THE MOBILE NETWORK TEST IN THE UNITED KINGDOM

In 2015 the Mobile Network Test in the UK is conducted the second time. Did Three, O2 or Vodafone manage to improve their performance enough to overtake last years clear winner EE?

Glasgow
Edinburgh
Livingston
Berwick-upon-Tweed
Hamilton
Morpeth
Dumfries
Carlisle
Penrith
Kendal
Heysham
Leeds
Wetherby
Hull
Manchester
Pontefract
Liverpool
Knutsford
Kirkby in Ashfield
Derby
Nottingham
Stafford
Leicester
Cannock
Birmingham
Bedworth
Coventry
Bletchley
Dunstable
Chippenham
Maidenhead
London
Bristol
Newbury

When it comes to mobile network testing P3 communications is probably the world leader. Being active in Germany, the USA, Australia, Austria, Switzerland, Spain, UK and many other countries, the mobile communication experts from Aachen have accumulated a lot of knowledge.

No wonder connect, the biggest European magazine on telecommunication has chosen P3 communications as its partner for the mobile network benchmark in Germany, Austria and Switzerland since 2002. The awareness of the public regarding the quality of mobile networks has driven operators to improve their networks considerably to stay competitive.

Focus on United Kingdom

But how does the United Kingdom compare to other countries? In 2014 the mobile network test showed EE as the clear winner followed by Three with the best voice performance. O2 and Vodafone followed almost head-to-head. The test also displayed much better performance in metropolitan areas than in smaller cities and on connecting roads. That fact and the population of 8.6 million people are good reasons to look at the results of the largest city London separately. The results can be found on page 7.

Compared to the leading operators in Europe and all over the world all UK networks revealed room for improvement. This headroom gives every operator the opportunity to make a big step forward and overtake formerly better competitors. It will be interesting to see which operator used the last year most effectively for its improvements.

TELEPHONY

Customers expect nothing but a great experience in mobile telephony. But LTE introduces high hurdles for perfect voice services. Which provider brings stability and speech quality to the highest level?

LTE is a great technology for handling large amounts of data with high speed. This is because it was designed to handle the fast growing amount of data present since the introduction of smartphones. But it was not designed to handle voice calls. As a workaround a technique called circuit switched fall back (CSFB) changes the connection to UMTS or GSM whenever a call is made. This additional handover takes time and reduces reliability, so providers must step up efforts to keep the quality up to the level of the pre-LTE-era. Voice over LTE is the new alternative to CSFB. This technique allows the smartphone to place and receive voice calls without leaving the LTE network. But since LTE networks are all-IP networks   and therefore not designed to handle real-time services like voice communication, VoLTE introduces new challenges to maintaining a good quality of service.

All operators in the United Kingdom are experimenting with VoLTE, but Three is the first and only one to have launched it. As only a very small number of smartphones are able to use VoLTE, this service was not part of this years benchmark.

Voice in Big Cities

Nonetheless Three managed to show the best result in big cities. With 97.2 % call success ratio the youngest operator in the united kingdom obtained the best result. Vodafone ranked second at 96.7 % while Telefonica and EE had severe problems with one out of 20 calls. A call setup time between 5.3 (Three) and 7.3 seconds (EE) is typical for 4G-Networks and slightly higher than those measured in pre-LTE times. The speech quality is measured on the MOS scale, which goes from 1 (bad) to 5 (excellent). All operators accomplished MOS ratings between 3.3 and 3.6, with Three again being best. This makes Three the best operator for voice performance in big cities, with Vodafone in a close second place.

Voice in small cities and on connecting roads

It is easier to provide a stable network for speech in big cities with their high demand on network capabilities and a correspondingly dense network of base stations. Three only lost 2 % of reliability in small cities and on connecting roads and increased its advantage over the competition. EE with a 92.6 % call success ratio and Vodafone with 92 % followed at a distance while Telefonica lost more than one out of ten calls in rural areas. Telefonica's problem can also be seen at the speech quality. With a MOS value of 2.8 it is only slightly better than „merely understandable". Call setup time stayed almost the same for all providers except of Three, who managed to reduce the time between dialing and an established call by another half a second.

OPERATOR	EE	THREE	VODAFONE	TELEFONICA
TELEPHONY (BIG CITIES;DRIVETEST)				
Call Success Ratio (%)	94.9	97.2	96.7	95.5
Call Setup Time (s)	7.3	5.3	6.3	6.5
Speech Quality (MOS-LQO)	3.5	3.6	3.4	3.3
TELEPHONY (SMALL CITIES AND CONNECTING ROADS;DRIVETEST)				
Call Success Ratio (%)	92.6	95.2	92.0	87.2
Call Setup Time (s)	7.1	4.8	6.5	6.9
Speech Quality (MOS-LQO)	3.4	3.6	3.0	2.8

A blade computer array in the car is used to steer twelve Samsung-Smartphones for the measurements.

Vodafone UK is part of the Vodafone Group which is also headquartered in the United Kingdom. The Vodafone Group owns and operates networks in 21 countries. Vodafone UK launched the first cellular network in 1985. The rollout of the first 3G network in the UK started in 2001. Now the company runs 2G at 900 and 1800 Mhz, 3G at 900 and 2100 MHz and LTE at 800 MHz and 2.6 GHz. During the last year Vodafone claims to have spent 1 billion pound on the networks. 200 Million have been spent in London alone to get the LTE population coverage above 99 %. VoLTE is currently on a trial with no release date yet. But the money is not only spent on LTE where Vodafone has licensed the largest bandwidth of all UK operators but also on extending 3G coverage in the formerly GSM-Band 900 MHz. This improves indoor reception for voice calls and older handsets without LTE and extends the reach of base stations.

Population coverage across all mobile network classes is 98 % and 18 Million customers have access to this network.

With approximately 30 million customers EE is the biggest operator in the UK. The company's 4G network of EE was officially launched on 30 October 2012 and the operator has acquired 10 Million customers with a 4G plan since then. The population coverage is 93 % according to the operator. EE has started the rollout in a comparatively dense network at 1800 MHz in 11 big cities. This was followed with another layer at 2600 MHz at locations with high traffic. EE is the first in the UK to provide carrier aggregation (CA) to make the most out of modern smartphones.
The deployment of 800 MHz LTE has recently started in rural areas to take advantage of the broader coverage of these lower frequencies. For the cities EE believes that 1800 MHz in a dense grid is perfect even for indoor use. EE's whole LTE network is VoLTE ready and a few hundred people are already using it in an expansive trial. But VoLTE will only be released to the public when the overall quality is as good as or better than HD voice over 3G.

Telefonica with its brand O2 claims to be the second largest mobile network operator in the UK with approximately 25 million customers.

Telefonica has deployed 2G networks at 900 and 1800 Mhz, 3G networks at 900 and 2100 MHz. Currently the LTE roll-out is in progress. Until now the 4G networks serve 78 % of the outdoor population, which translates to 66 % indoor population coverage at 800 MHz. To extend its LTE bandwidth Telefonica has started to refarm part of its GSM 1800 spectrum to LTE and to carrier aggregate both frequencies. 98 % population coverage at the end of 2017 was promised by Telefonica as part of the licensing obligations. VoLTE trials are currently in preparation and is predicted to start in December 2015 with the launch planned for the first half of 2016. Telefonica is currently progressing with a big initiative to modernize its network. According to the operator as a part of this more than 3 billion pounds will be invested in 2G, 3G and 4G services during the next five years.

Three started its service Network on 2003 in the UK and five other countries. So it is a comparatively young operator starting in the upcoming age of mobile data with the aim to leave legacy behind. Consequently Three was a 3G-only network supplemented by 2G via national roaming. Nowadays 2G is only sparingly used for voice support. Three started its 4G rollout at the end of 2013 at 1800 MHz, which needs a denser network of base stations due to the high frequency. Now the 800 MHz rollout has started and population coverage of LTE is 50 % right now and is predicted to reach 65 % by the end of this year. This is a good foundation for the recently started VoLTE (Voice over LTE) service, which at this time is used where no other voice service is available. With about 8.8 Million customers Three is the smallest mobile network operator but claims to carry 42 % of the traffic in the UK. The modern network together with a no limit policy (excluding tethering) brings the average traffic to 4.65 GB per customer.

The promise of LTE is high speed data access every-where. Can providers of the United Kingdom keep this promise?

Although the LTE deployment started long before last year's mobile network benchmark, it is still in progress in 2015. With one year of ongoing LTE roll-out we expect a considerable improvement in data speed. But with the shift from established legacy technology to the newer 4G standard, stability can always be an issue. Let's see how the operators coped with the challenge of increasing speed while retaining a low error rate.

Web-page download

One of the most often used services is web surfing which was tested with a mixture of 9 popular live and one static web-pages.

The winner of last year's benchmark EE managed to improve its session success ratio for live si-tes from 97 to 99 %. The average session time to download a popular live web site decreased from 4.1 to 2.7 seconds. The other three operators showed almost identical session times between 3.1 and 3.2 seconds, but on reliability Vodafone clearly ranked second with a healthy success ratio of 97.4 %, while Telefonica followed with 96.8 %. With an error rate of more than 5 % Three still has some work to do.

File up- and download

When it comes to file up- and downloads the opera-tors can show their best in speed and reliability. And with success ratios between 97,1 and 99.4 % the stability of the data sessions was indeed at a very high level.

This is also true for the speed of the networks, although a little more differentiation can be seen. Therefore the mobile network benchmark measures the transfer rates in two different ways. With files of fixed size the overall speed of the network is tested including the time it takes to initiate a speedy data stream. This is important in cases where many small files will be transferred. On the other hand the „10-seconds-measurements" show the peak per-formance once stable transmission is achieved. It gives insight on how the network behaves when lar-ge data files like high resolution photos or videos are up- or downloaded. The value given for „90 % faster" is what a customer can reasonably expect most of the time.

EE manages to increase its download perfor-mance by nearly 70 % and doubles the throughput of the next competitors. Vodafone und Telefonica still deliver more than 3 Mbit/s, which is enough for a good user experience, while Three at about 2 Mbit/s is a bit behind. The same superiority of EE is true for the upload performance. But this time the other operators are closer to EE and to each other and Telefonica comes closest to EE. The 10 seconds measurements show the same rank between ope-rators. At more than 58 Mbit/s in download and more than 37 Mbit/s in upload in more than 10 % of the measurements EE highlights its high speed capabilities.

YouTube in standard and high definition

Video transmission was long regarded as impossib-le in a mobile network. But once the faster networks started to become reality, services like YouTube be-came the major source of traffic. Today YouTube amongst other video services is a commodity in the mobile world and every operator should deliver a highly reliable stream at least in standard definition (SD). This is true for EE and Vodafone with success ratios above 98 percent while Telefonica is slightly below and Three loses nearly 5 % to perfection at 95.1 %. With high definition (HD) Video demands are even more stringent on the network and only EE manages to stay above 98%.

Better networks for more demanding users

There is a constant fight: As operators enhance the capabilities of their networks the demand on data also increases. EE manages to not only cope with increasing demand but also bring higher speed and reliability to its customers.

OPERATOR	EE	THREE	VODAFONE	TELEFONICA
WEB-PAGE DOWNLOAD (LIVE/STATIC)				
Success Ratio (%/%)	99.0/98.9	94.6/96.0	97.4/97.4	96.8/97.9
Avg. Session Time (s/s)	2.7/1.6	3.2/2.2	3.1/1.9	3.2/1.6
FILE DOWNLOAD (3MB)				
Success Ratio/Avg. Session Time (%/s)	99.2/1.8	98.0/6.0	98.7/3.6	98.9/4.1
90% faster than (kbit/s)	8840	1903	3405	3258
10% faster than (kbit/s)	44776	19339	30809	26230
FILE UPLOAD (1MB)				
Success Ratio/Avg. Session Time (%/s)	99.3/1.3	97.3/2.7	97.1/2.5	98.8/2.1
90% faster than (kbit/s)	3768	1489	1470	1780
10% faster than (kbit/s)	17778	7569	9217	10133
FILE DOWNLOAD (10 SECONDS)				
Sucess Ratio (%)	99.4	98.8	99.3	99.1
Avg. Throughput (kbit/s)	30344	11491	16887	13918
90% faster than (kbit/s)	9039	1454	3110	2751
10% faster than (kbit/s)	58408	24513	35728	28538
FILE UPLOAD (10 SECONDS)				
Sucess Ratio (%)	99.4	98.6	98.6	99.4
Avg. Throughput (kbit/s)	20003	6917	9685	9909
90% faster than (kbit/s)	4626	1165	1144	1331
10% faster than (kbit/s)	37161	15895	18846	18351
YOUTUBE SD				
Success Ratio/Start Time (%/s)	99.5/1.6	95.1/1.8	98.2/1.9	97.3/1.9
Video playouts without interruptions (%)	99.8	98.5	98.7	99.2
YOUTUBE HD				
Success Ratio/Start Time (%/s)	98.3/1.8	84.9/2.6	93.4/2.1	94.6/2.0
Video playouts without interruptions (%)	98.7	89.5	96.7	97.2

DATA ACCESS IN SMALL CITIES

While providers take great care in covering the metropolitan areas, small cities often lag behind. Is this true for the United Kingdom too?

OPERATOR	EE	THREE	VODAFONE	TELEFONICA
WEB-PAGE DOWNLOAD (LIVE/STATIC)				
Success Ratio (%/%)	93.2/94.9	91.3/92.8	83.2/85.3	78.8/81.7
Avg. Session Time (s/s)	3.1/2.1	3.5/3.0	4.0/3.3	3.9/2.8
FILE DOWNLOAD (3MB)				
Success Ratio/Avg. Session Time (%/s)	96.7/4.7	97.2/6.6	92.5/9.9	84.8/9.7
90% faster than (kbit/s)	2272	1550	916	953
10% faster than (kbit/s)	39409	20979	22018	25779
FILE UPLOAD (1MB)				
Success Ratio/Avg. Session Time (%/s)	94.8/3.4	93.8/5.3	82.8/5.6	83.5/4.8
90% faster than (kbit/s)	864	679	638	780
10% faster than (kbit/s)	12121	7181	8430	9346
FILE DOWNLOAD (10 SECONDS)				
Suvess Ratio (%)	97.7	95.5	94.8	93.6
Avg. Throughput (kbit/s)	20469	10076	8872	9044
90% faster than (kbit/s)	1813	1260	855	339
10% faster than (kbit/s)	47918	25873	24773	26828
FILE UPLOAD (10 SECONDS)				
Success Ratio (%)	98.0	96.2	92.9	89.0
Avg. Throughput (kbit/s)	10675	4374	4361	5799
90% faster than (kbit/s)	676	538	252	488
10% faster than (kbit/s)	27596	14746	16772	18842
YOUTUBE SD				
Success Ratio/Start Time (%/s)	93.1/1.9	90.1/2.1	87.6/3.1	79.2/2.9
Video playouts without interruptions (%)	98.9	98.5	96.1	97.6
YOUTUBE HD				
Success Ratio/Start Time (%/s)	87.2/2.1	74.1/2.7	74.2/3.1	67.8/3.0
Video playouts without interruptions (%)	96.2	87.0	89.7	91.6

The cells in big city networks are usually densely located to fulfill the data demand of the public. In small cities a more widespread network of base stations can support the data demand, but coverage will suffer. In small cities EE loses nearly 6 % of its excellent success ratio and nonetheless stays on top with 93.2 % of successful live web site downloads. Three demonstrates good coverage in small cities and manages to be a close follower with a success ratio of 91.3 %. Vodafone and Telefonica reached only around 80 %, so one out of five live web site downloads failed. Overall speed was good for all operators with session times between 3 and 4 seconds.

File Transfers and YouTube

The speed differences get bigger when it comes to file transfers. Customers interested in the best coverage should closely look at the speeds given, where 90 % of the samples are faster. Again EE succeeds in speed and stability, with Three as close follower in reliability. Vodafone and Telefonica show to a slightly lesser extent the same coverage problems also seen in the web-page download measurement. Looking at Youtube in standard definition EE and Three manage to be successfull in more than 90 %, while Vodafone is slightly below this mark.

DATA ON CONNECTING ROADS

Perfect coverage of roads is a difficult task for providers. Nonetheless customers have high expectations. Will they be disappointed?

OPERATOR	EE	THREE	VODAFONE	TELEFONICA
WEB-PAGE DOWNLOAD (LIVE/STATIC)				
Success Ratio (%/%)	92.4/94.1	89.9/91.1	75.8/77.8	75.6/78.7
Avg. Session Time (s/s)	3.0/2.1	3.6/3.0	3.5/2.4	3.5/2.0
FILE DOWNLOAD (3MB)				
Success Ratio/Avg. Session Time (%/s)	96.4/4.1	96.8/7.6	84.1/7.6	79.5/6.7
90% faster than (kbit/s)	2929	1374	1126	1365
10% faster than (kbit/s)	40438	16282	28537	27778
FILE UPLOAD (1MB)				
Success Ratio/Avg. Session Time (%/s)	95.9/2.9	96.0/5.0	77.2/3.5	79.7/3.2
90% faster than (kbit/s)	1110	811	885	1024
10% faster than (kbit/s)	14035	7024	8611	9780
FILE DOWNLOAD (10 SECONDS)				
Suvess Ratio (%)	98.5	97.9	86.9	81.4
Avg. Throughput (kbit/s)	22398	8596	12472	11998
90% faster than (kbit/s)	2444	919	908	976
10% faster than (kbit/s)	50474	19306	31503	27555
FILE UPLOAD (10 SECONDS)				
Success Ratio (%)	97.3	97.2	83.2	81.4
Avg. Throughput (kbit/s)	13094	3866	7068	8154
90% faster than (kbit/s)	988	631	400	541
10% faster than (kbit/s)	32762	11187	17931	18280
YOUTUBE SD				
Success Ratio/Start Time (%/s)	92.4/2.1	91.5/2.4	78.0/2.7	74.2/2.4
Video playouts without interruptions (%)	98.7	96.9	98.3	97.5
YOUTUBE HD				
Success Ratio/Start Time (%/s)	86.1/2.2	76.4/3.0	71.6/2.8	68.7/2.5
Video playouts without interruptions (%)	96.4	88.2	94.8	95.8

Mobile cells covering roads reach only a comparatively small number of customers. This makes the deployment of a mobile network along motorways a relatively costly affair. Nonetheless EE and Three managed to deliver results in connecting roads performance which were remarkably close to the benchmark results shown in small cities.

The key performance indicators in the web-page download sessions showed a success ratio of 92.4 % (EE) and 89.9 % (Three) which are slightly lower than in small cities. Vodafone with 75.8 and even more Telefonica with 75.6 % had noticeably more difficulties covering roads. The speed differences between big cities, small cities and connecting roads seem negligible by comparison. But speed differences become a major differentiator between the providers in the file transfer benchmarks. At the 3 MB download for instance EE reaches nearly 3 Mbit/s in 90 percent of the samples, while the other three operators stay shy of 1.5 Mbit/s. Vodafone and more so Telefonica again have issues with file transfer success ratios starting below 90 % and in many cases reaching around 80 %.

On YouTube SD EE and Three show a 90 % success rate while Vodafone and Three stay below 80 %. Youtube HD makes things worse.

The drive test is a perfect tool to accumulate a large database, but a walk test provides an even more customer centric insight.

A trolley with a large battery pack, a compact measurement system and smartphones enabled a team from P3 communication to reach areas in big cities restricted for cars. This setup was used to measure in areas of high interest like railway stations and pedestrian areas. The routes between those were mainly bridged by walking, subways, buses or trams and were also part of the measurement.

Telephony

EE lost a little bit of reliability in the telephony walk test compared to the drive test, while call setup time and the high speech quality stayed the same. Vodafone managed to increase its call success ratio from 96.7 to 97.1 % while Telefonica made an even higher jump from 95.5 to 97.1 percent. Nonetheless Three managed to prevail in the walk test with even slightly better results in the call success ratio (97.2 to 97.8 %) and consequently stayed on top. Three also reduced its overall call setup time and differences in speech quality were negligible.

Data services

While calls are handled in 2G (GSM) or 3G (UMTS) data usage should mainly rely on 4G (LTE). This is especially true for big cities with their high data demand. So it is interesting to see how a high percentage of LTE coverage enhances the results. At the web page download Vodafone slightly improved its result from the drive test and managed to show the highest reliability. EE ranked second with a slight reduction in success ratio but defended its first place in speed. Telefonica and Three again lost some ground. Speed was also the main advantage of EE at the file up- and downloads, the differences between drive- and walk test remained very low. This confirms the general validity of a sensibly executed drive test, even to judge the quality of networks for pedestrians. The success ratio of all operators was very close, except for some outliers. In Youtube performance with standard resolution Vodafone managed to reach the first place with an impressive success ratio of 99.3 %, while all other operators stayed slightly below 96 %. Placed overall first in the drive test, EE is also the first in the walk test. This is also true for the last place, while Vodafone and Telefonica although close together managed to change places.

OPERATOR	EE	THREE	VODAFONE	TELEFONICA
TELEPHONY (BIG CITIES WALKTEST)				
Call Success Ratio (%)	94.3	97.8	97.1	97.1
Call Setup Time (s)	7.1	5.0	6.2	6.5
Speech Quality (MOS-LQO)	3.5	3.7	3.5	3.4
DATA (BIG CITIES WALKTEST)				
WEB-PAGE DOWNLOAD (LIVE/STATIC)				
Success Ratio (%/%)	96.4/97.3	95.9/96.4	97.5/98.4	96.0/97.3
Avg. Session Time (s/s)	2.8/1.6	3.2/2.1	3.2/2.0	3.4/1.7
FILE DOWNLOAD (3MB)				
Success Ratio/Avg. Session Time (%/s)	98.2/1.8	97.8/6.2	99.1/4.0	98.5/5.3
90% faster than (kbit/s)	8359	1694	3055	2296
10% faster than (kbit/s)	40956	15789	27088	24316
FILE UPLOAD (1MB)				
Success Ratio/Avg. Session Time (%/s)	97.3/1.6	95.4/2.9	94.9/2.6	97.8/2.7
90% faster than (kbit/s)	3026	1260	1341	1357
10% faster than (kbit/s)	14011	7512	8989	9668
FILE DOWNLOAD (10 SECONDS)				
Sucess Ratio (%)	98.7	98.7	99.4	98.8
Avg. Throughput (kbit/s)	29493	9687	14337	11260
90% faster than (kbit/s)	7668	1698	3001	2055
10% faster than (kbit/s)	54581	19834	29715	24456
FILE UPLOAD (10 SECONDS)				
Sucess Ratio (%)	97.9	97.9	98.0	98.8
Avg. Throughput (kbit/s)	17007	6545	9427	8880
90% faster than (kbit/s)	3358	1204	920	1304
10% faster than (kbit/s)	33488	13542	17753	16944
YOUTUBE SD				
Success Ratio/Start Time (%/s)	96.9/1.7	96.6/1.8	99.3/1.8	96.4/1.9
Video playouts without interruptions (%)	99.7	98.5	99.7	99.2
YOUTUBE HD				
Success Ratio/Start Time (%/s)	95.3/1.9	85.1/2.3	93.1/2.2	91.9/2.1
Video playouts without interruptions (%)	98.3	90.7	92.3	95.6

Hakan Ekmen, Managing Director P3 communications

"We have extended our testing scope including indoor measurement. This way we can make a solid statement on how each operator performs."

The promise of LTE is high speed data access everywhere. Can the providers in the United Kingdom keep this promise?

More than 13 % of the population of the UK lives in its capital London, so clearly the city is very important for the operators. And with its very dense population roughly 20 times as high as on average in the UK it is a special terrain to deploy a mobile network. It is interesting to see if operators manage to cover London as well as or even better than the rest of the UK.

Telephony

With success ratios of 95.9 % in the drive and 97.6 % in the walk test Three showed itself to be the best provider of voice services in London. But this time it was a head to head race against Vodafone with only one point difference to second place.

Telefonica managed to win the third place this time with success ratios of nearly 96 %, while EE lost ground with 93 to 94 %.

Data

In the data benchmarks the ranking changed again. With sucess ratios between 97.0 % (1 MB upload) and 98.7 (10 sec. download) and with generaly by far the highest speed in each category EE again proved to be best data provider in the test. But Vodafone was on par in stability and more than speedy enough for a good user experience. With a little higher error rate in popular categories like web browsing and Youtube access Telefonica ranked third not far behind Vodafone, while Three was left with the last place.

Conclusion for London

With good results in telephony and data performance Vodafone managed to win the network test in London. Judged on voice performance alone Three managed to be a tiny bit better, while by far best the data results were again obtained by EE.

OPERATOR	EE	THREE	VODAFONE	TELEFONICA
TELEPHONY (LONDON DRIVETEST)				
Call Success Ratio (%)	93.0	95.9	97.5	95.5
Call Setup Time (s)	7.3	5.7	6.5	6.6
Speech Quality (MOS-LQO)	3.4	3.6	3.2	3.2
TELEPHONY (LONDON WALKTEST)				
Call Success Ratio (%)	93.8	97.6	95.2	95.8
Call Setup Time (s)	7.0	5.3	6.4	6.5
Speech Quality (MOS-LQO)	3.5	3.6	3.4	3.3
DATA (LONDON DRIVETEST)				
WEB-PAGE DOWNLOAD (LIVE/STATIC)				
Success Ratio (%/%)	98.9/97.9	90.5/92.6	97.3/97.6	95.8/96.9
Avg. Session Time (s/s)	2.7/1.7	3.4/2.3	3.1/2.0	3.3/1.6
FILE DOWNLOAD (3MB)				
Success Ratio/Avg. Session Time (%/s)	98.8/2.3	95.0/8.8	98.7/3.8	98.7/6.1
90% faster than (kbit/s)	7177	1157	3157	1994
10% faster than (kbit/s)	44199	13498	34237	25026
FILE UPLOAD (1MB)				
Success Ratio/Avg. Session Time (%/s)	99.0/1.5	95.8/2.8	97.5/2.6	98.5/2.6
90% faster than (kbit/s)	3506	1554	1480	1414
10% faster than (kbit/s)	17505	8065	10076	10444
FILE DOWNLOAD (10 SECONDS)				
Sucess Ratio (%)	99.8	97.9	99.5	99.2
Avg. Throughput (kbit/s)	32796	7394	18390	11241
90% faster than (kbit/s)	8744	702	2756	1857
10% faster than (kbit/s)	66348	18869	41448	25906
FILE UPLOAD (10 SECONDS)				
Sucess Ratio (%)	99.5	97.9	99.5	99.2
Avg. Throughput (kbit/s)	19111	5913	9935	7846
90% faster than (kbit/s)	4830	938	889	911
10% faster than (kbit/s)	37146	13022	20876	17030
YOUTUBE SD				
Success Ratio/Start Time (%/s)	99.5/1.7	89.8/2.0	97.7/1.8	96.1/1.9
Video playouts without interruptions (%)	99.8	96.8	98.7	98.4
YOUTUBE HD				
Success Ratio/Start Time (%/s)	98.0/1.9	71.2/3.1	93.4/2.4	93.6/2.2
Video playouts without interruptions (%)	98.0	84.1	96.2	96.1
DATA (LONDON WALKTEST)				
WEB-PAGE DOWNLOAD (LIVE/STATIC)				
Success Ratio (%/%)	97.5/97.8	95.9/97.7	97.1/96.8	96.0/97.8
Avg. Session Time (s/s)	2.7/1.5	3.3/2.3	3.2/2.0	3.2/1.6
FILE DOWNLOAD (3MB)				
Success Ratio/Avg. Session Time (%/s)	97.9/2.2	97.3/7.9	97.8/3.8	98.2/4.4
90% faster than (kbit/s)	5958	1386	3833	2876
10% faster than (kbit/s)	47619	15238	28269	25918
FILE UPLOAD (1MB)				
Success Ratio/Avg. Session Time (%/s)	97.0/2.0	95.9/3.2	95.6/2.6	99.1/2.6
90% faster than (kbit/s)	1911	1087	1087	1479
10% faster than (kbit/s)	13652	7240	8929	10296
FILE DOWNLOAD (10 SECONDS)				
Sucess Ratio (%)	98.7	97.8	98.3	97.8
Avg. Throughput (kbit/s)	31457	8700	16204	12211
90% faster than (kbit/s)	6410	1452	2731	2748
10% faster than (kbit/s)	61973	19360	30270	25311
FILE UPLOAD (10 SECONDS)				
Sucess Ratio (%)	96.6	97.3	96.9	97.8
Avg. Throughput (kbit/s)	15247	5685	9454	7984
90% faster than (kbit/s)	1956	1183	863	1341
10% faster than (kbit/s)	33456	12353	17690	14851
YOUTUBE SD				
Success Ratio/Start Time (%/s)	98.2/1.8	96.4/2.0	98.7/1.8	96.4/1.8
Video playouts without interruptions (%)	99.1	99.1	99.6	98.6
YOUTUBE HD				
Success Ratio/Start Time (%/s)	94.3/2.1	78.8/2.5	93.4/2.1	92.8/2.0
Video playouts without interruptions (%)	98.1	84.0	96.2	95.6

OPERATOR		EE	THREE	VODAFONE	TELEFONICA
VOICE	MAX. 285	**164**	**220**	**219**	**199**
London drivetest	220	57%	75%	79%	70%
London walktest	65	61%	84%	69%	71%
DATA	MAX. 425	**363**	**215**	**317**	**304**
London drivetest	325	87%	48%	75%	72%
London walktest	100	79%	60%	72%	71%
CONNECT RATING	MAX. 710	**527**	**435**	**536**	**503**

TEST METHODOLOGY

As in Germany, Austria and Switzerland P3 communications, connect's partner for executing network benchmarks, sent out two measurement cars to perform the tests. The cars were equipped with 8 Samsung Galaxy S5 and 4 Note 4 smartphones each. Eight of them where Cat4 devices and used for the voice test, the other four belonged in the Cat6 category and were used for data measurements.

As far as possible the smartphone's firmware matched the network operator's genuine ones. In cases where no operator specific firmware was available the most recent Samsung firmware was used.

Smartphone-Telephony

Data and voice services were executed with separate smartphones. Telephony was tested mobile-to-mobile from one car to the other. In order to ensure realistic testing conditions background data traffic was generated on the smartphones during a voice call.

The audio quality of the transmitted speech samples was evaluated using the HD-voice capable and ITU standardized so-called POLQA wideband algorithm.

All network operators offer 4G capable subscriptions for everybody interested in a high performance data network. To take the high share of LTE into account speech samples were acquired partly in 4G preferred to 3G preferred mode and partly in 4G preferred to 4G preferred mode. As a consequence, the phones in most cases needed to switch ("fall back") to 2G or 3G because they camped on the LTE service when a phone call was initiated. This procedure is known as circuit-switched fall back (CSFB).

Smartphone-Data

The testing of data services was done with four separate Samsung smartphones in the cars. As a first measurement task several popular live web pages were browsed using the built-in smartphone browser. The web pages had been selected previously according to the Alexa ranking. In addition, the artificial (static) "Kepler" test web page as specified by ETSI (European Telecommunications Standards Institute) for such testing purposes was used.

In order to test the data service performance, files of 3MB and 1MB for download and upload respectively were transferred from or to a test server located in the Internet. In addition, the peak data performance was tested in up- and downlink direction by assessing the amount of data that could be transferred within a 10 seconds time period. While 10 seconds peak throughput test focuses on network capability the YouTube tests add a more end user centric view to the test curriculum. Here, videos with standard definition (SD, 360p, 2.7MB, 30s) and high definition (HD, 720p, 11.9MB, 30s) were played using the YouTube player on the smartphones.

Route and Samples

The route is shown on page 1 of this report. In the big and small cities indicated the cars had to follow pre-defined routes to measure a choice. Altogether more than 90,000 speech samples were logged per operator, about half of them in 4G preferred to 4G preferred mode, while the other half 4G preferred to 3G preferred. For the data benchmark about 50,000 samples were obtained per operator. About 60 % of the samples were obtained in big cities while the remaining 40 % were collected in small cities and on connecting routes.

A new approach to measure mobile networks

Previously it was the usual approach to conduct mobile network drive tests with the measurement devices mounted in the car and connected to antennas in a roof box mounted on the vehicle. In accordance with ETSI TR 102 581 an attenuation of the roof antenna signals of -12 decibel was used to compensate for the antenna gain (+ 5 dB) and to simulate a typical attenuation (- 7dB) of a mobile used indoor. With modern smartphones having their orthogonal MiMo antenna arrangements used for HSPA and LTE and with the use of more intelligent antennas changing their directivity and tuning in relation to the signals received, a new approach is better suited to reflect real life conditions.

This new approach is a highly optimized mounting case for the smartphones. It is designed with unique materials selected for their specific absorption rate at high frequencies between 800 MHz 2,6 GHz. By choosing the right selection of materials in the right places an attenuation rate typical for indoor measurements can be achieved without altering the antennas of the smartphones. The validity of this approach, for which a patent is pending, has been confirmed by comparing measurements between unaltered phones. The legacy approach with antennas in a roof box and attenuators and the so called P3 Antenuatr has been further verified by comparing TIS (total isotropic sensitivity) and TRP (total radiated power) according to the CTIA test plan for over the air measurements in the Testlab owned by WEKA Media Publishing, the parent company of connect. These measurements confirmed an attenuation rate very close to the wanted - 7 dB from LTE band 20 (800 MHz) to LTE Band 7 (2,6 GHz). The variation is even smaller than with external antennas connected over wideband attenuaters.

Three of these antenna boxes were mounted in each of the two cars in the rear side and in the rear windows. One Antenuatr was responsible for 4G preferred to 3G preferred voice measurements, while the second was used for 4G preferred to 4G preferred voice measurements. The last Antenuatr was responsible for the data measurements.

Real live testing confirmed the advantage of using the differently polarized original MiMo antennas, as this increases the likeliness of achieving maximum data rates due the the higher linear independence of the antenna signals.
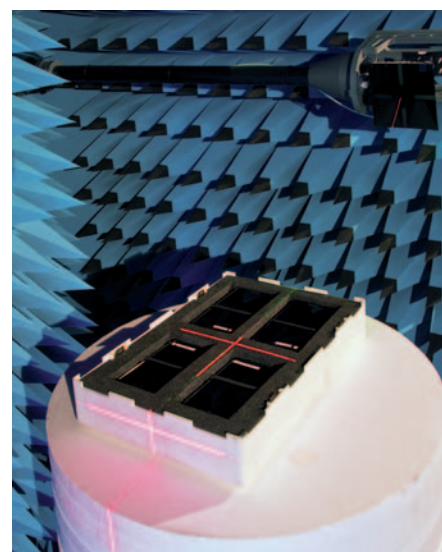
Measurement of one of an early Antenuatr prototype in the connect Testlab. The OTA-measurements (Over The Air) were used to confirm the predicted attenuation of the specialized high performance material in the P3 design.

Three P3 Antenuatr-Boxes are mounted into the back and side windows of each measuring car and four smartphones are used to test four operators simultaneously.
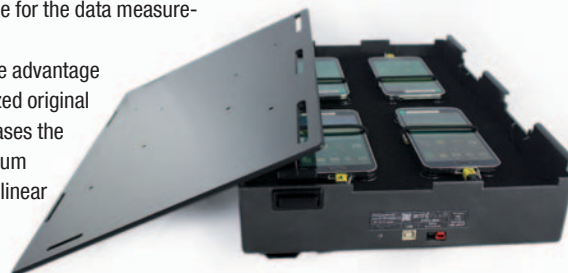
„EE defends its leading position and wins again this year. Due to its leading voice position Three ended up in second position, but Vodafone delivered the best balance between voice and data services.“

With a population density of 14200 per square mile Greater London is a challenge for operators, as the benchmark by P3 and connect reveals.

CONCLUSION
Bernd Theiss,
Head of Test & Technique connect, Head of Testlab WEKA

In last year's mobile network test it was mentioned that „compared with other leading operators in Europe and worldwide, all UK networks have significant potential to further improve their service quality and performance". We see some improvement in this year's benchmark, especially with EE in the data measurements. Here the best operator of last year's benchmark managed to make a big step ahead in speed. No wonder EE defends its leading position and contends for „best in test" seal again. But voice services from EE are handled only satisfactorily with success ratios slightly below 95 %. Other European operators constantly deliver above 98 %. Three also manages to offer a significantly better voice service and consequently reached second place in this year's mobile network benchmark. But this goes along with a trade-off in data performance. It is Vodafone that delivers the best combination of voice and data services and ended up in second position for each category seperately. Looking at big cities alone, Vodafone's results would have been even better, as the results for London on Page 7 show. Telefonica changed position with Vodafone and ranks fourth.

OPERATOR		EE	THREE	VODAFONE	TELEFONICA
VOICE	**MAX. 400**	270	333	300	268
Big cities drivetest	220	66%	82%	76%	70%
Big cities walktest	65	64%	86%	79%	78%
Small cities and connecting roads	115	73%	84%	70%	55%
DATA	**MAX. 600**	490	354	373	370
Big cities drivetest	325	89%	60%	75%	76%
Big cities walktest	100	79%	61%	73%	71%
Small cities	75	61%	47%	27%	23%
Connecting roads	100	76%	62%	36%	34%
connect RATING MAX. 1000		760	687	673	638

P3 connect
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