Comparing operators

SURVEY OF THE COVERAGE AND DATA SPEEDS
PROVIDED BY
UMTS MOBILE COMMUNICATIONS NETWORKS
AVAILABLE IN FINLAND

EuropeanCommunicationsEngineering

Tekniikantie 12
FI-02150 Espoo, Finland

Tel. +358 9 2517 3300
Fax +358 9 2517 3301

eceltd@eceltd.com
www.eceltd.com

CONTENTS

Summary

In this survey, the coverage of three 3G operators providing services in Finland (Elisa, DNA and Sonera) was examined in 100 municipalities. ECE included in the survey Finland's 50 most populous municipalities, 25 municipalities among those ranked between 51 and 100, and 25 smaller municipalities. The municipalities covered account for about 74% of the country's population.

The reception in each municipality was determined by carrying out measurements in central areas and residential and industrial zones. The limits of the coverage were examined by driving on the main roads leading away from the municipality until there was no longer any reception. Of the 17,428 road kilometres covered, 13,752 km were measuring routes. A total of 4,717,959 samples were collected on the measuring routes.

The measurements were analysed using computer software by first dividing each municipality into grid squares and then determining which of the operators had coverage in which squares. The comparison was carried out at various signal strength, interference and data speed levels.

The results for the country as a whole show that, on the basis of the measuring and analysis methods used, Elisa remains the operator with the broadest 3G coverage. In terms of reception quality (signal strength), Elisa's network offers the highest signal level and the lowest interference levels.

In line with the previous surveys, there was again little difference in reception coverage and signal strength between DNA and Sonera. In previous surveys, Sonera had a narrow lead over DNA, but it seems that the latter has improved its network and now has a slight edge over its competitor.

The quality of the data services was determined by measuring data speeds in different networks. There seems to be substantial differences in data speeds between the operators and in this respect, too, Elisa has a clear edge over DNA and Sonera. DNA and Sonera are in most cases only able to provide their customers with low-speed and medium-speed data services, while Elisa can also offer high-speed services.

Elisa also has by far the largest number of base station cells. A large number of cells means a broad coverage and a dense network. In this comparison, Sonera came second, followed by DNA.

General

This report presents the results of a measurement survey in which the coverage and data speeds of three Finnish mobile communications operators were examined. The project involved a field study in which measurements were carried out in 100 municipalities in different parts of Finland. The project was carried out between 23 February and 17 April 2009. The two previous surveys had been carried out in early 2008 and in the autumn of the same year.

Objective

The aim was to determine the regional coverage and reception quality (signal strength and interference level) of 3G networks operational in Finland. Regional coverage was determined on the basis of measurement on transport routes, which does not necessarily give an accurate picture of the coverage or indoor reception. However, as a substantial number of municipalities and routes were included, the results give a reliable overall picture of the coverage of the 3G networks. The principles used in the reception analysis are described in connection with the presentation of the results. The results were used for assessing the differences between the operators in the availability of voice and data services.

The aim was also to determine the maximum data speeds currently provided by the operators' 3G networks. This was examined by measuring the amount of data transferred per time unit. The measurement was carried out simultaneously with the coverage measurements and involved the same 100 municipalities, which means that it gives a reliable overall picture of the networks' current data speeds.

The coverage measurements were carried out by setting the measuring units in idle mode. They were on but were not used for producing voice or data connections during the measurements. The data-speed measurements were carried out by continuously downloading a data file of 50 MB (52,428,800 bytes) from the network to the measuring unit (in the downlink direction). SIM cards with unlimited data speeds were used.

The coverage survey was commissioned by Elisa and carried out by European Communications Engineering (ECE Ltd), an independent Finnish expert service company in the field of radio network design, training and development. For more information, please contact:
Elisa: www.elisa.fi / Eetu Prieur, +358 (0)10 26000
European Communications Engineering: www.eceltd.com / Risto Jurva, +358 (0)46 712 1130

Municipalities included

The measurements were carried out in 100 municipalities and in each of them, the following areas were covered:

- Central area: main streets
- Areas surrounding the central area and other important areas: main roads
- Main routes leading to the municipality

The limits of the coverage were determined by driving on the main roads leading away from the municipality until no signal was received from any of the 3G networks. The team carrying out the measurements was not familiar with the structures of the different operators' networks and the measuring routes were chosen at random so that they covered large tracts of the areas in question. Of the 17,428 road kilometres covered, 13,752 km were measuring routes. A total of 4,717,959 samples were collected on the measuring routes. The picture below shows a typical measuring route (Figure 1).

Figure 1. An image illustrating a measurement carried out during the field survey

ECE selected the municipalities for the survey as follows:
- 50 most populous municipalities
- 25 municipalities selected at random among those ranked 51-100
- 25 municipalities selected at random among those ranked 101 or below
- Geographical balance was also a consideration.

The municipalities selected for the survey, which are listed below, account for about 74% of Finland's population.

Finland's 50 largest municipalities, in order of size:

Helsinki	Hämeenlinna	Järvenpää	Vihti
Espoo	Rovaniemi	Kajaani	Sastamala
Tampere	Vaasa	Tuusula	Raisio
Vantaa	Seinäjoki	Kirkkonummi	Varkaus
Turku	Salo	Kerava	Jämsä
Oulu	Kotka	Nokia	Kemi
Jyväskylä	Mikkeli	Kaarina	Raahe
Lahti	Porvoo	Ylöjärvi	Tornio
Kuopio	Kokkola	Imatra	Iisalmi
Kouvola	Hyvinkää	Raasepori	Hollola
Pori	Rauma	Riihimäki	Hamina
Joensuu	Lohja	Kangasala	
Lappeenranta	Nurmijärvi	Savonlinna	

The 25 municipalities selected among those ranked 51-100, in order of size:

Valkeakoski	Lieto	Kontiolahti	Saarijärvi
Haukipudas	Länsi-Turunmaa	Lieksa	Huittinen
Mustasaari	Kempele	Eura	Hämeenkyrö
Sipoo	Nastola	Ilmajoki	Paimio
Kauhava	Akaa	Mänttä-Vilppula	
Laukaa	Ylivieska	Leppävirta	
Pirkkala	Ulvila	Pedersöre	

The 25 municipalities selected among those ranked 101 and below, in order of size:

Närpiö	Juuka	Tuusniemi	Pertunmaa
Alavus	Pihtipudas	Puumala	Enontekiö
Pudasjärvi	Vimpeli	Kuhmoinen	Kyyjärvi
Haapajärvi	Vihanti	Keitele	Pelkosenniemi
Virrat	Puolanka	Valtimo	
Parkano	Lemi	Isojoki	
Tammela	Hyrynsalmi	Muonio	

The location of the municipalities is shown in the map below (Figure 2).

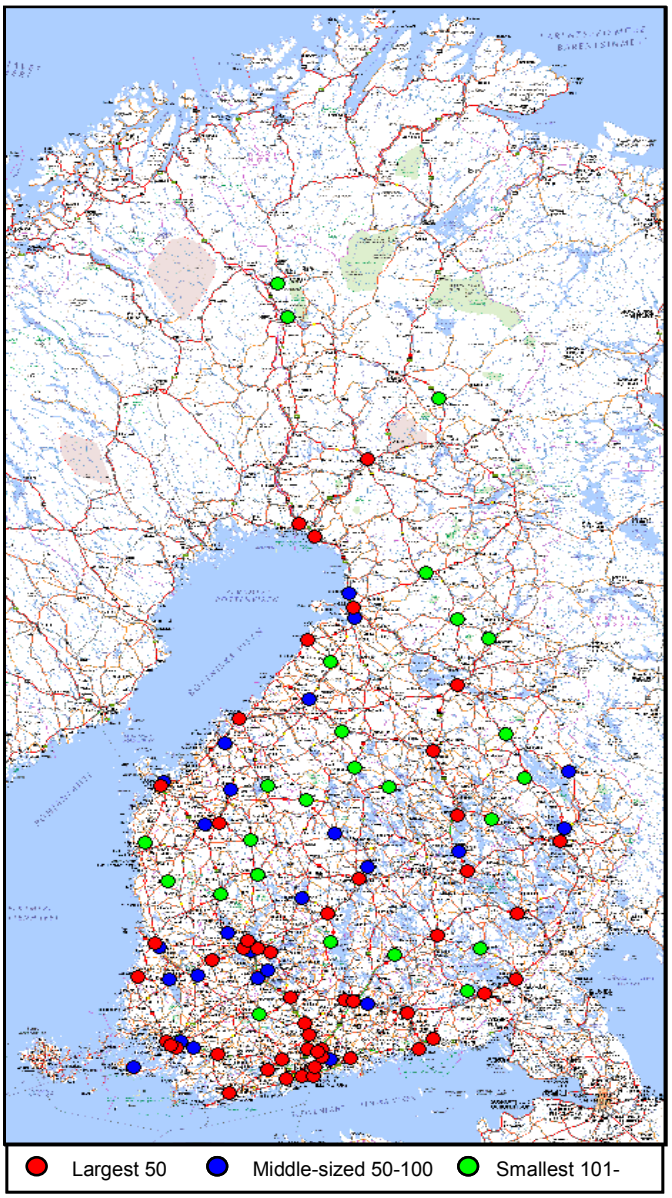

Figure 2. The municipalities included in the survey

Parameters measured and the system used

Parameters measured

The measurements were carried out using six measuring devices installed in the measuring vehicle. Two of the devices measured the network of one operator. In reception measurements, the units were locked so that they were only able to measure the UMTS system at frequencies of 900 and 2,100 MHz.

Signal strength and intereference levels, the parameters examined in reception measurements, were determined relative to the location. Signal strength is commonly described using the unit dBm *), which has a negative value. The higher the value, the stronger the signal. In this measurement, the signal strength required for a good voice connection corresponds to a signal strength of about -95 dBm, while that required for a high-speed data connection indoors corresponds to a signal strength of –75 dBm. In mobile communications networks, the range is typically between –60 and –100 dBm.

The quality of reception can be determined by measuring the interference level. A situation may arise in which both the signal strength and the interference level are high, which can have a substantial negative impact on the service available to the user. The interference level is measured using the parameter dB *), which has a negative value. Higher the value, lower the interference. The range is typically between –15 and –2 dB, and levels of –10 dB and higher can be considered good.

Measuring of data speeds helps to verify the quality of such data services as email and the Internet. High speeds mean that mobile phone users can also receive emails and attachments more quickly. Data speeds were measured using the parameter ‘kbps’ (or kbit/s = kilobits per second**), which gives the amount of data transferred in bits in one second. At the moment, speeds of up to 7.2 Mbit/s can theorically be achieved in UMTS networks (downlink). There can be substantial fluctuations in transfer speeds during the connection. Operators offer consumers connections with different speeds, which means that users can select the maximum speed they want.

In data-speed measurements, the measuring units were able to measure the GSM or UMTS system at frequencies of 900, 1,800 or 2,100 MHz. In the analysis stage, the focus was, however, on the higher data speeds offered by the UMTS system (>250 kbps).

The number of base station cells in each network was also determined. This is indicative of the network structure: a high number of cells usually means a dense or extensive network. Generally speaking, the quality and coverage of the network can be improved by increasing the number of cells.

*) Decibel describes the relationship of two figures of the same unit with each other. In such cases, a logarithmic scale is used instead of a linear one. The unit 'dBm' refers to the relationship between the decibel level and milliwatts. Examples:

dBm	W	dBm	W	dBm	W
-10	0.0001	-30	0.000001	-50	0.00000001
-20	0.00001	-40	0.0000001	-60	0.000000001

**) k = kilo = 1024
M = Mega = 1024 k = 1048576

Measuring system

The Nemo Outdoor system was used as the measuring system. It had the following components:

- Measuring software: Nemo Outdoor v.4.24.90
- Measuring unit. Nokia 6121 (3 pieces)
- Data-speed measurement: Huawei E169 (3 pieces)
- GPS receiver: RoyalTek RGM-3600 /LP
- Personal computer: Dell D630 (2 pieces)

Comparison principle

The results were compared on a municipality basis so that each measured area was dividided into a grid (100 by 100 metres) using GPS coordinates. Each measured sample was then placed on the grid using the coordinate value as a basis. Thus, the operator, which, on the basis of the samples, had the highest number of squares in a particular municipality also provides the broadest coverage. The principle is illustrated below (Figure 3).

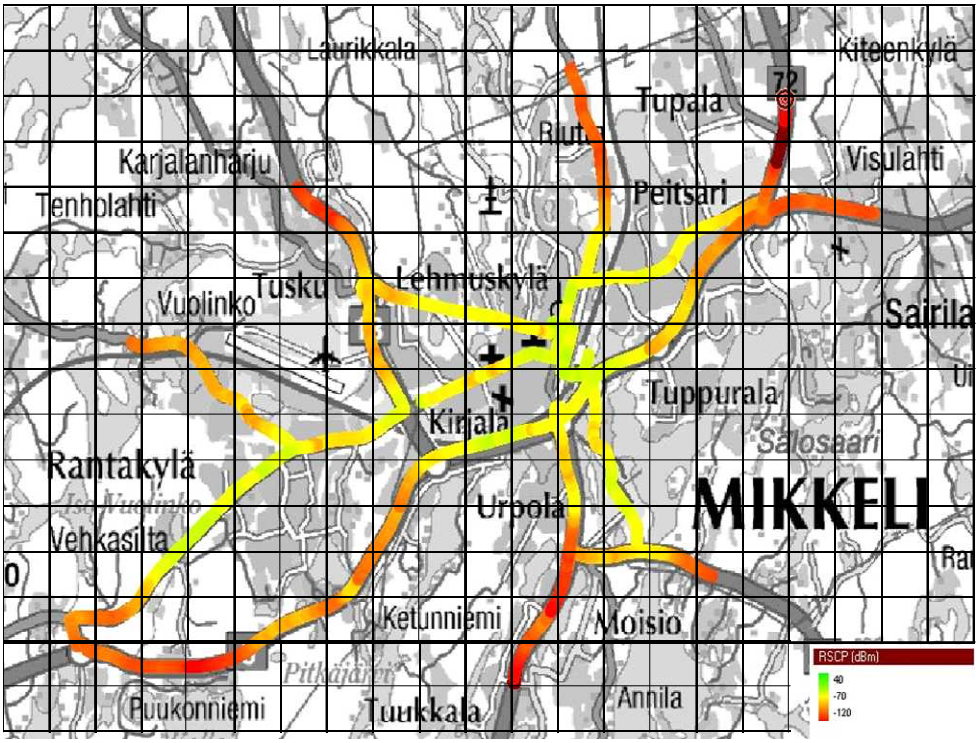

Figure 3. The principle used for analysing the coverage

When the reception quality was compared, the signal strength in each square was analysed. The division of samples in different signal strength categories shows the quality of reception: samples with high values also indicate better reception. The network interference level was also determined using the same method. In this case high values mean less interference.

Data speeds were divided into speed categories and the samples measured in each square were placed in appropriate categories. Samples with higher data speeds are also an indication of higher data service levels.

Results

The results of the measurements are presented below. Both the more detailed results, in which the focus is on technical aspects, and summarized findings, which give the viewpoint of the end users, are presented.

Coverage

The extent of the coverage was examined by calculating the number of geographical locations (squares) in which the operators' 3G signal (pilot signal or RSCP) was above a predetermined threshold value. As the number of squares for each operator was on the basis of the threshold values used, the analysis was carried out using a number of different threshold values. In Figure 4 below, pilot signal values between -100 dBm and -60 dBm are used as threshold values. The number of squares in which the operators' signal was higher than the threshold value are shown as curves. The results sum up the measurements carried out in 100 municipalities.

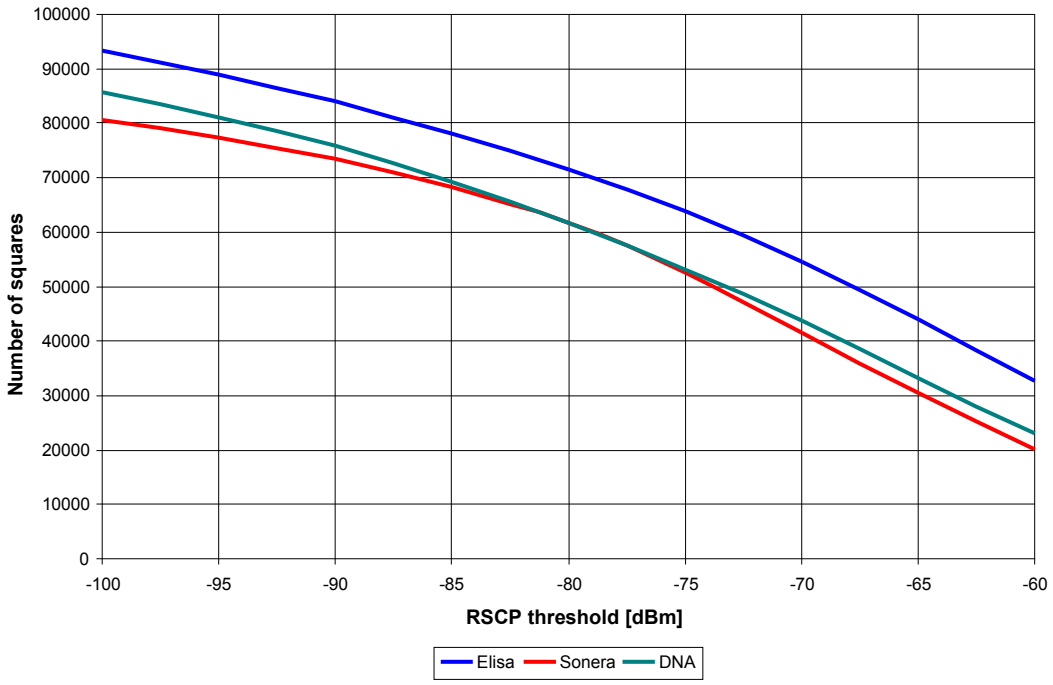

Figure 4. Number of squares at different threshold values.

All measured grids in which an operator provided coverage have been considered in the graph. It shows that Elisa has by far the broadest 3G coverage at all signal levels. This is in keeping with the previous surveys.
The survey indicates that DNA has a slightly more extensive coverage than Sonera. This means that, compared with the previous survey, DNA has

overtaken Sonera. However, in the range between –75 and –85 dBm, there is little difference between the two. The difference between Elisa and DNA is roughly the same at all signal levels, whereas the gap between Elisa and Sonera becomes wider at both low and high levels.

If there is a high likelihood that indoor 3G voice services can be provided at a pilot signal level of –95 dBm and indoor data services (for example, 1 Mbps) at a pilot signal level of –75 dBm, the coverage of these services can be described as shown below in Figure 5.

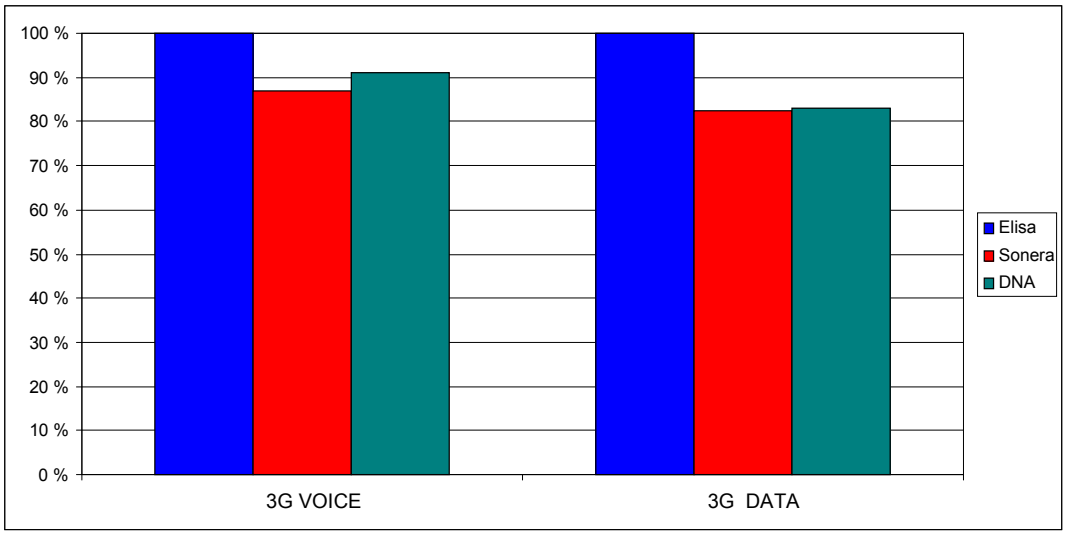

Figure 5. The relative number of squares covered – 3G voice and high-speed 3G data (The number of squares of the operator with the highest value equals 100 per cent)

The number of squares for each operator has been adjusted so that for the operator with the highest values the total equals 100%. This reception measurement gives Elisa the best result at the assumed signal strength for 3G voice services. DNA comes second, followed by Sonera. The order is the same for 3G data services. Elisa has a clear lead over Sonera and DNA, while there is only a slight difference between the latter two.

If the number of squares of each operator is compared with the squares in which at least one of the operators had coverage exceeding the threshold value, the number of squares can be presented as follows (Figure 6).

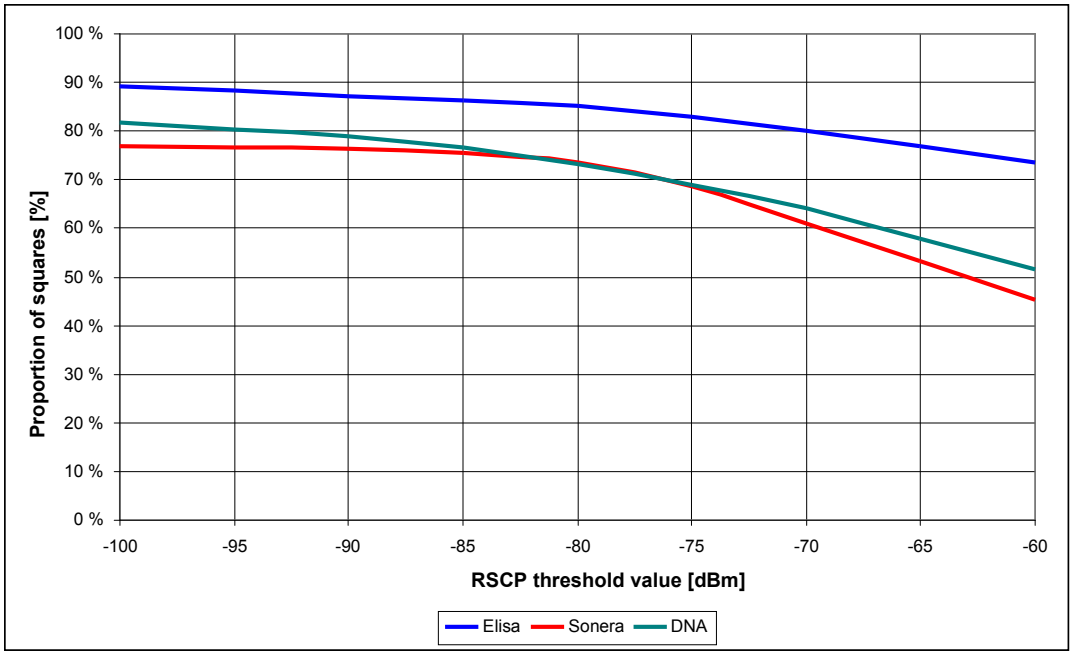

Figure 6. The relative number of squares covered. The number of squares in which at least one operator provides a coverage exceeding the threshold value has been used as reference.

There are also relative differences in reception coverage at signal strengths for 3G voice services (-95 dBm). Elisa has the broadest coverage, while DNA comes second, followed by Sonera. The gap between Elisa and its two competitors becomes wider at the assumed signal level for 3G data services (-75 dBm), and particularly at the higher levels (-70….-60 dBm). Compared with the previous survey, the difference between Elisa and its two competitors has slightly widened at low signal levels. At high signal levels, the difference between Elisa and the two other operators has slightly narrowed even though the gap remains substantial.

The figure below (Figure 7) illustrates the situation at signal strengths for voice services (-95 dBm) and high-speed data services (-75 dBm).

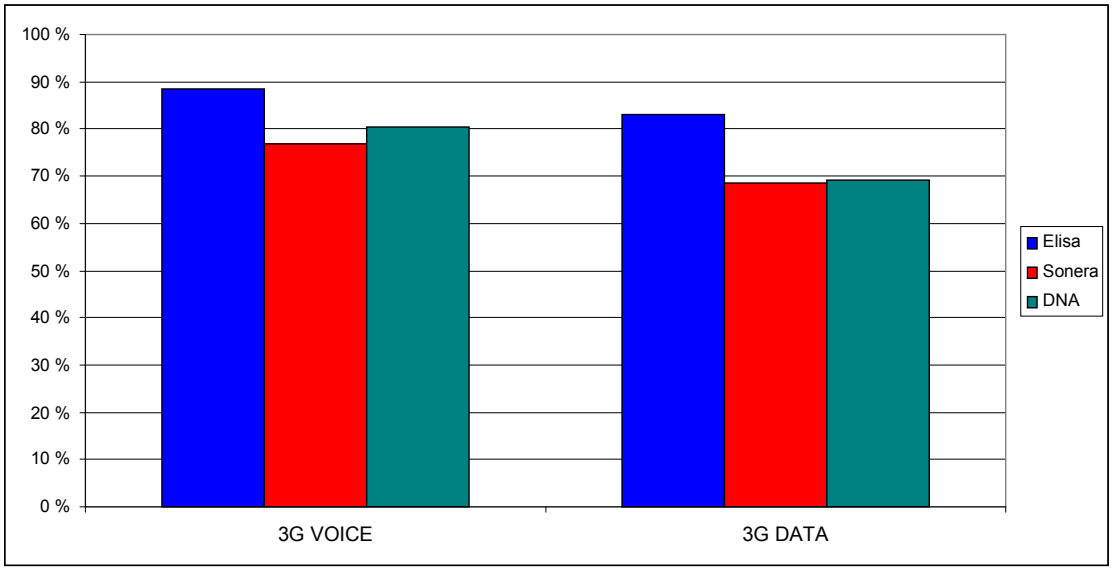

Figure 7. Likely reception of 3G services in measured areas in which at least one operator has 3G coverage.

There are differences in signal strengths for voice services, with Elisa coming first, followed by DNA and Sonera. In data service signal strengths, the order is the same, though Elisa has a clearer lead and the gap between DNA and Sonera is narrower. In this respect, too, DNA has overtaken Sonera since the previous survey.

Signal strength

In addition to coverage, the quality of reception was also studied. Operators may have different network-buildings strategies. For example, one operator may aim to construct an extremely broad but a thin coverage, which may mean weak reception indoors. Another operator may have a geographically more limited network that nevertheless provides superior indoor reception and fast data links.

The 3G signal strength was examined in geographical locations in which all three operators have coverage. Geographical areas were again defined as squares.

The figure below (Figure 8) shows the relative cumulative breakdown of the signal strengths in the shared 3G reception area.

The probality (horizontal axis) of reaching a certain signal level (vertical axis) in the operators' 3G networks can be determined using the graph. The curves for DNA and Sonera are fairly close and partially overlapping, which means that the likelihood of different signal levels is roughly the same. There are slight differences at signal levels of between –95 and –85 dBm, which are more likely to be reached in Sonera's network. Elisa clearly stands out, which shows that it is more likely to reach a certain signal level than the other operators. For example, Elisa's signal strength is better than –70 dBm in 50% of the shared coverage area, while the corresponding figure for DNA and Sonera is less than 40%.

Compared with the previous survey, the gap between Elisa and the two other operators may have narrowed slightly. Nevertheless, Elisa still has a clear edge over its competitors.

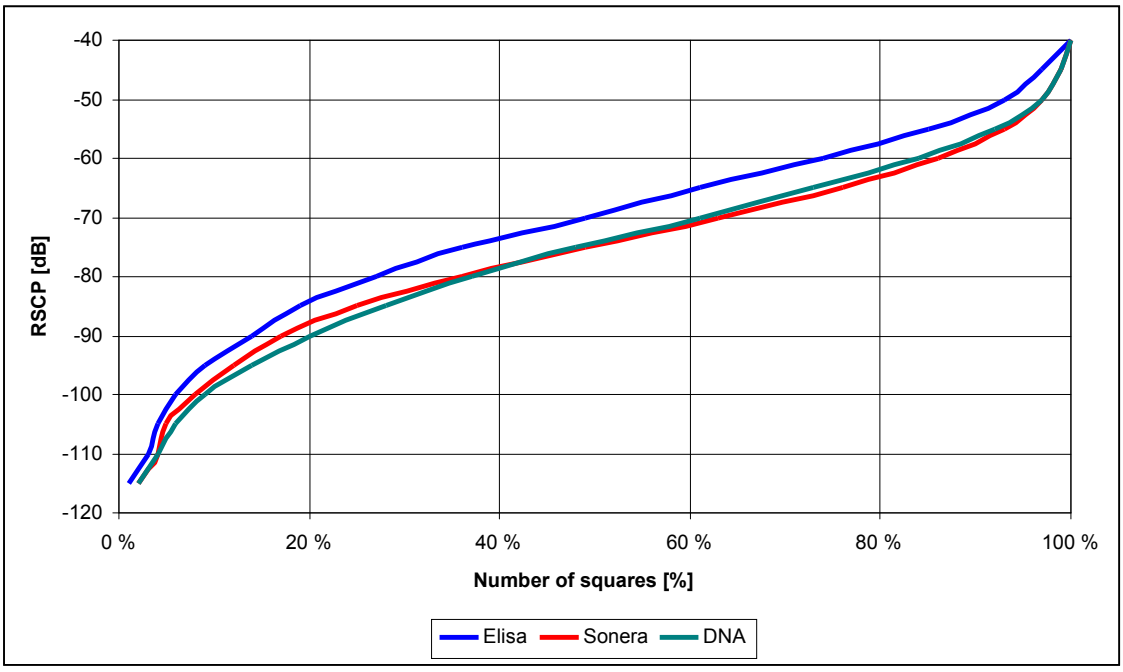

Figure 8. 3G coverage in the shared coverage areas

When assessing the extent of the 3G coverage, the availability of voice and high-speed data services in the shared coverage area can also be examined. The figure below (Figure 9) shows the measurement-based results.

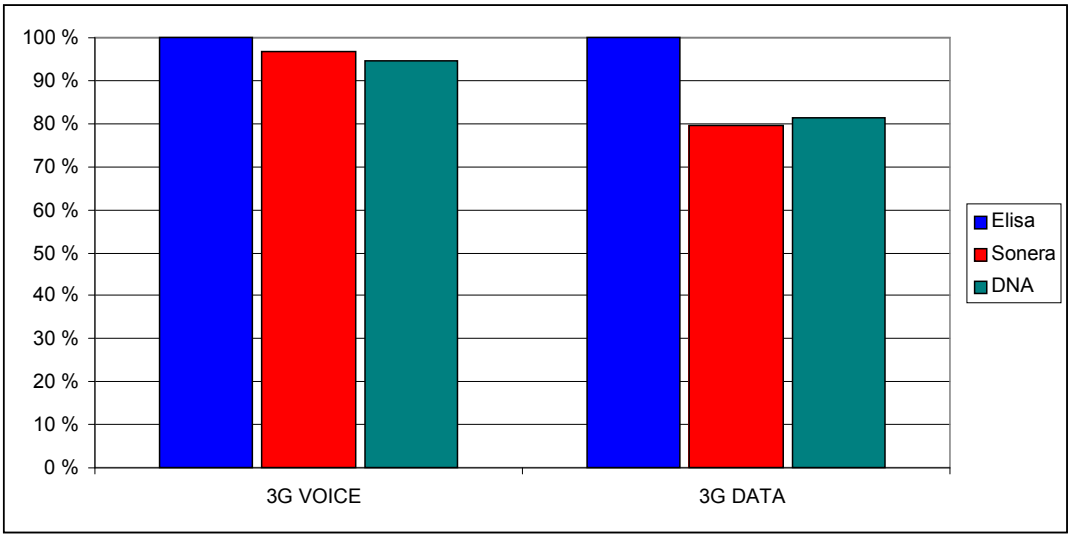

Figure 9. Likelihood of 3G reception in shared coverage areas on the basis of signal level. A signal level of at least –95 dBm is required for voice services, while the minimum for high-speed data is –75 dBm (The results for the operator with the highest value equal 100%).

When measured on the basis of signal levels, all three operators provide more or less similar 3G voice services in shared coverage areas. Elisa comes on top, followed by Sonera and DNA. When examining the assumed signal strength for high-speed 3G data services, Elisa is much more likely to provide a better service than DNA or Sonera. The gap between DNA and Sonera is narrow. Compared with the previous survey, DNA now has a slight lead over Sonera.

Signal-to-noise ratio

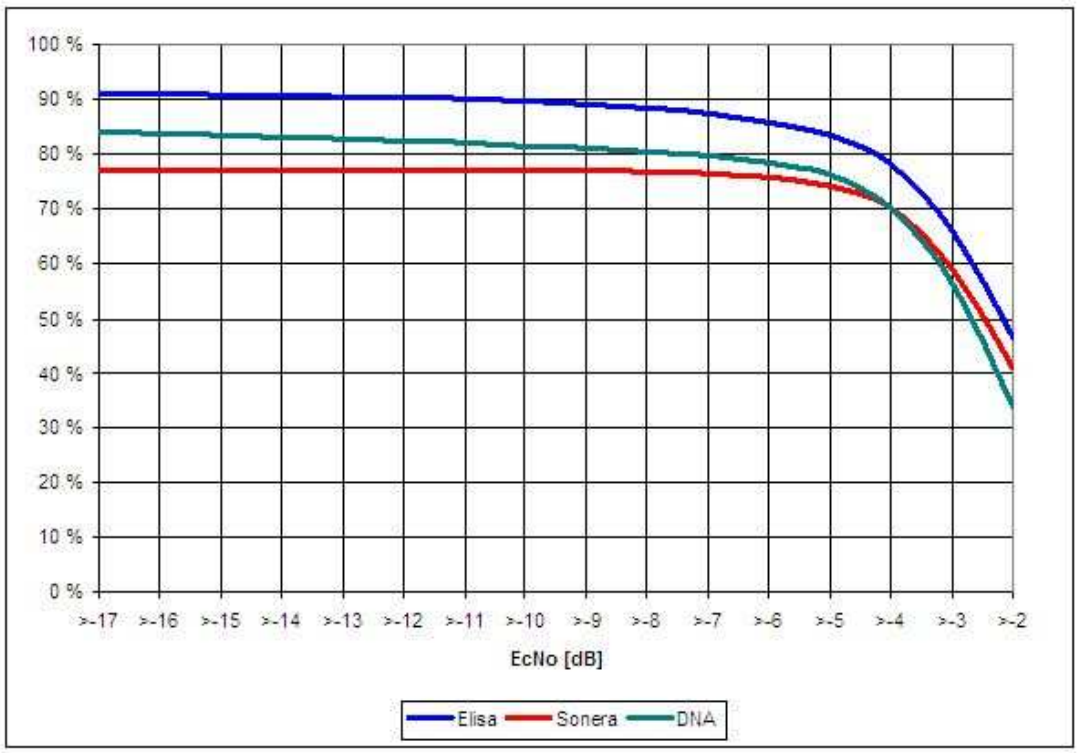

Figure 10. Cumulative EcNo distribution in areas in which at least one operator has 3G coverage.

The figure above (Figure 10) shows the distribution of the signal-to-noise ratio of the 3G networks in areas in which at least one operator has 3G coverage (on the basis of reception measurements). The graph shows the proportion of squares in which the measured signal-to-noise ratio exceeds the threshold value. When taking a typical EcNo value of –5 dB as an example, the survey shows that in Elisa's network the likelihood of it being achieved is 83%, compared with 77% for DNA and 74% for Sonera.

The measurement results show that Elisa has the best signal-to-noise ratio, which means that the typical range of between –10 and –2 is most likely to occur in Elisa's network. DNA comes second even though at the lowest interference levels it falls slightly behind Sonera.

The impact that interference has on service quality is usually on a case-by-case basis. A data connection usually becomes significantly slower at EcNo values of about –8 dB and below. Voice connections usually become weaker and interruptions start occurring if EcNo drops below –14 dB.

Data speed

Data speeds and the coverage of the data services were examined by determining the number of squares in different data-speed categories (kbps), in which at least one operator had coverage. In the figure below (Figure 11), data-speed values of 250-3,000 kbps have been used as threshold values, which means that the values have been divided into categories at intervals of 250 kbps. The squares in which speeds shown in each category have been reached are displayed as bars showing the number of squares in question. Furthermore, the number of squares in which data speeds of more than 3,000 kbps were reached, is shown as a bar on the right. The results sum up the measurements carried out in 100 municipalities.

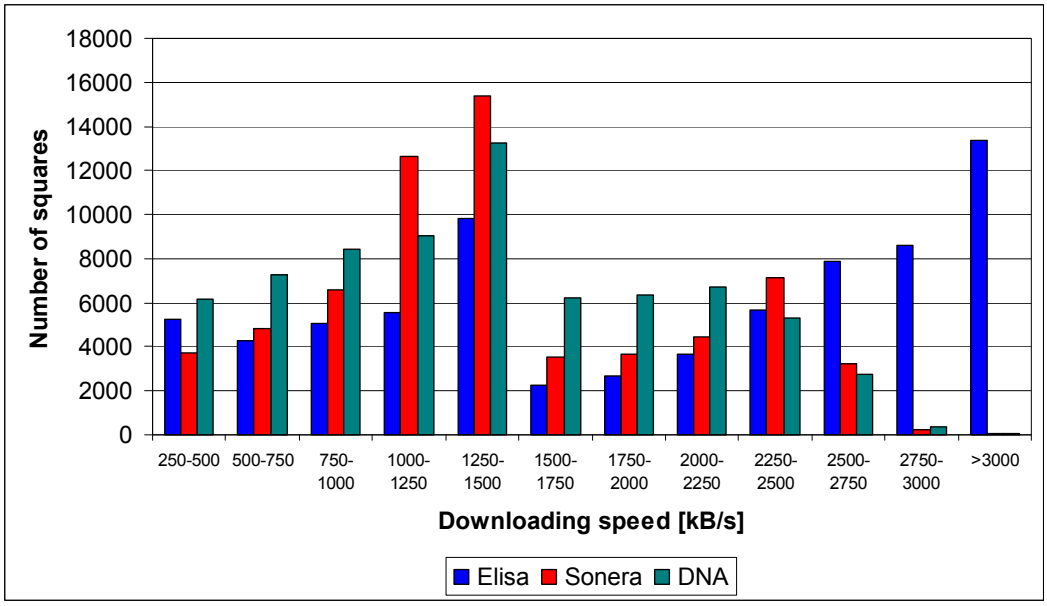

Figure 11. Data speeds by category in each operator's networks

The figure shows that there are significant differences in data speeds beween the operators. It shows that DNA's and Sonera's networks mostly provide their users with low (250…1,000 kbps) or medium (1,000…2,000 kbps or 1…2 Mbps) speeds, whereas Elisa can also offer speeds of more than 2 Mbps and more than 3 Mbps.

The figure below (Figure 12) shows the cumulative geographical extent of the data-speed categories when at least one operator has coverage. The figure shows that Elisa has the most extensive coverage and that it has a clear lead over other operators at data speeds of over 2 Mbps. Sonera and DNA are fairly close, except for the lowest speeds in which there is little difference between DNA and Elisa.

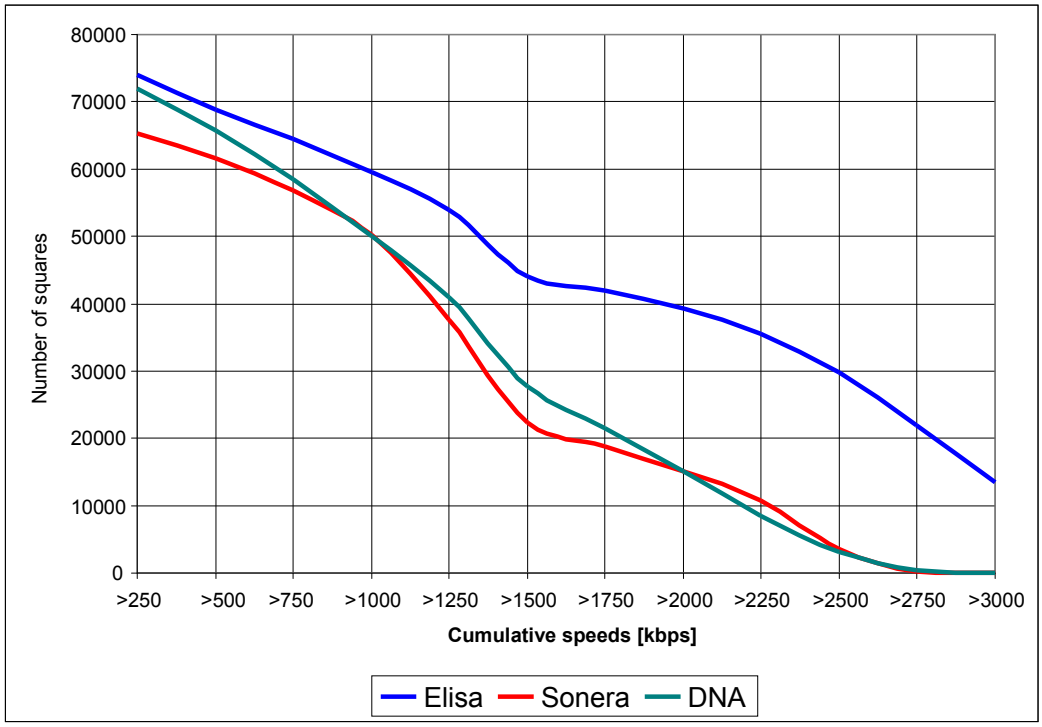

Figure 12. Cumulative data speeds in different operators' networks.

The combined total of squares of more than 1 Mbps and 2 Mbps and the examination of the relative coverage show that Elisa is in a class of its own. While DNA and Sonera can mostly provide their users with low-speed and medium-speed data services, Elisa can also offer high data speeds to its customers (Figure 13).

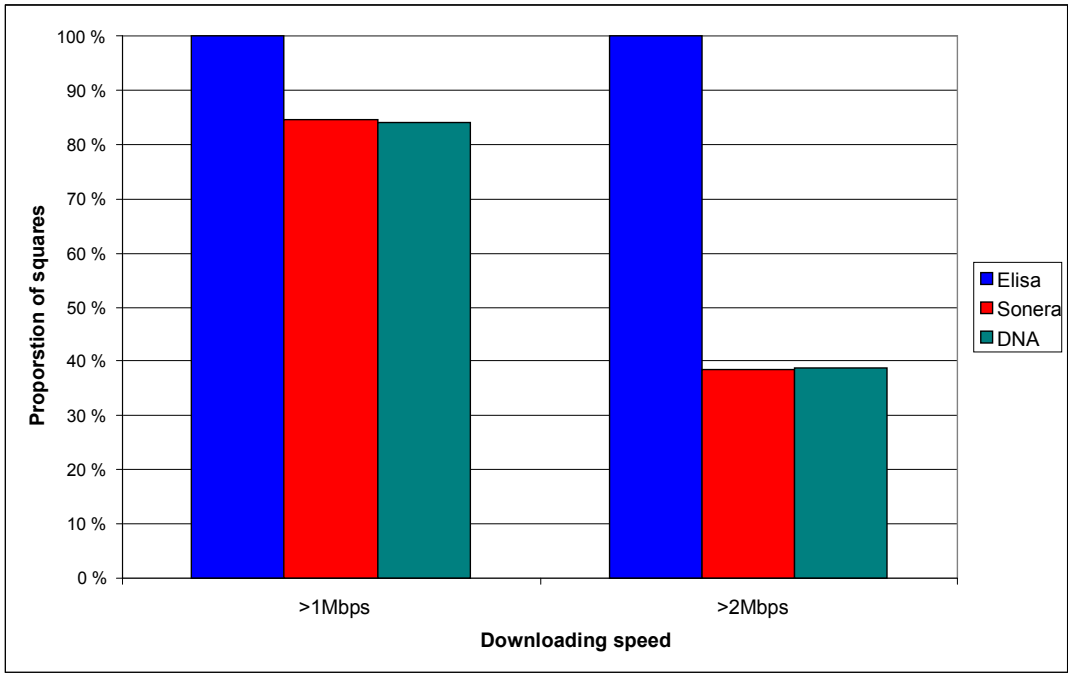

Figure 13. Cumulative and relative coverage of data services at data speeds of more than 1 Mbps and 2 Mbps (The squares of the operator with the highest value equals 100%)

Number of cells

The number of base station cells observed was also examined as part of the survey. The number of the cells is usually a good indication of the coverage of mobile phone networks.

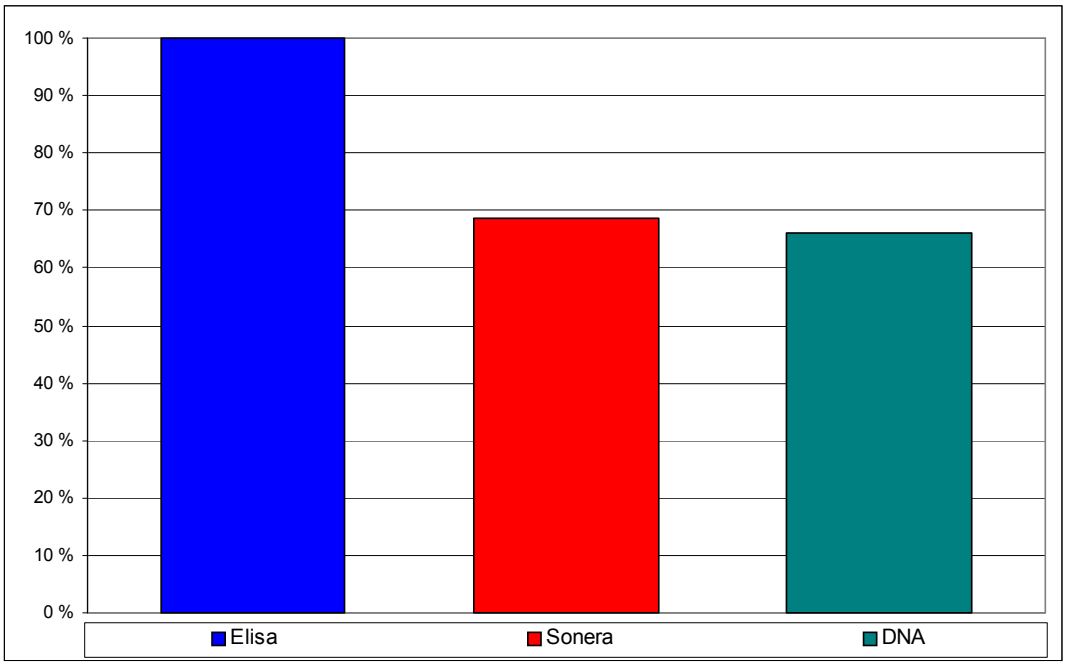

Figure 14. The number of 3G cells observed during the measurements (The number of cells for the operator with the highest value equals 100%).

The measurement results concerning the number of base station cells are in line with those concerning the coverage and reception quality. At the moment, Elisa's 3G network has by far the broadest coverage. It has a clear edge over Sonera, which comes second and is closely followed by DNA (Figure 14).

Conclusions

The coverage survey involving 100 municipalities, which was carried out in February-April 2009 shows that there are significant differences between mobile communications operators providing services in Finland. The results indicate that each operator is continuously extending its coverage.

As in previous surveys, Elisa remains number one in terms of the extent and quality of the coverage (signal strength). When examining the results for shared coverage area, this manifests itself as access to both voice services and high-speed data services. Elisa also comes first in the interference analysis which shows that in its network there is less interference than in the networks of its competitors. There is little difference between DNA and Sonera even though compared with the previous surveys, DNA seems to have overtaken Sonera in a number of areas.

The examination of data-speed measurement results shows that Elisa has a clear lead over other operators. It provides the broadest coverage in all data-speed categories and particularly in speeds over 2 Mbps it has a clear edge over its competitors. DNA and Sonera are mostly able to provide low-speed and medium-speed data services.

Elisa also has more base stations and consequently base station cells than its competitors. In terms of the cells measured, Sonere is slightly ahead of DNA.