

Mobile Communications Systems

GSM / UMTS

Quality of Service Assessment

Assessment of the QoS of Voice Telephony, Video Telephony and
GSM and WCDMA Network Coverage, on CP's Alfa Pendular Service
(Braga-Porto-Lisbon-Faro Line)

April 2011

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	Mean Opinion Score – Quality rate 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 situations where the connection was established and maintained for a given period are considered. “Five” never shows in the results either, because the CoDec7 used by mobile networks, renders impossible such high voice or video quality values (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 Listening 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 (GSM) terminal.
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 Listening Quality of a communication.
UMTS	Universal Mobile Telecommunications System – Third generation (3G) Mobile Communications System.
VQuad	Objective Model for Visual Quality Assessment – Algorithm used to analyse the Visual Quality of a communication (developed by SwissQual).
WCDMA	Wideband Code Division Multiple Access – Technology used in the radio component of the UMTS communications systems.

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I EXECUTIVE SUMMARY

I.I GENERAL FRAMEWORK

In April 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 on the Alfa Pendular Service of CP–Comboios de Portugal, E.P.E. (Braga-Porto-Lisbon-Faro railway line), by analysing technical parameters that express the quality perception from the consumer's standpoint.

The method used in this study relied on field tests performed from the user's standpoint, by using an automatic measurement system that reflects the several features affecting the quality of the services (end-to-end measurements). 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:

1. **Network Radio Coverage** – Availability of the GSM and WCDMA (UMTS) radio networks;
2. **Service Accessibility** (voice or video telephony) – probability of success when setting up calls;
3. **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);
4. **Call Completion Ratio** (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;
5. **Call Listening Quality** (voice or video telephony) – perceptibility of the conversation during a call;
6. **Call Visual Quality** (voice or video telephony) – perceptibility of the communication's visual feature.

Data collection took place on the trains during their normal operation, from April 5 to April 21. 3,106 test calls were made and 568,245 radio signal level measurements were taken, amounting to over 27 hours of measurements over approximately 2,800 kilometres.

The sample used provided overall results for each operator, with a maximum error below 4.7%, 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 itself, 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 overall behaviour of mobile communications systems on Porto's railway network, and it does not intend to evaluate the compliance with licences by the mobile operators. The transposition/extrapolation of these results to specific situations requires some prudence, to avoid biased conclusions being 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 inside trains while they were providing the regular Alfa Pendular service on the Braga-Porto-Lisbon-Faro line;
- Call duration, for both voice and video-telephony, was 120 seconds;
- Voice and video telephony were tested using automatic selection of the GSM or UMTS infrastructure;
- 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 on the Alfa Pendular Service at the time the measurements were taken, and no conclusions can be extrapolated to other services provided by CP, even those provided on same the railway line now under study.
- 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

The mobile communications systems present a poor performance inside CP's Alfa Pendular trains, showing quality of service indicators at levels that are considerably lower than those observed on mainland Portugal's major roads (*vide* study carried out in September-November 2010), particularly on the Lisbon-Faro line.

Mobile communications systems show different behaviours for each technology and location analysed. In general, there is better radio coverage on GSM than on WCDMA, voice telephony performs better than video telephony, and there is better performance on the Braga-Porto-Lisbon line than on the Lisbon-Faro one.

Compared with the previous study, carried out in April 2009 under the same circumstances, there is a general slight improvement in the video telephony service. For voice telephony, TMN and VODAFONE show performance improvement, while OPTIMUS shows a negative trend.

GSM and WCDMA Network Coverage

The mobile communication systems exhibit better GSM coverage levels than WCDMA, on the two railway routes analysed. However, radio coverage levels are very poor, except for the GSM coverage on the Braga-Porto-Lisbon line (Figure 1 – *Radio Coverage* indicator on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

, Figure 2 – *Radio Coverage indicator* on the Alfa Pendular Service on the Lisbon-Faro line.

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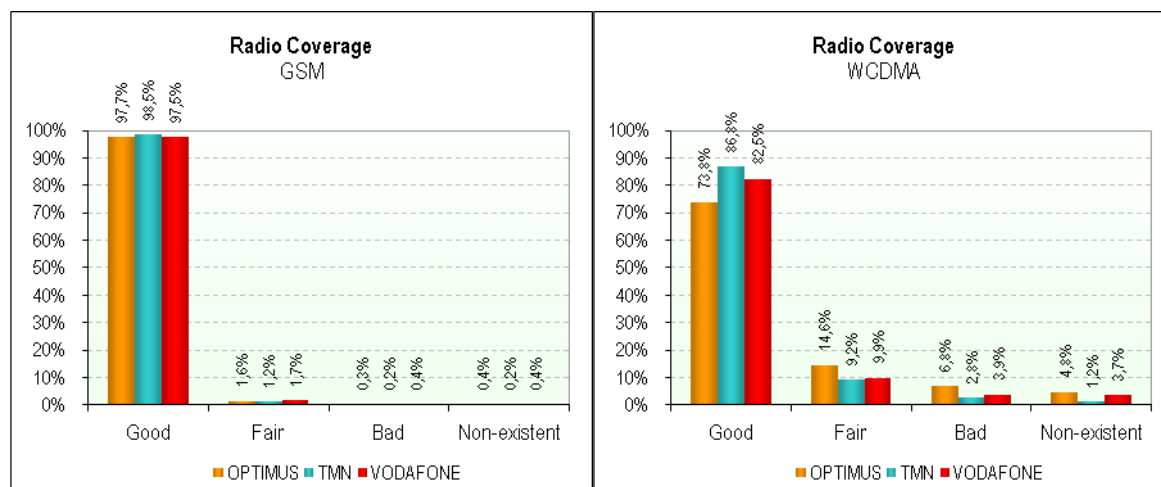


Figure 1 – Radio Coverage indicator on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

For WCDMA, there are large areas where coverage is bad or non-existent. The Lisbon-Faro line shows the lowest WCDMA coverage levels and the greatest performance differences between operators. On this line, TMN recorded the best performance, although the overall *good* and *fair* coverage levels only reach 82.3%, while VODAFONE and OPTIMUS record levels of 77.1% and 71.7%, respectively (Figure 2 – Radio Coverage indicator on the Alfa Pendular Service on the Lisbon-Faro line.

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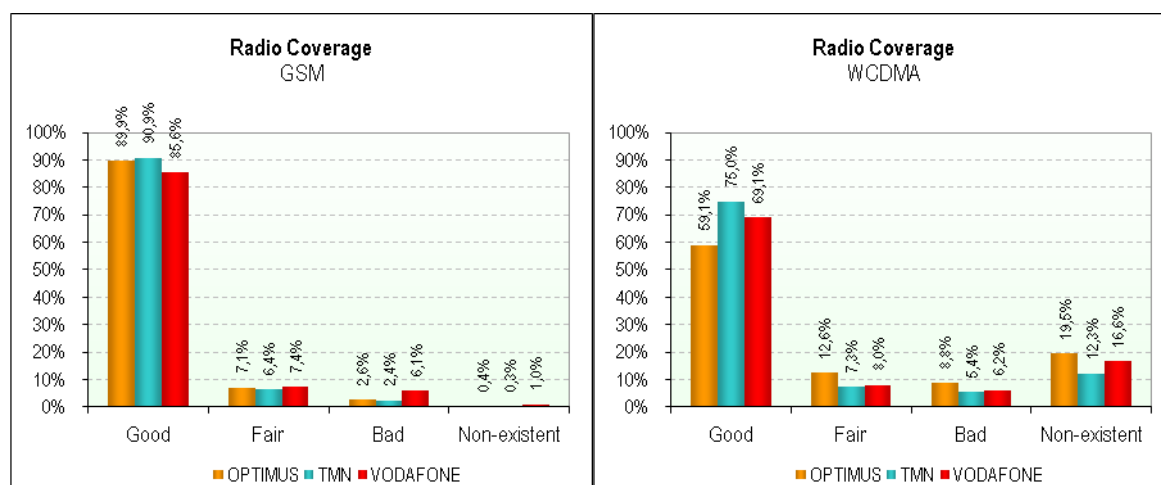


Figure 2 – Radio Coverage indicator on the Alfa Pendular Service on the Lisbon-Faro line.

Voice Telephony

The performance of voice telephony falls short of consumers' expectations. There are some differences between the operators and the locations analysed, particularly regarding *Service Accessibility* and *Call Completion Ratio* (Figure 3 – *Service Accessibility* and *Call Completion Ratio* indicators, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

, Figure 4 – *Service Accessibility* and *Call Completion Ratio* indicators, on the Alfa Pendular Service on the Lisbon-Faro line.

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On the Braga-Porto-Lisbon line, operator OPTIMUS has the best accessibility to voice telephony, with a 96.7% success rate for call setup, while VODAFONE has 93.4% and TMN 92.0%. Regarding the *Call Completion Ratio*, TMN recorded the best performance, with 96.8% of test calls for this operator's network being established successfully and maintained for the predetermined period of 120 seconds. VODAFONE and OPTIMUS recorded performances of 94.5% and 93.2% for the same indicator.

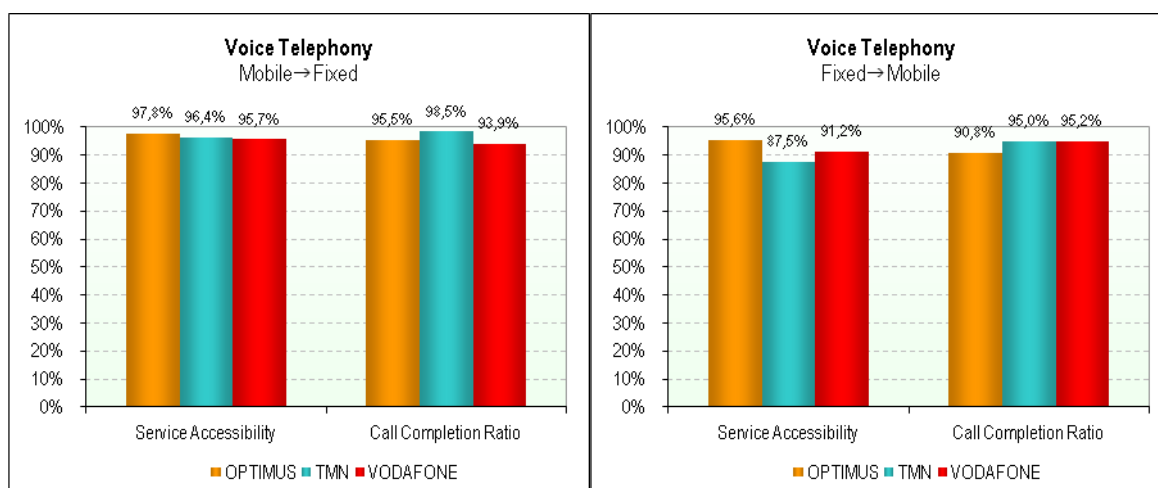


Figure 3 – *Service Accessibility* and *Call Completion Ratio* indicators, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

On the other hand, on the Lisbon-Faro line, the best performance was recorded by VODAFONE, with 94.8% of test calls being established successfully, 95.3% of which ended normally, i.e. after being maintained for the predetermined period of 120 seconds. For the same indicators, OPTIMUS has performance levels of 93.0% and 95.0%, and TMN 90.0% and 92.7%.

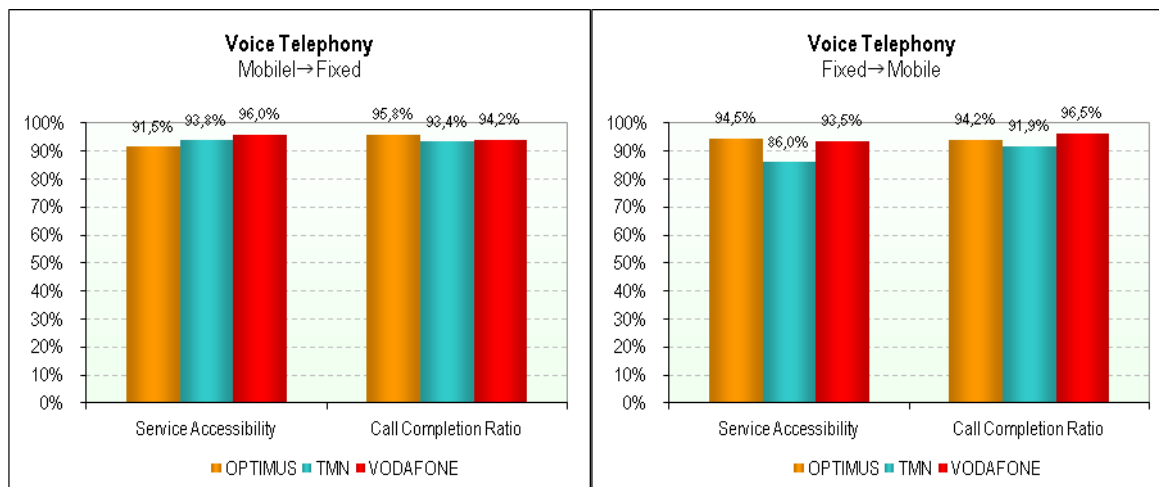


Figure 4 – Service Accessibility and Call Completion Ratio indicators, on the Alfa Pendular Service on the Lisbon-Faro line.

Average call setup times are within the levels expected for this service, with no major differences between the railway lines or operators studied (Figure 5 – Call Setup Time indicator, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

, Figure 6 – Call Setup Time indicator, on the Alfa Pendular Service on the Lisbon-Faro line.

and Section **Error! Reference source not found.**). The best average times were recorded by VODAFONE, with figures between 3.7 and 4.9 seconds, while the highest figures were recorded by TMN, with figures between 5.2 and 5.5 seconds.

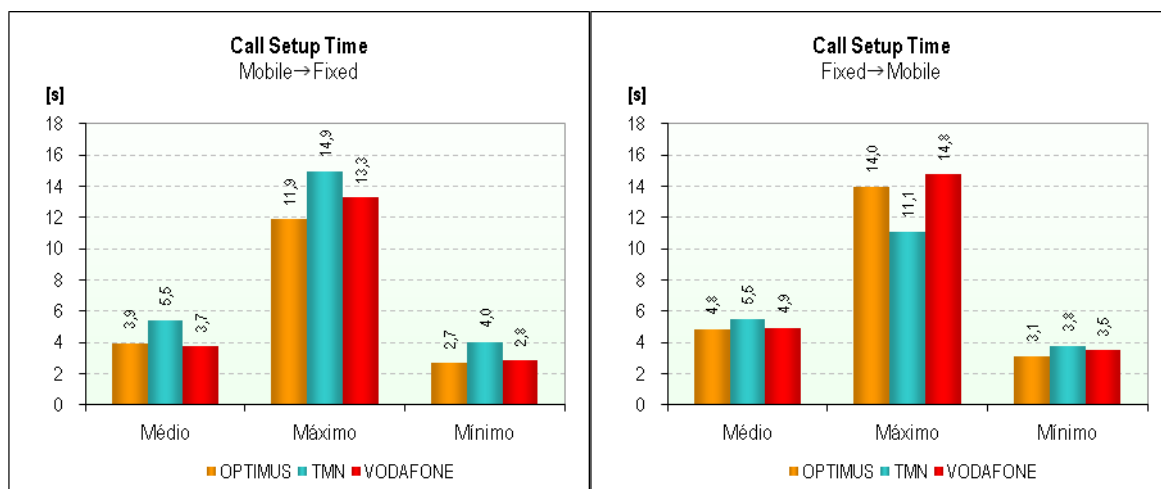


Figure 5 – Call Setup Time indicator, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

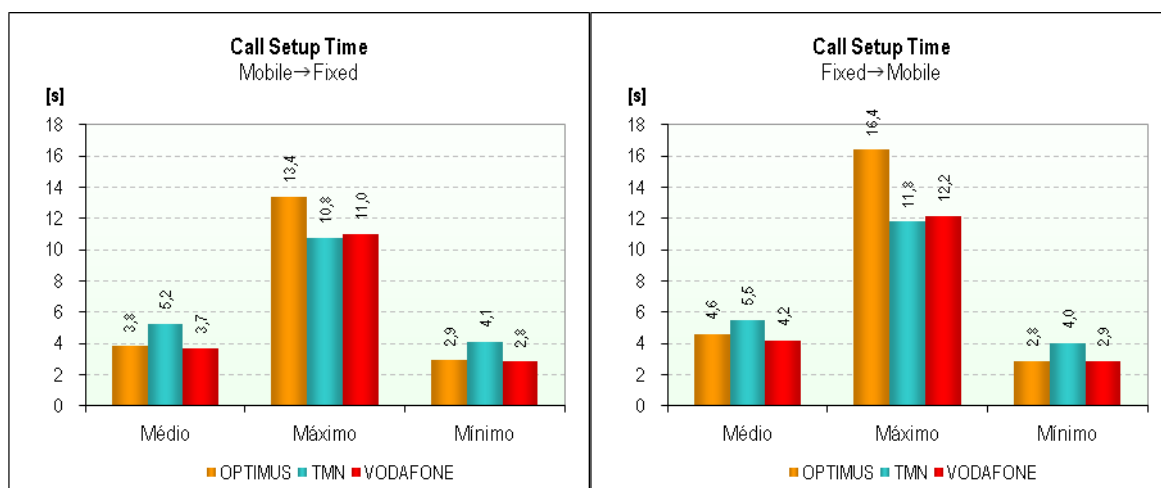


Figure 6 – Call Setup Time indicator, on the Alfa Pendular Service on the Lisbon-Faro line.

Normally-ended voice calls, i.e. those that were maintained for the predetermined period of 120 seconds, have good *Average Listening Quality* (Figure 7 – Call Listening Quality indicator, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

, Figure 8 – Call Listening Quality indicator, on the Alfa Pendular Service on the Lisbon-Faro line.

and Section **Error! Reference source not found.**). Listening quality for the operators is better on the Braga-Porto-Lisbon railway line.

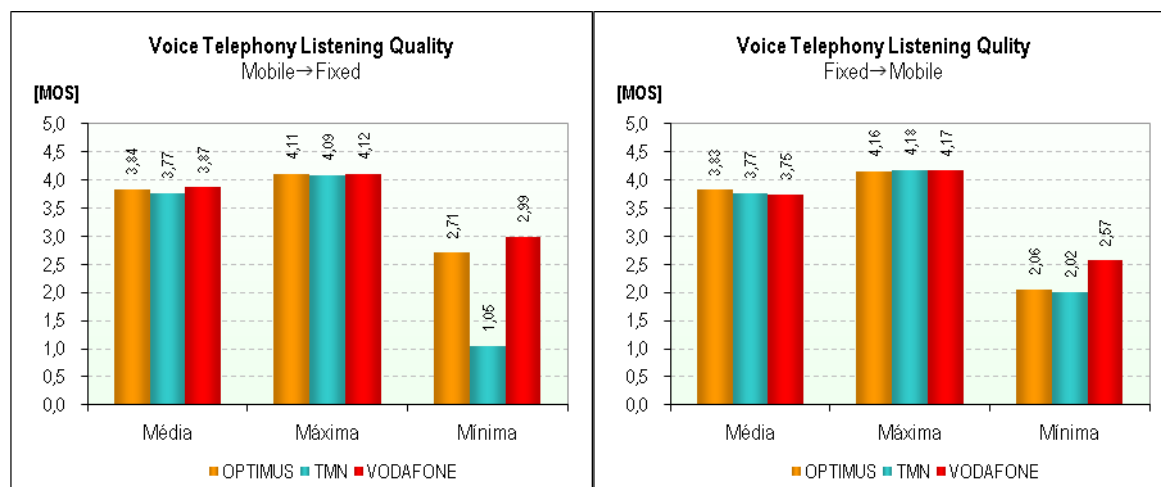


Figure 7 – Call Listening Quality indicator, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

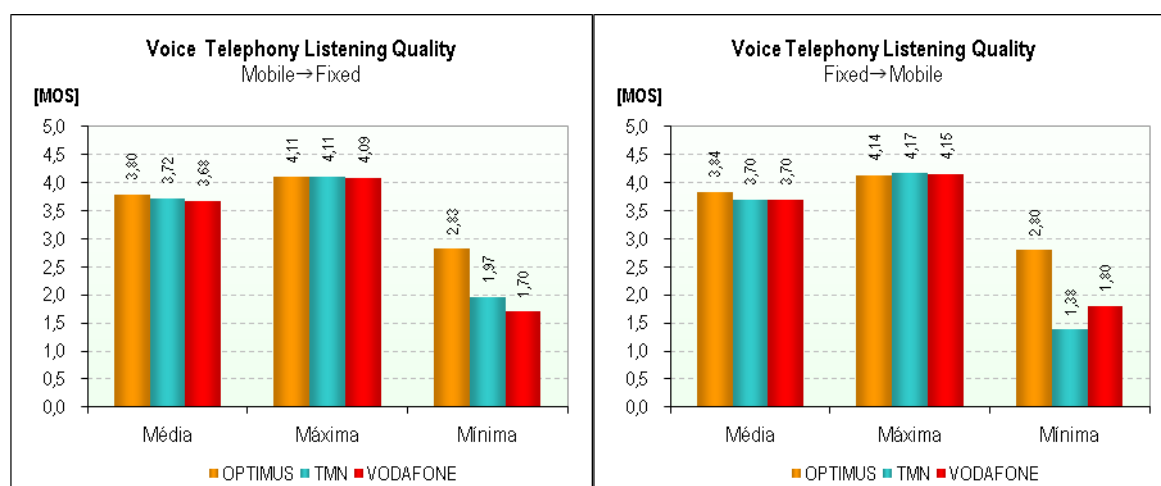


Figure 8 – Call Listening Quality indicator, on the Alfa Pendular Service on the Lisbon-Faro line.

Video Telephony

The performance of the video telephony service suffers greatly from the poor *Service Accessibility* offered by the networks, particularly on the Lisbon-Faro railway line (*Figure 9 – Service Accessibility, Call Completion Ratio, and Call Setup Time* Indicators, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

, *Figure 10 – Accessibility, Call Completion Ratio, and Call Setup Time* Indicators, on the Alfa Pendular Service on the Lisbon-Faro line.

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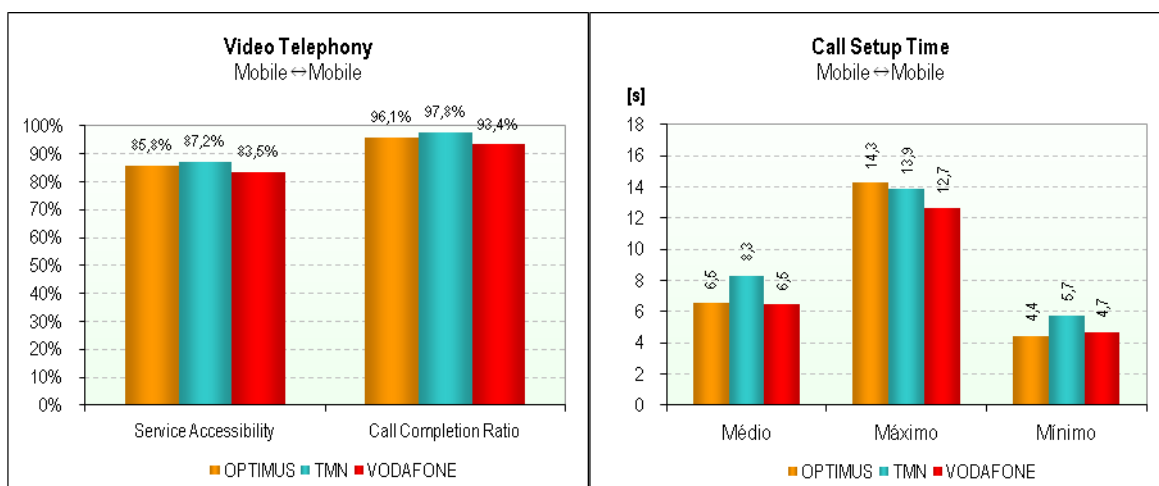


Figure 9 – *Service Accessibility, Call Completion Ratio, and Call Setup Time* Indicators, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

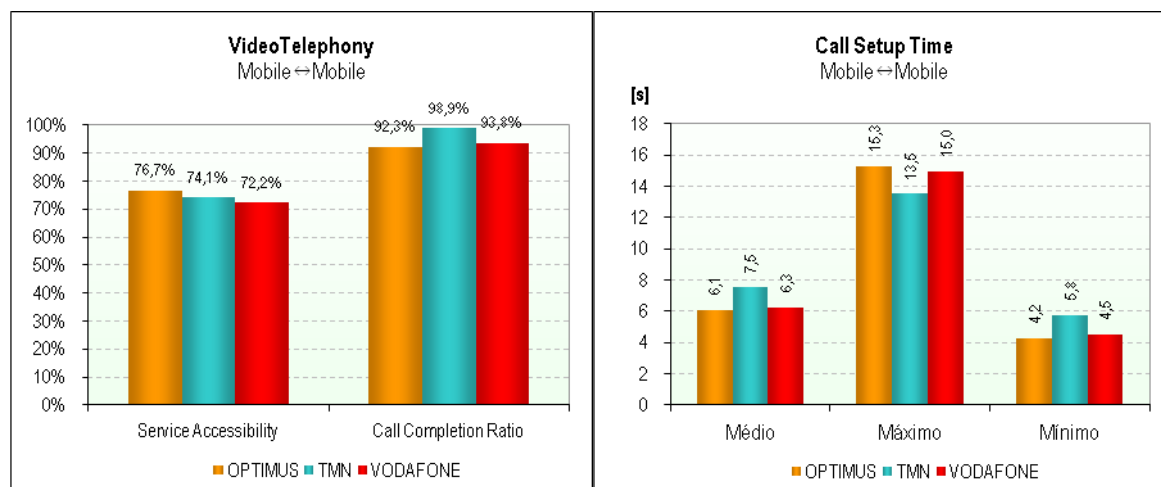


Figure 10 – Accessibility, Call Completion Ratio, and Call Setup Time Indicators, on the Alfa Pendular Service on the Lisbon-Faro line.

TMN has the best *Service Accessibility*, on the Braga-Porto-Lisbon line, with an 87.2% success ratio in the establishment of video telephony calls, while the figure for OPTIMUS is 85.8% and for VODAFONE 83.5%. On the Lisbon-Faro line the best performance was recorded by OPTIMUS, although the success rate in establishing video telephony calls is only 76.7%, while TMN and VODAFONE record levels of 74.1% and 72.2%.

The *Call Completion Ratio* indicator presents higher levels than *Service Accessibility*, showing the networks' ability to maintain the calls once successfully set up. The best performance was recorded by TMN on the Lisbon-Faro line, with 98.9% of test calls being established successfully and maintained for the predetermined period of 120 seconds. The lowest performance level for this indicator was registered by OPTIMUS, with a 92.3% rate.

Average call setup times are within the levels expected for this service, with no major differences between the railway lines or operators studied (*Figure 9 – Service Accessibility, Call Completion Ratio, and Call Setup Time Indicators, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.*

, *Figure 10 – Accessibility, Call Completion Ratio, and Call Setup Time Indicators, on the Alfa Pendular Service on the Lisbon-Faro line.*

and *Section Error! Reference source not found.*). The best results were recorded by OPTIMUS, with an overall average call setup time of 6.3 seconds, while for VODAFONE it is 6.4, and for TMN, 7.9.

Normally-ended video telephony calls (120 seconds long) have good average *Listening Quality* and fair

Visual Quality (Figure 11 – Call Listening Quality, and Call Video Quality indicators, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

, Figure 12 – Call Listening Quality and Call Video Quality indicators, on the Alfa Pendular Service on the Lisbon-Faro line.

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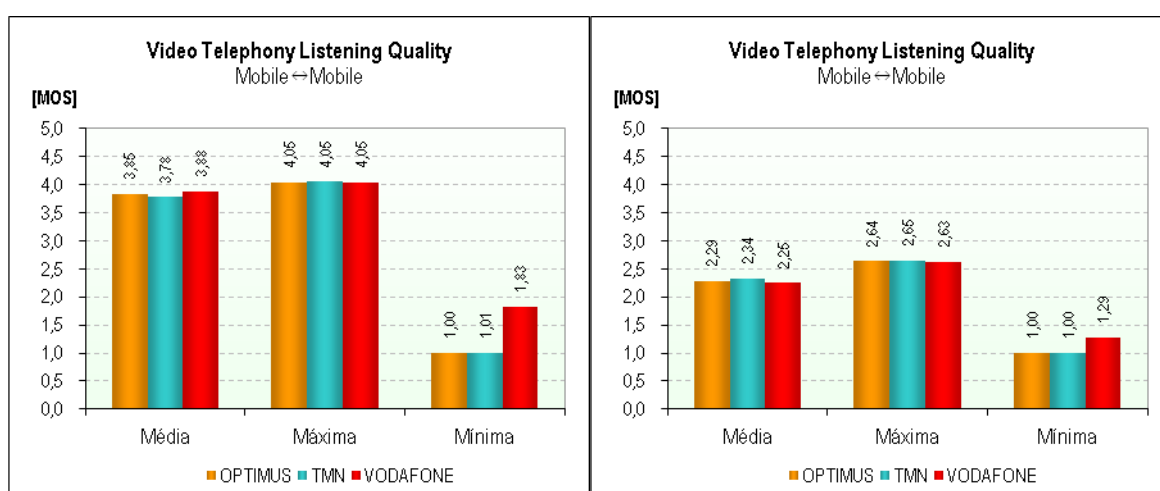


Figure 11 – Call Listening Quality, and Call Video Quality indicators, on the Alfa Pendular Service on the Braga-Porto-Lisbon line.

The best average *Listening Quality* and *Visual Quality* were recorded by VODAFONE on the Lisbon-Faro line, with MOS ratings of 3.88 and 2.43, respectively, while the lowest levels were recorded by TMN, on the same line, with MOS ratings of 3.77 and 2.16.

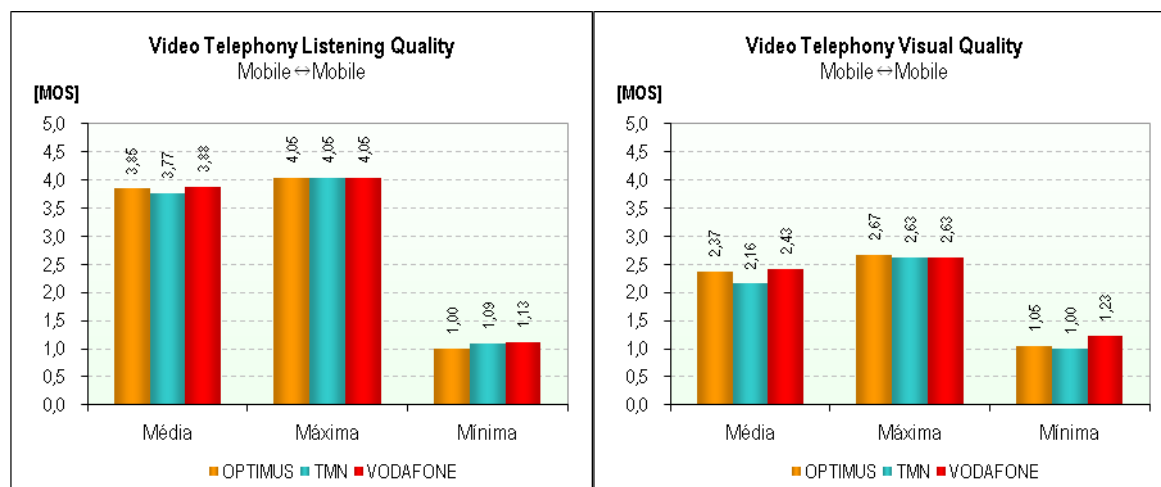


Figure 12 – Call Listening Quality and Call Video Quality indicators, on the Alfa Pendular Service on the Lisbon-Faro line.