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Annex 5

To the Invitation to Tender for Granting of the Rights to Use Radio Frequencies to Provide
Electronic Communications Networks
in the 700 MHz and 3400–3600 MHz Frequency Bands

Calculations and Measurements for the Purpose of Checking the Coverage of Territory and of Population

1 INTRODUCTION

The aim of this document is to stipulate a methodological procedure for controlling the fulfilment of the conditions which were set as a result of this Tender. All data provided by the Allocation Holder can be independently verified from the CTU side, including by own measurement.

1.1 Coverage of Population

- Decisive for the evaluation of coverage are the results of calculations based on technical parameters of base stations submitted by the network provider in the format specified in chapter 7.4 of the Invitation to Tender. The required minimum values of the intensity of electromagnetic field stem from the limit value of the reference signal for particular frequency bands which are specified in chapter 2.2.2 of this methodology.
- Calculation of coverage will be performed by using the ITU model of signal propagation ITU-R P.1812-4¹, model of terrain will be with the step 1x1 second with morphological data in the same or higher resolution in categorization (forests, low, medium and high height buildings) and with specified height according to satellite imagery service.
- Coverage of population will be evaluated according to address points which correspond to street numbers (house ID). Number of inhabitants at each address point will be set according to data provided by the Czech Statistical Office (ČSÚ) by census done in 2021. Should a calculation be needed before the date of availability of these data (e.g. to confirm own coverage for requesting national roaming obligation), the latest available data will be used.
- In case of discrepancy, i.e. should the calculated coverage value for every district be more than 2 % lower than the requested value, measurement of the necessary parameters will be done to allow for objective evaluation of the coverage. The measured parameters and their limit values are described for the particular frequency bands in this methodology and were set according to valid ETSI standards and 3GPP specifications.
- In case of identification of an uncovered address point (user's complaint, etc.), the measurement according to point 2.2 will be executed. If a difference between the result of the measurement and the calculation of CTU will be found, the result of measurement will be always taken into account for considering the fulfilling of the coverage conditions. It is possible to revise taking out of the address points if the operator proves re-setting its network and after new measurement executed by CTU proving extended coverage of the address points taken out.

1.2 Coverage of line constructions (roads etc.)

- Decisive for the evaluation of coverage are the results of calculations based on technical parameters of base stations submitted by the network provider in the format specified in chapter 7.4 of the Invitation to Tender. The required minimum values of the intensity of electromagnetic field stem from the limit value of the reference signal for particular frequency bands which are specified in chapter 2.2.2 of this methodology.
- Calculation of coverage will be performed by using the ITU model of signal propagation ITU-R P.1812-4, model of terrain will be with the step 1x1 second with morphological data in the same or higher resolution in categorization (forests, low, medium and high height buildings) and with specified height according to satellite imagery service.
- Coverage of line constructions will be evaluated on broken lines representing the line constructions which will be provided by the data manager (*Ředitelství silnic a dálnic ČR - ŘSD – Directorate for National Roads and Motorway*, or *Správa železniční dopravní cesty – SŽDC - state administration for railway infrastructure*) using a graticule of 25 m with division in the axes of the line construction. Different drive directions or railway tracks will be evaluated separately, if such data is available.

¹ Applicability of ITU 1812 ver. 4 for frequencies in the band 3440-3800 MHz was verified by the Office based on comparison of test measurements and calculations

- In case of discrepancy, i.e. should the calculated coverage value for road or railway corridors be more than 2 % lower than the requested value, measurement of the necessary parameters will be done to allow for objective evaluation of the coverage. The measured parameters and their limit values are described for the particular frequency bands in this methodology and were set according to valid ETSI standards and 3GPP specifications.
- In case of identification of uncovered parts of road or railway corridor (user's complaint, etc.), the measurement according to point 2.2 will be executed. If a difference between the result of the measurement and the calculation of CTU will be found, the result of measurement will be always taken into account for considering the fulfilling of the coverage conditions. It is possible to revise taking out of the address points if the operator proves re-setting its network and after new measurement executed by CTU proving extended coverage of the address points taken out.

1.3 Coverage of territory

- Coverage of territory will be evaluated primarily according to the results of calculations based on technical parameters of base stations submitted by the network provider in the format specified in chapter 7.4 of the Invitation to Tender. The required minimum values of the intensity of electromagnetic field stem from the limit value of the reference signal for particular frequency bands which are specified in chapter 2.2.2 of this methodology.
- Calculation of coverage will be performed by using the ITU model of signal propagation ITU-R P.1812-4, model of terrain will be with the step 1×1 second with morphological data in the same or higher resolution in categorization (forests, low, medium and high height buildings) and with specified height according to satellite imagery service.
- Coverage of territory will be evaluated in squares of 50×50 meters.
- In case of identification of an uncovered territory (user's complaint, etc.), the measurement according to point 2.2 will be executed. If a difference between the result of the measurement and the calculation of CTU will be found, the result of measurement will be always taken into account for considering the fulfilling of the coverage conditions. It is possible to revise taking out of the address points if the operator proves re-setting its network and after new measurement executed by CTU proving extended coverage of the address points taken out.

2 CONTROL OF FULFILMENT OF THE DEVELOPMENT CRITERIA

2.1 Calculation of coverage

CTU will perform in regular intervals of one month, or possibly one quarter, calculation of coverage in all relevant categories based on technical parameters of the base stations submitted by the network provider. The gained results will be published at CTU website².

Upon request of the Allocation holder, CTU will perform a control of fulfilment of the development criteria for a specified municipality, district or a category of line constructions, based on technical parameters of base stations submitted by the network provider. CTU will confirm to the requesting person in writing whether the requested value specified in the Invitation to Tender was met at the date of the control.

The deadlines and requested levels of coverage are specified in chapter 7.5 of the Invitation to Tender.

2.2 Measurement of coverage

2.2.1 Conditions of measurement

- a) Measurement of parameters of mobile networks signal will be performed by a drive test with an omnidirectional aerial placed at a height of 1,5m or 3m.
- b) The calculation of coverage is done for an aerial at the terminal at a height of 1.5m; if it is necessary to measure with a 3m aerial height, k_v correction is used to convert the level (of power, of intensity of the electromagnetic field) to the reference height of the 1,5m aerial:

$P_{1,5m} = P_{3m} - k_v$, in which k_v is set for particular frequency bands as follows:

frequency band	k_v [dB]
700 MHz	4
800 MHz	4
900 MHz	4
1800 MHz	5
2100 MHz	5
2600 MHz	6
3440–3800 MHz	9

- c) Diversity measurement with 2 aerials (MIMO) is preferred.
- d) When measuring the levels, the measured value is corrected such as to correspond to gain of the aerial of $G_i = 0$ dB and attenuation of the feeder of 0 dB.
- e) If required, this corrected value is converted into the intensity of the electromagnetic field (measurement in the case of disputes with foreign administrations in border areas).
- f) Measurements are only being performed outside buildings; for assumptions of coverage inside buildings coefficients are used for each frequency band (due to the necessity to use one coefficient, the assumption is invariably loaded with a significant error.)
- g) Coefficients representing attenuation of signal as a result of passing through a wall of a building are set for particular frequency bands as follows:

² <https://digi.ctu.cz/>

Frequency band	k [dB]
700 MHz	9
800 MHz	9
900 MHz	9
1800 MHz	11
2100 MHz	12
2600 MHz	13
3440–3800 MHz	18

2.2.2 Measured parameters

With respect to the intelligence of elements of radio networks, in particular BS (dynamic changes of power, forming radiating bundles of aeriels according to the requirement of the UE etc.) for the objective evaluation of territorial coverage, the parameters of the signal (frequency) will be measured with limit values ensuring the functionality of the radio network:

a) **Reference signal receiving power – RSRP**

minimum value: -122 dBm based on physical features of UE
margin: 4 dB for real environment

Limit value for unpopulated territories is **-118 dBm** (outdoor). Limit values for populated areas (with correction for attenuation of buildings) are listed in the table below. E.g. for reception in 700MHz band and for 75% probability of reception the value is **-109 dBm**. These limit values concern solely reception in mobile networks and will not be applied for reception at a fixed location.

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

limit value: -5 dB

The stated limit value is applicable under the same conditions as defined for reference signal receiving power.

Limit values of reference signal and signal to interference plus noise ratio for controlling measurements are defined in the table below.

Frequency band	RSRP for unpopulated territories [dBm]	RSRP for populated territories [dBm]	RSRP for road corridors [dBm]	RSRP for railway corridors [dBm]	SINR [dB]
700 MHz	-118	-109	-118	-114	-5
800 MHz	-118	-109	-118	-114	-5
900 MHz	-118	-109	-118	-114	-5
1800 MHz	-118	-107	-118	-113	-5
2100 MHz	-118	-106	-118	-113	-5
2600 MHz	-118	-105	-118	-112	-5
3440–3800 MHz	-118	-100	-118	-109	-5

Note: Limit values of the measured parameters are stated for the aerial height of the UE of 1,5m, outside railway corridors where the assumed height of the aerial is 4,5m (roof of the wagon).

c) **Parameters of provided data services**

Within the development criteria of block allocations in the 700 MHz band, the qualitative parameters were set for development criteria based on chapter 7.5.1 (b, c) of the Invitation to Tender, where the maximal latency (RTT) measured between terminal and peering centre is set to 25 ms.

The 5G Standard will be verified based on a technology provider's statement on compatibility of the implemented technology with the requirements set within the development criteria, i.e. with the standards 3GPP/ETSI with specification ETSI TS 123 501 (3GPP TS 23.501) and ETSI TS 138 401 (3GPP TS 38.401) or more recent, which the Allocation Holder will provide.

2.2.3 Requirements on measuring equipment

a) Measuring aerial

- For drive tests, an aerial will be used with an omnidirectional radiating diagram, vertical polarisation and defined gain (to allow correction of the resulting value for the defined system gain of $G_{ant} - b_{nap} = 0$ dB).
- The coaxial cable between the aerial and the receiver input (if used) must have a defined attenuation in the band of operation frequencies (to allow correction of the resulting value).

b) The scanner

- Measuring receiver – analyser of mobile networks (scanner) must allow for measuring the RSRP and SINR parameters on reference signals according to relevant specifications of ETSI and 3GPP.
- Measuring can also be performed with a UE with corresponding parameters or with any equivalent equipment compliant with requirements on objective measurement of the mentioned parameters.

c) Measuring terminal

- Measuring terminal supporting the 5G Standard for controlling the data parameters.

2.2.4 Measurement procedure

General principles used during measurements:

- a) Measurements of RSRP and SINR in populated areas, on highways and expressways will be carried out in a standard way like measurements of signals from other mobile networks (on-the-fly measurements).
- b) Measurements of coverage of a populated area shall always be made on all available roads in the selected area.
- c) Measurements of motorways, expressways and railway corridors shall be made while driving along the entire length of the controlled corridor.
- d) Measurements of intensity of electromagnetic field must be performed in order to evaluate adherence to the planning parameters in border areas, in accordance with the valid recommendations in frame of the HCM agreement or other international agreements on the use of frequencies in border areas.
- e) In case of measuring the territory coverage, at least 3 measurements on different places must be executed in each measured square and for fulfilling the coverage, the final average of all measurements in the measured square must be higher than relevant limit values set in chapter 2.2.2.

- f) Measurement of the data parameters in an inhabited territory, on road or railway corridors will be executed according to methodology "*Measurement and evaluation of data parameters in mobile networks*" in current wording.³

³ The current version is available in Czech language only on <https://www.ctu.eu/measuring-transfer-data-speed>.