Planning and Optimization of Ultra-short Wave Communication Network Resources in Sea-air Cooperative Operations

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I Introduction

Communication networking is the key of the whole communication network construction in communication support. Its networking resources include all kinds of land (Island) based fixed communication stations, marine mobile (ship) terminal stations, and all kinds of communication frequency, space and time resources. As an important means of communication in sea-air cooperative operations, ultra-short wave communication plays an important role in our army's joint operations. Because of the limitation of line-of-sight communication, it is easily affected by terrain in the process of cooperative operation. In order to better serve the maritime and air cooperative operations and achieve the military purpose, it is particularly important to plan the terminal station and relay station reasonably and make effective use of space, time and frequency resources.

The existing red and blue warring parties plan to carry out sea and air operations in zone Z. Red fighters from different airfields, maneuvering to the combat area. During the maneuver, the Red Fighter must navigate within the communication coverage of the communication stations as far as possible to ensure real-time access to the combat network.

II Ultra-short wave communication coverage model

A. Egli Model of Radio Wave Propagation

The maximum distance of Ultra-short wave communication is affected by many factors [3], including antenna transmitting power P_t (dBm), transmitting antenna gain G_t (dBi), attenuation factor of media μ, receiving antenna gain G_r (dBi), communication frequency f (MHz) and receiver sensitivity P_r (dBm), etc. The media attenuation factor μ is related to the media. In military communication, μ=0.9 is usually used in ground to air communication, and μ=0.95 is usually used in air-to-air communication. The maximum communication distance formula is

$$20\lg d(\mathrm{km}) = PT\,(\mathrm{dBm}) - PR\,(\mathrm{dBm}) + GR\,(\mathrm{dBi}) + GT\,(\mathrm{dBi}) + 20\lg \mu - 32.44 - 20\lg f\,(\mathrm{MHz})$$

II Ultra-short wave communication coverage model

B. Model of Ultra-short Wave Communication Coverage

As a way of line-of-sight communication, the model of ultra-short wave communication can be simplified: the included angle between radio waves and a certain elevation terrain is α_i and the range of the included angle ray extending along this direction is considered to be the communication blind area; under the condition that the altitude is h, when the ultrashort wave reaches the maximum transmission distance, the inclination is θ, where:

$$\sin\theta = \frac{h}{d_{\max}}$$

II Ultra-short wave communication coverage model

C. Model Solving

Implementation steps

①*Determine the target elevation;*

②*Determined the straight-line distance between the bottom of the antenna and the bottom of the target position (according to the difference of longitude and latitude or the difference of coordinates in the coordinate system);*

③*Determine the tangent value of α according to the above two distances;*

④*Compare the tangent value of α and θ to carry out secondary screening:*

D.Calculation results

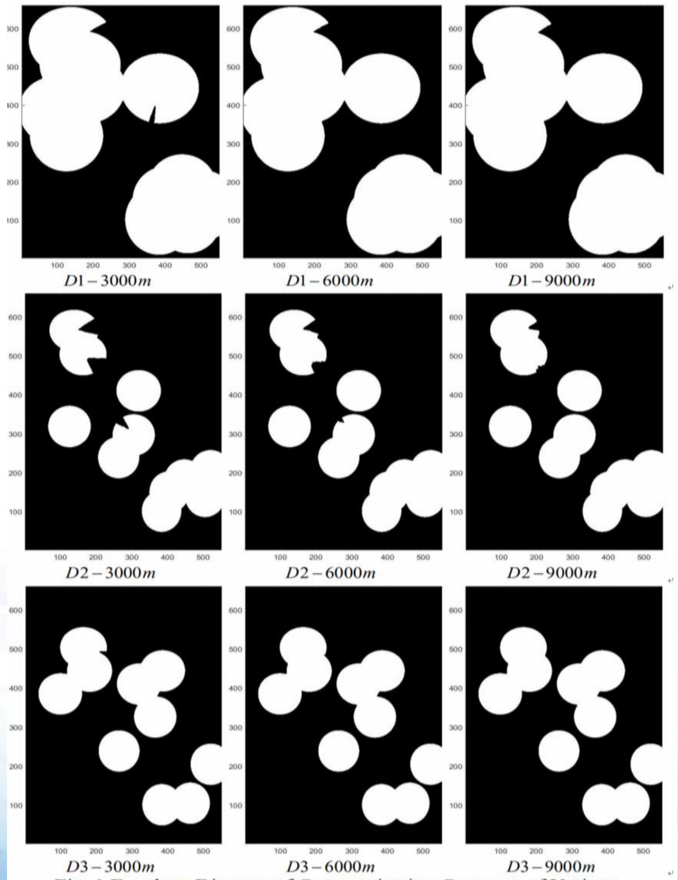


Fig. 1 Envelope Diagram of Communication Coverage of Various Communication Means at Different Altitudes

III Optimal route planning model

A. Area Model

The task area is built into a 661*621 grid model :

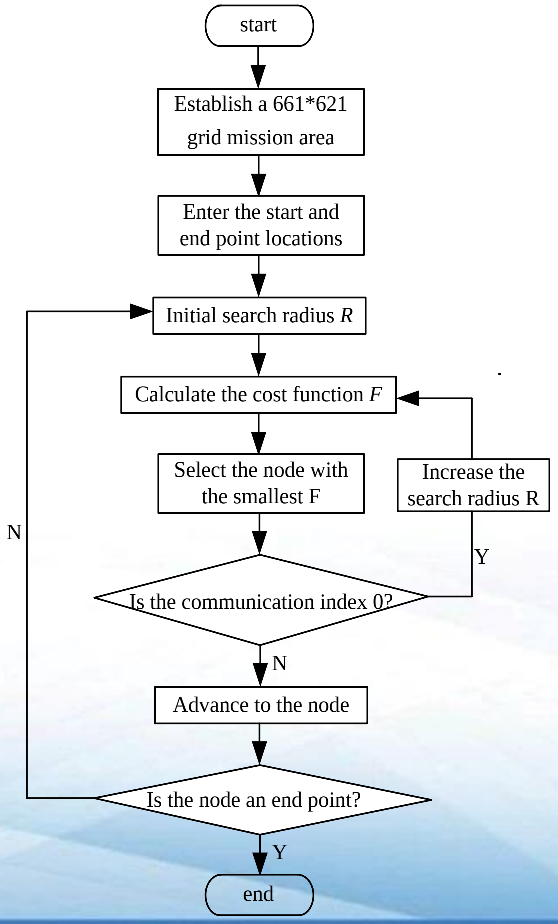
$$U=\begin{cases} V \\ <v_{i,j},v_{i\pm1,j\pm1}> \quad 1\le i\le 661, 1\le j\le 621 \\ N \end{cases}$$

B. Algorithm of Route Planning Model

Evaluation function:

$$\begin{cases} F(v_{i,j})=G(v_{i,j})+H(v_{i,j}) \\ n_{i,j} \end{cases}$$

C.Route planning flow chart



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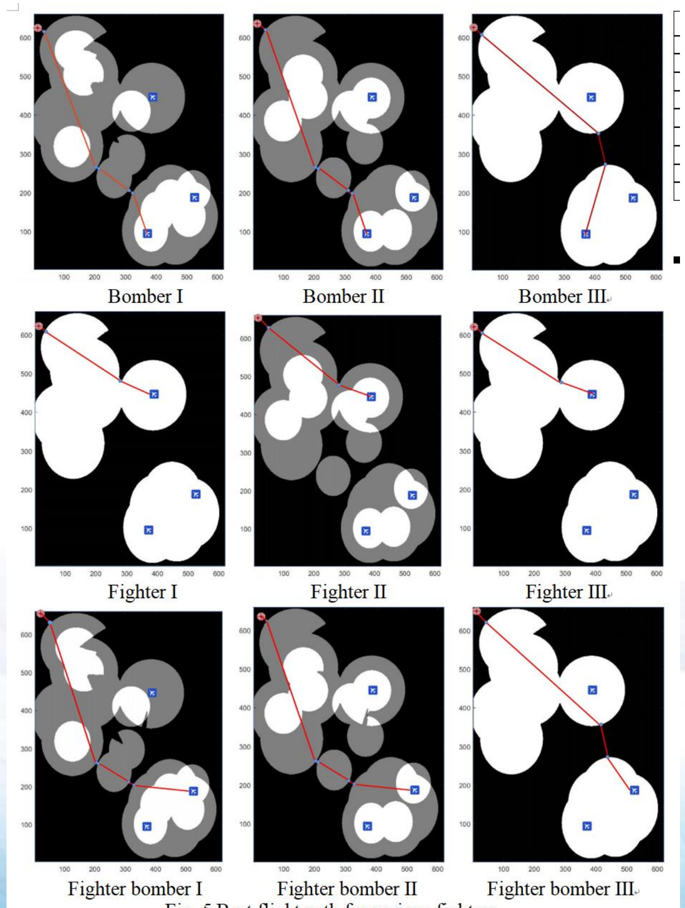

Fig. 5 Best flight path for various fighters

IV Conclusion

Ultra-short wave communication networking is playing an increasingly important role in sea-air cooperative operations. Reasonably planning and utilizing networking resources, setting up fixed stations and deploying relay stations can provide reliable communication guarantee for cooperative operations, which is of great military significance. According to the communication coverage and flight path model constructed in this paper, it can minimize the communication blind area and reduce the communication interruption time when planning the flight path of aircraft, so as to provide better quality and reliable communication guarantee. In the next step, further research can be carried out from the establishment of the optimal blinding strategy model of mobile equipment, which can provide a powerful reference for military decision-making.

V References

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Thanks!