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RFI Prediction for QTT Restricted Area

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Abstract

The construction of Radio Quiet Zones (RQZ) is an important guarantee of the radio telescope. According to the local conditions, Qi Tai radio Telescope (QTT) established a protection area with a radius of 30 km, including core area, restricted area and coordination area. The paper focus on the potential RFI sources in the restricted area, such as the villages, mobile communication stations and 35 kV power supply engineering. A simulation method based on topographical radio wave propagation was established to predict the influence of the main interference sources on the QTT. Then we have proposed some mitigated plans for the villages affected observations, mobile communication stations and critical points of 35 kV power supply engineering. Therefore, RFI in restricted area effectively can be mitigated effectively.

1. Introduction

The ongoing building of Qi Tai radio Telescope (QTT) is located in the Shi He-zi ranch, Qi Tai county, Chang Ji prefecture, Xinjiang, China, where the longitude is 89°40'56".99, the latitude is 43°36'4".03, and the altitude are 1760 meter. The QTT working frequency will cover from 150 MHz to 115 GHz, and play important roles for the fundamental research of radio astronomy in the aspects of total power, polarization, spectrum and VLBI observations [1].

The establishment of Radio Quiet Zones (RQZ) is the first step to ensure the safety and high efficiency operation of radio telescope. Jodrell Bank sets the radio silence area radius to about 2 km, a quiet area of 34000 m^2 has been set up in the Green Bank, FAST has set up a quiet zone with a radius of 30 km [2]. QTT set up a radius of 30 km RQZ (Figure 1), and the protection measures were passed in August 2018 through Chang Ji prefecture legislation. The core area is a rectangular region of about 2.5 × 4 km^2, and the restricted area is about 10 × 15 km^2. Inside the restricted area, it is banned for the addition of mobile communication stations, broadcasting stations, televisions, radars, and other high-power transmitters.

Currently, the existing main interference sources in the restricted area include typical electronic equipment in the village (such as Cordless phone, Wi-Fi, and Microwave oven, etc.), mobile communication stations, and the 35 kV power supply engineering. In this paper, based on the topographical radio wave propagation, we will simulate and analyze the path loss of those main interference sources in the restricted area when they reach to the QTT feed aperture. We will obtain the interference level threshold of the main area by the combination of the feed aperture [3-4] and side lobe gain [5] of the QTT limits. We also provide the degree of the influence of the main sources of interference in the restricted area with a scientific and reasonable evaluation which will have an important guiding value for the removal of radio transmission equipment and relocation of local villages.

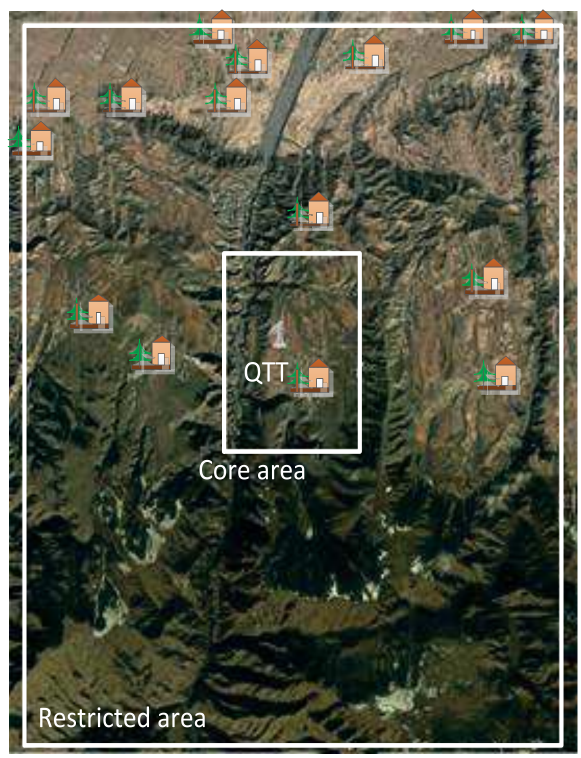


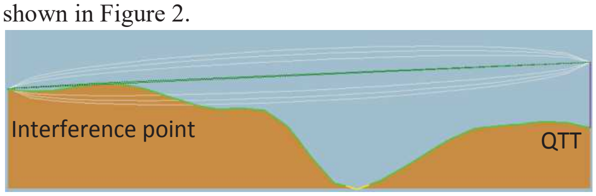
Figure 1. The QTT protected area (core area, restricted area).

2. Analysis of RFI effect

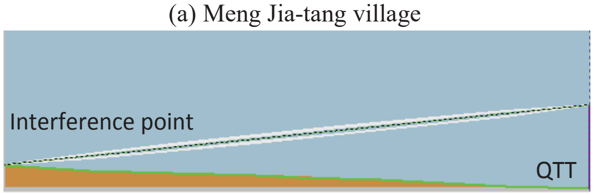
In this section, we will simulate and analyze the path loss of the main sources of interference in the restricted area when they reach to the QTT feed aperture, and Longley-Rice model [6] and Two-Ray model [7] were applied in this work. Where the Longley-Rice model will be used if a source is outside the QTT line of sight, otherwise the Two-Ray model will be used.

2.1 Electronic equipment in the village

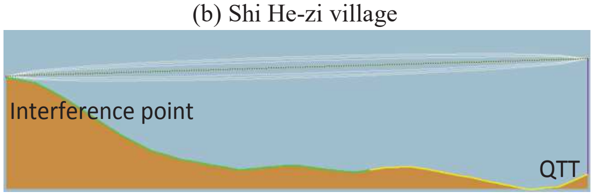
There are 15 villages in the restricted area of the QTT station, as shown in Figure1, involving more than 1500 herders and villagers. The distance between a village and the QTT center is shown in Table 1. Through simulated analysis, it is found that for the villages that obscured by a mountain the average path attenuation value is between 133-220 dB, whereas for other villages such as Meng Jia-tang, Shi He-zi and Pan po, the average path attenuation value is between 90-130 dB because of their close distance and/or high altitude. The simulation results are shown in Figure 2.



(a) Meng Jia-tang village



(b) Shi He-zi village



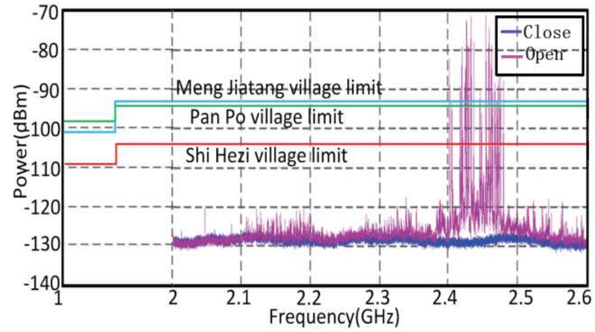
(c) Pan Po village

Figure 2. Simulated wave propagation from villages that within the field of vision of the QTT.

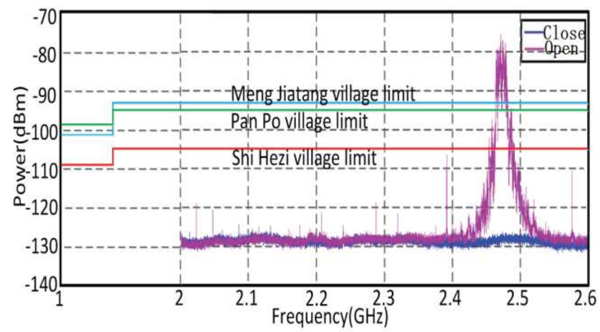
The village limit P_{AL} requirements are obtained according to formula (1):

$$P_{AL} = P_L + L - G(\emptyset) \quad (1)$$

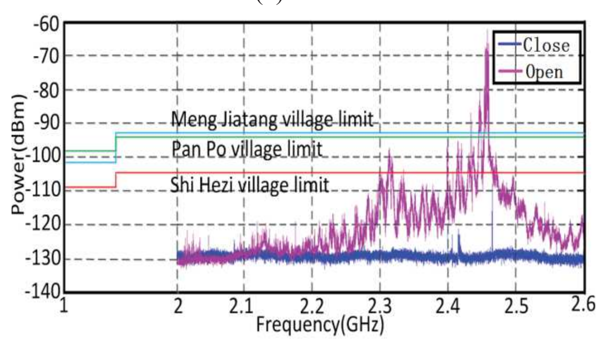
Where P_L is the limits of the telescope feed aperture, L is the path loss, $G(\emptyset)$ is the antenna side lobe gain. The electromagnetic radiation spectrum of the typical electronic equipment (Cordless phone, Wi-Fi, Microwave oven) in the village is compared with the limit of each village. It is found that the three villages mentioned above do not meet the limit requirements, while the remaining villages meet the QTT limit requirements (Figure 3). In consultation with the government, the villages that do not meet the limit requirements will be relocated to ensure a good electromagnetic environment at the QTT station.



(a) Cordless phone



(b) Wi-Fi



(c) Microwave oven

Figure 3. Comparison of electromagnetic radiation of the typical electronic equipment with the limit requirement of the three villages.

2.2 Mobile communication station

The high-power mobile communication stations can increase the noise floor and the out-of-band interference of the signal of the radio telescope. After on-site investigation of the QTT restricted area, 16 communication stations were found, including 12 large stations and 4 relay stations (Figure 4).

Figure 4 shows the distribution of mobile communication stations in the QTT restricted area. The average distance from large mobile communication station to QTT is 5-9km, and the signal transmitted by the mobile communication stations are obscured by the mountain, leading to the signal attenuation which can be in a level of

110 dB. However, due to the widely and sparsely local population, the transmission power is relatively high for the mobile communication stations. Generally, the transmission power of the 2G, 3G and 4G network is 60 W, 40 W, and 20 W, respectively. Currently, the mobile communication service in the QTT restricted area is mainly 2G. Through the simulated analysis of the radio wave propagation, it is found that the stations in the red circle in Figure 4 do not meet the QTT protection limit requirement.

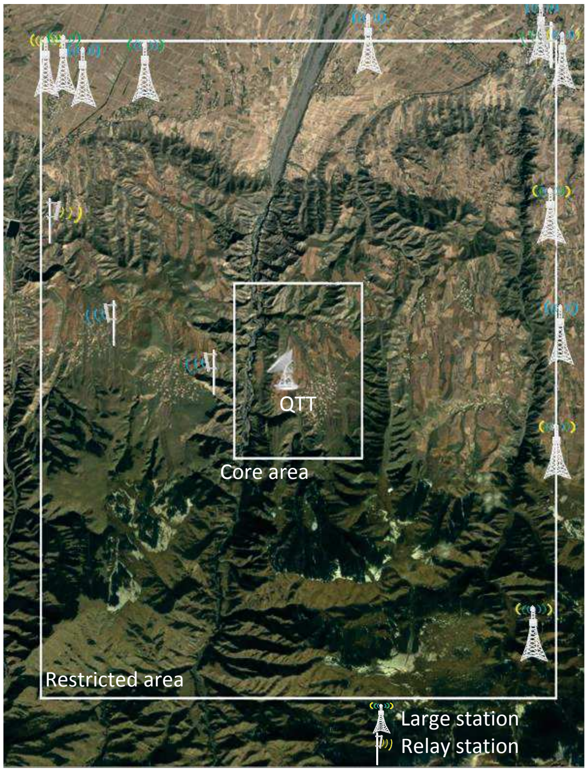


Figure 4. Distribution of mobile communication stations in QTT restricted area

This can be done by reducing the transmission power, offsetting sector direction, or dismantling to eliminate the influence of the mobile communication stations. After consultation with the government and the three major operators (China Mobile, China Telecom, China Unicom), there are a few specific steps to do:

(1) No adding any new electromagnetic transmitting equipment in the QTT restricted area.

(2) Evaluate the degree of the influence of the mobile communication stations by the combination of the statistics of the transmission power intensity in the restricted area and simulated analysis of radio wave propagation.

(3) For the lower degree of the influence mobile communication stations, reducing the transmission power and offsetting the sector direction.

(4) For the higher degree of the influence and mobile communication stations of the long distant, removing or reducing the height of the antenna tower, reducing the transmission power, offsetting the sector direction.

(5) For the higher degree of influence and mobile communication stations of the close distance, removing the antenna tower.

2.3 The 35 kV power supply engineering

The 35 kV Jiang Bu-la-ke high-voltage line (abbreviation: 35 kV line) is start from the agricultural 110 kV substation and terminate at the 35 kV substation in Jiang Bu-la-ke scenic area. The total length of the line is 34.87 km, and there is 16.89 km length of line entering the QTT restricted area.

Through simulated analysis, it is found that for the first half of the line, due to its low altitude, far distance from QTT, and obscure by the mountain, the interference signal caused by the potential difference is mostly eliminated by the path loss and the consumption of the mountain. However, for the latter half line, due to the high altitude, close distance, and partly obscured by the mountain, the path loss is small, and the contribution to the antenna side

Table1. Distance between village and QTT

village	Jian Quan-zi	Meng Jia-tang	Shi He-zi	Quan Gou	Xiao Shui-shan
d/km	3.903	2.272	0.66	3.695	3.923
village	Shang Bu-zi	Tang Fang-men	Lao Ge-gen	Pan Po	Huang Jia-gou
d/km	6.954	7.771	3.283	2.099	6.846
village	Gan Jia-tai	Sheng Jia-zhuang	Ying Pan-tan	Dong Wan	Ban Jie-gou
d/km	6.471	7.374	6.81	6.816	8.163

-lobe grain increased.

Therefore, by taking 22 turning points of the line as the reference point and through simulated analysis, we propose the following solutions:

(1) For some points that appear in the QTT field of view, by negotiate with the power company, using the method of re-selection to reduce the altitude, reducing the tower height and burying, to ensure that the line is not within the QTT field of view.

(2) For some points that partly obscured by the mountain, but the path loss is less than 130 dB, by negotiate with the design company, re-selecting a way to reduce the altitude or reduce the tower height, ensuring meet the limit requirement.

(3) For some points with high altitude, due to its large contribution to the antenna side lobe gain, considering away from the QTT as far as possible when building the tower, and making better use of the effect of the mountain.

(4) In consultation with the design company, the selection of the 35 kV new substation should be in a low altitude.

3. Conclusions

By the establishment of a terrain model, and simulated analysis of interference sources in the QTT restricted area, it is found that most of electronic equipment which inside the field view of the QTT, will have an influence for the high efficiency operation of the QTT, for other electronic equipment which outside the field view of the QTT, will still exceed the threshold line for the high efficiency operation of the QTT due to the incomplete obscure by the mountain. In response to the above problems, we shall further analyze the impact of RFI source in-side and off-site QTT, proposing more favorable mitigation methods, and coordinating and discussing with local government as well. So we still have a long way to do for mitigating RFI at QTT site.

4. Acknowledgements

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