Prospects of using medium-wave band for radio communication with rescue mobile teams of EMERCOM of Russia

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Abstract. The results of tests in-situ of the prototype of medium-wave mobile radio station «Noema-SV» in Western Siberia, Omsk region and Vorkuta Arctic Integrated Emergency and Rescue Center of EMERCOM of Russia are presented. Radio paths tests in-situ in the Far North show the possibility of radio communication with rescue mobile teams of EMERCOM of Russia in the medium-wave band within distances of several tens of kilometers of rugged topography. The radio range on a flat terrain increases to several hundreds of kilometers. Shortened medium-wave band antennas developed at OmSTU and employed by rescue mobile teams of EMERCOM of Russia were used in.

1. Introduction

The short-wave band (SW), used traditionally for ionospheric long distance (up to a thousand km) and super-long distance (several thousand km) radio communication, is limited in its application by complicated conditions of radio-wave propagation caused by the non-stationary state of the ionosphere. It is challenging and often impossible to use short-wave band in the Arctic, since the ionosphere in polar areas is more perturbed. Moreover, its closest to the Earth layer D absorbs much of the radio wave energy passing through this layer. The most dangerous types of abnormal absorption at high latitudes are the absorption of polar cap and auroral absorption.

The degree of absorption depends on a solar elevation angle, site latitude, solar activity, and radio paths geography [1, 2], which can be divided into three groups.

1. Short-range paths, being entirely inside the polar cap and crossing no auroral oval. Reliability of communications is basically determined by absorption of the polar cap on them.

2. Mid-range paths with at least one end point being located in an auroral zone. Fade-outs are the most probable on such paths, and signal attenuation can reach 30–60 dB depending on the emission frequency.

3. Long-range paths crossing an auroral oval. In this case radio conditions are more favorable as opposed to the second case.

Thus, in waters of the Northern Sea Route the issue is to organize radio on the mid-range radio paths where VHF could not work any longer, but SW has not worked yet. This task can be solved by means of the medium-wave band (MW) of the surface wave [3]. The longer wave length allows you to connect by the surface wave over distances far exceeding the line of sight due to diffraction and
refraction. This ensures communication in this band over distances from several tens and even hundreds of kilometers providing transhorizon radio communication.

2. Problem statement

In order to determine the potential range of signal transmission between mobile objects in the medium-wave (MW) frequency bands on the real radio path, tests in-situ of the prototype of marine medium-wave mobile radio station «Noema-SV» (Figure 1) were conducted, this station comprising of: «Noema-SV» transceiver of 8 W, off-chip power amplifier «Noema-SV-U1» of 100 W and whip antenna of 6 m with the inductive antenna tuning unit with the capacity of 100 W [4].

![Figure 1. General view of the prototype of marine medium-wave mobile radio station «Noema-SV».

The two prototypes of radio station «Noema-SV» were mounted on motor cars (Figure 2) and KamAZ 4803 and TRECOL-39294 based accident rescue vehicles (Figure 3). Shortened medium-wave band antennas developed in OmSTU were used in tests and proved to be of high efficiency, despite their small size compared to the wavelength used for radio communication.

![Figure 2. Antenna location of medium-wave mobile radio station «Noema-SV» on motor cars.](image-url)
3. Testing procedure

Tests were performed in two stages on real radio paths. The first stage of the tests took place on 12 April 2017 in Omsk region, the second stage was conducted from 19 to 21 April, in the Komi Republic at Vorkuta Arctic Integrated Emergency and Rescue Center of EMERCOM of Russia - a branch of the North-West Regional Rescue Center of EMERCOM of Russia (Vorkuta AIERC of EMERCOM of Russia – branch of the NWRSRT of EMERCOM of Russia). The radio stations worked in the frequency range of 440–450 kHz during the tests.

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During the tests, the range of the following types of signals was tested:

– analog telephony, emission class J3E, on the lower sideband;
– digital selective calling messages (DSC), emission class F1B, frequency shift of 170 Hz, transfer rate of 100 b/s recommended in the ITU-R M. 493-12 guidelines, except that transmitted information was arbitrary;
– digital data at the rate of 1200 b/s, emission class - fast frequency shift keying (FFSK.).

In determination of the radio range for analog voice telephony/voice message communication sessions of satisfactory quality were taken into consideration (3 points on a five-point scale). While receiving digital messages, sessions complying with a standard were those without errors.

4. Results of experiments and discussion

The choice of method to clarify the current storage area is done by enterprise staff through establishing the rules of work in the storage area.

Radio paths tests in-situ in the Far North including showed the possibility of radio communication with rescue mobile teams of EMERCOM of Russia in the range of medium-wavelength over distances of several tens of kilometers of rugged topography. The radio range on a flat terrain increases to several hundreds of kilometers.

Figures 4 and 5 show the location of radio paths in the field tests (Figure 4 is the first stage and Figure 5 is the second stage of the tests) [5].
At the first stage of the tests with the transmitter power of 100 W, the voice message radio range reached up to 130 km (radio path 3 in Figure 4), and the receiving range of digital data with the transfer rate of 1200 b/s was 190 km (radio path 6 in Figure 4). The same radio range of 190 km was provided with DSC signals, but with a transmitter capacity of 8 W. With 100 W transmitter capacity,
the consistent signal reception of DSC was provided to ranges more than 220 km (radio path 7 in Figure 4).

The second stage of the test showed the possibility of a sustained voice signal radio communication and message communication of a digital selective call in the MF band with the transmitter capacity of 100 W up to the distance of 60 km (radio path 1-3 in Figure 5), in motion including (radio path 1 in Figure 5). There was no radio communication on radio paths of 120–155 km (paths 4 and 5 in Figure 5).

The radio communication loss on radio paths 4 and 5 in Figure 5 is due to a significant change in topography. At the first stage of the tests and on the entire radio paths 1, 2 and 3 of the second stage of the tests (Figure 5), the altitude differences of local terrain did not exceed 100 m and were much smaller than wavelengths for radio communications. Cross-section path profiles 1, 2 and 3 are shown in Figures 6, 7 and 8, respectively [5]. On radio paths 4 and 5 (Figure 5), the altitude differences of local terrain were of several hundred meters and exceeded the wavelength for radio communications. Cross-section path profiles 4 and 5 are shown in Figures 9 and 10, respectively [5].

Figure 6. Cross-section path profile 1.

Figure 7. Cross-section path profile 2.
To solve the problem of communications with «dead» zone objects outside radio visibility on mid- and short-range radio paths, the short-wave communication method can be applied with near vertical ionospheric exposure, known as NVIS (Near Vertical Incidence Skywave Propagation) [6]. The key points for such type of radio communications are the application of NVIS antennas and choice of an operating frequency.
In applying NVIS radio communication, radio waves reflecting from layer E at the height of 90...120 kilometers are absorbed by layer D at the height of 50 kilometers. Layer D does not have the maximum of height density and smoothly transacts to layer E, passing it twice [6]. Therefore, while selecting frequencies for NVIS radio communications, the conflicting requirements should be taken into account: as the signal frequency increases, the reflection factor of a vertical down going wave decreases, but in case of frequency decrease, its ionospheric absorption increases. So, a fairly narrow range of applicable frequencies remains suitable for radio communication, this range being dependent on time of day, season and solar activity determining electron density. The antenna used in the test provides the possibility to work in nearly vertical incidence sky wave mode (Figure 11) [7], but abnormal absorption of radio waves in the Arctic remain this type of radio communication problematic.

**Figure 11.** Whip antenna located on a motor car as NVIS antenna.

For the Arctic Zone of the Russian Federation, installation of MW radio communication network with automatic relaying of signals by remote repeaters can be preferable due to the possibility to operate in an autonomous, unattended mode. "Dead" zones arising from a local terrain and optimum repeater locations can be calculated using the recommendations of International Telecommunications Union ITU-R P.526-10 "Propagation by Diffraction" [8].

5. Conclusion

Radio paths tests in-situ in the Far North including showed the possibility of radio communication with rescue mobile teams of EMERCOM of Russia in the range of medium-wavelength over distances of several tens of kilometers and in the plain terrain up to several hundred kilometers, in motion including.

Radio communication was provided in the vicinity of the town of Vorkuta. Much narrow-band interference indicates in itself the intensive use of medium-wavelength range in the Far North. This range is proved to be a very promising and sometimes a single frequency resource for the operation of various radio engineering systems.

Shortened medium-wave band antennas developed at OmSTU can be located on motor cars used by rescue mobile teams of EMERCOM of Russia, these antennas providing good efficiency.

It is necessary to continue the tests with a special emphasis on «dead» zone radio communications due to topographic obstacles in highlands.

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