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MATTERS OF SATELLITE QUEUING NETWORK DESIGN IN KA-BAND FOR REPUBLIC OF KAZAKHSTAN

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ABSTRACT

This work was carried out within the framework of research opportunities of using Ka - band satellite communication systems in the Republic of Kazakhstan. Paper deals with the multi-beam coverage in Kazakhstan (the distribution of beams in area and determine their capacity), as well as evaluation of the main parameters of subscriber channels. The need for this research was due to the fact that the design of multi-beam network for Kazakhstan is important to consider a distinct uneven distribution of the population (or potential users), low average density (about 6 persons / sq km.) and a fairly significant differences in some areas of the territory on the rain intensity.

Key words: *satellite networks, Ka-Band, multi-beam antennas, bandwidth, signal-code constructions*

1. GENERAL

Recent years, the accelerated development of Ka-bandas a global trend is observed in satellite communication. A considerable number of works devoted to the review of existing and planned satellite queuing systems [1-3], operating experience [4] and the results of research on the optimization of their parameters [5-7]. Before application of multi-beam technology the provision of broadband services to the mass consumer in Ka - band was considered less profitable because of the need for a super-cheap VSAT - terminals. With an advent of queuing systems, which are based on the technical application of multi-beam receiver and transmitter onboard antennas, the above mentioned problem has been solved.

The present work was carried out within the framework of research opportunities for application of Ka-band satellite communication systems in the Republic of Kazakhstan. The work is devoted to the study of multi-beam coverage in Kazakhstan (the distribution of the beams of the grounds and the determination of their capacity), as well as the evaluation of the main parameters of subscriber channels. The need for these studiesis due to the fact that the design of multi-path network for Kazakhstan it is important to take into account the pronounced uneven distribution of the population (potential customers), lower average density (about 6 persons / sq km.) [8] and is quite a significant difference on the territory of the individual zones of intensity rain. The most densely populated region, where 1 sq.km for about 20 people, is the South-Kazakhstan region, and the most sparsely populated region with a minimum density of 2.3 people per 1 sq. km. km – is Aktobe region.

Levels of rainfall intensity exceeding the 0.01% of the year duration change from 10 mm / h in the western and central regions of up to 30 mm / hour in the East Kazakhstan region [9].

When choosing a geostationary satellite orbital position 58.5 E stage by stage was taken into account the fact that Kazakhstan submitted to the ITU in the Ka-band for this position 3 applications [9] (the latter KAZSAT-1R with a priority date of 11.14.2012 and was valid until 30 / 03/2018).

Among three options forming of working area and satellite distribution capacity in the beams considered in [5, p.1] for Kazakhstan (considering the uneven population density) is set equal distribution of the beams of the grounds and the uneven distribution of capacity in the beams.

In accordance with the documents of ITU and CEPT for projected satellite network the frequency bands listed in Table 1 were selected.

TABLE 1. Frequency bands for Kazakh satellite

The transfer hub (CES)	The transfer ST
29,0 – 29,7GHz	30,0 – 30,5GHz
The receptionhub (CES)	The receptionST
18,3 – 19,0 GHz	19,2 – 19,7GHz

Note: The hub - the central earth station (gateway); ST - subscriber (user) terminal.

In Kazakhstan satellite repeater is supposed to apply separate receiving and transmitting multi-beam antennas (MBA), which will optimize the antenna maximum gain (MG), lower level of the side lobes (LSL) and reduce the cross-polarization radiation, and more precisely, sustain mutual consistency of the viewing zones at the reception and transmission. The distribution of the beams on the territory of the Republic of Kazakhstan is shown in Figure 1.

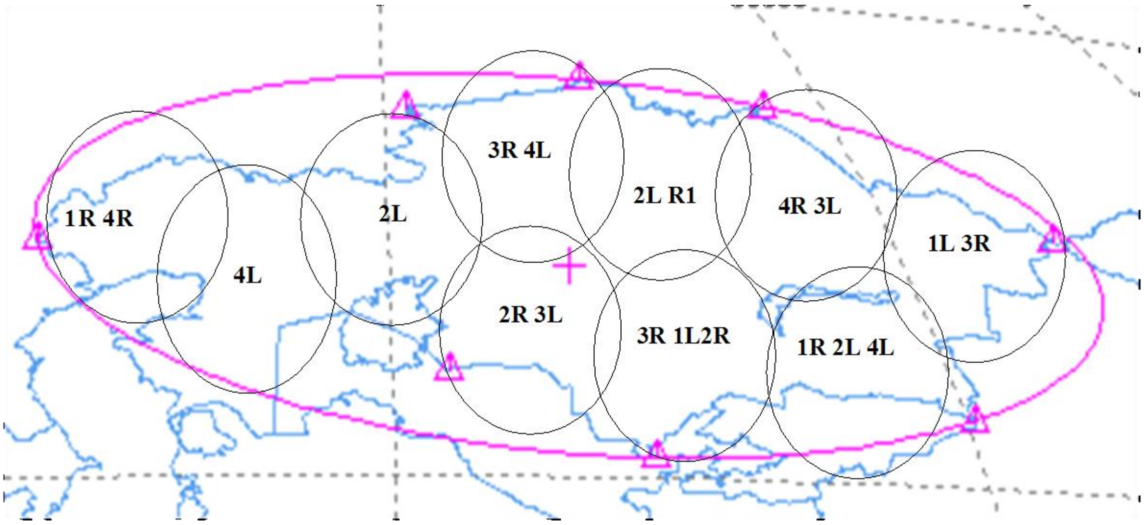

FIGURE 1. THE UNIFORM DISTRIBUTION OF BEAMS ON THE TERRITORY OF THE REPUBLIC OF KAZAKHSTAN AND THE UNEQUAL DISTRIBUTION OF CAPACITY IN THE BEAMS

Working frequency range of 500 MHz, of the band 30,0-30,5 / 19,2-19,7 GHz, is divided not by 4 but 8 liters (125 MHz each) with polarization (circular - left L and right R). The integrated frequency resource will be 2500MHz (2 beams to 1 Liter, 6 - 2 letters and 2 - to 3 letters).

To assess the throughput (C) of the forward and reverse subscriber channels their energy potentials EP and the threshold ratio of received binary symbols energy E to the power spectral density of the noise - N_o (h_p^2) were used

$$C = \frac{EP}{h_p^2} \quad (1)$$

Let us consider the work area on the satellite uplink beams (reverse subscriber) channel. The main characteristic of the satellite transponder (ST) receiving channel is a quality factor

$$Q = \frac{G_{rec}}{T} \tag{2}$$

where $G_{rec} = 27843 / \beta^2$ [10] –is ST receiving antenna gain, T = 1000 K [7, p.1] –is noise temperature of the receiving path STr. The work area will be characterized by a quality factor Q = 46,9 - 30 = 16.9 dB / K.

As for the determination of the energy potential of the channel it is important to know the attenuation in the rain, calculations for the city of Ust-Kamenogorsk (rain intensity of 30 mm / hour) at 30 GHz for a circularly polarized radio signals in accordance with the procedure of the ITU [11] were performed. The calculation results are shown in Table 2.

Through put of reverse user channel was determined under the condition that the probability of erroneous reception of the transport stream packets is not more than 10^{-7} (ST output at 1 W bandwidth Δf = 125 MHz and the energy potential of the channel is 71.1 dBHz).

TABLE 2. 30 GHZ RADIO SIGNAL ATTENUATION (CIRCULAR POLARIZATION) IN THE RAIN AT DIFFERENT PERCENTAGES OF TIME EXCEEDING

The percentage of time exceeded	Attenuation, dB
0,1	9,8
0,01	25,6

Calculations showed that in the case of input data for clear weather, and when using the SCM in standard DVB-S2 [QPSK (m = 2), FEC (r = 9/10)] reverse channel throughput will be 5.26 Mbits / sec. In this case, the required frequency resources will be 2.94 MHz. The obtained value of the throughput corresponds to about design parameters of Inmarsat-5, where the reverse link with an antenna diameter of 0.6 m is set to maximum speed of 5 Mbit/s. Table 2 shows that the loss of signal in the rain (0.1 percent of time) is 9.8 dB. In such weather conditions throughput significantly reduced (up to 550 kbit / s). The transition from rain to a new option (QPSK, r = 1/4) will increase this value to approximately doubled (up to 1.14 Mbit/s). Usually downloading of the reverse channel is relatively low, which makes it possible to use the reverse channel unclaimed resource for the organization of video surveillance systems [4, p.1].

Throughput offorward user channelsis determined at 20 GHz, provided that the probability of erroneous reception of the transport stream packets are not more than 10^{-7} (with a satellite transponder EIRP 65.9 dBW bandwidth Δf = 125 MHz and the channel energy potential of 90.2 dBHz).

Calculations showed that in the case of input data for clear weather, and when using the SCM option for DVB-S2 standard [8-PSK (m = 3), FEC (r = 9/10)] forward subscriber channel throughput will be 224 Mbit /sec. In this case, therequired frequency resource will be 83.6MHz. Signal loss in the rain at 20 GHz (0.1 percent of time) is 5.1 dB. In such weather conditions throughput decreases to values 69.2 Mbit/s. The transition in the rain to a new option (8-PSK, r = 3/5) will raise the value of the throughput up to 162.2 Mbit/s. The transition in the rain on the option (QPSK, r 4/5) will raise the amount of throughput up to 175 Mbit/s (with the occupied band will be approximately 110 MHz).

The total throughput of forward user channels in clear weather will be (2*224 +6*448+2*672)=4480 Mbit/s. The specific rate determines the number of subscribers, who can be connected to the network. If to focus on the specific rate adopted for cable networks, such as 30 kbit/s, it is possible to connect approximately 149 thousand subscribers. If to provide a service similar to Wild-Blue and available in the U.S. today, it is possible to connect the 44.8 million subscribers [4, p.1].

2. CONCLUSIONS

10 beams with an angular size of 0,75º are determined in the practice of building a multi-band satellite operating in the territory of Kazakhstan.

Energy potential of subscriber channels increases by about 10.5 dB in the transition from a single-beam to multi-beam coverage area of Kazakhstan (β = 0,75°).

The results of reverse subscriber channels through put calculations have shown that by selecting the signal-code structures (parameter h_p^2) can be provided with value in the range of 5-6 Mbit/s, which corresponds, for example, the design parameters of satellites of the Inmarsat-5 [1, p. 1].

The total throughput of forward user channels is 4480 Mbit/s, which is at a specific speed of 100 kbit/s will let to connect 44.8 million subscribers to the network.

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