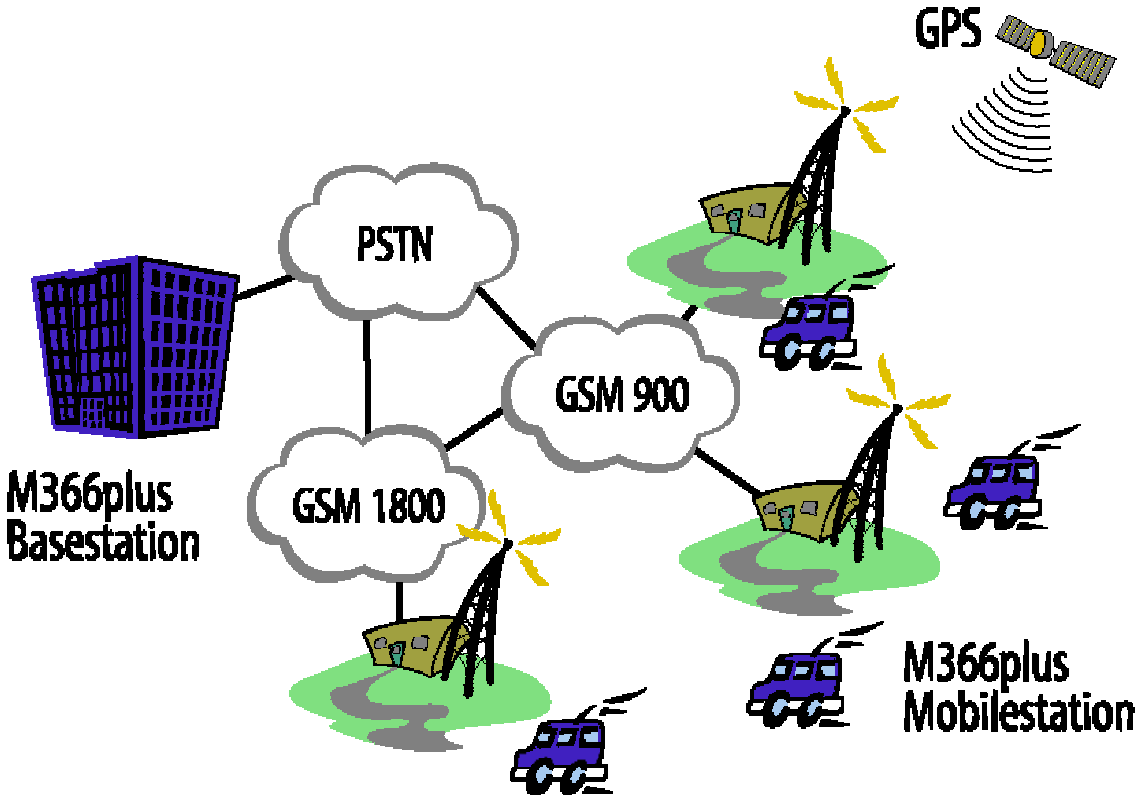
GSM Mobile Networks

Quality of Service Survey

July 2002



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I EXECUTIVE SUMMARY

I.I BACKGROUND

The Autoridade Nacional de Comunicações (ANACOM) has carried out for the third consecutive year a survey on the quality of service of GSM mobile networks. As in previous years, an aim was to assess the angle of consumers, so that the results could reflect their perception of the performance of mobile networks.

The study methodology is identical to the one used last year. However, a number of changes were introduced, namely:

- The measurement gathering time for each urban area depended on the number of inhabitants in the respective county (*concelho*);
- Measurement gathering in the Azores and Madeira autonomous regions was extended to all the islands.

We must however insist that due to the greater territorial and demographic coverage, the sampling criteria and the large increase in the number test calls, the study results for the current year are more representative of the overall performance of GSM mobile networks from the user standpoint.

On-the-ground measurements were effected between 18 February and 20 June 2002. Some 49,999 test calls were made in 30 cities and along 10 major road arteries on the mainland and in three cities and along main road arteries in **all** the islands of the Azores and Madeira. The time involved was 704 hours, over a distance of 27,722 kilometres covered. The number of samples gathered increased by 25% over the previous year's study and by 113% over the study for the year 2000.

The operators whose networks were the object of the study – OPTIMUS, VODAFONE and TMN – were invited to take part in defining the test methodology, along with the Portuguese Consumer Defence Organisation (DECO). The constructive atmosphere, which resulted in an enhanced spirit of collaboration by all, must be highlighted. This facilitated to a large degree the accomplishment of the goals proposed by ANACOM for the preparation and subsequent realisation of the work.

Three vitally important **mobile network indicators** were studied, considering the quality perspective from the users' standpoint:

a. **Coverage;**
b. **Accessibility;**
c. **Audio Quality.**

The methodology followed is based on automatic end-to-end testing. Although expensive and time-consuming, it enabled on-the-ground verification of the quality of service (QoS) provided by a given telecommunications operator, by means of a picture as realistic as possible of network performance from the user standpoint.

As exhaustive measurement was impractical for all areas, a representative sample was chosen. This enabled the results obtained to indicate the comprehensive performance of the mobile networks. The selection of test areas was thus in accordance with related criteria, namely those with higher service usage rates, i.e., main road arteries and large urban areas.

Another similarly important criteria was to consider geographic distribution of the areas in order to cover regions of the interior as well as Madeira and the Azores. This approach meant the sample was richer and avoided the effect of results solely based on measurements taken in the more densely populated areas of Lisbon and the northern coast.

Tests were thus performed in all the country's district capitals, expanding the gathering area to the Lisbon and Oporto metropolitan areas, and to the mainland's main road arteries and to all the islands in Madeira and the Azores.

The population present in the sample's urban areas represents 45% of Portugal's total population, according to preliminary results of the last census (2001).

Given the population density of the Greater Lisbon and Greater Oporto regions, and in order to enhance the sample representation, testing in those areas lasted 215 and 107 hours respectively. Data collection was effected during normal working ours on weekdays, in two daily measurement sessions: from 8 a.m. to 11:30 a.m., and from 4:30 p.m. to 8 p.m.

In the remaining urban areas, measurement time was weighted according to the number of inhabitants present in the respective counties:

- Up to 50,000 inhabitants: 7 hours;
- From 50,000 to 100,000 inhabitants: 10 hours;
- More than 100,000 inhabitants: 14 hours.

Measurement sessions in these urban areas took place during normal working hours on weekdays.

On major road arteries, four trips along same were made to enhance sample representation.

According to the most recent statistical data available to ANACOM, there are more than 8 million mobile subscribers. If we take into account the diversity of available terminal equipment on the market and the very subjectivity inherent to each user, it then becomes impossible to rigorously duplicate the conditions of each consumer's interaction with the networks. In this context, the study results should be viewed as an indicator of overall network performance. Their transposition/extrapolation to specific situations should be undertaken with caution, at the risk of drawing conclusions that are not in line with reality.

The technical and methodological options used in this study directly influenced the results obtained and should be taken into consideration when analysing the results, namely the following:

- The **terminal equipment** used was **Dual-Band with EFR**. Users whose equipment does not have the same characteristics are likely to have results different from those obtained in this study;
- The testing was effected exclusively via a **technical solution** (equipment + software) and processed in an entirely automatic manner. This enabled the homogeneous establishment of assessment conditions for the three operators and elimination of the subjectivity inherent to human users;
- The tests were conducted in **moving vehicles with exterior antennas**;
- To simultaneously study the accessibility and audio quality of conversations, a standard **conversation time** of **100 seconds** was used. This approximates the average conversation time for such communications for the networks in question in the first quarter of 2002; this criterion was considered when making the choice;
- Results of the study reflect network behaviour only in the places and times in which measurements were taken;

- Operators are continually improving their networks. The technical intervention needed for such work can lead to momentary interruptions of service in the respective geographical area.

I.II MAJOR CONCLUSIONS

Analysis of the study results enables the conclusion that the coverage and performance level of GSM mobile networks is very good and is equal or superior to that of their foreign counterparts.

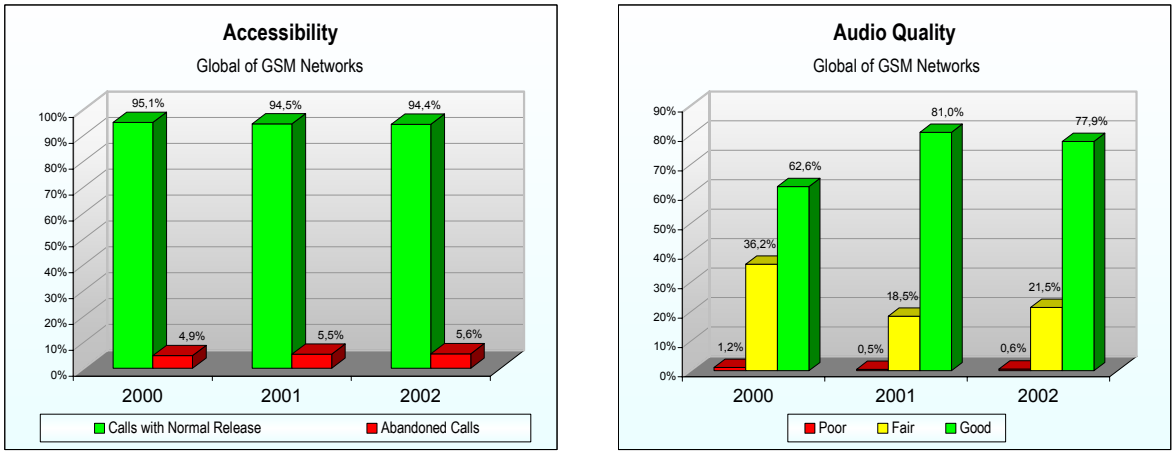


Figure 1 – Performance of GSM Mobile Networks

About 95% of the test calls were made successfully, with the conversation phase taking place properly and ending normally (by disconnection) at the end of a pre-determined time. It must also be stressed that 99.4% of the test calls had good or fair average audio quality levels. Only 0.6% had poor or bad levels.

We may thus conclude that the **Accessibility and Audio Quality** indicators remain at very good levels for such networks, even though the number of users has increased by more than 3 million in the last two years.

There are no major differences for **Audio quality** indicator between the results obtained on major road arteries and in urban areas, either on the mainland or in the Azores. In Madeira, it was verified that this indicator has higher values on major road arteries, i.e., the number of calls with “good” average quality is close to 90%.

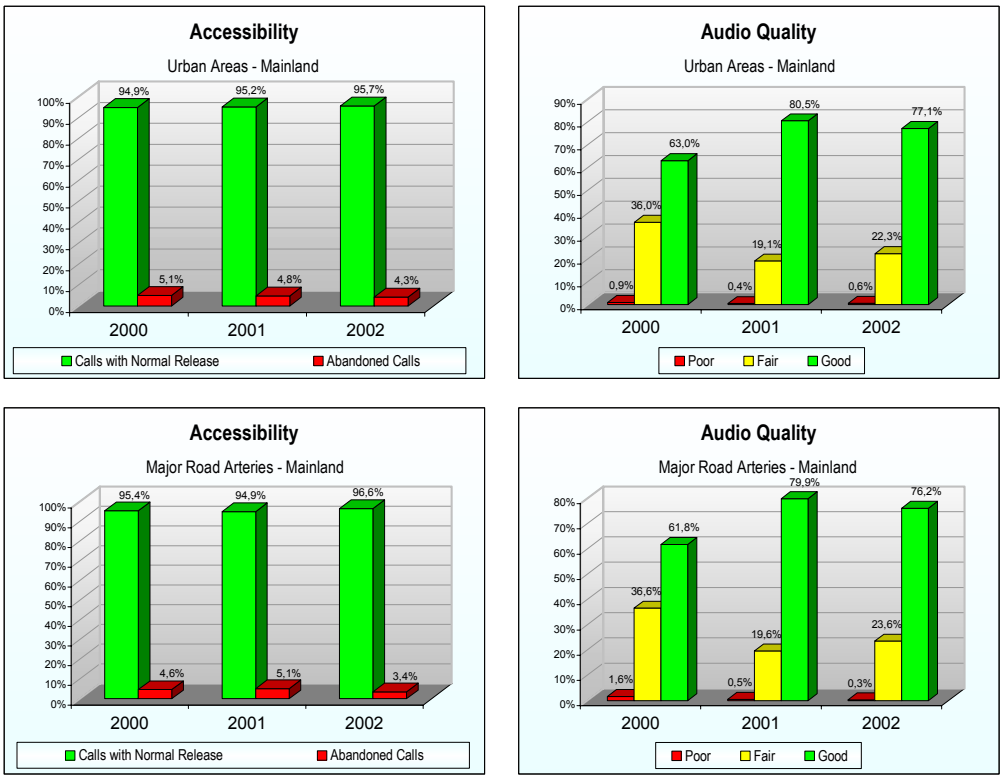


Figure 2 – Results on the mainland

Regarding the **Accessibility** results, although good from an overall standpoint, there are major differences between the mainland and the autonomous island regions. On the mainland the network figures for calls ending normally are above 95%, with no significant differences between major road arteries and urban areas.

The figures for **Accessibility** in the Azores and Madeira are very different for urban areas and major road arteries. In urban areas the verified levels for calls ending normally are very good – 97% in Madeira and 99% in the Azores. On major road arteries in Madeira, the level is very good; the progress made in the past year must be highlighted, as there was a substantial increase in the levels of calls successfully made and ended, from 81% to 93%.

In the Azores autonomous region accessibility was very poor, with 28% of calls abandoned. This situation is due to the existence of areas not covered by the networks of some operators – indicative of the need for additional investment efforts in order to overcome this deficiency.

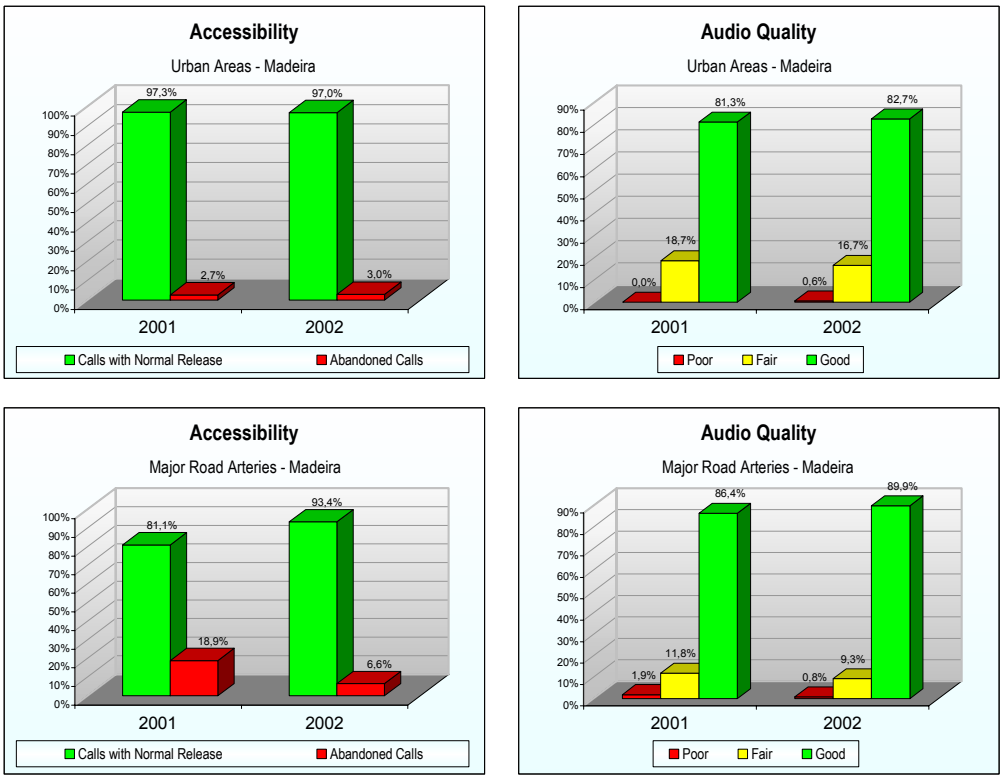


Figure 3 – Results in Madeira

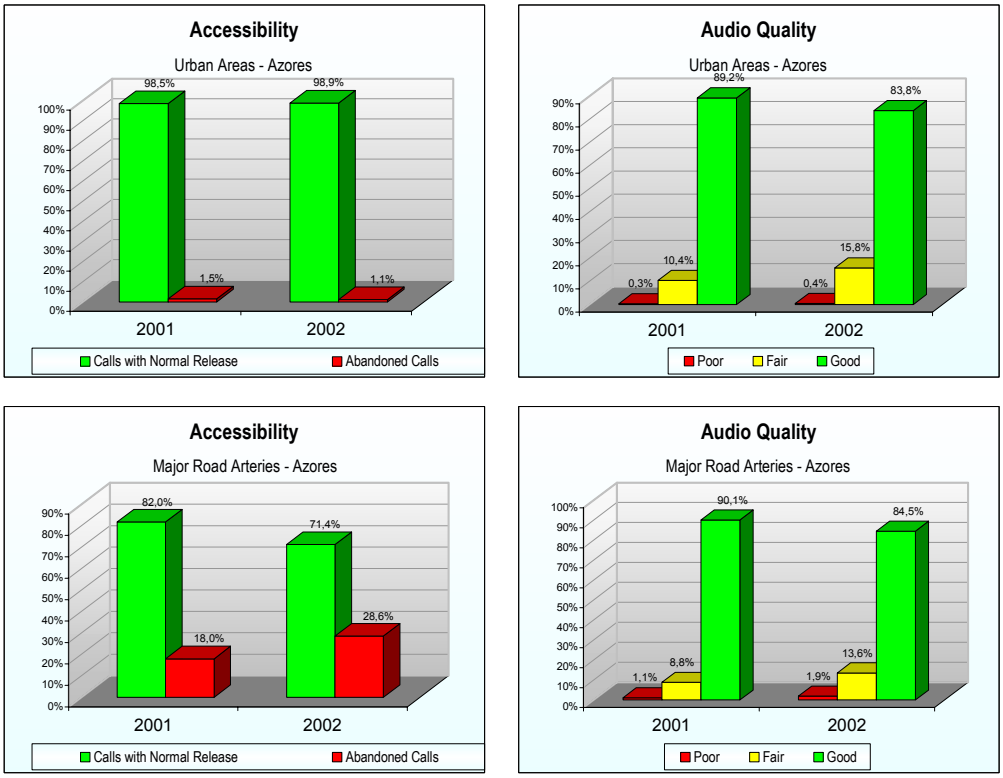


Figure 4 – Results in the Azores

Regarding the **coverage** indicator, the study enables us to detect two distinct situations:

- On the mainland and in Madeira this indicator has good levels in both the urban areas and major road arteries assessed;

- In the Azores there is good coverage in the assessed urban areas and insufficient coverage in less densely populated areas and along major road arteries. It was also noted that the operator OPTIMUS was not present on the islands of Flores, Corvo, Santa Maria and Graciosa.

1 SURVEY TECHNICAL DETAILS

1.1 QUALITY OF SERVICE INDICATORS

The survey analysed three mobile network quality indicators that are considered fundamental from the user viewpoint:

a) Coverage: Verification of signal levels.

The test equipment allowed us to measure the strength of the signal received by the mobile terminal. Measurements were made on the BCCH[1] control channel and were thus not affected by the frequency hopping and downlink power control algorithms.

All measurements were geo-referenced to enable them to be represented later on a chart. This facilitates visualisation of the coverage levels of each operator on the assessed routes.

Table 1 – Signal strength on the control channel

Signal Strength (dBm)	
> -100	Coverage
> -110 ∧ <= -100	Bad Coverage
<= -110	Absence of Coverage

b) Accessibility: Consists of verifying a mobile network's capacity to make calls.

The capacity to successfully make voice communication calls between two terminals – one in a mobile network and one in a fixed network.

In cases where it is not possible to establish communication or same was interrupted during the conversation phase, the test system identifies the cause of interruption or failure.

c) Audio quality: Consists of verifying conversation perception during a successful call and over a pre-set period of time.

[1] Broadcast control channel – Transports information to all mobile stations (MSs) served by a given BTS (Base Transceiver Station). Transmission occurs in downlink mode and carries various parameters, such as: CI (Cell Identity), LAC (Local Area Code), MCC (Mobile Country Code), MNC (Mobile Network Code), FH Algorithm.

To measure this indicator, a telephone conversation between two users is simulated.

The assessment method for audio quality as perceived by users is based on the "E-model" recommended by international agencies such as ETSI[2] (ETR 250) and the ITU[3] (ITU-T *Recommendation* G.107). The MOS (Mean Opinion Score) index is calculated based on this model.

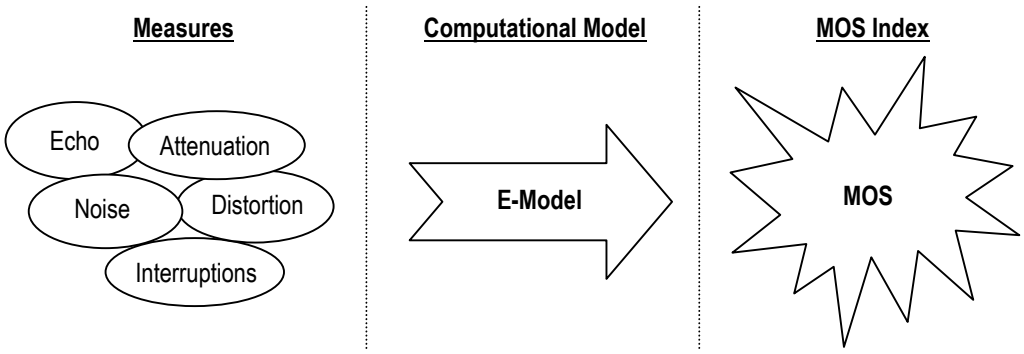


Figure 5 – Methodology used for assessing audio quality

The MOS scale quantifies the effort needed to perceive a conversation. When perception is non-existent the MOS value is 0, it is 5 when communication is perfect.

Table 2 – MOS Scale

MOS	Qualidade
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

2 *European Telecommunications Standards Institute*.
3 *International Telecommunications Union.*

1.2 METHODOLOGY

The methodology used in this study is based on three fundamental aspects.

a) **End-to-end measurements:** Measurements are effected between two terminal points, one in a **mobile network** and the other in a **fixed network.**

   The benefits of end-to-end tests are:

   - Same viewpoint of consumers;
   - Reflect interconnection problems as they are felt by consumers;
   - Enable sample selection so that results reflect the real situation felt by most consumers (route selection, call number and length, time of day when measurements are made, etc.);
   - Reveals and locates problems affecting networks;
   - Allows analysis and comparison of the various networks' performance.

b) **Impartiality:** Measurements were carried out simultaneously for the three operators (OPTIMUS, VODAFONE and TMN), thus ensuring equality of test conditions.

c) **Objectivity:** The system tests were entirely automatic. This enabled elimination of the subjectivity inherent to human intervention or decisions.

Tests consisted in the establishment and holding of voice calls under the following conditions:

1. Tests were performed between mobile and PSTN (Public Switched Telephone Network) terminals, designated in this document as "Mobile-Fixed".

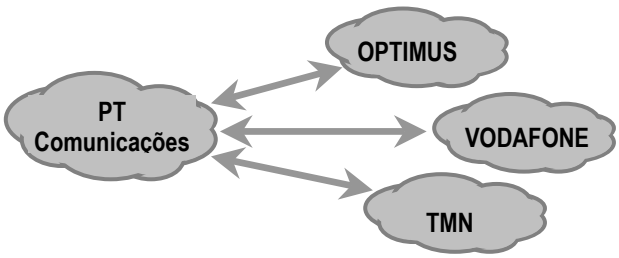


Figure 6 – Origin and Destination of test calls

2. During the measurement phase the mobile terminal equipment (1 per operator) moved along the route being assessed.

3. The two terminals, mobile and fixed, alternately initiated calls.

4. The time interval between consecutive calls was 150 seconds.

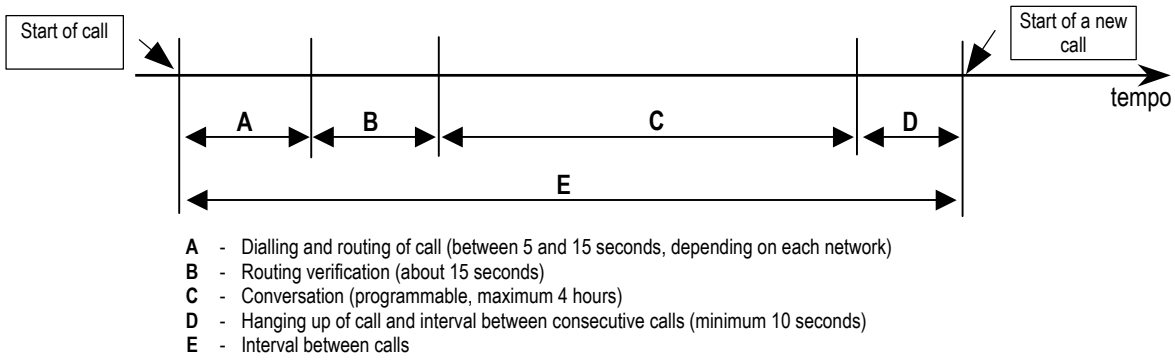


Figure 7 – Time structure of a voice call made with Tektronix M366plus, the test and measurement equipment

5. Once a call was successfully established, a conversation phase (simulation of a real conversation) was held for a maximum duration of 100 seconds[4] (less if the call was interrupted or the time taken to set it up was long).

6. During the conversation phase, audio quality measurements (MOS) were made at each of the call terminals.

1.3 Data Gathered During Field Work

a) **MOS (*Mean Opinion Score*)** – Audio quality index for an end-to-end call. Average values were obtained for each call and at each terminal involved.

b) **Routed Calls** – Telephone calls successfully established by the network and between the two terminals in question (the call reached the called terminal).

c) **Non-routed Calls** – Telephone calls not established by the network between the two terminals in question (the call did not reach the called terminal).

d) **Calls Abandoned During Conversation** – Telephone calls successfully set up by the network but abandoned during the conversation phase.

[4] The average length of voice calls, taking into account incoming and outgoing traffic, was 99 seconds in the 1st quarter of 2002.

e) **Calls with Normal Release** – Telephone calls successfully set up by the network and which ended as expected.

f) **Reasons Why Calls Were Abandoned** – Situations leading to call abandonment: no service, congestion, radio link failure, others.

g) **Level of RSSI (*R*eceived *S*ignal *S*trength *I*ndication**, in **dBm) Signal** – Indication of the signal strength received by the mobile terminal.

h) **Geographic Co-ordinates** – Correspond to the places where measurements were taken.

1.4 Tested Areas

Since the aim of this study is to gauge the quality of GSM mobile service from the consumers' standpoint, we planned to carry out measurements in all places where such kind of telecommunications are or could be made available. At most, the whole of the geographic area of Portugal could be considered, including the interior of buildings. However, the realisation of tests in all these places is impractical.

Instead of carrying out exhaustive measurements, a more realistic solution was chosen. This consisted of choosing a sample that would adequately set an indicator of the mobile networks' overall performance. Major road arteries and urban areas were thus chosen, as they reflect more intense service usage.

Yet exclusive adoption of this criterion would lead to an excessive concentration of measures in the more densely populated coastal areas. For this reason, a decision was also made with respect to the geographic distribution of places, so as to cover interior regions and the Madeira and Azores autonomous regions.

Tests were thus conducted in all of the country's district capitals, expanding the collection area to the Lisbon and Oporto metropolitan regions, and to the major road arteries.

Table 2 – Sample chosen and respective population

Territorial Unit	Resident Population (a)	Population Present (a)
Aveiro	73.136	76.415
Beja	35.659	37.001
Braga	163.981	165.048
Bragança	34.689	37.170
Castelo Branco	55.909	56.280
Coimbra	148.122	159.039
Évora	56.359	58.564
Faro	57.151	59.527
Guarda	43.759	44.593
Leiria	119.319	119.065
Portalegre	25.814	26.511
Santarém	63.418	63.106
Setúbal	113.480	112.227
Viana do Castelo	88.409	86.355
Vila Real	49.928	52.129
Viseu	93.259	93.041
Total	**1.222.392**	**1.246.071**
Greater Oporto		
Oporto	262.928	266.790
Gondomar	163.462	159.547
Maia	119.718	117.539
Matosinhos	166.275	162.671
Vila Nova de Gaia	287.597	280.466
Total	**999.980**	**987.013**
Greater Lisbon		
Lisbon	556.797	559.248
Amadora	174.788	169.507
Cascais	168.827	166.539
Loures	198.685	193.320
Oeiras	160.147	157.152
Sintra	363.556	351.976
Almada	159.550	156.746
Seixal	150.095	146.843
Odivelas	132971	130569
Total	**1.932.445**	**1.901.331**
Madeira Autonomous Region		
Madeira Island	238.162	248.851
Porto Santo Island	4.441	4.631
Total	**242.603**	**253.482**
Azores Autonomous Region		
São Miguel Island	131.510	131.530
Terceira Island	55.794	58.275
Pico Island	14.804	14.661
Faial Island	15.476	15.449
Santa Maria Island	5.628	5.587
Graciosa Island	4.770	4.674
São Jorge Island	9.681	9.419
Flores Island	3.992	3.899
Corvo Island	418	401
Total	242.073	243.895
Overall Total	**4.639.493**	**4.631.792**

(a) Preliminary results of the 2001 Census.
Source: INE – National Statistics Institute

Table 4 – Major Road Arteries

Major Road Artery	Approximate Distance	(Km)
Lisbon-Sintra-Cascais-Lisbon (A5 + IC19)	60	(a)
Lisbon-Oporto (A1)	320	(b)
Lisbon-Torres Novas-Castelo Branco (A1 + IP6 + IP2)	240	(b)
Lisbon-Vila Real de S ^{to}. António (A2 + IC1 + IP1)	335	(b)
Vila Real de S ^{to}. António-Lagos (EN 125)	135	(b)
Lisbon-Évora-Elvas (A2 + A6)	210	(b)
Oporto-Braga-Valença-Viana do Castelo-Oporto (A3 + IC1)	240	(b)
Oporto-Bragança (A4 + IP4)	250	(b)
Aveiro-Vilar Formoso (IP5)	200	(b)
Vila Real-Figueira da Foz (IP3)	245	(b)
Total	**2235**	

(a) – Measurements taken during 12 trips.
(b) – Measurements taken during 4 trips.

In Madeira and the Azores measurements were carried out in the cities of Funchal, Ponta Delgada and Angra do Heroísmo, as well as on major road arteries on all the islands.

The population present in the urban areas comprised by the chosen sample represent 45% of the total Portuguese population, according to preliminary results of the last census (2001).

1.5 Measurement Conditions

Given the population density of the Greater Lisbon and Greater Oporto regions, and to make the survey as representative as possible, tests in those areas lasted 215 and 105 hours respectively. Data collection was undertaken during normal working hours on weekdays, with two daily sessions: from 8 a.m. to 11:30 a.m. and from 4:30 p.m. to 8 p.m.

In the remaining urban areas, measurement time was set according to the number of inhabitants in the respective counties:

- Up to 50,000 inhabitants: 7 hours;
- From 50,000 to 100,000 inhabitants: 10 hours;
- More than 100,000 inhabitants: 14 hours.

The measurement sessions in these urban areas were carried out during normal working hours on weekdays.

Table 5 – Measurement time in urban areas

Territorial Unit	Present Population (a)	Measurement Hours
Aveiro	76.415	10
Beja	37.001	7
Braga	165.048	14
Bragança	37.170	7
Castelo Branco	56.280	10
Coimbra	159.039	14
Évora	58.564	10
Faro	59.527	10
Guarda	44.593	7
Leiria	119.065	14
Portalegre	26.511	7
Santarém	63.106	10
Setúbal	112.227	14
Viana do Castelo	86.355	10
Vila Real	52.129	10
Viseu	93.041	10
Angra do Heroísmo	35.720	7
Ponta Delgada	66.450	10
Funchal	112.362	14
Greater Lisbon	1.932.445	210
Greater Oporto	999.980	105

(a) Preliminary results of the 2001 census.
Source: INE – National Statistics Institute

Regarding major road arteries, 4 trips were made along each of them to make the sample as representative as possible.

1.6 Testing and Measurement Equipment

The testing and measurement equipment chosen by ANACOM to carry out the tests was the *TEKTRONIX M366plus*, a service quality analyser for GSM networks.

Main features:

- Allows measurements in GSM 900, DCS 1800 or Dual-Band;
- Allows simultaneous measurement of 3 operators/networks;
- Allows geo-referencing of all measurements;
- Measurement data is post-processed with specific manufacturer-developed tools for the elaboration of detailed reports.
- The equipment can be configured, namely with respect to call length, the number to dial and the time between calls.

The equipment is composed of two kinds of modules:

a) ***Base Station*:** the fixed node of the M366plus system. Have interfaces for three analog PSTN lines and also DSP measurement boards[5]. It includes a PC that interacts with the module to allow its configuration and maintenance.

   This module performs all the demanded operations: it makes and receives voice calls, carries out quality measurements and stores data.

b) ***Mobile Station*:** This module includes three mobile terminal interface boards with incorporated DSP, which are linked to three SAGEM OT75-M *Dual Band* mobile telephones with EFR[6]. It also includes a component (board) for processing GPS signals. The antennas associated to GPS and to the three mobile telephones are placed on the outside of the vehicle (when the module is mounted in a vehicle). It also includes a portable PC, for configuration and maintenance.

   The operations performed by this module are identical to those of the Base Station module, i.e., to make and receive voice calls, measure audio quality and store data.

1.7 Post Processing Tools

A software tool known as "Report" is associated to the M366plus equipment. It stores, organises and generates information statistics collected by the measurement units.

The files generated by the measurement units are organised in a database structure; "Report" may use "MS ACCESS" or "ORACLE" to this end.

Various reports may be obtained from a single or multiple sessions with this tool, with different degrees of detail.

The M366 equipment includes a GPS receiver that enables geo-referencing of all measurements. This information is handled by the "GeoReport" tool, which, parallel to a third tool – "MAPINFO" – enables the statistical information generated by "REPORT" to be viewed in digital geographical charts.

[5] Digital Signal Processor
[6] *Enhanced Full Rate* – Voice Coder/Decoder that permits audio quality comparable to fixed telephony.

2 RESULTS

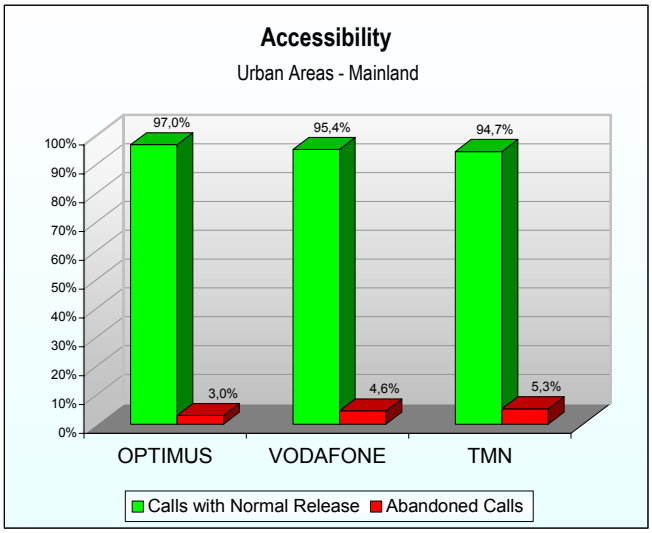
2.1 DEFINITIONS

MOS	***M**ean **O**pinion **S**core* – Level of audio quality for an end-to-end communication. Value is 0 when there is no communication and 5 when communication is perfect. The 0 and 5 values are theoretical and thus never appear in measurements. The presented data refer to average values per call.
Routed Calls:	Routed Calls – Telephone calls successfully established by the network and between the two terminals in question (the call reached the called terminal).
Abandoned during conversation:	Calls successfully set up by the network but abandoned during the conversation phase.
Normal release:	Calls successfully set up by the network and which end normally.
Calls Not Routed:	Calls not established by the network between the two terminals in question (the call did not reach the called terminal).
Abandoned calls:	Calls interrupted both in the phase of setting up the connection or during conversation.
Call ending cause:	Reasons for the interruption of communications.
No service:	Service unavailable (no network).
Congestion:	Network congestion.
Radio link failure:	Failure of the radio link between the mobile terminal and the base station. This can occur when passing through a network shadow area.
Other:	Other reasons for call interruption.
RSSI (dBm):	***R**eceived **S**ignal **S**trength **I**ndication* – Indication of signal strength received by the mobile terminal. Measured on the control channel (BCCH) and therefore not affected by frequency hopping and downlink power control algorithms.
BCCH	***B**roadcast **C**ontrol **Ch**annel* – Conveys information to all mobile terminals (MSs) served by a given BTS (Base Transceiver Station). Transmitted in downlink mode and transports numerous parameters, among them CI (*Cell Identity*), LAC (*Local Area Code*), MCC (*Mobile Country Code*), MNC (*Mobile Network Code*), FH (*Frequency Hopping*) algorithm.
PSTN	**P**ublic **S**witched **T**elephone **N**etwork

2.2 URBAN AREAS – MAINLAND

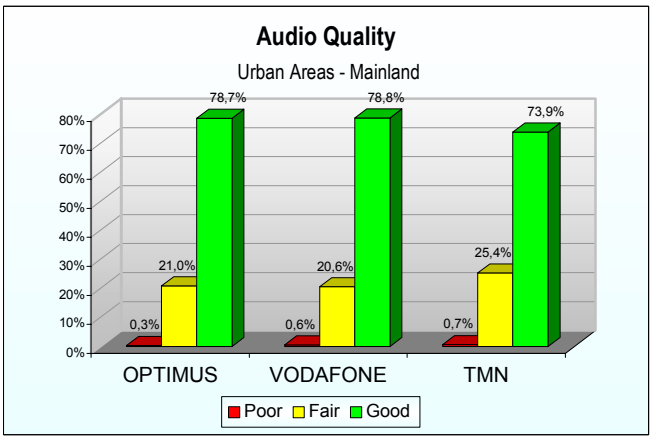
2.2.1 ACCESSIBILITY

			OPTIMUS	VODAFONE	TMN
Performed Calls		Total	11644 100%	11639 100%	11645 100%
Routed Calls		Total	11433 98,2%	11301 97,1%	11275 96,8%
		Abandoned During Conversation	136 1,2%	198 1,7%	251 2,2%
		Normal Release	11297 97,0%	11103 95,4%	11024 94,7%
Calls Not Routed			211 1,8%	338 2,9%	370 3,2%
Abandoned Calls		Total	347 3,0%	536 4,6%	621 5,3%
	Call Ending Cause	No Service	21 0,2%	25 0,2%	24 0,2%
		Congestion	162 1,4%	189 1,6%	215 1,8%
		Radio Link Failure	73 0,6%	142 1,2%	152 1,3%
		Others	91 0,8%	180 1,5%	230 2,0%



2.2.2 AUDIO QUALITY

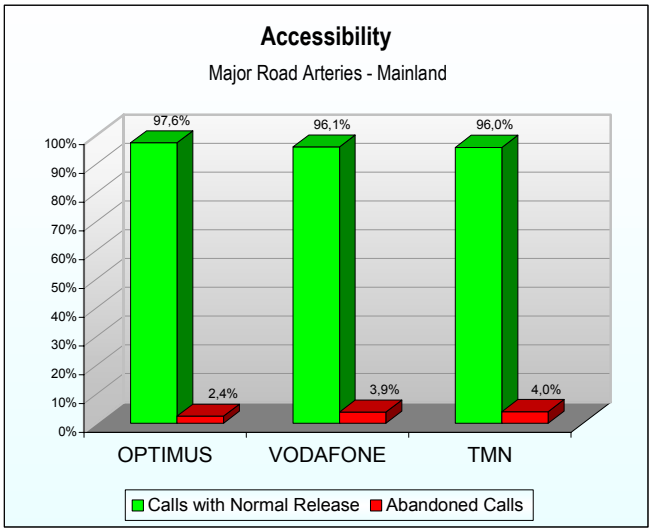
		OPTIMUS	VODAFONE	TMN
Calls With Measurements	Total	22787 100%	22527 100%	22431 100%
Audio Quality (MOS)	Poor	79 0,3%	139 0,6%	156 0,7%
	Fair	4778 21,0%	4645 20,6%	5693 25,4%
	Good	17930 78,7%	17743 78,8%	16582 73,9%



2.2.3 Major Road Arteries - Mainland

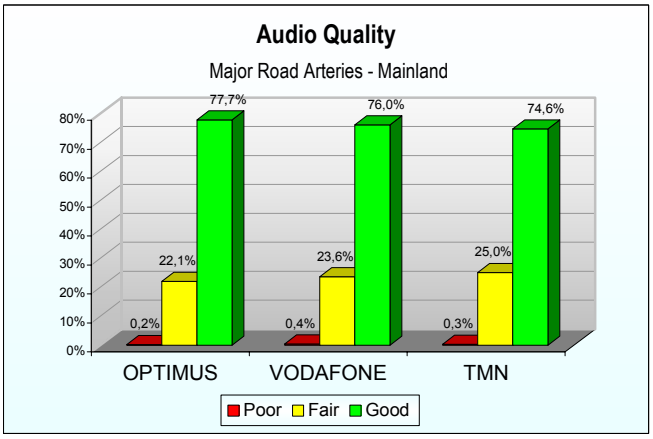
2.2.4 Accessibility

Performed Calls		Operator	OPTIMUS	VODAFONE	TMN
		Total	2834 100%	2833 100%	2836 100%
Routed Calls		Total	2796 98,7%	2761 97,5%	2771 97,7%
		Abandoned During Conversation	31 1,1%	38 1,3%	49 1,7%
		Normal Release	2765 97,6%	2723 96,1%	2722 96,0%
Calls Not Routed			38 1,3%	72 2,5%	65 2,3%
Abandoned Calls		Total	69 2,4%	110 3,9%	114 4,0%
	Call Ending Cause	No Service	0 0,0%	4 0,1%	4 0,1%
		Congestion	31 1,1%	38 1,3%	37 1,3%
		Radio Link Failure	20 0,7%	32 1,1%	38 1,3%
		Others	18 0,6%	36 1,3%	35 1,2%



2.2.5 Audio Quality

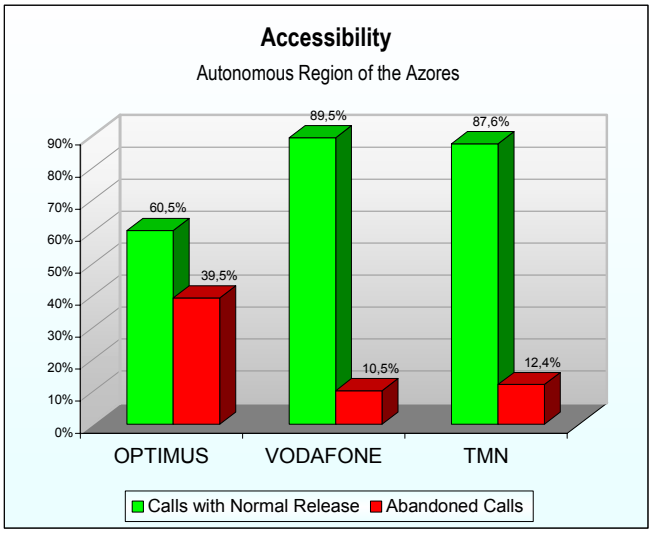
Calls With Measurements	Operator	OPTIMUS	VODAFONE	TMN
	Total	5572 100%	5507 100%	5509 100%
Audio Quality (MOS)	Poor	11 0,2%	20 0,4%	17 0,3%
	Fair	1229 22,1%	1299 23,6%	1380 25,0%
	Good	4332 77,7%	4188 76,0%	4112 74,6%



2.3 AZORES

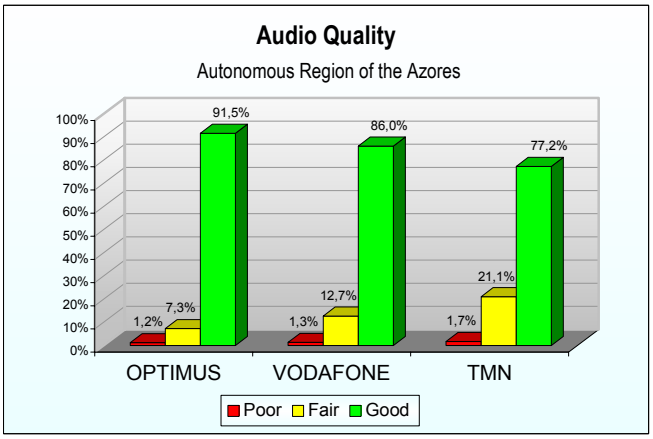
2.3.1 ACCESSIBILITY

Performed Calls	Operator	OPTIMUS	VODAFONE	TMN
	Total	1452 100%	1458 100%	1448 100%
Routed Calls	Total	910 62,7%	1346 92,3%	1290 89,1%
	Abandoned During Conversation	31 2,1%	41 2,8%	21 1,5%
	Normal Release	879 60,5%	1305 89,5%	1269 87,6%
Calls Not Routed		542 37,3%	112 7,7%	158 10,9%
Abandoned Calls	Total	573 39,5%	153 10,5%	179 12,4%
	Call Ending Cause: No Service	363 25,0%	21 1,4%	29 2,0%
	Call Ending Cause: Congestion	172 11,8%	30 2,1%	4 0,3%
	Call Ending Cause: Radio Link Failure	12 0,8%	18 1,2%	21 1,5%
	Call Ending Cause: Others	26 1,8%	84 5,8%	125 8,6%



2.3.2 AUDIO QUALITY

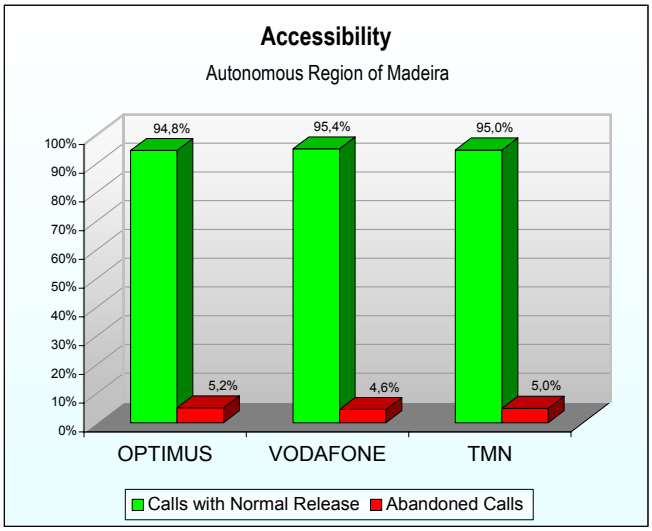
Calls With Measurements	Operator	OPTIMUS	VODAFONE	TMN
	Total	1804 100%	2678 100%	2566 100%
Audio Quality (MOS)	Poor	22 1,2%	34 1,3%	43 1,7%
	Fair	132 7,3%	340 12,7%	541 21,1%
	Good	1650 91,5%	2304 86,0%	1982 77,2%



2.4 MADEIRA

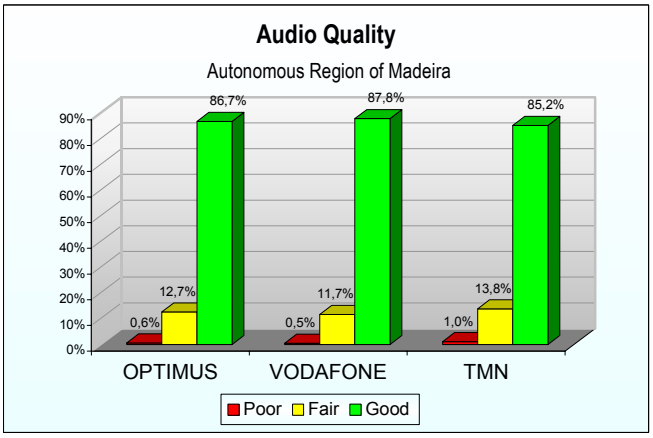
2.4.1 ACCESSIBILITY

			OPTIMUS	VODAFONE	TMN
Performed Calls		Total	734 100%	738 100%	738 100%
Routed Calls	Total		708 96,5%	719 97,4%	725 98,2%
	Abandoned During Conversation		12 1,6%	15 2,0%	24 3,3%
	Normal Release		696 94,8%	704 95,4%	701 95,0%
Calls Not Routed			26 3,5%	19 2,6%	13 1,8%
Abandoned Calls	Total		38 5,2%	34 4,6%	37 5,0%
	Call Ending Cause	No Service	9 1,2%	2 0,3%	0 0,0%
		Congestion	22 3,0%	12 1,6%	13 1,8%
		Radio Link Failure	3 0,4%	5 0,7%	9 1,2%
		Others	4 0,5%	15 2,0%	15 2,0%



2.4.2 AUDIO QUALITY

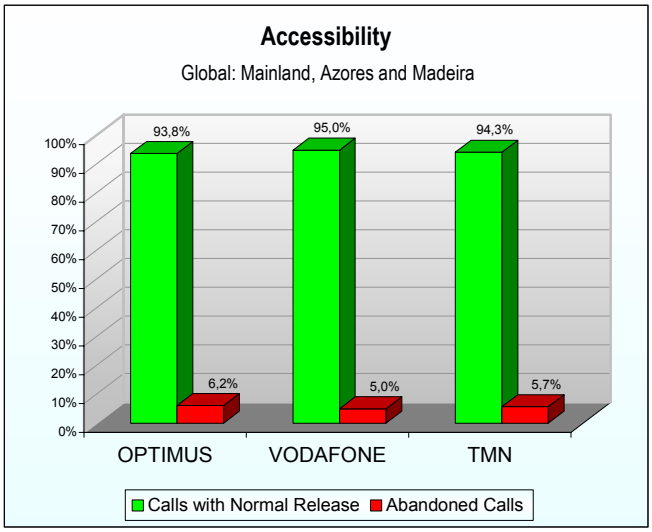
		OPTIMUS	VODAFONE	TMN
Calls With Measurements	Total	1407 100%	1419 100%	1429 100%
Audio Quality (MOS)	Poor	9 0,6%	7 0,5%	15 1,0%
	Fair	178 12,7%	166 11,7%	197 13,8%
	Good	1220 86,7%	1246 87,8%	1217 85,2%



2.5 GLOBAL: MAINLAND, AZORES AND MADEIRA

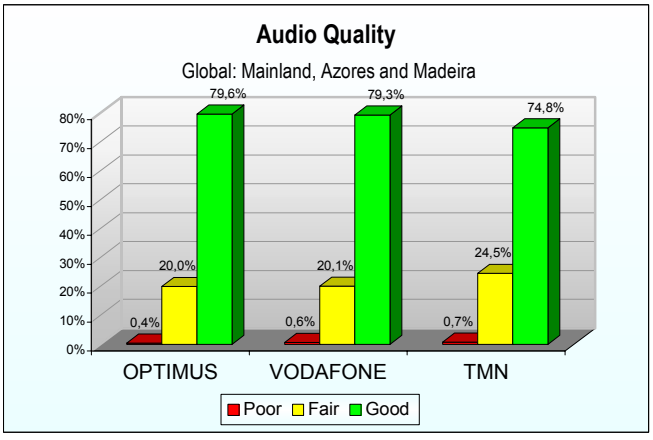
2.5.1 ACCESSIBILITY

			OPTIMUS	VODAFONE	TMN
Performed Calls		Total	16664 100%	16668 100%	16667 100%
Routed Calls		Total	15847 95,1%	16127 96,8%	16061 96,4%
		Abandoned During Conversation	210 1,3%	292 1,8%	345 2,1%
		Normal Release	15637 93,8%	15835 95,0%	15716 94,3%
Calls Not Routed			817 4,9%	541 3,2%	606 3,6%
Abandoned Calls		Total	1027 6,2%	833 5,0%	951 5,7%
	Call Ending Cause	No Service	393 2,4%	52 0,3%	57 0,3%
		Congestion	387 2,3%	269 1,6%	269 1,6%
		Radio Link Failure	108 0,6%	197 1,2%	220 1,3%
		Others	139 0,8%	315 1,9%	405 2,4%



2.5.2 AUDIO QUALITY

		OPTIMUS	VODAFONE	TMN
Calls With Measurements	Total	31570 100%	32131 100%	31935 100%
Audio Quality (MOS)	Poor	121 0,4%	200 0,6%	231 0,7%
	Fair	6317 20,0%	6450 20,1%	7811 24,5%
	Good	25132 79,6%	25481 79,3%	23893 74,8%



2.5.3 COVERAGE

(Following pages)