



Č e s k ý t e l e k o m u n i k a č n í ú ř a d

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Appendix 3

to the invitation to tender for the award of the rights to use radio frequencies
for providing a public communications network in the 800 MHz, 1800 MHz
and 2600 MHz bands

Calculation and measurements for the purposes of controlling mobile broadband data network signal coverage

(Methodical Procedure)

1. Introduction

The purpose of this document is to set out the methodical procedure and basic conditions of the coverage calculation and control measurements for the purposes of assessing the compliance with the conditions laid down for the holders of authorisations to use radio frequencies in the 800, 1800 and 2600 MHz bands.

- a) The assessment of LTE signal coverage in terms of population is based on the document issued by the Ministry of Industry and Trade, entitled "Draft Development Criteria for Radio Frequency Allocations in the 790-862 MHz Band". Covering (coverage) is understood to mean the operation of a public electronic communication network using frequency allocations in the 800 MHz, 1800 MHz and 2600 MHz bands, via which the high-speed internet access service can be provided at a download speed of at least 2 Mbit/s within 7 years since the coming into effect of the allocation and 5 Mbit/s download speed for the following period with the understanding that such service will be available to at least 95% of the given district's population with a 75% probability of indoor coverage without using an external antenna and at an 85% probability of indoor coverage with using an external antenna During the 5 years transition period since the coming into effect of the allocation also the number of inhabitants of a district covered by the UMTS networks is included into the coverage.
- b) Of priority importance for the assessment of the coverage of a district by mobile network signals are the results of the predictive calculations submitted to the Office by the network operator in the form of properly structured data.
- c) The assessment of the coverage will be carried out at a map of the Czech Republic with the defined network of 100 × 100 m squares (UTM format coordinates).
- d) The calculation (for parameters according to the point 4) will be done on the basis of the network technical parameters submitted by the allocation holder with the use of the statistical model of signal propagation (ITU-R P.1546-2CA) and will be compared with the predictive calculations submitted by the network operator (the resolution of the model of the terrain used in the SW for the calculation is of 2 × 2 seconds).
- e) In case of a dispute, that is to say when the result of the calculation of the achieved coverage made by the Office is equal to 90% of the district population or less it is supposed that re-calculation will be made according to the diffractive model (ITU-R P.1812) which works better in the capturing of the influence of morphology for higher frequencies in rural areas and the subsequent measurement of the necessary parameters for the possibility of an objective assessment of the coverage of the territory and of the number of inhabitants by mobile data networks signals.
- f) The measured parameters and their limits are related to the LTE and UMTS systems operated according to the current ETSI standards and the 3GPP specifications. In the case of use of another system (e.g. LTE-A) the equivalent parameters according to its specification will be measured and assessed.
- g) Outside the coverage of the inhabited territories (inhabitants with permanent residence) the availability of this service is required for transit railway corridors I-IV (the availability in 80% of the 100 × 100 m squares defined by the Office that the corridor intersects) and for motorway and express roads (the availability in 90% of the 100 × 100 m squares defined by the Office that the corridor intersects).
- h) To prove the compliance with the coverage conditions representing at least 95% of the population the operator submits the coverage maps from computer predictions which prove the fulfilment of the conditions of the coverage of the population, railway corridors, motorways and express roads.

2. Data assessment

- a) The predictive maps of the coverage will be submitted in all instances of an inspection of the fulfilment of the conditions of an effective use of the frequencies according to the chapter 5.3 of the Invitation to Tender. The map will at all times contain the district covered together with the adjacent districts.
- b) The aggregate data will be submitted to the Office with the initial period of 1 month (depending on the development of the situation of the coverage the frequency may be adjusted later on).
- c) On request, the Office will provide to the allocation holder the vector map of the Czech Republic with the 100 × 100 m square network according to the point 1(c) with the attributes district, municipality, number of inhabitants, location of railway corridors, motorways, local roads and also a detailed methodology of the work with the map as well as support programmes for the assessment.
- d) The operator will fill in the map with his own layer with the coverage identification (covered/not covered) of each 100 × 100 m square. In the case of transformation from a more detailed segmentation (e.g. 20 × 20 m) the arithmetic average will be applied. The coverage map (layer) will be submitted separately on the one hand for each frequency band and, on the other, as the total coverage of the district, railway corridors, motorways and express roads.
- e) Should the allocation holder lay claim to the inclusion into the coverage of the stations working in the UMTS system, it will be necessary to provide, in the same format, the data allowing to verify the coverage for the base stations working in the UMTS system.
- f) When the data according to the point 2 (e) are not provided the stations working in the UMTS system will not be included by the Office for the purpose of the inspection of the coverage.

3. Overlap into an adjacent district

The following approach will be taken to assess the overlap from an 'A' district to a 'B' district:

- a) An assessment will be made of the number of inhabitants covered by the BS signal in the 'B' district installed for the coverage of the 'A' district according to the conditions under the point 4.2.
- b) in the 'B' district maximum 25% of the district inhabitants may be covered by the overlap for the 'A' district.
- c) The assessment is based on the predicted values of the coverage acquired by the calculation and the number of inhabitants' determination according to the point 2.
- d) When submitting the map of the coverage of an 'A' district, the operator will submit the number of inhabitants covered in the adjacent 'B' districts.
- e) In the case of coverage of transit railway corridors, motorways and express roads the overlap into the adjacent districts will not be assessed.

4. Coverage measurement

One of the parameters monitored in the control of compliance with the frequency allocation conditions is the determination of the mobile high-speed data service access signal coverage.

4.1. Measurement conditions

- a) The parameters of the LTE and UMTS signal are measured in a drive test with an omni-directional antenna held at a height of 1.5 or 3 m.
- b) The calculation of the coverage is done for the antenna height of 1.5 m and if an antenna height of 3 m has to be used, k_v correction must be used for conversion of the level (power, electromagnetic field intensity) to the antenna reference height of 1.5 m:

$$P_{1,5m} = P_{3m} - k_v, \text{ where } \begin{array}{ll} k_v = 4 \text{ dB} & \text{for the band of } 800 \text{ MHz} \\ 5 \text{ dB} & 1800 \text{ MHz} \\ 5 \text{ dB} & 2100 \text{ MHz,} \\ 6 \text{ dB} & 2600 \text{ MHz} \end{array}$$

- c) Priority is given to diversity measurements with 2 antennas.
- d) During measurement of the levels, the measured value is corrected so that it corresponds to the antenna's gain of $G_i = 0$ dB and feeder attenuation of 0 dB.
- e) If necessary, this corrected value is converted to the intensity of the electromagnetic field (measuring in the case of disputes with foreign administrations in border areas).
- f) All measurements are made outside buildings. Coefficients for each frequency band are used for assessing indoor coverage (this assessment is always affected by a significant error due to the need to use one coefficient).
- g) The selected coefficients representing LTE and UMTS signal attenuation due to passage through the wall of a building are as follows:

$$k = \begin{array}{ll} 9 \text{ dB} & \text{for the band of } 800 \text{ MHz} \\ 11 \text{ dB} & 1800 \text{ MHz} \\ 12 \text{ dB} & 2100 \text{ MHz,} \\ 13 \text{ dB} & 2600 \text{ MHz} \end{array}$$

4.2 Parameters measured

With respect to the intelligence of the elements of the radio networks, especially the BSs (dynamic changes in power, formation of antenna radiation beams to meet the requirements for the user equipment [UE] etc.), signal (frequency) parameters with limit values securing radio network functionality will be used for objective assessment of LTE and UMTS signal coverage in territory terms:

4.2.1 LTE system

a) Reference signal received power - RSRP

minimum value:	-122 dBm	- given by UE's physical properties
margin:	4 dB	- for a real environment
limit value:	-118 dBm	(outdoor)

limit indoor values (with correction for indoor attenuation), reception without external antenna for 75% reception probability:

frequency band	RSRP
800 MHz	-109 dBm
1800 MHz	-107 dBm
2600 MHz	-105 dBm

When an external antenna is used, coverage can be expected to be provided with an 85% probability (the antenna gain is at least 2.5 dBi, location is well-selected), outdoor reception being automatically provided.

b) Signal-to-interference-plus-noise ratio – SINR

Limit value: - 5 dB

SINR measured on the reference channels is clearly related to the attainable data speed. Due to the same attenuation of the useful and interfering signal, it is not necessary to correct the value according to the frequency bands used. The limit value applies to the same conditions as the RSRP power of the reference signal.

4.2.2 UMTS system (2100MHz)

a) Reference signal power – RSRP (CPICH)

Limit values -98 dBm (outdoor)
-86 dBm indoor

b) Signal-to-interference ratio E_c/I_o

Limit value -12 dB

Chart of limit values for inspection coverage measurement

system	frequency	RSRP			SINR	E_c/I_o
	band	residential	motorways	railway. corridors		
	[MHz]	[dBm]	[dBm]	[dBm]		
LTE	800	-109	-118	-114	-5	--
LTE	1800	-107	-118	-113	-5	--
UMTS	2100	-86	-98	-93	--	-12
LTE	2600	-105	-118	-112	-5	--

Note: The parameters' limit values are given for the antenna height UE of 1.5 m outside the railway corridors where the supposed antenna height is of 4.5 m (railway carriage roof).

4.3 Requirements for the measuring device

a) Measuring antenna

- Antennae with an omnidirectional radiation pattern, vertical polarisation and a defined gain are used for drive test measurement (for the possibility of the correction of the measured value for the defined system gain $G_{ant} - b_{nap} = 0$ dB).
- The coax cable between the antenna and the receiver input (if used) must have a defined attenuation in the operating frequency band (for the possibility to correct the measured value).

b) Measuring receiver

- The measuring receiver (scanner) must enable the measurement of the RSRP, SINR and E_c/I_o parameters on the reference signals in accordance with the relevant ETSI and 3GPP specifications.
- UE with appropriate parameters or any equivalent equipment meeting the requirements for objective measuring the above parameters can also be used for the measurement.

5. Data speed measurement

The data speed velocity in mobile networks according to the point 1 (a) will be measured through the source verified by the operator in the following cases:

- a) During the investigation of a complaint about network operation interference or in case of failure to respect contractually guaranteed speeds between the client and the service operator.
- b) During a random measurement to check if the conditions laid down by the tender procedure are respected.

The measurement of the data transmission speed will be done as follows:

- In the case of dispute solution according to the point 1 (e) – during four subsequent hours, always four times in one hour at least, with the minimum 10 minute separation between the individual measurements.
- In the case of measurement for the Office's needs to verify the coverage – during 1 hour.

The required speed is achieved if:

- The transmission speed achieves the required value (2 Mbit/s or 5 Mbit/s) in 50% of the measurements in the given series and location.
- The average speed of all measurements in the given series and location will achieve at least 75% of the required value (1.5 Mbit/s or 3.75 Mbit/s).

To measure the data speed a measuring terminal or other equivalent equipment with the software allowing to follow the time course of the transmission speed and to make statistical calculations over the established data.

The measurement will be done with the above mentioned measuring equipment through the operator's server against the server located at the Office with the guaranteed connectivity in the backbone network.

Should the above mentioned conditions of the speed not be met a repeated measurement will be carried out for the sake of verification.

6. Measurement procedure

General principles of measurement:

- a) The measurement of the RSRP, SINR and E_b/I_0 parameters in residential areas, on motorways and express roads will be performed in a standard manner as drive test measurement – in the same way as in the signal measurements in other mobile networks (GSM, CDMA).
- b) In coverage measurement of residential areas, the drive test measurements are first performed along the main roads in the given area and the results are then compared with the coverage maps submitted by the network operator. In the event that the measured values are substantially different from the forecast values, detailed measurements in the municipalities will be performed along all accessible roads in the area.
- c) The measurement of the coverage of transit railway corridors will be done by the Office's equipment in the proximity of railways (parallel communications, railway stations or crossing) and that in the case of complaints.
- d) During the measurements for the purpose of the coverage of motorways and express communications the measurement will be done while driving along the whole length of the road under inspection.

- e) In the event that the measured coverage according to the points 6 (d) to (e) will be diametrically different from the predicted measurement, a negotiation must be held between the Office and the network operator to agree on how to proceed further to identify and confirm the causes of the differences.
- f) To assess compliance with the planning parameters in the border areas, the intensity of the magnetic field must be measured in accordance with relevant recommendations or bipartite/tripartite agreements under the HCM Agreement.
- g) During the evaluation, the measured data will be compared to the forecast coverage values provided in the form of maps submitted by the network operators according to the point 2(d).

7. List of acronyms

BS	<i>"Base Station"</i> – in the LTE system also referred to as eNodeB
UE	<i>"User Equipment"</i> – a terminal