The Design and Implementation of General Aviation Surveillance System Based on Beidou

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***Abstract* — The surveillance and communication system based on BDS is compatible with both BDS short-message communication and 1090ES data link communication in parallel. This maximum synergy is achieving seamless surveillance and communication coverage airspace in China. The system consists of portable navigation, surveillance, communication airborne equipment and BDS ground command centre. System uses BeiDou/GPS dual-mode GNSS to obtain key navigation information and transmits aircraft ICAO ID, call-sign, latitude, longitude, speed, heading, etc. on 1090ES channel and BDS short message channel to the ground ADS-B station and BDS command centre. Simultaneously, the aircraft airborne equipment with two-way communications capability can receive information from the BDS ground command centre.**

Keywords - GNSS; ADS-B; BDS; surveillance; communication

I. INTRODUCTION

As a replacement technology of SSR, the Automatic Dependent Surveillance–Broadcast (ADS-B) is a recommended advanced surveillance technology in the Next Generation Air Transportation System by ICAO. With ADS-B, aircrafts use transmitters to automatically broadcast their GNSS position information, including but not limited to latitude, longitude, pressure altitude, speed, heading and 24bits identification and so on.

The core technology of ADS-B system is GNSS and data communication link. Throughout the world, the majority ADS-B system uses GPS signal as GNSS navigation signal source. Once the failure of GPS, the ADS-B system can't work normally, aviation surveillance system will lose its role. So there are some ADS-B manufacturers design the ADS-B system based on GPS and Glonass system, and Glonass is arranged as a backup navigation signal source.

The Chinese BeiDou Navigation Satellite System (BDS) has been independently developed and established, which is similar in principle to global positioning system (GPS) and compatible with other global satellite navigation systems (GNSS). The BDS will provide highly reliable and precise positioning, navigation, and timing services, as well as the unique short-message communication for all type of users under all-weather, all-time. Now, BDS provides the full services in whole China and the most of Asia–Pacific area, and it is estimated to be operational with global coverage at the latest in 2020 [1, 2].

Although ADS-B is an advanced technology but there is still some defect limiting it developing and popularization in China general aviation (GA), such as the airborne equipment with TSOA is expensive and a ground station only can serve 200NM airspace distance to the station. It needs to increase investment on ground facilities construction.

II. THE SITUATION & REQUIREMENTS OF CHINA GA

Before describing the surveillance system in the next section it is important to understand the requirements of China GA such a system has to meet.

In 2012, the first time China GA industry was listed in the national strategic emerging industries, GA industry went into the explosive development stage, the number of GA aircraft from December 2012 of 1342 grew to March 2015 1894.

Meanwhile, GA flight safety issues emerged. According to statistics, in recent years, GA accident and incident rate was three times the transport aviation. Analysis the main reason: China's GA fleet composed of complex type, simple aircraft instrument, the vast majority is not equipped with advanced airborne surveillance equipment; Due to GA operation feature of flexible airspace and working time, most of the GA flight is lacking ATM server.

There are a wide variety of GA aircrafts, but the same type of small number. Due to the high cost of TSO and TC authorization, there are few avionic airborne equipment manufacturers would like to invest a lot of money and effort to apply TSO and TC authorization for a single type with low market share.

To promote GA operational safety standards, the low cost and easily deployed surveillance and ATM system should be researched and developed for China GA. This system does not only require the airborne surveillance equipment has the advantages of flexible installation, easy to use, low cost, but also require ground infrastructure can serve wider coverage and service airspace with minimizing the cost of ground facilities construction.

III. THE SCHEME OF SURVEILLANCE SYSTEM BASED ON BDS

A. The System Structure

The core technologies of ADS-B system is GNSS and data communication link. Throughout the world, most ADS-B system uses GPS signal source as GNSS navigation signal source. Once the failure of GPS, the ADS-B system can't work normally, then aviation surveillance system will lose its role [3]. So there are some ADS-B corporations design the ADS-B system based GPS and Glonass system, and Glonass is arranged as a backup navigation signal source.

The CAAC intends to implement rulemaking that by the 13th Five Years, all aircrafts must be equipped with ADS-B airborne devices to operate, so design and development of the new ADS-B system products have been highly concerned by Chinese avionics industry. In recent years, China has also increased investment on researching and developing, demonstration and application ADS-B system.

At present, the Chinese BDS has built a regional satellite navigation system covering the Asian region, so BDS has meet the requirement of ADS-B GNSS system. It can provide technical basis for the application of BDS navigation in aviation field in Asian region. In this system, the BDS is selected as mainly GNSS, while GPS is a backup.

The GA surveillance and communication system based on BDS is composed of airborne device, ground command center, and data fusion server. The Fig.1 illustrates the basic system architecture.

The surveillance systems based on BDS mainly collects aircraft position (latitude, longitude, and barometric altitude), velocity, heading, ICAO ID address and other parameters, and airborne device broadcasts these parameters on 1090ES data link and sends these parameters to the ground BDS command centre through BDS short message communication synchronously. The ADS-B ground station and the BDS ground command centre can receive, process, display these message independently, and the data fusion server also can get and fusion data from two station with internet. So the GA ATM staffs can access the data fusion server to surveillance aircrafts on internet with PC, ipad, intelligent mobile and son on.

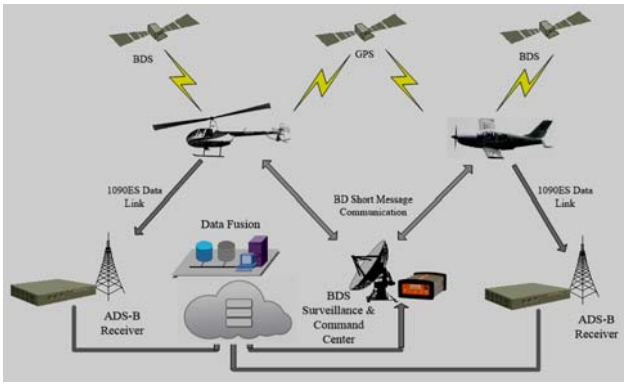

Figure1. The principle diagram of system

Thanks for bidirectional communications of BDS, the information and instruction from the BDS Ground Command Centre can transmit information to airborne equipment, so the GA pilots can communication with ground command centre.

B. Portable Airborne Equipment Design

Due to lack of standards and existing ADS-B airborne transmitter, the majority general aircrafts need to be modified achieving ADS-B function to improve safety. The standard aircrafts modification is complicated and expensive, so the portable airborne device is a good choice for GA aircraft owner.

R&D team references RTCA and ARINC technical standards, as well as ICAO and CAAC regulations, requirements to design portable surveillance airborne equipment. The GA airborne surveillance device, integrated with navigation and communication function, to improve GNSS integrity and high accuracy[4], the device selects the BDS and GPS dual-GNSS module as GNSS position provider[5][6]. The airborne equipment is compose of the GPS/BDS (integrated with RNSS and RDSS) satellite navigation module, the message encoding module, information processing module, RF module, the BDS communication module and power module of six parts, the composition structure shown in Fig.2.

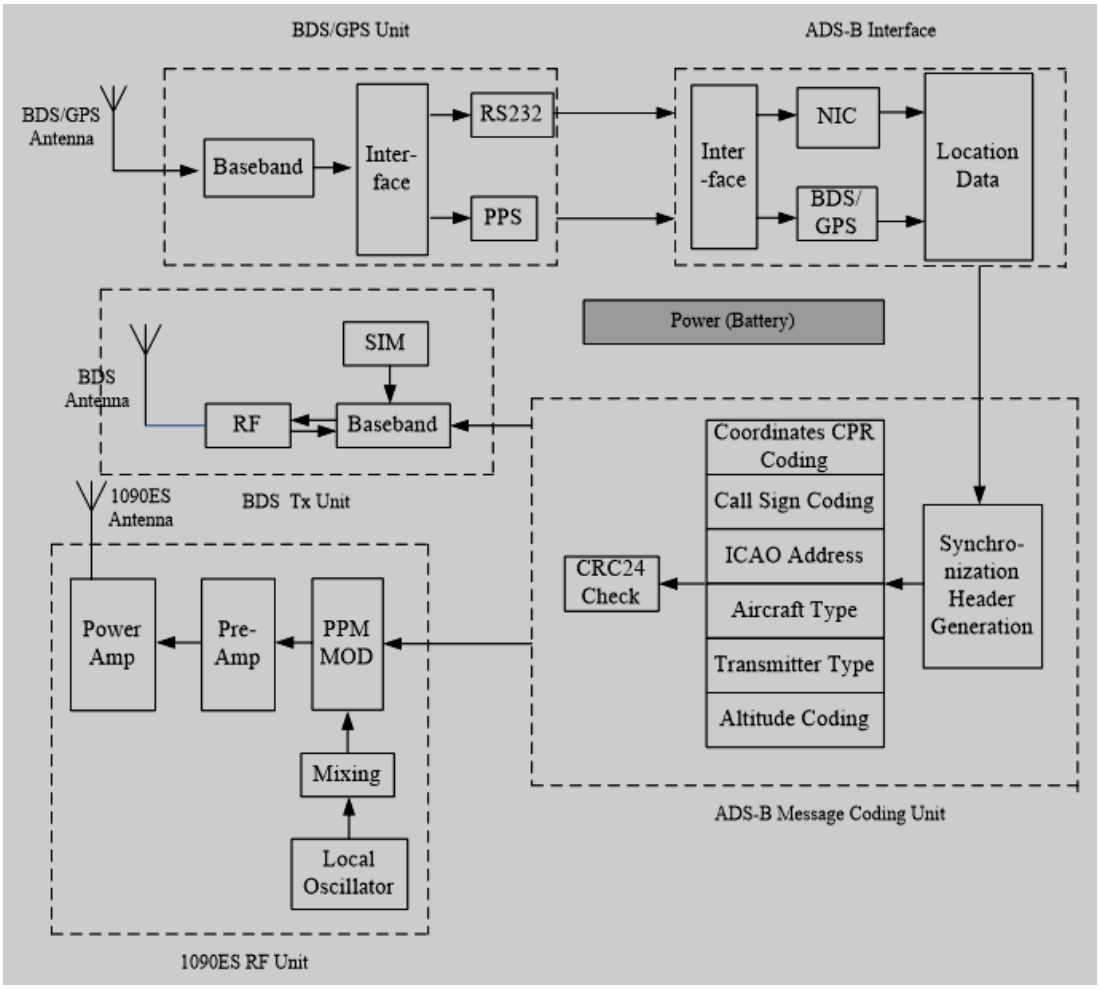

Figure 2. The principle of airborne device

C. BDS Ground Command Center Design

BDS ground surveillance and command centre is composed of the BDS commanding receiver, data communication unit, data processing server, and surveillance and command platform. The system schematic is shown in Fig.3.

Figure 3. The principle diagram of BDS command centre

BDS command device can receive the short message from its subordinate's user devices. [7][8]Then the message can be sent to message decoding unit through data interface module, then to server, after processing in server, the platform server can display and save the location information of airborne equipment on display terminal. At the same time, taking advantage of t BDS two-way short message communication function, the command centre can provide information service for the pilot who installing the BDS airborne device[9].

IV. APPLICATION

Flight tests with the classic general aircrafts, such as Cessna 172, Seminole, are selected to assess the portable BDS surveillance system performance.

The software structure of the BDS surveillance and command centre server is Client/Server, after installing the client application software, the other GA user who is located in other place can access the platform through internet with PC,IPAD,or intelligent mobile phone, just as the Fig.4 shows. In Fig.4, the BDS command centre was located in Beijing, the testing aircraft flew in Shanghai,the distance is about 1200KM,and the accurate, real-time traffic displays are available, research staffs can analysis the display figure,

conclude quantitative evaluation about the portable ADS-B transmitter based on Beidou.

Figure 4. The display of aircraft with BDS airborne device(PC client)

The Fig.5 is the screen shot of intelligent mobile phone which accesses the fusion data server from ADS-B and BDS command centre. From the picture we can get the aircrafts information on GIS or the message information in text.

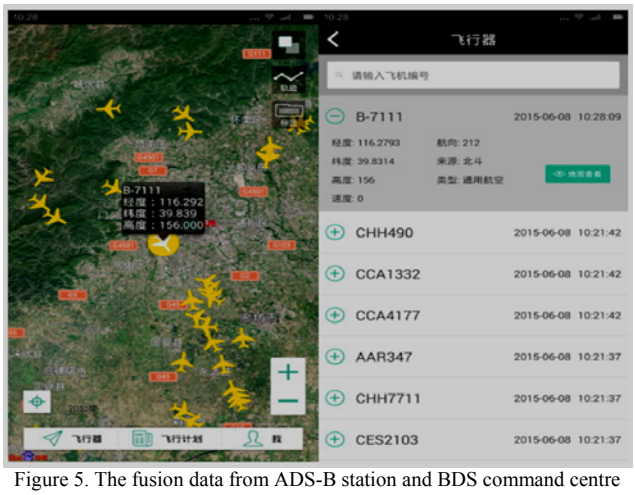

Figure 5. The fusion data from ADS-B station and BDS command centre (android client)

V. CONCLUSION

There is only one GA surveillance and command centre based on BDS built in Beijing, building the whole general aviation airspace, seamless GA surveillance network in China.

The research results of this project provides an effective means for GA surveillance, makes ensure the safe operation of the GA. At the same time with the innovative application of Beidou navigation and communication technology in the field of civil aviation, greatly reduces the cost of hardware purchase, modification and maintenance.

ACKNOWLEDGMENT

This work is supported by the CAAC technology innovation guide fund,China(No.20150214),Civil aviation flight technology and flight safety research base open topic,China(F2014KF03), Civil Aviation Flight University of China Science and Technology Research Fund project,China(J2014-52), and Asian Regional Cooperation Projects of Special Funds, China.

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