

# AUDIT REPORT

P3 communications GmbH  
Am Kraftversorgungsturm 3, D-52070 Aachen, Germany  
Has been tasked by



Vodafone Portugal, Av. D. João II, Lote 1.04.01, Parque das Nações, 1998 - 017 Lisboa, Portugal

to audit the

**performance of its voice and data services on smartphones**

in comparison to other GSM/UMTS/LTE mobile radio networks in metropolitan and rural areas of Portugal.

The audit was done as an performance benchmark commissioned by Vodafone Group and performed by P3 communications between April 29<sup>th</sup> and May 13<sup>th</sup>, 2015 in Lisboa and 17 further cities and towns as well as on connection roads. Measurements have been executed as drive tests outdoors using a Samsung Galaxy S4 LTE+ Smartphone (150 Mbit/s Download / 50 Mbit/s Upload). All data measurements have been performed in LTE/3G/2G mode (LTE preferred). Voice measurements have been done in LTE preferred mode on one side and 3G preferred mode on other side, while call origin has been alternated.

The following pages provide a comparative overview about the performance results observed for the different tested service types. Unless otherwise stated the shown bar graphs present the average value of the respective KPI and the error bars indicate the 95% confidence interval.

Smartphone Voice - mobile-to-mobile communication  
Smartphone Data - HTTP Web Browsing, HTTP File Transfer and YouTube Video

A handwritten signature in black ink, appearing to read "M. Kianzad".

Maziar Kianzad  
Head of International Benchmarking

# Audit Result Summary

## LTE/3G preferred Smartphone Voice Service

Service Type	Requirement	KPI Name and Description	Result								
Voice mobile-to-mobile service measured with two independent devices and systems at different locations. One party was set to LTE preferred, the other to 3G preferred mode.	<p>In order to offer a good Voice Service a network has to provide reliable service access and stable voice calls.</p> <p>Call Success Ratio values around 97% indicate a sufficient, values around 98% a good and values around 99% an excellent quality.</p>	The Call Success Ratio includes the Call Setup Success Ratio and the composite Dropped Call Ratio.	<table border="1"> <thead> <tr> <th>Operator</th> <th>Call Success Ratio [%]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>98.48</td> </tr> <tr> <td>Operator 1</td> <td>93.86</td> </tr> <tr> <td>Operator 2</td> <td>96.84</td> </tr> </tbody> </table>	Operator	Call Success Ratio [%]	Vodafone	98.48	Operator 1	93.86	Operator 2	96.84
	Operator	Call Success Ratio [%]									
Vodafone	98.48										
Operator 1	93.86										
Operator 2	96.84										
<p>In order to offer a good Voice Service a network has to provide reasonable speech quality. Offered speech codecs, share of low and empty speech samples and general network performance impact the mean speech quality score.</p>	Average Speech Quality on Call Basis is adapted from POLQA wideband evaluation. Each recorded speech sample is compared with a German wideband reference sample. The POLQA algorithm determines a value between 1.0 and 4.5 where 4.5 is the best value.	<table border="1"> <thead> <tr> <th>Operator</th> <th>Call Speech Quality [POLQA MOS]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>3.65</td> </tr> <tr> <td>Operator 1</td> <td>3.44</td> </tr> <tr> <td>Operator 2</td> <td>2.88</td> </tr> </tbody> </table>	Operator	Call Speech Quality [POLQA MOS]	Vodafone	3.65	Operator 1	3.44	Operator 2	2.88	
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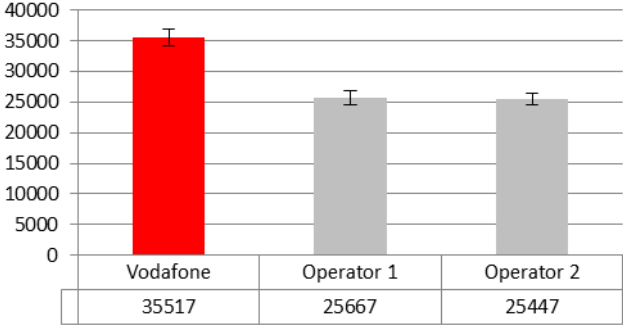
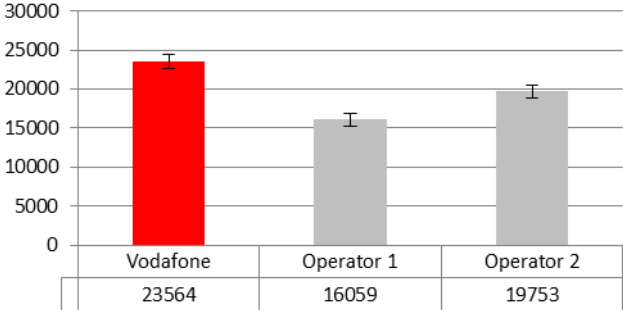
# Audit Result Summary

Smartphone Data Service											
Service Type	Requirement	KPI Name and Description	Result								
Smartphone Data – Static Web Browsing ,Kepler‘ reference page	In order to offer a good HTTP Static Web Browsing service the content must be transferred quickly and reliably. Further the content must not be compressed in a way that lossy compression affects the user perception.	Static Web Page Session Time including DNS resolution time, IP Service Access Time and Transfer Time.	<p><b>Overall Session Duration [seconds]</b></p> <table border="1"> <thead> <tr> <th>Operator</th> <th>Duration [seconds]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>1.05</td> </tr> <tr> <td>Operator 1</td> <td>1.42</td> </tr> <tr> <td>Operator 2</td> <td>2.02</td> </tr> </tbody> </table>	Operator	Duration [seconds]	Vodafone	1.05	Operator 1	1.42	Operator 2	2.02
		Operator	Duration [seconds]								
Vodafone	1.05										
Operator 1	1.42										
Operator 2	2.02										
Static Web Page Session Success Ratio including DNS Resolution Success, IP Service Access Success.	<p><b>Overall Session Success Ratio [%]</b></p> <table border="1"> <thead> <tr> <th>Operator</th> <th>Success Ratio [%]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>99.75</td> </tr> <tr> <td>Operator 1</td> <td>99.75</td> </tr> <tr> <td>Operator 2</td> <td>99.62</td> </tr> </tbody> </table>	Operator	Success Ratio [%]	Vodafone	99.75	Operator 1	99.75	Operator 2	99.62		
Operator	Success Ratio [%]										
Vodafone	99.75										
Operator 1	99.75										
Operator 2	99.62										

## Audit Result Summary

<p>Smartphone Data – Live Web Browsing. 5 Top live web pages in Portugal have been measured:</p> <p><b>google.pt</b>  <b>m.youtube.com</b>  <b>en.m.wikipedia.org</b>  <b>m.abola.pt</b>  <b>sapo.pt</b></p>	<p>In order to offer a good HTTP Live Web Browsing service the content of 5 Top Live pages must be transferred quickly and reliably. Further the content must not be compressed in a way that lossy compression affects the user perception.</p>	<p>Live Web Page Session Time including DNS Resolution Time, IP Service Access Time and Transfer Time.</p>	<p><b>Overall Session Duration [seconds]</b></p> <table border="1"> <thead> <tr> <th>Operator</th> <th>Session Duration [seconds]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>2.74</td> </tr> <tr> <td>Operator 1</td> <td>2.74</td> </tr> <tr> <td>Operator 2</td> <td>2.99</td> </tr> </tbody> </table>	Operator	Session Duration [seconds]	Vodafone	2.74	Operator 1	2.74	Operator 2	2.99	<p style="text-align: center;">Better</p>
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Vodafone	2.74											
Operator 1	2.74											
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	<p>Live Web Page Session Success Ratio including DNS Resolution Success, IP Service Access Success and Transfer Success. A Web Browsing session is successful, if the complete page has been completely received at least within 10s.</p>	<p><b>Overall Session Success Ratio [%]</b></p> <table border="1"> <thead> <tr> <th>Operator</th> <th>Session Success Ratio [%]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>97.79</td> </tr> <tr> <td>Operator 1</td> <td>96.72</td> </tr> <tr> <td>Operator 2</td> <td>92.42</td> </tr> </tbody> </table>	Operator	Session Success Ratio [%]	Vodafone	97.79	Operator 1	96.72	Operator 2	92.42	<p style="text-align: center;">Better</p>	
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Operator 1	96.72											
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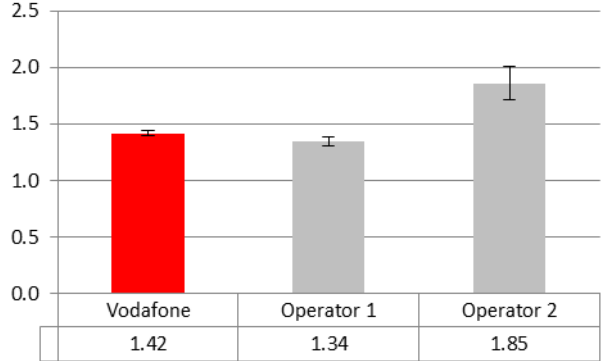
## Audit Result Summary

<p>Smartphone Data - Data Transfer in uplink and downlink direction</p>	<p>In order to offer a good HTTP Data Transfer downlink or uplink service the uncompressible content must be transferred quickly and reliably.</p>	<p>Average Mean User Data Rate based on a 10 second HTTP file download. An infinite file is downloaded for 10 seconds. The transferred amount of data is divided by 10 seconds to calculate the mean user data rate.</p>	<p><b>Downlink Mean User Data Rate [kbit/s]</b></p>  <table border="1"> <thead> <tr> <th>Operator</th> <th>Mean User Data Rate [kbit/s]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>35517</td> </tr> <tr> <td>Operator 1</td> <td>25667</td> </tr> <tr> <td>Operator 2</td> <td>25447</td> </tr> </tbody> </table>	Operator	Mean User Data Rate [kbit/s]	Vodafone	35517	Operator 1	25667	Operator 2	25447	<p style="text-align: center;">Better</p>
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Operator 1	25667											
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<p>Average Mean User Data Rate based on a 10 second HTTP file upload. An infinite file is uploaded for 10 seconds. The transferred amount of data is divided by 10 seconds to calculate the mean user data rate.</p>	<p><b>Uplink Mean User Data Rate [kbit/s]</b></p>  <table border="1"> <thead> <tr> <th>Operator</th> <th>Mean User Data Rate [kbit/s]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>23564</td> </tr> <tr> <td>Operator 1</td> <td>16059</td> </tr> <tr> <td>Operator 2</td> <td>19753</td> </tr> </tbody> </table>	Operator	Mean User Data Rate [kbit/s]	Vodafone	23564	Operator 1	16059	Operator 2	19753	<p style="text-align: center;">Better</p>		
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## Audit Result Summary

<p>Smartphone Data - YouTube Video HD</p>	<p>In order to provide a good quality regarding the YouTube service, a smooth Playout of the reference video without any interruptions is required.</p>	<p>Percentage of uninterrupted Playouts without any interruptions. This KPI aims at fixed line YouTube Experience without any interruptions.</p>	<p><b>Uninterrupted Playouts [%]</b></p> <table border="1"> <thead> <tr> <th>Operator</th> <th>Percentage [%]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>98.17</td> </tr> <tr> <td>Operator 1</td> <td>99.63</td> </tr> <tr> <td>Operator 2</td> <td>96.27</td> </tr> </tbody> </table>	Operator	Percentage [%]	Vodafone	98.17	Operator 1	99.63	Operator 2	96.27	<p>Better</p>
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Vodafone	98.17											
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	<p>In order to provide a good quality regarding the YouTube service, a smooth Playout of the reference video without major interruptions is required.</p>	<p>Percentage of successful downloads including minor interruptions. Single interruptions up to 8 seconds and a total interruption length of 15 seconds are accepted.</p>	<p><b>Playout Success Ratio [%]</b></p> <table border="1"> <thead> <tr> <th>Operator</th> <th>Percentage [%]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>99.63</td> </tr> <tr> <td>Operator 1</td> <td>100.00</td> </tr> <tr> <td>Operator 2</td> <td>98.12</td> </tr> </tbody> </table>	Operator	Percentage [%]	Vodafone	99.63	Operator 1	100.00	Operator 2	98.12	<p>Better</p>
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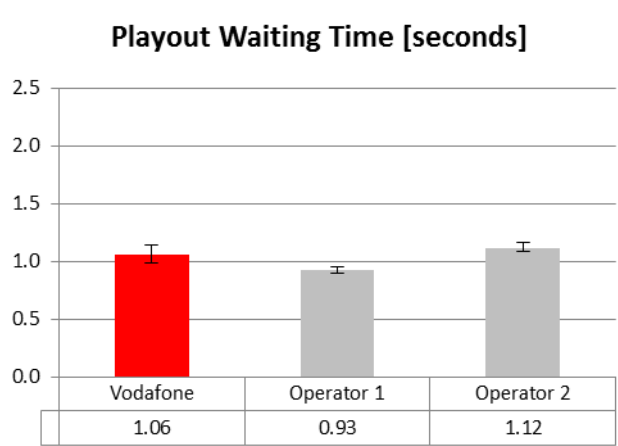
	<p>In order to offer a good quality regarding the YouTube service a short waiting time before the video starts playing is required.</p>	<p>The Playout Waiting Time includes video Catalogue Service Access and Download time, video IP Service Access and video buffering time.</p>	<p><b>Playout Waiting Time [seconds]</b></p>  <table border="1"><thead><tr><th>Operator</th><th>Playout Waiting Time [seconds]</th></tr></thead><tbody><tr><td>Vodafone</td><td>1.42</td></tr><tr><td>Operator 1</td><td>1.34</td></tr><tr><td>Operator 2</td><td>1.85</td></tr></tbody></table>	Operator	Playout Waiting Time [seconds]	Vodafone	1.42	Operator 1	1.34	Operator 2	1.85	<p>Better</p>
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Smartphone Data - YouTube Video SD	<p>In order to provide a good quality regarding the YouTube service, a smooth Payout of the reference video without any interruptions is required.</p>	<p>Percentage of uninterrupted Playouts without any interruptions. This KPI aims at fixed line YouTube Experience without any interruptions.</p>	<p><b>Uninterrupted Playouts [%]</b></p> <table border="1"> <thead> <tr> <th>Operator</th> <th>Value [%]</th> </tr> </thead> <tbody> <tr> <td>Vodafone</td> <td>100.00</td> </tr> <tr> <td>Operator 1</td> <td>100.00</td> </tr> <tr> <td>Operator 2</td> <td>98.50</td> </tr> </tbody> </table>	Operator	Value [%]	Vodafone	100.00	Operator 1	100.00	Operator 2	98.50	<p>Better</p>
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