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## **Underground mobile coverage: problems and solution**

As the result of significant growth of subscribers in the market of telecommunication services., there is a strong need to make communication available everywhere. That is why mobile operators are trying to cover the whole area of Ukraine with a stable and high quality mobile network. There is no problem of network coverage in the open space in Ukraine, although inside commercial buildings, basements and underground, where mobile signal cannot pass physically it is rather problematic. Telecommunication providers face the problems related to difficult unrolling the indoor network, especially when an organization coverage is limited in space. A project how to solve this problem in Dnipro city are proposed in this paper.

Modern opportunities of indoor coverage are targeted primarily at ensuring high-quality voice service at least, but it is not always able to provide network capacity to work in its applications and data. Recently coverage in the underground station(s) was almost impossible and/or rather time consuming process that were caused by different factors, where high cost is the first one and the limited scalability and low capacity is the second one.

Today people are used to the mobile gadgets. Moreover, some of them are addicted to mobile phones. There is no problem to cover streets and buildings with the instant mobile network by installing standard equipment and using classic network planning, but underground use is rather problematic and needs special telecommunication solution(s).

In both cases, there is a need to start with installing the base station (BS). There are some options of BS:

1. Macro base station in one or more cabinets: Indoor Model: BTS3900, BTS3900L  
Outdoor Model: BTS3900A
2. Distributed Base Station DBS3900
3. Install Pico-BTS

There are 2 ways of the distribution of electromagnetic signals from a base station: installation antennas at the station and construction of radiating cable.

There are some specific features of mobile planning in a subway. Radio waves are not always sufficient to reach at the depth necessary for mobile communication underground. The special equipment is needed to be installed for cellular network. In the city of Dnipro the macro - powerful device designed for many customers over a large area is used.

Planning telecommunication in metro station can be specified by the following features:

- 1) coverage areas are usually quite small - platforms and escalators, which are often extracted (eg - high escalator), and the possibility of installation can only be on one side of the object.
- 2) During rush hours indoor cell can gain hundreds of people as much as a "great" cell one outdoor.
- 3) As there is simply no neighborhood, there is absence of difficulties with interference and crossings with neighbouring cells.
- 4) Increased safety as in many places people are pretty close to the equipment which emits waves of hazardous frequency.
- 5) Reflection of the signal by reinforced-concrete columns located on the station reduce radio signal at the input to the 20-25 dB.

Projecting is one of the most important and most difficult stage of deployment of mobile network as it must ensure the most optimal cost for building a close network on the criterion of efficiency. Formally, the task of designing is rather simple: to determine the place of establishment of a base station, antenna location, choose the optical fiber and other feeder lines, but in fact, this problem is rather complex. Since the configuration and parameters of the network depend significantly on the network sweep and in the course of the work execution, calculations that require intensive use of computer facilities will be required.

Design begins with the scheme of the place of introducing mobile communication with the parameters and characteristics that are important for the project. Further, taking into account all the characteristics of the equipment to be used for the project, and the results of a rough estimate of the energy balance, preliminary design is carried out. For the obtained scheme using the existing models of propagation of radio waves and terrain characteristics, the parameters of the electromagnetic field within the serviced territory are calculated more accurately, which will allow us to estimate which coatings.

In addition, in the projected network, experimental measurements of the characteristics of the electromagnetic field are carried out and according to the results of measurements, the network design is also corrected.

Finally, the quality of the project is clarified and evaluated already at the stage of network operation, where its corrections and modifications are also inevitable, especially at the very beginning of the work, when the network is tuned and optimized. This phase of work is actually the most time consuming.

The quality of the project could be provided by taking into consideration a type of a base station, ways of the distribution of electromagnetic signals from a base station, careful planning and designing.