ANACOM

AUTORIDADE
NACIONAL
DE COMUNICAÇÕES

Mobile Communications Systems

GSM/UMTS

Quality of Service Assessment

Assessment of the QoS of Voice and Video-telephony Services, and GSM and WCDMA Network Coverage, in the main Urban Agglomerations and on the Major Roads of Mainland Portugal.

November 2011

ANACOM

ABBREVIATIONS AND ACRONYMS

CoDec   Codifier/De-codifier

CPICH RSCP   Common Pilot Channel, Received Signal Code Power – Level of the signal received by a mobile terminal (WCDMA).

ETSI   European Telecommunications Standards Institute

GSM   Global System for Mobile communications – Second generation (2G) Mobile Communications System.

ITU   International Telecommunications Union.

MOS   MOS Mean Opinion Score – Quality index quantifying the effort to understand an end-to-end type conversation. Its limits are 0 (zero) when there is no communication and 5 (five) when the communication is perfect. The value "zero" never shows in the results since only connections that were established and maintained for a given period are considered. "Five" never shows in the results either, because the CoDec used by mobile networks renders such high voice or video quality values impossible (the voice or video quality reached with the CoDec usually used gives MOS values lower than 4.5).

PESQ   Perceptual Evaluation of Speech Quality – Algorithm used to analyse the audio quality of a voice communication (Recommended by ITU: ITU-T Recommendation P.862 (02/2001); ITU-T Recommendation P.862.1 (11/2003)).

ISDN   Integrated Services Digital Network – Technology used on the fixed access network.

RF   Radio Frequency.

RxLev   Received signal level, at a mobile terminal (GSM).

s   Second – time unit.

Scanner   Scanner Measurement equipment that collects radio signal levels for each channel of a frequency band.

SQuad-LQ   SwissQual's speech quality algorithm for Listening Quality – Algorithm developed by SwissQual to analyse the audio quality of a communication.

UMTS   Universal Mobile Telecommunications System – Third generation (3G) Mobile Communications System.

VQuad   Objective Model for Video Quality Assessment – Algorithm used to analyse the video quality of a communication (developed by SwissQual).

WCDMA   Wideband Code Division Multiple Access – Technology used in the radio component of the UMTS communications systems.

Contents

I   EXECUTIVE SUMMARY

I.I   GENERAL FRAMEWORK

In September and October 2011 the Autoridade Nacional de Comunicações (ANACOM) carried out an assessment of the quality of mobile services – voice telephony, video telephony and coverage of the GSM and WCDMA (UMTS) networks – provided by operators OPTIMUS, TMN and VODAFONE in the main urban agglomerations and on the major roads in mainland Portugal. For this, the technical parameters which reflect the perception of quality from the consumer standpoint were analysed.

The method used in this study relied on field tests performed from the user's standpoint. An automatic measurement system that reflects the several features affecting the quality of the services (end-to-end measurements) was used. Measurements were carried out on equal terms for the three operators, i.e. at the same time, in the same locations and with the same parameters, thus making it possible to perform a comparative analysis of the observed performances.

The main quality indicators were analysed, considering the user's perspective and the services under study:

Network Radio Coverage – Availability of the GSM and WCDMA (UMTS) radio networks;

Service Accessibility (voice or video telephony) – probability of success when setting up calls;

Call Setup Time (voice or video telephony) – period of time that the network takes to establish the communication, after the correct sending of the request (target telephone number);

Call Completion Rate (voice or video telephony) – Probability of a call being maintained for a period of time after it is successfully set up, and ending normally, i.e. according to the user's will;

Call Listening Quality (voice or video telephony) – perceptibility of the conversation during a call;

Call Visual Quality (voice or video telephony) – perceptibility of the communication's visual feature.

Data were collected on working days during normal working hours, from 19 September to 25 October 2011. 25,710 test calls were made and 4,679,015 radio signal level measurements were taken, amounting to over 223 hours of measurements over approximately 10,000 kilometres.

The sample used provided global results for each operator, with a maximum error below 2.3% in urban agglomerations, and below 3.5% on major roads, for a 95% confidence level.

In view of these services' penetration rate and the diversity of the terminal equipment that is used, and given each user's subjective view, it is impossible to rigorously reproduce each consumer's conditions of interaction with the networks. In this context, the results of this study must be taken as an indicator of the networks' global behaviour, since it does not intend to evaluate the compliance with licenses by the mobile operators. The transposition/extrapolation of these results to specific situations requires some prudence, at the risk that biased conclusions might be drawn.

The technical and methodological options of this study directly influenced its results and must be taken into account when analysing the results, as follows.

- Tests were exclusively based on a technical solution (hardware + software) and performed totally automatically, thereby setting a level playing field for the monitoring of the three operators and eliminating the subjectivity inherent to the human user;

- It used *NOKIA N95* and *NOKIA 6680* terminal equipment;

- Tests were carried out in moving vehicles and with outdoor antennas (without gain);

- Call duration, for both voice and video telephony, was 120 seconds;

- Voice and video-telephony tests were made with automatic selection of the GSM or UMTS infrastructure;

- Radio coverage indicators, particularly WCDMA coverage, do not take into account networks' loads (number of simultaneous users and type of services used);

- The results of the study only reflect the behaviour of the networks in the locations and at the time the measurements were taken;

- Operators are constantly improving their networks. The technical interventions necessary for these improvements can cause momentary degradation of the service in the geographic area of intervention.

I.II   MAIN RESULTS AND CONCLUSIONS

Mobile communications systems present good GSM coverage levels and a good performance for the voice service, in the urban centres and on the major roads of Mainland Portugal.

The video-telephony service and the WCDMA coverage perform differently according to the location analysed. In urban agglomerations the video-telephony service shows good performance levels and WCDMA coverage is good. On major roads, performance and coverage levels are fair for operator OPTIMUS and TMN, and poor for VODAFONE.

GSM and WCDMA Network Coverage

The mobile communications systems studied have good GSM coverage levels, both in urban agglomerations and on major roads, with no significant differences between operators (*Figure 1 – Radio Coverage* Indicator in the Urban Agglomerations of Mainland Portugal.

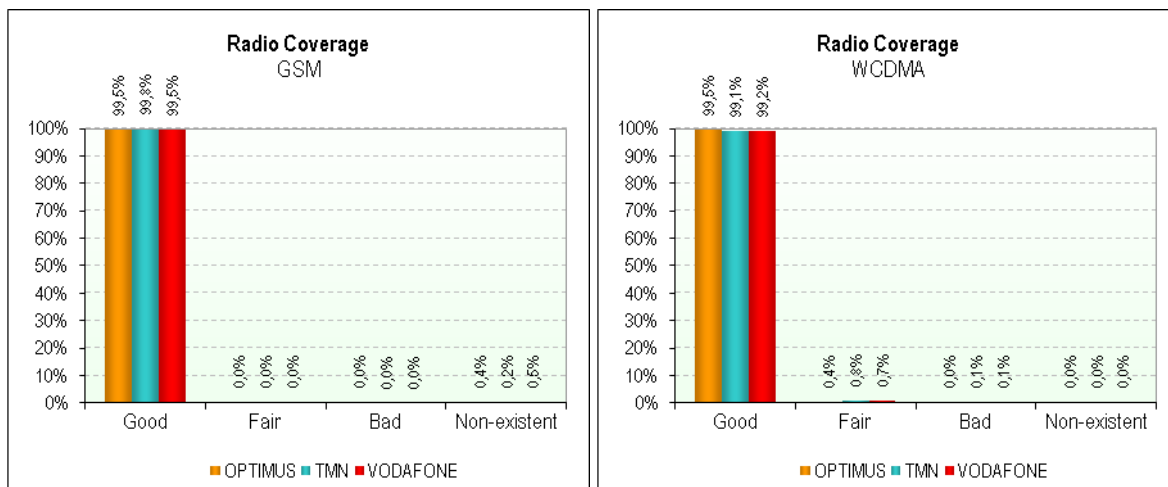and *Figure 2 – Radio Coverage* Indicator on the Major Roads of Mainland Portugal.

), maintaining the same levels as in the study carried out in September-November 2010 (*Figure 1 – Radio Coverage* Indicator in the Urban Agglomerations of Mainland Portugal.

and *Figure 2 – Radio Coverage* Indicator on the Major Roads of Mainland Portugal.

).

Figure 1 – *Radio Coverage* Indicator in the Urban Agglomerations of Mainland Portugal.

Table 1 **–** Evolution of the Radio Coverage indicator from 2010 to 2011 in the Urban Agglomerations of Mainland Portugal.
(Difference between the values recorded in the 2011 study and the values recorded in the 2010 study)

		GSM			WCDMA		
		OPTIMUS	TMN	VODAFONE	OPTIMUS	TMN	VODAFONE
Radio Coverage	Good	-0.12%	0.03%	-0.13%	1.39%	1.63%	2.14%
	Fair	-0.02%	-0.01%	-0.02%	-1.22%	-1.40%	-1.74%
	Poor	0.00%	0.00%	0.00%	-0.16%	-0.20%	-0.35%
	Non-existent	0.14%	-0.02%	0.15%	-0.01%	-0.03%	-0.06%

WCDMA (UMTS) networks have better radio coverage levels in urban areas than in major roads (*Figure 1 – Radio Coverage* Indicator in the Urban Agglomerations of Mainland Portugal.

and *Figure 2 – Radio Coverage* Indicator on the Major Roads of Mainland Portugal.

). In comparison with the study carried out in September-November 2010, there is an improvement in the *Good Radio Coverage* levels particularly on major roads (*Figure 1 – Radio Coverage* Indicator in the Urban Agglomerations of Mainland Portugal.

and *Figure 2 – Radio Coverage* Indicator on the Major Roads of Mainland Portugal.

). Differences between operators are not relevant in urban agglomerations, since they all have *Good*

Radio Coverage in over 99% of the measurements made. On major roads, *WCDMA Radio Coverage* is poorer, given the number of areas where coverage is poor or even non-existent, and there are also significant differences between operators. TMN and OPTIMUS have the best performances, with 95% of measurements rating as *Good Radio Coverage* levels, while the figure for VODAFONE is only 84.1%.
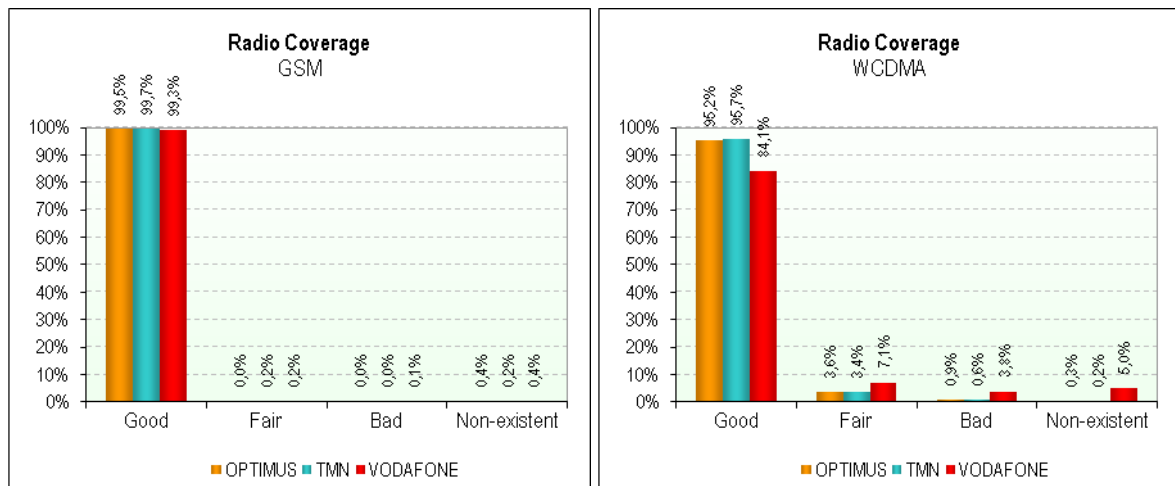

Figure 2 – *Radio Coverage* Indicator on the Major Roads of Mainland Portugal.

Table 2 – Evolution of the *Radio Coverage* indicator from 2010 to 2011 in the Urban Agglomerations of Mainland Portugal.
(Difference between the values recorded in the 2011 study and the values recorded in the 2010 study)

		GSM			WCDMA		
		OPTIMUS	TMN	VODAFONE	OPTIMUS	TMN	VODAFONE
Radio Coverage	Good	0.17%	0.11%	0.58%	8.10%	5.67%	8.74%
	Fair	-0.22%	-0.08%	-0.57%	-5.10%	-3.76%	-2.94%
	Poor	-0.01%	-0.01%	-0.06%	-2.14%	-1.43%	-1.82%
	Non-existent	0.06%	-0.02%	0.05%	-0.86%	-0.48%	-3.98%

Voice Service

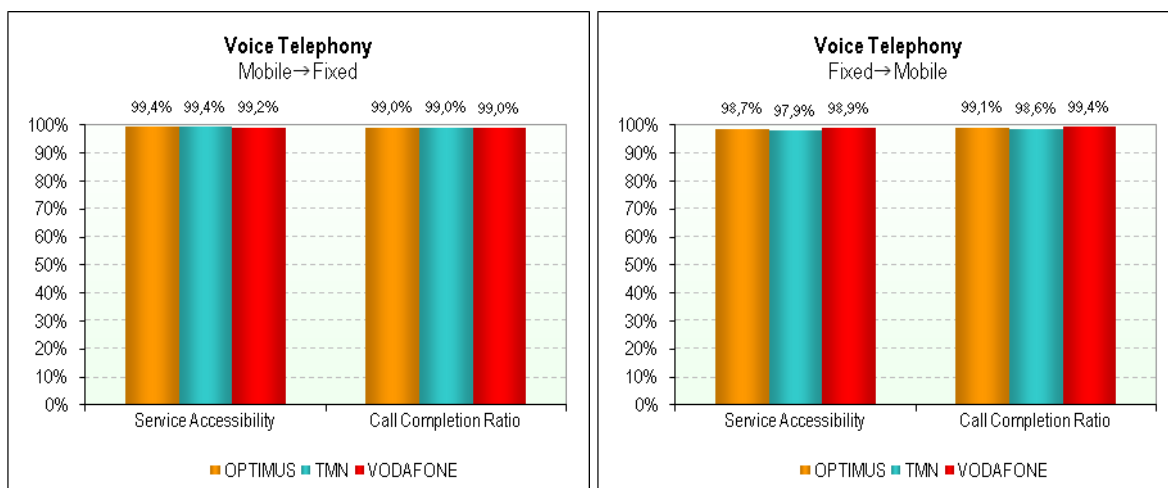The voice service has good results in all analysed indicators, both in urban agglomerations and on major roads (*Figure 3 – Service Accessibility* and *Call Completion Rate* indicators in the Urban Agglomerations of Mainland Portugal.

, *Figure 4 – Service Accessibility* and *Call Completion Rate* indicators on the Major Roads of Mainland Portugal.

, *Figure 5 – Call Setup Time* indicator in the Urban Agglomerations of Mainland Portugal.

, *Figure 6 – Call Setup Time* indicator on the Major Roads of Mainland Portugal.

, *Figure 7 – Call Listening Quality* indicator in the Urban Agglomerations of Mainland Portugal.

and *Figure 8 – Call Listening Quality* indicator on the Major Roads of Mainland Portugal.

), and no major changes were observed in comparison with the performance recorded in the study carried out in September-November 2010 (*Figure 4 – Service Accessibility* and *Call Completion Rate* indicators on the Major Roads of Mainland Portugal.

and *Table 4* – Evolution of the *Service Accessibility*, *Call Completion Rate*, *Average Call Setup Time* and *Average Audio Quality* indicators, from 2010 to 2011, on the Major Roads of Mainland Portugal.

).

Figure 3 – *Service Accessibility* and *Call Completion Rate* indicators in the Urban
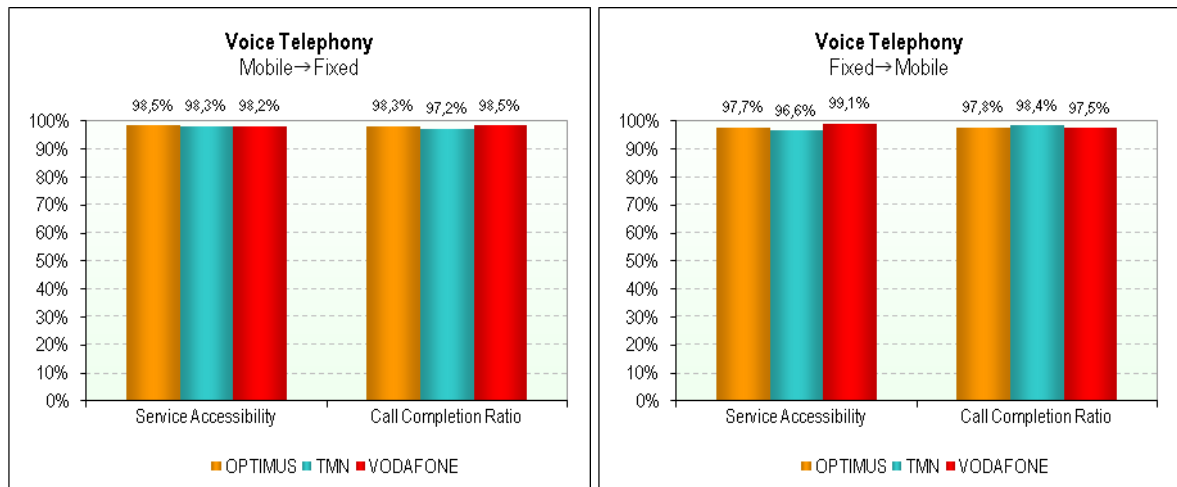Agglomerations of Mainland Portugal.

Figure 4 – *Service Accessibility* and *Call Completion Rate* indicators on the Major Roads
of Mainland Portugal.

Table 3 – Evolution of the *Service Accessibility*, *Call Completion Rate*, *Average Call Setup Time* and *Average Listening Quality* indicators,
from 2010 to 2011, in the Urban Agglomerations of Mainland Portugal.
(Difference between the values recorded in the 2011 study and the values recorded in the 2010 study)

		OPTIMUS		TMN		VODAFONE	
		Mobile→Fixed	Fixed→Mobile	Mobile→Fixed	Fixed→Mobile	Mobile→Fixed	Fixed→Mobile
Voice Service	Service Accessibility	-0.13%	0.08%	-0.19%	1.36%	0.00%	-0.52%
	Call Completion Rate	0.33%	0.01%	-0.06%	-0.31%	-0.26%	-0.13%
	Average Call Setup Time [s]	-0.15	-0.83	-0.23	-0.49	-0.07	-0.61
	Average Listening Quality	-0.044	-0.028	0.091	0.075	-0.015	-0.033

Table 4 – Evolution of the *Service Accessibility*, *Call Completion Rate*, *Average Call Setup Time* and *Average Audio Quality* indicators,
from 2010 to 2011, on the Major Roads of Mainland Portugal.
(Difference between the values recorded in the 2011 study and the values recorded in the 2010 study)

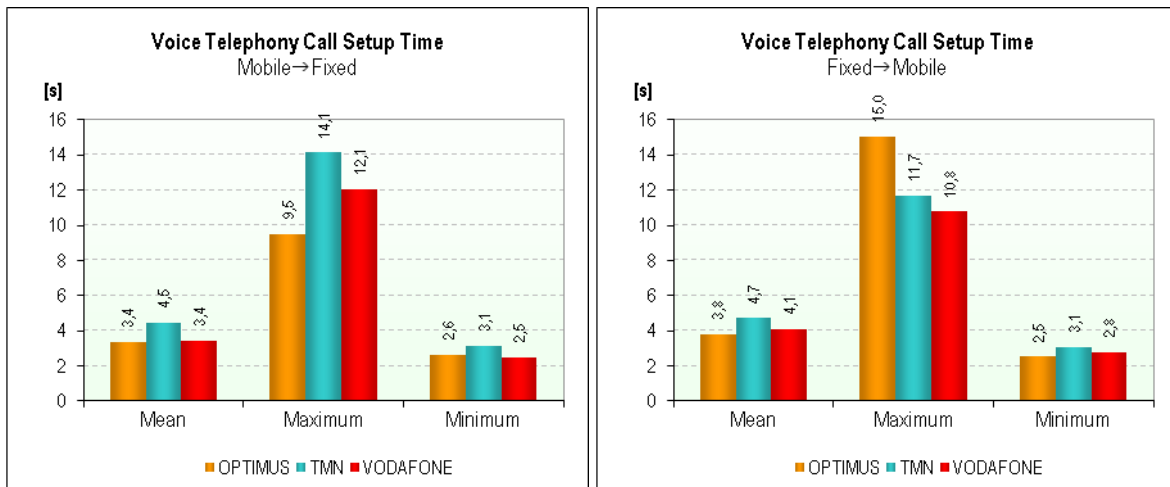|		OPTIMUS		TMN		VODAFONE	
		Mobile→Fixed	Fixed→Mobile	Mobile→Fixed	Fixed→Mobile	Mobile→Fixed	Fixed→Mobile
Voice Service	Service Accessibility	-0.01%	0.14%	-1.22%	1.05%	-0.62%	0.44%
	Call Completion Rate	0.29%	0.62%	0.25%	1.62%	0.87%	-0.66%
	Average Call Setup Time [s]	-0.29	-0.74	-0.41	-0.57	-0.13	-0.75
	Average Listening Quality	-0.054	-0.054	0.109	0.019	-0.031	-0.033

Figure 5 – *Call Setup Time* indicator in the Urban Agglomerations of Mainland Portugal.
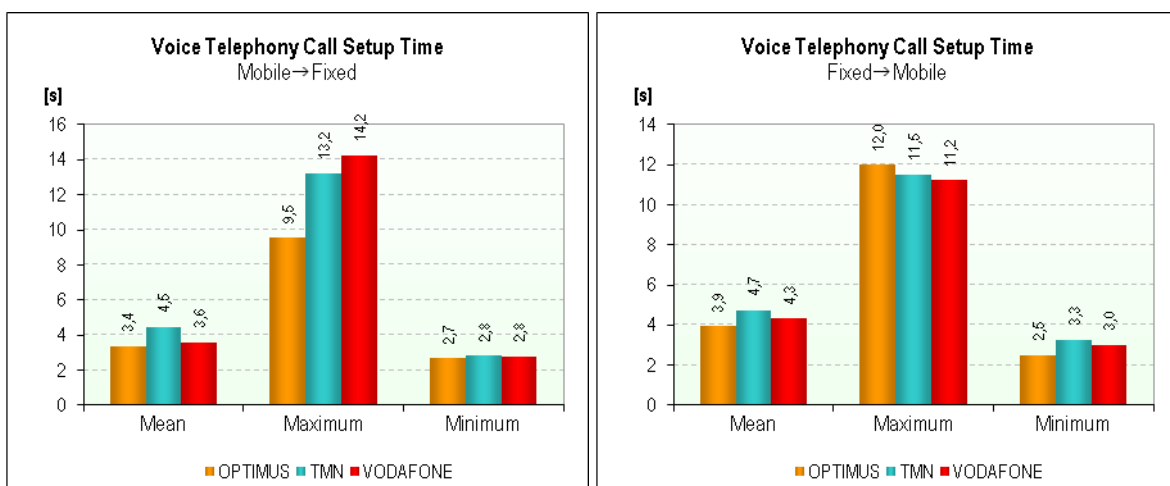

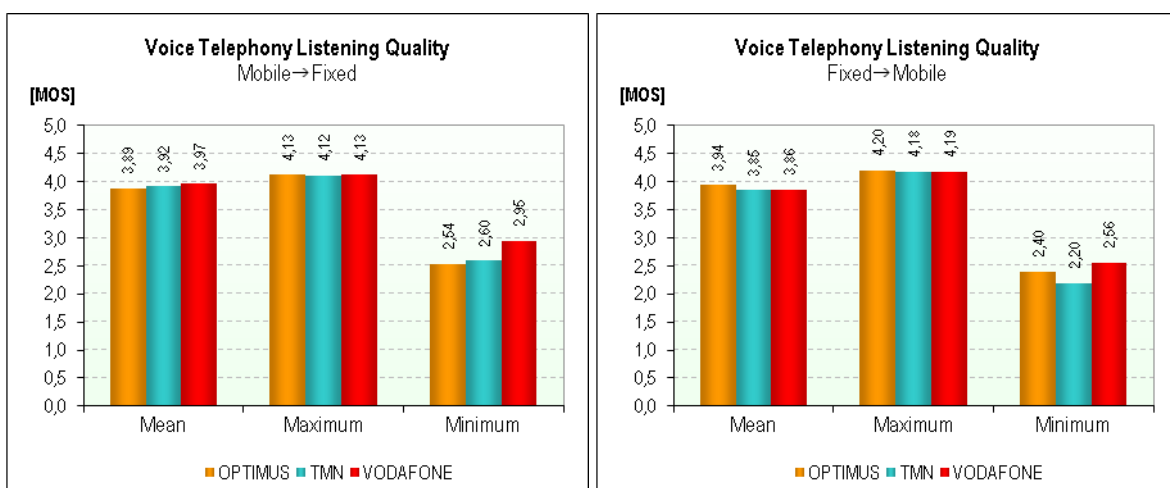Figure 6 – *Call Setup Time* indicator on the Major Roads of Mainland Portugal.

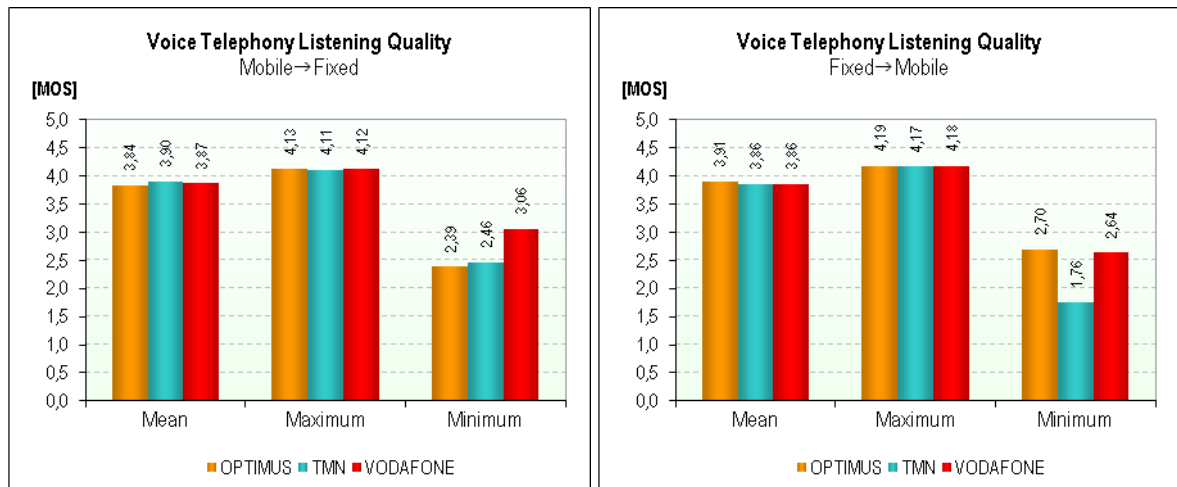Figure 7 – *Call Listening Quality* indicator in the Urban Agglomerations of Mainland Portugal.

Figure 8 – *Call Listening Quality* indicator on the Major Roads of Mainland Portugal.

Video-telephony Service

The video-telephony service performs differently according to the type of location analysed.

Urban agglomerations record good levels for *Service Accessibility* and *Call Completion Rate* (*Figure 9 – Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators in the Urban Agglomerations of Mainland Portugal.

). Operators OPTIMUS and VODAFONE record the best levels of *Service Accessibility* with a 98.0% and 97.7% rate of success when establishing calls, respectively, while TMN registers 94.5%. In regard to the *Call Completion Rate*, operators present very similar levels, all 98.7% or higher. Comparing this study's results with those of the previous year there are no significant changes, except for operator TMN, which shows a slight deterioration in *Service Accessibility* (*Figure 9 – Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators in the Urban Agglomerations of Mainland Portugal.
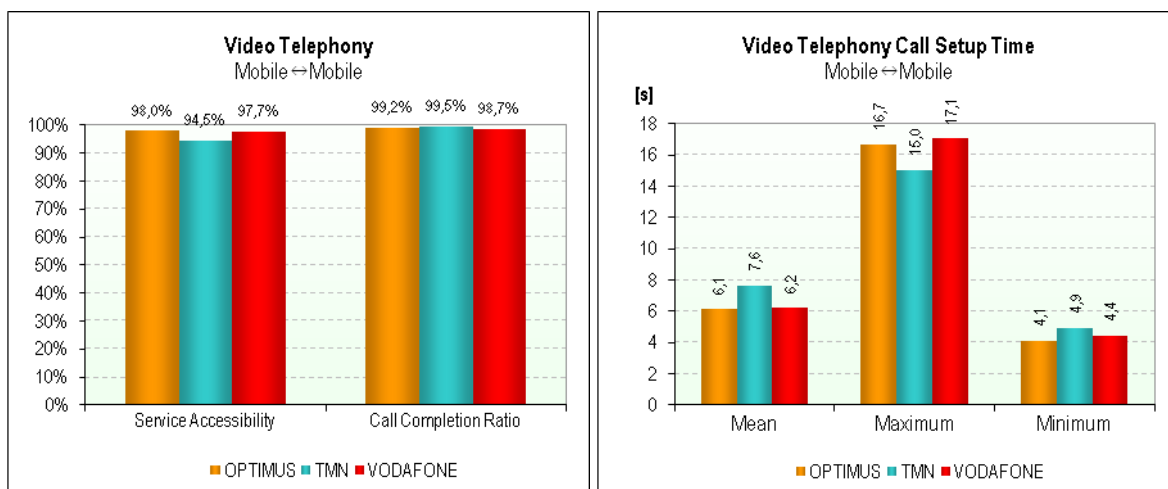
).

Figure 9 – *Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators in the Urban Agglomerations of Mainland Portugal.

Table 5 – Evolution of the *Service Accessibility*, *Call Completion Rate*, *Average Call Setup Time*, *Average Listening Quality*, and *Average Visual Quality* indicators, from 2010 to 2011, on the Urban Agglomerations of Mainland Portugal.
(Difference between the values recorded in the 2011 study and the values recorded in the 2010 study)

		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
Video-telephony Service	Service Accessibility	-0.61%	-1.70%	0.34%
	Call Completion Rate	0.38%	-0.30%	-0.34%
	Average Call Setup Time [s]	1.11	1.34	0.74
	Average Listening Quality	0.050	0.004	-0.012
	Average Visual Quality	0.133	0.017	0.016

Performance levels are lower on major roads than on urban agglomerations. Operator OPTIMUS has the best performance, with *Service Accessibility* levels of 94.1%, and *Call Completion Rates* of 97.4%. For the same indicators TMN has levels of 91.3% and 98.2%, respectively. VODAFONE posts considerably lower levels, with 77.5% for *Service Accessibility*, and 94.7% for the *Call Completion Rate* (*Figure 10 – Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators on the Major Roads of Mainland Portugal.

). In comparison with the study carried out in 2010, VODAFONE and TMN show a considerable deterioration in the *Service Accessibility* levels (*Figure 10 – Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators on the Major Roads of Mainland Portugal.
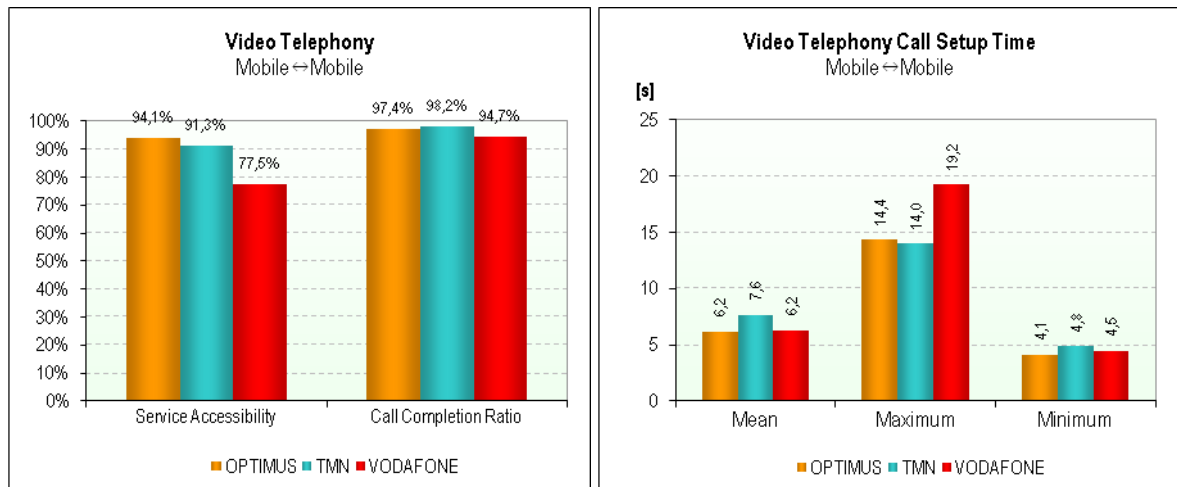
).

Figure 10 – *Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators on the Major Roads of Mainland Portugal.

Table 6 – Evolution of the *Service Accessibility*, *Call Completion Rate*, *Average Call Setup Time*, *Average Listening Quality*, and *Average Visual Quality* indicators, from 2010 to 2011, on the Major Roads of Mainland Portugal.
(Difference between the values recorded in the 2011 study and the values recorded in the 2010 study)

		OPTIMUS	TMN	VODAFONE
		Mobile⇔Mobile	Mobile⇔Mobile	Mobile⇔Mobile
Video-telephony Service	Service Accessibility	-0.74%	-3.62%	-4.81%
	Call Completion Rate	1.39%	-1.33%	0.24%
	Average Call Setup Time [s]	0.92	1.19	0.68
	Average Listening Quality	0.029	0.025	-0.016
	Average Visual Quality	0.116	0.064	0.028

The average call set up times show no significant differences between urban agglomerations and major roads (*Figure 9 – Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators in the Urban Agglomerations of Mainland Portugal.

and *Figure 10 – Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators on the Major Roads of Mainland Portugal.

). The best average time was recorded by OPTIMUS, with 6.1 seconds, and the longest one was registered by TMN at 7.6 seconds. Compared with the 2010 results all operators showed a slight worsening of this indicator, both in urban agglomerations and on major roads (*Figure 9 – Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators in the Urban Agglomerations of Mainland Portugal.

and *Figure 10 – Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators on the

Major Roads of Mainland Portugal.

).

Normally-ended video-telephony calls (120 seconds) have good *Listening Quality* average values and fair *Visual Quality* average values (*Figure 11 – Call Listening Quality* and *Call Visual Quality* indicators in the Urban Agglomerations of Mainland Portugal.

and *Figure 12 – Call Listening Quality* and *Call Visual Quality* indicators on the Major Roads of Mainland Portugal.

). No significant differences were observed between urban agglomerations and major roads. In comparison with the previous year, operator OPTIMUS shows a significant improvement in the *Average Visual Quality*, both in urban agglomerations and on major roads (*Figure 9 – Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators in the Urban Agglomerations of Mainland Portugal.

and *Figure 10 – Service Accessibility*, *Call Completion Rate, and Call Setup Time* indicators on the Major Roads of Mainland Portugal.
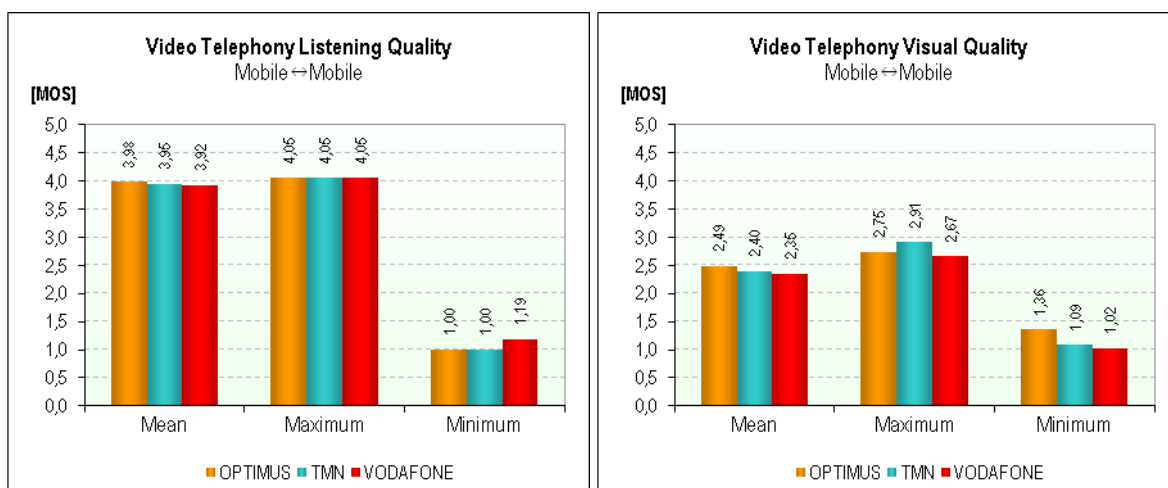
).

Figure 11 – *Call Listening Quality* and *Call Visual Quality* indicators in the Urban Agglomerations of Mainland Portugal.
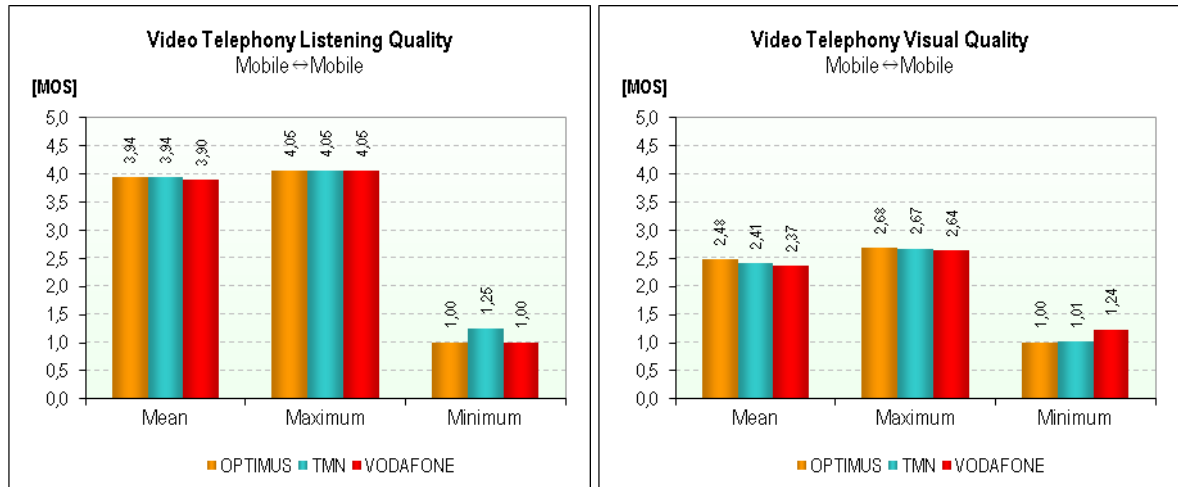
Figure 12 – *Call Listening Quality* and *Call Visual Quality* indicators on the Major Roads of Mainland Portugal.