Airport terminal area visualization decision system research

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ABSTRACT

Information communication ability is very important in the airport terminal area, especially for the commander, who needs to grasp and analyse a large number of data to make the accurate command decision in real time. Aiming at this problem, this paper introduces the visualization decision-making system of airport terminal area, which changes the input and output flow of a large number of data and graphs in the past evaluation system, and integrates a great deal of technical work such as organization planning, implementation and efficiency evaluation of air communication in the background. The visual graphical interface provides a convenient situation analysis and assistant decision-making tool for the commander. The system realizes the communication planning and coordination matching with the mission, the information identification and fusion corresponding to the flight dynamics, the analysis and application of the interference response, and the data analysis and evaluation of the post-mission summary support.

Keywords: Airport, visualization, spectrum, decision-making

1. INTRODUCTION

In order to improve the efficiency of information communication, it is necessary to combine the terminal area with the task requirements, for electromagnetic situation, mission, station deployment, flight path and other factors to accurately assess[1, 2]. For this reason, the commander needs to grasp and analyse a large amount of data to make an accurate command decision in real time. Therefore, by changing the input and output flow of a large number of data and graphs in the previous evaluation system, a great deal of technical work such as the planning, implementation and effectiveness evaluation of the air-to-air communication organization will be integrated in the background, with an intuitive graphical interface. It is an important research subject to provide commanders with convenient situation analysis and assistant decision-making tools[3-11]. The Terminal Area visualization decision-making system introduced in this paper can realize the communication planning and coordination matching with the flight task, the information identification and fusion corresponding with the flight dynamic, and the analysis and application of the interference response, data analysis and evaluation supported by post-mission summary.

2. STUDY OPTION

2.1 Radio wave propagation model

2.1.1 Prediction of Ground Diffraction Propagation Loss. The subpath is the propagation form when the ground invades the first Fresnel zone but not the least Fresnel zone under the condition of smooth ground, in which the propagation loss factor is obtained from the following formula:

$$\mathrm{A} = \left[1 - \frac{5h}{3R_1}\right] A_h \tag{1}$$

In the formula, R_1 is the first Fresnel radius, h is Path gap, A_h is diffraction loss factor on the horizon. The transmission loss factor of smooth ground is obtained by the following formula:

$$\mathrm{A} = \mathrm{F(x)} + \mathrm{G}(y_1) + \mathrm{G}(y_2) \tag{2}$$

In the formula, $\mathrm{F(x)}$ is the distance loss factor, which is obtained by the following formula:

$$\mathrm{F(x)} = 17.6\mathrm{x} + 10\mathrm{lgx} - 11 \tag{3}$$

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$G(y_1)$ and $G(y_2)$ is the height loss factor of the transmitting antenna or receiving antenna, which is obtained by the following formula:

$$G(y) = \begin{cases} 8 + 5\lg(y-1.1) - 17.6(y-1.1)^{\frac{1}{2}} & (y > 2) \\ -20\lg(y + 0.1y^3) & (10 \propto < y \le 2) \\ 9\left(1 - lg\frac{\propto}{y}\right) lg\frac{\propto}{y} - 20lg \propto -2 & (\frac{\propto}{10} y \le 10 \propto) \\ -20lg \propto -2 & (y \le \frac{\propto}{10}) \end{cases} \quad (4)$$

x is the normalized path length between the transmitting antenna and the receiving antenna taking into account the parameters of the ground type, which is obtained by the following formula:

$$x = 6.37 \cdot 10^{-3} \beta k^{-\frac{2}{3}} f^{\frac{1}{3}} d \quad (5)$$

k is the equivalent earth radius coefficient, y is the normalized height of the transmitting or receiving antenna, which is obtained by the following formula:

$$y = 5.16 \cdot 10^{-4} \beta k^{-\frac{1}{3}} f^{\frac{2}{3}} h \quad (6)$$

h is the height of the transmitting antenna or the receiving antenna, $\propto$ and β is the normalized surface admittance factor, and the intensity of the tropospheric scattering propagation of the receiving field are obtained by the following formula:

$$E = 74.8 + P_t + G_t + 20lgf - L \quad (7)$$

In the formula, E is field strength, P_t is transmit power, G_t is transmit antenna gain, f is operating frequency, the annual tropospheric scattering transmission loss with probability greater than 50% in time no more than p% is obtained by the following formula:

$$L(p) = M + 30lgf + 10lgd + 30lg\theta + 20\lg(5 + 7.5 + 10^{-2}\gamma\theta d)$$
$$+5.43 \cdot 10^{-7} \gamma \theta^2 k\alpha + 0.07\exp[0.055(G_t + G_r)] - G_t - G_r + E(p)F(c) \quad (8)$$

In the formula, k is the equivalent earth radius, θ is the minimum scattering angle, the angle between the antenna beam and the horizon, which is obtained from the following formula:

$$\theta = \frac{7.85 \cdot 10^{-5}(2d - d_t - d_r)}{k} + \frac{(h_1 - h_t) \cdot 10^{-3}}{d_t} + \frac{(h_2 - h_r) \cdot 10^{-3}}{d_r} \quad (9)$$

E(p) represents a function of the log-normal distribution, which slope is p, M andγ are the meteorological factors and atmospheric structure parameters in the climatic region where the link is located, F(c) is the transmission loss difference between 50% and 90% time probability, h_1 and h_2 is the elevation of the line-of-sight point of the transmitting and receiving antenna, d_t and d_r is the ground distance from the receiving station to the line-of-sight point.

2.1.2 The Basic Transmission Loss for Aviation and Satellite Services in the Frequency Range of 125 MHz to 15.5 GHz. It provides a step-by-step method to calculate the basic transmission loss. The only data required for this method are the distance between the antennas, the antenna height above mean sea level, the frequency and the percentage of time.

The geometric parameter associated with each terminal is calculated with following these steps. The actual height of the terminal above mean sea level $h_{r1,2}$ is given, then arc length from the smooth horizon $d_{1,2}$; the angle of incidence of a ray from a terminal point into the smooth horizon $\theta_{1,2}$; adjusted terminal height above mean sea level $h_{1,2}$; terminal altitude correction $\Delta h_{1,2}$; the maximum line of sight between the two terminals $d_{ML} = d_1 + d_2$ can be calculated.

The linear modelling of smooth earth diffraction can be done by selecting two distances that are much larger than d_{ML}, calculating the smooth earth diffraction loss at these distances, and constructing a smooth earth diffraction line through these two points.

The path d whether within the line of sight or beyond the line of sight can be determined. If $d < d_{ML}$, the path is within the line of sight, else the path is within beyond the line of sight.

Beyond the line of sight, with the distance increasing, the propagation path will transition from smooth earth diffraction to tropospheric scattering. The following iterative process ensures that the transition between the two models is uninterrupted. The free space loss of the path A_{fs} can be obtained from the following formula:

$$r_{1,2} = [h_{r1,2}^2 + 4(a_0 + h_{r1,2}) \cdot a_0 sin^2(\frac{0.5d_{1,2}}{a_0})]^{0.5} \quad (10)$$

$$r_{fs} = r_1 + r_2 + d_s \quad (11)$$

$$A_{fs} = -32.45 - 20log_{10}f - 20log_{10}r_{fs} \quad (12)$$

The atmospheric absorption loss of beyond the line of sight path A_a can be calculated, given terminal height $h_{1,2}$; terminal horizontal distance$d_{1,2}$; take-off angle in radians of grazing rays near the terminal $\theta_{1,2}$; frequency f; the height of the community h_v; cross angle θ_A; half of the scattering distance d_z.

The long-term variable loss Y(q) can be calculated, given actual terminal height $h_{r1,2}$; the distance of the path of interest d; frequency f; time percentage q.

The basic transmission loss A can be obtained from the following formula:

$$A = A_{fs} + A_a + A_T + Y(q) \quad (13)$$

2.2 The visual decision system of airport terminal area

The data and information related to the anti-jamming of airport terminal area communication are studied, and the visual and Intelligent Communication Command assistant decision-making platform is designed. The electromagnetic spectrum planning and interference information are analyzed, the spectrum overlap, the Spectral density and the dry pass ratio are calculated, and the visualization of the spectrum and the communication range of the communication signal and the interference signal is realized.

3. SYSTEM COMPOSITION AND EACH MODULE FUNCTION

3.1 System composition

The visual decision system mainly includes: spectrum plan management, communication deployment planning, deployment efficiency evaluation, visual frequency analysis and system management etc.

The airport terminal area visualization decision system is shown as Figure 1.

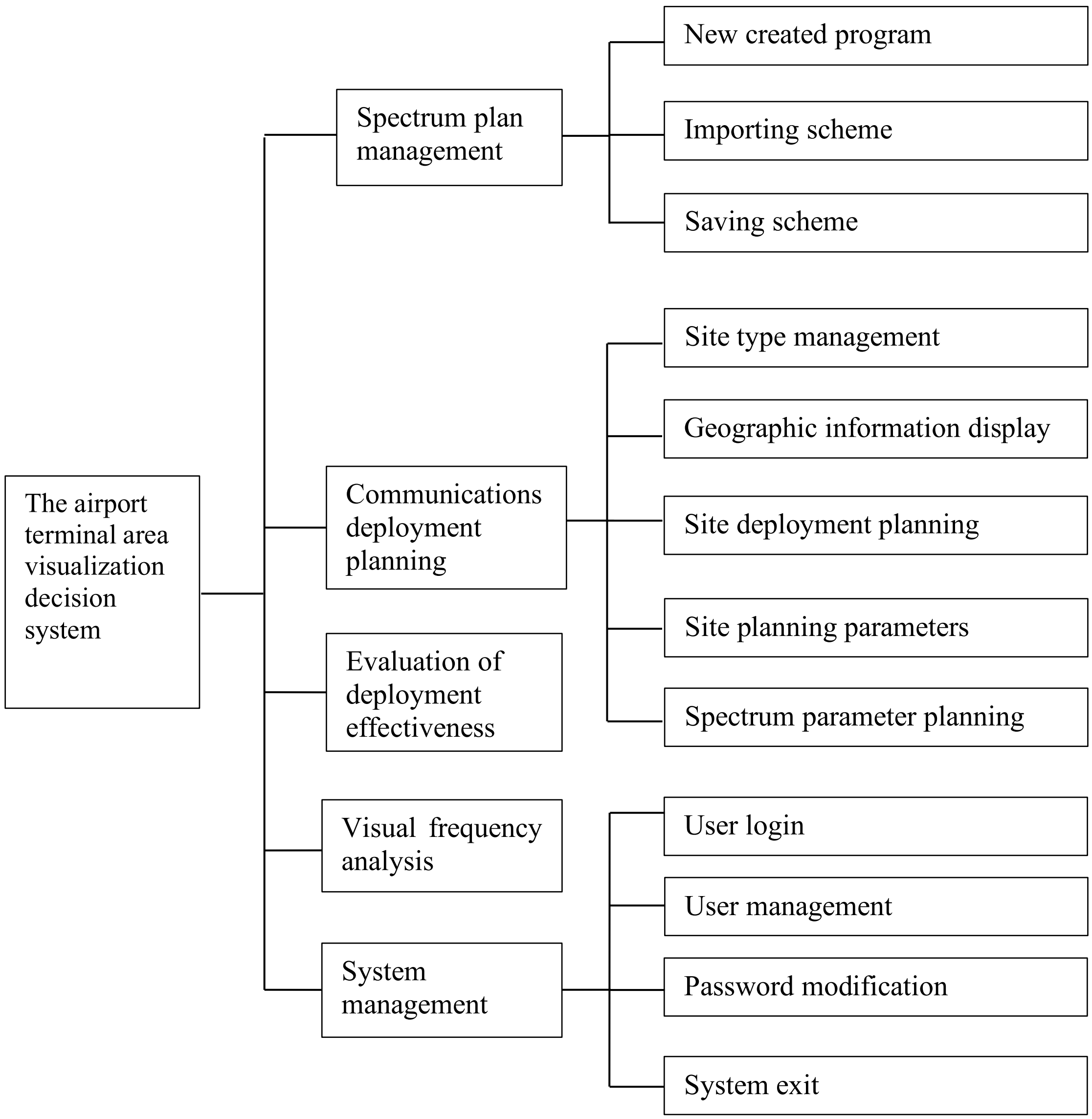

Figure 1. The airport terminal area visualization decision system components.

3.2 Each module function

The function of spectrum plan management includes: site information, channel information, frequency hopping table information, disabled band information and so on. The file is stored in MD5 encryption mode.

The function of new created program can create a blank program document that stores data related to user decision analysis using the software, including site information, channel information, frequency hopping table information, disabled frequency information, interference frequency information and so on.

The function of importing scheme can import the decision-aid analysis data saved by the user into the system by the plotting software, which is convenient for the user to do the electronic defense analysis.

The function of saving scheme can save the edited solution information to the solution file.

The site type management system built-in site types include: communications stations, navigation stations, monitoring stations, weather radar; and the default site type icons are defined, respectively. Users can add or remove site types and customize site icons for use in the site deployment planning module.

The geographic information display provides visual display based on Google satellite map, the map can be scaled up, scaled down, moved and other operations.

The function of site deployment planning can construct an airport terminal area within a panoramic element model. Depending on the task, the user may construct an element model based on a preliminary scenario of the airport terminal area, mainly including the ground station, the air platform, the jamming platform model and so on. The ground station model mainly refers to the air-to-air communication stations set up within the regional support scope, including the ultra-short wave air-to-air communication stations and the data link. According to the transmission characteristics of ultra-short wave line-of-sight communication, the station's geographical position (latitude and longitude) is input, considering the influence of Earth curvature radius, antenna, altitude and flight altitude, including the gain of Directional Antenna, the communication support space range of each station can be calculated under different conditions. The aerial model can show the electromagnetic environment according to its position and altitude. According to the height and position of the jamming platform, the range of jamming is calculated by electromagnetic calculation and dry pass ratio equation. After the site is deployed, the user can move the site anywhere by dragging.

The site planning parameters: after users click on the site icon deployed on the map, site parameters can be configured, including site name, site longitude, site latitude, and number of stations, antenna height and other parameter information.

The spectrum parameter planning includes channel planning, frequency hopping table planning, disable frequency planning, and interference frequency planning.

The function of evaluation of deployment effectiveness is as follows. In the process of communication planning and organizing, according to the flight route and altitude, through each station model, calculating the maximum guaranteed link rate that can be reached by the existing deployment (under the condition of no external interference, the line-of-sight communication is affected by factors such as geographical altitude, low-altitude flight and so on, and the maximum link rate) , and predicting the maximum interference intensity, the minimum guaranteed link rate is calculated, and the maximum and minimum link rate is a prerequisite for communication planning and organization. At the same time, the model can also be used to simulate the electromagnetic environment of the terminal area of the airport.

The visual frequency analysis is used to visualize the frequency used by each channel, to distinguish the color of each channel spectrum; there are five color chart and comb display mode, according to the need to switch. The spectrum mainly includes our communication spectrum and interference spectrum. Through the calculation of fusion degree, Spectral density and so on, combined with regional model and anti-jamming tactics, we select pre-used channel for ground station and air plane, and frequency aided decision-making for air-to-air multi-element complex network.

The system management includes: user login, user management, password modification, and system exit.

4. APPLICATION EXAMPLE

Using the visual decision system introduced in this paper as an example, a large amount of technical work, such as the planning, implementation and effectiveness evaluation of Air Communication Organization, is integrated in the background according to an airport drill, with an intuitive graphical interface, the convenient situation analysis and assistant decision-making tools are provided to the commander, which realizes the communication planning and coordination of the flight task matching, the information identification and fusion corresponding to the flight dynamics, and the analysis and application of the interference response, data analysis and evaluation supported by post-mission summary.

5. CONCLUSION

Information communication ability is very important in the airport terminal area. This paper introduces a visualization decision-making system of airport terminal area, which is provided to the commander. This system provides a visualization graphical interface through accurately evaluating the electromagnetic situation, flight mission, station deployment, flight route and other elements, based on combining the electromagnetic situation of airport terminal area with the mission requirements. This visualization decision-making system is efficient and reliable through application example. At the same time, the research method of this paper can also be used for reference in the research of related visualization fields.

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