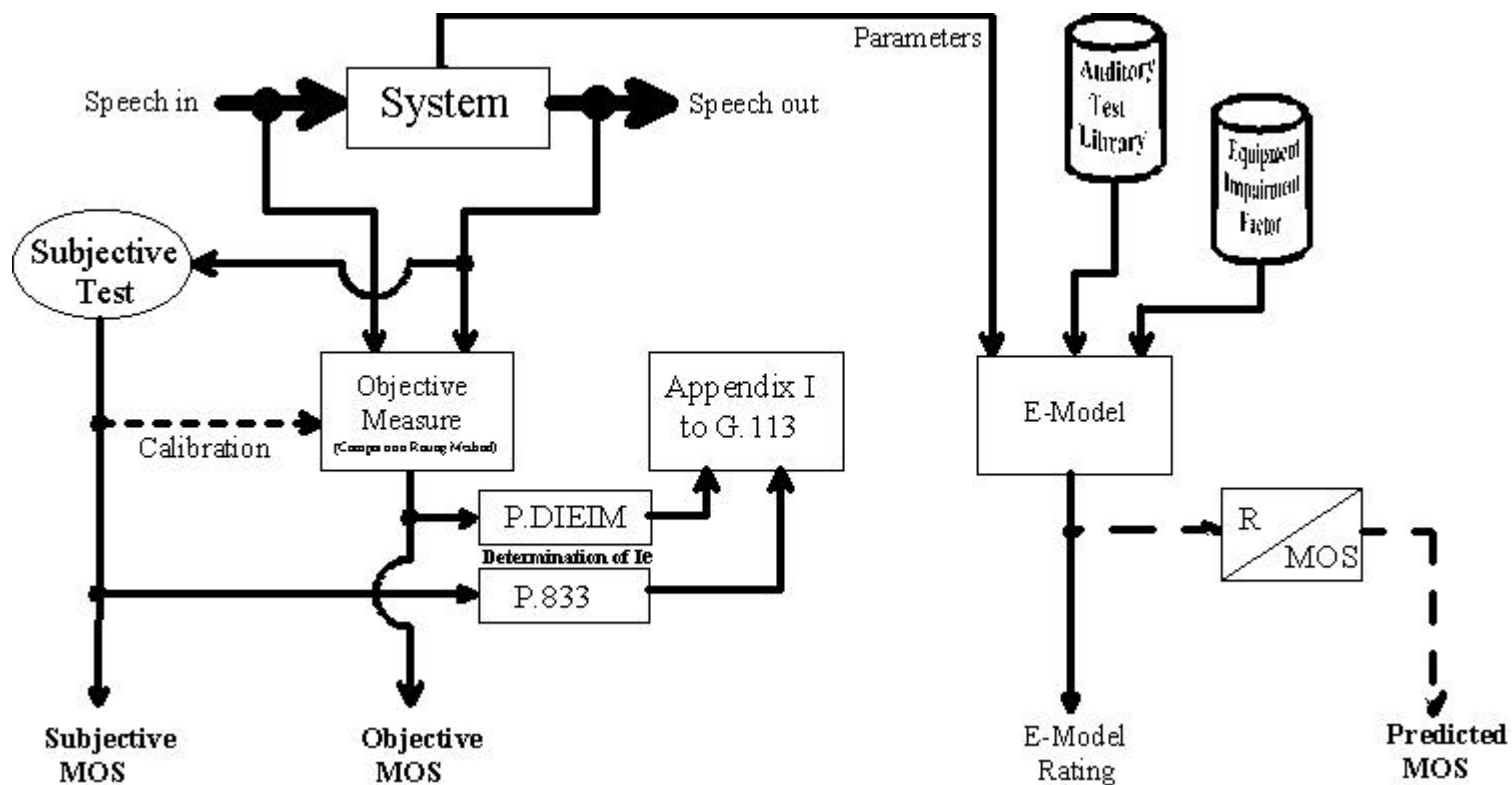
- Transmission planning, based on the E-Model, provides a prediction of the quality, as perceived by the user, for an investigated connection.
- Based on subjective testing users' perception is expressed in terms of MOS, %GoB or %PoW.
- Objective measures ... ( see session 6 )



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# MOS ≠ MOS





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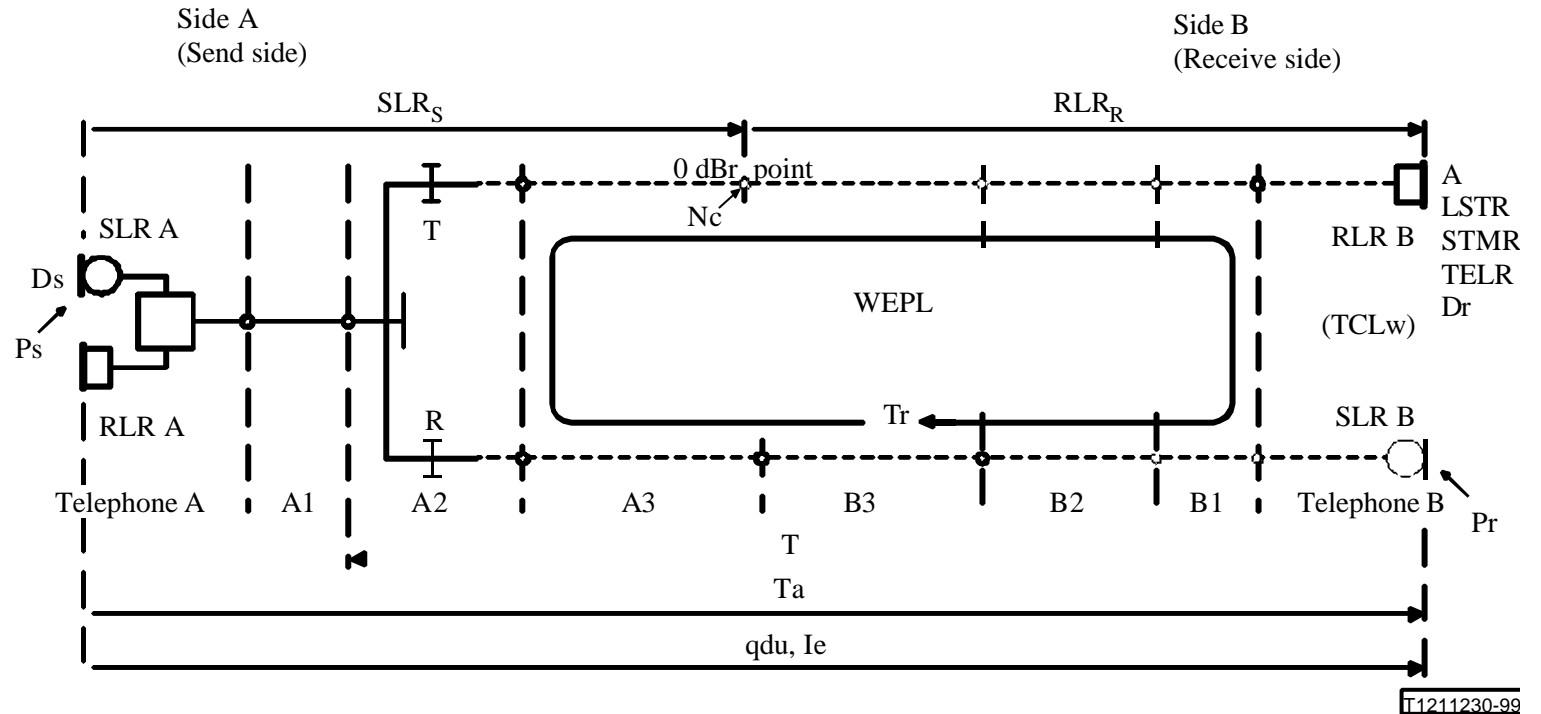
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## Transmission Planning: Second Step

- o Resulting from the first step the transmission planner receives a whole bunch of parameter values assigned to specific sections or pieces of equipment.
- o In order to model the end-to-end quality the planner - in a second step - has the task to condense the information he collected on your reference connection.
- o This is a complex task and has to be performed with due care.



# Your Reference Connection



Working configuration 2-wire/4-wire (Figure 20/G.108)



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# The use of Computer Programs (1)

The E-Model, the recommended common tool for all planning purposes, comprises a number of complex formulae.

Hence, the planner usually relies on computer programs which perform the calculations.

It is strongly advised that the user be fully familiar with the use of such programs and the limits of their application.



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## The use of Computer Programs (2)

Computer programs do assist the planner with a variety of features, such as the handling of input parameters, necessary pre-calculations, storing of frequently-used configurations, etc.

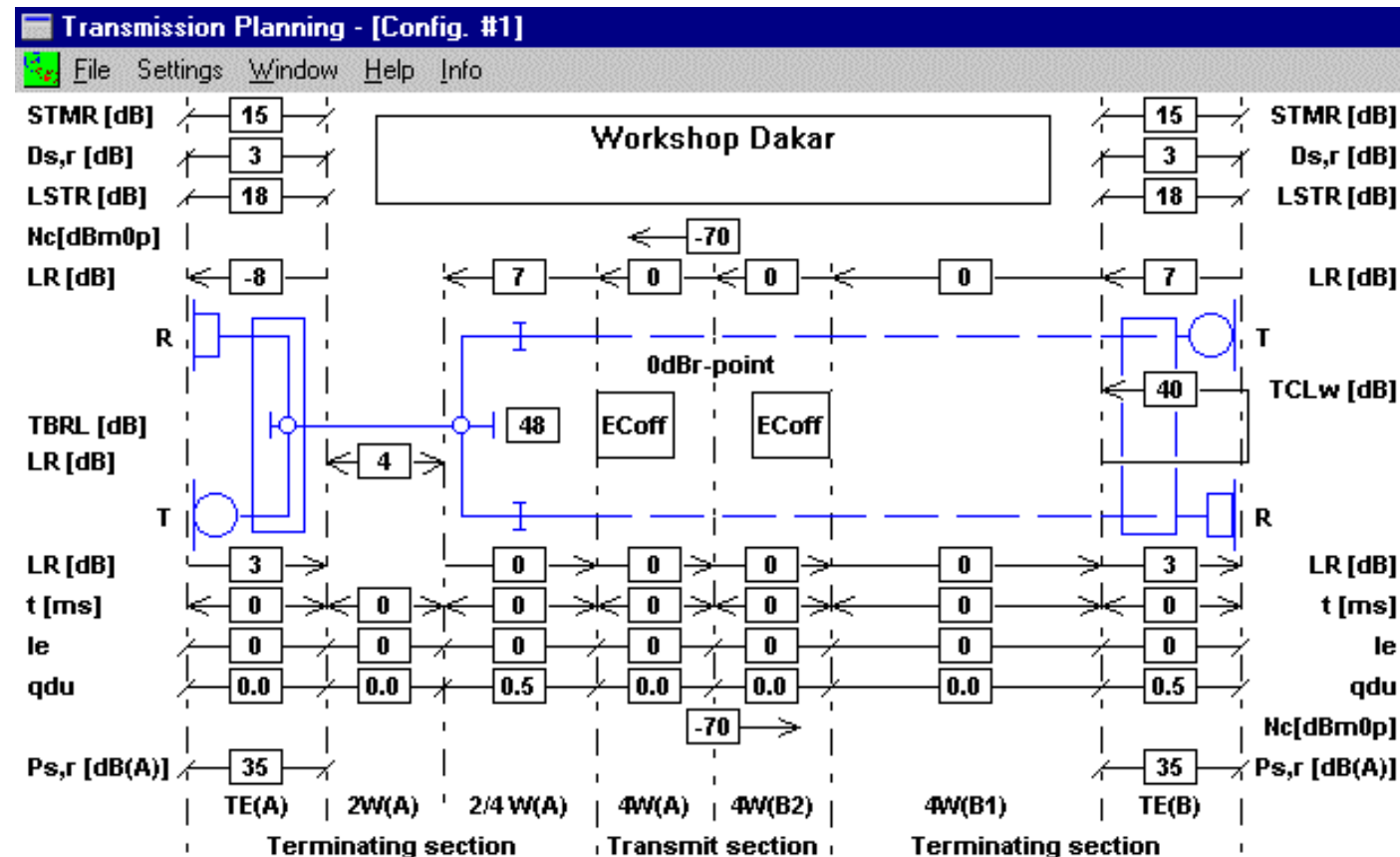
The correct handling of loudness rating values in conjunction with the necessary pre-calculations is very important and can be supported by such programs.





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# Computer Program: Example



Quality left Side					Variable	Quality right side				
R	GOB%	POW%	TME%	MOS	---	R	GOB%	POW%	TME%	MOS
93.3	98.1	0.1	0.0	4.4		93.3	98.1	0.1	0.0	4.4



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## **TP: Third Step Categorization**

Five categories of end-to-end speech transmission quality are defined in terms of "users' satisfaction" (Rec. G.109).

They are tied to the Ratings given by the transmission planning tool of Rec. G.107.

This takes into account the combined effects of various transmission impairments.

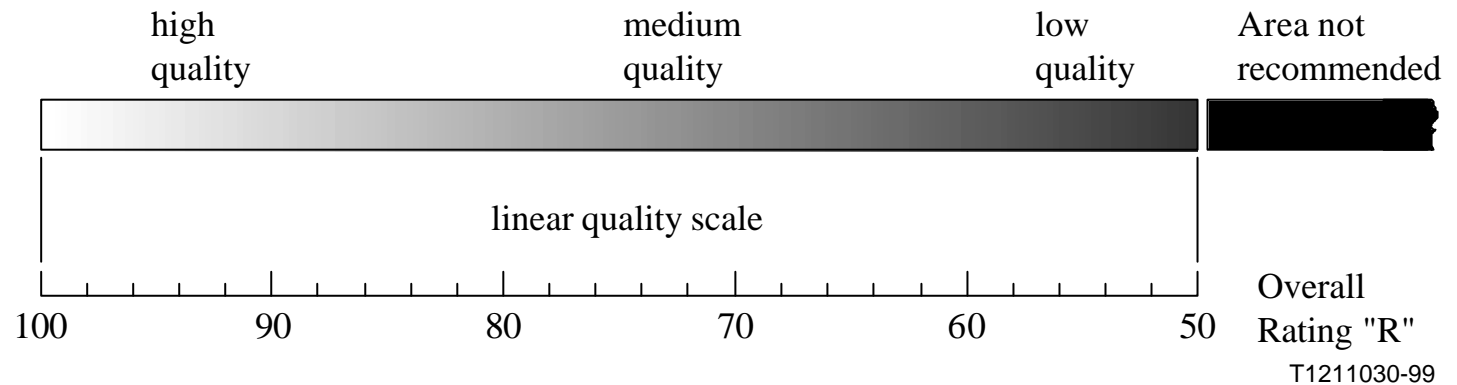
The definitions are independent of any specific technology that may be prevalent in different types of network scenarios.



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# Determination on a Linear Quality Scale



*(Figure 26/G.108)*



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# Categories of Speech Transmission Quality

- o The quantitative terms should be viewed as a continuum of perceived speech transmission quality varying from high quality through medium values to a low quality as illustrated in the previous slide.
- o The following table gives the definitions of the categories of speech transmission quality in terms of ranges of Transmission Rating Factor R and descriptions of "users' satisfaction" for each category.

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# Categories of Speech Transmission Quality

*(from Table 1/G.109)*

<b>R-Value Range</b>	<b>Speech Transmission Quality Category</b>	<b>User satisfaction</b>
$90 \leq R < 100$	Best	Very satisfied
$80 \leq R < 90$	High	Satisfied
$70 \leq R < 80$	Medium	Some users dis-satisfied
$60 \leq R < 70$	Low	Many users dis-satisfied
$50 \leq R < 60$	Poor	Nearly all users dis-satisfied



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## Typical Scenarios for each Category

As a guidance for the practical usage of G.109 the following slide provides one typical scenario per G.109 category.

Finally, the transmission planner compares the result of his calculation with the predictions of users' satisfaction of Recommendation G.109.



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# Typical Scenarios for each Category

(Table 2/G.109)

Service/network scenario	R value	Deviations from table 3/G.107
ISDN subscriber to ISDN subscriber, local connection	94	Note 1
Analogue PSTN subscriber to analogue PSTN subscriber, 20 ms delay (average echo path losses; no active echo control)	82	Note 2
Mobile subscriber to analogue PSTN subscriber as perceived at mobile side	72	Note 3
Mobile subscriber to analogue PSTN subscriber as perceived at PSTN side	64	Note 4
Voice over IP connection using G.729A + VAD with 2% packet loss	55	Note 5
NOTE 1: No deviations		
NOTE 2: TELR = 35 dB, WEPL = 50 dB, T = 20 ms, Tr = 40 ms, Ta = 20 ms		
NOTE 3: TELR = 68 dB, WEPL = 101 dB (EC with ERLE = 33 dB assumed), T = 110 ms, Tr = 220 ms, Ta = 110 ms, Ie = 20		
NOTE 4: TELR = 53 dB, WEPL = 101 dB (EC with ERLE = 33 dB assumed), T = 110 ms, Tr = 220 ms, Ta = 110 ms, Ie = 20		
NOTE 5: T = 300 ms, Tr = 600 ms, Ta = 300 ms, Ie = 19		



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## References

- o G.107 - The E-Model, a computational model for use in transmission planning
- o G.108 - Application of the E-Model: A planning guide
- o G.108.1 - Guidance for assessing conversational speech transmission quality effects not covered by the E-Model
- o G.109 - Definition of categories of speech transmission quality

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# Abbreviations

o %GoB	Percentage Good or Better
o %PoW	Percentage Poor or Worse
o ANSI	American National Standards Institute
o CN	Corporate Network
o EC	Echo Canceller
o EIA	Electronic Industries Alliance
o ETSI	European Telecommunications Standardization
o EU	European Union
o le	Equipment Impairment Factor
o IP	Internet Protocol
o LSQ	Listener Speech Quality
o MOS	Mean Opinion Score
o OLR	Overall Loudness Rating
o OVR	Overall Speech Quality Rating
o PSTN	Public Switched Telephone Network
o QoS	Quality of Service
o R	E-Model Rating
o TCLw	Terminal Coupling Loss (weighted)
o TELR	Talker Echo Loudness Rating
o TIA	Telecommunications Industry Association
o TIPHON	Telecommunications & Internet Protocol Harmonization Over Networks
o WEPL	Weighted Echo Path Loss

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