Coverage survey

SURVEY OF THE COVERAGE PROVIDED BY UMTS MOBILE NETWORKS OPERATING IN FINLAND

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General

This report presents the results of a survey in which the coverage of three mobile communications operators providing services in Finland was examined. The survey involved the carrying out of measurements in 100 municipalities in different parts of Finland between 20 August and 4 November 2008. A similar study was last conducted in February 2008.

Objective

The aim of the survey was to determine the regional coverage and reception quality (signal strength) of Finland's 3G networks. Regional coverage was determined on the basis of measurements on transport routes, which does not necessarily give an accurate picture of the coverage area. However, as a substantial number of municipalities and routes were included, the results give a reliable overall picture of the coverage of 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 operators in the availability of voice and data services.

The measurements were carried out by setting the measuring units in idle mode. They were on but not used for producing voice or data connections during the measurements.

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.
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Summary

The survey involved the examination of the coverage of 3G operators providing services in Finland (Elisa, DNA and Sonera) and was carried out in 100 municipalities. ECE Ltd included in the study Finland's 50 most populous municipalities, 25 municipalities among those ranked between 51 and 100, and 25 smaller municipalities. The municipalities covered account for 70 per cent of the country's population.

The reception in each municipality was determined by carrying out measurements in the central area and residential and industrial areas. 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 17,090 road kilometres covered, 12,849 km were measuring routes. A total of 3,813,273 samples were collected on the measuring routes.

The analysis was carried out using computer software by first diving 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 threshold levels.

The results for the country as a whole show that, on the basis of the indicators used in the survey, Elisa still has the broadest 3G coverage. In terms of reception quality (signal strength), Elisa's network offers the highest signal level (best reception). In this comparison, Sonera came second, followed by DNA.

An examination of the number of network base stations shows that Elisa has built a more comprehensive 3G network than Sonera or DNA. A large number of base station cells usually means a broad coverage and a dense network. Here, too, Sonera came second, followed by DNA.

Municipalities included

The measurements were carried out in one hundred municipalities. In each municipality, 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 examined by driving on the main roads leading away from the municipality until there was no longer any reception. 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. Of the 17,090 road kilometres covered, 12,849 km were measuring routes on which 3,813,273 samples were collected. The picture below shows a typical measuring route (Figure 1).

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

ECE Ltd, the company carrying out the survey, selected the municipalities for the survey as follows:

– 50 most populous municipalities
– 25 municipalities selected among those ranked 51–100
– 25 municipalities selected among those ranked 101 or below

For the municipalities ranked 51 and below, geographical balance was also a consideration. The municipalities selected for the survey account for about 70 per cent of Finland's population.

Finland's 50 largest municipalities in order of size:

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

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

Pieksämäki	Anjalankoski	Lapua	Keuruu
Äänekoski	Janakkala	Naantali	Sotkamo
Pietarsaari	Jämsä	Loimaa	Kurikka
Lempäälä	Uusikaupunki	Kiiminki	Kuhmo
Mäntsälä	Tammisaari	Kankaanpää	
Forssa	Orimattila	Liperi	
Kuusamo	Kauhajoki	Nivala	

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

Kitee	Kokemäki	Säkylä	Kemiö
Kalajoki	Ikaalinen	Karstula	Utajärvi
Sodankylä	Kristiinankaupunki	Pello	Rautavaara
Kemijärvi	Juva	Savitaipale	Pulkkila
Nurmes	Pyhäjärvi	Hartola	
Alajärvi	Kittilä	Padasjoki	
Jalasjärvi	Ruovesi	Töysä	

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

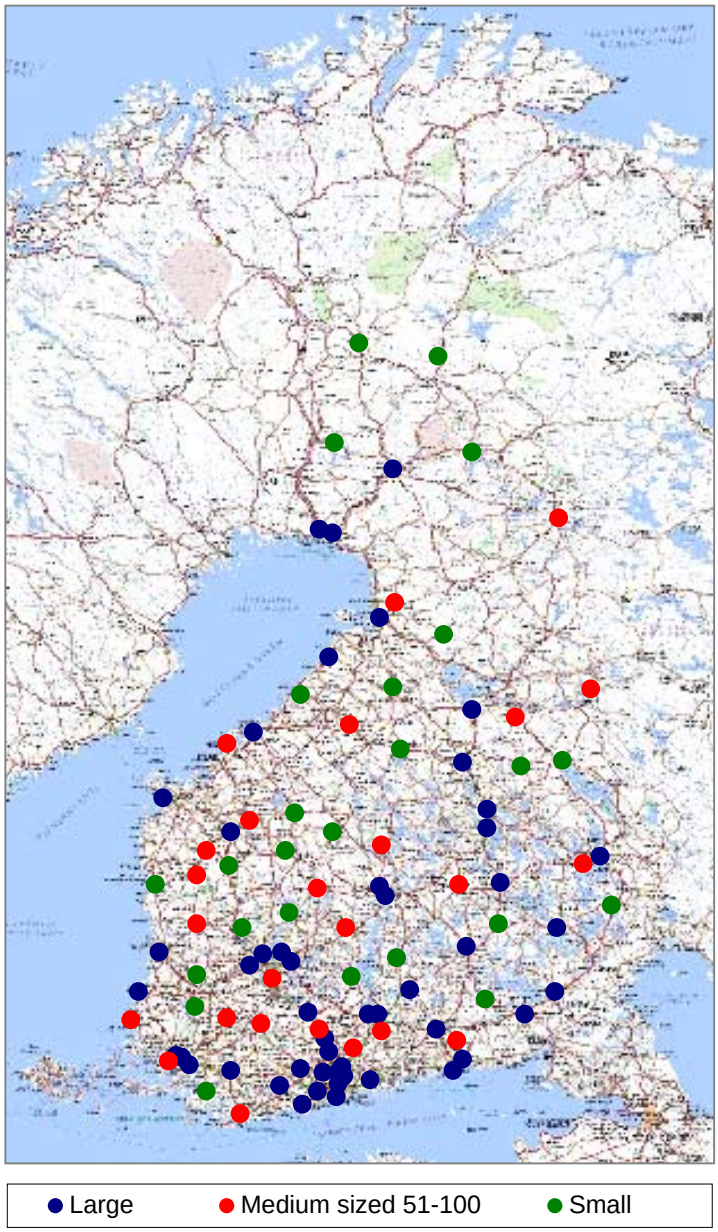

Figure 2. The municipalities included in the survey

Parameters measured and the system used

Parameters measured

The measurements were carried out using special equipment installed in the measuring vehicle, enabling each network to be measured simultaneously. The measuring units were locked so that they were only able to measure the UMTS system at frequencies of 900 and 2100 MHz.

Signal strength, the parameter measured, was 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. A signal strength required for a good connection indoors corresponds to an in-car signal strength of about -95 dBm (voice connection) and -75 dBm (data connection). In mobile communications networks, the range is typically between -60 and -100 dBm.

The number of base station cells in each network was also determined. This is indicative of the network structure: the higher the number of cells, generally the denser or more extensive the network. In other words, 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

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)
– GPS receiver: RoyalTek RGM-3600 /LP
– Personal computer: Dell D630

Comparison principle

The results were compared on a municipality basis so that each measured area was divided 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 in Figure 3.

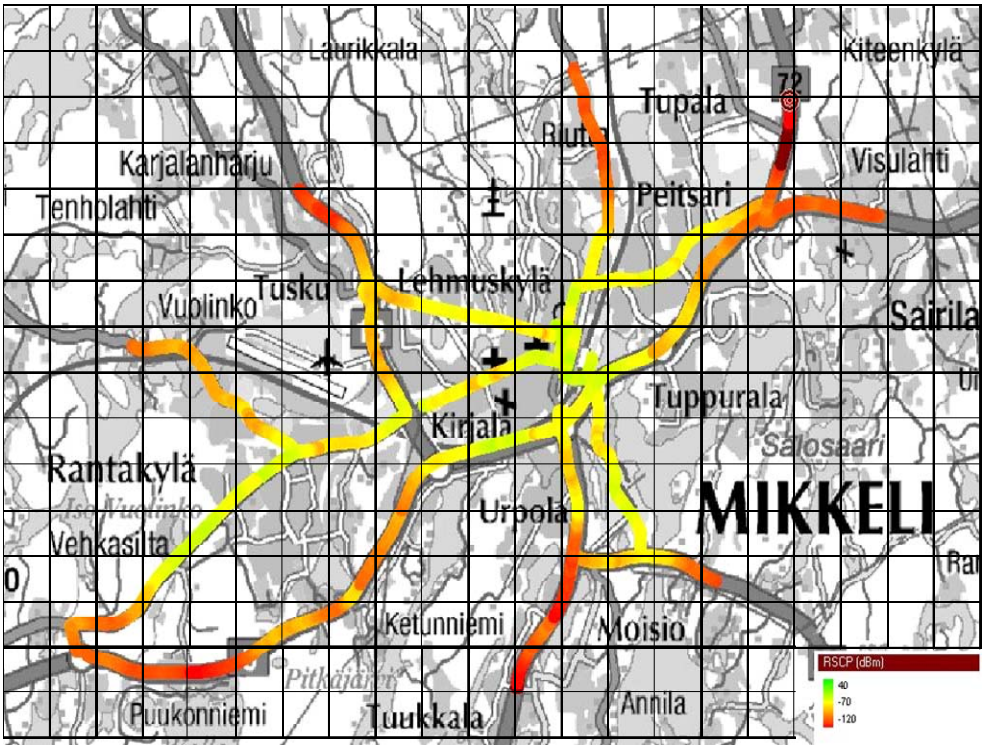

Figure 3. The principle used for analysing the coverage.

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 the reception: samples with high values also indicate better reception.

Results

The more detailed results, in which the focus is on technical aspects, are described first, followed by summarized findings which give the viewpoint of the end users.

Coverage

The extent of the coverage was examined by calculating the number of geographical locations (squares) in which the operators' 3G signal (so called 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, 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 all the measurements carried out in one hundred municipalities.

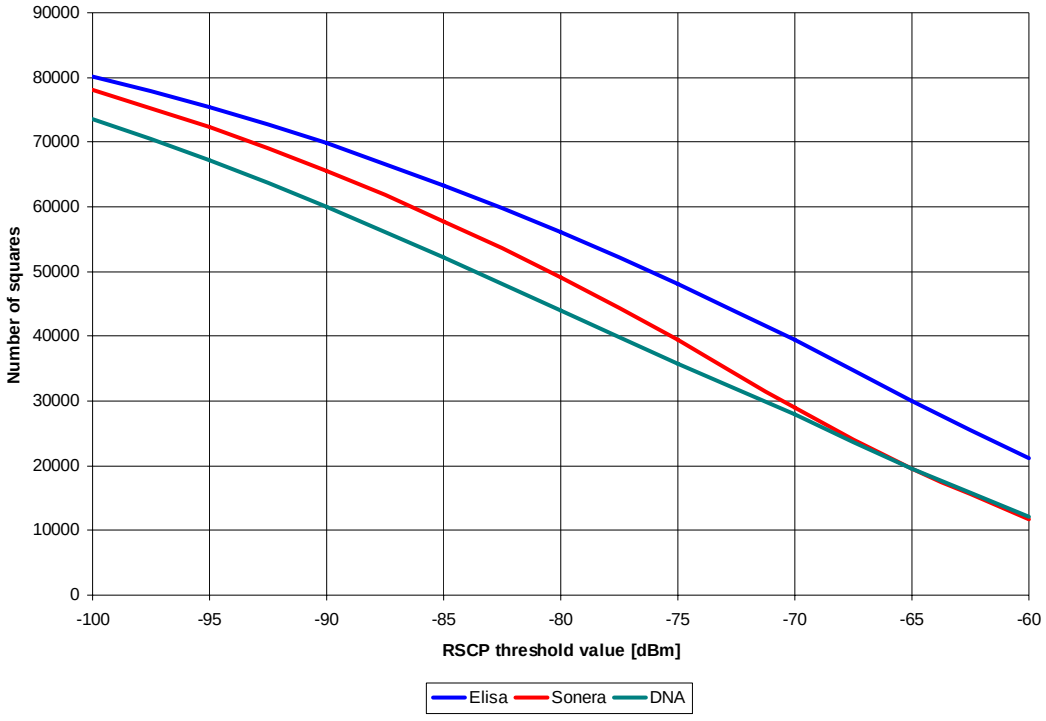

Figure 4. Number of squares at different threshold values.

All the measured squares in which an operator provided coverage have been considered in the graph (Figure 4). It shows that Elisa has the broadest 3G coverage at all signal levels. At lower signal levels, Sonera comes close, while at higher levels, there seems to be little difference between Sonera and DNA.

If the assumption is that 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 in Figure 5.

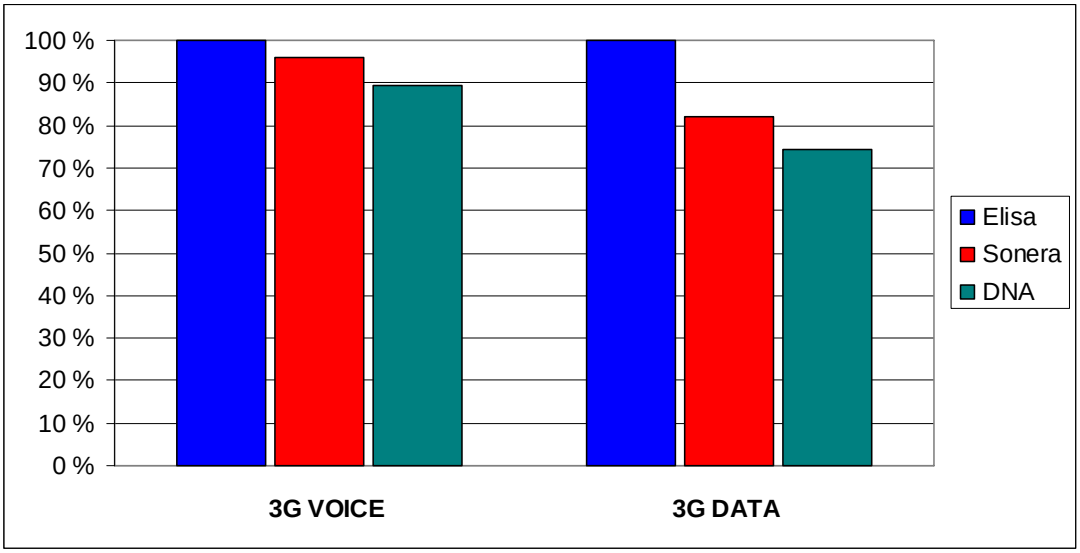

Figure 5. The relative number of squares covered - 3G voice and 3G data (the number of squares of the operator with the highest value equals 100 per cent).

The number of squares for each operator has been adjusted so that for the operator with the highest value it equals 100 per cent. This reception measurement gives Elisa the best results at the assumed signal strength for 3G voice services (-95 dBm inside the measurement vehicle). Sonera comes second, followed by DNA. The order is the same for 3G data services (signal strength inside the measurement vehicle -75 dBm). Elisa has a clear lead over Sonera and DNA.

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).

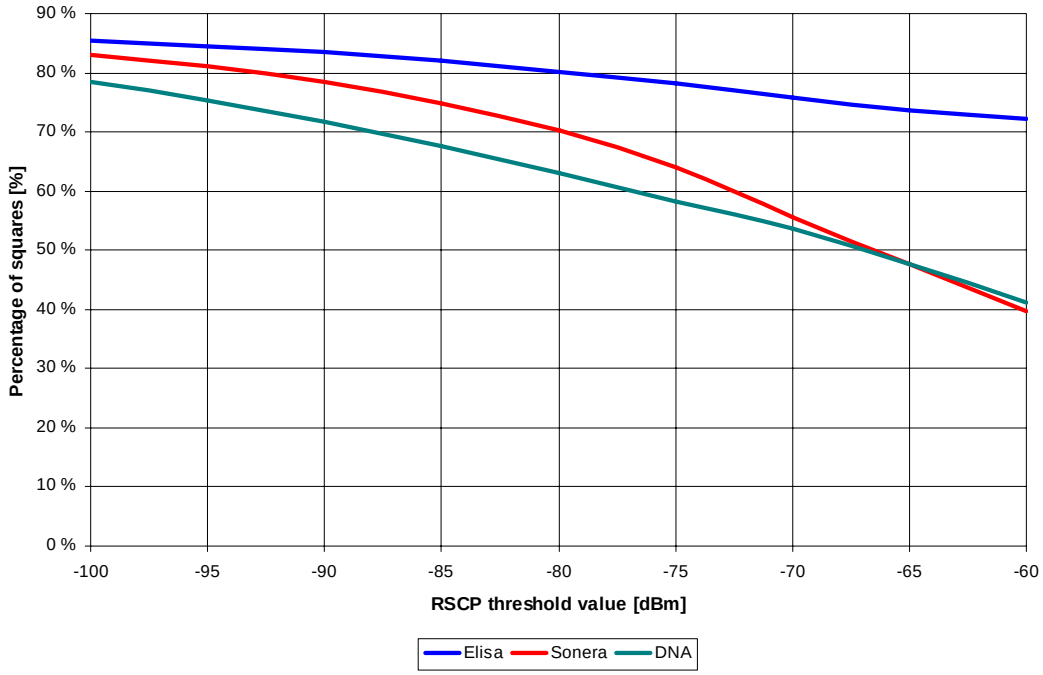

Figure 6. The relative number of squares covered. The number of squares in which at least one operator provides a coverage exceeding the threshold value has been used as the reference.

The figure above shows that there are slight geographical differences in the reception of the operators' 3G voice services (-95 dBm). Elisa has the broadest coverage and Sonera comes second, followed by DNA. An examination of the assumed signal level of 3G data services (–75 dBm) and particularly the stronger levels (-70...-60 dBm) shows that the gap between Elisa on the one hand and Sonera and DNA on other, becomes wider, while the gap between Sonera and DNA narrows.

The figure below illustrates the situation at voice service signal strength (–95 dBm) and data service signal strength (-75 dBm) (Figure 7).

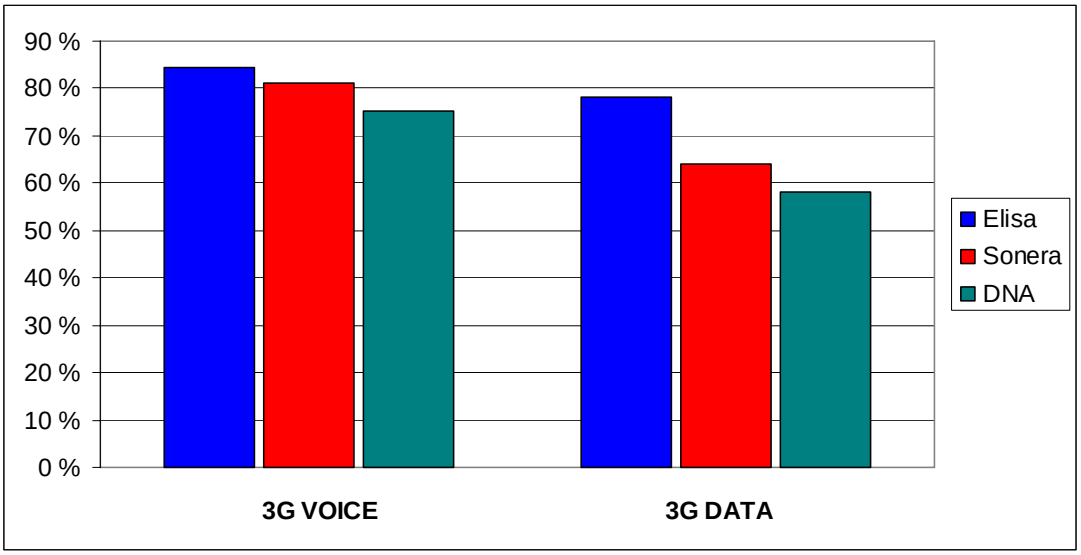

Figure 7. Likely reception of 3G services in measured areas in which at least one operator has 3G coverage.

The reception measurements show that there are differences in voice service signal strengths even though the order remains unchanged: Elisa comes first, followed by Sonera and DNA. The advantage of Elisa becomes clearer at signal strengths for data services. The difference between Sonera and DNA is the same as in voice services.

Signal strength

In addition to coverage, the quality of reception provided by the operators was also studied. There may be differences between network-building strategies; for example, one operator aims to have a broad but thin coverage, which may mean weak reception indoors. Another operator may have a geographically more limited network that nevertheless provide superior indoor reception and fast data links.

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

Figure 8 shows the relative cumulative breakdown of the signal strengths measured in reception areas shared by the three operators. The probability (horizontal axis) of reaching a certain signal level (vertical axis) in the 3G networks of different operators can be determined using the graph. The curves for Sonera and DNA are fairly close and partially overlapping, which means that the likelihood of different signal levels is roughly the same. Elisa clearly stands out, which shows that it is more likely to reach a certain signal level than the other two. In the shared coverage area, Elisa's signal strength is better than -70 dBm in 50 per cent of the locations, while the probability of Sonera and DNA of reaching the same level is less than 40 per cent.

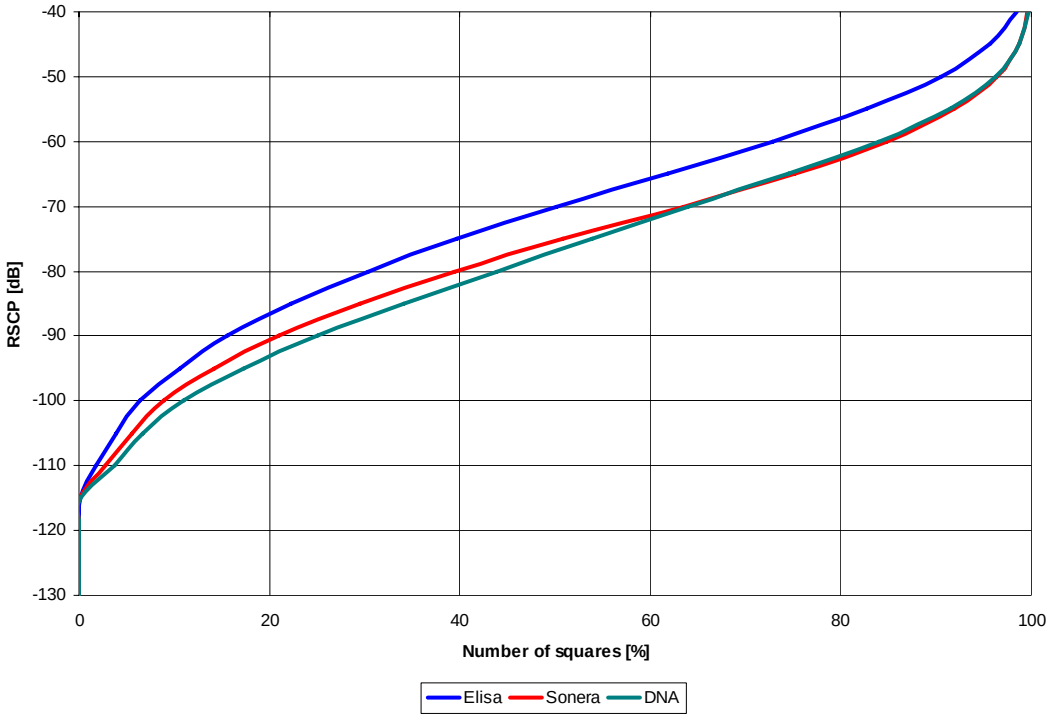

Figure 8. 3G coverage in the shared coverage areas.

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

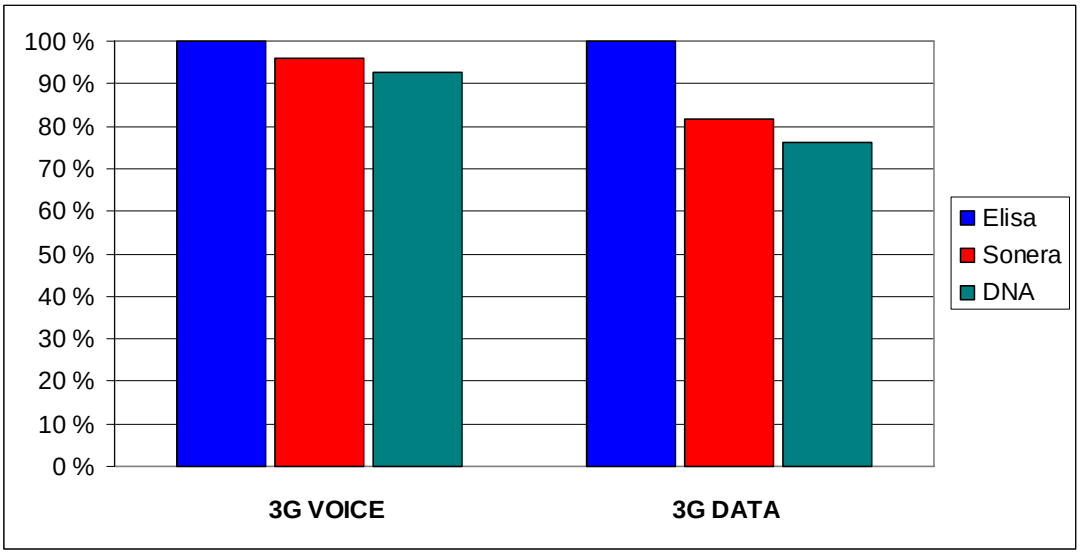

Figure 9. Likelihood of 3G reception in shared coverage areas (based on signal level). A signal level of at least -95 dBm is required for voice services, while the minimum for data is -75 dBm (The results for the operator with the highest value equal 100 per cent).

When measured on the basis of signal levels, all three operators provide more or less similar 3G voice services in shared coverage areas. As far as the assumed signal strength for 3G data services is concerned, Elisa is much more likely to be able to provide a better service in the measured areas than DNA or Sonera. The gap between Sonera and DNA is narrow.

Number of cells

The measurements also included the examination of the number of cells observed. The number of cells is usually a good indication of the coverage of mobile phone networks.

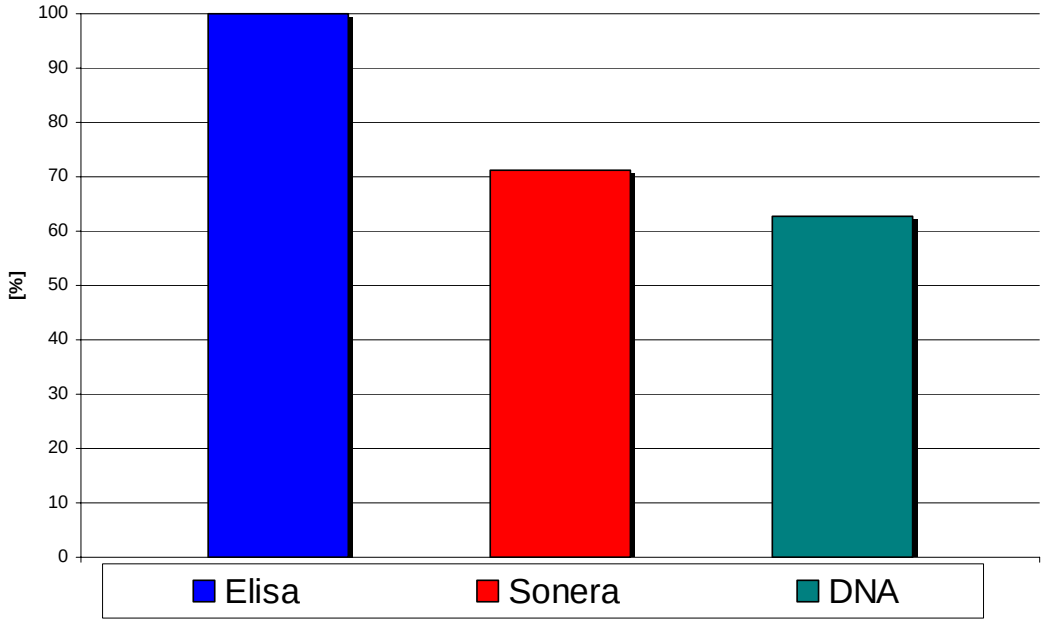

Figure 10. The number of 3G cells observed during the measurements (The number of cells for the operator with the highest value equals 100 per cent).

The measurement results concerning the number of base station cells are in line with those concerning the coverage and reception quality. They indicate that, at the moment, Elisa's 3G network has by far the broadest coverage. When measured by the number of cells, Sonera comes second, closely followed by DNA (Figure 10).

Conclusions

The coverage survey carried out in August-October 2008 showed that there are a number of differences between mobile communications operators providing services in Finland. The results for the country as a whole show that, on the basis of the indicators used in the survey, Elisa still has the broadest 3G coverage. In terms of reception quality (signal strength), Elisa's network offers the highest signal level (best reception). Sonera came second, followed by DNA.

An examination of the number of network base stations shows that Elisa has built a more comprehensive 3G network than Sonera or DNA. A large number of base station cells usually means broad coverage and a dense network. Here, too, Sonera came second, followed by DNA. A comprehensive network and sufficient signal strength are basic requirements for 3G voice services and particularly for data services.