GSM Mobile Networks
Quality of Service Survey

Long Calls

May 2005

Index

I EXECUTIVE SUMMARY

I.I FRAMEWORK

In the framework of its current activities, ANACOM carries out once again a survey of the quality of the services provided by the mobile operators in Portugal, by analyzing technical parameters that translate the quality perception from the Consumer's standpoint.

In view of the evolution of mobile services in Portugal, with one of the European Union's highest penetration rates, this year's analysis enters a new phase, now surveying with even bigger severity the quality of the operators' service provision. The evaluation of the quality of service is now more frequent along the year and broader, in terms of coverage, and it also includes new analysis approaches.

Verification of the mobile network capacity of the operators OPTIMUS, VODAFONE and TMN to maintain long calls was thus carried out, during May 2005.

For testing purposes, the study considers long calls those with a 5 minute-duration[1].

Critical factors for the maintenance of a call, namely mobility, were taken into account when selecting the areas for measurement-taking. Thus, these first tests were made on road axles Lisbon-Porto (A1), Porto-Valença-Porto (A3+IC1), Lisbon-Sintra-Cascais-Lisbon (A5+IC19) and Lisbon-Vila Real de Sto. António (A2+A22).

The sample was sized for global results with maximum standard errors of 3%, at a 95% confidence level.

Three mobile network indicators of capital importance were analyzed, considering the quality perspective from the standpoint of the user/consumer:

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

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[1] As specified by ETSI - European Telecommunications Standards Institute (TS 102 250-5 V1.1.1 (2004-09)) for this type of analysis.

The methodology is based on automatic end-to-end tests, in order to identify the quality of service on the field and providing the most realistic perspective on the networks' performance, from the user standpoint.

In view of these services' penetration rate, of the diversity of the terminal equipment that is used, and given the users' subjective views themselves, it is impossible to rigorously reproduce each consumer's conditions of interaction with the networks. The results of this study must thus be understood as an indicator of the networks' behaviour. Its transposition/extrapolation to specific situations requires some prudence, at the risk that biased conclusions might be taken.

Technical and methodological options of this study directly influenced its results and must be taken into account when analyzing these results, namely the following:

- It used **EFR Dual-Band terminal equipment**;

- The tests were exclusively based on a **technical solution** (equipment + software) and performed in a totally **automatic** way, thereby setting homogenous conditions for the monitoring of the 3 operators and eliminating the subjectivity inherent to the human user;

- The tests were carried out in **moving vehicles and with outdoor antennas**;

- The results of the study only reflect the behaviour of the networks on the places and moments of the measurements;

- On the other hand, the operators are permanently improving their networks. The technical interventions necessary to these improvements can cause momentary degradations of the service in the geographic area of intervention.

I.II MAIN CONCLUSIONS

The analysis of the results of this study shows that the GSM mobile networks have a good capacity to keep long voice calls.

Over 93% of the test calls were established successfully and the communication kept during a period of 5 minutes.

Indicator precision, at a 95% confidence level	
	May 2005
Accessibility	1.27%
Poor Audio Quality	0.48%
Acceptable Audio Quality	1.77%
Good Audio Quality	1.79%
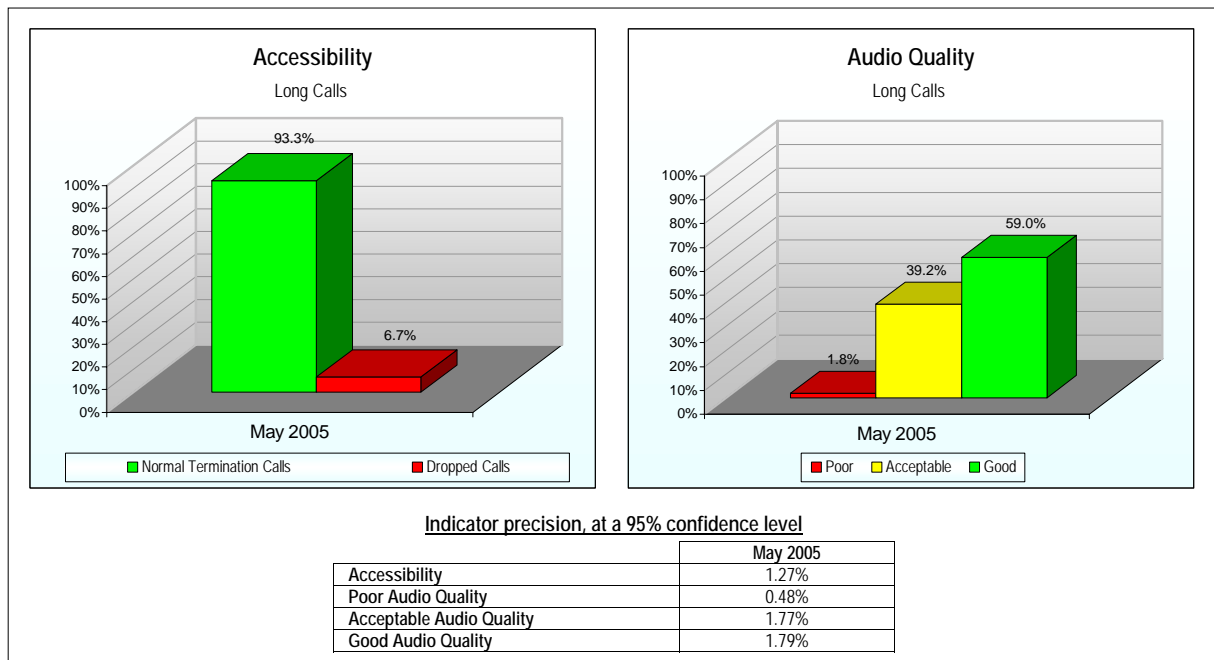
Figure 1 – GSM Mobile Networks Performance

Regarding the perceptiveness of voice communications on these networks, about 98% of test calls show good or acceptable Audio Quality average values. But about 2% of the calls had poor or bad levels.

The Coverage indicator, as with other studies carried out previously on the same places, shows adequate levels.

No significant differences were registered among the results of the several operators, as can be observed in Figure 2.
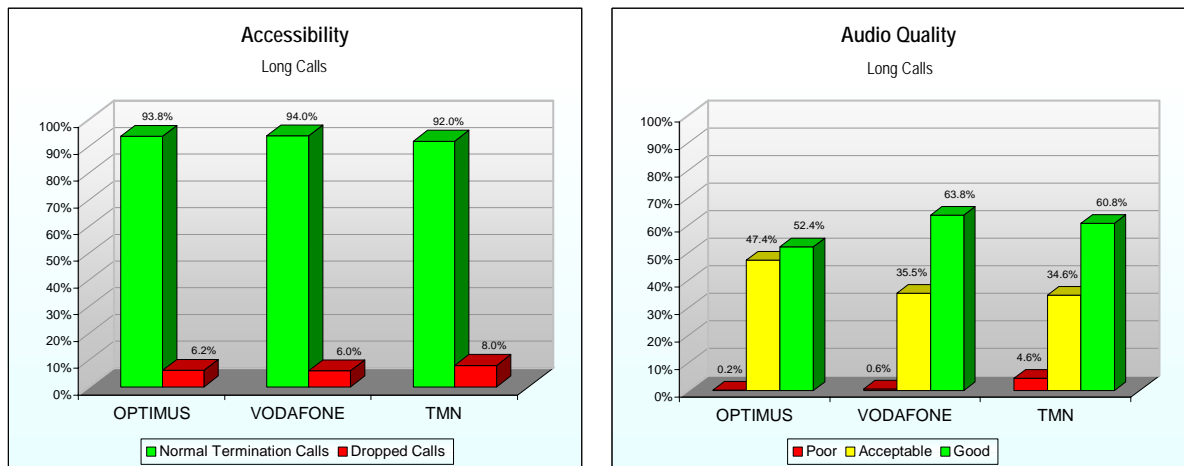
Figure 2 - Results by operator.

Comparing the results of this study with the results of the study with average duration calls (110 seconds), carried out on the same places in October/December 2004, the Accessibility indicator shows lower levels for long calls. The increase of lost calls during the conversational phase was decisive to that situation.

The Audio Quality indicator does not show significant differences between the results of the studies with long average duration calls.

Indicator precision, at a 95% confidence level

	May 2005	Oct./Dec. 2004
Accessibility	1.27%	0.74%
Poor Audio Quality	0.48%	0.30%
Acceptable Audio Quality	1.77%	1.58%
Good Audio Quality	1.79%	1.59%

Figure 3 - Performance of GSM Mobile Networks, in situations of long and average duration calls.

1 TECHNICAL ASPECTS

1.1 METHODOLOGY

1.1.1 FUNDAMENTALS

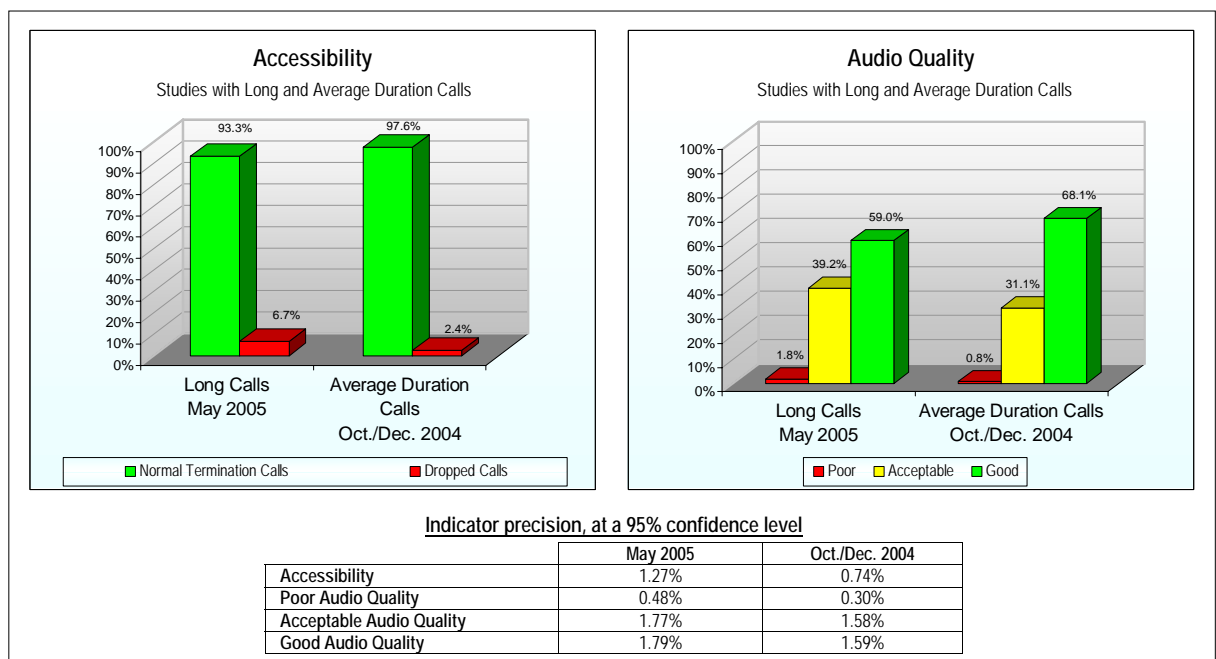This study's methodology is based on 3 fundamental aspects:

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

b) **Impartiality**: The 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**: The 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 test and measurement equipment 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 $\land$ <= -100	Poor Coverage
<= -110	No Coverage

b) **Accessibility**: It verifies 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 long period of time (5 minutes, such as specified by ETSI - European Telecommunications Standards Institute (102 TS 250-5 V1.1.1 (2004-09)) for this type of analysis).

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

c) **Audio Quality**: It verifies 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 sensed by users, is based on the "E-Model" model, which is recommended by international bodies such as ETSI[2] (ETR 250) and ITU[3] (ITU-T *Recommendation G.107*). The *MOS* (*Mean Opinion Score*) index is calculated base on this model.

Figure 4 - Methodology used for audio quality monitoring.
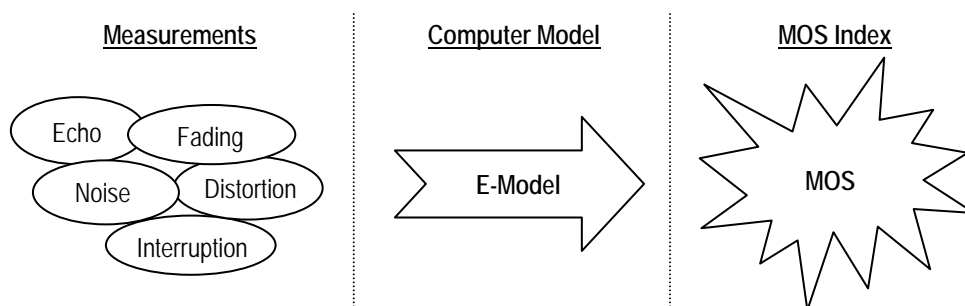
The MOS scale quantifies the effort that it takes to understand a conversation. Its value is 0 when there is no communication and 5 when the communication is perfect. Values 0 and 5 are only theoretical and, therefore, they never appear in the results of the measurements.

[2] European Telecommunications Standards Institute.
[3] 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);
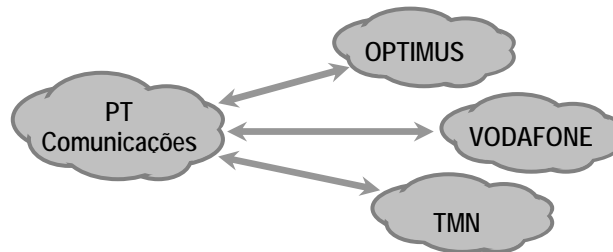
Figure 1 – Origin and Destiny of test calls.

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

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

4. The time gap between consecutive calls is 5 minutes and 50 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 2 – Time structure of a voice call, made with 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 duration of 5 minutes[4] (inferior if the call was dropped or the dialling time too long);

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

1.2 TESTED AREAS

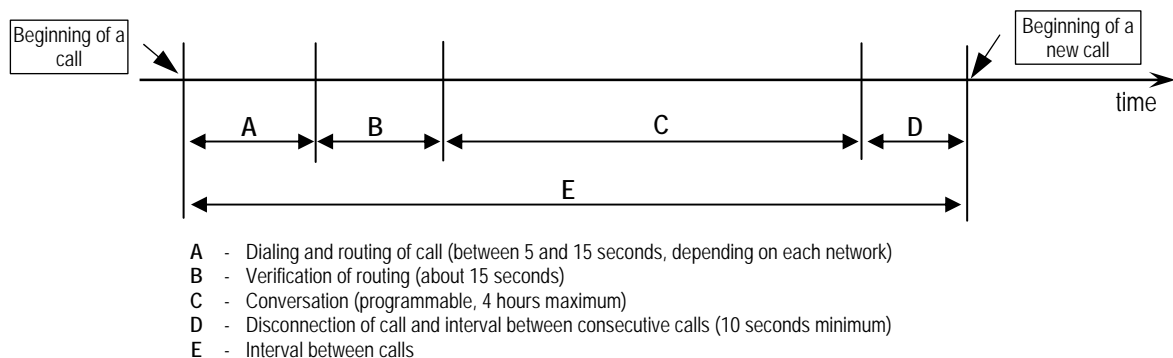Critical factors for the maintenance of a call, namely mobility, were taken into account when choosing the areas where measurements should be made.

Thus, the following road axels where analyzed for this first set of tests:

- Lisbon-Porto (A1);
- Porto-Valença-Porto (A3 + IC1);
- Lisbon-Sintra-Cascais-Lisbon (A5 + IC19);
- Lisbon-Vila Real de Sto. António (A2 + A22).

1.3 SAMPLE SIZE

Table 3 – Length of measurement collection

Long Calls	Road Axels	Lisbon-Cascais-Sintra-Lisbon (A5 + IC19)	12 h 38
		Lisbon-Porto (A1)	12 h 35
		Lisbon-Vila Real de Sto. António (A2+A22)	12 h 45
		Porto-Valença-Porto (A3+IC1)	12 h 06
		Total	50 h 04
		Total Long Calls	50 h 04

1.4 DATA COLLECTION CONDITIONS

On the Lisbon-Sintra-Cascais-Lisbon axle, measurement collection was divided into four 3-hour sessions. On the other axels, measurement collection was made in 4 trips.

The measurement sessions took place during normal working periods on weekdays.

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[4] Just as specified by ETSI - European Telecommunications Standards Institute (TS 102 250-5 V1.1.1 (2004-09)) for this type of analysis

1.5   TEST 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.
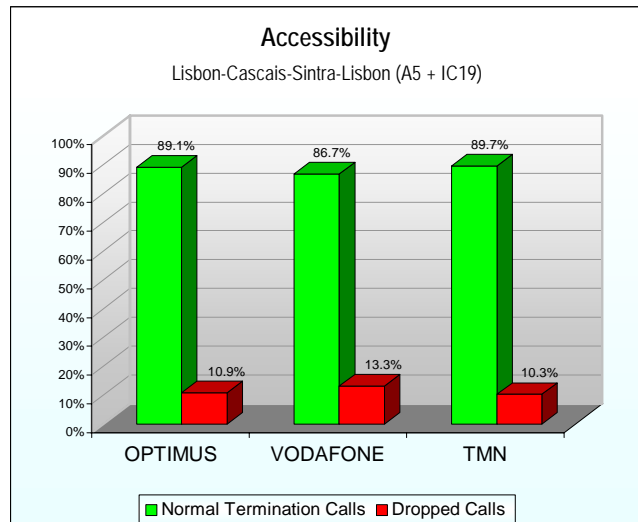
2 RESULTS

2.1 LISBON-CASCAIS-SINTRA-LISBON (A5 + IC19)

> Measurement Sessions performed on:
> - **9 May 2005** between 9h02 and 12h14
> - **10 May 2005** between 16h21 and 19h35
> - **11 May 2005** between 7h56 and 11h05
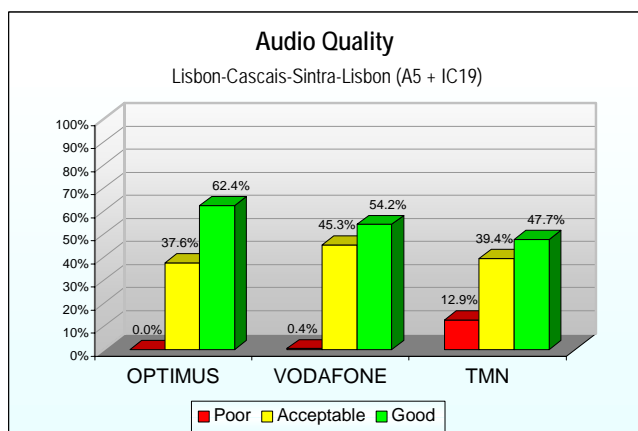> - **12 May 2005** between 17h10 and 20h13

2.1.1 ACCESSIBILITY

	Operator	OPTIMUS	VODAFONE	TMN
Calls Made	Total	128 100%	128 100%	126 100%
Routed Calls	Total	124 96.9%	118 92.2%	122 96.8%
	Abandoned During Conversation	10 7.8%	7 5.5%	9 7.1%
	Normal Termination Calls	114 89.1%	111 86.7%	113 89.7%
Non-Routed Calls		4 3.1%	10 7.8%	4 3.2%
Dropped Calls	Total	14 10.9%	17 13.3%	13 10.3%
Call Ending Cause	No Service	0 0.0%	2 1.6%	0 0.0%
	Congestion	5 3.9%	8 6.3%	4 3.2%
	Radio Link Failure	3 2.3%	2 1.6%	7 5.6%
	Other	6 4.7%	5 3.9%	2 1.6%

Accessibility — Lisbon-Cascais-Sintra-Lisbon (A5 + IC19)

- OPTIMUS: Normal Termination Calls 89.1%, Dropped Calls 10.9%
- VODAFONE: Normal Termination Calls 86.7%, Dropped Calls 13.3%
- TMN: Normal Termination Calls 89.7%, Dropped Calls 10.3%

2.1.2 AUDIO QUALITY

	Operator	OPTIMUS	VODAFONE	TMN
Calls With Measurements	Total	242 100%	236 100%	241 100%
Audio Quality (MOS)	Poor	0 0.0%	1 0.4%	31 12.9%
	Acceptable	91 37.6%	107 45.3%	95 39.4%
	Good	151 62.4%	128 54.2%	115 47.7%

Audio Quality — Lisbon-Cascais-Sintra-Lisbon (A5 + IC19)

- OPTIMUS: Poor 0.0%, Acceptable 37.6%, Good 62.4%
- VODAFONE: Poor 0.4%, Acceptable 45.3%, Good 54.2%
- TMN: Poor 12.9%, Acceptable 39.4%, Good 47.7%

2.1.3 COVERAGE

(Following pages)

Lisbon-Cascais-Sintra-Lisbon (A5 + IC19)

OPTIMUS – PSTN

Nível de Sinal - RSSI (dBm)

● > -100	Cobertura
● > -110 <= -100	Má Cobertura
— <= -110	Ausência de Cobertura
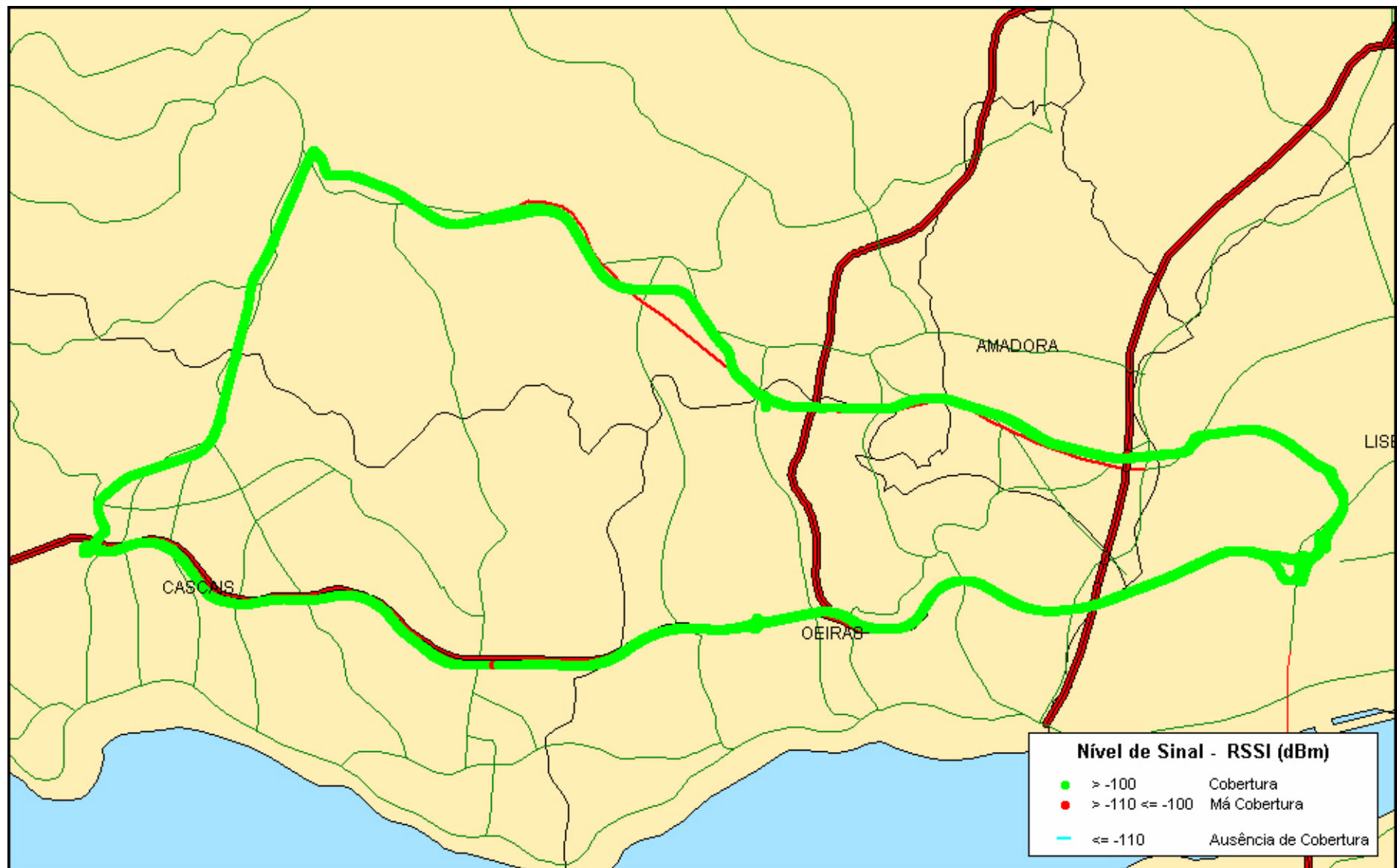
Lisbon-Cascais-Sintra-Lisbon (A5 + IC19)

VODAFONE – PSTN

Nível de Sinal - RSSI (dBm)

●	> -100	Cobertura
●	> -110 <= -100	Má Cobertura
—	<= -110	Ausência de Cobertura
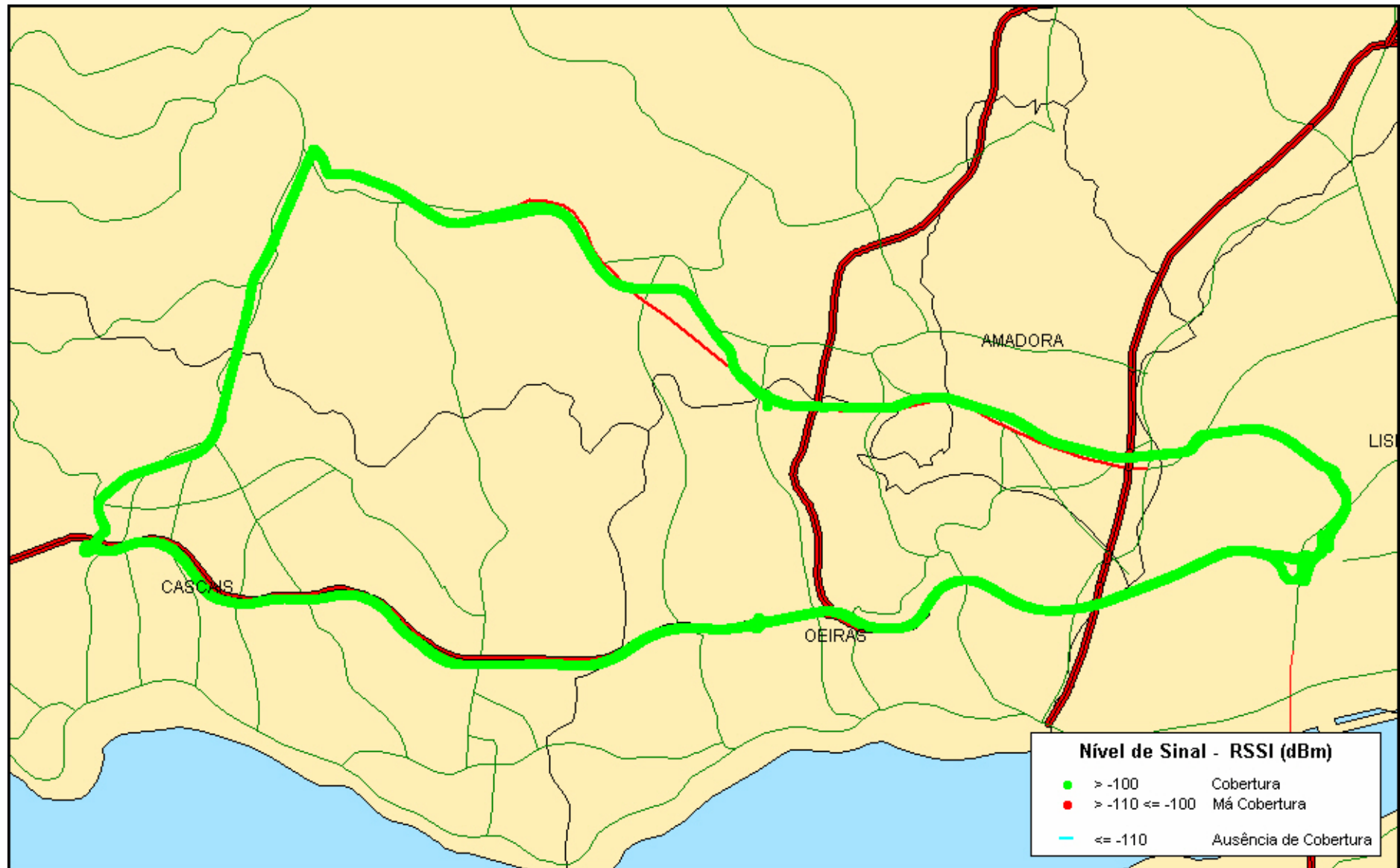
LISBON-CASCAIS-SINTRA-LISBON (A5 + IC19)

TMN – PSTN

Nível de Sinal - RSSI (dBm)

- > -100   Cobertura
- > -110 <= -100   Má Cobertura
- <= -110   Ausência de Cobertura
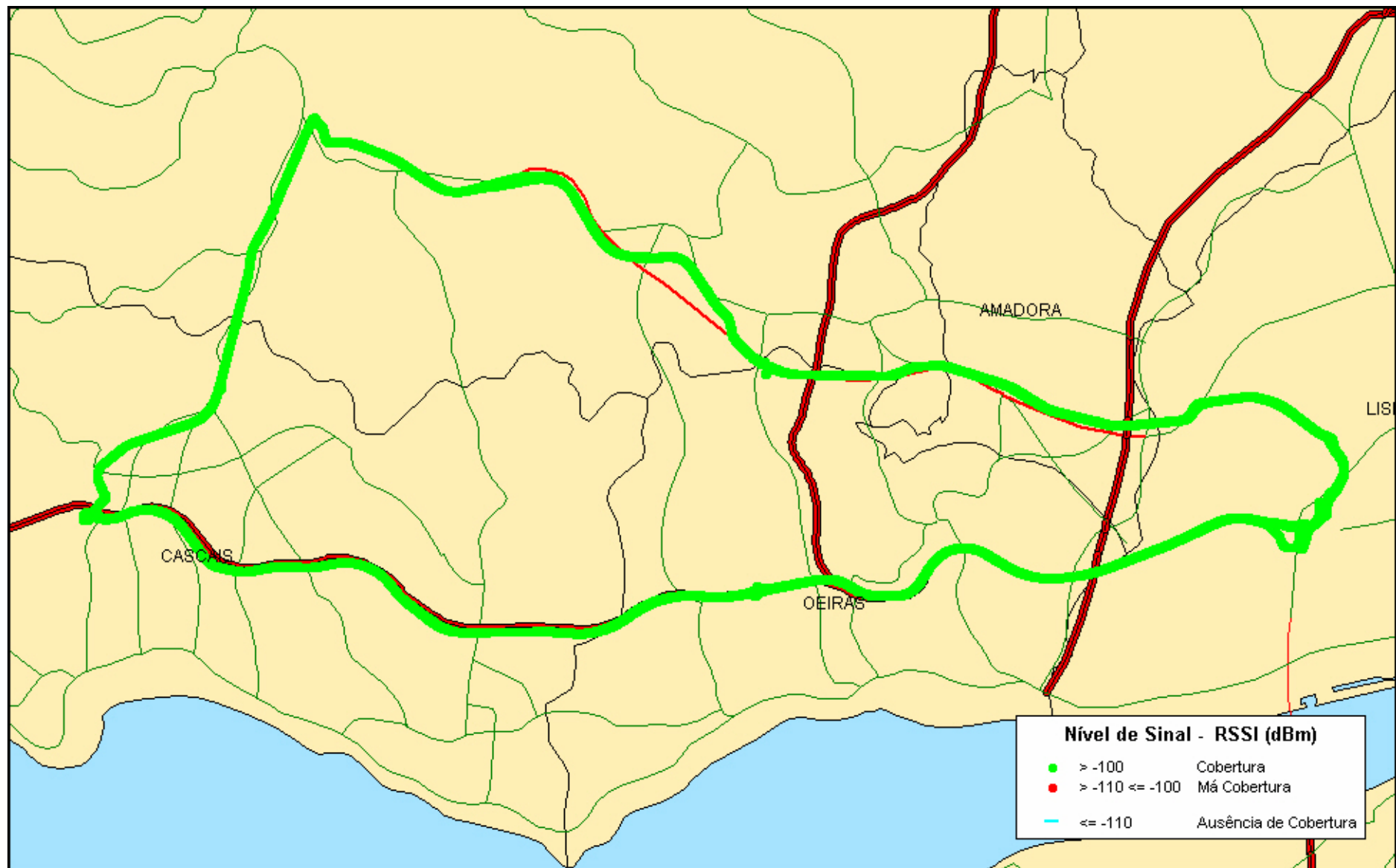
2.2 LISBON-VILA REAL DE STO. ANTÓNIO (A2 + A22)

Measurement Sessions performed on:
- **9 May 2005** between 14h19 and 17h25
- **10 May 2005** between 8h56 and 12h03
- **11 May 2005** between 13h26 and 16h43
- **12 May 2005** between 9h07 and 12h22

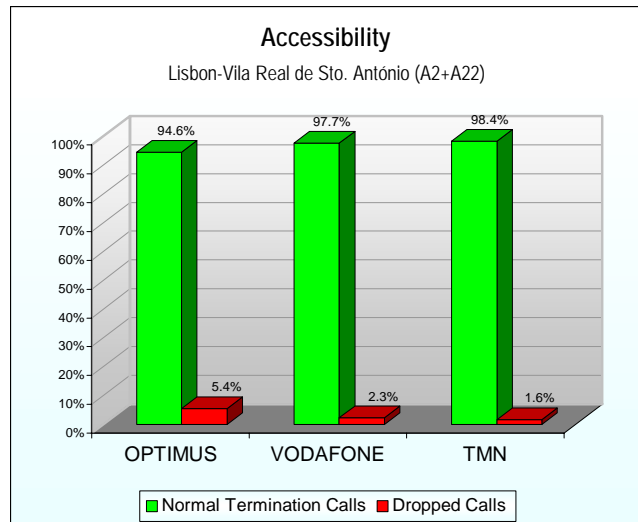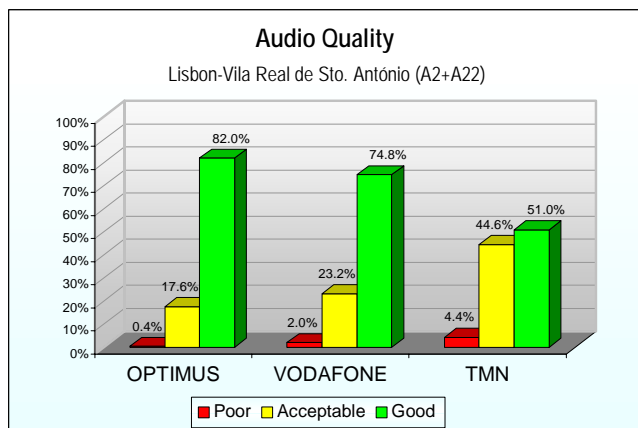### 2.2.1 ACCESSIBILITY

	Operator	OPTIMUS	VODAFONE	TMN
Calls Made	Total	129 100%	128 100%	127 100%
Routed Calls	Total	127 98.4%	126 98.4%	126 99.2%
	Abandoned During Conversation	5 3.9%	1 0.8%	1 0.8%
	Normal Termination Calls	122 94.6%	125 97.7%	125 98.4%
Non-Routed Calls		2 1.6%	2 1.6%	1 0.8%
Dropped Calls / Call Ending Cause	Total	7 5.4%	3 2.3%	2 1.6%
	No Service	0 0.0%	0 0.0%	0 0.0%
	Congestion	3 2.3%	2 1.6%	0 0.0%
	Radio Link Failure	2 1.6%	0 0.0%	1 0.8%
	Other	2 1.6%	1 0.8%	1 0.8%

Accessibility
Lisbon-Vila Real de Sto. António (A2+A22)

OPTIMUS: Normal Termination Calls 94.6%, Dropped Calls 5.4%
VODAFONE: Normal Termination Calls 97.7%, Dropped Calls 2.3%
TMN: Normal Termination Calls 98.4%, Dropped Calls 1.6%

2.2.2 AUDIO QUALITY

	Operator	OPTIMUS	VODAFONE	TMN
Calls With Measurements	Total	250 100%	250 100%	251 100%
Audio Quality (MOS)	Poor	1 0.4%	5 2.0%	11 4.4%
	Acceptable	44 17.6%	58 23.2%	112 44.6%
	Good	205 82.0%	187 74.8%	128 51.0%

Audio Quality
Lisbon-Vila Real de Sto. António (A2+A22)

OPTIMUS: Poor 0.4%, Acceptable 17.6%, Good 82.0%
VODAFONE: Poor 2.0%, Acceptable 23.2%, Good 74.8%
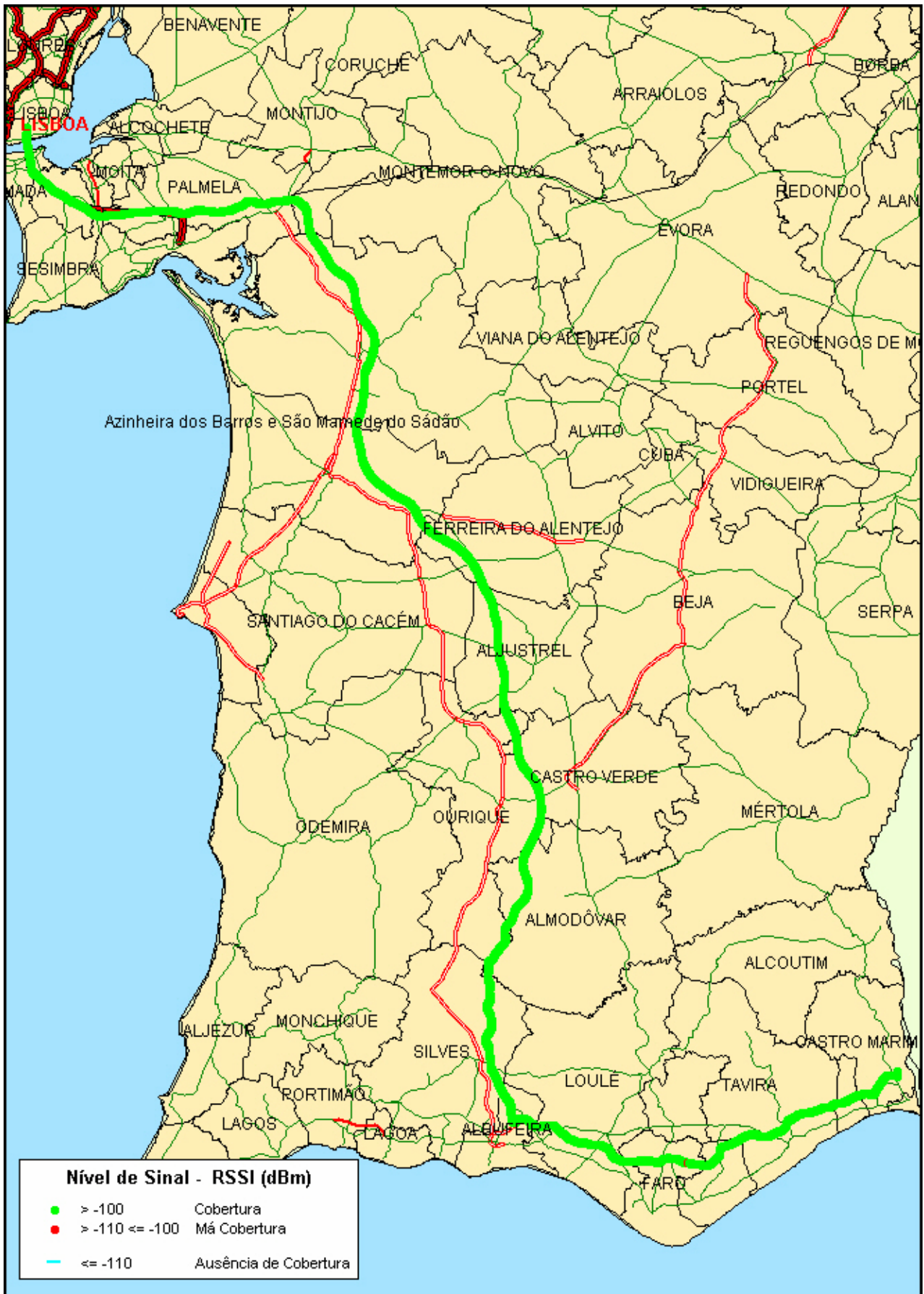TMN: Poor 4.4%, Acceptable 44.6%, Good 51.0%

2.2.3 COVERAGE

(Following pages)

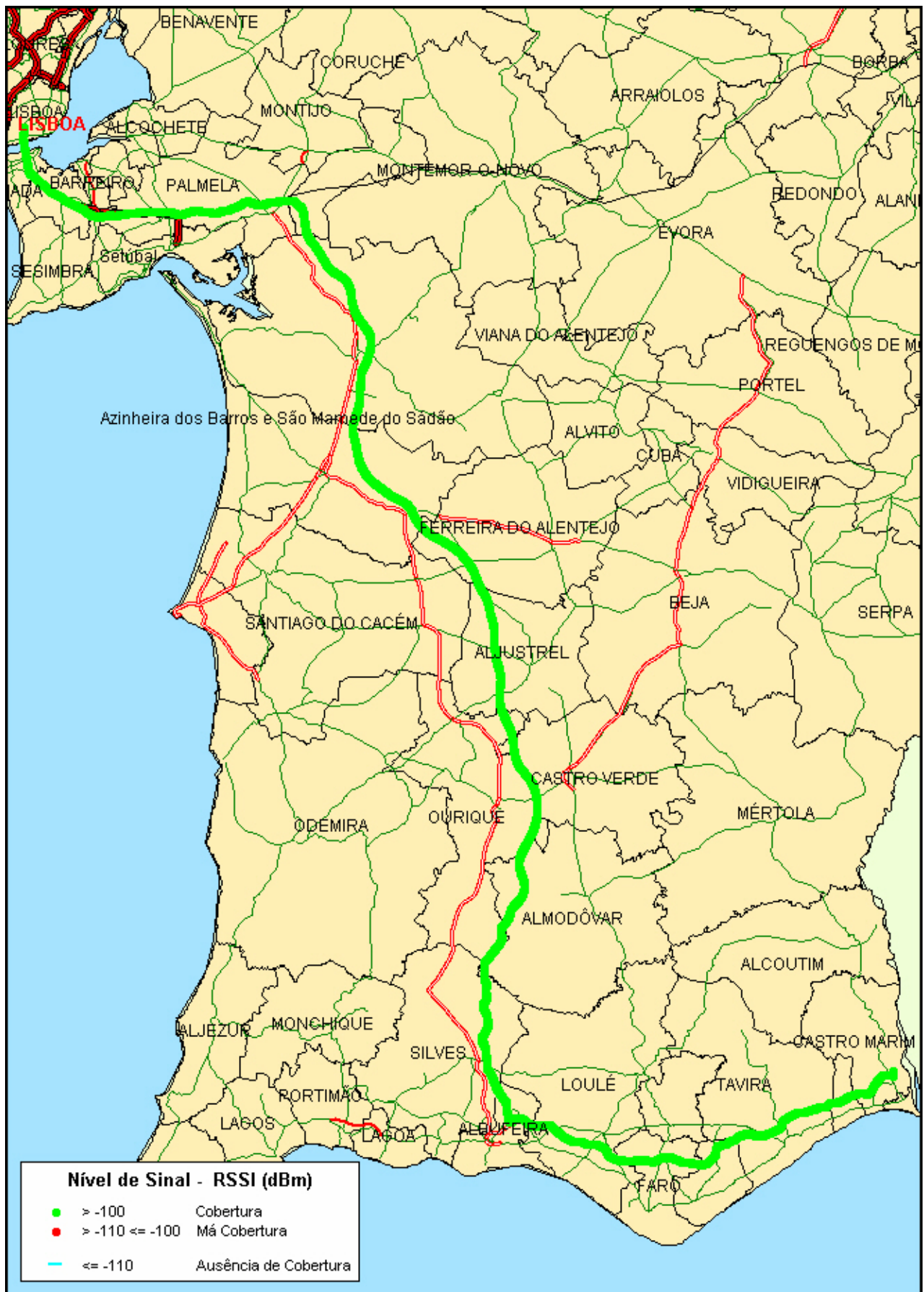## LISBON-VILA REAL DE STO. ANTÓNIO (A2 + A22)

OPTIMUS – PSTN

LISBON-VILA REAL DE STO. ANTÓNIO (A2 + A22)

VODAFONE – PSTN

Nível de Sinal - RSSI (dBm)

- ● > -100   Cobertura
- ● > -110 <= -100   Má Cobertura
- — <= -110   Ausência de Cobertura

LISBON-VILA REAL DE STO. ANTÓNIO (A2 + A22)

TMN – PSTN

Nível de Sinal - RSSI (dBm)

●	> -100	Cobertura
●	> -110 <= -100	Má Cobertura
—	<= -110	Ausência de Cobertura
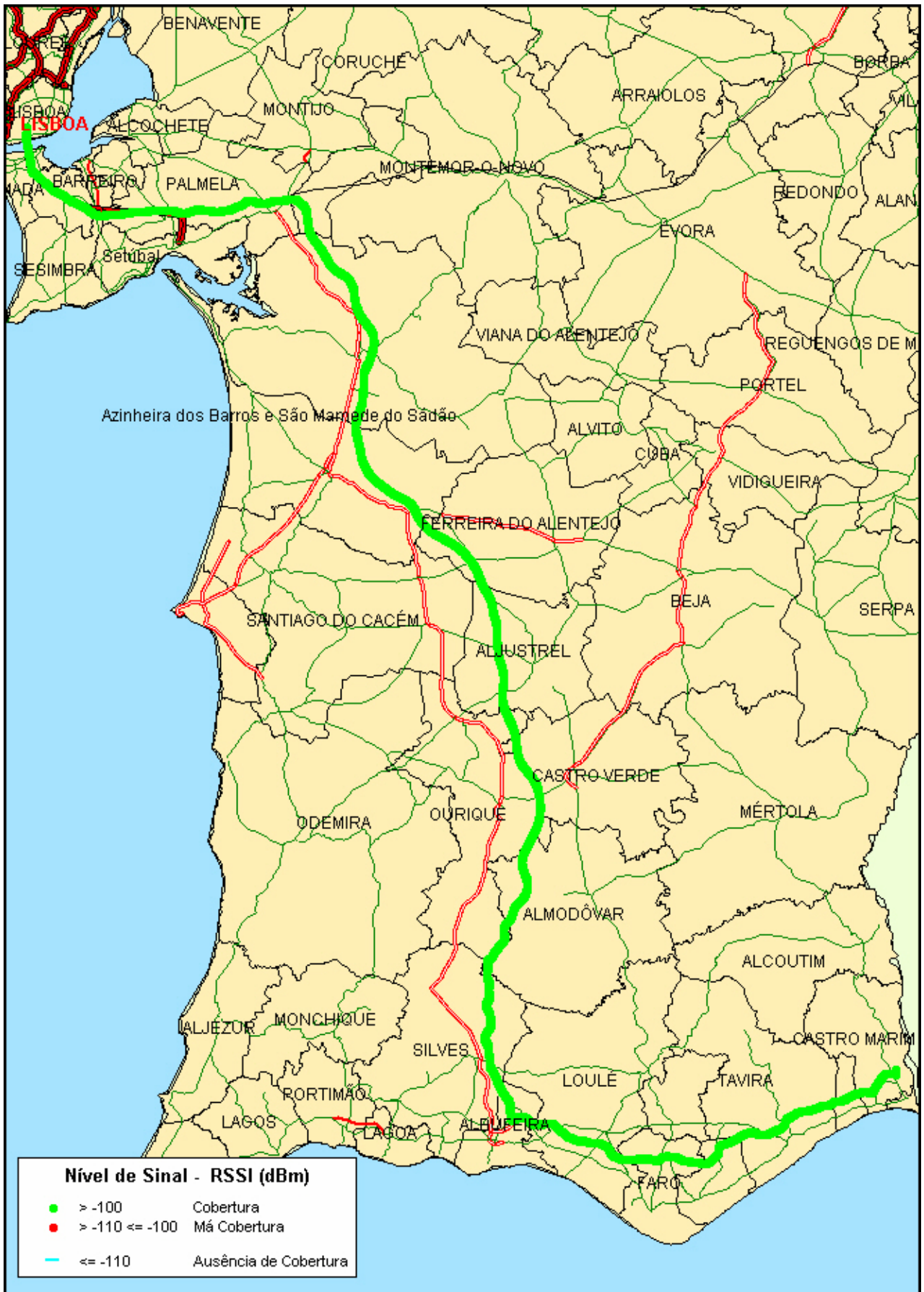
2.3 LISBON-PORTO (A1)

Measurement Sessions performed on:
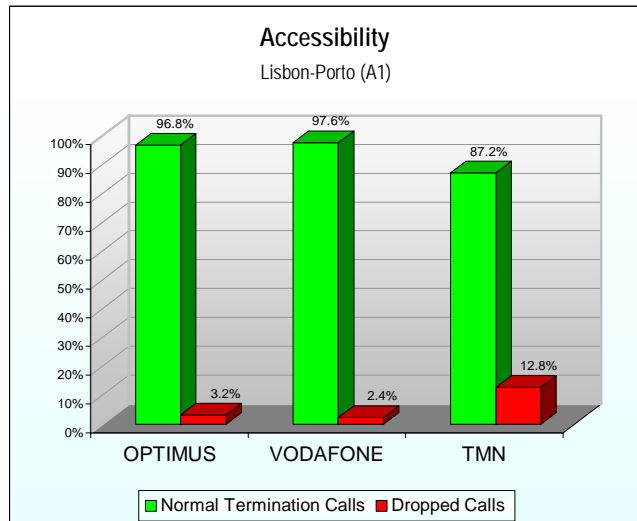- **10 May 2005** between 8h27 and 11h40 and 13h35 and 16h38
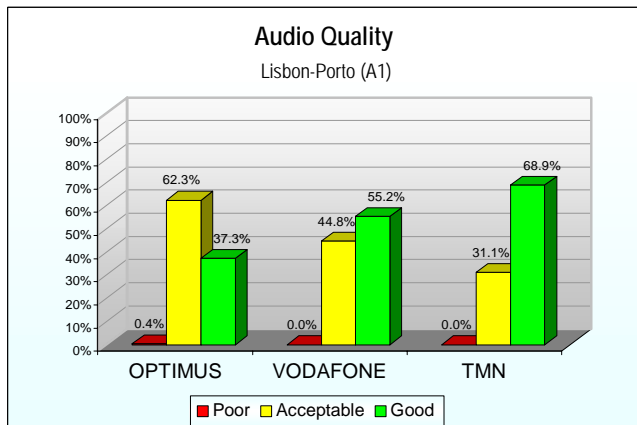- **18 May 2005 between** 8h33 and 11h40 and 12h21 and 15h33

2.3.1 ACCESSIBILITY

Calls Made		Operator	OPTIMUS	VODAFONE	TMN
		Total	124 100%	125 100%	125 100%
Routed Calls		Total	122 98.4%	125 100.0%	122 97.6%
		Abandoned During Conversation	2 1.6%	3 2.4%	13 10.4%
		Normal Termination Calls	120 96.8%	122 97.6%	109 87.2%
Non-Routed Calls			2 1.6%	0 0.0%	3 2.4%
Dropped Calls	Call Ending Cause	Total	4 3.2%	3 2.4%	16 12.8%
		No Service	0 0.0%	0 0.0%	0 0.0%
		Congestion	3 2.4%	1 0.8%	9 7.2%
		Radio Link Failure	1 0.8%	0 0.0%	1 0.8%
		Other	0 0.0%	2 1.6%	6 4.8%

Accessibility
Lisbon-Porto (A1)

2.3.2 AUDIO QUALITY

Calls With Measurements	Operator	OPTIMUS	VODAFONE	TMN
	Total	244 100%	248 100%	238 100%
Audio Quality (MOS)	Poor	1 0.4%	0 0.0%	0 0.0%
	Acceptable	152 62.3%	111 44.8%	74 31.1%
	Good	91 37.3%	137 55.2%	164 68.9%

Audio Quality
Lisbon-Porto (A1)

2.3.3 COVERAGE

(Following pages)

LISBON-PORTO (A1)

OPTIMUS – PSTN

Nível de Sinal - RSSI (dBm)

- > -100   Cobertura
- > -110 ^ <=-100   Má Cobertura
- <=-110   Ausência de cobertura

Lisbon-Porto (A1)

VODAFONE – PSTN

Nível de Sinal - RSSI (dBm)

- **> -100**   Cobertura
- **> -110 ^ <=-100**   Má Cobertura
- **<=-110**   Ausência de cobertura

LISBON-PORTO (A1)

TMN – PSTN

Nível de Sinal - RSSI (dBm)

- > -100   Cobertura
- > -110 ^ <=-100   Má Cobertura
- <=-110   Ausência de cobertura
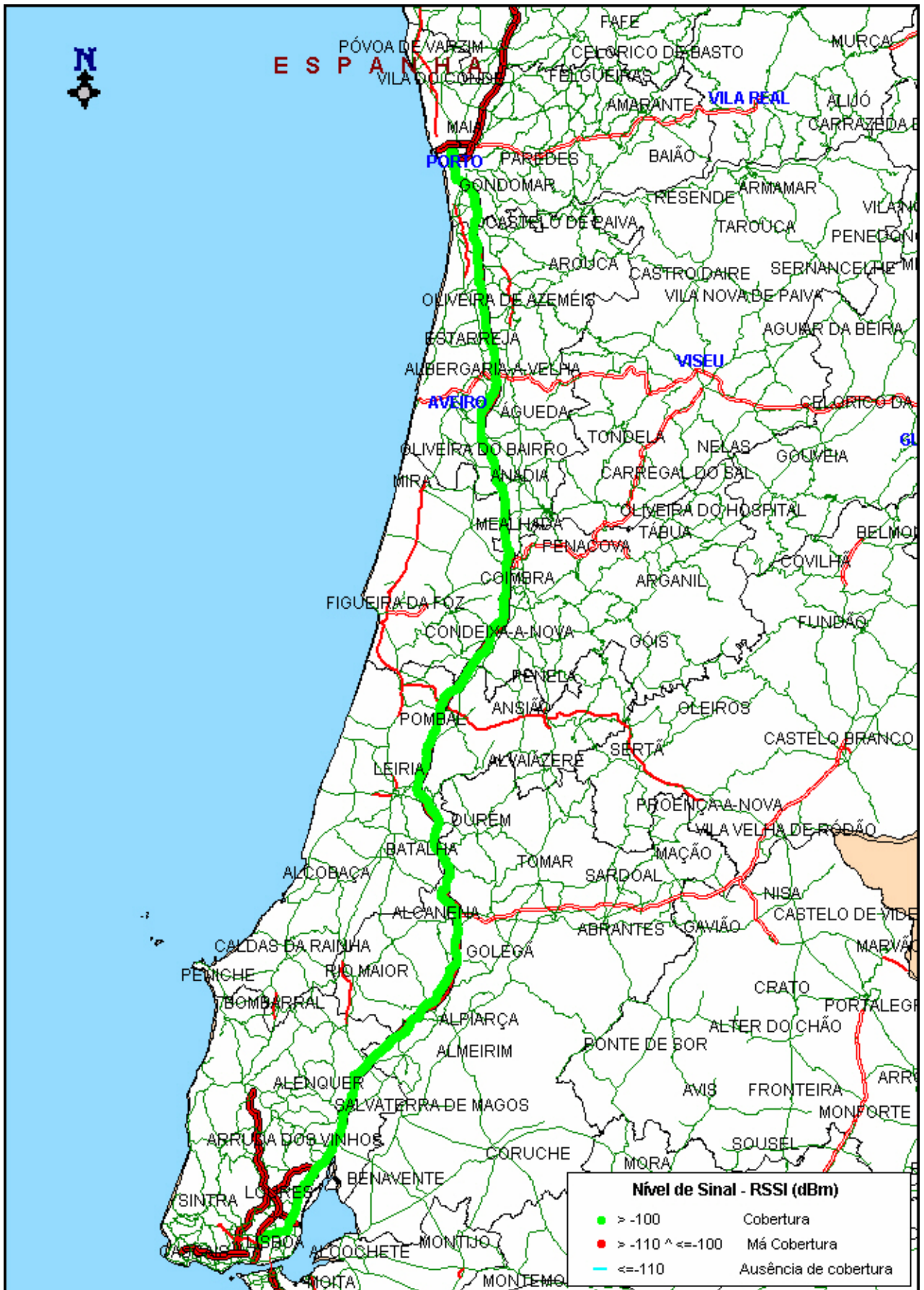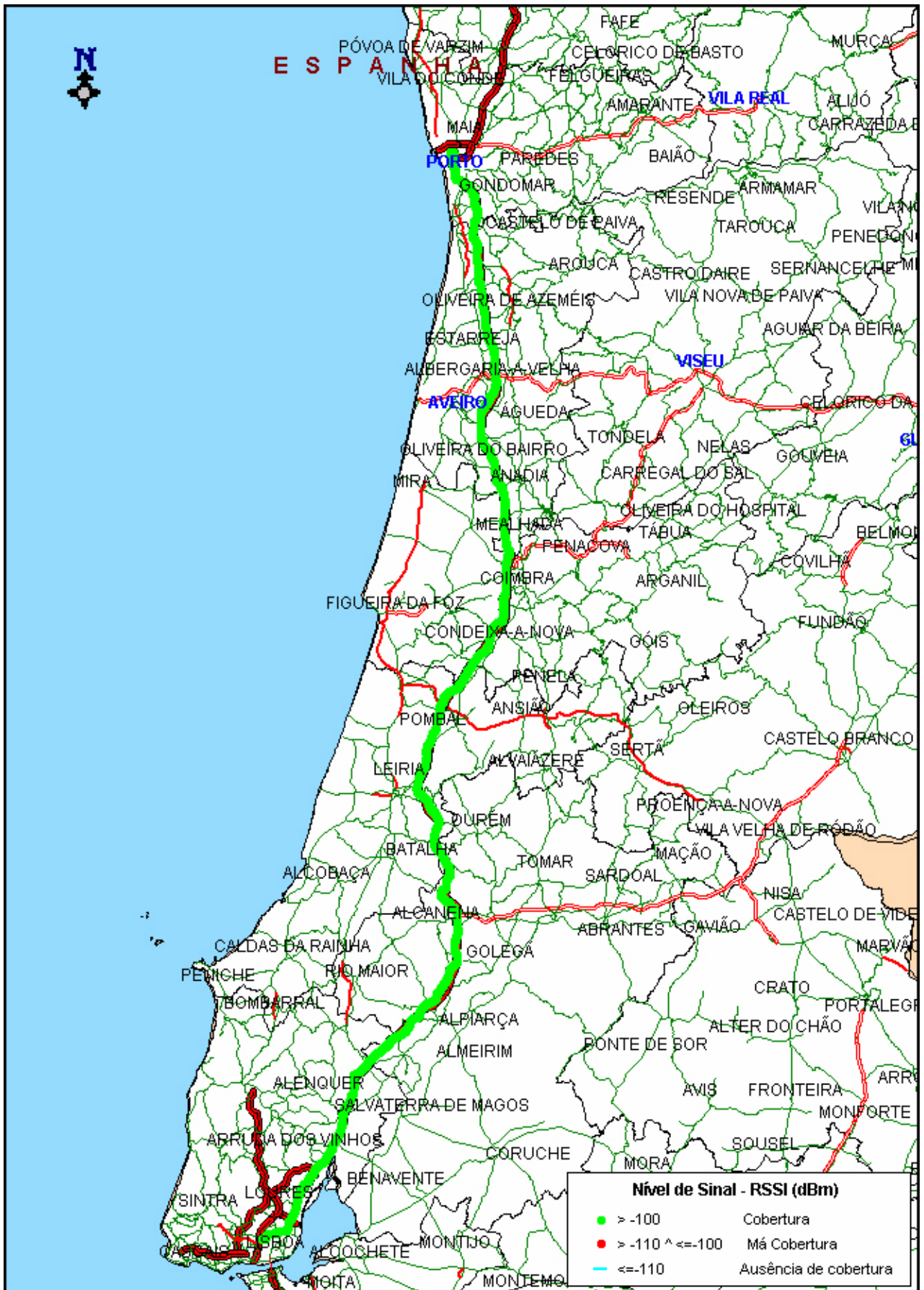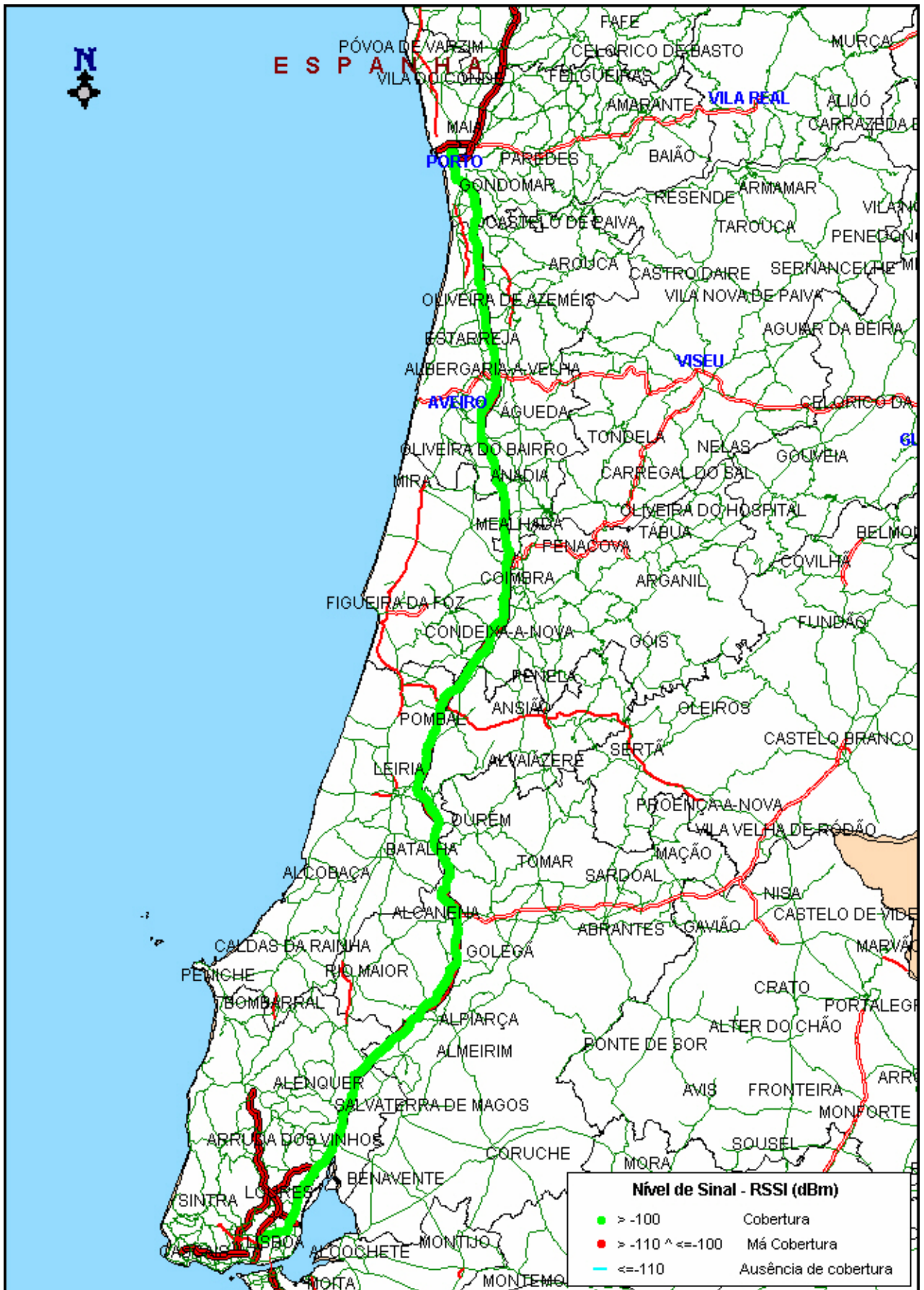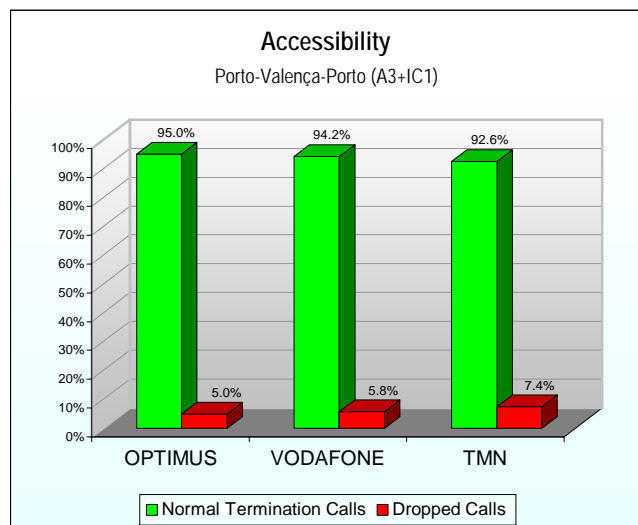
2.4 PORTO-VALENÇA-PORTO (A3 + IC1)

> **Measurement Sessions performed on**:
> - **9 May 2005** between 9h53 and 12h45 and 13h59 and 16h55
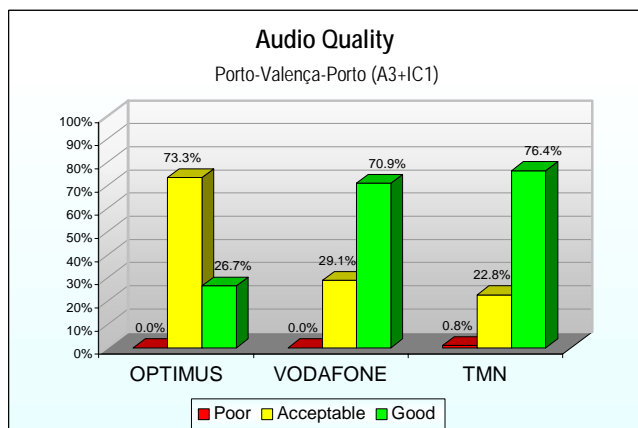> - **17 May 2005** between 8h39 and 11h52 and 13h15 and 16h20

2.4.1 ACCESSIBILITY

	Operator	OPTIMUS	VODAFONE	TMN
Calls Made	Total	121 100%	121 100%	121 100%
Routed Calls	Total	120 99.2%	118 97.5%	119 98.3%
	Abandoned During Conversation	5 4.1%	4 3.3%	7 5.8%
	Normal Termination Calls	115 95.0%	114 94.2%	112 92.6%
Non-Routed Calls		1 0.8%	3 2.5%	2 1.7%
Dropped Calls (Call Ending Cause)	Total	6 5.0%	7 5.8%	9 7.4%
	No Service	0 0.0%	0 0.0%	0 0.0%
	Congestion	3 2.5%	4 3.3%	5 4.1%
	Radio Link Failure	1 0.8%	0 0.0%	2 1.7%
	Other	2 1.7%	3 2.5%	2 1.7%

Accessibility
Porto-Valença-Porto (A3+IC1)

	OPTIMUS	VODAFONE	TMN
Normal Termination Calls	95.0%	94.2%	92.6%
Dropped Calls	5.0%	5.8%	7.4%

2.4.2 AUDIO QUALITY

	Operator	OPTIMUS	VODAFONE	TMN
Calls With Measurements	Total	240 100%	234 100%	237 100%
Audio Quality (MOS)	Poor	0 0.0%	0 0.0%	2 0.8%
	Acceptable	176 73.3%	68 29.1%	54 22.8%
	Good	64 26.7%	166 70.9%	181 76.4%

Audio Quality
Porto-Valença-Porto (A3+IC1)

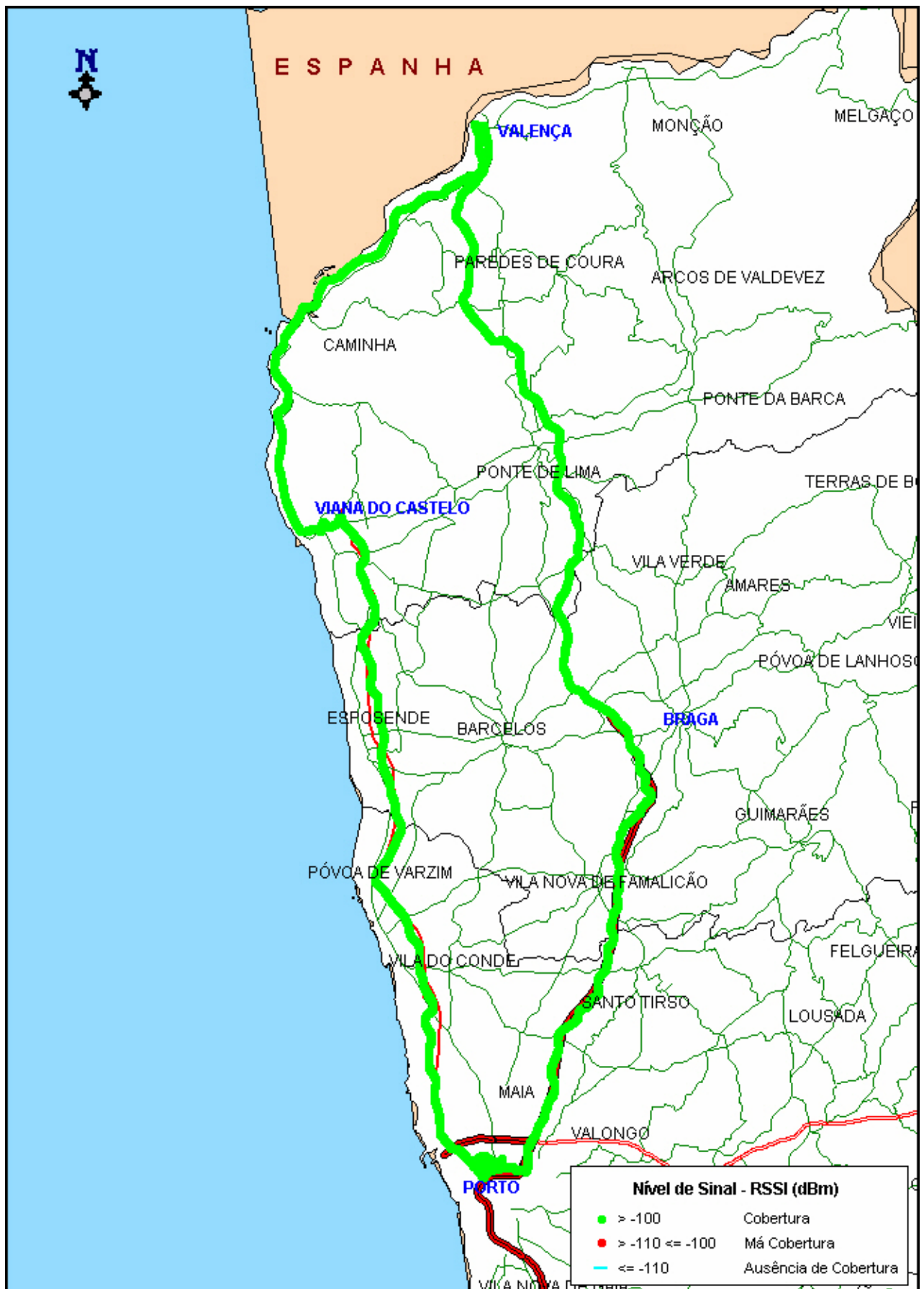|	OPTIMUS	VODAFONE	TMN
Poor	0.0%	0.0%	0.8%
Acceptable	73.3%	29.1%	22.8%
Good	26.7%	70.9%	76.4%

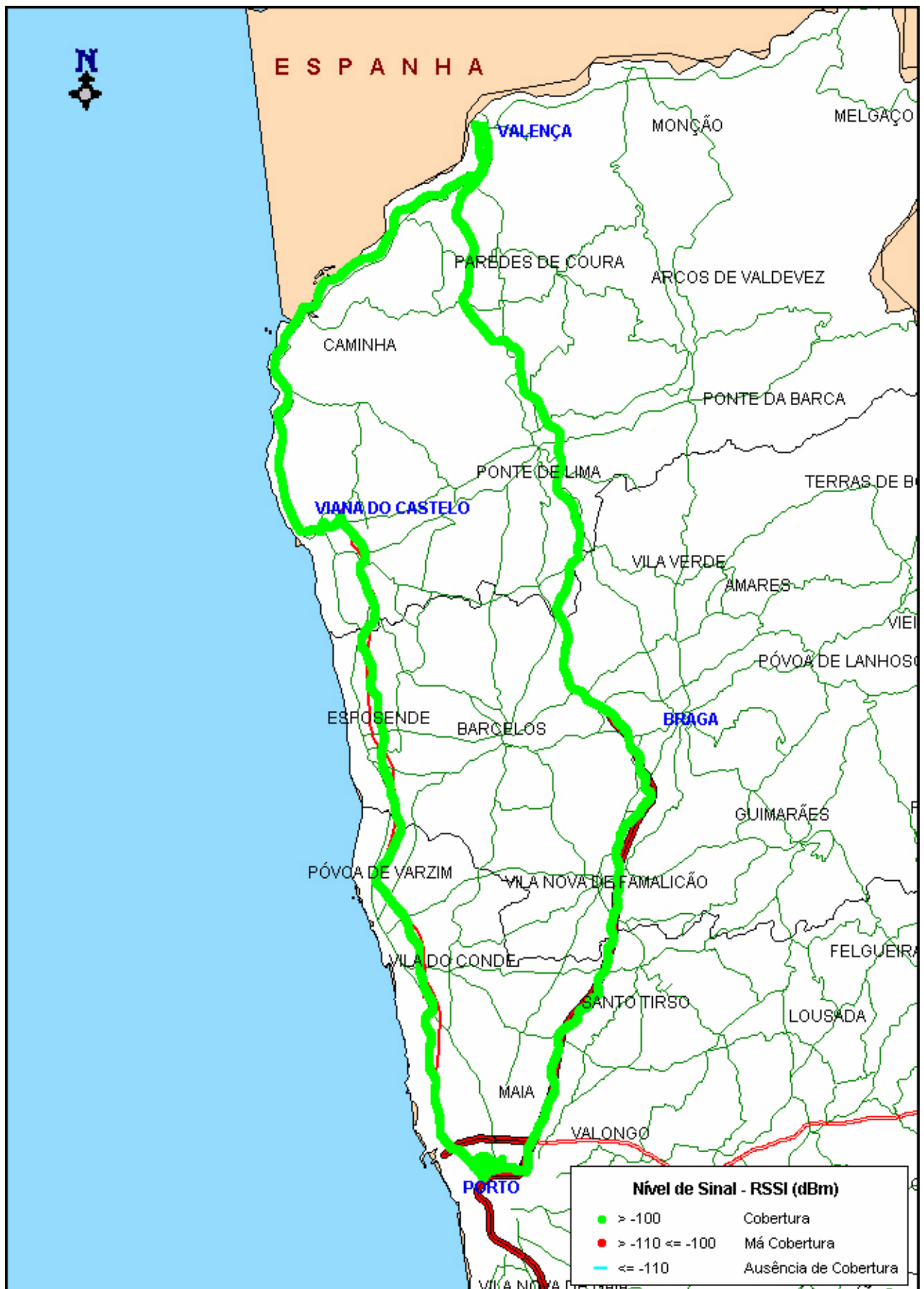### 2.4.3 COVERAGE

(Following pages)

PORTO-VALENÇA-PORTO (A3 + IC1)
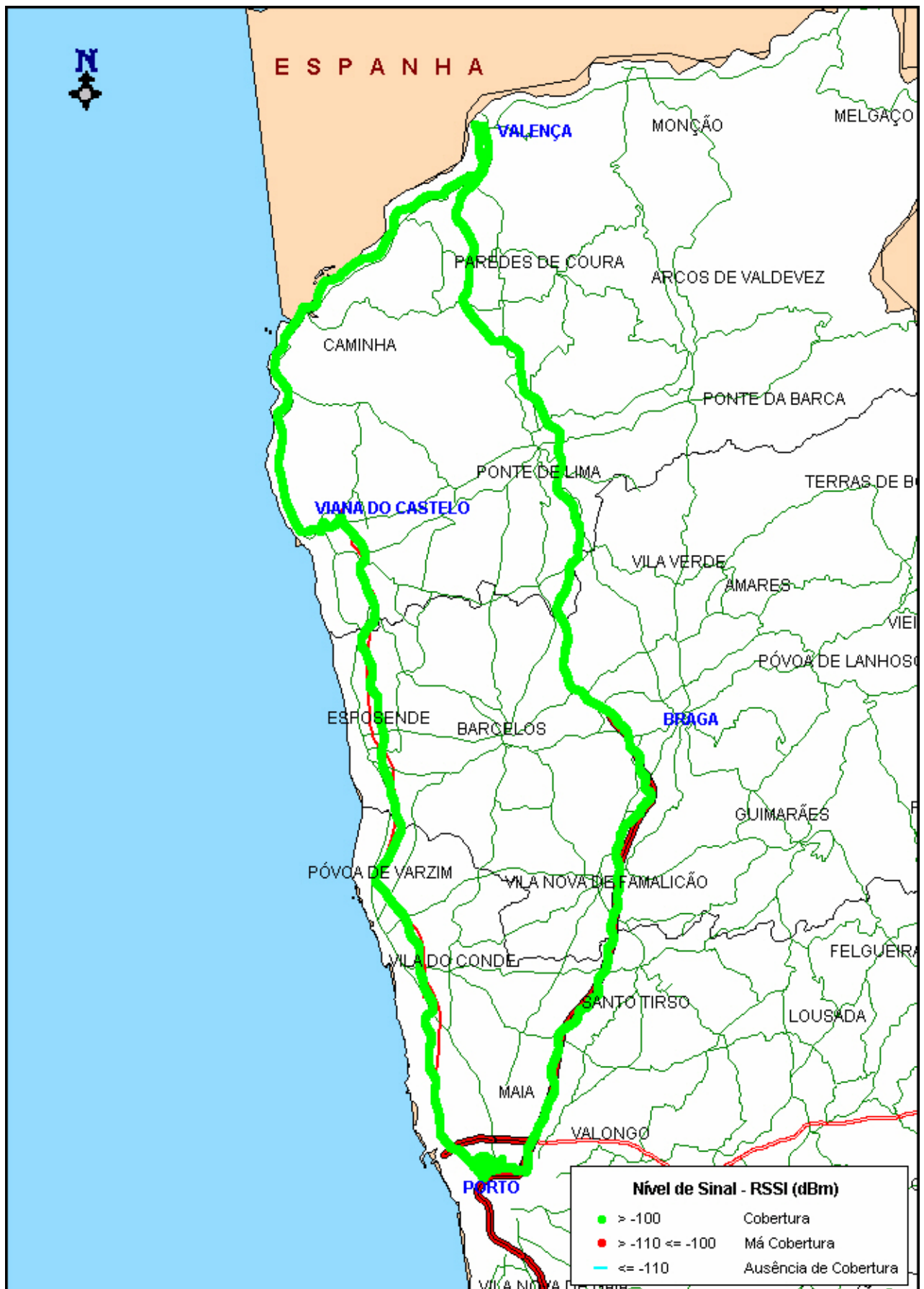
OPTIMUS – PSTN

PORTO-VALENÇA-PORTO (A3 + IC1)
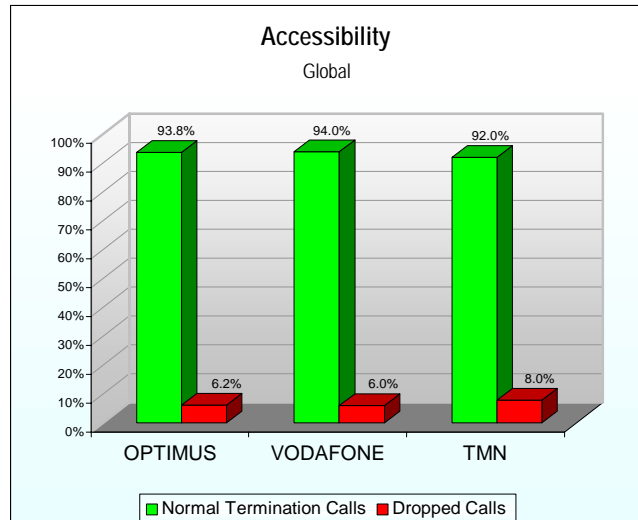
VODAFONE – PSTN

PORTO-VALENÇA-PORTO (A3 + IC1)

TMN – PSTN

2.5 GLOBAL

Precision Indicators, at a 96% confidence level

	OPTIMUS	VODAFONE	TMN
Accessibility	2.11%	2.07%	2.38%
Poor Audio Quality	0.28%	0.49%	1.31%
Acceptable Audio Quality	3.13%	3.02%	3.00%
Good Audio Quality	3.13%	3.03%	3.08%

2.5.1 ACCESSIBILITY

	Operator	OPTIMUS	VODAFONE	TMN
Calls Made	Total	502 / 100%	502 / 100%	499 / 100%
Routed Calls	Total	493 / 98.2%	487 / 97.0%	489 / 98.0%
Routed Calls	Abandoned During Conversation	22 / 4.4%	15 / 3.0%	30 / 6.0%
Routed Calls	Normal Termination Calls	471 / 93.8%	472 / 94.0%	459 / 92.0%
Non-Routed Calls		9 / 1.8%	15 / 3.0%	10 / 2.0%
Dropped Calls	Total	31 / 6.2%	30 / 6.0%	40 / 8.0%
Dropped Calls / Call Ending Cause	No Service	0 / 0.0%	2 / 0.4%	0 / 0.0%
Dropped Calls / Call Ending Cause	Congestion	14 / 2.8%	15 / 3.0%	18 / 3.6%
Dropped Calls / Call Ending Cause	Radio Link Failure	7 / 1.4%	2 / 0.4%	11 / 2.2%
Dropped Calls / Call Ending Cause	Other	10 / 2.0%	11 / 2.2%	11 / 2.2%

Accessibility — Global

OPTIMUS: Normal Termination Calls 93.8%, Dropped Calls 6.2%
VODAFONE: Normal Termination Calls 94.0%, Dropped Calls 6.0%
TMN: Normal Termination Calls 92.0%, Dropped Calls 8.0%

2.5.2 AUDIO QUALITY

	Operator	OPTIMUS	VODAFONE	TMN
Calls With Measurements	Total	976 / 100%	968 / 100%	967 / 100%
Audio Quality (MOS)	Poor	2 / 0.2%	6 / 0.6%	44 / 4.6%
Audio Quality (MOS)	Acceptable	463 / 47.4%	344 / 35.5%	335 / 34.6%
Audio Quality (MOS)	Good	511 / 52.4%	618 / 63.8%	588 / 60.8%

Audio Quality — Global

OPTIMUS: Poor 0.2%, Acceptable 47.4%, Good 52.4%
VODAFONE: Poor 0.6%, Acceptable 35.5%, Good 63.8%
TMN: Poor 4.6%, Acceptable 34.6%, Good 60.8%

White