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GSM Mobile Networks – Quality of Service Survey

Lisbon, Oporto and A1

December 2002

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1 Introduction

A survey of GSM mobile network performance in the cities of Lisbon and Oporto, as well as along the major road artery linking the two urban areas (A1 motorway), was undertaken in December 2002.

Once again, the quality of GSM Mobile Service provided to the public in general by the operators OPTIMUS, VODAFONE and TMN was verified. Three fundamental mobile network indicators were subject to quality analysis from the point of view of users/consumers:

- a. **COVERAGE;**
- b. **ACCESSIBILITY;**
- c. **AUDIO QUALITY.**

The methodology was based on automatic end-to-end testing. This enabled on-the-ground verification of Quality of Service, providing a picture of network performance from the user standpoint that was as realistic as possible. In accordance with the guidelines, the targeted operators were not informed that the study was being carried out. The overall study methodology was the same as used in the first half of 2002.

The following sections present the methodology followed, the results and the conclusions.

2 Technical Aspects of the Study

2.1 Quality of Service Indicators

Three mobile network indicators were analysed, considered to be fundamental for quality from the user standpoint:

- a) **COVERAGE:** Verification of signal levels.

Table 1 – Signal strength on the control channel

Signal Strength (dBm)	
> -100	Coverage
> -110 \wedge \leq -100	Bad Coverage
\leq -110	Absence of Coverage

- b) **ACCESSIBILITY:** Capacity to establish voice communications between two terminals: one mobile network terminal and one fixed network terminal.

In cases where it was not possible to establish communication or where same was abandoned during conversation, the cause of the failure or abandonment was identified.

- c) **AUDIO QUALITY:** Verification of conversation perception by means of a successful connection and for a pre-determined time period.

To measure this indicator the system simulated a telephone conversation between two users.

The evaluation method for audio quality, as perceived by users, is based on the “E-Model” recommended by international bodies such as the ETSI¹ (ETR 250) and the ITU² (ITU-T *Recommendation G.107*). The MOS (*Mean Opinion Score*) index is calculated based on this model.

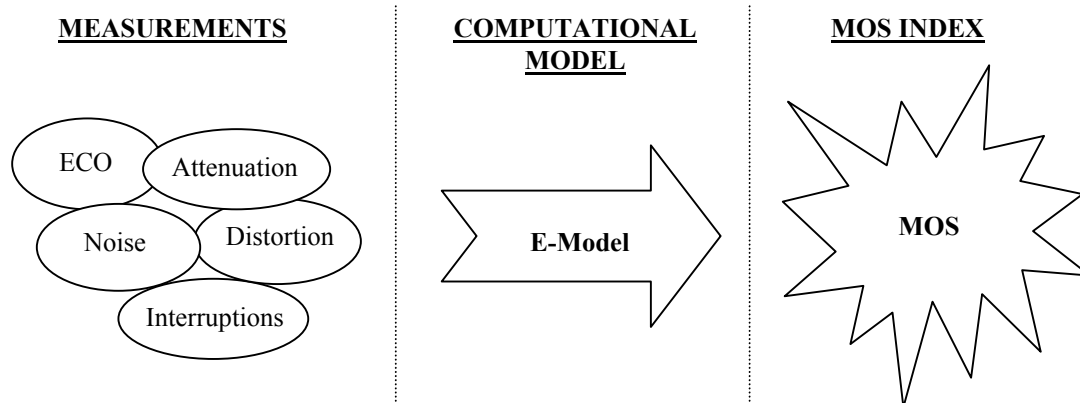


Figure 1 – Methodology used to gauge audio quality.

The MOS scale quantifies the effort needed to perceive a conversation. It has a value of 0 when there is no communication and 5 when communication is perfect. The values 0 and 5 are theoretical and thus never appear in the measurements.

Table 2 – MOS scale

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

2.2 Methodology

The methodology was based on three fundamental aspects:

- End-to-end measurements:** Measurements were carried out between two terminal points, one in a mobile network and the other in a fixed network.
- Impartiality:** Measurements were carried out simultaneously for the three operators (OPTIMUS, VODAFONE and TMN), thus ensuring equality of test conditions.

¹ European Telecommunications Standards Institute.

² International Telecommunications Union.

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

The tests comprised the establishment and holding of voice calls under the following conditions:

1. Tests were performed between mobile and PSTN (Public Switched Telephone Network) terminals;

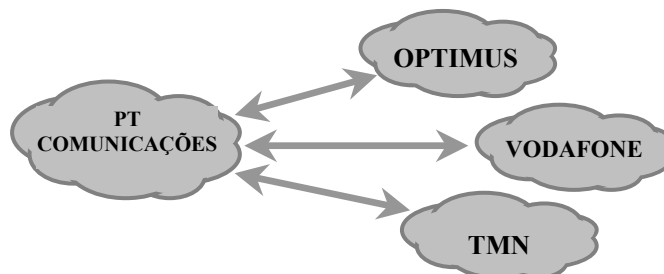


Figure 2 – Origin and destination of test calls.

2. During the measurement phase the mobile terminal equipment (1 per operator) moved along the routes under study;
3. Calls were alternately initiated by the two terminals in question;
4. The time interval between consecutive calls, for each operator, was 150 seconds;
5. The establishment of a successful call was followed by a conversation phase (simulation of a real conversation) lasting a maximum of 100 seconds (less if the call was interrupted or if it took a long time to make the connection);

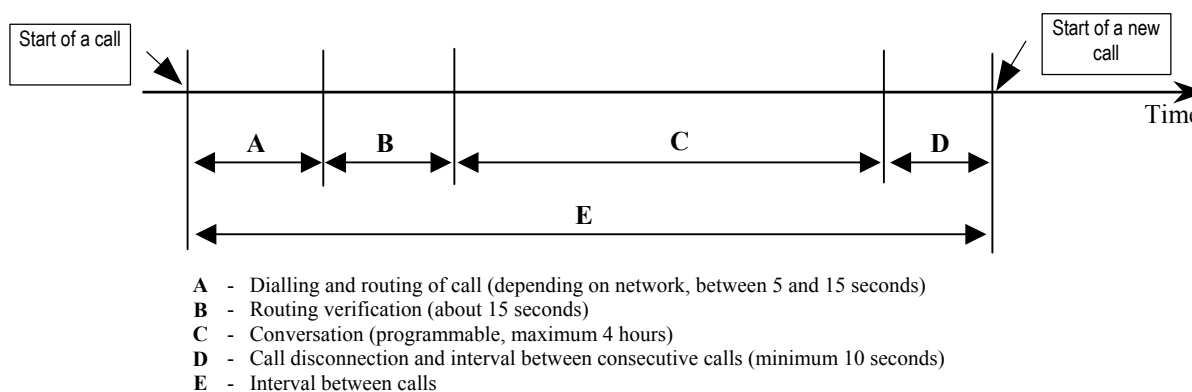


Figure 3 – Time structure of a voice call made with Tektronix M366plus, test and measurement equipment.

6. Independently of which point started the call, audio quality (MOS) was measured for both directions, thus simulating a conversation.

2.3 Data Collected 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.
- e. **Calls with normal termination** – Telephone calls successfully set up by the network and which ended normally.
- f. **Reasons Why Calls were Abandoned** – Situations leading to call abandonment: no service, congestion, radio link failure, etc.
- g. **RSSI (*Received Signal Strength Indication*, in **dBm**) signal level** – Indication of signal strength received by the mobile terminal.
- h. **Geographic co-ordinates** – Corresponding to measurement locations.

2.4 Tested Areas

Tests were carried out in the following places:

- **Cities:** Lisbon and Oporto
- **Road artery:** Lisbon-Oporto motorway (A1)

2.5 Data Collection Conditions

Data was collected in the cities of Lisbon and Oporto during normal working hours on weekdays. Two measurement sessions were effected for each day of field work: from 8 a.m. to 11:30 a.m. and from 4:30 p.m. to 8 p.m.

Four measurement sessions were effected on the A1 road artery, with each session corresponding to a trip between the end cities.

2.6 Testing and Measurement Equipment

TEKTRONIX M366plus equipment, which analyses service quality for GSM networks, was used to conduct the tests.

2.7 Post-Processing Tools

A software tool called “Report” is associated to the M366plus equipment and was used to store, organise and generate information and statistics collected by the measurement units.

The files generated by the measurement units were organised in a database structure using MS ACCESS.

These tools enabled compilation of various reports from a single or multiple session, with varying degrees of detail.

Another tool – “GeoReport” – together with a third one – “MAPINFO” – enables visualisation in digital geographic maps of statistical information generated by “Report”.

3 Results

3.1 Definitions

MOS	Mean Opinion Score - 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:	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 either when setting up the connection or during conversation.
Call ending cause:	Reasons for the interruption of communication.
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):	Received Signal Strength Indication – 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

Broadcast Control Channel – 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) and FH (Frequency Hopping) algorithm.

PSTN

Public Switched Telephone Network.

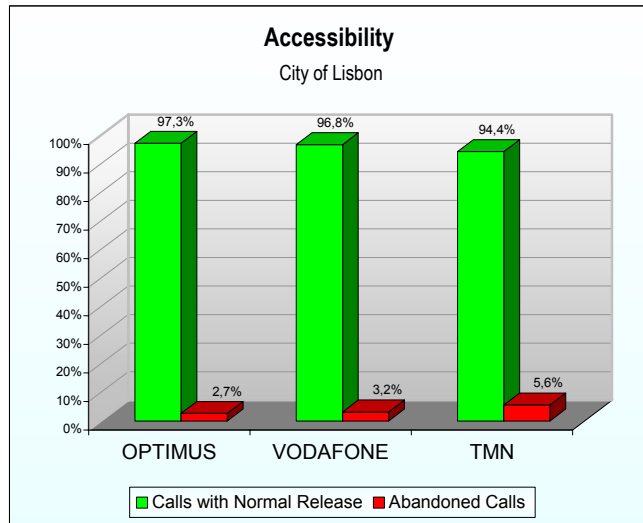
3.2 City of Lisbon

Measurement sessions on:

- **10 December** from 07:58 to 11:37 and from 16:28 to 20:02
- **11 December** from 08:00 to 11:35 and from 16:30 to 20:02
- **12 December** from 08:11 to 11:47 and from 16:40 to 20:15
- **13 December** from 08:10 to 11:47 and from 16:30 to 20:02
- **16 December** from 08:08 to 11:52 and from 16:30 to 20:02

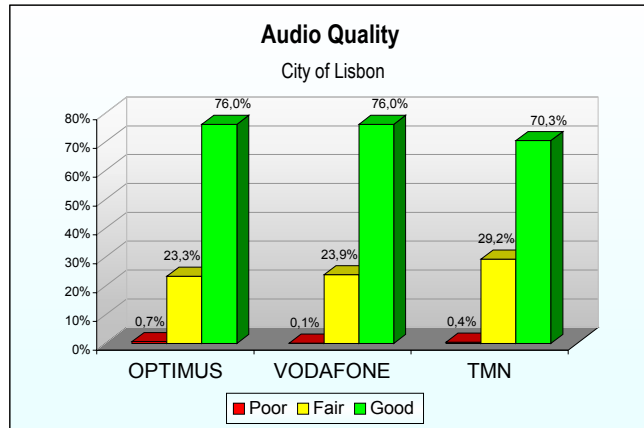
3.2.1 ACCESSIBILITY

Performed Calls		Operator	OPTIMUS	VODAFONE	TMN
		Total	854 100%	853 100%	853 100%
Routed Calls	Total	841 98.5%	834 97.8%	826 96.8%	
	Abandoned During Conversation	10 1.2%	8 0.9%	21 2.5%	
	Normal Release	831 97.3%	826 96.8%	805 94.4%	
Calls Not Routed		13 1.5%	19 2.2%	27 3.2%	
Abandoned Calls	Total	23 2.7%	27 3.2%	48 5.6%	
	Call Ending Cause	No Service	3 0.4%	2 0.2%	1 0.1%
		Congestion	10 1.2%	8 0.9%	13 1.5%
		Radio Link Failure	5 0.6%	9 1.1%	17 2.0%
		Others	5 0.6%	8 0.9%	17 2.0%



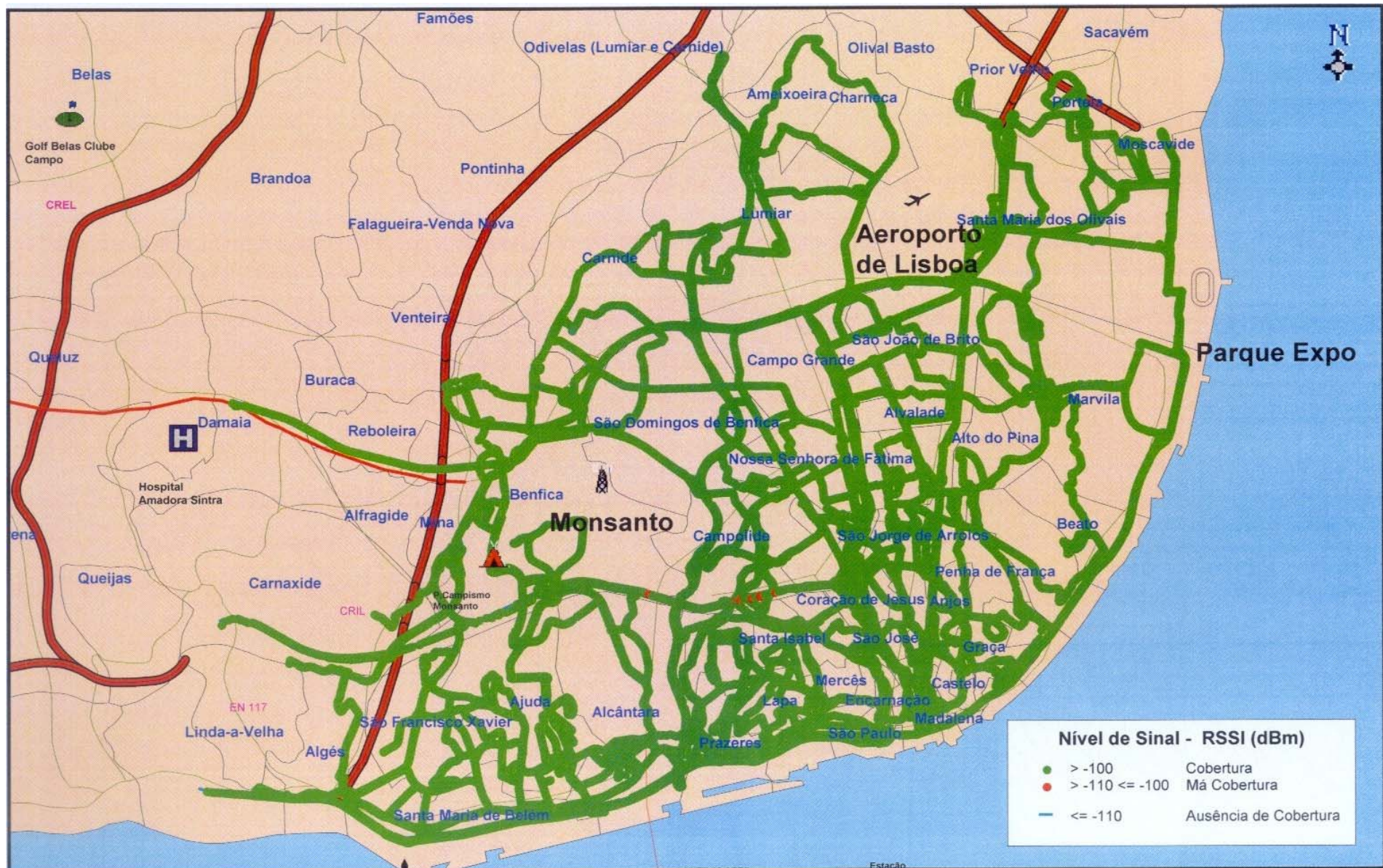
3.2.2 AUDIO QUALITY

Calls With Measurements	Operator	OPTIMUS	VODAFONE	TMN
	Total		1678 100%	1667 100%
Audio Quality (MOS)	Poor	12 0,7%	2 0,1%	7 0,4%
	Fair	391 23,3%	398 23,9%	482 29,2%
	Good	1275 76,0%	1267 76,0%	1159 70,3%

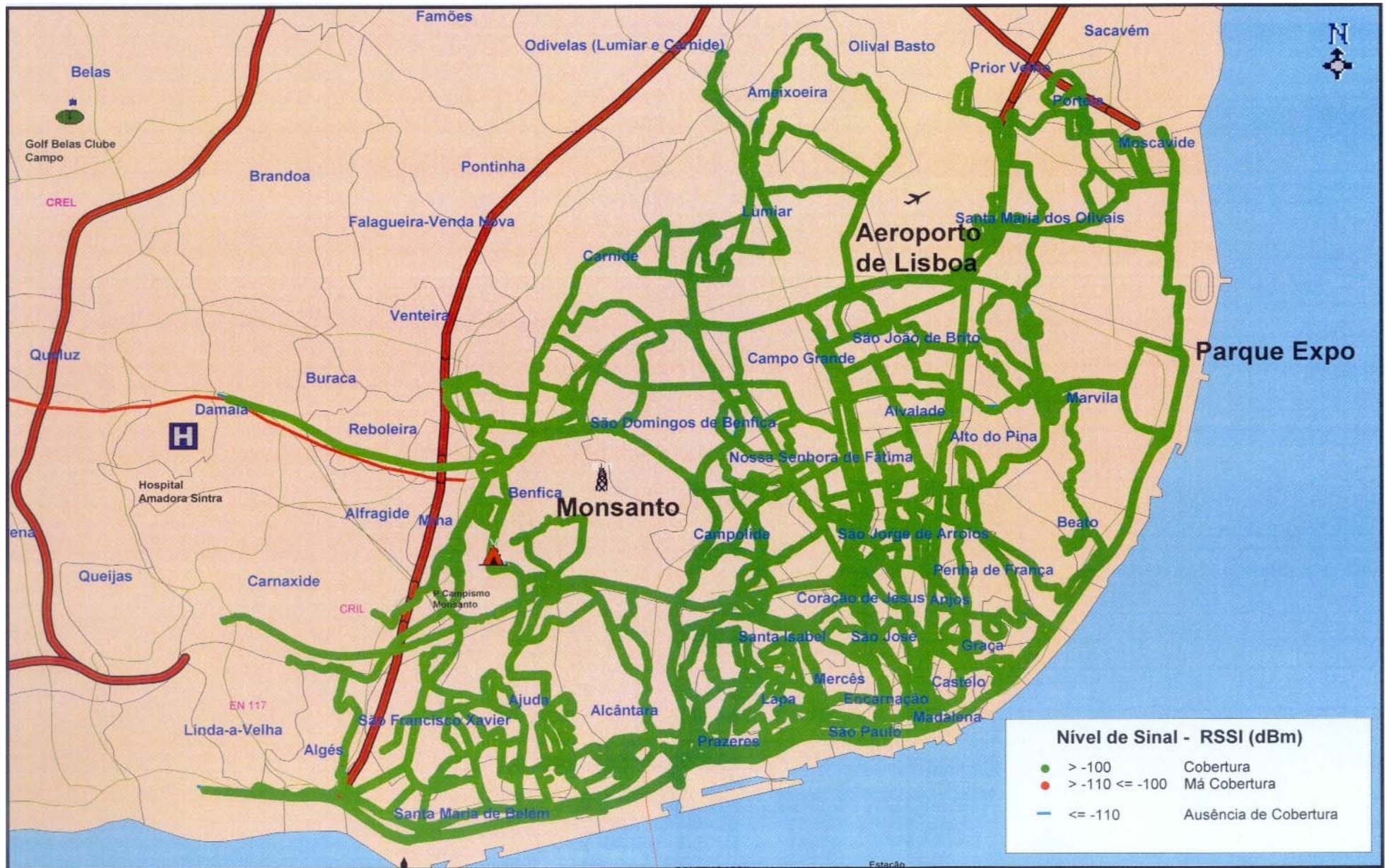


3.2.3 COVERAGE

CITY OF LISBON
OPTIMUS - PSTN

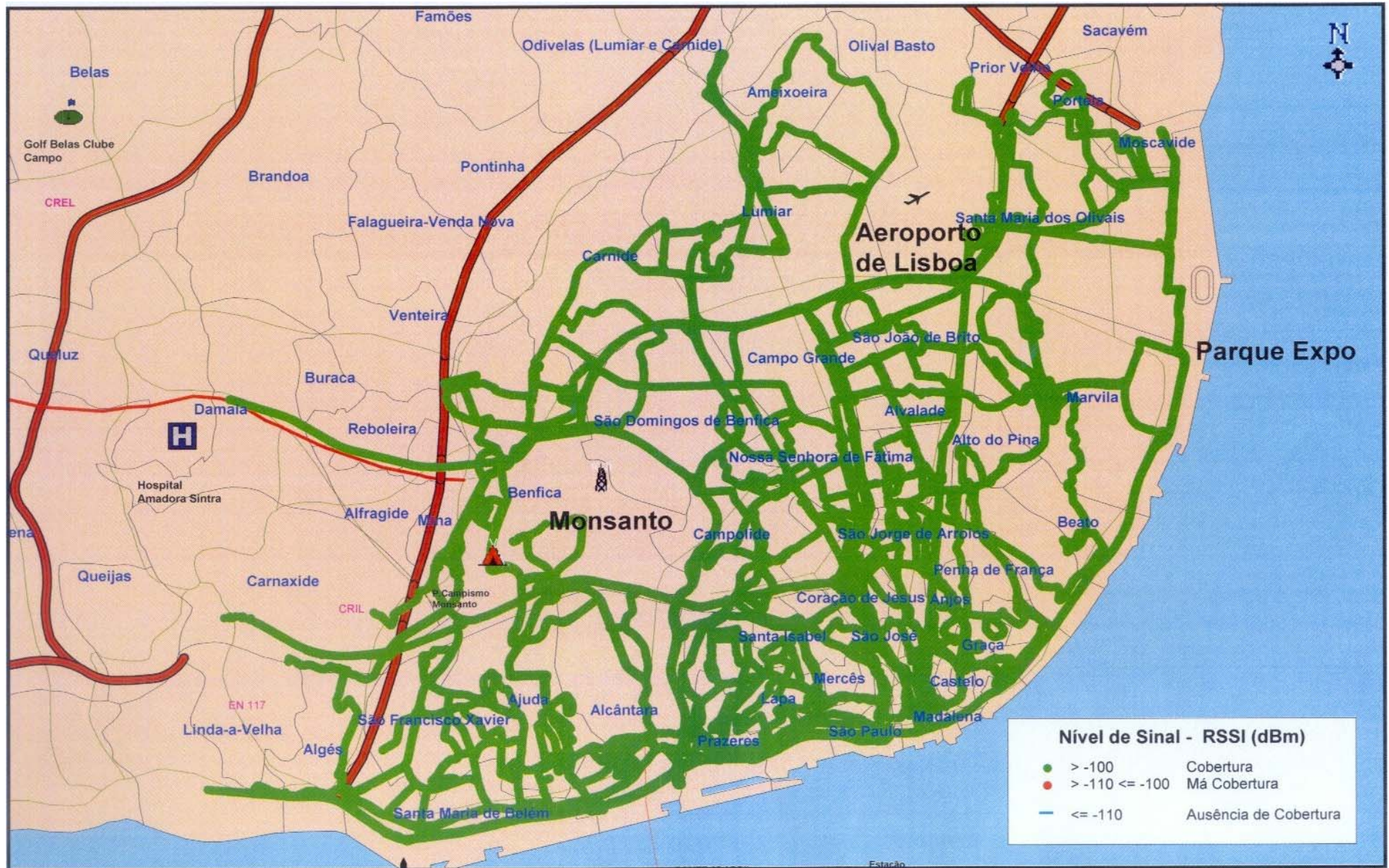


CITY OF LISBON
VODAFONE - PSTN



CITY OF LISBON

TMN - PSTN



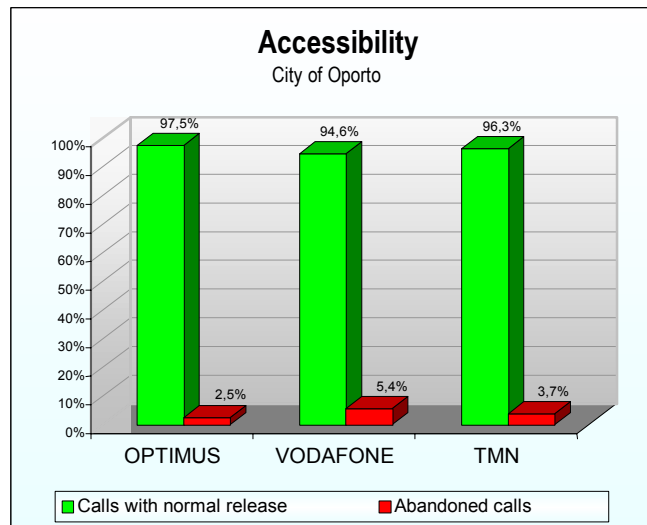
3.3 City of Oporto

Measurement sessions on:

- **18 December** from 07:53 to 11:35 and from 16:32 to 20:02
- **19 December** from 07:56 to 11:40
- **20 December** from 07:55 to 11:35 and from 16:32 to 20:02
- **26 December** from 16:28 to 20:05

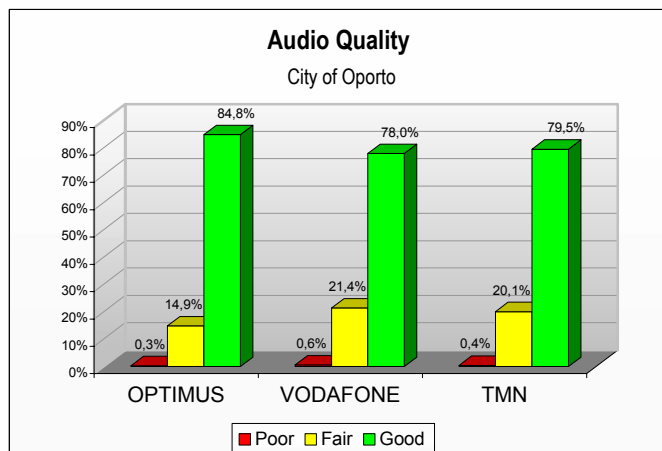
3.3.1 ACCESSIBILITY

Calls made		Operator	OPTIMUS	VODAFONE	TMN
		Total	516 100%	515 100%	515 100%
Routed calls	Total		509 98,6%	492 95,5%	503 97,7%
	Abandoned conversation		6 1,2%	5 1,0%	7 1,4%
	Normal release		503 97,5%	487 94,6%	496 96,3%
Non-routed calls			7 1,4%	23 4,5%	12 2,3%
Abandoned calls	Total		13 2,5%	28 5,4%	19 3,7%
	Causes	No service	0 0,0%	1 0,2%	1 0,2%
		Congestion	6 1,2%	8 1,6%	10 1,9%
		Radio link failure	6 1,2%	8 1,6%	4 0,8%
		Other	1 0,2%	11 2,1%	4 0,8%



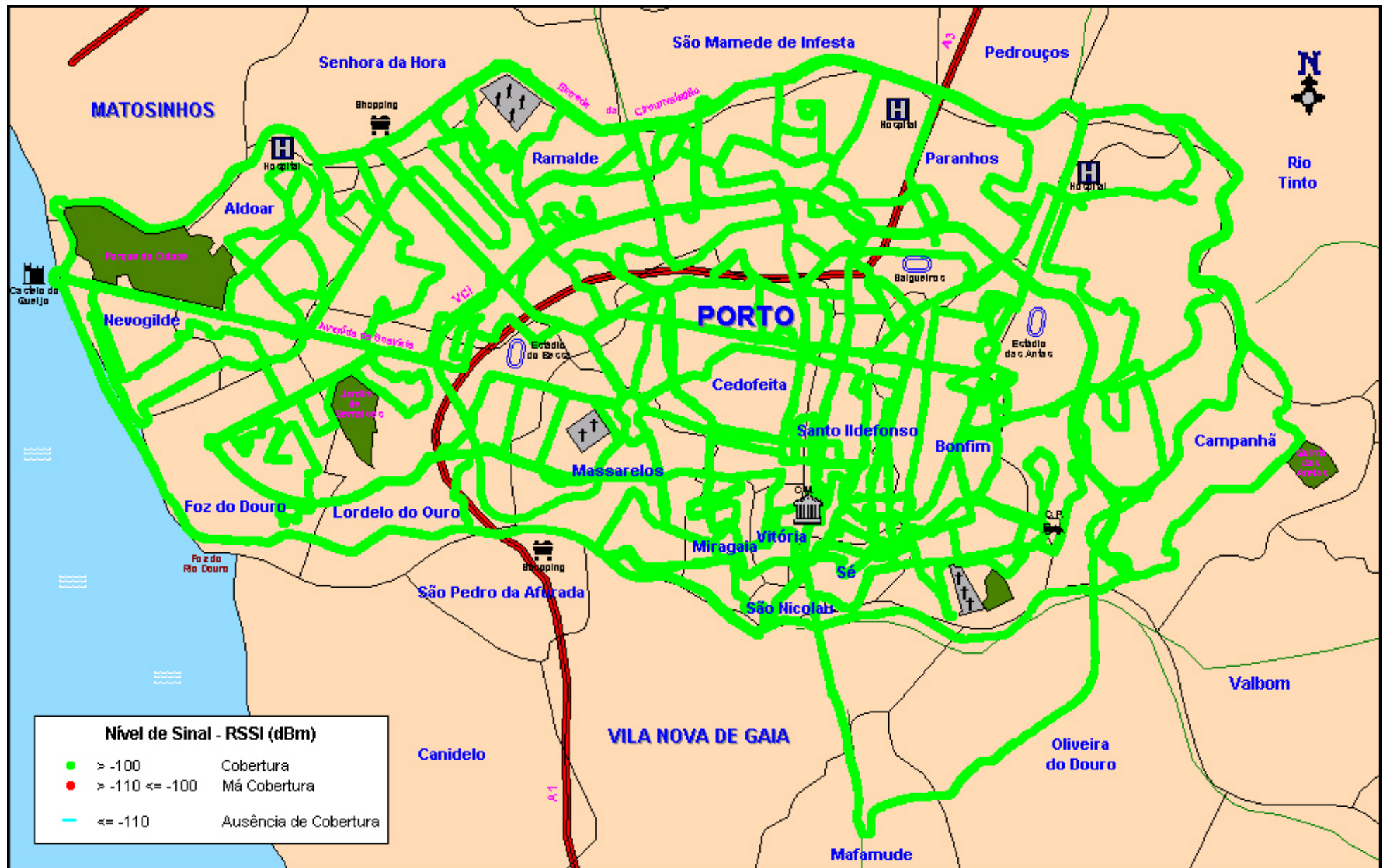
3.3.2 AUDIO QUALITY

Calls With Measurements		Operator	OPTIMUS	VODAFONE	TMN
		Total	1014 100%	980 100%	1001 100%
Audio Quality (MOS)	Poor		3 0,3%	6 0,6%	4 0,4%
	Fair		151 14,9%	210 21,4%	201 20,1%
	Good		860 84,8%	764 78,0%	796 79,5%

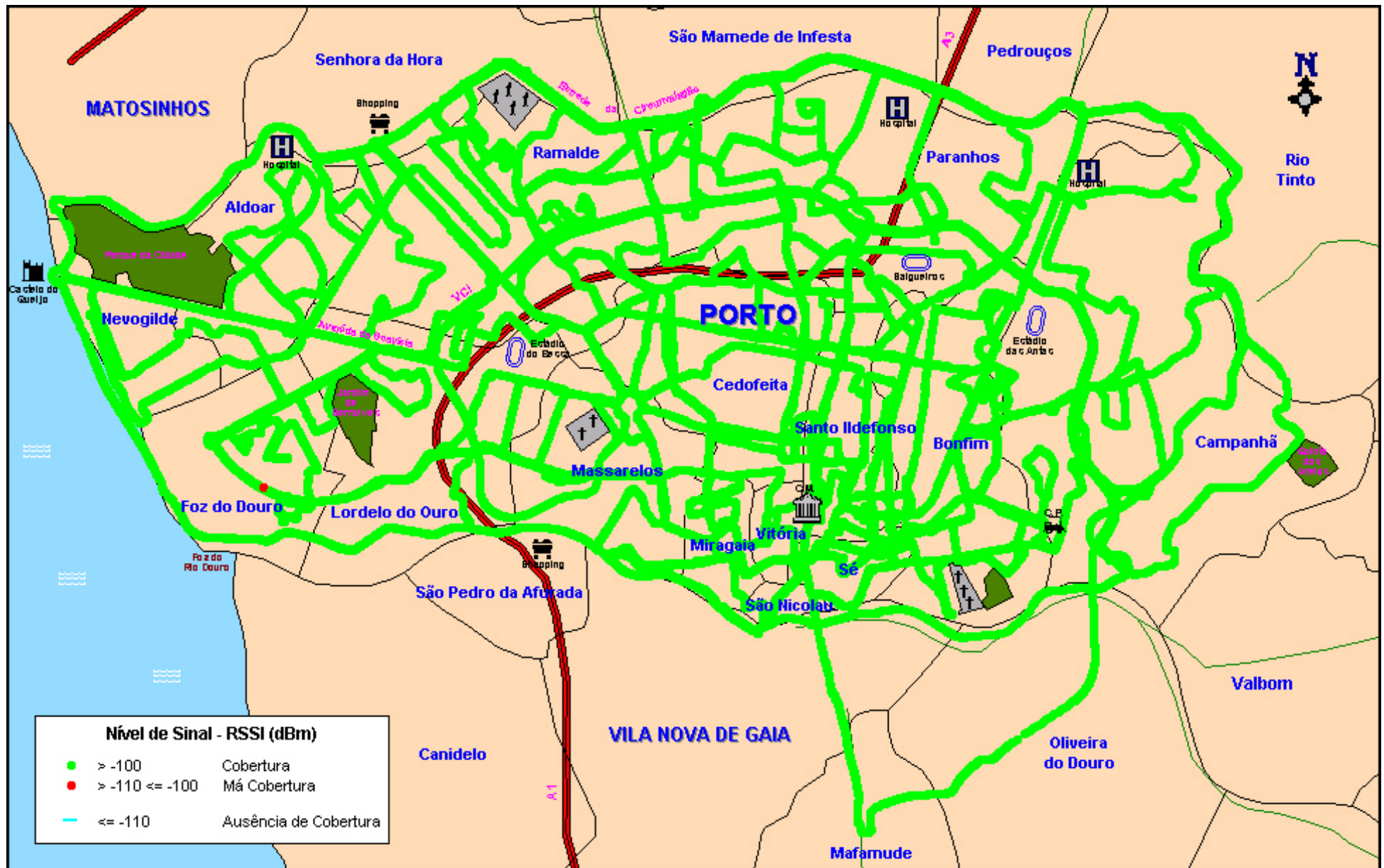


3.3.3 COVERAGE

CITY OF OPORTO
OPTIMUS - PSTN

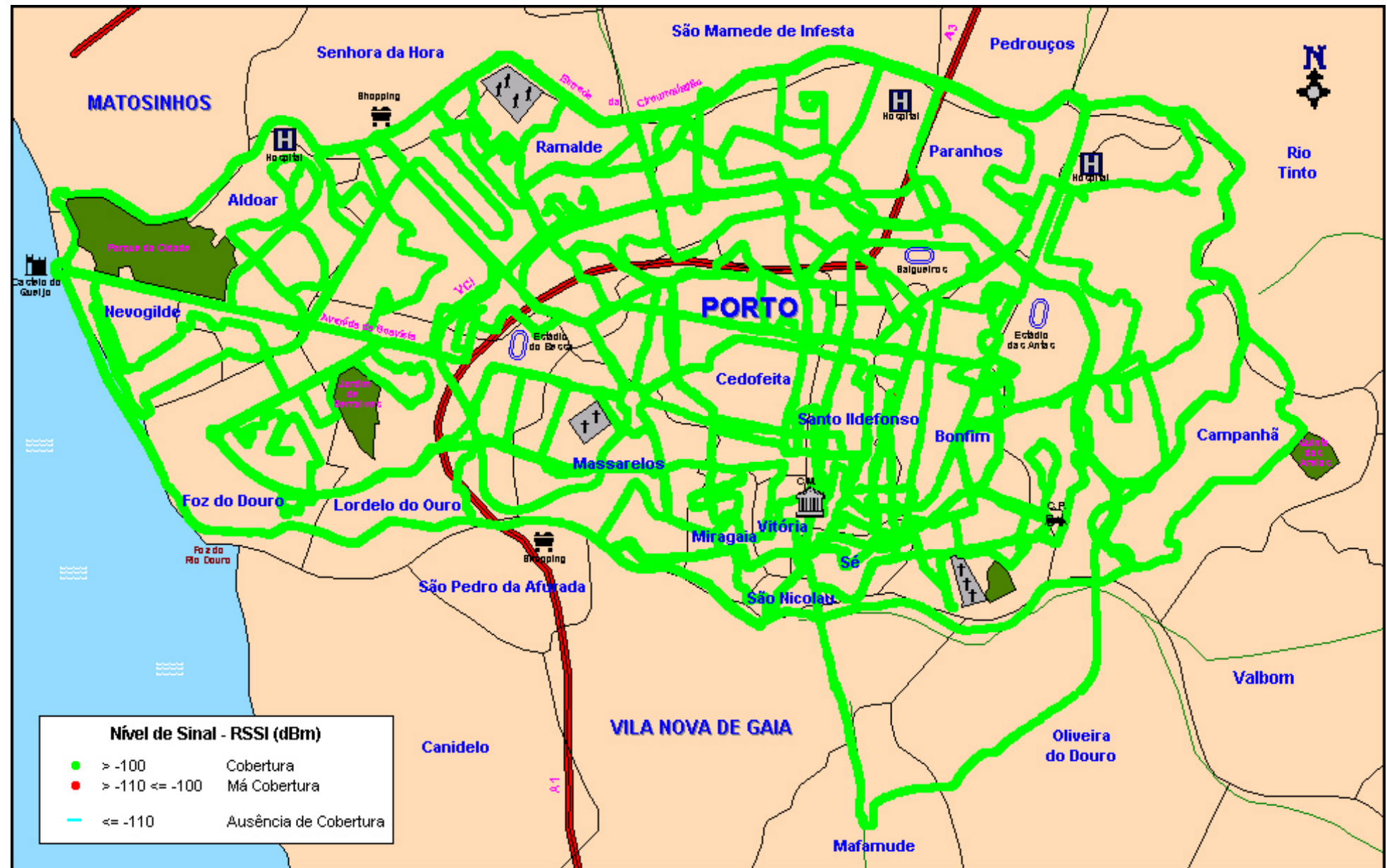


CITY OF PORTO
 VODAFONE - PSTN



CITY OF OPORTO

TMN - PSTN



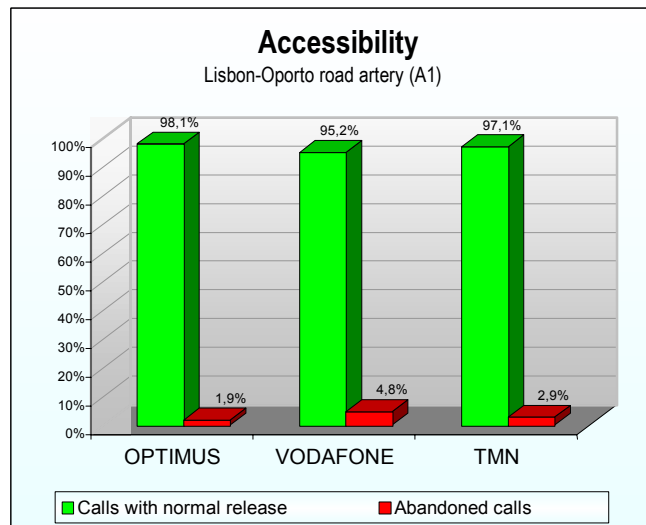
3.4 Lisbon-Oporto Road Artery (A1)

Measurement sessions on:

- 23 December from 13:45 to 16:48
- 27 December from 08:07 to 11:35 and from 12:18 to 15:40
- 30 December from 08:20 to 11:40

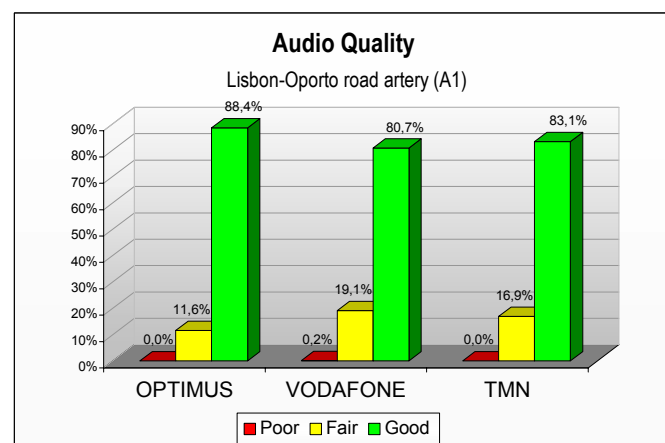
3.4.1 ACCESSIBILITY

Calls made		Operator	OPTIMUS	VODAFONE	TMN
		Total	315 100%	312 100%	312 100%
Routed calls	Total		310 98,4%	303 97,1%	310 99,4%
	Abandoned conversation		1 0,3%	6 1,9%	7 2,2%
	Normal release		309 98,1%	297 95,2%	303 97,1%
Non-routed calls			5 1,6%	9 2,9%	2 0,6%
Abandoned calls	Total		6 1,9%	15 4,8%	9 2,9%
	Causes	No service	0 0,0%	1 0,3%	4 1,3%
		Congestion	4 1,3%	7 2,2%	1 0,3%
		Radio link failure	1 0,3%	4 1,3%	2 0,6%
		Other	1 0,3%	3 1,0%	2 0,6%



3.4.2 AUDIO QUALITY

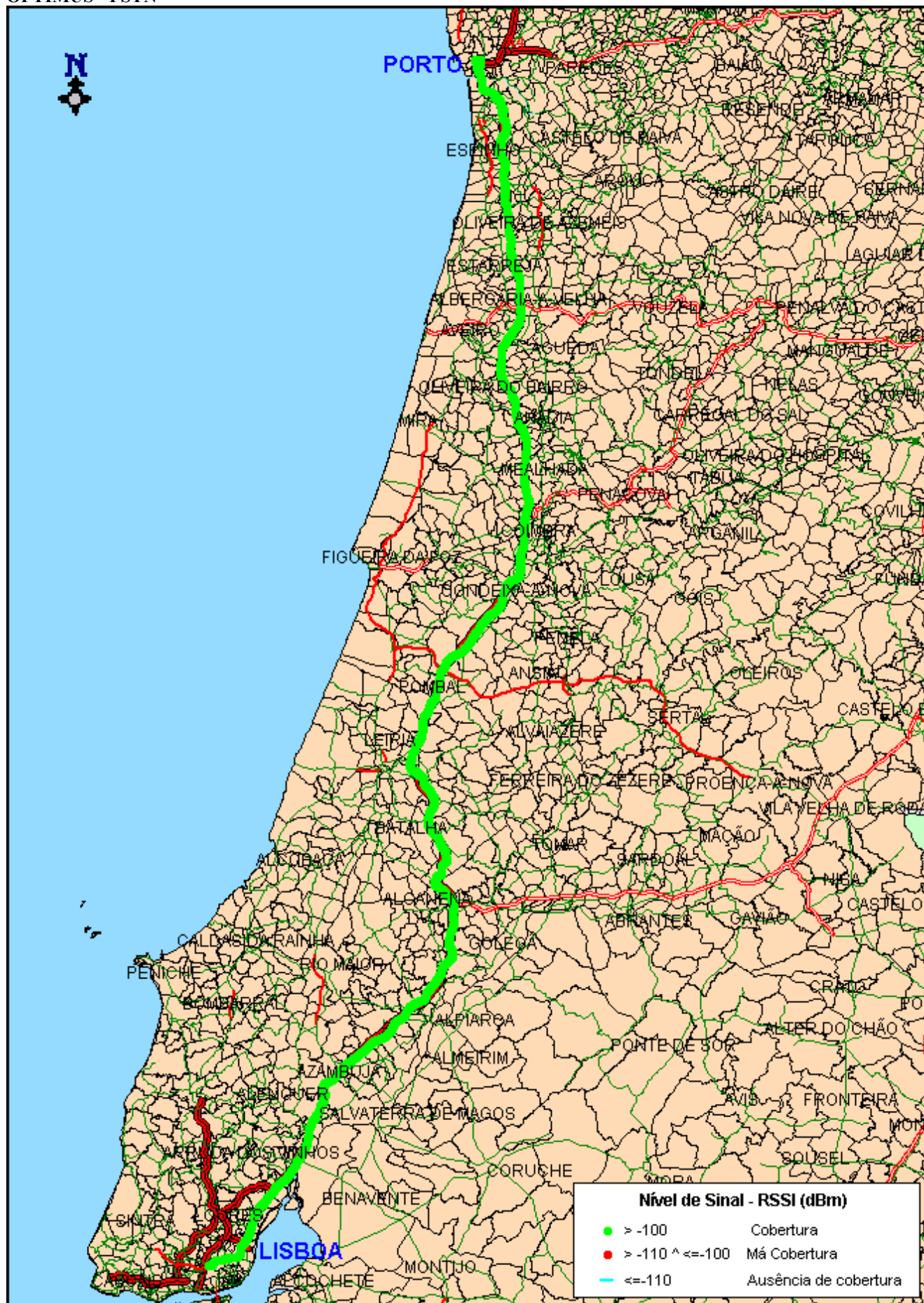
Calls With Measurements		Operator	OPTIMUS	VODAFONE	TMN
		Total	620 100%	607 100%	616 100%
Audio Quality (MOS)	Poor		0 0,0%	1 0,2%	0 0,0%
	Fair		72 11,6%	116 19,1%	104 16,9%
	Good		548 88,4%	490 80,7%	512 83,1%



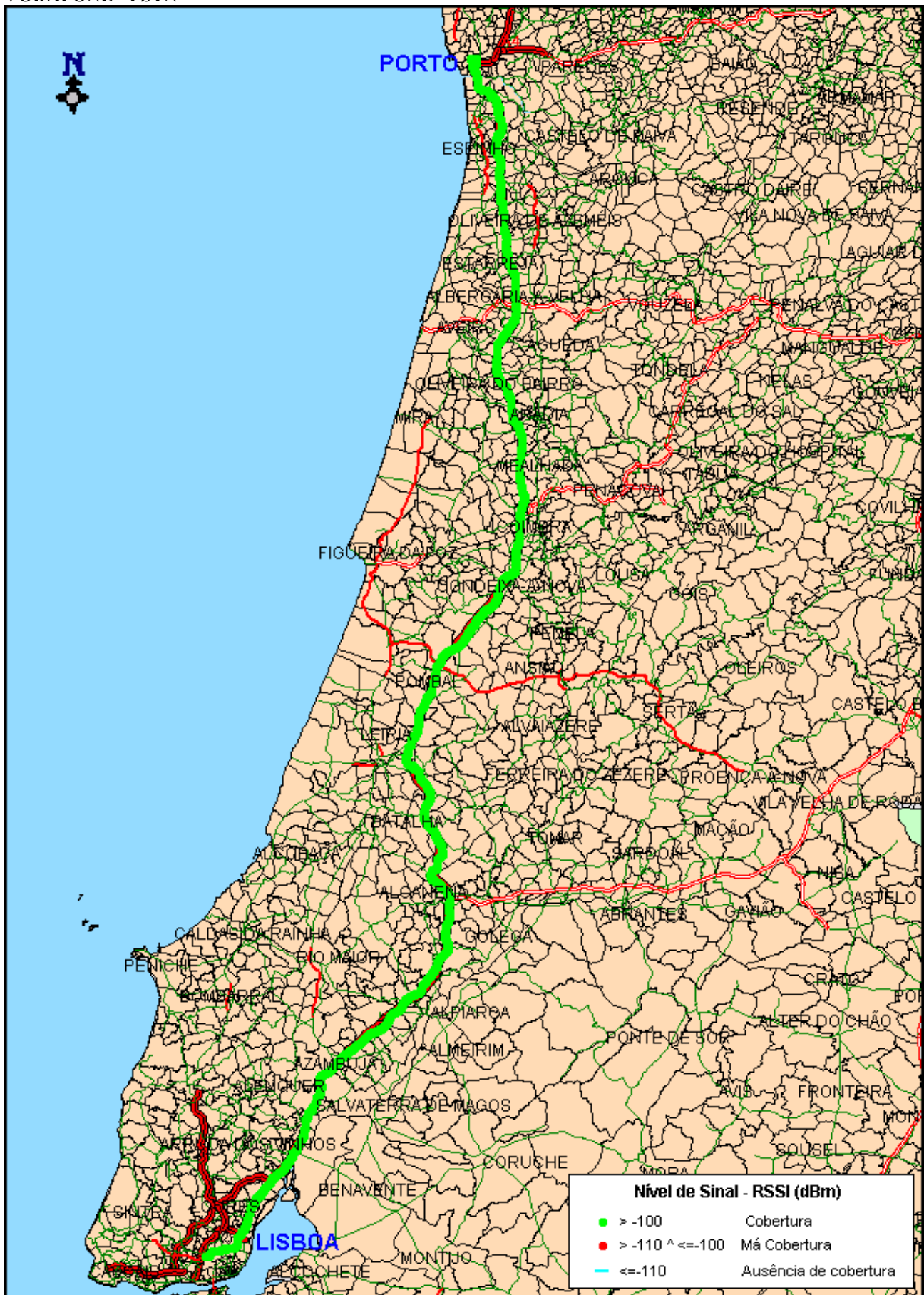
3.4.3 COVERAGE

LISBON-OPORTO ROAD ARTERY (A1)

OPTIMUS - PSTN

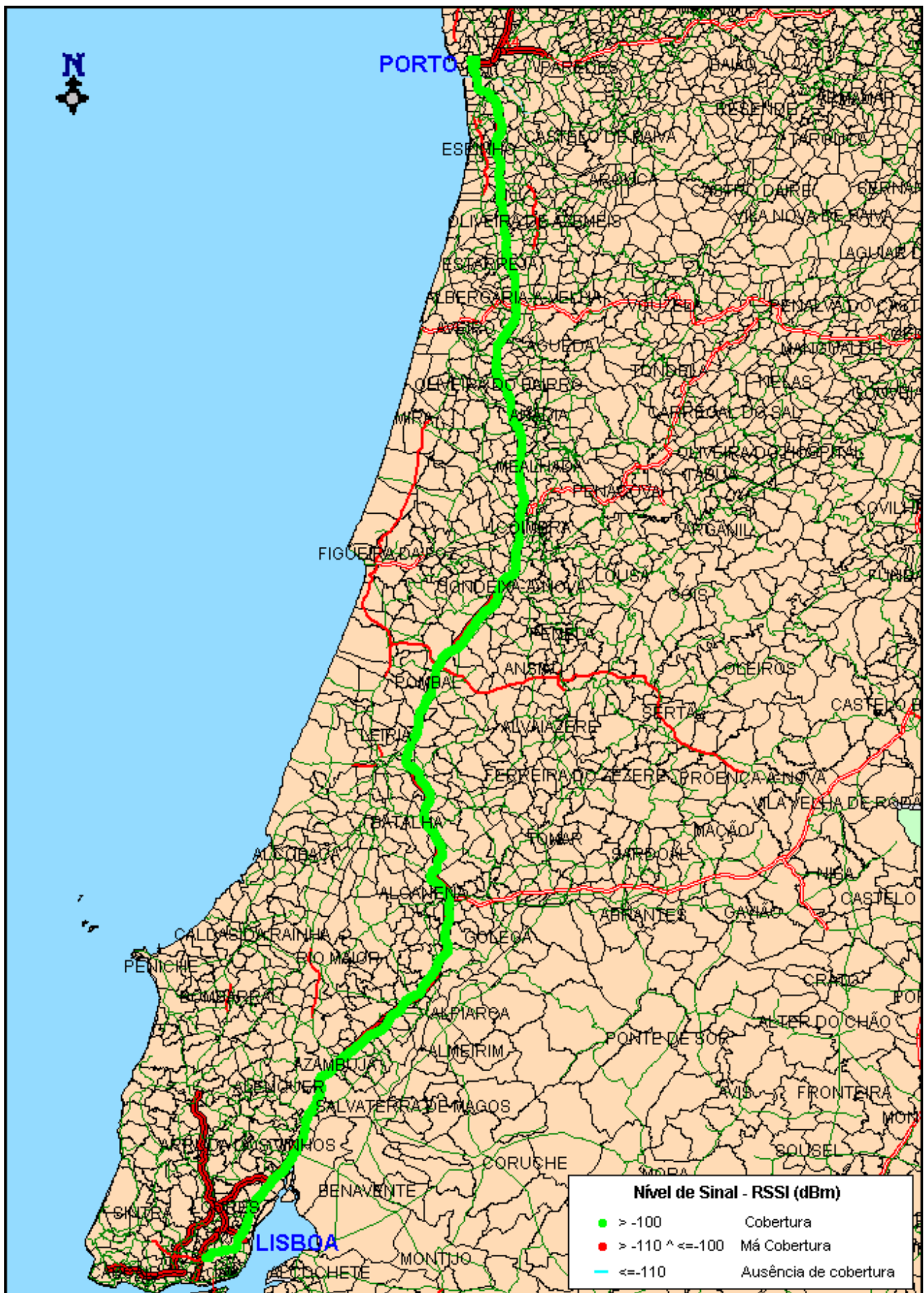


LISBON-OPORTO ROAD ARTERY (A1)



LISBON-OPORTO ROAD ARTERY (A1)

TMN - PSTN



4 Conclusions

This study verified that the GSM mobile networks continue to present very good levels of coverage and performance.

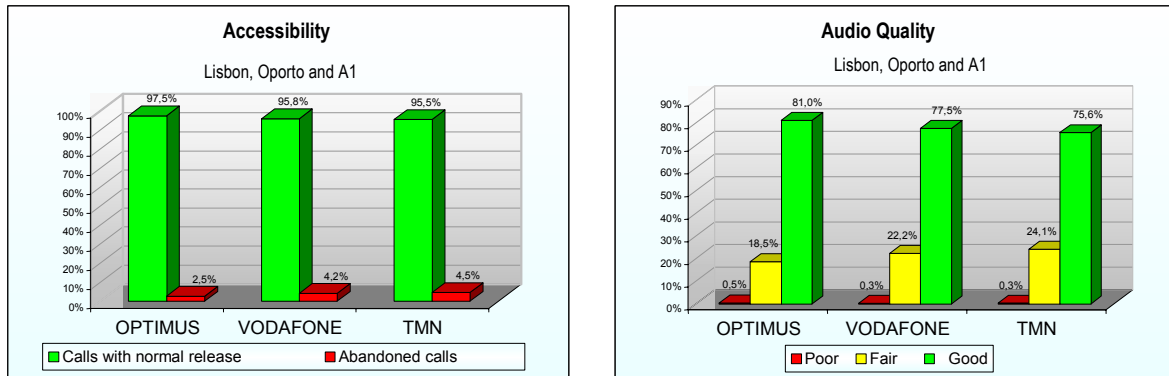


Figure 4 – Results obtained with this study.

Measurements were carried out between 10 and 30 December 2002 in the cities of Lisbon and Oporto and along the main road artery linking those two cities (A1).

A total of 5,045 test calls were made, of which 4,857 (96.3%) were successfully established, with the subsequent conversation phase ending normally (by hanging up) after a pre-set time period.

For 99.6% of calls the average audio quality values were good or fair; only 0.4% of calls had poor or bad average values.

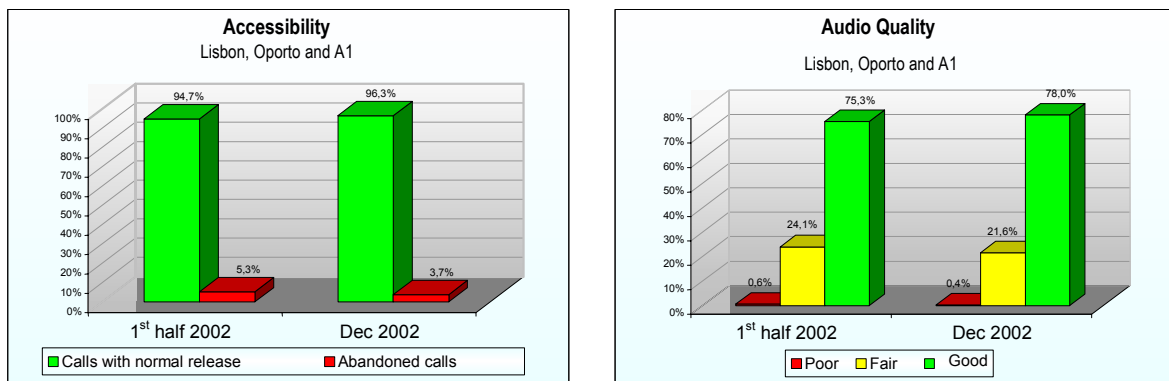


Figure 5 – Performance of GSM mobile networks in 1st half of year and in December.

With these results, it was concluded that the indicators for accessibility and audio quality continue to present very good values for such networks.

Regarding coverage, it was verified that the areas covered by this study were uniformly covered by the mobile networks. Comparison of the results obtained in December and in the 1st half of 2002 in Lisbon and Oporto should only be made with much reservation, as the samples are very different with respect to both the number of calls made and the geographic coverage.

Table 3 - Samples

	Calls made	Counties covered
1st half of year	15 395	Lisbon, Almada, Amadora, Cascais, Loures, Odivelas, Oeiras, Sintra and Seixal
	7 658	Oporto, V. N. de Gaia, Maia, Matosinhos and Gondomar
December	2 560	Lisbon
	1 546	Oporto

The samples are identical for the A1 road artery.

In the city of Lisbon the accessibility and audio quality indicators did not change significantly: accessibility showed a slight improvement while audio quality was reduced in the same proportion.

Major improvements were observed in the city of Oporto and on the A1 road artery, mainly for the audio quality indicator.

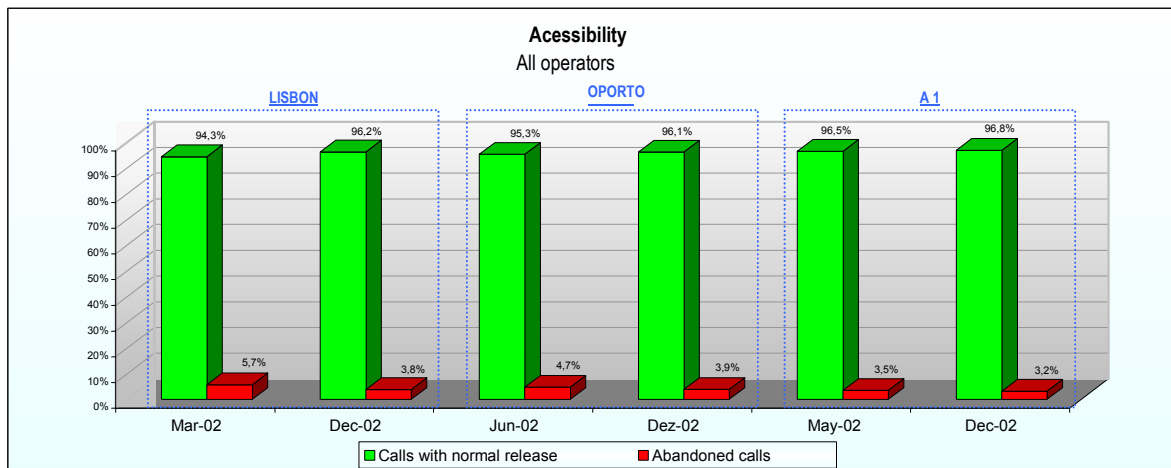


Figure 6 – Evolution of GSM mobile network accessibility, by area.

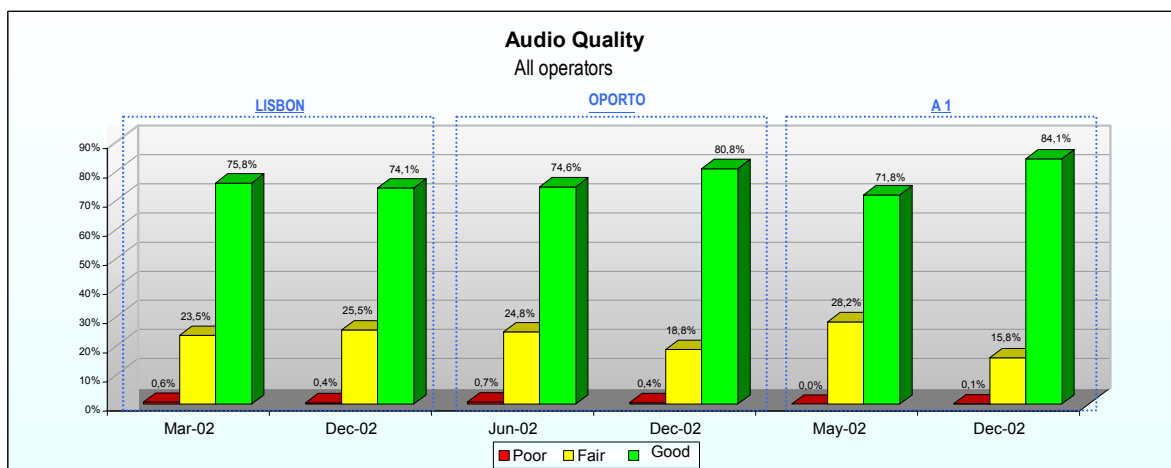


Figure 7 – Evolution of GSM mobile network audio quality, by area.

The graphs on the following pages indicate the evolution of the accessibility and audio quality indicators for each operator and in each area covered by the study.

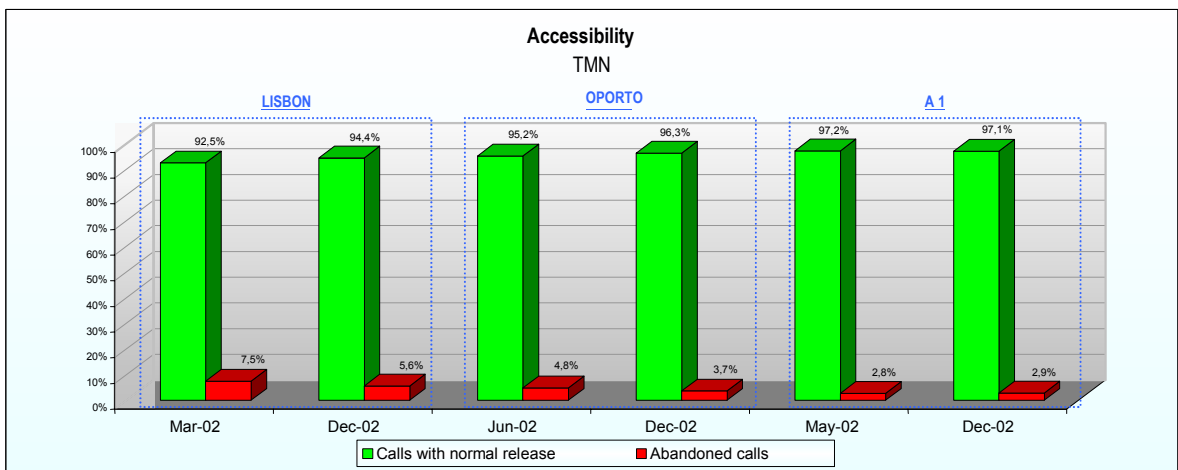
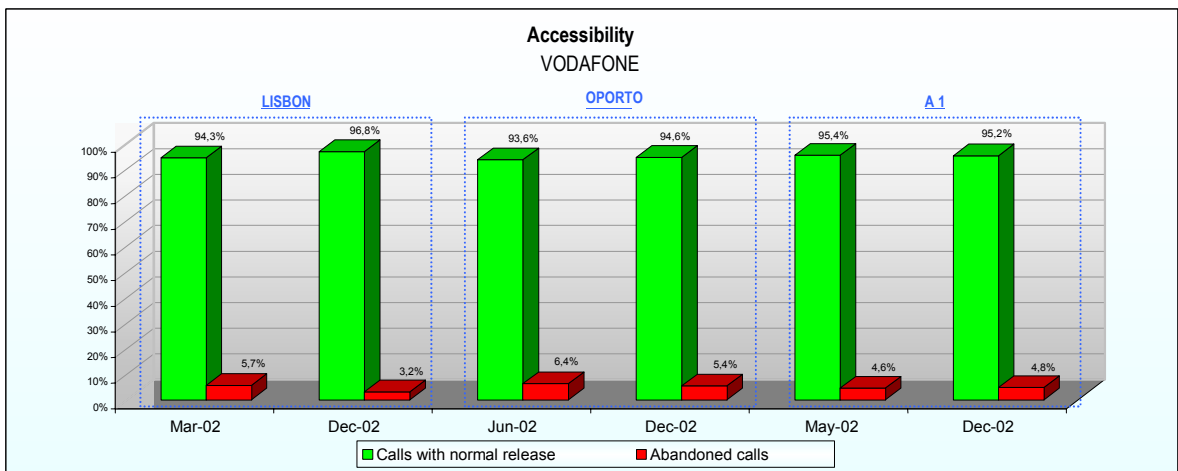
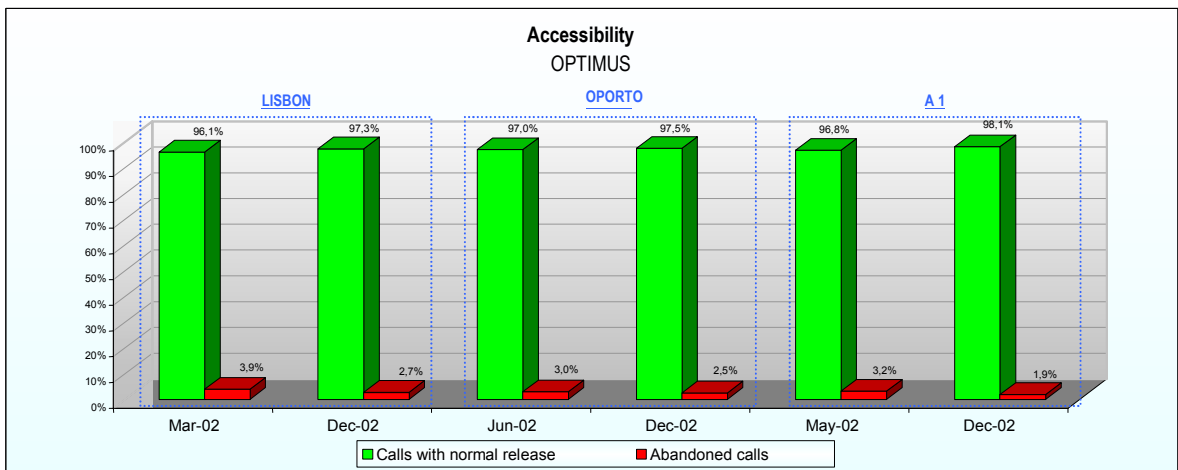


Figure 8 – Evolution of GSM mobile network accessibility, by operator and by area.

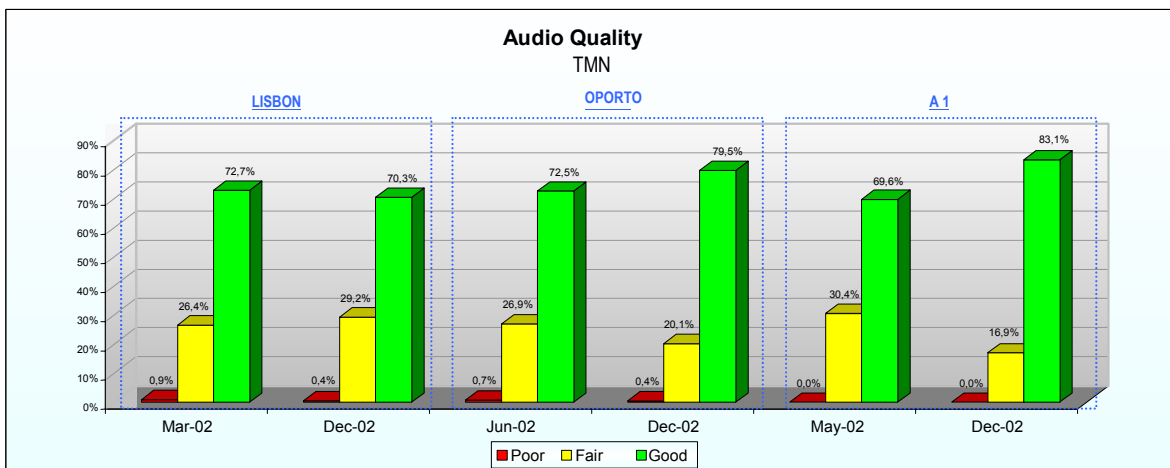
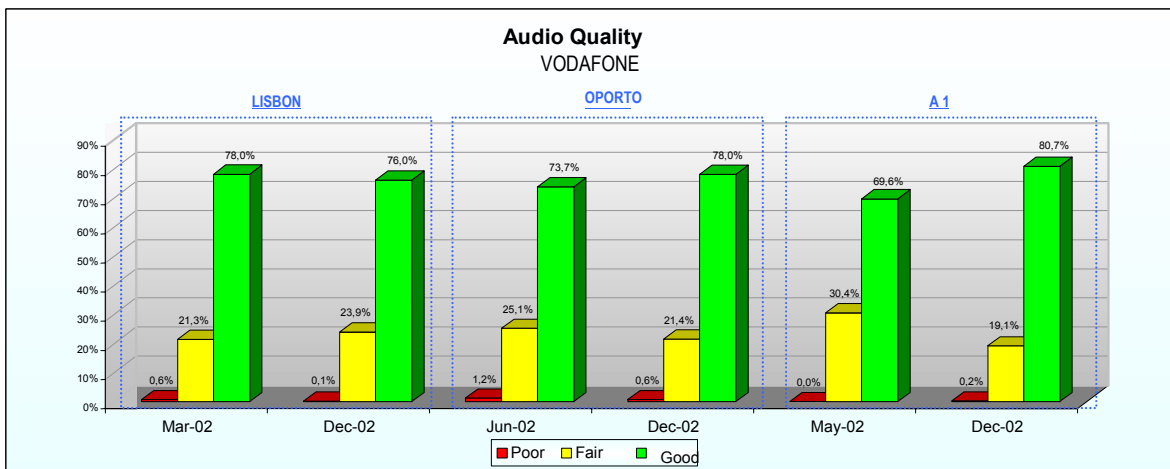
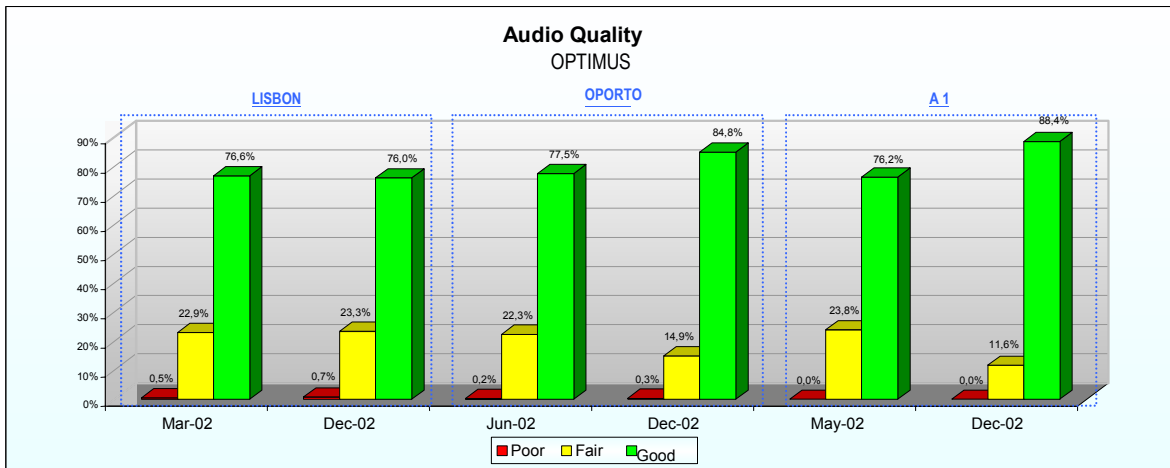


Figure 9 – Evolution of GSM mobile network audio quality, by operator and by area.

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