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**Procedure to Measure the Data Transmission
Speed in Mobile Networks
in Accordance with the LTE Standard**
(Methodical procedure)

Published in connection with the 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

Section 1

Purpose of the document

This document specifies in more detail the procedure of measuring the data transmission speed specified in item 5 of the Office's document: Annex 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 [1].

Section 2

Definition of concepts

For the purposes of this methodology, the following terms have the following meanings:

- a) Measurement square $K_{x,y}$ is a 100x100m standardised square with an exactly defined GPS location and orientation in accordance with the Czech territory coverage document prepared by the Office. The x, y indices show the relative location to the x, y axes, which are not interconnected with the maps of the Czech Republic. Each measurement square has a unique identifier, denoted as ID, which consists of the row and column number of the initial graticule. Each measurement square's attributes include its association with community and district, the number of population in the measurement square and the information whether it belongs to motorways, expressways or rail corridors;
- b) Rank k measurement sample is a continuous time interval of 1 second during which the transmitted test data volume $w(k)$ is measured in bytes, where k is a positive integer, indicating the measurement sample's rank in time;
- c) Measurement sample of data transmission speed $v_d(K_{x,y}, k)$ is the speed of data transmission pertaining to measurement square $K_{x,y}$, where k is a positive integer indicating the measurement sample's rank in time. The value of data transmission speed in bits per second is obtained from the volume of data $w(k)$ in bytes transmitted in the k^{th} second-interval as follows: $v_d(K_{x,y}, k) = 8 \cdot w(k)$;
- d) Average data transmission speed $\overline{v_d(K_{x,y})}$ is the data transmission speed taken from all the N data transmission speed measurement samples $v_d(K_{x,y}, k)$ measured in the given measurement square $K_{x,y}$ as follows: $\overline{v_d(K_{x,y})} = \frac{1}{N} \sum_{k=1}^N v_d(K_{x,y}, k)$;
- e) The required minimum value of data transmission speed v_{dmin} is the speed value of 2 Mbit/s (2,000,000 bit/s) for the downlink direction within 7 years from the finality of the acquisition of the allocation. Afterwards the minimum value of data transmission speed is increased to 5 Mbit/s (5,000,000 bit/s) for the downlink direction. This speed applies to one piece of mobile equipment and one SIM;
- f) Relative coverage success rate $R(K_{x,y})$ is a dimensionless number between 0 and 1 (or percentage between 0 and 100 %) indicating the rate of successful coverage of a given stationary point or measurement square $K_{x,y}$ for the defined limit v_{dmin} . It is calculated as follows:
$$R(K_{x,y}) = \frac{N_{OK}(K_{x,y})}{N(K_{x,y})}$$
, where N_{OK} is the number of measurement samples k in the given measurement square $K_{x,y}$, or which the condition of $v_d(K_{x,y}, k) \geq v_{dmin}$ is satisfied, and N

is the total number of measurement samples of data transmission speed in the given measurement square $K_{x,y}$.

This parameter is determined so as to ensure that $R(K_{x,y}) \geq 0.5$;

- g) Measurement time T_m is a continuous time interval in seconds, during which the test data are transmitted and the data transmission speed is measured;
- h) Interval between measurements T_p is a continuous time interval in seconds, during which no test data are transmitted and the data transmission speed is not measured;
- i) Measurement period $T = T_m + T_p$ is a time interval in seconds consisting of two immediately succeeding intervals: the measurement time and interval between measurements;
- j) Measurement series is the sequence of a finite number M of successive measurement periods T , where M is a positive integer;
- k) Number of repetitions is a series of measurements whose number is L , where L is a non-negative integer.

Section 3

Initial conditions of data transmission speed measurement

(1) A measuring terminal or an equivalent piece of equipment (modem and computer) is used for the data transmission speed measurement. The software in the terminal should be able to record the time course of data transmission speed at one-second intervals and then to make statistical calculations, using the measured data, under the following conditions:

- a) The measurement is performed using a measuring device via the network of the operator being tested against a server with guaranteed Internet connectivity of at least 1 Gbit/s and with a computing performance which at least ensures that the measurement is not adversely affected;
- b) The measurement is performed on business days between 7 a.m. and 7 p.m., unless the measurement itself requires the measurement to be performed at any other time;
- c) SIM cards with activated public (personal) mobile internet access service with the highest available data limit, or with no limit, are used for the measurement;
- d) The measurement is performed on the IP (Internet Protocol) layer, using the TCP Transmission Control Protocol) downlink from the server to the measuring terminal;
- e) UMTS measurement will be performed as alternative to the LTE measurement for a transient period of 5 years in accordance with [1] as follows: two measuring terminals (modems) will be used, one being primarily set at the LTE mode and the other at the UMTS mode. In the case that in the relevant measurement sample the data are not transmitted by the LTE system, or the transmitted data volume is smaller than the data volume transmitted by UMTS system operating in parallel, the data transmission speed measured by the UMTS system will be used for the given measurement sample. This procedure reduces the adverse impact of any outages when the measuring terminal passes from the LTE-covered area to the UMTS-covered area and vice versa;
- f) The current location of the measuring terminal will be monitored by a GPS receiver with a ± 5 m position identification error and with a 5% maximum probability of position identification error;
- g) The location of the measuring antenna must ensure that the adverse impacts of the

measurement car on the measurements being taken is minimised.

(2) All measurements must be performed with three TCP connections simultaneously open under the following conditions:

- a) The method of measurement and of interpreting the results is specified in detail in the IETF RFC 6349 document [2], unless otherwise provided;
- b) TCP flows are generated continuously during the entire time of measurement;
- c) With respect to the assumed data transmission speed and the value of delay in data flow transmission, the size of the TCP reception window will be set at a value of at least 64 kB for each open session;
- d) The size of the packets must be set so as to prevent packet fragmentation in the entire network being tested.

Section 4

Measuring data transmission speed

(1) Data transmission speed is measured at a single point with no movement of the measuring terminal (stationary measurement) or in a drive test. The calculations of coverage and data transmission speed are described in detail in Section 5 below.

(2) Stationary measurement of data transmission speed in mobile networks will be performed [1] as follows:

- a) During random measurement to check compliance with the conditions specified in the tender, measurements will be taken within four consecutive hours at least four times in each hour with an interval between measurements of at least 10 min. (see Section 5, Subsection (1));
- b) In the case of an investigation upon a complaint of interference with network operation or complaint of failure to maintain the data transmission speed guaranteed on the basis of agreement between the client and the service operator, the measurement will be taken for a period of 1 hour (see Section 5, Subsection (2)).

(3) In stationary measurement (measurement at a single point with no movement of the measuring terminal), the requirement for the desired data transmission speed is met if and when:

- a) The data transmission speed reaches the required value (2 Mbit/s or 5 Mbit/s) in at least 50% of the measurement samples;
- b) The average data transmission speed for all measurements reaches at least 75% of the required value (1.5 Mbit/s or 3.75 Mbit/s);
- c) Should the above conditions of data transmission speed fail to be met, one repeated measurement will be taken for verification.

(4) For the purposes of checking the coverage of a populated area, continuous measurement of the coverage of such an area is performed by drive test measurement at a drive speed of 40 km/hour (if this is impossible due to the conditions prevailing at the time of measurement, a lower speed is used) along the major roads pertaining to the site (community) being measured. The requirement for the desired data transmission speed is met if and when:

- a) The data transmission speed in the given measurement square reaches the required value (2 Mbit/s or 5 Mbit/s) in at least 50 % of the measurement samples;

- b) The average data transmission speed in the given measurement square reaches at least 75% of the required value (1.5 Mbit/s or 3.75 Mbit/s);
- c) One repeated measurement will be taken for verification in the measurement squares in which the above data transmission speed conditions are not met;
- d) Major roads should be understood to mean the major roads and local roads through towns/villages and the village greens and town squares. The smallest possible number of measurement squares will be selected along the major roads so that these selected measurement squares cover at least 50 % of the population of the community being measured.
- e) The condition of coverage of a community will be satisfied if the measurement squares meeting the criteria referred to under a) and b) above cover at least 95 % of the population within the measurement squares selected in the given community according to d) above.

(5) For the purposes of checking the coverage of motorways and expressways [1], continuous measurement is performed by drive test measurement at a drive speed of 90 km/hour at the maximum (if this is impossible due to the conditions prevailing at the time of measurement, a lower speed is used) along the entire length of the road. Data communication must be available in at least 90 % of the length of the road being measured. The requirement for the desired data transmission speed is met if and when:

- a) The measurement is performed twice in succession, i.e. by driving in one and the other direction along the measured segment of the motorway or expressway. The measurement samples from both measurements are taken as one whole;
- b) The data transmission speed reaches the required value (2 Mbit/s or 5 Mbit/s) in at least 45 % of all measurement samples;
- c) The average data transmission speed for all the measurement samples reaches at least 67.5 % of the required value (i.e., 1.35 Mbit/s or 3.375 Mbit/s).

(6) Coverage of transit rail corridors will be measured, using the Office's equipment, near the railway lines (parallel roads, railway stations, flyovers or crossings) in the cases of complaints. In the case of measurement at one point, the stationary measurement procedure is used in accordance with item (3) above. In the case of measurement along parallel roads, continuous measurement by the drive test procedure is used in accordance with item (4) above.

Section 5

Calculation of coverage and data transmission speed

(1) Stationary measurement of coverage according to Section 4 Subsection 2(a) will be performed in a series of measurement periods T , the number of the periods being $M = 16$, with a measurement time $T_m = 300$ s and with an interval between measurements $T_p = 600$ s.

(2) Stationary measurement of coverage according to Section 4 Subsection 2(b) will be performed in a series of measurement periods T , the number of the periods being $M = 4$, with a measurement time $T_m = 300$ s and with an interval between measurements $T_p = 600$ s.

(3) For the stationary measurement, a measurement square $K_{x,y}$ is defined, corresponding to the GPS position identified during the measurement.

(4) For the stationary measurement, the number of measurement samples N is calculated as follows: $N = M \cdot T_m \cdot (1+L)$, where L is the number of repetitions.

(5) For the drive test measurements, no measurement time T_m and no interval between

measurements T_p are determined. The measurement is taken on a continuous basis and its length depends on the area being tested, i.e. on the number and composition of the measurement squares $K_{x,y}$, in which the coverage measurements are being performed, or on the length of the motorway or expressway.

(6) For the drive test measurements, a measurement square $K_{x,y}$, corresponding to the GPS position identified during the measurement, is defined for each measurement sample.

(7) For the drive test measurements, the number of measurement samples $N(K_{x,y})$ of data transmission speed in the given measurement square $K_{x,y}$ is defined on the basis of Item (6) by summing up all the measurement samples belonging to the given measurement square.

(8) The requirement for the desired data transmission speed in the given measurement square $K_{x,y}$ or at a stationary point within the given measurement square $K_{x,y}$ is met if and when the following two conditions are simultaneously met:

a) The data transmission speed $v_d(K_{x,y}, k)$ reaches a value of v_{dmin} in at least 50% of all measurement samples in the given measurement square $K_{x,y}$. The relative coverage success rate must therefore be $R(K_{x,y}) = \frac{N_{OK}(K_{x,y})}{N(K_{x,y})} \geq 0.5$, where $N_{OK}(K_{x,y})$

is the number of measurement samples k , for which the condition $v_d(K_{x,y}, k) \geq v_{dmin}$ is satisfied, and $N(K_{x,y})$ is the total number of the measurement samples of data transmission speeds in the given measurement square $K_{x,y}$.

b) The average data transmission speed $\overline{v_d(K_{x,y})}$ from all $N(K_{x,y})$ measurement samples in the given measurement square $K_{x,y}$ must reach at least 75% of the v_{dmin} , which means that $\overline{v_d(K_{x,y})} = \frac{1}{N(K_{x,y})} \sum_{k=1}^{N(K_{x,y})} v_d(K_{x,y}, k) \geq 0,75 \cdot v_{dmin}$ must be valid.

(9) In the case of repeated measurements, the number of measurement repetitions being L , the calculation is performed as follows:

a) The relative coverage rate is calculated by summing up the number of measurement samples of the basic measurement with the index 0, and of the repeated measurements, in the given measurement square $K_{x,y}$. The value $N_{OK}(K_{x,y}) = \sum_{i=0}^L N_{OK}(K_{x,y})_i$ and $N(K_{x,y}) = \sum_{i=0}^L N(K_{x,y})_i$ is therefore used in item (8) above.

b) The resultant average data transmission speed $\overline{v_d(K_{x,y})}$ from the basic measurement with the index 0 and from the repeated measurement, in the given measurement square $K_{x,y}$ is calculated as follows: $\overline{v_d(K_{x,y})} = \frac{1}{(1+L)} \sum_{i=0}^L \overline{v_d(K_{x,y})}_i \geq 0,75 \cdot v_{dmin}$.

(10) The number of repetitions L is as follows:

- a) For measurement without repetition the $L = 0$.
- b) For measurement with repetition according to Section 4 Subsection 3c) and 4c), the $L = 1$.
- c) For measurement along motorways and expressways by driving once in one direction and once in the other direction, as referred to in Section 4 Subsection 5, the $L = 1$.

(11) The tender conditions for the desired data transmission speed according to Item 5 in the document [1] are fulfilled if and when the number of population in the measurement squares meeting the conditions of Item (8) of this methodical procedure is at least 95% of the total population of the set of measurement squares selected according to Section 4 subsection 4) of this methodical procedure.

(12) The tender conditions for measurement along motorways and expressways are met if and when data transmission is available along at least 90% of the total length of the motorway or expressway being measured. The data transmission speed should reach the required value (2 Mbit/s and 5 Mbit/s, respectively) in at least 45% of all measurement samples. The average data transmission speed for all measurement samples should reach at least 67.5% of the required value (i.e., 1.35 Mbit/s and 3.375 Mbit/s, respectively) in keeping with Section 4 Subsection 5 of this methodical procedure.

References and sources:

- [1] ČTÚ: Annex 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
- [2] IETF: rfc6349 Framework for TCP Throughput Testing

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