1 TECHNICAL ASPECTS

1.1 METHODOLOGY

1.1.1 FUNDAMENTALS

This study's methodology is based on 3 main aspects:

a) End-to-end measurements: Measurements are carried out between a mobile network terminal point and a fixed network terminal point;

b) Impartiality: Measurements are carried out simultaneously, in time and space, for the three operators (OPTIMUS, VODAFONE and TMN), thus guaranteeing equality of testing conditions;

c) Objectivity: Tests are carried out in a totally automatic way, eliminating the subjectivity inherent to human intervention or decision.

1.1.2 QUALITY OF SERVICE INDICATORS

With this study three mobile network indicators of basic importance are analyzed, considering quality from the user's standpoint:

a) Coverage: Verification of the signal levels.

The testing and measurement equipment that was used measures the level of signal received by the mobile terminal. All these measurements are geo-referenced and then described on a map, thereby making it easy to view the coverage levels of each operator on the several studied routes.

Table 1 - Signal level

Signal Level (dBm)	
> -100	Coverage
> -110 ∧ <= -100	Poor Coverage
<= -110	No Coverage

b) Accessibility: Verification of a mobile network's ability to establish and maintain calls.

It analyses the ability to successfully establish voice communications between two ends, a mobile network terminal and a fixed network terminal, and the ability of networks to maintain this call during a pre-established period of time.

In the cases when it was not possible to establish communication or when communication was dropped during the conversational phase, the cause for this failure or drop is identified.

c) Audio Quality: Verification of the perceptivity of conversations by means of establishing a successful connection and during a period of time.

In order to evaluate this indicator, the system simulates a telephone conversation between two users.

The method to evaluate audio quality, such as perceived by users, is based on the "E-Model" model, which is recommended by international bodies such as ETSI[1] (ETR 250) and ITU[2] (ITU-T *Recommendation G.107*). The reckoning of the *MOS* (*Mean Opinion Score*) index is based on this model.

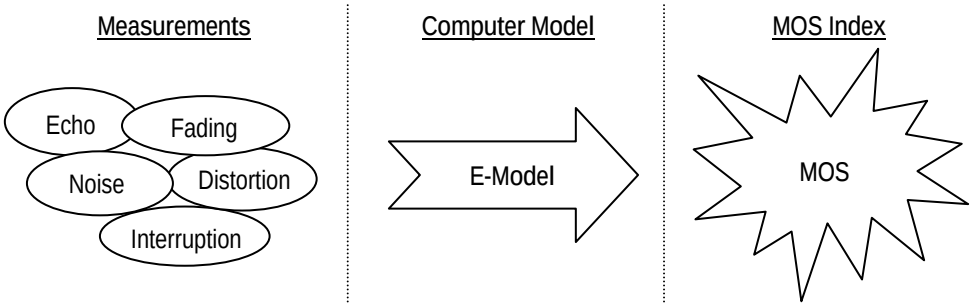


Figure 4 - Methodology used for audio quality monitoring.

The MOS scale quantifies the effort that it takes to understand a conversation. Its value is 0 when there is no communication and 5 when the communication is perfect. Values 0 and 5 are only theoretical and, therefore, they never show in the results of the measurements.

[1] European Telecommunications Standards Institute.

[2] International Telecommunications Union.

Table 2 - MOS Scale

MOS	Quality
5	Excellent
4	Good
3	Acceptable
2	Poor
1	Bad

1.1.3 MEASUREMENT PROCEDURES

The tests are indeed the establishment and maintenance of voice calls under the following conditions:

1. Between the GSM Mobile Network terminals and a Fixed Telephone Network (Mobile-Fixed);

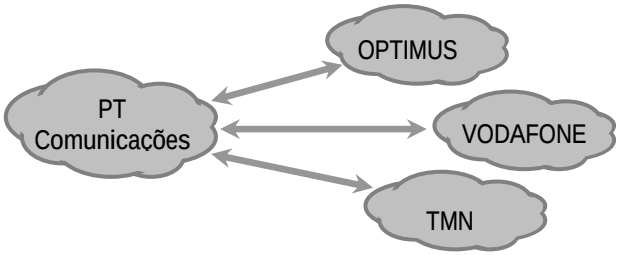
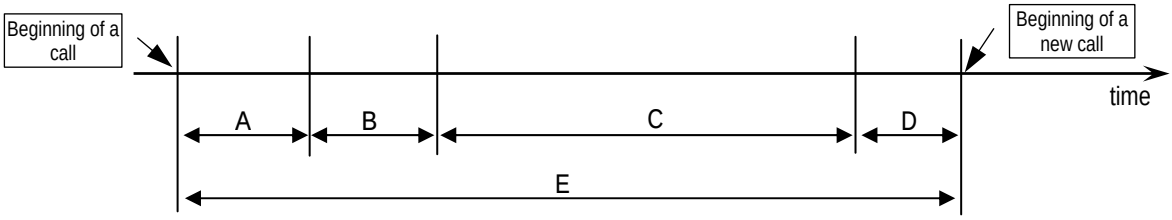


Figure 1 – Origin and Destination of test calls.

2. During the collection of measurements, the mobile terminal equipment (1 per operator) moves along the studied route;

3. Calls are made in alternation from mobile and fixed terminals;

4. The time gap between consecutive calls is 160 seconds;



A - Dialing and routing of call (between 5 and 15 seconds, depending on each network)
B - Verification of routing (about 15 seconds)
C - Conversation (programmable, 4 hours maximum)
D - Disconnection of call and interval between consecutive calls (10 seconds minimum)
E - Interval between calls

Figure 7 – Time structure of a voice call using the Datamat M366plus equipment.

5. After the successful establishment of a call, a conversational phase (a real conversation is

simulated) takes place, with a maximum length of 110 seconds (inferior if the call was dropped or the dialing time too long);

6. During the conversational phase, audio quality measurements (MOS) are made for each of the ends of the call.

1.2 TESTED AREAS

The following main Portuguese rail axels where analyzed for this first set of tests:

- Braga-Lisbon;
- Lisbon-Faro;
- Lisbon-Guarda.

1.3 SAMPLE SIZE

Table 3 – Length of measurement collection

Rail Axel	Hours of Measurements
Braga-Lisbon	15 h 59
Lisbon-Faro	12 h 54
Lisbon-Guarda	17 h 37
Total	46 h 30

1.4 DATA COLLECTION CONDITIONS

Data collection took place during normal working hours on working days and included 4 runs by each rail axle.

1.5 TESTING AND MEASUREMENT EQUIPMENT

For the conduction of these tests, ANACOM used the *DATAMAT M366plus* testing and measurement equipment, which is a Quality of Service analyzer for GSM networks.

1.6 POST-PROCESSING TOOLS

There is a software tool named “Report” that is associated to the M366plus equipment, which stores, organizes and generates statistics from the information previously collected by the measurement units.

The M366plus equipment includes a GPS receiver that enables geo-referencing for all measurements made. This information is handled by the “GeoReport” tool which, in parallel with a third tool – “MAPINFO” – enables viewing of the statistical information generated by “REPORT”, on digital geographical charts.