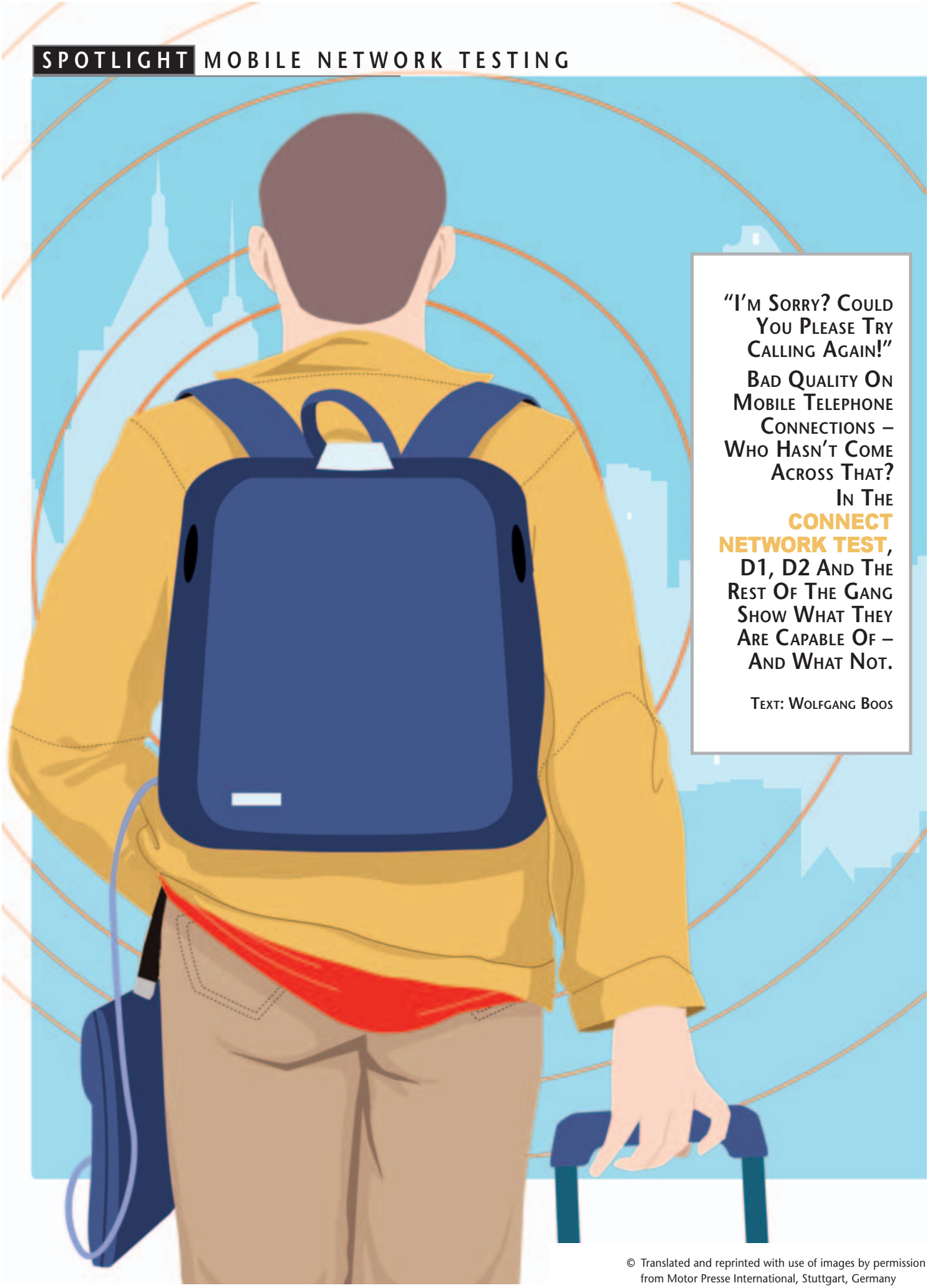
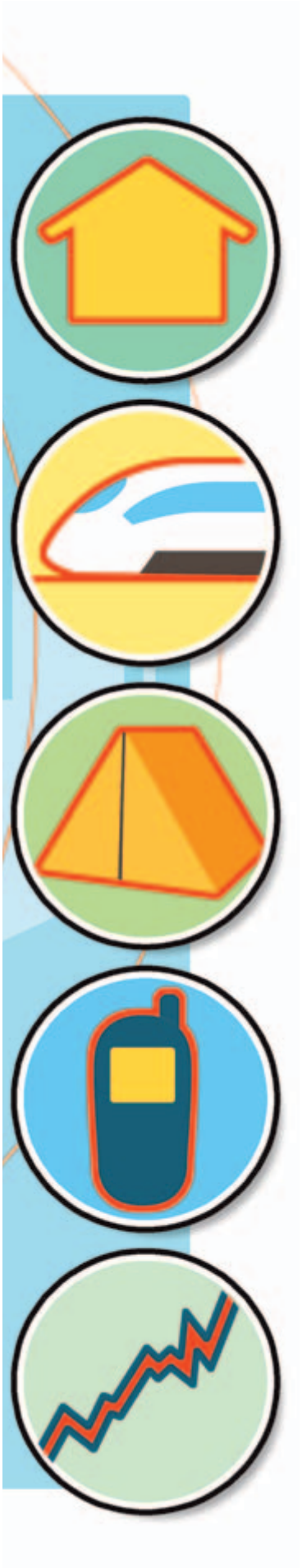


"I'm Sorry? Could You Please Try Calling Again!"

Bad Quality On Mobile Telephone Connections – Who Hasn't Come Across That? In The CONNECT NETWORK TEST, D1, D2 And The Rest Of The Gang Show What They Are Capable Of – And What Not.

Text: Wolfgang Boos



Search of a Network

Most mobile radio network tests involve measurement vehicles that are stuffed up to the roof with hi-tech equipment. That's fine as far as it goes. But do you really only ever make phone calls from your car? That's exactly the point. Mobile phones are also frequently used in places where mobile test vehicles simply can't go – in pedestrian zones, in shopping passages and, not least, at home or in the office. And there is one phenomenon that certainly rings a bell from personal experience: often you can be sitting in the middle of a 'radio silence' zone, while just a few metres away, on the balcony or outside the front door, it's possible to have a phone conversation without any problem. Now that is annoying – but it's something that published network tests to date have simply not taken account of.

Even here at *connect*, we were not able – until now – to account for this factor. However, measurement technology has made considerable progress in recent times. And that is how it came to pass that *connect* – with the help of Swiss hi-tech company Ascom – was able to try out a new method, and perform a network test that produced significant information about speech quality, network reliability and reception strength of all four (German) networks both inside buildings and in city centres.

Measurement system and test procedures

The measurement system used by *connect* for the Network Test 2002 goes by the name of QVoice, and comprises two sub-systems – QVoice Mobile (QVM) and QVoice Stationary (QVS). But what lies behind the name? QVM consists in turn of four OT 96 mobile phones from Sagem that have been specially developed for such measurement tests, each of which is equipped with a SIM card from one of the four German network operators and then connected to a measurement computer programmed to perform real-time speech evaluation. A GPS receiver ensures that the exact location outside buildings can always be defined, and the required power supply comes in the form of two 12-volt batteries with a capacity of 9 ampere-hours. The QVM system is carried in a hard-frame rucksack that guarantees the tester the maximum possible mobility in the big city jungle – notwithstanding 10 kilogrammes of hi-tech on his back. It may not be the most aesthetic transport option, but it's all the more practical for that.

As for control and monitoring of what must be one of the world's most expensive rucksack, that is done with the aid of a small touch-screen monitor, which is connected to the measurement computer inside the rucksack. The system records the protocol traffic of mobile phones and base stations, as well as the measurement results of the speech evaluation – both on the hard disc and, to be absolutely safe, on an additional back-up storage card. The test produces about one megabyte worth of data per hour and per mobile network measured.

In order to avoid possible errors due to the unavoidable serial scattering of the mobile phones, the SIM cards were exchanged between the phones on a daily basis. The stationary counterpart of the rucksack equipment, QVS, also consists of a measurement computer with real-time speech evaluation, which is connected to the public telephone network via four ISDN channels.

But how are the tests actually carried out? The QVM mobile phones have to make regular attempts to establish connections to QVS. When they succeed, and a connection exists between QVM and QVS, the mobile phones in the rucksack send 90 seconds worth of speech samples over the airway, which are immediately evaluated and graded by QVS. After a short pause, the sender and receiver change roles: QVS rings the mobile phones in the rucksack and sends speech samples, which are evaluated in turn by QVM. At the same time, the system records a whole range of additional data that is important for purposes of test evaluation by the professionals at Ascom and the editors at *connect*.

Test cities and test focus

Previous network tests have been carried out only in one type of environment – either streets, trains, or whatever. This time, *connect* decided to set their sights higher, and to perform the tests as from the perspective of a normal city visitor, who arrives with the ICE (German high-speed train system), and goes to a variety of shops, restaurants and standard tourist attractions.

As test locations, *connect* chose the following six major cities in the Federal Republic of Germany: Munich, Berlin, Hamburg, Cologne, Frankfurt am Main and Stuttgart. With this choice, *connect* made sure that it was examining conditions in a whole range of cities visited frequently by both business people and tourists. After all, at the end of the day, the mobile phone user has the right to expect that he will find

Blue marked Expressions are explained in the Lexicon on page 8.

The measurement system performs test calls completely automatically, and records successes and failures, both in terms of reception level and in terms of speech quality.

an adequate network infrastructure in every large German city, as well as on the ICE transit routes. However, there is no doubt that the main focus of this year's test was network quality inside public buildings such as shopping centres, hotels and banks. For that reason, a particularly large number of test calls were made in these types of buildings.

With regard to the train journey assessment, *connect* limited itself to evaluating the **RxLev Sub** reception level and correcting for it by 10 per cent of the value for reception strength. The editorial team decided not to attempt evaluating and taking into account the speech quality and call statistics during the actual train journeys. The reason for this was simple: phoning in or from the train is only recommended to a limited extent (see also separate text / box on page 7). Like any other network test, this one is also a random check, carried out at a given moment in time. Factors such as the weather or unusual situations in a city can obviously affect the outcome, but the fact remains that all networks started off with exactly the same conditions.

Testing speech quality (200 points)

Speech quality was measured using the **PACE** algorithm, which was developed and patented by Ascom of Switzerland. Selected speech samples of 5 seconds duration were transmitted and evaluated by the measurement computer. For **GSM**-ISDN measurements, the highest possible value on the PACE scale is 3.9. By way of comparison, measurements on an ISDN fixed-line network can reach 4.3. For ease of representation, Ascom has prepared a classification of the PACE values (see table below).

Points are awarded proportionally to the number of good speech quality samples. Merely sufficient quality has no effect on the outcome, while points are subtracted for connections with poor quality, once again in proportion to the number of speech samples taken.

Testing call statistics (200 points)

Is it possible to establish a connection? Is the call dropped? These aspects were grouped together by *connect* under the overall term "call statistics". The percentage of successfully established and uninterrupted connections was represented in the overall measurement by the proportional awarding of points. Thus, network operators suffered a loss of points every time a call attempt failed or a call was dropped prematurely.

Testing reception strength (100 points)

The reception level Rxlev Sub was collected in **Dedicated Mode** every 480 milli-seconds, and allows conclusions to be drawn about the actual reception strength at the time of a given call. Values above -80 dBm are counted as good. The proportion of such measurements is recorded in point format on a 1:1 basis. No points are awarded for reception levels between -80 dBm and -100 dBm, which are counted as medium quality. Bad levels (under -100 dBm) are subtracted from the total point score.

SIGNIFICANCE OF THE PACE CLASSIFICATIONS

Pace Value	Classification	Practical Significance
≥1.0 to <2.0	Bad	**Bad speech quality:** Verbal communication is impossible, or largely incomprehensible. These types of connections are usually broken off mostly by the participants.
≥2.0 to <2.7	Poor	**Poor speech quality:** The participants can understand one another, but there is audible interference in the form of speech gaps, noise interruptions, distorted voices. The participants' voices cannot always be recognised.
≥2.7 to ≤4.0	Good	**Good speech quality:** Very good to good comprehensibility; the participants' voices are recogniseable. The speech quality can reach values that are hardly distinguishable from those reached in fixed line conversations.

SPEECH QUALITY

DURING THE TEST CAMPAIGN, THE QUALITY OF CONNECTIONS OFTEN PROVED TO BE VERY HIGH – NOTWITHSTANDING THE FACT THAT VODAFONE AND E-PLUS WERE RESPONSIBLE FOR MORE SLIP-UPS THAN T-MOBILE AND O_2.

Crackling and hissing were both characteristics of vinyl records – and they were largely responsible for their eventual demise. Over the course of the years and with the advent of digitalisation, home telephone connections also came to benefit from good connection quality. However, in the mobile telephony sector, the problem is not so easy to solve. The breaking point of the system – often in the literal sense of the phrase – is the radio spectrum used, which may be digital, but is also very narrow and gives rise to a whole host of physical obstacles and other unpredictable elements between the mobile phone and the base station.

A high-level fight

The more closely-meshed the network, the better the average connection quality will be. Even a quick glance at the table on the right shows that all the networks have attained a very high level of quality in recent times: the speech quality of test calls in six German cities was bad in at most 2.44 per cent of cases. Ironically enough, this maximum value for bad connections was recorded by none other than E-Plus, whose advertising slogans – "The High Quality Network" and "So Near, You Could Almost Be There" – have suggested exactly the opposite for many years.

Apart from results recorded inside buildings within the urban jungle, Vodafone performed excellently, with very good speech quality results. However, the mobile telephony giant proved a disappointment when it came to calls inside shops, office buildings or restaurants – while some 89 per cent of conversations inside buildings were set up with "good" speech quality, T-Mobile and O_2 did better still, with 94 per cent (these figures are to be found in the table on the back page). For the overall evaluation, both inside buildings and outside, T-Mobile performed significantly better than Vodafone, with 95.25 per cent compared to 91.43 per cent; the GSM 1800 networks came in at place two and three respectively, showing little difference to T-Mobile.

In Frankfurt am Main – although this is now pure speculation – the Vodafone network seemed to reach a capacity limit. The reasoning behind this conclusion is that, in about one quarter of the conversations indoors, the network switched to the use of **Half-Rate** Codec. While this is a well-recognised technique for saving network resources by creating extra capacity, it also often leads to a degradation of speech quality.

During the tests, O_2 was responsible for a small surprise. When it came to indoor testing, none of the rival networks did better than the Munich-based operator. Unfortunately, that good impression is not borne out when one looks at the statistics for stability – no other network was responsible for so many failed calls inside buildings.

E-Plus had to make do with third place in the indoor sound measurement classification. Inside buildings, one clear disadvantage of the GSM 1800 networks seems to become apparent – the 1800 MHz radio waves of the GSM1800 networks are more prone to significant muffling by the walls of buildings and by other physical obstacles than are the 900 MHz radio waves of their competitors. This is a phenomenon that can have very direct consequences for speech quality.

Local differences

However, differences in speech quality do not exist only between individual networks. The sometimes considerable local differences did not escape the notice of the computer inside the rucksack:

While Vodafone showed just 59.2 per cent "good" quality calls inside buildings in Munich, the measuring equipment recorded no less than a 100 per cent record of top-quality calls for the same service provider inside buildings in Cologne.

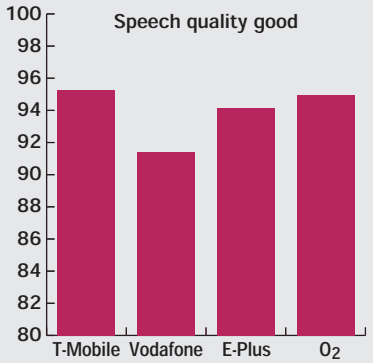
And it is not only Vodafone that performed less well in the Bavarian capital: for market leader T-Mobile, the territory-wide introduction of the improved speech codec **EFR** left a lot to be desired. It was the same story in Munich. Instead, the original Full-Rate-Codec was often brought into play. The Bonn-based provider also failed to deliver in terms of average indoor PACE values in the 'Veal Sausage Capital': with a value of 3.3, the market leader E-Plus had to admit clear defeat at the hands of E-Plus, whose nationwide introduction of EFR paid off – at least in Munich – with an average value of 3.6.

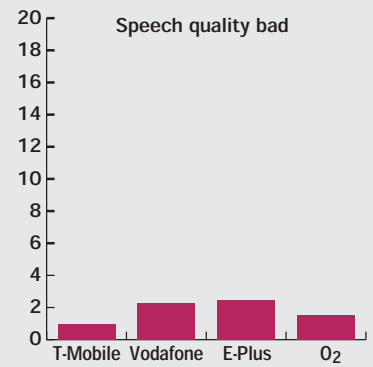
Everything under control: connect's test operator on the road in Cologne with the QVoice system. A touch screen shows the operating status of the complex measurement technology concealed inside the rucksack.

T-MOBILE: NUMBER ONE FOR SPEECH QUALITY

PACE CLASSIFIC./VALUES	T-Mobile	Vodafone	E-Plus	O_2
Good (≥2.7 to ≤4.0)	95.25	91.43	94.16	94.49
Satisfactory (≥2.0 to <2.7)	3.77	6.29	3.41	3.96
Bad (≥1.0 to <2.0)	0.98	2.27	2.44	1.55

The values indicate what percentage of calls was performed with good, poor or bad speech quality.





Neck-to-Neck:
The diagram above shows that T-Mobile, coming in just narrowly ahead of O_2, recorded the best speech quality results in the cities where tests were performed. E-Plus takes third place, while Vodafone is fourth, some way behind. The 'negative check' shows a similar picture: T-Mobile had the fewest instances of 'bad' speech quality (in just 0.98 per cent of test cases). None other than E-Plus came in last in this field, with the most poor-quality calls – just behind Vodafone. O_2 was in the middle. In order to test speech quality, connect carried out a total of 2379 test telephone calls in six cities.

Frequent traveller: connect writer Wolfgang Boos with the fully-automated measurement system in the harbour at Hamburg.

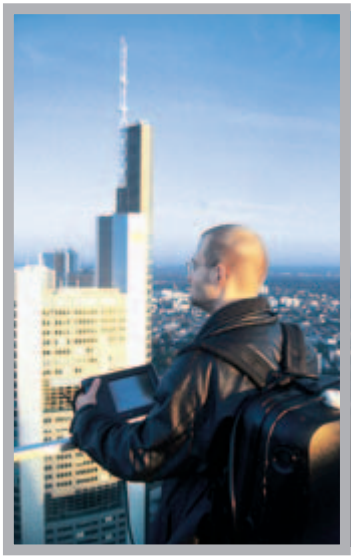
Focus of attention: The testers this year were particularly interested in network conditions inside heavily-used city buildings.

CALL STATISTICS

AN AUTOMATED PRACTICAL TEST WITH THOUSANDS OF CONVERSATIONS: T-MOBILE SET UP *CONNECT'S* PHONE CALLS IN THE TEST PERIOD THE MOST RELIABLY – WITH O_2, BY CONTRAST, NEARLY EVERY TENTH CALL FAILED.

Nearly one million measurement values relating to reception strength (see table on the back page) were not enough to satisfy the testers, because calls can also fail with good reception – for instance, if networks are overloaded. Mobile networks should actually set up pretty well every call, and then maintain the connection for as long as the customer wants to do so. So *connect* tested this aspect too, using automated test calls.

In this area too, T-Mobile takes first place – but by the narrowest possible of margins. The measurement computer was able to set up calls and subsequently exchange speech samples without interruption for no fewer than 94.14 per cent of call attempts. The Düsseldorf-based mobile telephony provider E-Plus notched up an equally good record: 93.9 per cent of the test calls reached their target with no problems. With Vodafone, on the other hand, there were minor problems in the area of stability with a lot of test calls. Inside buildings (see table on the back page), nearly four per cent of all connections broke down during the network test, and about 6.5 per cent of call attempts failed right at the dial-up stage. As for O_2, it came off even worse; in nearly nine per cent of cases, call attempts inside buildings 'fizzled out' – and that figure is definitely too high by any standards.



Up and away: connect test operator Wolfgang Booos in Frankfurt am Main.

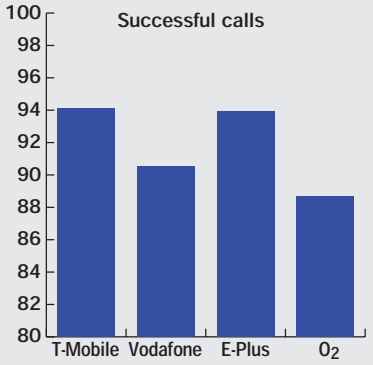
A bitter set-back for O_2

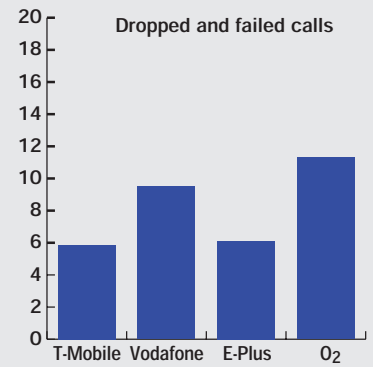
Outside buildings, however, the mobile radio technology of all four service providers had very few problems in the field of connection stability. Only O_2 customers had to hit the redial button on a regular basis even under the clear blue sky – 9.6 per cent of outdoor connection attempts also failed. The result was a painful loss of points, which meant that O_2 had to make do with last place in this field. A major disappointment for the Munich-based company, which had managed to keep well up with the competition in all the other test areas.

T-MOBILE PROVES THE MOST RELIABLE

CRITERION	T-Mobile	Vodafone	E-Plus	O_2
Successful calls	94.14	90.51	93.90	88.70
Dropped calls	2.16	3.48	2.13	2.29
Failed calls	3.70	6.01	3.96	9.01

The values indicate the percentage of calls that could be set up and carried out, and the percentage for which the connection was interrupted or could not be established at all.





Considerably more connections could be established and followed through without problem in the networks of T-Mobile and E-Plus than in those of the two competitors. Vodafone came in considerably behind. The market number two processed calls successfully in about 90 per cent of cases, but the call set-up failed from the beginning in some six per cent of cases. As for O_2, it suffered a painful set-back in the network test: nine per cent of call attempts failed, and a further 2.3 per cent of cases ended in dropped calls – a total of more than 11 per cent. In other words, there were significant problems of one kind or another in more than every tenth case.

RADIO RECEPTION STRENGTH

E-PLUS PERFORMED POORLY IN TESTS INSIDE BUILDINGS, WHILE T-MOBILE PRODUCED THE BEST RESULTS IN THE CITIES.

In parallel with the conversation in progress, the computer recorded the RxLev-Sub value, which allows conclusions to be drawn about the radio reception strength – for this test, connect collected 989 780 such values. One result is of particular interest for anyone who telephones a lot from the office – 6.72 per cent of calls over the E-Plus network recorded bad RxLev-values inside buildings (see detailed table at the end). That is a shocking result because, in comparable circumstances, the figure for Vodafone was just 0.28 per cent – an absolutely top value, followed in second place by the 'indoor' number two, T-Mobile, with 0.84 per cent. O_2, a GSM1800 network like E-Plus, also provided a little surprise: only 3.86 per cent of the Munich operator's indoor calls showed bad quality levels – and that despite the fact that the mobile phones were only registered with T-Mobile via National Roaming for 34 out of 655 test calls.

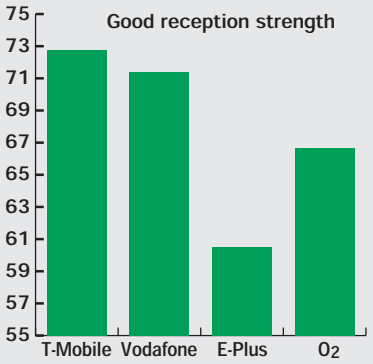
With the exception of E-Plus, all the networks showed levels of over 85 per cent outside buildings. On ICE routes, the reception level influenced the reception value to the tune of 10 per cent of the total – telephoning in the train is problematic bynature. The GSM 900 networks handled this aspect better: four points for O_2 and E-Plus, six points apiece for T-Mobile and Vodafone.

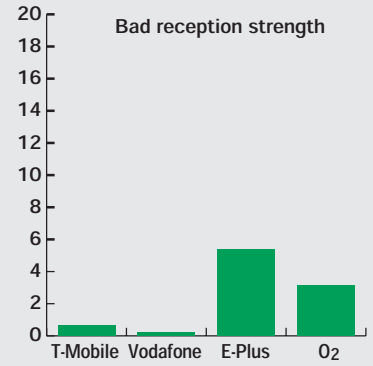
Searching for radio silence zones: *connect's* test operator on travel in Stuttgart (right) and in the ICE train (top).

RECEPTION STRENGTH IN THE CITIES

CRITERION	T-Mobile	Vodafone	E-Plus	O_2
-79 to -49 dBm (good)	72.78%	71.39%	60.53%	66.64%
-80 to -100 dBm (medium)	26.57%	28.39%	34.09%	30.24%
-101 to -110 dBm (bad)	0.65%	0.22%	5.39%	3.12%

The values indicate the percentage of calls carried out with good, medium or bad speech quality.





GSM900 network superiority: While bad reception strength hardly played a role in the GSM900 network telephone calls, E-Plus failed the test in 5.39 per cent of reception level measurements and O_2 in 3.12 per cent of cases. By contrast, both GSM900 networks showed bad reception in only 0.65 per cent (T-Mobile) and 0.22 per cent (Vodafone) of cases – a notable performance. However, it should be borne in mind that reception strength alone does not make a reliable network. If the base station channels are all occupied or the network is overloaded in some other way, then all bets are off again. This aspect was considered by connect under the test category of 'call statistics'.

TEST RESULTS

Criterion	Maximum	T-Mobile	E-Plus	Vodafone	O_2
CALL STATISTICS	**200**	**Very good (176)**	**Very good (176)**	**Good (163)**	**Good (154)**
Inside buildings	150	129	129	119	116
Outside buildings	50	47	47	44	38
SPEECH QUALITY	**200**	**Very good (188)**	**Very good (184)**	**Very good (179)**	**Very good (186)**
Inside buildings	150	139	135	129	140
Outside buildings	50	49	49	50	46
RECEPTION STRENGTH	**100**	**Satisfactory (71)**	**Adequate (54)**	**Satisfactory (70)**	**Adequate (62)**
Inside buildings	68	46	33	45	39
Outside buildings	22	19	17	19	19
Train	10	6	4	6	4
OVERALL RESULT	**500**	**435**	**414**	**412**	**402**
connect rating		**Very good**	**Good**	**Good**	**Good**

Mobile Phones travel freight class

MOBILE PHONE CONNECTIONS IN THE TRAIN END ALL TOO OFTEN THE MOMENT YOU LEAVE THE STATION – DESPITE SO-CALLED 'MOBILE PHONE CARRIAGES'.

Mobile telephony reception in modern trains is generally a problem – not least because the reflective panels of the steel compartments make it virtually impossible for radio waves to get through. However, at least on the ICE trains, German railway operator Deutsche Bahn is making a real effort to ensure its many business travellers in particular can enjoy disturbance-free mobile telephony reception. So-called 'repeaters' receive the signals from the base stations over external antennae, strengthen them and relay them to the interior of the the specially-equipped mobile phone carriages. At least, that is the theory. Because, as the *connect* test results show, clear mobile telephony reception on many parts of the ICE routes is still some way from becoming reality.

There are many reasons for this. First of all, the repeater often simply fails to receive the signal that it is supposed to strengthen. This occurs mostly when the train line runs through a sparsely-populated area, where none of the network operators has bothered to invest money in an additional base station.

The same is true of tunnels: during the test on the high speed route between Stuttgart and Mannheim, mobile network provision regularly broke down in the numerous rail tunnels. The news is equally bad for mobile phone users on the routes Munich-Berlin and Berlin-Hamburg – nearly every other attempted call, regardless of network, left the measurement computer with the designation 'Failed Call'. The conclusion is clear – the best approach is to forget even trying to call from the train, and to switch on your mailbox before you begin the journey.

But it is not only the lack of network provision along train routes that causes many mobile phone conversations to end up 'running on empty'. The repeaters themselves can often be the root of the problem. If they are insufficiently tuned, this can also prevent the successful set-up of a network connection. The result for mobile phone users in trains is often despairing appeals along the lines of "Hallo, are you still there?" and baffled inspections of the mobile phone display panel – as we know from experience.

Wasted effort: Despite the use of repeaters, mobile phones in trains often fail to operate.

Conclusion

Wolfgang Boos, *connect* Writer

Of the four network operators, market leader T-Mobile has a clear lead over all its competitiors, thanks to a well-balanced performance in all three areas evaluated – as a result, it wins a well-earned overall victory. Vodafone and O_2 lose valuable points in the area of stability of mobile connections, while E-Plus continues to show weakness in the area of network availability. This is somewhat of a shame, as the Düsseldorf-based network operator tends to offer very stable connections in those areas where provision is good. Furthermore, phone conversations using E-Plus generally enjoy very good speech quality. In spite of the criticism, one general word of praise is definitely merited – over the past few years, all four operators have clearly and continually improved their networks. As a result, all the candidates deserve at least a "good" rating in the overall evaluation. However, they could all still do better. *connect* will stay on the case.

Lexicon

- **Dedicated Mode**: In this mode, the mobile phone is actively connected to the network.
- **EFR**: The modern Enhanced Full Rate speech codec operates at just 12.2 kb/s, but offers superior speech quality compared to Full Rate.
- **FR**: The Full Rate codec transmits speech information at a data transfer rate of 13.0 kb/s.
- **GSM**: The Global System for Mobile Communications is the most commonly-used mobile telephony both in Europe and across much of the world.
- **HR**: The operator can switch to the Half Rate speech coding. Network capacity increases, but speech quality tends to deteriorate accordingly.
- **Handover**: At this event, the connection is 'handed on' from one base station to the next.
- **Idle Mode**: In this mode, the mobile phone has no active connection to the network.
- **National Roaming**: This enables telephony across several mobile networks. In Germany, O_2 customers are able to use the D1 network in many regions.
- **RxLev Sub**: The RxLev value indicates how strongly a base station is received. In RxLev Sub, value evaluation is limited to the frames generally transmitted from the base station.
- **PACE**: A method developed by Ascom for the automatic evaluation of speech quality.

MEASUREMENT VALUES AND FIGURES FOR THE 2002 NETWORK TEST

OPERATOR	T-Mobile		Vodafone		E-Plus		O_2	
CALL STATISTICS	**Calls**	**Percent**	**Calls**	**Percent**	**Calls**	**Percent**	**Calls**	**Percent**
City, inside buildings								
Total call attempts	493	100.00	488	100.00	496	100.00	499	100.00
Successful calls	459	93.10	437	89.55	461	92.94	443	88.78
Dropped calls	12	2.43	19	3.89	10	2.02	12	2.40
Failed calls	22	4.46	32	6.56	25	5.04	44	8.82
City, outside buildings								
Total call attempts	155	100.00	144	100.00	160	100.00	156	100.00
Successful calls	151	97.42	135	93.75	155	96.88	138	88.46
Dropped calls	2	1.29	3	2.08	4	2.50	3	1.92
Failed calls	2	1.29	6	4.17	1	0.63	15	9.62
SPEECH QUALITY	**Calls**	**Percent**	**Calls**	**Percent**	**Calls**	**Percent**	**Calls**	**Percent**
City, inside buildings								
Overall speech quality	459	100.00	437	100.00	461	100.00	443	100.00
Good speech quality	432	94.12	389	89.02	429	93.06	420	94.81
Poor speech quality	21	4.58	35	8.01	17	3.69	16	3.61
Bad speech quality	6	1.31	13	2.97	15	3.25	7	1.58
City, outside buildings								
Overall speech quality	151	100.00	135	100.00	155	100.00	138	100.00
Good speech quality	149	98.68	134	99.26	151	97.42	129	93.48
Poor speech quality	2	1.32	1	0.74	4	2.58	7	5.07
Bad speech quality	0	0.00	0	0.00	0	0.00	2	1.45
RECEPTION STRENGTH	**Calls**	**Percent**	**Calls**	**Percent**	**Calls**	**Percent**	**Calls**	**Percent**
City, inside buildings								
Overall reception quality	110966	100.00	109659	100.00	111187	100.00	104490	100.00
Good	76602	69.03	73157	66.71	61038	54.90	63784	61.04
Medium	33433	30.13	36193	33.01	42681	38.39	36668	35.09
Bad	931	0.84	309	0.28	7468	6.72	4038	3.86
City, outside buildings								
Overall reception quality	32325	100.00	30455	100.00	33158	100.00	29885	100.00
Good	27682	85.64	26871	88.23	26334	79.42	25767	86.22
Medium	4638	14.35	3579	11.75	6519	19.66	3968	13.28
Bad	5	0.02	5	0.02	305	0.92	150	0.50
Rail journey								
Overall reception quality	111396	100.00	106010	100.00	112782	100.00	97467	100.00
Good	69064	62.00	61382	57.90	61645	54.66	49117	50.39
Medium	41646	37.39	44182	41.68	35339	31.33	39592	40.62
Bad	686	0.62	446	0.42	15798	14.01	8758	8.99