Design of Relay Communication System Based on Aerial Platform

Li Yong-Zhi and Liu Ting

***Abstract*—A Relay Communication System Based on Aerial Platform was designed in the paper. Main technique indexes as communication distance, link electricity level margin of system were demonstrated combining with system task requirements. The system functions and constitutes were also analyzed. The validity and correctness of designed were validated in development and test of relative communication systems.**

***Index Terms*—Aerial platform, relay, communication system**

I. Introduction

Increase communication distance, improve reliability of communication system and maneuver flexibly beyond topographical constraints are always importance topics in the communication field. In variety of distance and non-line-communication applications, aerial platform relay communication is always the ideal means to extend wireless communication distance in complex terrains as oceans, mountains and deserts. In recent years, with mature of typical aerial platform technologies as unmanned vehicles, tethered balloons and airships and others, combining with characteristics of aerial platform that low cost-effective, easy to deploy and control, flexible communication networking as communication relay node, the communication relay based on aerial platform has been used widely. The paper designed a relay communication system based on aerial platform and analyzed its functional components as well as some technical indexes. The paper is organized as follows: section 2 introduces advantages of aerial platform relay communication; section 3 gives system constitutes; section 4 analyzes system application prospects; section 5 performs system design and section 6 concludes our work.

II. Advantages of Aerial Platform Relay Communication

Currently, main over-the-horizon communication means mainly include HF communication and satellite communication. Compared with these communication approaches, relay communication with aerial platform has many advantages as follows. Firstly, it can work in all-weather and large cross-domain, especially suitable for providing emergency communication support for public unexpected emergencies. Secondly, it has wide service objects, which can flexibly equipped with various communication resources to provide variety communication means for rapid and effective command and collaboration for emergencies. Thirdly, it has high mobility and easy to be allocated. The system can be arranged on land or in ocean area. Fourthly, it uses FM communication as main over-the-horizon communication means, which has higher reliability than HF communication and less subject to seasonal and diurnal variation, so it has more stable communication quality. Fifthly, it uses FM communication with less antenna size and simple structure, higher gain, so it can equipped with low power transmitter. Sixthly, the HF has higher frequency and wider band, so it can be used for multi-channel communications.

III. System Function Constitutes

The system can be sued from relay communication in complex terrain environment as ocean, mountain and desert to complete over-the-horizon voice, data and video communication, so as to ensure communication among ships in large region and maneuver nodes in mountains or deserts. The mobile nodes within line of sight can directly communicate, while that beyond line of sight can only achieve communication depend on aerial relay communication system. The system can complete relay communication of land node within 100km.

The communication relay system based on aerial platform mainly includes aerial data terminal, shipboard data terminal and ground data terminal, the component of which is shown in Fig. 1.

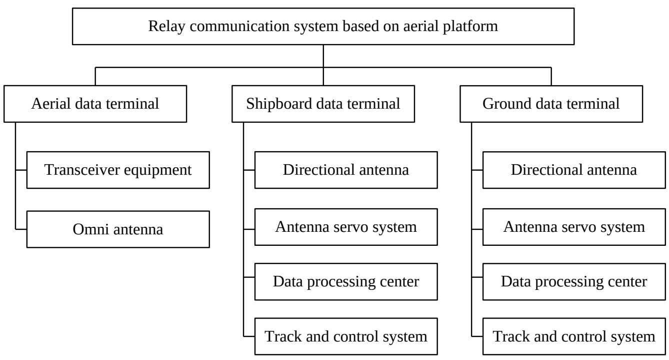

Fig. 1. Relay communication system constitutes.

The aerial data terminal is made up of transceiver equipment and omni-antenna. The transceiver equipment includes frequency changing combination, RF front end, amplify, encoder-decoder, data multiplexer unit. Shipboard data terminal consists of directional antenna, data processing center, antenna servo system and track control equipment, mainly including channel group, terminal group, servo control, power group and directional antennas. The

Manuscript received March 16, 2012; revised May 11, 2012.
The authors are with Unit 91404 of PLA, Qinhuangdao, China (e-mail: yongzhili@163.com).

shipboard terminal was placed in unobstructed operation area, which can be unattended after booting. Constitutes of ground data terminal is same as that of shipboard data terminal.

IV. SYSTEM DESIGN

A. Aerial Data Equipment Design

Aerial data equipment mainly completes data forwarding, the equipment of which is transceiver. It mainly includes omni-antenna, duplexer, power amplifier, encoder, decoder, data multiplexer unit, upconverter, downconverter, modulator, power and other parts. The diagram is shown in Fig. 2. The RF signal from ground station after low-noise amplifier, down conversion, demodulation decoding, will be inputted into data multiplexer unit for processing. Then it will be inputted into encoder, modulator, upconverter and transmitted to other stations with omni-antenna after power amplifier. After omni-antenna received RF signal from multiple ground stations, the signal is selective output from multiplexer. Then it is outputted to each shipboard station after multi-channel low-noise amplifier, down conversion, demodulation and decoding. Data from each shipboard was framing by data multiplexer, then set to upconverter and sent to each ground station after power amplifier. The receiver is set with multiple channels to effectively reduce frequency combination interference.

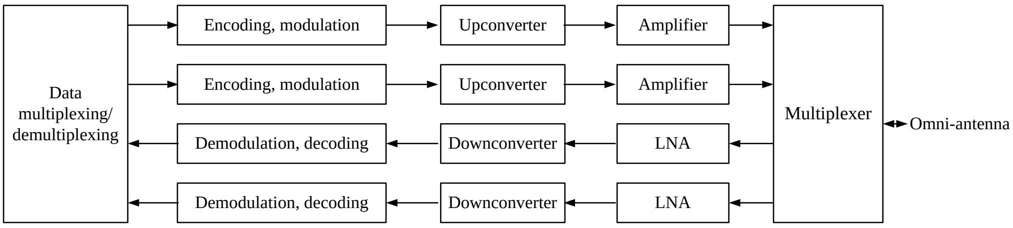

Fig. 2. Constitutes of aerial equipment.

Shipboard station/ground station data terminal equipment is source and destination of data. It mainly completes data receiving and transmitting. Its composition includes directional antenna, duplexer, power amplifier, terminal processor, combination of upper frequency and lower frequency, transmitter, receiver, servo and other equipments. After data from shipboard station was encrypted, it was sent to terminal processor, transmitter, upconverter, and then sent to aerial station with directional antenna after power amplifier. The directional antenna received RF signal from aerial station, it was sent to frequency combination of receiver. The IF signals are divided into two sections. One section is inputted to track receiver to be demodulated error voltage before servo unit, so as to achieve automatic tracking. Another section is sent to ground processing terminal to complete demodulation and decoding of data. The shipboard station determines data in the manner of address code matching. It sends local data to shipboard data processing center from network interface or synchronous interface and other data were discarded.

B. Working Distance Index Demonstration

The working distance of microwave communication is restricted by radio line-of-sight and link level. Radio line-of-sight is the maximum distance to keep barrier-free communication between two antennas, which is relative to many factors as earth curvature, atmospheric refraction, ground reflection, climate, topography and others.

The line-of-sight formula only considering earth curvature is:

$$d_0 = 3.57(\sqrt{h_1} + \sqrt{h_2}) \tag{1}$$

where h_1 and h_2 are height of antennas in two ends in *m*; d_0 is line-of-sight in *km*.

If atmospheric refraction is considered, the line-of-sight formula is:

$$d_0 = 4.12(\sqrt{h_1} + \sqrt{h_2}) \tag{2}$$

The line-of-sight distance with different computation method is shown in Table 1.

TABLE 1: LINE-OF-SIGHT DISTANCE WITH DIFFERENT METHODS.

Height/*m*	Distance/*km*		
	Considering atmospheric refraction and elevation is 0°	Only considering earth curvature and elevation is 0°	Considering atmospheric refraction and elevation is 0.5°
1000	130	112	62
1500	159	137	91

From the above analysis we can see that the working distance computed by 0.5° elevation is relatively conservative. But it indicates that if the system want to ensure 100*km* working distance, the height of aerial platform should be rose to 1500*km* height.

C. Link Level Margin Estimation

Link fading margin is related to transmission speed, working distance, antenna gain and transmitter power. Table 2 shows link fading margin corresponding to different transmission rate in the 100*km* working distance.

From the computation result we can know that if the aerial antenna is omni-antenna and ground/shipboard is directional antenna, transmitter power from aerial power amplifier 10w, the working distance between ground station and shipboard is up to 100*km*.

D. Environment Adaptation Design

The aerial platform is vulnerable to sudden flow in hovering, resulting in instable channel quality, poor communication and even interrupts. To address the problem, the system mainly takes the following measures to improve environment adaptability. One is to add antenna platform servo system and adjust antenna according to attitude automatically, so as to ensure optimal direction of antenna beam will not deviate. The second is to add communication margin, namely to added some level remaining to compensate communication signal lass cased by shifting of level remaining. The thirds is to solve signal fading in receiver environment with e anti-fading synchronization and error correction measures

TABLE 2: LINK FADING MARGIN CORRESPONDING TO DIFFERENT TRANSMISSION RATE.

	Computation result			
Transmission bit rate (kbps)	256	512	1024	2Mbps
Transmission error rate	$\leq 10^{-5}$	$\leq 10^{-5}$	$\leq 10^{-5}$	$\leq 10^{-5}$
Distance (km)	100	100	100	100
Transmitter power (dBm)	40	40	40	40
Total loss in transmitter (dB)	-1.5	-1.5	-1.5	-1.5
Aerial antenna gain (dB)	0	0	0	0
Free space loss (dB)	-137.0	-137.0	-137.0	-137.0
Shipboard antenna gain (dB)	17	17	17	17
Total loss in receiver (dB)	-1	-1	-1	-1
Receive signal level (dBm)	-82.5	-82.5	-82.5	-82.5
Receiver sensitivity (dBm)	-117	-114	-111	-98
Fading margin (dB)	34.5	31.5	28.5	15.5

V. APPLICATION PROSPECTS

For characteristics as low cost, easy to arrange and flexible communication resources, the communication system based on aerial platform has wide application fed. It is firstly supplement of sight. In current stage, as the line-of-sight communication is restricted to terrain conditions, its communication scope is very limited. The communication relay platform by aerial platform equipped with VHF communication devices and encryption devices can greatly improve communication distance, enhance remote command capability. It can be used to complement of distance conventional communication manners to ensure communication service quality and improve command efficiency.

Secondly, distance monitoring and online command applications. Aerial platform can also be equipped with radio communications base stations, infrared imaging devices and other equipments to serve as floating base station to quickly provided wide range of mobile communications. At the same time, the loaded infrared imager can monitor sensitive area and send collected image information to relative post for analysis, so as to provide important intelligent support for task decision-making and implementation of disposal options.

Thirdly, it has wide application prospects as emergency communication means. Public emergency events as forest fire, emergency relief and other are frequent, the uncertainty of public emergency events on communication time, place, communication capacity, network forms and etc proposed on higher needs of site communication means and service forms. In the emergency conditions as 5.12 earthquake and others, the communication device loaded on platform serves as floating base station and floating communication relay platform to provide communication for emergent events.

VI. CONCLUSION

The paper focused on functional constitutes, part of technical and tactical indexes of relay communication system based on aerial platform and proposed a practical system solution. In the development and test of relative system, the design correctness is verified, which can act as reference for similar aerial relay communication.

REFERENCES

[1] L.-Q. Liu and F. Han, "Design of an Aerial Platform Relay Communication System," *Computer and Network*, 2008, vol. 16, pp. 37-39.

[2] W.-B. Luo and Y.-S. Wang, "Beyond visual range multi-link relay of unmanned platform," *Journal of Telemetry, Tracking and Command*, vol. 3, 2003, pp. 32-35.

[3] T. Zhang, J.-W. Huang, and H. Han, "Aerostat communication relay system," *Science and Technology Consulting Herald*, vol. 25, 2010, pp. 16.

[4] Z.-Y. Chen and C. Wang, "Air-land Relay Communication System and Its Application in Mountain Area," *Communications Technology*, vol. 6, 2001, pp. 91-93.

[5] W. Yang, "A communication system application based on floating platform," *Communication & Information Technology*, vol. 4, 2010, pp. 72-74.