

THE GREAT MOBILE NETWORK TEST

Often copied, never bettered: For the 16th time running, connect tested the quality of the mobile networks in Germany, Austria and Switzerland. Who is providing their customers with the best voice and data services in this high-speed 4G world?



And here we are: The network operators are equipping their networks over large areas with LTE. The German operator E-Plus is the only exception in Germany, Austria and Switzerland. Smartphones with the new mobile standard are now available everywhere. Based on insider information, the sales share of 4G devices is up to 70 percent for some network operators. A good reason for connect to perform the complete network test with modern 4G/LTE smartphones and tablets (read more on page 42).

Smartphone and Tablet Data

This year the data measurements were executed with eight high-performance smartphones mounted in two different cars. They ensured that the networks on streets, inside and outside of cities and on connecting roads, could benefit from their high-speed LTE services. In addition, both cars checked selected hotspots and areas of interest in the cities. More crowded city centers were additionally measured by walk tests. The walk test team was equipped with four au-

tomated measurement tablets which enabled them to carry out indoor measurements as well.

The LTE Voice Challenge

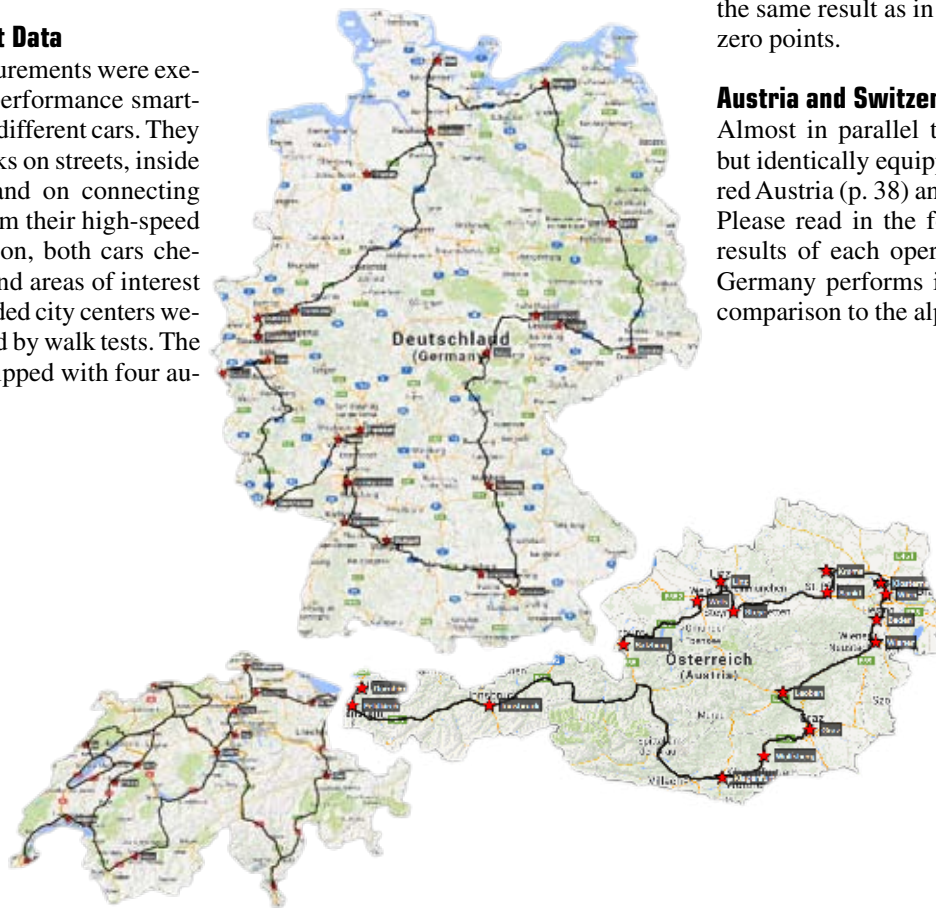
As experts know, voice is a particular challenge in LTE. At this point neither the networks nor the end user equipment allow telephony over LTE, therefore before each call initiation the device has to switch to legacy network standards. Mobile experts refer to this as Circuit Switched Fallback

(CSFB). In order to use CSFB, the device needs to detect a 2G or 3G network and has to switch to it. Due to this procedure, call setup takes longer and the possibility of a failure increases. As a result, we adjusted our test conditions and left on average two and a half seconds more time for the call setup compared to previous years, to achieve a given score. This seems to be a fair compromise for the significantly increased data rates. On the other hand we allow no compromises on call success ratio: If one out of ten calls fails in the cities, we obtain the same result as in the previous year, i.e. zero points.

Austria and Switzerland

Almost in parallel to Germany, different but identically equipped test teams measured Austria (p. 38) and Switzerland (p. 40). Please read in the following the detailed results of each operator. Especially, how Germany performs in this age of LTE in comparison to the alpine countries.

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Telephony

LTE makes high demands on the networks for fast and reliable phone calls. Does the quality have to suffer this year?

GSM and UMTS use circuit switched technology for telephony. For each voice call there is a separate data channel with assigned reserved bandwidth, even if the calling parties remain silent. On the other hand, LTE is based on a pure All-IP-Network concept. Voice will be transmitted over data packets and does not need reserved resources anymore. Because in the mobile networks the necessary exchange between the two methods is very complicated, up to now voice calls have not been carried over LTE.

Once an LTE device receives a call, it has to search for a 2G or 3G network. Then it must change to that network and last but not least, it can answer the call. No wonder that some network operators criticize our voice tests with LTE devices in advance.

Two disturbing phenomena could be observed by some operators beforehand. The relevant ETSI-Norm defines the call setup time as the time between pushing the green button and the first ring.

Nevertheless, in some networks the ring tone is heard by the caller, even though the person called has not yet been reached. In order to overcome this effect, connect measured the time until the connection is truly established. Additionally, some operators maintain the connection for a few more seconds, even if the voice transmission is missing or unintelligible. Connect considers this in the evaluation of the continuous and sustainable connections without long phases of unclear or unavailable voice communication.

Voice in Cities

Within German cities, Telekom achieved the best results. Their success ratios of 98 percent and for an LTE network and excellent call setup times of 6.5 seconds, add up to stress free calling.

Also E-Plus demonstrates a high quality level for telephony. Only when it comes to speech quality are they behind Telekom and Vodafone, who both show a new sound dimension through their high HD-Voice share. However, 6% voice call failures and call setup times of almost 10 seconds shown by Vodafone, that LTE requires tribute. With a pure UMTS and GSM measurement their results would have probably been better, which can be seen in call stability once the calls are established.

O2 is closer to E-Plus in reliability and speech quality, but still remains behind. This is even more valid while 1 percent of calls have disturbing interrupts. The relatively new LTE network revealed itself through long call setup times.

Voice on Transfer Routes

On the connecting routes, Deutsche Telekom suffers the least compared to its inner city performance. E-Plus gains second place, well ahead of the others. Although O2 achieved a slightly better success ratio, they have to fight with more disturbances during calls. Vodafone is more stable during the call connections, but it seems suffers from the typical LTE weaknesses. >>



Measurement equipment of one of the two cars establishing the mobile to mobile calls.

Conclusion

With its high stability and fast call setup times, Deutsche Telekom shows that LTE networks and good voice calls can go hand in hand. In addition, they provide in cities with HD-Voice an exceptional good sound experience. E-Plus, with a pure 2G and 3G network, stays right behind. Especially in inner cities, E-Plus shows an impressive performance.

O2 and Vodafone are obviously fighting with the LTE-specific Circuit Switched FallBack challenge between LTE and 3G/2G. Here the technicians could achieve a better performance with further optimization.

GERMANY				
Operator	Telekom Deutschland	Vodafone	O2	E-Plus
TELEPHONY (CITY AND SUBURBS)				
Success Ratio (%)	98,0	94,1	97,2	97,9
Call Setup Time (%)	6,3	9,8	10,4	6,5
Speech Quality (MOS-LQO)	3,2	3,1	2,6	2,7
sustainable Connection (%)	99,6	99,7	99,0	99,7
TELEPHONY (HIGHWAYS)				
Success Ratio (%)	96,1	91,5	93,7	93,5
Call Setup Time (%)	8,7	11,0	9,5	7,3
Speech Quality (MOS-LQO)	2,7	2,6	2,5	2,6
sustainable Connection (%)	99,0	98,7	97,8	98,5

Smartphone Data in Cities

Big challenge for mobile operators: high demand for smartphone data services in cities. How well do they cope?

The network rollout in cities is a race, because an ever-growing number of people continuously use an increasing variety of services via the mobile networks, which are constantly extended. Since all users at one location share the full bandwidth of their network, their operator always tries to stay one step ahead.

The different carriers follow different strategies: Deutsche Telekom focuses in the cities on the rollout of LTE at 1800 MHz using double the spectrum of LTE at 800 MHz.

From the beginning, Vodafone focused on this spectrum and argues for the better indoor coverage of these frequencies. The smaller operator O2 took a somewhat slower LTE approach

and instead of LTE E-Plus concentrated on an extensive network overhaul, rolling out DC-HSPA+ with 42Mbit/s.

Web-Browsing

The real deal is shown in the performance test of web browsing. The test devices downloaded the 10 most popular German web pages. In addition, the standardized ETSI test page, the so called KEPLER-page, was downloaded. E-Plus was able to cut last year's failure rate in half: more than 98% of the accessed pages were downloaded fast and without any failures. But the competitors improved even more: their success rates were beyond 99.5%. This means that only one of every 200 down-

loads caused problems. Fastest was Deutsche Telekom with Vodafone close on its heels, both on average 1-2 seconds faster than E-Plus. O2 performs between the two bigshots and E-Plus.

Data-Transfer

Data transfers show the current status of the LTE rollout. The LTE1800 network of Deutsche Telekom with its higher bandwidth results in approximately double the throughput of Vodafone, which has a much larger LTE footprint than O2. Even though refraining from LTE, E-Plus is very close to O2. Remarkably, in 90% of cases E-Plus is faster than 2.6s of the test runs and Deutsche Telekom reaches

even DSL-like 13Mbits/s in 90%.

For upload, O2 is way ahead of E-Plus, but is still clearly behind the two close leaders, Vodafone and Telekom.

YouTube

Whereas YouTube runs without any issues in normal resolution (SD) more (Telekom, O2) or less (Vodafone, E-Plus), in HD this video service performs DSL-like only on Deutsche Telekom. >>



GERMANY					
Operator		Telekom Deutschland	Vodafone	O2	E-Plus
DATA SMARTPHONE (CITY AND SUBURBS)					
Web Page Access (live / reference)					
Success Ratio	(%/%)	99,6/99,5	99,5/99,4	99,6/99,2	98,4/97,3
Session Duration	(s/s)	3,4/1,0	3,8/1,2	4,4/1,8	5,2/3,0
File Download (3 MB)					
Success Ratio	(%)	99,9	99,4	99,5	98,2
Session Duration	(s)	1,6	2,8	5,1	6,2
90 % faster than	(kbit/s)	11722	6255	2453	2263
File Upload (1 MB)					
Success Ratio	(%)	99,7	99,8	99,4	98,5
Session Duration	(s)	2,1	2,6	4,9	10,2
90 % faster than	(kbit/s)	1788	1885	1135	452
File Download (10 MB)					
Average Throughput	(kbit/s)	35811	19754	15499	9919
90 % faster than	(kbit/s)	13463	6381	2570	2629
File Upload (10 MB)					
Average Throughput	(kbit/s)	14061	11237	6970	1550
90 % faster than	(kbit/s)	1920	2003	1167	402
YouTube (SD)					
Success Ratio	(%)	99,3	97,3	99,0	97,9
Startup Time	(s)	1,0	1,8	1,6	2,2
Interruption-free Share	(%)	99,5	99,6	99,0	98,0
YouTube (HD)					
Success Ratio	(%)	99,3	94,1	90,4	89,4
Startup Time	(s)	1,2	2,3	3,1	4,4
Interruption-free Share	(%)	99,4	95,9	89,0	87,6

Conclusion

When it comes to downloading webpages, all carriers perform well to very well. Also downloading an app or a music track once in a while or sending emails they all have enough bandwidth most of the time. Only for those who have to upload or download large amounts of data – maps, documents or multimedia files, is data fastest with Deutsche Telekom. Also Vodafone looks very good in this discipline. The biggest difference is in YouTube HD, where only Deutsche Telekom outperforms the market.

Data on Tablets...

Using tablets, our crew tested the network performance in public transport and indoors.

For this task P3 communications mainly tested in buildings open to the general public. Vodafone excelled in this download task due to its large LTE footprint at 800 MHz, resulting in supreme reliability. In 4% of the tests runs, Deutsche Telekom fell back onto GSM/EDGE. In several cases with O2 and even more E-Plus you

would have to move closer to the window to get decent coverage.

This was even more true of

the upload, where Deutsche Telekom was on average 5 times faster than E-Plus and also showed a higher reliability. Vo-

dafone performed very close to Deutsche Telekom and again O2 was third in between Vodafone and E-Plus.

GERMANY					
Operator		Telekom Deutschland	Vodafone	O2	E-Plus
DATA TABLETS (CITY AND SUBURBS)					
File Download (3 MB)					
Success Ratio	(%)	98,6	99,1	97,5	97,0
Session Duration	(s)	3,2	2,7	5,4	8,3
90 % faster than	(kbit/s)	12585	5727	2354	1893
File Upload (1 MB)					
Success Ratio	(%)	98,4	98,0	96,5	95,8
Session Duration	(s)	2,6	3,6	6,6	14,0
90 % faster than	(kbit/s)	2114	1483	691	297

... and between the cities

Outside the large cities the network rollout is less lucrative. How do the operators deliver?

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Webstreaming, online navigation or the quest for a nice restaurant off the beaten track by a friend in the passenger se-

at – there are many reasons to use the mobile web also when en-route between cities. But don't depend too much on the reliability.

After all, Deutsche Telekom delivered 97-98% stable file transfers and web downloads. With only 0.5-1.5% more losses Vodafone also performed really well. Speed was close to Deutsche Telekom, even outperforming the speed of its

competitor in some cases.

E-Plus cannot keep up and drops one in every 10 connections. The speed for surfing and downloading is OK for E-Plus. This is also true for O2, which only falls behind E-Plus due to the higher drop rate.

YouTube on highways is still a challenge for the operators. This becomes obvious looking at the higher failure rates.

GERMANY					
Operator		Telekom Deutschland	Vodafone	O2	E-Plus
DATA SMARTPHONE (HIGHWAYS)					
Web Page Access (live / reference)					
Success Ratio	(%/%)	98,0/97,3	96,9/95,6	88,1/85,1	91,7/87,5
Session Duration	(s/s)	4,7/2,3	4,7/2,1	7,0/4,6	7,0/4,8
File Download (3 MB)					
Success Ratio	(%)	97,0	96,5	89,9	88,7
Session Duration	(s)	7,0	9,8	26,3	18,1
90 % faster than	(kbit/s)	4245	2064	311	708
File Upload (1 MB)					
Success Ratio	(%)	98,4	96,7	90,2	89,5
Session Duration	(s)	7,1	7,5	15,4	14,6
90 % faster than	(kbit/s)	674	526	213	249
File Download (10 MB)					
Average Throughput	(kbit/s)	18919	12952	8865	7383
90 % faster than	(kbit/s)	4542	2365	142	185
File Upload (10 MB)					
Average Throughput	(kbit/s)	5689	7907	3639	1286
90 % faster than	(kbit/s)	463	362	40	41
YouTube (SD)					
Success Ratio	(%)	95,0	92,0	82,8	85,6
Startup Time	(s)	2,5	3,0	7,6	6,0
Interruption-free Share	(%)	96,1	95,2	86,2	88,0
YouTube (HD)					
Success Ratio	(%)	92,8	84,2	63,9	72,4
Startup Time	(s)	3,1	3,8	7,1	7,5
Interruption-free Share	(%)	94,0	89,3	68,4	73,2



Conclusion

Vodafone showed the best average throughput for the tablet test case in the cities, even though Telekom showed the highest peak throughput. O2 cannot keep up with these two since its LTE-rollout is still behind. E-Plus is handicapped by UMTS2100: this frequency band has a lower building penetration than LTE at 800 MHz.

On the transfer routes between the cities Telekom and Vodafone improved massively compared to last year's result, where all four were close to each other. Both are now in a league of their own. But E-Plus also leaped ahead – even without LTE – and is even ahead of O2 outside the cities.

How the network testing activity works

In the short term, the network test provides information for the customer. Long-term it can contribute to the improvement of the networks' quality. For this, transparency is key.

Right after the current year's network test, P3 communications and connect start with a telephone conference where the feedback they got from their readers and from the network operators is discussed. Here the main technical telecommunication market evolutions are identified to be taken into account in the next year. Accordingly, it was for instance decided in 2012 to put emphasis on LTE in this year's test. In February, the basic points like test equipment, services and network properties under test as well as the geographical scope and the draft time schedule are agreed and finalized by May.

Involving the network operators

Once the basic concept for the network benchmark is ready, it is provided to the technical management (the CTOs) of the network operators (see also info package at www.connect.de/netztestplanung). In this way, the CTOs have an option to give feedback. For instance, it would be unfair to test during periods of heavy network reconstruction. Furthermore, it is ensured that the high-end smartphone type chosen for the test works well in all networks under test. Not least, the technical experts on the network operator's side like to discuss testing methodology since they have intimate knowledge of the subject. The testing experts from P3 communications and connect appreciate the enthusiastic engagement with the network operators. However, the final decision about the test scope is with connect. Once all details are fixed each network operator gets a finalized info package (see www.con

nect.de/netztestplanung). In preparation for the connect network test, quarterly pre-tests are conducted that serve to verify and fine-tune the test methodology. Since 2011, the results of these pre-tests (but not the scoring applied by connect) have regularly been purchased by the network operators.

The main principle: transparency

Based on the information provided, the network operators get the chance to optimize their network accordingly. Some pretended insiders actually accused connect of this, connect was even threatened with uncovering this as an unfair practice. Of course, the operators can put special effort into preparing their networks for the connect test – but as the test takes into consideration the main quality aspects relevant for the end user at relevant locations, ultimately all users benefit from these network optimizations.

For instance, the tests unveiled serious effects of Circuit Switched Fallback (CSFB) on the call setup duration and stability in LTE. In early 2012 this was initially hardly noticed by users, since only a small portion of them was using LTE-capable smartphones with LTE-based tariffs. But LTE being part of the connect test methodology put the ball in the operator's court quite early and emphasized the importance to them of optimizing their CSFB parameters. As a consequence, the quality of the networks improved over the year for the benefit of all users, even those not living in the cities tested by connect.

Turn of the year 12/13

Telephone conference between connect and P3 communications to finalize the previous network test and to identify the basic points for the upcoming test.

February 2013

First workshop between P3 communications and connect regarding the network test. Clarification of requirements and capabilities. Start of planning.

May 2013

Network operators are provided with the first pre-information briefing. Full integration of LTE in the test and the Samsung Galaxy SIII LTE as test device are agreed since January as well as the candidate cities for the test. Operators are invited to give feedback.

July 2013

Network operators are provided with the second, more detailed pre-information. The tariffs and device firmware chosen for the tests are announced. Fixing of the final network test time schedule.

September 2013

Additional Information provided to the network operators. Revised measurement methodology ensures that early alerting does not manipulate the evaluated call setup time. Announcement that voice calls with muted or heavily distorted audio channels will reflect negatively in the test result.

2./8./10. October 2013

Announcement of test start in Germany, Austria and Switzerland.

3. October 2013

A routing problem related to the peering of the test server with the mobile radio networks was detected and solved. In order to maintain fair test conditions for all networks the test was suspended for a short period.

24. October 2013

Announcement to the operators that the time period planned for the test in Germany needs to be extended by two days.

24./28. October 2013

Announcement that the measurements for the network tests Austria and Switzerland (24.) and Germany (28.) are finished.



Individual results

After very detailed consideration – what is the overall conclusion about the German mobile radio networks?



Deutsche Telekom

Deutsche Telekom is clearly heading the field.

Finally, Deutsche Telekom achieved the hat-trick: three times connect test winner in a row. This is even more surprising since, although data virtually rushes through a good LTE network, the voice telephony stability and call setup time are a critical thing because the phone has to switch from LTE to 2G or 3G network for each call. Even with an 80% portion of LTE this is hardly noticeable. Compared to last year's non-LTE test Deutsche Telekom shows nearly the same performance in city centers this year. Even on the transfer routes the call setup time

is just marginally longer than before. The LTE technology speeds up the data transfer by three to four times for file downloads. Telekom actually reaches an average throughput of 36 Mbit/s. And even for playing YouTube videos the success ratio exceeds 99 percent. Telekom increases the distance to its competitors and reveals that CTO Bruno Jacobfeuerborn has used the price premium to cleverly invest in the network. Congratulations to Bonn!

connect-rating
very good (454 points)

Vodafone

With data the Vodafone Network shows its power, though the voice service could be optimized.

Clearly the LTE deployment doesn't necessarily make it easier to provide a reliable voice call setup. Switching the line between two mobile phones takes about two seconds longer in the Vodafone network compared to Telekom and call setup failures occur more often than in the test winner's network. However, once the call is set up the service quality is at the same high level as on the Telekom network, especially with respect to audio quality and call stability. This shows the high quality of Vodafone's voice service on 2G and 3G. For data services Vodafo-

ne is the undisputed number two, not least thanks to an LTE portion of 75 percent. Even if Telekom lies ahead of Vodafone, mobile surfing enthusiasts are well served with a Vodafone SIM card – an average throughput of 20Mbit/s would wow many a DSL-user these days. If Vodafone continues optimizing its network as has recently been observed it may change the game next year.

connect-rating
good (383 points)



02

The results clearly show: 02 needs to catch up with its LTE rollout.

Owing to a later start of its LTE rollout 02 showed just a 65 percent LTE portion along our test routes. The fact that LTE calls are usually switched back (CSFB) to GSM rather than to UMTS leads to longer call setup times and a voice quality that is not as good as in the competitor's networks. Furthermore, last year's voice call success ratios were between half and one percentage point higher. Finally, 02 scores 3rd for telephony, behind E-Plus and Telekom. The same rank is reached for data services behind Telekom and Vo-

dafone. Compared to last year, 02 has significantly improved its data service but in the cities 02 still scores 3rd behind Telekom and Vodafone. The average throughput has doubled in some cases and an average throughput of 15,5 Mbit/s when downloading big files is more than enough for most applications. Outside the cities the reliability of the data services decreases.

connect-rating
satisfactory
(349 points)

E-Plus

Without LTE E-Plus shows strong results for telephony and room for improvement with data.

At the moment the E-Plus LTE rollout announced for 2014 is still some way off. Instead, the network was upgraded to state-of-the-art UMTS technology. This progress is clearly visible in the telephony tests where E-Plus benefits from an improvement compared to last year and scores 2nd place right after Telekom. E-Plus could be a choice for those wishing to make phone calls swiftly, reliably and at low cost. Thanks to the consequent 3G network modernization E-Plus significantly improved its data services

as well. For instance, uploading a 3MB file takes just on average 6 seconds compared to 22 seconds last year. Also the other performance indicators are on a level that is fine for everyday usage of mobile internet. Nevertheless, the competitors are better – Telekom and Vodafone additionally provide higher reliability on the routes outside the cities.

connect-rating
satisfactory
(339 points)

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Austria

Twice in a row the smallest network operator was able to win the big connect network test in Austria. Will it be possible to achieve the hat-trick this year or will others be able to close the gap?



The mobile communication market in Austria is in motion as no other in the region Germany/Austria/Switzerland. There is the relatively small operator Drei who acquired the second small provider Orange in August. Thus Drei is now on similar level to A1 Telekom Austria and T-Mobile Austria in terms of subscriber count. However there is a lot of technical integration work pending until the networks are finally merged. As if that were not difficult enough, the auction of the LTE long-distance coverage relevant 800 MHz frequency blocks was not done before September. Furthermore 800 and 1900 MHz blocks have been reassigned in that process. Due to the late assignment of 800 MHz frequencies, Austria was falling behind in regards to 4G deployment. Even LTE smartphone offers are available only from one operator.

Voice Service

A1 Telekom Austria anyway reached already a CSFB ratio of about 60%. That means that in more than 60% of the phone calls the smartphone was in LTE mode initially and had to find a 2G or 3G network. Nevertheless, the largest operator in Austria achieved a success ratio of 98% and the call setup time is on a very good level given that it is at 6.6 seconds. In addition, the MOS value is 3,3, most of the calls are performed

in brilliant HD-Voice quality and almost all are successfully terminated. Therefore A1 should not be concerned that T-Mobile and Drei are even slightly more reliable, faster and offering HD-Voice taking into account that they do not have to deal with LTE difficulties. This is especially relevant since the incumbent operator is well ahead on transfer routes. However, T-Mobile and A1 also provide better service than all German operators. In Austria telephony must be real fun!

Data Service in Cities

For smartphone data service measurements that do not require continuous mobile radio technology changes, A1 with a LTE ratio of 80% is finally in advance of the competitors that do not offer LTE for smartphones. There is almost no category in city measurements where A1 is not leading by a factor of 2 or 3. That results in average data rates of almost 44 Mbit/s for large file downloads – no other operator in the region Germany/Austria/Switzerland can keep up with that. In the upload case and under the same conditions it's 27 Mbit/s, which is 10 times more than T-Mobile Austria provides and still about double that of Deutsche Telekom, which is best-in-class in Germany. Drei and T-Mobile Austria also provide good performance despite

not using LTE. Only for large files and specifically for uploads and Youtube videos do the limitations of 3G become visible for smartphone measurements. A1 Telekom Austria on the other hand is brilliant for low density (SD: Standard- Definition) as well as more challenging High-Definition format.

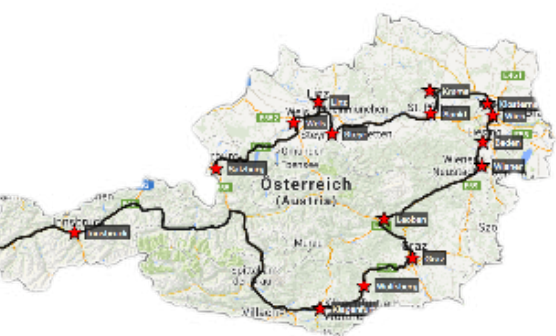
With regards to the tablet measurements T-Mobile Austria and Drei are also in the game. The contracts offered by these providers only exclude the smartphone relevant voice telephony option due to difficulties with Circuit Switched Fallback, which would be needed here. T-Mobile Austria shows a significant performance improvement; in Germany the results of the measurements that are impacted by high indoor ratio would have been sufficient for rank one. In Austria A1 Telekom Austria again shows how excellence looks. In contrast to that, for Drei the tablet measurement results are not convincing. Failure ratios of 5% for download and 7.5% for upload together with relatively low data rates in indoor cases do not offer a really fun experience.

Data Service on Transfer Routes

Despite that, Drei greatly improves for smartphone measurements on transfer routes beyond the cities.

AUSTRIA

Operator		A1 Telekom Austria	T-Mobile	Drei
Telephony (City and Suburbs)				
Success Ratio	(%)	98,8	99,3	99,2
Call Setup Time	(%)	6,3	5,0	4,5
Speech Quality	(MOS-LQO)	3,3	3,2	3,3
sustainable Connection	(%)	99,8	99,8	99,6
Telephony (Highways)				
Success Ratio	(%)	97,5	96,5	97,1
Call Setup Time	(%)	5,5	5,6	4,8
Speech Quality	(MOS-LQO)	3,1	3,0	3,1
sustainable Connection	(%)	99,3	98,4	99,1



For Web Browsing stability Drei can even leave the robust A1 behind, and still achieves best speed. Also for smaller files the race between Drei and A1 is neck-and-neck, for large files A1 was clearly leading again. Youtube SD shows disturbing failure ratios for both operators, for HD the performance of Drei drops more significantly. T-Mobile Austria has highest failure ratios for Youtube and Web Browsing beyond the cities and is losing some points against Drei in that discipline but without risking the 2nd rank for data service overall in Austria. It is remarkably that T-Mobile Austria even has better data performance with a pure 3G smartphone service compared to the German 4G operator O2 in international benchmark.

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Conclusion

Austria again shows how good mobile communications can be. With 472 out of 500 possible points A1 Telekom Austria has the second best result of all times and by far the best result in the network test in Germany, Austria and Switzerland. Congratulations to CTO Marcus Grausam. Also T-Mobile achieves with very good voice quality, and especially in cities convincing data service, a very good network test result. Even the operator Drei which is possibly temporarily impacted by the acquisition of Orange has overall good results and for voice even slightly best performance among all operators under test.

AUSTRIA				
Operator		A1 Telekom Austria	T-Mobile	Drei
DATA SMARTPHONE (CITY AND SUBURBS)				
Web Page Access (live / reference)				
Success Ratio	(%/%)	99,6/99,6	99,1/98,9	99,6/99,8
Session Duration	(s/s)	2,8/0,9	4,0/2,1	4,8/3,2
File Download (3 MB)				
Success Ratio	(%)	98,8	99,2	99,7
Session Duration	(s)	1,5	4,3	7,0
90 % faster than	(kbit/s)	15045	4361	2118
File Upload (1 MB)				
Success Ratio	(%)	99,3	99,7	99,9
Session Duration	(s)	2,0	6,3	6,6
90 % faster than	(kbit/s)	2111	955	957
File Download (10 MB)				
Average Throughput	(kbit/s)	43932	13171	7214
90 % faster than	(kbit/s)	16959	4579	2067
File Upload (10 MB)				
Average Throughput	(kbit/s)	27315	2280	1969
90 % faster than	(kbit/s)	2674	1011	943
YouTube (SD)				
Success Ratio	(%)	99,6	98,5	99,2
Startup Time	(s)	1,0	1,9	2,6
Interruption-free Share	(%)	99,7	98,7	98,8
YouTube (HD)				
Success Ratio	(%)	99,0	96,0	88,9
Startup Time	(s)	1,2	3,0	4,7
Interruption-free Share	(%)	99,4	95,4	84,0
Data Tablets (City and Suburbs)				
File Download (3 MB)				
Success Ratio	(%)	99,6	99,2	95,4
Session Duration	(s)	1,6	3,7	7,1
90 % faster than	(kbit/s)	16374	6231	2030
File Upload (1 MB)				
Success Ratio	(%)	99,6	99,5	92,5
Session Duration	(s)	2,8	4,3	8,5
90 % faster than	(kbit/s)	1612	1014	668
Data Smartphone (Highways)				
INTERNET-SEITENAUFTRUF (Live/Statistisch)				
Success Ratio	(%/%)	97,6/96,6	96,2/96,3	98,1/97,9
Session Duration	(s/s)	4,2/2,9	5,4/3,7	5,4/3,9
File Download (3 MB)				
Success Ratio	(%)	98,3	96,7	97,2
Session Duration	(s)	16,6	14,6	13,5
90 % faster than	(kbit/s)	1143	787	1676
File Upload (1 MB)				
Success Ratio	(%)	97,7	100,0	98,7
Session Duration	(s)	8,1	12,8	9,2
90 % faster than	(kbit/s)	873	454	675
File Download (10 MB)				
Average Throughput	(kbit/s)	14175	9714	7461
90 % faster than	(kbit/s)	2628	652	1244
File Upload (10 MB)				
Average Throughput	(kbit/s)	4334	1805	1801
90 % faster than	(kbit/s)	267	440	582
YouTube (SD)				
Success Ratio	(%)	94,7	91,0	94,4
Startup Time	(s)	3,5	3,8	3,8
Interruption-free Share	(%)	95,3	91,2	94,4
YouTube (HD)				
Success Ratio	(%)	91,6	84,2	87,4
Startup Time	(s)	2,9	5,6	5,5
Interruption-free Share	(%)	95,1	83,4	85,0

A1 Telekom

In international comparison of the LTE smartphone networks, A1 Telekom Austria shows highest reliability for voice service, call setup time is short and the speech quality is excellent almost everywhere. However, mostly impressive is the very quick and stable data service as well as the highest measured data rate of 96 Mbit/s. Performance has a name in the network test 2013: A1 Telekom.

T-Mobile

Austria is challenging mobile operators; T-Mobile Austria shows that. Reliability and fast call setup also rely on missing usage of LTE for phones; the great speech quality is based on engagement. Stability and speed of smartphone data service shows that T-Mobile Austria in part achieves more with 3G than others do with LTE. That is very good overall.

Drei

For two years in a row, Drei was number one in connect network test, this time it only achieves rank three. This could be partly related to problems an acquisition like the one with Orange Austria bring, and furthermore to the competition level in the country. This is also visible in the fact that the Austrian number three is number one in voice service among Germany/Austria/Switzerland and achieves a good ranking with 400 points.

Switzerland

In last year's Network Test LTE was yet to be deployed in Switzerland. This year LTE is an integral part of the service offering. How successful was the upgrade?

While Deutsche Telekom and Vodafone in Germany have rolled out their LTE networks very early, the wide-area introduction of LTE in Switzerland is not yet that advanced. The fraction of data sessions in LTE for Swisscom – which counts the highest number of customers – has been around 70 percent, slightly ahead of O2. Sunrise ends up further down with a similar offset.

Only Orange managed to exceed the 80-percent, having switched on their urban LTE offer at explosive speed, ranging overall on a similar penetration level as Deutsche Telekom and Vodafone. Has it paid off?

Voice Service

All Swiss network operators offer LTE-enabled Smartphone Tariffs. This offers fast data transfer, but makes reliable and swift establishment of phone calls a particular challenge.

Swisscom and Sunrise handle this quite reliably, as success ratios of 98 percent for mobile-to-mobile voice calls show. The calls are carried out between the two test cars. Orange follows suit with 97,3 percent and offers high speech quality with an average MOS of 3,3. Also Swisscom scores

well with a MOS of 3,2. Despite the higher LTE-share, Orange earns merits with the leading call setup time at 5,9 seconds, ahead of Swisscom with still passable 6,8 seconds. All three operators achieve to maintain sustainable calls on equally good level.

On the transfer routes, reliability deteriorates perceptibly. Swisscom is the clear front-runner outside of the cities and shows 95 percent success ratio and 99,3 percent sustainable calls. Compared to that Orange, with the highest LTE share in cities, only achieves 90,7 percent successful calls, 1,9 percent of which are affected by major interruptions and/or unintelligible portions. The call setup takes longest on Swisscom networks, while Sunrise is quickest. HD voice quality on the highways is not commonly observed with any of the Swiss operators. Sunrise does not offer the high audio quality feature at all.

Data Service in Cities

While the test result in the telephony area is clearly in favor of Swisscom, Orange benefits from its high share of LTE in the data domain. When accessing a mix of popular Internet pages this advantage is not obvious, as Swisscom are yet some split se-

conds faster and some tenths of a percent more reliable. Sunrise finishes closely behind.

Relative strengths are similar looking at the download of both small and large files. When uploading small files, Sunrise manages to get clearly ahead of Orange, but still clearly defeated by Swisscom.

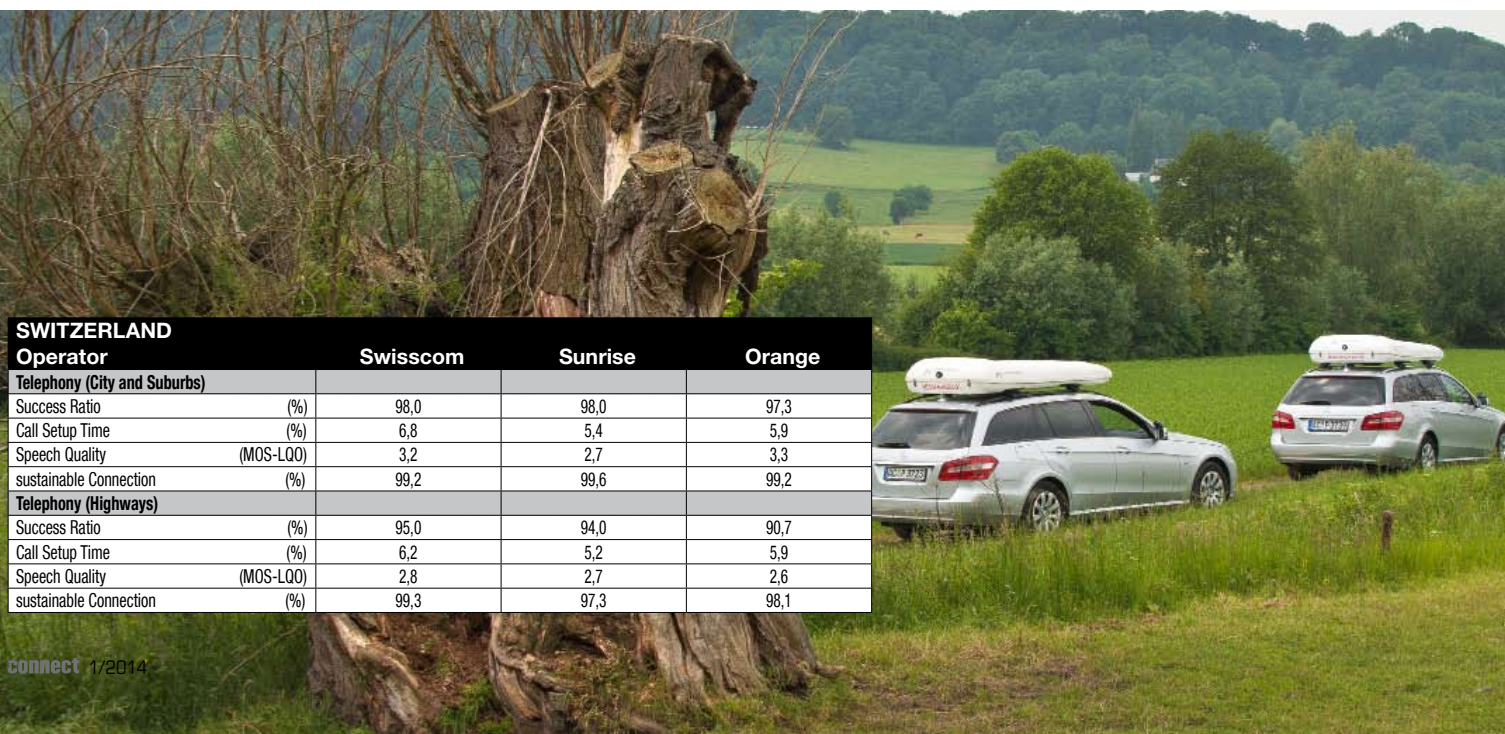
All network operators manage standard-definition (SD) YouTube on acceptable level, Swisscom again showing the best result. They also dominate high-definition (HD) YouTube, although the overall quality level is comparably low.

Data Service on Transfer Routes

On the transfer routes, Swisscom's web page session times increase by roughly a second and reliability goes down one percent. In the D-A-CH competition this is a good result, above all as the local competitors lose slightly on session times and substantially on reliability.

Swisscom finishes file downloads on average more than 60 percent quicker than the next-best competitor Sunrise. Even more impressive, 90 percent of all measurements showed more than 2250 kbit/s, Sunrise achieves 685 kbit/s.

The picture is similar for other up- and



SWITZERLAND				
Operator		Swisscom	Sunrise	Orange
Telephony (City and Suburbs)				
Success Ratio	(%)	98,0	98,0	97,3
Call Setup Time	(%)	6,8	5,4	5,9
Speech Quality	(MOS-LQO)	3,2	2,7	3,3
sustainable Connection	(%)	99,2	99,6	99,2
Telephony (Highways)				
Success Ratio	(%)	95,0	94,0	90,7
Call Setup Time	(%)	6,2	5,2	5,9
Speech Quality	(MOS-LQO)	2,8	2,7	2,6
sustainable Connection	(%)	99,3	97,3	98,1



download tests, where the difference between competitors increases as file sizes grow. Orange by and large manages to keep with the pace, but loses considerably in terms of reliability.

This shows particularly in the domain of YouTube-streams, where Swisscom manages a 96% success ratio for low-resolution videos while on Orange it falls below 85%. Outside of cities, HD quality YouTube is generally affected by interruptions, leaving still room for improvements.

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Conclusion

The picture is clear is Switzerland: Swisscom is very good in Telephony and Data Services and is well superior in 3 out of 4 test disciplines. This means sure victory in Switzerland's network test. Congratulations to Heinz Herren, Swisscom's CTO. But despite the undisputed win, Sunrise and Orange deliver good results. Sunrise in particular finishes on eye-level with Swisscom for telephony in cities and for indoor data service on tablet PCs. Thus they give clear evidence that the Swiss number one may not rest on their laurels.

SWITZERLAND				
Operator		SWISSCOM	SUNRISE	ORANGE
DATA SMARTPHONE (CITY AND SUBURBS)				
Web Page Access (live / reference)				
Success Ratio	(%/%)	99,5/99,3	99,1/99,4	99,4/98,7
Session Duration	(s/s)	3,7/1,3	4,3/2,0	3,8/1,6
File Download (3 MB)				
Success Ratio	(%)	99,7	99,4	99,4
Session Duration	(s)	3,0	6,2	3,2
90 % faster than	(kbit/s)	5427	2566	4006
File Upload (1 MB)				
Success Ratio	(%)	99,8	99,2	98,2
Session Duration	(s)	2,6	4,7	8,0
90 % faster than	(kbit/s)	1758	1299	430
File Download (10 MB)				
Average Throughput	(kbit/s)	20561	13814	16828
90 % faster than	(kbit/s)	6047	2898	4134
File Upload (10 MB)				
Average Throughput	(kbit/s)	11391	7587	7477
90 % faster than	(kbit/s)	1789	1300	365
YouTube (SD)				
Success Ratio	(%)	98,6	97,3	98,5
Startup Time	(s)	1,3	2,1	1,6
Interruption-free Share	(%)	98,7	97,4	98,6
YouTube (HD)				
Success Ratio	(%)	93,8	90,1	91,5
Startup Time	(s)	2,2	3,8	2,7
Interruption-free Share	(%)	93,1	89,9	89,9
Data Tablets (City and Suburbs)				
File Download (3 MB)				
Success Ratio	(%)	99,8	99,4	99,8
Session Duration	(s)	5,0	3,2	2,4
90 % faster than	(kbit/s)	2360	4979	5337
File Upload (1 MB)				
Success Ratio	(%)	99,9	99,3	98,7
Session Duration	(s)	2,6	2,6	5,3
90 % faster than	(kbit/s)	2169	1847	949
Data Smartphone (Highways)				
Web Page Access (live / reference)				
Success Ratio	(%/%)	98,2/97,3	96,4/95,4	96,8/93,4
Session Duration	(s/s)	4,5/2,5	5,3/4,1	5,2/5,6
File Download (3 MB)				
Success Ratio	(%)	98,8	97,7	93,4
Session Duration	(s)	9,4	16,2	20,5
90 % faster than	(kbit/s)	2252	685	642
File Upload (1 MB)				
Success Ratio	(%)	99,3	95,9	93,6
Session Duration	(s)	7,6	10,4	12,2
90 % faster than	(kbit/s)	768	374	286
File Download (10 MB)				
Average Throughput	(kbit/s)	13278	6063	7816
90 % faster than	(kbit/s)	3055	827	624
File Upload (10 MB)				
Average Throughput	(kbit/s)	5166	2814	3389
90 % faster than	(kbit/s)	572	275	105
YouTube (SD)				
Success Ratio	(%)	96,0	92,3	84,6
Startup Time	(s)	2,8	4,3	5,0
Interruption-free Share	(%)	95,8	92,8	85,6
YouTube (HD)				
Success Ratio	(%)	88,3	62,5	58,7
Startup Time	(s)	3,6	9,0	8,5
Interruption-free Share	(%)	87,8	58,7	60,3

Swisscom
They have a clean record: connect tests the networks in Austria and Switzerland since 2009 and every single time, Swisscom came first. Just like this year, in which Swisscom is defeated by its competition only in one of twenty test categories and finishes with a 36 point lead to be the only Swiss operator with the "very good" verdict.

Sunrise
In the most important category "telephony in cities", Sunrise can equal Swisscom's performance. On the important web browsing they also lose only one point on Swisscom. They even surpass Swisscom in the tablet PC measurements. This earns them 405 points and takes them from last year's third place to a "good" second.

Orange
For city telephony and smartphone data services, Orange finishes almost on eye-level with Sunrise. Also the tablet PCs are served well, in the download case even best in Switzerland. But when it comes to the main highway stretches, Orange falls behind and therefore has to be content with still "good" 385 points and third place.

THE CONNECT METHODOLOGY

As in the previous year, connect magazine and P3 communications once again sent two measurement cars out. These were equipped with up to 10 Samsung Galaxy SIII LTE smartphones. The firmware version in use corresponded to the original network operator versions. If no operator firmware was available the latest original Samsung firmware version was used instead.

Smartphone-Telephony

One half of the smartphones installed in the two vehicles were used for telephony measurements from car to car (mobile-to-mobile). In order to simulate a typical smartphone environment which may include voice and data traffic in parallel, one of two involved phones was downloading e-mails in the background simultaneously (Multi-RAB).

The speech quality was evaluated using the POLQA-Wideband algorithm, which has become mandatory since many networks offer HD Voice service which is based on new AMR wideband speech co-

ding. All phones were configured to LTE preferred mode as long as the network operator offered a Smartphone LTE tariff to its customers. For networks not offering LTE tariffs for smartphones the devices measuring data services were also set to 3G preferred mode. This is the usual operational mode for smartphones in a network without Circuit Switched Fallback.

Smartphone-Data

The former USB dongle data measurements could be completely replaced by high end smartphone tests in 2013 because the latest smartphones devices offer exactly the same technical capabilities as the dongle solution and are even more representative in respect of the growing smartphone and tablet PC market shares.

One of the major services under test is the assessment of live web pages, which are selected from the popular ranking page Alexa.com. Besides a top ranking, the live pages under test must also fulfil other criteria such as stability

in terms of the page size or sufficient page coding to be proper test candidates. Furthermore, the standard ETSI reference web page – the Kepler page – was measured in order to rate the networks' web browsing performance independently from complex live page structures and peering constraints towards live servers. Another important service under test is HTTP file transfer in both the uplink and downlink directions. This evaluation contains two different approaches, one user perception approach and one network capability approach. The user perception approach is based on 3 and 1 MB file sizes and simulates up- and downloads of small files like pictures, music files or smartphone apps. The network capability approach is based on continuous 10 second up- and downloads which aim at the network's peak performance. YouTube measurements are performed using original Android player for a low and high resolution test videos (SD 360p, 2.7 MB, 30 sec, HD 720p, 11.9 MB,

30 seconds). All smartphone are equipped with 12 dB attenuation and external antennas which are located on the roof top of the test vehicles. The data test smartphones are equipped with two instead of one antenna in order to support the performance boosting diversity and MIMO technology for HSDPA+ and LTE. In total 16.000 mobile to mobile calls and 160.000 speech samples form the basis for the telephony assessment in Germany. In addition up to 100.000 live web pages and 40.000 file transfers guarantee statistically firm results.

Indoors with Tablets

But that's not enough: With a slightly stripped-down data measurement program an additional walk test team was sent to urban areas. Four (Germany) or three (Austria, Swit-



COUNTRY

Operator

Telephony	max. 190	
City and Suburbs	125	
Highways	65	
Smartphone Data (City and Suburbs)	max. 160	
Web Page Access	56	
File-Download	32	
File-Upload	32	
Youtube	40	
Tablet Data (City)	max. 80	
File-Download	40	
File-Upload	40	
Smartphone Data (Highways)	max. 70	
Web Page Access	25	
File-Download	14	
File-Upload	14	
Youtube	18	

Score max. 500



Conclusions

Bernd Theiss,
connect editor

zerland) Samsung Galaxy Note LTE 10.1 Tablet PCs were equipped with the most powerful data tariffs offered by the operators. The main goal of these measurements was to evaluate data performance at locations of social and public interest which are not accessible for measurement cars, such as cafes, shopping malls, train stations, airport terminals and public transport. The only exception was that the underground was not used by the teams in 2013.

Logistics & Routes

The test vehicles were driving the same cities in parallel but both avoided staying in the same area at the same time. This approach was chosen to avoid one vehicle distorting the measurements of the other. As in past years the measurements comprise drive tests, but also

stationary measurements at so-called areas of interest (AOI). Areas of interest were railway stations, airports but also recreational areas and densely populated residential areas. Especially at these crowded places the networks have to prove that enough capacity is available for all users in the area and also shared fairly among the users. The candidate cities were chosen in order to reflect the highest share of population for all of the three countries under test. In Germany the five largest, in Austria and Switzerland the four largest cities were picked first. Additionally another 19 of the 50 largest (Germany) and for Austria and Switzerland 10 to 12 out of the 25 largest cities were chosen. Furthermore most transfers between the cities were driven on the connecting highway routes.

Network operators face the LTE challenge in different ways. In Germany, Vodafone and Deutsche Telekom were early adopters – even by international standards. O2 is following up and E-Plus modernize their network to the latest UMTS evolution and prepare for LTE. In the network test, E-Plus benefits from this strategy as not having LTE makes good telephony scores easier to achieve. Looking at data speeds the “Greens” have considerably improved, but so have test requirements in the face of LTE. LTE-operator O2 shows losses in telephony, also the data provisioning on transfer routes is still behind. But the performance in cities has been leveraged through LTE to reach a stable 3rd place ahead of E-Plus. Vodafone looses slightly more on telephony, as optimization is still underway. But for data services, Vodafone shows a universally deployed network, hard on Telekom’s heels and therefore scores an overall “good” result. Telekom is very advanced in optimizing its high-speed network, both data and telephony are on top-level, leading to a “very good” test win in Germany. A1 Telekom Austria shows that even more can be achieved. With top scores in all categories they reach an almost “outstanding” overall 472 points. Also the other 5 operators from Austria and Switzerland show scores superior to all German networks except Telekom – a model result.

	GERMANY				AUSTRIA			SWITZERLAND		
	Telekom	Vodafone	O2	E-Plus	A1 Telekom Austria	T-Mobile	Drei	Swisscom	Sunrise	Orange
	164	111	129	151	179	176	181	160	149	139
	89 %	60 %	73 %	86 %	96 %	98 %	98 %	87 %	87 %	83 %
	81 %	56 %	59 %	65 %	92 %	82 %	91 %	78 %	62 %	53 %
	153	141	130	105	155	135	117	145	132	129
	93 %	90 %	86 %	72 %	96 %	85 %	82 %	95 %	93 %	94 %
	98 %	93 %	85 %	78 %	96 %	90 %	73 %	94 %	87 %	92 %
	96 %	95 %	91 %	57 %	98 %	87 %	85 %	95 %	91 %	62 %
	96 %	76 %	65 %	55 %	96 %	78 %	52 %	77 %	58 %	68 %
	74	74	61	49	78	76	46	76	77	76
	92 %	95 %	79 %	68 %	98 %	94 %	63 %	91 %	96 %	99 %
	92 %	90 %	73 %	56 %	97 %	96 %	52 %	99 %	96 %	91 %
	63	57	29	34	60	51	56	61	47	41
	92 %	88 %	54 %	65 %	91 %	86 %	92 %	93 %	85 %	84 %
	94 %	93 %	36 %	48 %	94 %	79 %	92 %	97 %	82 %	68 %
	88 %	82 %	54 %	47 %	72 %	69 %	75 %	83 %	60 %	50 %
	84 %	65 %	22 %	28 %	81 %	51 %	62 %	74 %	37 %	25 %
	454	383	349	339	472	438	400	442	405	385
	very good	good	satisfactory	satisfactory	very good	very good	good	very good	good	good

