SYNCHRONIZATION OF RECEIVER FOR DECODING AUTOMATIC DEPENDENT SURVEILLANCE BROADCAST SIGNALS

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DEDICATION

To my Family, who gave me endless love, trust, constant encouragement over the years, and for their prayers, their patience, support, and for enduring the ups and downs during the completion of this project.

This project is dedicated to them.

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ABSTRACT

The proposed research investigates the design of a receiver to decode ADS-B signals. After the ADS-B data has been detected by the receiver the bits are decoded base on the message type and format. The format must be known to ensure the correct bits are used for altitude, latitude, longitude and aircraft ID. DF17 message format is used to give an interpretation for the individual components of the message. To ensure correct detection of data, the receiver should use the preamble to detect the received ADS-B. Preamble sequence method was used previously to detect the wanted preamble. Correlation method used on a simulator before implement on the Software Defined Radio to check the ability of detecting the preamble at the correct time. Both methods evaluated, and performance verified by Monte Carlo simulation at various signal-to-noise ratio conditions and compared with existing system to determine the percentage of error in detecting the preamble at the right position. Using correlation method reduce the error in detection by 17% of the preamble sequence method.

ABSTRAK

Penyelidikan yang dicadangkan menyiasat reka bentuk penerima untuk menodalkan isyarat ADS-B. Selepas data ADS-B telah dikesan oleh penerima, bit-bit dibina berdasarkan jenis mesej dan format. Format mesti diketahui untuk memastikan bit yang betul digunakan untuk ketinggian, latitud, longitud dan ID pesawat udara. Format mesej DF17 digunakan untuk memberikan tafsiran untuk komponen individu mesej tersebut. Untuk memastikan pengesanan data yang betul, penerima harus menggunakan mukadimah untuk mengesan ADS-B yang diterima. Kaedah urutan mukadimah digunakan sebelum ini untuk mengesan mukadimah yang dikehendaki. Kaedah korelasi yang digunakan pada simulator sebelum dilaksanakan pada Radio Ditetapkan Perisian untuk memeriksa keupayaan mengesan pembukaan pada masa yang betul. Kedua-dua kaedah tersebut dinilai, dan prestasi disahkan oleh Monte Carlo simulasi pada pelbagai keadaan nisbah isyarat-ke-bunyi dan berbanding dengan sistem sedia ada untuk menentukan peratusan kesilapan dalam mengesan mukadimah di kedudukan yang betul. Menggunakan kaedah korelasi mengurangkan kesilapan dalam pengesanan dengan 17% daripada kaedah urutan preamble.

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LIST OF ABBREVIATIONS

AWGN	-	Additive White Gaussian Noise
ADS-B	-	Automatic Dependent Surveillance Broadcast
ATC	-	Air Traffic Control
CA	-	Capability
DF	-	Downlink Format
FAA	-	US Federal Aviation Administration
FPGA	-	Field-Programmable Gate Array
GNSS	-	Global Navigation Satellite System
GPS	-	Global Positioning System
ID	-	Identification
ICAO	-	International Civil Aviation Organization
NextGen	-	Next Generation
PSR	-	Primary Surveillance Radar
RADAR	-	Radio Detection and Ranging
SDR	-	software defined radio
SESAR	-	Single European Sky ATM Research
SSR	-	Secondary Surveillance Radar

CHAPTER 1

INTRODUCTION

1.1 Background

The air traffic control (ATC) radar is referred for detection and monitoring of commercial aircrafts for air traffic management. ATC surveillance provides to close the gap between the radar expectations of aircrafts and the actual path of the aircrafts [1]. ATC surveillance radar consists of primary surveillance radar (PSR) and secondary surveillance radar (SSR). The PSR transmits high power signal which is reflected off the skin of the aircraft back to the radar to estimate the range and azimuth of the aircrafts. The SSR sends interrogation signal to the aircraft and receives the reply from the aircraft transponder that contain identification based on Mode A, Mode S, and Mode C.

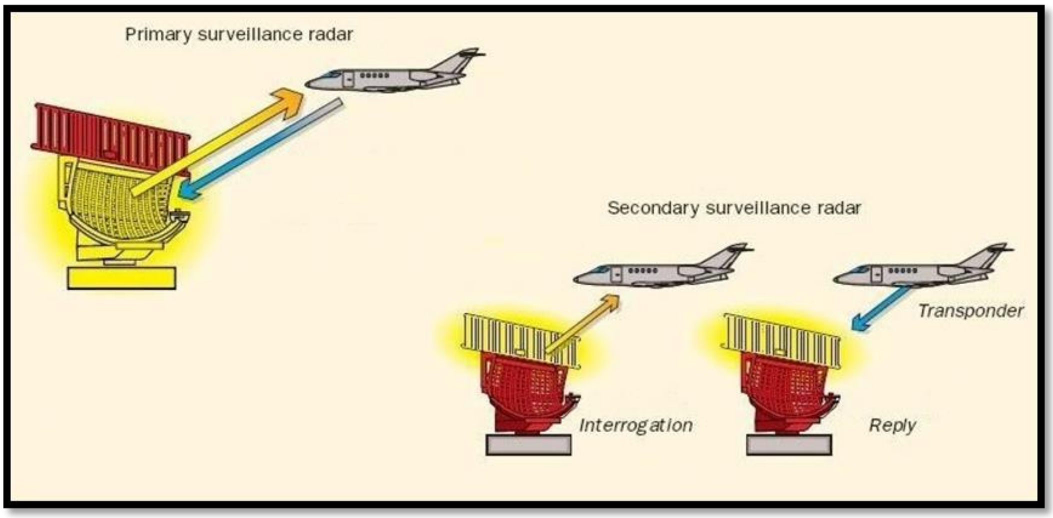

Figure 1-1: ATC radar system [1][9]

Aircraft needs to be prevented from coming into contact during flight. The new technology commonly referred to as Automatic Dependent Surveillance – Broadcast (ADS – B). ADS – B uses transmission from aircraft to provide identification, altitude, latitude, and longitude by depending on position sensor receiver [2]. This technology typically involves airplanes constantly sending in real time position and flight parameters. ADS – B enables the widespread use of satellite based Global Positioning System (GPS) technology, it provides air traffic controllers and pilots with information that will help aircraft efficiently navigate by allowing panels to determine their exact location and the information is broadcast to other nearby aircrafts and ADS – B ground station [1]. The information transmitted from aircraft provides identification, altitude, latitude, and longitude. The ground system is non-rotating antenna, simple pole antenna can be used. The main purpose of ADS – B system is to determine the position of an aircraft without any action from the pilot and then broadcast same information detected at every second unlike the ATC radar which detects aircrafts at 4 – 12 seconds depending on the antenna rotation speed [1]. It has been standardized and the US Federal Aviation Administration (FAA) as well as EUROCONTROL have mandate its deployment for 2020 as part of next generation air transportation systems NextGen and SESAR [2].

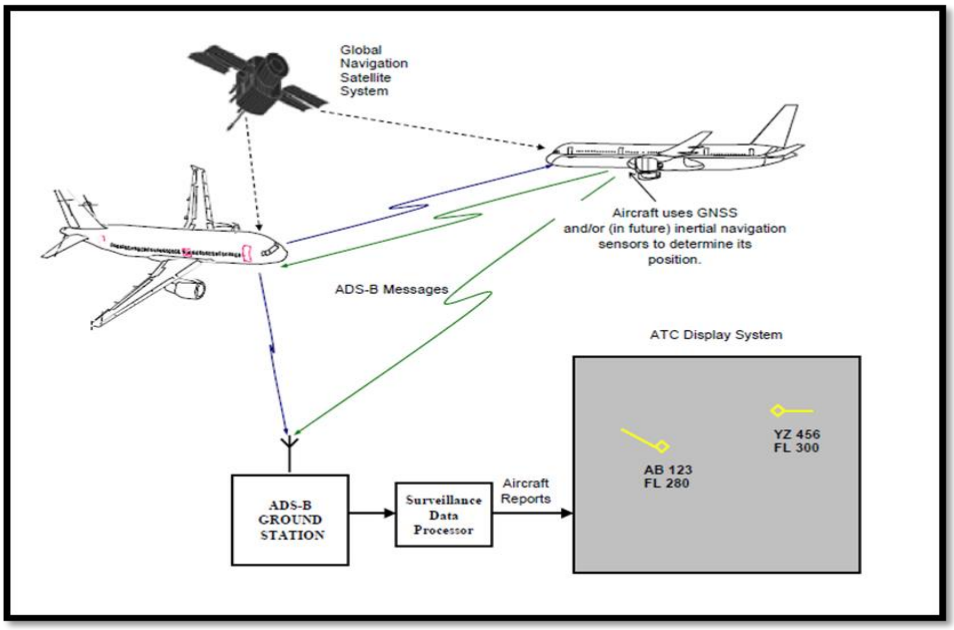

Figure 1-2: ADS-B system [2]

1.2 Problem Statement

- Noise in the signal make it difficult to detect the preamble in the right position which leads to incorrect signal decoding.
- Hardware for current ATC surveillance system is fixed for a specific functionality and cannot be easily customized.

1.3 Objectives

The objectives of the project are described as follows:

- To improve ADS – B decoding by enhancing the preamble detection.
- To implement ADS – B decoding on SDR in real-time.

1.4 Scope of work

The scope of the project is described below:

- Design and verification of preamble detection algorithm on MATLAB mathematical software.
- Implement on SDR using C language.
- ADS – B operates at 1090 MHz
- SDR and antennas at DSP Lab. are used to receive ADS – B signals in real-time.
- Real data received are applied for the simulated algorithm.
- The aircraft identification and position estimated from SDR will be compared with existing system such as Flightradar24.

1.5 Research Methodology

The project was carried out according to the following order shown in the flowchart in Figure 1-3:

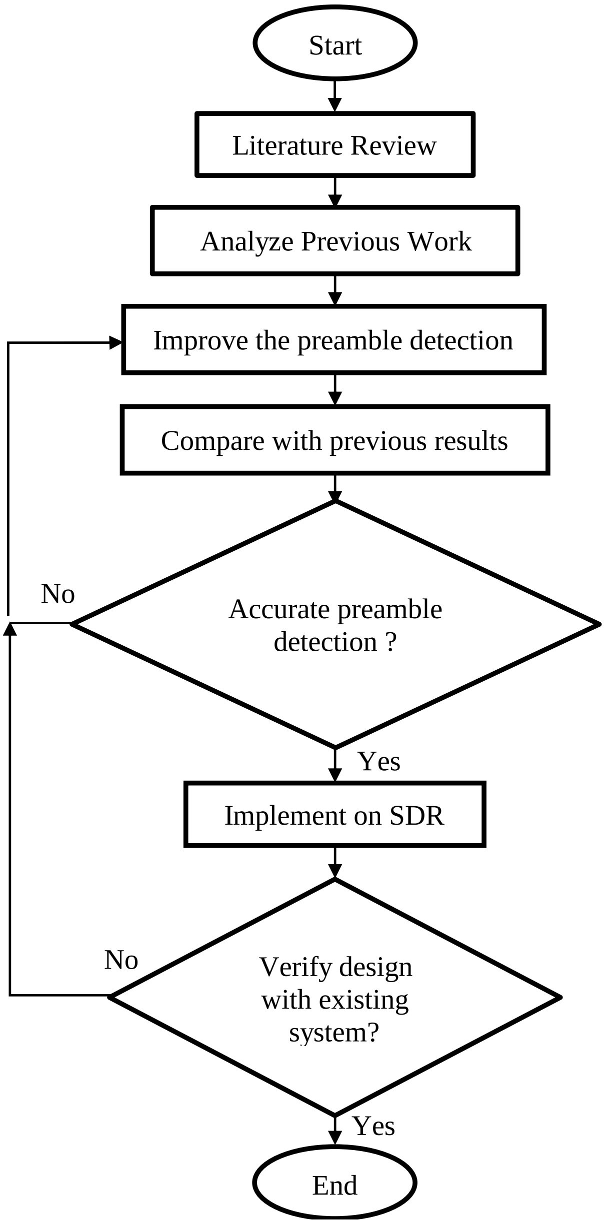

Figure 1-3: Flowchart for the work flow

Firstly, a literature review on preamble detection of ADS – B and software defined radio implementation were carried out, based on message type and format. This is done to ensure that appropriate bits are used for the preamble of the signals.

Secondly, after analyzing previous work, matlab code written to generate the preamble and perform proper preparations to detect the preamble at the right time. The process included filtering and thresholding the received signals. The new results compared with the previous one to ensure the signal received correct, Monte Carlo simulation done at a given range of signal-to-noise ratio (SNR) to determine the accuracy of detection.

Finally, the new detection method implemented on SDR and the received signals verified with existing system such as Flightradar24.

1.6 Organization of The Project

This project is outlined in the following manner. Chapter 2 provides literature review on aircraft surveillance systems, ADS-B, and the software defined radio system. Chapter 3 describes the steps involved in achieving the objectives mentioned in the project. Chapter 4 the results, discussion, and analysis of the capabilities of the system. Finally, Chapter 5 contains conclusions and recommendations.

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