Proposal:

Recommendations for Installing Underground Cable System Funded by Public Funds, and Utilization of Existing Underground Cable System

Contents

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Purpose of this Document

Implementation of these Recommendations across all phases of planning, design, construction and maintenance of underground cable system имплементација ensures infrastructure capacities for the next few decades, which are utmost necessity for meeting the following strategic goals:

- Attainment of national fixed broadband targets set forth in NOBP, i.e.:
    a. By the end of 2029, at least 50% of the total number of household subscriber contracts across the country should cover internet access of at least 100 Mbps;
    b. By the end of 2029, all households should have affordable opportunity to access a network that allows download speed of at least 100 Mbps, with a possibility for upgrade to Gigabit speed;
    c. By the end of 2029, all public institutions (schools, universities, research centers and other education institutions, healthcare facilities, ministries, courts, local self-governments and other state authorities and bodies) should have symmetrical internet access with a speed of at least 1Gbps;

- Further development of Government fiber optic network with appropriate redundancy level t.e. the network that connects (or would connect) the Government, all ministries, Government bodies and authorities and other public institutions, future Government IT-platforms and capacities (data centers, cloud systems, crisis data recovery centers network operation center), MKD-CIRT etc., with a view to provide e-Government services, electronic identification card, e-Health, to secure mutual security communication, data exchange etc. applying the highest standards and highest computer security level;

- Provision of underground cable system for the needs of security services in[1];

- Fiber optic connection of free WiFi hotspots across the entire territory of RNM (over 1000);

- Conditions for development of the Fourth Industrial Revolution (4IR), based on new ICT, such as 5G, Artificial Intelligence (AI), Internet of Things (IoT), Advanced Data Analytics, Robotic Process Automation, Blockchain, Robotics, Cloud Computing, Virtual and Augmented Reality, 3D-printing, drones, Smart Grid, Smart Cities, Smart Home etc.

[1] This underground cable system will be managed and used by security services in RNM

Summary

Recommendations for PE MB and other public institutions that construct infrastructure objects (investors) financed with public funds (roads, railways, electricity transmission, gas pipeline, water supply, sewerage etc.):

1. Construction of underground cable system in and outside settlements

   - For construction of underground cable system in and outside settlements, PE MB and other public institutions – investors should install 4 tubes with internal diameter of at least 40 mm;
   - To connect the tubes along the route of the underground cable system, at pre-defined distance and at every point of route branching, PE MB and other public institutions – investors should install or build cable shaft assemblies/connectors wherein tubes would be connected/extended, microtubes would be drawn in and fiber optic cables would be drawn in/blown in;
   - The installed tubes should be used for the following purposes, i.e. in the following manner:
     - 1 x construction tube – tube in which PE MB would be able to draw in microtubes and draw in/blow in fiber optic cables, depending on the horizontal dimension of the fiber optic network and defined needs for fiber optic network capacity;
     - 1 x tube for needs related to maintenance of fiber optic network;
     - 1 x tube for future needs, and
     - 1 x tube for needs of security services of RNM.
   - Should the need arise to utilize the tube in the future, PE MB must draw in it an optimal number of microtubes with defined dimensions, pursuant to current underground cable system construction technologies.

2. If there is an unoccupied underground cable system (empty pipe/tube and/or unoccupied space in partially occupied pipe/tube) under public ownership, PE MB should primarily use that space, whereby the following capacities are needed for development of broadband networks in RNM:

   - For underground cable system in and outside settlements:
     - If there are at least 4 empty tubes, they shall be used for purposes pursuant to Item 1;
     - If there are 3 empty fiber optic tubes, they shall be used for the following purposes:
       - 1 x construction tube – tube in which PE MB would be able to draw in microtubes and draw in/blow in fiber optic cables, depending on the horizontal dimension of the fiber optic network and defined needs for fiber optic capacity;
       - 1 x for needs related to maintenance of fiber optic network and for future needs, and
       - 1 x tube for needs of security services of RNM.
     - If there are 2 empty fiber optic tubes, in one of the tubes PE MB should draw in an optimal number of microtubes with defined dimensions, pursuant to the current underground cable system construction technology, whereas the second tube should be left as a backup tube for future needs;
     - If there is one empty tube, PE MB should draw in an optimal number of microtubes with defined dimensions therein, pursuant to the current underground cable system construction technology;
     - If, in addition to the aforementioned empty tubes, there is unoccupied space in a tube to draw in microtubes, PE MB shall use that unoccupied space for purposes pursuant to Item 1.

3. If there is no unoccupied underground cable system under public ownership, but there is an unoccupied underground cable system (empty pipe/tube and/or unoccupied space in partially occupied pipe/tube) under private ownership, PE MB shall rent it only If there are acceptable technical and economic conditions to do so. Notably, the following capacities are needed for development of broadband networks in RNM:

   - For underground cable system in and outside settlements:
     - One tube with internal diameter of at least 32mm or combination of unoccupied space in one of multiple partially occupied pipes/tubes, wherein PE MB should draw in an optimal number of microtubes with certain dimensions, pursuant to the current underground cable system construction technology and defined needs for fiber optic network capacity.

4. PE MB should anticipate construction of new underground cable system to set fiber optic cable(s), if the existing (public or private) underground cable system does not have the minimum recommended available capacity (taking into account the network construction location), and if no acceptable technical or economic conditions are in place to use/rent the needed optical fibers under public/private ownership.

5. PE MB should anticipate construction of new underground cable system for a backhaul network whereby, pursuant to NOBP, PE MB would allow access thereto to operators, so they could provide access to white/gray zones, if the existing (public or private) underground cable system does not have the minimum recommended available capacity for PE MB to install fiber optic cable(s), and if there is no possibility to use optical fibers under public ownership.

6. Prior to preparation of underground cable system construction project or construction project for other type of infrastructure object, PE MB and public institutions-investors should request opinion from NBCO[2] about the underground cable system type and capacity, as well as about latest quality standards that need to be met for materials that would be used for underground cable system that would be constructed with public funds.

7. Prior to adopting decision on utilization of existing underground cable system and/or utilization of existing optical fibres under public ownership, as well as on renting available underground cable system capacities and/or renting optical fibres under private ownership, PE MB should request opinion from NBCO.

8. On its GIS platform, PE MB should establish and maintain electronic space register of public and/or state-managed telecommunications infrastructure. The electronic space register should cover physical and attributive data to fully describe all element of:

   - Public and/or state-managed underground cable system (pipes, tubes, microtubes, cable shaft assemblies, connectors etc.), and
   - Public and/or state-managed fiber optic network (fiber optic cables, mini fiber optic cable, microfiber optic cables, fiber optics, connectors, terminals etc).

[2] NBCO competence pursuant to Article 71-a paragraph (2) items 4 and 6 under the Law on Electronic Communications ("Official Gazette of the Republic of Macedonia ", no. 39/2014, 188/2014, 44/2015, 193/2015, 11/2018, 21/2018 and "Official Gazette of the Republic of North Macedonia ", no. 98/2019 and 153/2019)

Access to these data shall be established by the Government of RNM, upon previously submitted opinion/recommendation from NBCO.

1. Competence for Adoption and Application of Recommendations

Pursuant to the Law on Electronic Communications (LEC) and the National Operational Broadband Plan (NOBP), one of the tasks of the National Broadband Competence Office (NBCO) is to provide the most optimal and most economically efficient technical solution for development of broadband networks in RNM, which is widely based on development of national transport fiber optic network (NTON) and on fiber optic access networks or Next Generation Access networks with minimal public funds and maximum utilization of existing resources and existing public and private infrastructure.

In that regard, NBCO adopts these recommendations for installing underground cable system financed with public funds, as well as utilization of existing underground cable system financed with public and/or private funds.

Underground cable system is a physical infrastructure consisting of canals (pipes, tubes, microtubes) and canal connectors (galleries and cable shaft assemblies) that serves for multiple installations and protection of electronic communication cables.

The recommendations give clear guidelines for actions, primarily to PE MB as the only law-stipulated institution competent for construction of NTON and NGA networks in white zones, as well as to other institutions that construct infrastructure objects financed with public funds (roads, railways, electricity transfer, gas pipeline, water supply etc.). Specifically, when constructing these infrastructure objects, it gives instructions to these institutions to also anticipate installing underground cable system with defined characteristics and capacity that would be utilized for future placement of fiber optic cables, which, in turn, would decrease costs for implementation of NTON and NGA networks in white zones. On the other hand, these recommendations provide guidelines to PE MB about the manner of utilization of the existing underground cable system.

2. Technical Specifications of Broadband Communication Networks

2.1. Concept of broadband communication network

The concept of communication network that provides broadband access pursuant to NOBP Is based on construction of fiber optic cables to connect:

- NTON network nodes:
  - Points from which operators would be able to access NTON, at least one such point should be available in all cities;
  - Data centers of target areas, central white zone points, central justified gray zone points – points wherein operators would be able to install their active equipment;
  - Other network nodes not falling into aforementioned categories;
- End users – households and private companies in white and justified gray zones, public institutions and free WiFi hotspots – access points wherein fast/ultrafast internet access service should be provided.

The horizontal dimension of broadband networks is defined depending on which points are being connected. Those could be:

- Backbone network – fiber optic network that interconnects NTON network nodes from the highest level of hierarchy, network that extends across a wider region and connects multiple municipalities and cities;

- Backhaul network – fiber optic network that interconnects NTON network nodes with access nodes/data centers of target areas, central points of white zones and central points of justified gray zones, as well as network that transfers traffic from access fiber optic networks to a higher level;
- First-mile fiber optic network – fiber optic network from access nodes to end users.

When preparing these recommendations, account has been given to horizontal dimension of broadband networks, i.e. whether construction of the infrastructure object is planned in an area wherein backbone, backhaul or first mile fiber optic network would be constructed during development of NTON. According to construction location, the backbone network and the backhaul network may also be constructed outside settlements, whereby the first-mile fiber optic network is usually constructed within settlements, given that it is intended to connect end users.

2.2. Broadband Network Elements

2.2.1. Underground cable system

Unlike in the past, when due to the large external dimensions of fiber optic cable, one to maximum two fiber optic cables of lower capacity could be drawn in one tube of the underground cable system, today's technology for development of fiber optic cables with small external diameter and relatively large capacity (mini fiber optic cables), allows better utilization of the existing underground cable system and requires lower costs for construction of underground cable systems.

Below are enlisted typical dimensions (internal diameter) of pipes/tubes/microtubes that are currently used for construction of underground cable system for fiber optic cables.

- Pipes/tubes with internal diameter:
  - 110 mm;
  - 50 mm;
  - 40 mm;
  - 32 mm.
- Microtubes with internal diameter:
  - 16 mm;
  - 10 mm;
  - 8 mm;
  - 3,5 mm.

2.2.2. Fiber optic cables

Typical capacities of fiber optic cables that are currently used for construction of fiber optic cables are the following:

- Fiber optic cables/mini fiber optic cable for construction of backbone and backhaul networks:
  - 12 optical fibers (o.f.);
  - 24 o.f.;
  - 48 o.f.;
  - 72 o.f.;
  - 96 o.f.;
  - 144 o.f.;
  - > 144 o.f.
- Microoptical fiber cables for construction of fiber optic access network:

- 1 o.f. (for overhead fiber optic access networks);
- 2 o.f.;
- 4 o.f.;
- 8 o.f.;
- 12 o.f.;
- 24 o.f.

2.3. Possible constructions of underground cable system

According to dimension of the internal diameter of the pipes, tubes and microtubes of underground cable systems, as well as according to dimensions of the external diameter of tubes, microtubes and fiber optic cables/mini fiber optic cables, many different combinations are possible for construction of underground cable systems for development of broadband networks.

Pursuant to the current technology for production of pipes, tubes, microtubes, fiber optic cables and mini fiber optic cables, below are enlisted several examples of possible constructions of underground cable system:

- Pipe with internal diameter of 110 mm, can accommodate can fit:
  - 4 tubes with internal diameter of up to 40 mm;
- Pipe/tube with internal diameter of 50 mm can fit:
  - 7 microtubes with dimensions of up to 12/10mm (external/internal diameter);
- Tube with internal diameter of 40 mm, can fit:
  - 7 microtubes with dimensions of up to 12/10mm (external/internal diameter);
- Tube with internal diameter of 32 mm, can fit:
  - 4 microtubes with dimensions of up to 10/8 mm (external/internal diameter);
- Microtube with internal diameter of 10mm, can fit:
  - Fiber optic cable with capacity of up to 144 o.f.;
- Microtube with internal diameter of 8mm, can fit:
  - Fiber optic cable with capacity of up to 72 o.f.;
- Microtube with internal diameter of 3.5mm, can fit:
  - Microoptical fiber cable with capacity of up to 24 o.f..

Factory-packed microtube bundles can also be found on the market, those being 1, 4, 7 or 12 tubes per bundle. Moreover, pipes/tubes are also produces wherein a microtube bundle with specific dimensions (external/internal diameter) is factory-inserted, whereby the external pipe/tube is an additional mechanic protection during direct burying in the ground.

Two options of microtubes are produced:

- Direct buried - DB – construction with additional mechanic protection, intended for direct burying in the ground, and
- Direct installation - DI – no additional mechanic protection, intended for drawing in pipes/tubes/microtubes with larger diameters.

3. Recommendations for Underground Cable System

3.1. Construction of underground cable system financed with public funds

This section covers recommendations for installation of underground cable system with defined characteristics and minimum underground cable system capacity, depending on the type (horizontal dimension) of the fiber optic network, which PE MB and other institutions should apply when constructing infrastructure objects financed with public funds (roads, railways, electricity transmission, gas pipeline, water supply, sewerage etc.).

3.1.1. Construction of underground cable system in and outside settlements

The following recommendations are adopted for construction of underground cable system in and outside settlements (underground cable system for backbone networks, underground cable system for backhaul network and underground cable system for first-mile fiber optic network):

- For construction of underground cable system in and outside settlements, PE MB and other public institutions – investors should install 4 tubes with internal diameter of at least 40 mm;
- To connect the tubes along the route of the underground cable system, at pre-defined distance and at every point of route branching, PE MB and other public institutions – investors should install or build cable shaft assemblies/connectors wherein tubes would be connected/extended, microtubes would be drawn in and fiber optic cables would be drawn in/blown in;
- The installed tubes should be used for the following purposes, i.e. in the following manner:
    - 1 x construction tube – tube in which PE MB would be able to draw in microtubes and draw in/blow in fiber optic cables, depending on the horizontal dimension of the fiber optic network and defined needs for fiber optic network capacity;
    - 1 x tube for needs related to maintenance of fiber optic network;
    - 1 x tube for future needs, and
    - 1 x tube for needs of security services of RNM.
- Should the need arise to utilize the tube in the future, PE MB must draw in it an optimal number of microtubes with defined dimensions, pursuant to current underground cable system construction technologies.

The type of cable shaft assemblies/connectors and the distance at which they would be installed during construction of underground cable system for backbone network and underground cable system for backhaul network would depend on the current underground cable system construction technology and the maximum factory lengths of fiber optic cables/mini fiber optic cables.

3.1.2. Conclusion

The aforementioned underground cable system characteristics and capacities are dimensioned to meet the needs for construction of fiber optic network for implementation of NOBP, as well as to meet current and future needs of security services in RNM. The proposed capacities will meet the needs of future mutual connection NTON network nodes and access nodes (data centers of target areas, central white zone points, central justified gray zone points), as well as connection of NTON network nodes and access nodes with central Government data center and with disaster recovery data center, if needed.

Prior to preparation of underground cable system project of project for construction of other type of infrastructure object financed with public funds (roads, railways, electricity transmission, gas pipeline, water supply, sewerage etc.), PE MB and public institutions-investors should ask for opinion from NBCO about the underground cable system type and capacity, as well as for quality standards that need to be met for materials that would be used for underground cable system that would be constructed with public funds.

3.2. Utilization of existing underground cable system

In terms of utilization of existing underground cable system for construction of NTON and NGA networks in white zones, two situations are distinguished:

- The underground cable system is under public ownership, and
- The underground cable system is under private ownership.

3.2.1. Existing underground cable system under public ownership

In terms of the underground cable system under public ownership, i.e. constructed with public funds, it is recommended that the institution that manages said underground cable system to transfer managing rights for all available capacities thereof to PE MB, by means of contract.

To construct NTON and NGA networks in white zones, PE MB would need the following underground cable system capacities:

- For underground cable system in and outside settlements:
  - If there are at least 4 empty tubes, they shall be used for the following needs, i.e. in the following manner;
    - 1 x construction tube – tube in which PE MB would be able to draw in microtubes and draw in/blow in fiber optic cables, depending on the horizontal dimension of the fiber optic network and defined needs for fiber optic network capacity ;
    - 1 x tube for needs related to maintenance of fiber optic network;
    - 1 x tube for future needs, and
    - 1 x tube for needs of security services of RNM..
  - If there are 3 empty fiber optic tubes, they shall be used for the following purposes:
    - 1 x construction tube – tube in which PE MB would be able to draw in microtubes and draw in/blow in fiber optic cables, depending on the horizontal dimension of the fiber optic network and defined needs for fiber optic capacity;
    - 1 x for needs related to maintenance of fiber optic network and for future needs, and
    - 1 x tube for needs of security services of RNM.
  - If there are 2 empty fiber optic tubes, in one of the tubes PE MB should draw in an optimal number of microtubes with defined dimensions, pursuant to the current underground cable system construction technology, whereas the second tube should be left as a backup tube for future needs;
  - If there is one empty tube, PE MB should draw in an optimal number of microtubes with defined dimensions therein, pursuant to the current underground cable system construction technology;
  - If, in addition to the aforementioned empty tubes, there is unoccupied space in a tube to draw in microtubes, PE MB shall use that unoccupied space to develop broadband networks in RNM.

In all aforementioned instances, if there is a need to utilize the pipe for future needs during exploitation of the underground cable system, PE MB PE MB must draw in it an optimal number of microtubes with defined dimensions therein, pursuant to the current underground cable system construction technology.

When constructing NTON and NGA networks in white zones, PE MB should primarily use underground cable system under public ownership.

3.2.2. Existing underground cable system under private ownership

If, at a certain section of the route anticipated for construction of NTON and/or NGA networks in white zones there is no unoccupied underground cable system (empty pipe/tube and/or available space in partially occupied pipe/tube) under pubic ownership, but there is an unoccupied underground cable system (empty pipe/tube and/or available space in partially occupied pipe/tube) under private ownership. PE MB shall rent it only the technical and economic criteria thereof are acceptable. In that, to construct NTON and NGA network in white zones, PE MB needs the following capacities:

- For underground cable system in and outside settlements:
  - One tube with internal diameter of at least 32mm or a combination of available space in one or more partially occupied pipes/tubes, wherein would be able to draw in an optimal number of microtubes with specific dimensions, pursuant to the current underground cable system construction technology and defined fiber optic network needs.

When renting capacities from underground cable system under private ownership, a legal solution needs to be found to sign longer period lease agreements. Pursuant to the current legal solution, the maximum duration of signed contracts between public institutions and private companies is 3 years.

PE MB should anticipate construction of new underground cable system to set fiber optic cable(s), if the existing (public or private) underground cable system does not have the minimum recommended available capacity (empty pipe/tube and/or available space in partially occupied pipe/tube), taking into account the network construction location and established needs for fiber optic network capacities, and if no acceptable technical or economic conditions are in place to use/rent the needed optical fibres under public/private ownership.

PE MB should anticipate construction of new underground cable system for a backhaul network whereby, pursuant to NOBP, PE MB would allow access thereto to operators, so they could provide access to white/gray zones, if the existing (public or private) underground cable system does not have the minimum recommended available capacity for PE MB to install fiber optic cable(s).

In dispersed rural settlements wherein construction of underground fiber optic access network is technologically impossible or is economically unjustifiable, the possibility to construct overhead fiber optic access network should be considered.

Prior to adopting decision to utilize unoccupied capacity of existing underground cable system under public ownership, to rent unoccupied capacity of underground cable system under private ownership, as well as to construct overhead fiber optic access network as opposed to underground cable system, PE MB should request opinion from NBCO.

List of Abbreviations

4IR –4th Industrial Revolution

5G – Fifth Generation Mobile Network

AI –Artificial Intelligence

DB – Direct Buried microtubes, with additional mechanical protection, intended to be installed directly in the ground

DI – Direct installation microtubes, without any additional mechanic protection, intended for drawing in pipes/tubes/microtubes with larger diameters

ICT –Information and Communication Technologies

IoT –Internet of Things

MKD-CIRT –National Center for Computer Incident Response

NGA –Next Generation Access networks

Wi-Fi – Wireless networking technology

GIS – Geographic Information System

LEC – Law on Electronic Communications

PE MB – Public Enterprise Macedonian Broadcasting

NBCO – National Broadband Competence Office

NOBP – National Operational Broadband Plan

NTON – National Transport Optical fiber Network

o.f. – optical fibers