Visvesvaraya Technological University, Belagavi – 590018

PROJECT REPORT
ON

HELICAL ANTENNA FOR AIRCRAFT COMMUNICATION

Submitted in partial fulfillment for the award of degree of

BACHELOR OF ENGINEERING
in
ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted by

Aishwarya H S	4CB21EC001
Lata Keshav Naik	4CB21EC020
Sonali S	4CB21EC053
Spandana	4CB21EC054

Under the Guidance of

Mr. Sreerama Samartha
Assistant Professor, Department of Electronics and Communication Engineering

DEPT. OF ELECTRONICS AND COMMUNICATION ENGINEERING

CANARA ENGINEERING COLLEGE

(Affiliated to VTU Belagavi, Recognized by AICTE, Accredited by NBA)

Benjanapadavu, Sudheendra Nagar, Mangaluru - 574219, Karnataka.

2024-25

CANARA ENGINEERING COLLEGE

(Affiliated to VTU Belagavi, Recognized by AICTE, Accredited by NBA)

Benjanapadavu, Sudheendra Nagar, Mangaluru - 574219, Karnataka

DEPT. OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the project work entitled **"HELICAL ANTENNA FOR AIRCRAFT COMMUNICATION"** carried out by

Aishwarya H S	**4CB21EC001**
Lata Keshav Naik	**4CB21EC020**
Sonali S	**4CB21EC053**
Spandana	**4CB21EC054**

the bonafide students of VII semester Electronics and Communication Engineering in partial fulfillment for the award of Bachelor of Engineering in Electronics and Communication Engineering of the Visvesvaraya Technological University, Belagavi during the year 2024-2025. It is certified that all corrections/suggestions indicated for Internal Assessment as indicated during internal assessment. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said degree.

Mr.Sreerama Samartha	**Dr.Raghavendra M Shetty K**	**Dr.Nagesh H R**
Project Guide	HOD-ECE	Principal

External Viva:

Examiner's Name ... Signature with Date

1. ....

2. ....

CANARA ENGINEERING COLLEGE

(Affiliated to VTU Belagavi, Recognized by AICTE, Accredited by NBA)

Benjanapadavu, Sudheendra Nagar, Mangaluru - 574219, Karnataka

DEPT. OF ELECTRONICS AND COMMUNICATION ENGINEERING

DECLARATION

We hereby declare that the entire work embodied in this Project Report titled **" HELICAL ANTENNA FOR AIRCRAFT COMMUNICATION"** has been carried out by us at CANARA ENGINEERING COLLEGE, Mangaluru under the supervision of **Mr. Sreerama Samartha** for the award of **Bachelor of Engineering** in **Electronics and Communication Engineering**. This report has not been submitted to this or any other University for the award of any other degree.

Aishwarya H S	**4CB21EC001**
Lata Keshav Naik	**4CB21EC020**
Sonali S	**4CB21EC053**
Spandana	**4CB21EC054**

Acknowledgement

We dedicate this page to acknowledge and thank those responsible for the shaping of the project. Without their guidance and help, the experience while constructing the dissertation would not have been so smooth and efficient.

We sincerely thank our Project guide **Mr.Sreerama Samartha**, Assistant Professor, Electronics and Communication Engineering for his guidance which helped us to complete this project. We also thank our Project coordinator **Dr.Dayanand G K**, Dept of Electronics and Communication Engineering, for their consistent encouragement.

We owe a profound gratitude to **Dr.Raghavendra M Shetty K**, Head of the Department, Electronics and Communication Engineering, whose kind support and guidance helped us to complete this project work successfully. We also take this opportunity to thank our Dean Academics/Vice-Principal **Dr. Demian Antony D'Mello** and We are extremely thankful to our Principal, **Dr.Nagesh H R**, for their support and encouragement.

We would like to thank all faculty and staff of the Department of Electronics and Communication Engineering who have always been with us extending their support, guidance, and encouragement through the project. We also express our gratitude to our beloved friends and parents for their constant encouragement and support.

Aishwarya H S
Lata Keshav Naik
Sonali S
Spandana

Abstract

The tremendous increase in air travel has put a lot of pressure on the conventional radar systems which fail to give an accurate and timely tracking particularly in the hinterlands. This drawback in turn affects air traffic control, situational awareness and the security of the airspace as a whole. In order to solve these problems, this project emphasis's the work on the optimized design of a helical antenna which will boost aircraft communication systems. The key purpose is to enhance the strength, reliability and coverage of signals so that there is uninterrupted and every time real time data transfer on the positions of aircraft, weather monitoring and safety procedures. Important design factors include limit of size and weight, resistance to hostile environment, low power and adaptability to different aircraft classes. To assess the antenna's impact on the overall communication strategy for aircraft monitoring, traffic control and weather surveillance, the antenna's characteristics will be extensively examined in numerous operational conditions. Such progressive designs will assist in optimizing aircraft operations and enhancing airspace security thereby revolutionizing the aviation communication and prediction of weather patterns.

Keywords : Helical Antenna, Aircraft Communication Systems, Air Traffic Control, Airspace Surveillance

Table of Contents

Chapter 1

Introduction

1.1 Background

The rapid growth of the aviation sector has highlighted challenges in air traffic management and communication systems. The conventional radar systems sometimes fail in real-time tracking within a few distinct regions and leave air safety as a compromise. This project investigates the feasibility of developing helical antennas, which are very compact, high gain, and circularly polarized, for this purpose. These antennas would achieve improved communication signal gain and enable real-time tracking of aircraft, data transfer, and weather monitoring. Design and fabrication of helical antennas will be done with an optimized size, weight, and durability, along with low power consumption for better headroom and safety operations in the airspace.

1.2 Motivation and Problem Statement

Motivation: Due to the increasing rate of air travel, there is a need for better air traffic control systems. As a consequence, there has been growing complexity of the system making the old system approaches useless. This is an important issue which needs addressing in order to maintain the safety and efficiency. New developments help to mitigate the barriers created by the rapid growth of the aviation business. There is also a need for enhanced air traffic control systems.

Problem statement: The exponential growth of the aviation industry has overwhelmed traditional radar systems, compromising real-time tracking reliability. This poses serious concerns for situational awareness and safety, particularly in remote areas with limited coverage, leading to airspace congestion and safety risks. There is an urgent need for improved air traffic monitoring systems that are reliable, efficient, and offer wide-area coverage.

1.3 Objectives

Obj 1:Increased signal strength and dependability to facilitate uninterrupted and real-time voice and data communication between the land stations and the aircraft in flight.

Obj 2:Allow the an accurate monitoring and control of the elevations,speeds and positions of the flight craft for better management of the air space

Obj 3:Implementing in-flight reliability provided by integration of real-time weather data acquisition and transfer technology enhancing safety operations for active systems and enabling quicker response for the pilots and air traffic controllers.

1.4 Scope and Limitations

Scope: Enhance and evaluate the antenna for use in different location scenarios, aiming at enhancing the communication directed to the aircraft monitoring system including real time traffic information as well as meteorological information to allow for enhanced decision making in the operations of aircraft and forecasting of weather.

Limitations:Helical antennas suffer from various limitations that include the size and weight constraints, sensitivity to environmental conditions such as temperature, humidity, and vibration, and narrow operational bandwidth.

1.5 Organization of the Report

The report begins with a Title Page and an Abstract summarizing the learning objectives and significance. The remaining part of the report are organized as following chapters:

Chapter-1: It includes sections such as the Introduction, which outlines the scope and motivation, followed by sections on Objectives, Scope, and Limitations.

Chapter-2: This Literature Survey includes a review of various articles and the design, methodology, and techniques adopted from each. It also presents the results achieved in those articles.

Chapter-3: This chapter explains design methodology, schematics, simulations, and optimization tailored to meet the demands of efficient aircraft communication systems.

Chapter-4: This chapter discusses antenna implementation, testing setups, and evaluation results, including parameters like gain and frequency critical for aircraft communication reliability. The chapter concludes with a summary.

Chapter-5: These were the Software Requirements Specification, which includes detailed descriptions of functional and non-functional requirements, hardware and software requirements, performance requirements, and other specific requirements. The chapter concludes with a summary.

Chapter-6: Results and Discussion This chapter presents design and testing outcomes, evaluates antenna performance for aircraft communication, highlights strengths, and suggests improvements for future use. The chapter concludes with a summary.

Chapter-7: Conclusion and Future Work This chapter summarizes achievements in aircraft communication enhancement, reflects on objectives met, and proposes advanced designs for improved aviation communication systems.

The report concludes with references and drill-bit plagiarism report.

Chapter 2

Literature Survey

Recent studies note the growing role of helical antennas in boosting the aircraft communication system, including some applications that improve reliability and coverage as well demonstrated. Studies indicate that helical antennas have enhanced capability of transmitting and receiving signals due to their structural design which makes them very useful in emergency surveillance, air traffic control and even weather forecasting. Moreover, the enhancement of television reception with advanced antenna Technologies is taking shape in line with the performance enhancement of antenna materials and designs in addressing the harsh performance conditions. The Helical antennas are noted to be a game changer in the aviation communication by most of the authors in the studied literature.

2.1 Article 1: Receiving and processing ADS-B signals for aircraft tracking

Automatic Dependent Surveillance-Broadcast (ADS-B) is one of the recent additions to radar systems that primarily aims at providing real time operational and positional information from one aircraft to another or to the ground. In this project, we explore ADS-B signals collected in the vicinity of the Barcelona airport, employing an inexpensive RTL-SDR for signal reception, and MATLAB for signal extraction and analysis. Other data collected, such as position, altitude, speed, as well as the ID of the aircraft, helps the pilot to be aware of his environment and increases overall flight safety. Signal spectrum analysis was done using Simulink. And signals were observed at various distances in order to assess how distance affected the reception of the signal..[8]

2.1.1 Brief Findings of Article 1

The research emphasizes characteristics of the systems of ADS-B as a new effective system for air traffic control. It allows to monitor the air traffic more safely and with more convenience than radar systems. An ADS-B receiver for Barcelona airspace was built and tested using RTL-SDR and MATLAB to capture and decode signals containing geographical location, height and speed information. The approach is based on PPM at 1090 MHz and the spectrum analysis shows high signal power indicates around the center frequency signal.

2.1.2 Design, Methodology & Techniques Adopted in Article 1

• The project employed an ADS-B receiver operating at a frequency of 1090 MHz. The receiver consisted of an RTL-SDR card and a vertically polarized antenna. MATLAB coordinates its different Simulink models to decode the obtained data and carry out further analysis..

• As the modulation scheme for encoding voice signals into pulse signals, this study presents the use of pulse position modulation (PPM) and and methods at both frequency and time domains were also employed to analyze the signals in order to reduce noise.

2.1.3 Results Achieved in Article 1

Using an RTL-SDR receiver and Matlab, the study was able to capture and decode ADS-B Transmissions of the aircraft located in the airspace of Barcelona. Information such as the position, altitude, speed and identification of the aircraft was successfully extracted. Extended squitter messages were more reliably decoded than short squitter messages. Analysis revealed a significant signal strength at 1090 MHz, with a corresponding time-domain analysis revealing oscillographs exhibiting the desired waveforms but also revealing some noise interference. Conclusively, the incorporation of ADS-B technology was effective for the purpose of real-time monitoring of air traffic control.

2.2 Article 2:Performance Analysis of ADS-B Signal Receiver SDR for Low Cost ADS-B Mini Radar

The present study investigates the application of Software Defined Radio (SDR) technology in developing a low-cost ADS-B radar system. It examines the comparative advantage of employing two antennas: VERT 900 and RTL-SDR standard, in different scenarios while emphasizing the role of frequency compatibility and placement. Again, the use of RTL-SDR antenna goaded much higher performance due to its frequency range and gain optimization. Higher and open places resulted in better signal strength and range with real-time data correlating with dynamic tracking systems. The work provides a low-cost and mobile approach to air traffic surveillance, detailing prospective interventions on enhancing grounding antennas.[7]

2.2.1 Brief Findings of Article 2

This research shows that reception of ADS-B signals achieved using RTL-SDR technology which is inexpensive and portable. The VERT 900 was also outperformed by the standard antenna of RTL-SDR since it works best at 1090 MHz frequency with better gain. The placement of antennas at higher and open areas increased both the range and strength of the signals. The accuracy of the real-time flight data compared to the live data tracking system was validated. Mainly, this study seeks to demonstrate that there is a clear potential for the use of software-defined radios to monitor air traffic in an efficient and cost effective manner.

2.2.2 Design, Methodology & Techniques Adopted in Article 2

• In association with a Raspberry Pi, and ADSB decoded signals are captured using an RTL-SDR dongle followed by software like dump 1090 or Pi-aware for visualizing the positions of aircraft in real time.

• Place antenna tested in two environments - airport lobby and multi-story buildings with consideration of aspects like signal strength, aircraft observation and range of detection.

• Two types of antenna (VERT 900; RTL-SDR) have been compared with respect to their frequency matching, gain, placement and height and performance.

2.2.3 Results Achieved in Article 2

By utilizing an RTL-SDR receiver and MATLAB, the project was able to successfully obtain and decode ADS-B signals with real time data on the position, altitude and speed of the aircraft. It also showed an ability to decode the extended squitter messages reliably and looked into the frequency and time domains of the signals along with the message signals, thereby proving the benefits that could be gained in respect to air traffic control and safety using the systems.

2.3 Article 3: Security Issues in Automatic Dependent Surveillance- Broadcast

The ADS-B architecture face challenges on security because of its reliance on an open communication protocol that is unencrypted. This makes it easily eavesdropped, jammed, and sent fake messages. In support of wider systemic integrity secure measures like location verification propagation limitations amongst others and kalman filter are enhancing security. Authentication and message security have been proposed using data fusion and integration of blockchain technology. [9]

2.3.1 Brief Findings of Article 3

The study finds that ADS-B systems are vulnerable to eavesdropping, jamming, and message modification due to their open protocol. Solutions like multilateration, Kalman filtering, and data fusion improve security, but they vary in cost and feasibility.

2.3.2 Design, Methodology & Techniques Adopted in Article 3

• The research aims at assessing threats faced by the Automatic Dependent Surveillance – Broadcast (ADS-B) system and recommends measures such as location verification and broadcast authentication to improve security.

• The study reviews ADS-B security enhancing methods including but not limited to, multilateration, Kalman filtering, data fusion, and blockchain technologies.

2.3.3 Results Achieved in Article 3

A research conducted shows that because of their unencrypted systems, the ADS-B systems are subject to attacks such as eavesdropping, jamming or even message tampering. The research assesses that although security enhancements like multilateration and Kalman filtering are helpful, they have cost and scaling limitations. While blockchain offer more advanced solutions, their use comes with complexities in execution.

2.4 Article 4: Rectangular Monopole Antenna Design for ADS-B Application

The study designs a rectangular monopole antenna for ADS-B (Automatic Dependent Surveillance-Broadcast). Beginning the design, the RTL-SDR stock antenna was examined geometrically and scaled. Numerous measurements were taken to evaluate the antenna's performance at the ADS-B frequency of 1090 MHz. Hereof, a new design for a monopole rectangular antenna was proposed which will be constructed using FR 4 PCB material with the thickness of 1.6 mm and which will replace the conventional antenna.[3]

2.4.1 Brief Findings of Article 4

This work describes a rectangular monopole antenna dedicated to ADS-B systems which works at a frequency of 1090 MHz. The antenna is built using FR-4 PCB material, possesses a gain of 3.05 dB, and has an omnidirectional radiation pattern. It meets the operational frequency band for ADS-B and exhibits better performance than standard antennas. The design is aimed at improving aviation safety by Increasing the coverage of surveillance airborne systems for efficient air traffic management and awareness.

2.4.2 Design, Methodology & Techniques Adopted in Article 4

• The antenna consists of a rectangular shaped monopole with a mane covered on one side and slots cut on the radiation surface made of FR-4 material (1.6 mm thick).

• In the course of how the work was done, the basic design of an RTL-SDR antenna was examined in relation to its use at the ADS-B velocity (1090 MHz), and the patch sizes were adjusted accordingly to maintain its effective performance.

• The antenna covers in excess of three frequency bands (1036-2204 MHz, 2313-7504 MHz, 8000-9451 MHz) and provides an omnidirectional radiation cover with 3.05 dB gain at the frequency of 1090 MHz.

2.4.3 Results Achieved in Article 4

In summation, the constructed rectangular monopole antenna is functional at a center frequency of 1090 MHz with a gain of 3.05 dB and an omnidirectional radiation pattern. It caters a number of frequency bands inclusive of 1036–2204 MHz, 2313–7504 MHz, and 8000 to 9451 MHz, making it applicable for ADS-B: system. Its small dimension (100 × 125 × 1.6 mm) allows it to replace conventional ones without much struggle. All in all, it boosts the efficiency of the ADS-B system by improving performance and coverage.

2.5 Article 5: Protection Method for Data Communication between ADS-B Sensor and Next-Generation Air Traffic Control Systems

The paper discusses the weaknesses of air traffic management communication systems. The author's focus on the vulnerabilities of the ADS-B system, i.e. spoofing and eavesdropping, which arise from the lack of encryption of such communication. Risks have been admitted, but there are no adequate means of prevention. The investigation advances a security model Suggesting the use of SPKI certificate and symmetric key encryption in order to raise the security of ADS-B communication, thus making the management of air traffic operations within the CNS/ATM system safer.[6]

2.5.1 Brief Findings of Article 5

The research tackles the security threats concerning ADS-B communication systems with specific reference to issues such as data spoofing and data tampering by proposing a system that adopts lightweight SPKI certificates for authentication and symmetric encryption for data security. The design overcomes dangers such as ghost injection and ground station flooding, which in turn strengthens and protects the security of ADS-B communication for effective management of air traffic.

2.5.2 Design, Methodology & Techniques Adopted in Article 5

• Employs SPKI certificates for sensor verification, AES-128 algorithm for data security, and an XML signature module for assurance of data integrity.

• This encompasses secure ADS-B communication aspects such as key generation, certificate validation, issuing of encryption keys, and regular re-authorization.

• Lightweight cryptography ensures low computational overhead, making it ideal for real-time air traffic management systems.

2.5.3 Results Achieved in Article 5

The key improvement proposed in this framework enhancement of ADS-B security is the use of SPKI for the data access control, and with the integration of the AES-128 encryption which prevents any unauthorized access or eavesdropping, as well as data tampering. This approach addresses the challenges associated with ghost aircraft injection, however it does not strain the system's processing power making it fit for real time application. The offered solution improves on the air traffic management system, however it is necessary to carry out realistic tests for operational validation.

2.6 Article 6: Broadband High Gain Helical Antenna for Satellite Communication Applications

The document outlines the structure and construction of a broadband helical antenna specifically developed for GPS satellite communication. Its advantages include wide bandwidth, high gain, circular polarization, and operation within GPS frequency bands L1, L2, and L5 The antenna's durability is enhanced by the inclusion of a radome to prevent the failure of the antenna from the weather.[1]

2.6.1 Brief Findings of Article 6

The helical antenna proposed shows good impedance matching, wide coverage, and a high gain level attaining as much as 12.5 dBi at 1.7 GHz. It is highly effective in the frequency band from 1.1 GHz to 1.9 GHz while keeping the reflection coefficient under -10 dB, which makes it ideal for use in GPS and other forms of satellite communication systems. In addition, the radome is also helpful as it improves the reflection coefficient and the gain resulting in a more effective overall system for outdoor purposes.

2.6.2 Design, Methodology & Techniques Adopted in Article 6

• The suggested broadband helical antenna accomplishes a tremendous impedance matching, with a wide operation of frequency range of up to 12.5 dBi gain at 1.7 GHz, implementing efficiently from 1.1-1.9 GHz with a reflection coefficient of better than -10 dB. The radome offers performance benefits and raises the gain and reflection coefficient raising its viability to systems such as GPS and other satellite communication systems.

• The antenna is designed with a Teflon core which has a copper wire covered on the outside, internally it has a ground plane measuring300mm and is topped with an impact resistant ABS plastic cover. A rectangular dielectric material transformer is used to achieve impedance matching. CST Microwave Studio simulations were also used to optimize the parameters and to investigate the influence of the radome and dielectric materials on the performance of the antenna.

2.6.3 Results Achieved in Article 6

The antenna achieves a reflection coefficient lower than -10 dB in the frequency band of 1.1–1.9 GHz and has better reflection performance when it is coated with a radome. It has an axial mode circular polarization which is proper for GPS applications. The radiation pattern confirms the presence of directed and helically polarized signals along the axis of the helix.

2.7 Article 7: Quadrifilar Helix Antenna for Enhanced Air-to-Ground Communications

The design and evaluation of a quadrifilar helix antenna aimed at improving air-to-ground communications. The antenna minimizes signal losses which occur due to the alignment of airborne and ground systems not coinciding. This works in all respects as it relates designed for the purpose of stable links and incorporates circular polarization. Tests showed good performance with less interference from the metallic body of an aircraft. [5]

2.7.1 Brief Findings of Article 7

The construction of a self - phased Quadrifilar Helix Antenna aimed at improving the air to ground and air assisted ground to ground communication. The primary purpose of the QHA is to minimize the reduction in axial ratio when the antenna is mechanically tilted, which is common when using which uses linear polarized antennas, The said QHA design works in the frequency range (above 1.765 up to 1.805GHz) with a gain varying from 4 - 4.5 dBiC. The use of RF absorbing material reduced performance losses attributed to the use of metallic ground planes effectively making the QHA suitable for use in military communication systems.

2.7.2 Design, Methodology & Techniques Adopted in Article 7

• The QHA incorporates two bifilar helical antennas for circular polarization which provides a compact, uniform distribution of coverage over the vertical plane for airborne systems. Performance characteristics such as axial ratio and reflection coefficients for the antenna were simulated in Altair FEKO under the effects of various ground and absorber configurations.

• The manufactured antenna is based on 3D printing with complex designed molds, 12-gauge bus wires, and semi-rigid coaxial cables; then parameters of reflection coefficients, gains, and axial ratios were investigated.

At this stage the optimization parameter included the spacing shall be set at /4 from the ground plane and the RF absorbers applied to minimize interference.

2.7.3 Results Achieved in Article 7

The QHA demonstrated good performance and stable axial ratios less than 3 dB when tacky RF absorbers were used. The RF absorbers helped mitigate the problems faced due to the metallic ground planes enhancing the dependability of the design. The antenna appears suitable for use in military communication systems.

2.8 Article 8: The Recent Advancement in Unmanned Aerial Vehicle Tracking Antenna

Unmanned Aerial Vehicles (UAVs) play a crucial role in sectors such as firefighting, emergency rescue, and military operations. Their ability to operate autonomously above the ground makes them essential in these areas, leading to growing demand across military, emergency, and commercial industries. This increased reliance on UAVs necessitates the development of reliable communication networks. In this paper, we offer an extensive review of the evolution of UAV tracking antennas, focusing on high-gain directional antennas. These antennas are designed to address the limitations of conventional systems, aiming to enhance overall performance and ensure efficient communication.[4]

2.8.1 Brief Findings of Article 8

This paper explores recent innovations in UAV tracking antennas, focusing on enhancing communication between ground control stations and UAVs. It critiques the limitations of traditional systems, such as reliance on mechanical steering, and discusses how MIMO and sectorized beamforming address challenges in achieving 360-degree coverage.

2.8.2 Design, Methodology & Techniques Adopted in Article 8

• The focus of the design was to improve in the tracking precision and dependability using directional antennas, with the introduction of Mimo and sectorized beam forming as substitutes for the use of mechanical steering.

• The strategy consisted of an examination of the already existing UAV tracking devices, the assessment of its drawbacks and other designs such as directional antennas and electrically steered antenna arrays.

• The methods applied included sophisticated techniques of beam steering (monopulse tracking, TDOA, RSSI) in addition to the use of GPS and microcontrollers to enhance the overall functionality.

2.8.3 Results Achieved in Article 8

The research introduced MIMO beamforming as a cheaper alternative to conventional systems which allows uninterrupted tracking in 360°. It was demonstrated that sectorized beamforming facilitated uninterrupted communication in difficult environments. The integration of MIMO technology with complex algorithms improves the efficiency and accuracy of tracking the UAV.

2.9 Article 9: Optimization of Helical Antennas

In the article helix antenna optimization by Djordjevic et al., a more advanced approach towards helix antenna design is put forward to resolve shortcomings of the classical models. Sampling and inscribing by a number of basic antennas, worked out in this research, achieves the optimum of such parameters Angle of the wire pitch, physiognomy length and diameter of the wire that grant the improved gain bandwidth. It also presents easy-to-use designing schemes for narrow and wide-band applications targeting efficient performance. The experimental values support the validity of the new methodology and it is better than the old ones. The work is focused on developing a complete design procedure that leads to the formation of economical, workable and precise designs of helical antennas suited for modern communications.[2]

2.9.1 Brief Findings of Article 9

This paper attempts to resolve the infodemic expectations existing in the literature on the design of helical antennas. It points out the inconsistencies in theoretical predictions and experimental and simulation results concerning antenna gain and pitch angles or operating frequency. The authors set out to enhance the performance of helical antenna by adjusting their shape geometrical parameters like the pitch, radius, and length. The authors daft new antenna design diagrams and principles in addition to those for various antennas over planar infinite grounds, which provide a better and more effective way of antenna designing. The experimental results confirm this approach, providing accurate predictions of antenna performance within narrowed and broadband applications. The results show that wire radius and axial length are critical in achieving maximum gain and bandwidth as well as minimizing the axial ratio and VSWR.

2.9.2 Design & Methodology Adopted in Article 9

• To resolve contradictions about current design parameters the authors performed theoretical and experimental research. With the help of NEC computational modeling, antenna performance evaluation was conducted with changing of pitch angle, circumference and wire radius. The design of antenna was wideband that is maximizing gain over several frequencies and narrowband that is maximizing gain at a particular frequency. A database was constructed as the result of calculations with different constructive materials, dimensions and ratios for modeling gain and bandwidth dependencies.

• The antenna is designed for two primary purposes: narrow band (NB) and wide band (WB) Applications. In order to approve the design, structures were made according to specified parameters and their performance evaluated with regards to simulations and measurements in the field. Other ways, including changing the shapes of the ground conductors and altering the input impedance, were investigated to increase gain and matching performance. Ideal models were incorporated into the designs, such as those that presupposed infinite ground planes, and 300 MHz copper conductors with no losses.

2.9.3 Results Achieved in Article 9

The research presents considerable innovations towards the design of helical antennas, including new schematics and optimization instructions for accurate gain, bandwidth and axial ratio predictions. For instance, narrowband antennas recorded maximum gains of 15.5 dBi at the central frequency, while wideband designs exhibited stable gains within ±1.5 dBi at the target range. There was experimental validation for the achieved consistent gain and bandwidth efficiency that was better than the classical design. The optimization of such parameters as wire radii and pitch angles, for example, offset the challenges posed by the traditional gains prediction, which was typically the case of overstated gains. Thus, these developments underpin a robust approach for the realization of custom built efficient helical antennas.

2.10 Article 10: Aircraft monitoring by the fusion of satellite and ground ADS-B data

The focus of the article is on the integration of ground-based and space-based systems in the monitoring of aircraft at all times. It is noted that ground systems have an advantage in coverage of lower elevations; however, they are deficient in very far installations, and that CubeSats such as the STU-2C have developed a technology that uses software-defined radio receivers and a helical antenna in order to sense ADS-B signals in those areas that are too far to reach. In this way, the combination of ground radars and satellite radars improves global coverage, with the former taking almost all the images, even over the oceans and poles, that the STU-2C has very important applications. However, even if restrictions such as limited memory are present, this research proves the advantages of the different systems and tools aimed at enhancing airspace management and the evolution of satellite receivers.[10]

2.10.1 Brief Findings of Article 10

The purpose of the article is the enhanced aircraft tracking through the combination of ground-based and satellite-based ADS-B (Automatic Dependent Surveillance-Broadcast) systems. With ground-based ADS systems, the air traffic coverage of the aircraft is comprehensive. However, such systems have their own limitations in remote areas such as oceans and polar regions, as well as mountainous terrains. In order to support this goal, small satellites (CubeSats) containing ADS-B receivers were placed into orbit around the Earth at Low Earth Orbit (LEO) altitude. The satellite system that is developed, in particular the STU-2C CubeSat, was shown to be capable of receiving ADS-B aircraft data across areas where ground stations are ineffective. The paper discusses the useful of data available from both sources in the closing the gap presented above to improve the effectiveness of ATC and monitoring systems through effective global surveillance coverage.

2.10.2 Design, Methodology& Techniques Adopted in Article 10

• The research utilized integrated ground and satellite ADS-B technologies, deploying three CubeSats in this configuration including STU-2C, in 481 km low Earth orbit. The STU-2C CubeSat was fitted with an SDR based ADS-B receiver and a helical antenna, both of which underwent extensive performance trials in laboratory conditions.

• STU-2C utilized its position and line of sight to capture ADS-B signals from far-off areas. Solutions like real-time decoding and partial telemetry downloads helped address issues such as limited memory and the angles at which the satellites were tilted.

• Data collected from the satellites was validated with the ground-based ADS-B data on the same participants, specifically in cases where the region was infrastructure deficient, or the terrain was rough. The performance metrics demonstrated the complementary advantages of the systems.

2.10.3 Results Achieved in Article 10

It was demonstrated within the scope of the research that ADS-B system using satellites onboard captured adequate values of aircraft flying in remote places, gathering a total of 132,425 signals from 19,381 airplanes within a period of four months. Ground systems available performed well at lower altitudes and over airport coverage areas but satellites also helped in monitoring areas that were not reachable completing the air traffic picture when data sets were integrated. In spite of limitations such as small storage space and lower detection probability the satellite system enhanced the global air traffic control and gave insights on the improvements of satellite receiver designs in the upcoming years.

2.11 Comparision Table

Table 2.1: Comparison of existing work and Gap Identification

Project Title and Author	Problem Addressed	Implementation and Results	Limitations/ Future Scope
Receiving and Processing ADS-B Signals for Aircraft Tracking By Xin Wang	Restrictions of conventional air traffic systems based on radar. Improving accuracy, coverage, and real-time data transmission.	Utilized RTL-SDR receiver and MATLAB to capture and process ADS-B signals. Decoded signals provided insights into aerial traffic patterns.	• Aims to deploy in high-traffic regions, enhance scalability, and extend to UAV tracking.
Performance Analysis of ADS-B Signal Receiver SDR for Low-Cost ADS-B Mini Radar By Hadid Malik, I Gede Puja Astawa.	The unencrypted data transmission of the ADS-B system makes it vulnerable to the cyberattack.	After studying evaluated solutions like data fusion in connection with ADS-B, the results reveal that no one solution is sufficient but calls for a multi-layered approach.	•The current solutions are primarily curtailed by high cost and compatibility issues.
Security Issues in Automatic Dependent Surveillance-Broadcast (ADS-B): A Survey By Zhijun Wu	By visualizing the overview these project implies Elections are the primary	This research work demonstrates novel online voting systems	• Online voting systems are susceptible to security risks
Rectangular Monopole Antenna Design for ADS-B Application By Firdaus, Muhammad Amirul	ADS-B systems transmit unencrypted information, available for cyberattacks through eavesdropping, jamming, and tampering.	ADS-B systems transmit unencrypted information, available for cyberattacks through eavesdropping, jamming, and tampering.	• High costs and interoperability issues limit the present solutions.
Protection Method for Data Communication between ADS-B Sensor and Next-Generation Air Traffic Control Systems by Seoung-Hyeon Lee.	By visualizing the overview project implies the external security threats of an Automatic Dependent Surveillance-Broadcast system.	A security model was presented for ADS-B sensor authentication with SPKI certificates as a way for information encryption.	• Implementation, validation at the level of the laboratory, and testing on an actual ATC system.

Table 2.2: Comparison of existing work and Gap Identification

Project Title and Author	Problem Addressed	Implementation and Results	Limitations/ Future Scope
Broadband High Gain Helical Antenna for Satellite Communication Applications By Mohammed A. Alzabidi.	The project develops a broadband helical antenna with enhanced impedance matching, high gain, and circular polarization.	The antenna, featuring a Teflon core and ABS radome, achieved a reflection coefficient below -10 dB and circular polarization at 1.557 GHz.	• The design's practical implementation and field testing are not reported.
Quadrifilar Helix Antenna for Enhanced Air-to-Ground Communications By Steven D. Keller	The project is aimed at dealing with polarization loss during air-to-ground and airborne-assisted communication.	The design, simulation, and production of a compact, self-phased quadrifilar helix antenna achieved.	• Realized gain and axial ratio degrade when RF absorbers are not used.
The Recent Advancement in Unmanned Aerial Vehicle Tracking Antenna: A Review By Anabi Hilary Kelechi et al.	Conventional UAV tracking antennas are not considered as a lot of complicated, expensive and inefficient.	The proposal therefore of MIMO technology as an alternative to mechanical tracking is promising with benefits of high-speed, low-cost antenna in airborne vehicles.	•There is a need for additional research before optimization could be done for MIMO based techniques.
Optimization of Helical Antennas by Antonije R.	Existing design data and methods for helical antennas are inaccurate and lead to suboptimal performances such as poor gain and poor bandwidth.	Developed an optimized design methods through simulation and experimental verification with diagrams and formulas for an optimized helical antenna.	• Needs further refinement for application, such as ground plane shaping to improve gain.
Aircraft Monitoring by the Fusion of Satellite and Ground ADS-B Data by Xuan Zhang.	This project is aimed at limitations of ground-based ADS-B systems in providing global coverage, especially over oceansand remote areas.	An ADS-B receiver demonstrated successful in-orbit data reception and enhanced hard-to-reach air traffic monitoring.	• Data storage SD card failure limited memory of satellites and the performance of antennas require improvements.

2.12 Gap's Identified & Addressed

Gap's Identified: The study of ADSB-signal in aviation revels the following gaps

• The precision and dependability of a signal reception is compromised owing to noise disturbances and hardware constraints.

•Additionally, Improve aviation safety, which complies with the regulatory requirements mandating the installation of ADS-B on all transport category aircraft in Indonesia.

• The paper addresses the limitations of conventional antennas, offering improved gain and performance at the ADS-B frequency.

Gap's Addressed: Conventional ADS-B antennas did not optimize for 1090 MHz leading to poor signal performance.

•Gain and radiation patterns are enhanced by the new antenna thereby ensuring reliable and uniform coverage.

•The paper deals with the shortcomings of the typical ADS-B antennas which were not designed for the purpose of optimizing the 1090 MHz frequencies and hence had poor gain and radiation patterns. A new rectangular monopole antenna was designed in order to ameliorate the reliability of signal transmission with the gain of 3.05 db and universal coverage.

•Traditional ADS-B antennas were limited to smaller bandwidths, preventing the incorporation of other important aircraft frequencies. The new mast design has a wider operational frequency range thus making it usable for different aviation communication systems.

•Insufficient Coverage: Previous designs of antennas had radiation patterns which were aimed leading to poor signal reception in some locations. The new antenna is capable of providing coverage in all directions thus ensuring that all signals are received regardless of direction, improving communication reliability.

2.13 Summary

Developing a helical antenna for communication in aircraft, the main objectives are to obtain high gain, large bandwidth, and to ensure circular polarization. These antennas are meant for supporting efficient transmission and reception of the signals in motion, avionic. The number of turns, pitch angle, diameter and other such parameters are optimized for performance. Many systems such as ADS-B and GPS incorporate helical antennas for effective communication between the aircraft and the ground. Its streamlined design and functionality offers efficiency required by current air traffic requirements. This means they are important in improving aerial communications and safety.

Chapter 3

Software Requirements Specification

3.1 Functional Requirements

The antenna system must reliably receive and transmit signals at the required communication frequencies, ensuring consistent performance. It should provide a radiation pattern that offers uniform coverage in all directions, eliminating signal dead zones. The system needs to operate with high efficiency, minimizing power consumption while maintaining effective communication. Additionally, the antenna must integrate seamlessly with existing software platforms for signal processing and satellite image decoding. It should be adaptable to various aircraft types and operational environments, ensuring versatility. The antenna design must also ensure durability and reliability, capable of withstanding harsh environmental conditions such as extreme temperatures and vibrations.

3.2 Non-Functional Requirements

- Integrity - The application is designed in the integrated development environment so that all the packages hold most of the source file showing maximum integrity in the entire structure.
- Portability - The application is developed in open-source GNU software.
- Extensions - This software can gain new capabilities without any major alteration to the existing architecture.

- Modularity-This unit of software consists of well defined independent components that contribute to maintainability better. The components could be implemented and tested in isolation before being integrated to form the desired software system. This allows work to be divided among team members at any point in a software development project.

- Reliability: The software can do a required function under stated conditions for a particular time period.

- Software Reusability: The software could be add on with further features and changes with very little or no change at all.

3.2.1 Safety Requirements

The antenna must ensure reliable signal transmission and withstand harsh environmental conditions like temperature and vibration. It must comply with aviation safety standards, including electromagnetic compatibility. Materials used should be fire-resistant and safe for aircraft use. Rigorous testing is required to ensure performance under various conditions and support emergency communications.

3.3 Hardware and Software Requirements

• Hardware requirements: Antenna needs a 2-inch diameter pipe, approximately 4 feet in length, to serve as the main structural element of the antenna body. and a $\frac{1}{2}$" pipe which should be about 6 feet as the 'supports'. To top off the "body," a 2" PVC cap will be required. Furthermore, it will also be crucial to procure a BNC to Coax Cable Adapter, an MCX to BNC Cable Adapter, BNC to Coax and MCX to BNC cables in order to make the signal connections.

• Software requirements: Regarding the software requirements, the system shall employ SDR SHARP for signal processing, WXtoImg for weather satellite image decoding, and the Python programming language with its accompanying packages for writing scripts and performing automation in the maneuvers of the antenna system.

3.4 Performance Requirements

The antenna must ensure reliable signal transmission at the ADS-B frequency of 1090 MHz with adequate range. It should operate efficiently, minimizing power loss, and support a wide frequency range for various communication bands. The antenna needs an omnidirectional radiation pattern for uniform coverage in all directions. It should offer a gain of at least 3.05 dB at 1090 MHz for effective communication. The design must be compact, lightweight, and durable to withstand harsh environmental conditions.

3.5 Summary

The development of an optimized helical antenna for weather forecasting and aircraft surveillance applications has the potential to significantly enhance data reception and transmission. By addressing the limitations of current systems, including limited communication range, signal loss, and atmospheric interference, the optimized helical antenna improves the accuracy of weather forecasting and the reliability of aircraft tracking.

Chapter 4

Helical antennna design

4.1 Materials and plans

PVC piping in two sizes:
2” pipe roughly 4’ in length for the ”body”
1/2” pipe roughly 6’ in length for the ”supports”
2” PVC Cap for the top of the ”body”
2”PVC Glue/Cement
BNC to Coax Cable Adapter
MCX to BNC Cable Adapter

Figure 4.1: Materials used

4.2 Holes and supports

The process outlined involves creating a precise cutting template for a PVC Quadrifilar Helix (QFH) antenna to receive signals. This template is essential for accurately marking and drilling holes in the PVC tubing, ensuring proper alignment and spacing of antenna elements. Here's a summary of the steps and considerations:

1. **Template Creation**: Utilize a template specifically designed for the QFH antenna. Print the template in actual size without scaling options enabled, ensuring accurate dimensions. Enhance durability by reinforcing the template with clear packing tape.
2. **Cutting the Template**: Use an x-acto knife to carefully cut out the holes from the template. This precision ensures that the holes are accurately positioned and maintain 90° angles, crucial for optimal antenna performance.
3. **Marking Hole Locations**: Wrap the template around the PVC tubing, ensuring the holes align correctly at the top or middle, depending on preference. Lightly mark the hole positions as a preliminary check before committing to drilling.
4. **Final Marking and Measurement**: Double-check distances between holes to avoid placing them too close to edges or connectors. Use colour coding for accuracy, ensuring that corresponding holes for each section of the antenna are properly aligned.
5. **Drilling Holes**: Once satisfied with the alignment, proceed to drill the marked holes in the PVC tubing. Use a drill press for best results, ensuring perpendicular holes.
6. **Testing and Adjustment**: Test-fit 1/2" PVC supports into drilled holes to ensure a snug fit.Mark each hole with corresponding colour coding for easy assembly.

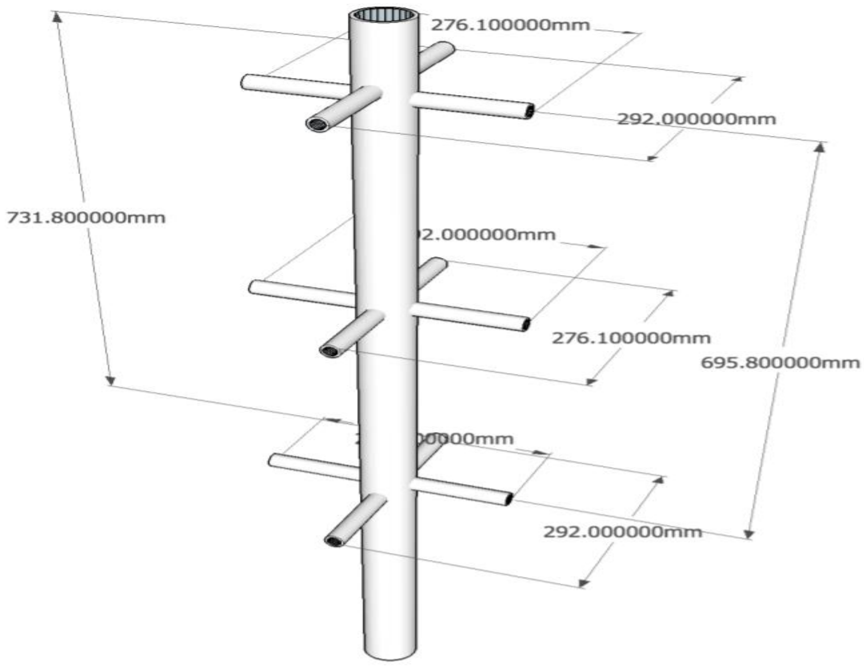


Figure 4.2: Reference Design

4.3 Wiring

the wiring process for the PVC QFH antenna involves meticulous planning and referencing detailed diagrams to ensure accurate assembly. Each step, from drilling holes in the centre supports to threading the coaxial cable and other wires according to color-coded instructions, is critical for achieving optimal antenna performance.

1. **Diagram Reference**: Begin by referring to color-coded diagrams to understand the wiring layout. These diagrams clarify how each wire and the coax cable should be threaded through the antenna structure.
2. **Drilling Holes:** Drill holes in the canter supports of the antenna to allow wires and the coaxial cable to pass through. This step ensures that cables are neatly integrated into the antenna structure.
3. **Coax Cable Handling**: Thread the coax cable first, following a counter-clockwise path from top to bottom. Mark contact points with the antenna structure in blue for clarity and alignment verification.
4. **Wiring Order**: Thread the remaining wires (Blue "Big Loop" B1, Red

B2, Yellow ”Small Loop” S1, Green S2) according to the wiring diagram. Ensure connections are made as specified to maintain correct polarization and signal integrity.

5. **Soldering:** Use flux and appropriate soldering techniques to secure connections, especially with the thick 12-AWG wires and coax shielding. Carefully manage heat buildup to avoid damaging components.

6. **Wire Management**: Secure wires along the supports using plastic zip ties and tape. Ensure wires follow a natural, curved path from top to bottom support to prevent strain and maintain alignment.

7. **Final Checks:** Double-check all connections and alignments before finalizing the assembly. Ensure wires are securely fastened and do not interfere with each other or the antenna structure.

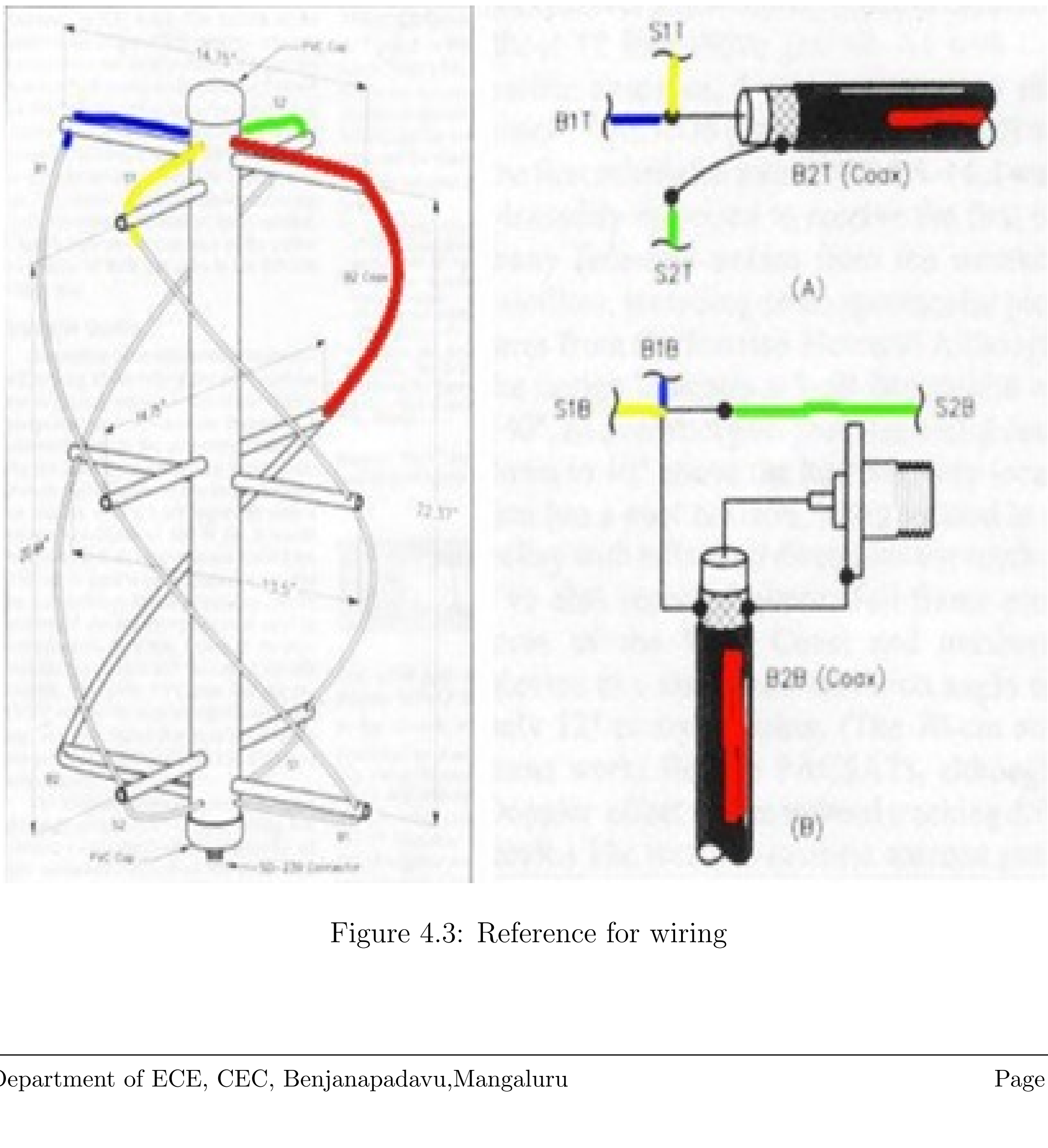


Figure 4.3: Reference for wiring

Chapter 5

Implementation

5.1 Sequence diagram

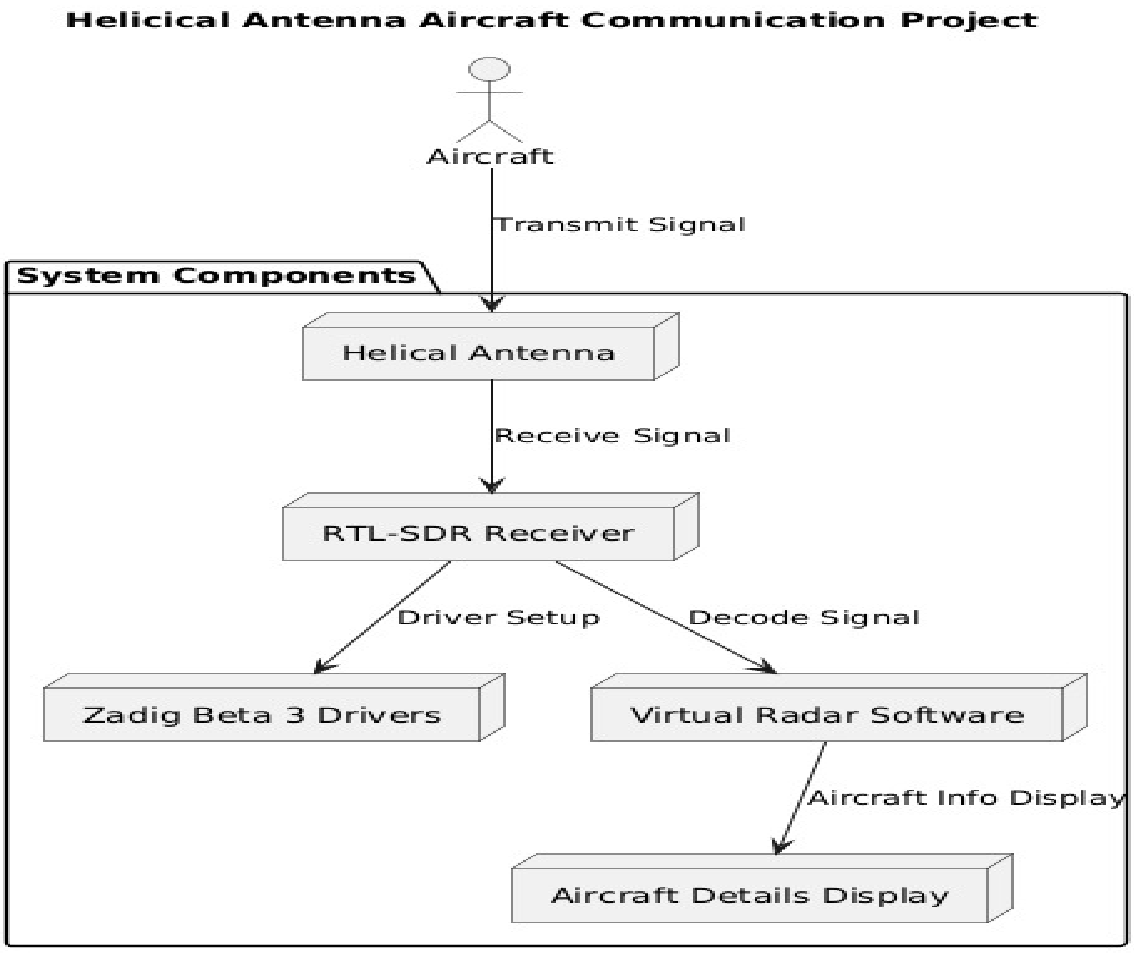


Figure 5.1: Helical antenna aircraft communication sequence diagram

Helical antenna airborne communication has set up equipment for receiving and decoding aircraft signals that are displayed in various systems as shown in the sequence diagram detailing several surviving steps of this process.

The process begins with an aircraft transmitting critical flight information, such as its location, altitude, and speed. These signals are received on the ground using a helical antenna, which is the first hardware component in the system. The antenna is specifically designed to provide directional and high-gain properties for efficient reception of RF signals transmitted by aircraft flying.

These signals are then collected and filtered before being sent to the RTL-SDR. An RTL-SDR, is a Software Defined Radio receiver, is an important block present within this setup, which digitizes the RF signals so that the received radio signals are analyzed further using software. Using this configuration, integrating into a computer is done by installing Zadig Beta 3 Drivers.This provides the required interfacing to run the hardware with software.

When a signal has been received and converted to digital form, it is then processed by the Virtual Radar Software application for decoding. There are other details related to flight that the software picks up, and the major ones include location coordinates (usually latitude and longitude), altitude, speed, and other information.

After decoding, the data is subject to more processing for visualization and is presented through an Aircraft Details Display. The final outcome appears in a clear graphical form that integrates maps and even forms the basis for monitoring and tracking aircraft live. This new way aids situational awareness, as well as efficient tracking of aviation details.

5.2 Flow diagram

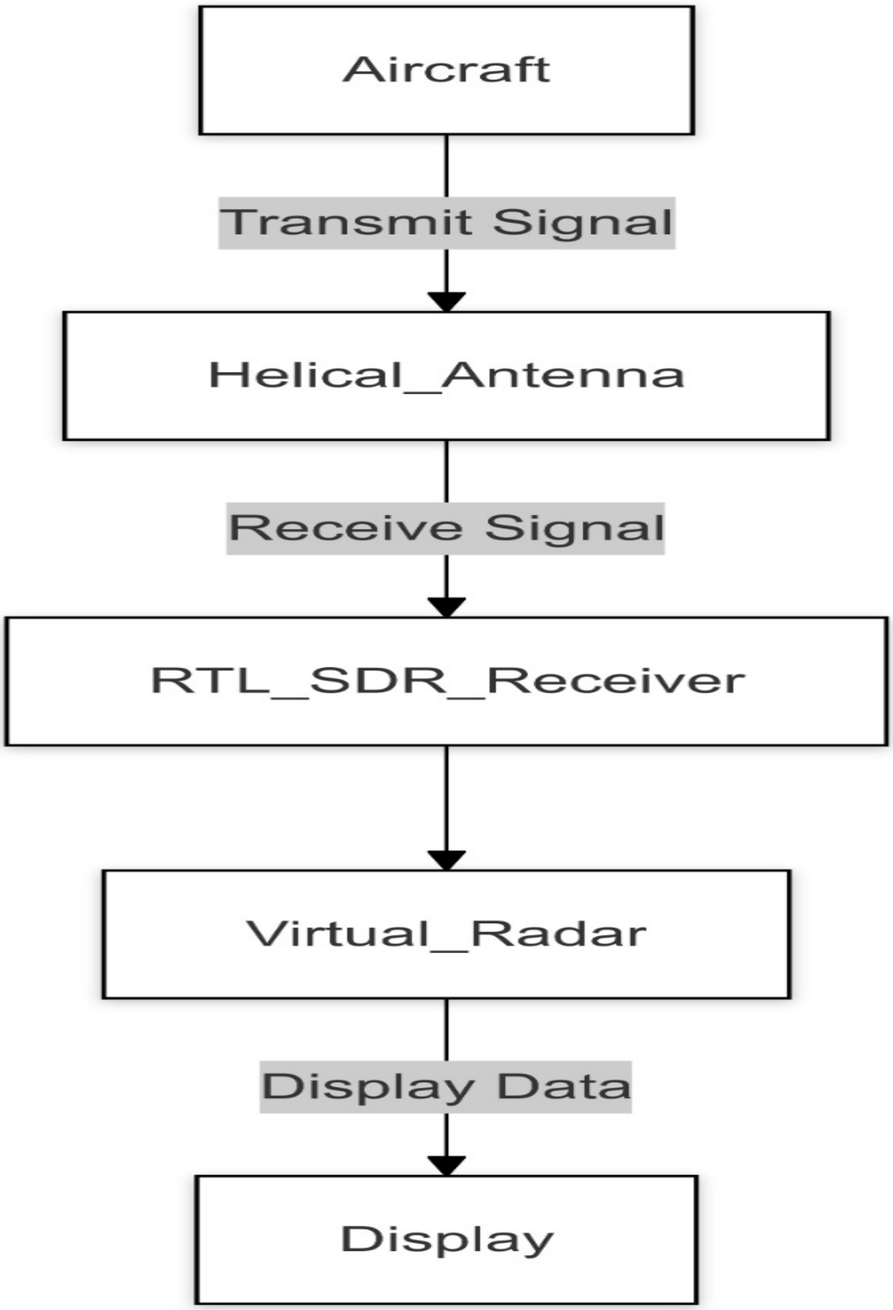


Figure 5.2: Flow diagram

- Aircraft: The procedure initiates relaying some important information regarding the flight from the aircraft, which includes geographical position, altitude, speed, among others. The information is delivered as radio frequency (RF) waves that are received and processed on the ground.

- Transmit Signal: The aircraft transmits RF signals with flight data embedded in it. The RF signals would fall into certain aviation frequencies. Through these signals, data is tracked and monitored by ground systems in real-time.

- Helical Antenna: The first hardware component is a helical antenna. It is found to effectively capture RF signals from the aircraft primarily due to the directional and high-gain properties. Thus, this guarantees reception of a strong signal with the minimum rejection.

- Receive Signal: Now, the transmitted RF signals are received by the helical antenna; the signals are filtered and readied for processing. This marks the connection to the next system stage from the antenna.

- RTL-SDR Receiver: The RTL-SDR converts RF signals into digital form. It links up with a computer by drivers like Zadig Beta 3.

- Virtual Radar: Virtual Radar is the software responsible for decoding these digital signals.This data is then categorized, allowing for visualization and subsequent utilization in further applications or analyses.

- Display Data: Processing for display of the flight information is applied to the data. This step organizes the output for easy reading and interpretation. Thus, this ensures that the ending output is organized and elucidating.

- Display: The final display would be the aircraft details in graph form. This is usually supplemented with maps to keep track of the movement in real-time.

5.3 Software Tools Used

5.3.1 Zadig

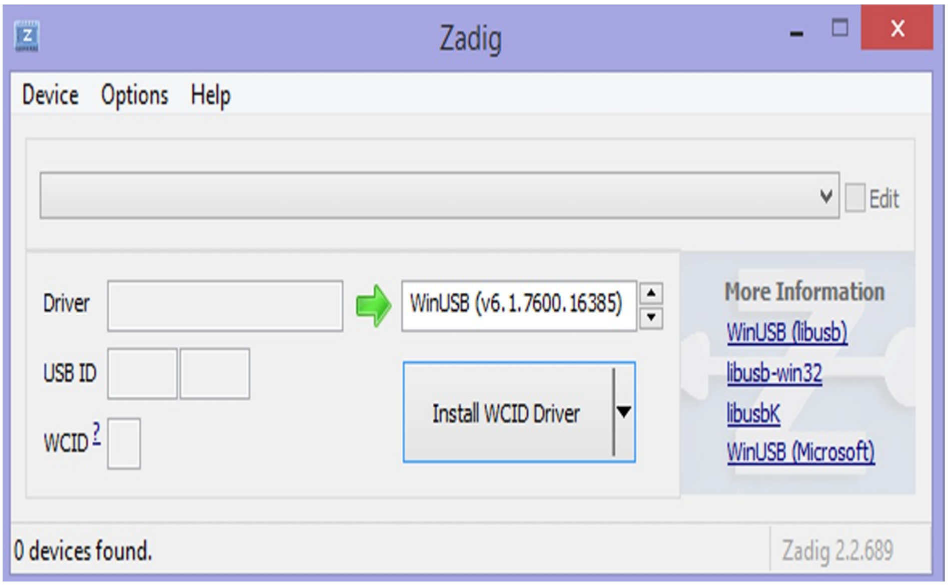


Figure 5.3: Zadig

- Zadig's Mission: Zadig installs USB drivers that enable the use of RTL-SDR dongles, allowing ADS-B signals at 1090 MHz to be received for tracking and monitoring aircraft.
- Procedure of Driver Installation: Download Zadig, connect the RTL-SDR dongle along with a 1090 MHz antenna to the computer After opening Zadig, list all devices and select RTL-SDR as the device to install WinUSB as the driver. Press on ”Install Driver” to finish the installation in a few seconds.
- Result of Driver Installation: Thus, the RTL-SDR dongle will work perfectly with all applications decoding ADS-B in order to process aircraft data.
- Decoding ADS-B Signals: If set well, this would decode flight parameters like position, altitude, and speed and enable real tracking in real time.

- Significance of Zadig: Thus, Zadig makes devices and applications have a bridge to an intermediary enabling their translated function in radio frequency applications.
- Visualization Tools: Tuned antennas and software have been coupled with data such as that from Virtual Radar Server for visualization of air traffic in real-time.
- Impact: Zadig turns the RTL-SDR dongle into a very good ADS-B receiver, which is necessary for any aircraft tracking system.

5.3.2 RTL1090

Figure 5.4: RTL1090

1.Purpose of RTL1090 Software: ADS-B signals broadcasted by an aviation communication system (1090 MHz) are decoded by RTL1090. This decoded information helps to track an aircraft live; extracts data like position, altitude, speed, etc. from these signals.

2.Execution Process: Simply connect the RTL-SDR dongle to the computer. And then, run either rtl1090.exe or rtl1090.beta3.exe to start decoding signals. This software decodes real-time incoming ADS-B signals and beautifully extracts the data pertaining to various aircraft.

3.Real-Time Tracking: The decoded information is useful for real-time tracking of aircraft along with valuable data for air traffic monitoring purposes.

4.Visualization Integration: Integrate tools like Virtual Radar Server with RTL1090 to visualize decoded aircraft data. The interactive map effectively shows real-time aircraft positions and movements, plus any other details derived from the measurement of the 1090 MHz signal.

5.Coverage and Range: Depending on the RTL-SDR dongle and the right antenna configuration, this might bring tracking either of local airports or worldwide.

6.Efficiency and Accessibility: Thus, for tracking an aircraft, the combination with RTL-SDR will give a very efficient, cheap solution. It best suits enthusiast pilots, researchers, and persons keen about traffic data.

7.User Experience Enhancements: It is worth noting that combining RTL-1090 with a virtual radar server can transform the experience into an interactive, educational, and engaging one. This combination opens up new possibilities, creating a powerful tool for monitoring air traffic with a wide range of capabilities.

5.3.3 Virtual Radar Server

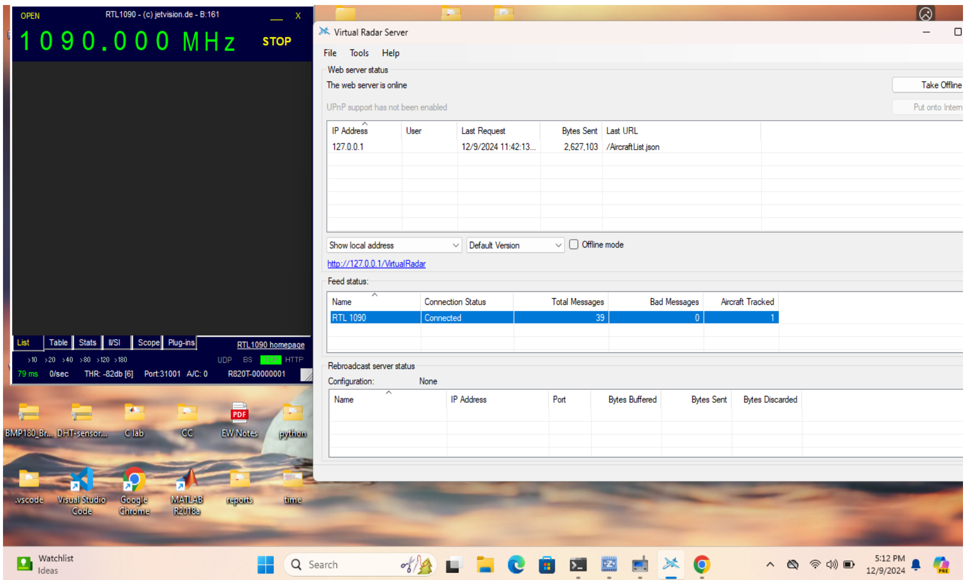


Figure 5.5: Virtual Radar Server

Virtual Radar in Aircraft Communications Using Helical Antenna Virtual radar based on helical antenna marks an evolution in the way aircraft communicate with radar systems. The virtual radar processes the signals received through the antenna into visualization data like aircraft positions, altitudes, and trajectories. This type of radar function simulation has been more widely employed in modern aviation systems for its efficiency and cost-effectiveness.

The helical antenna has been selected as the primary signal receiver for our project. The antenna is known for its high gain, circular polarization, and broadband characteristics, making it very much applicable for dynamic cases of aerial reception, especially when the antenna constantly changes orientation. This includes Automatic Dependent Surveillance-Broadcast (ADS-B) signals that provide the identity of the sensed aircraft besides route, callsign, ICAO code, altitude, speed, and heading.
The helical antenna integration with virtual radar is a standard process for aiding the aircraft in better accuracy tracking and monitoring all the precision:

1. Receiving the signal: The helical antenna receives ADS-B signals from flying aircraft and offers an obviously effective reception of signals through enough circular polarization and wide bandwidth.

2. Decoding the signal: The SDR hooks up the received signals into decoding and isolates the required items as location, altitude, and speed from the ADS-B signals.

3. Data visualization: The decoded information is processed and finally presented into virtual radar wherein it gets visualized in the real-time, such positions of the aircraft, flight paths, and more.

Virtual radar effectively reduces the requirement for traditional bulky radar within the institution infrastructure as it is shaped up with more compact, economically viable, and better developing alternatives. Therefore, this leads to better air traffic monitoring that is simpler for the professionals involved in aviation as well as aviation enthusiasts.

5.4 Hardware used

5.4.1 BNC to Coax Cable Adapter

BNC to Coax Cable Adapter is a purpose-built small equipment to connect BNC devices to common coaxial cables. BNC is a durable type of quick connect and disconnect connector that is popular in RF- applications like video and testing. Coaxial cables are also found in various applications such as networking, antennas, and signal transmission because of their lowered effective signal loss. An adapter used to connect a coax cable to an antenna. For instance, an RTL-SDR dongle in aircraft tracking systems would need a BNC to coax cable adapter to connect it to a 1090 MHz antenna. Very important for RF communication, video observing, and test applications because it transfers signals seamlessly

Figure 5.6: BNC to Coax Cable Adapter

5.4.2 RTL-SDR 1090 MHz Hardware Setup

RTL-SDR 1090 MHz Hardware Setup Assembling the components required for connecting the RTL-SDR dongle in order to receive ADS-B signals at the frequency of 1090 MHz is done with attachment of certain key items. This includes the installation of helical antenna offering high gain and circular polarization to receive signals from aircraft. The antenna is attached to the RTL-SDR dongle via coaxial cable, such that strong signals are transmitted. This dongle is then plugged into the appropriate USB port on the computer. The components are optional yet may also include the Low-Noise Amplifier (LNA) enhanced to boost signals regarded as weak..

Figure 5.7: RTL SDR 1090

5.4.3 MCX to BNC Cable Adapter

MCX to BNC Cable Adapter is used to connect devices with a Micro Coaxial Socket to BNC sockets. Making it possible for smaller electronic devices such as GPS receivers, wireless communication systems, and some Software Defined Radio (SDR) dongles to use an MCX connector-its compact, lightweight design. The BNC connector is larger as well-known for its secure, fast bayonet-lock design commonly found in RF (radio frequency) applications, video systems, and test equipment.

The MCX-BNC connector is highly convenient for connecting MCX-outletted devices, such as SDR dongles, to BNC antennas or other testing equipment. In applications like aircraft tracking or radio signal monitoring, this connector allows for the attachment of competitive BNC antennas to SDRs with MCX connectors, enhancing signal reception and overall performance.

The ability to communicate among all these varied types of connectors will make the MCX to BNC Cable Adapter a perfect choice for versatility and reliability in its communications, testing, and signal processing functions. Whatever may be the function, MCX devices integrate seamlessly into professional-grade equipment,improving both their utility and application across various use cases.

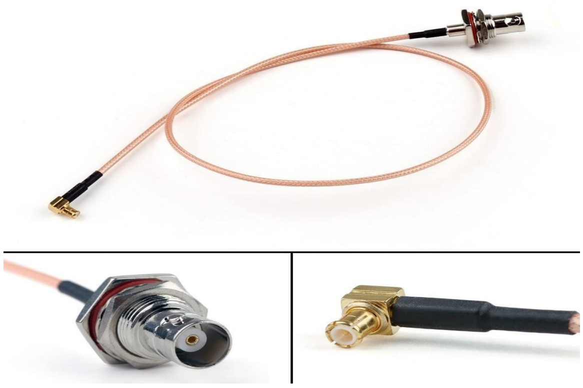


Figure 5.8: MCX to BNC Cable Adapter

5.5 Summary

To receive ADS-B signals at 1090 MHz from an aerial source, the helical antenna is presumably the most suitable without question, considering high gain, circular polarization, and wide bandwidth. In hardware configuration, the antenna is linked to RTL-SDR dongle through coax where it captures signals transmitted by the computer for processing into good software like SDR or Virtual Radar Server which decode sources into some values related to aircraft like position speed altitude and heading. Live tracking and monitoring become possible this way, hence bringing more information on what happens in the airspace to the aviation enthusiasts and professionals.

Chapter 6

Result and Discussion

6.1 Result

Figure 6.1: Final design of helical antenna

The final design of the helical antenna for aircraft communication is optimized for receiving ADS-B signals at 1090 MHz. Its helix-shaped wire provides circular polarization, ensuring reliable signal reception from aircraft in varying orientations. The antenna is designed for high gain and broad bandwidth, capturing weak signals over a large area. It is ideal for dynamic aerial environments, handling rapid orientation changes. The antenna connects to an RTL-SDR dongle via coaxial cable, transmitting signals to a computer for decoding and visualization using software like SDR or Virtual Radar Server, enabling real-time aircraft tracking

6.1.1 Final output

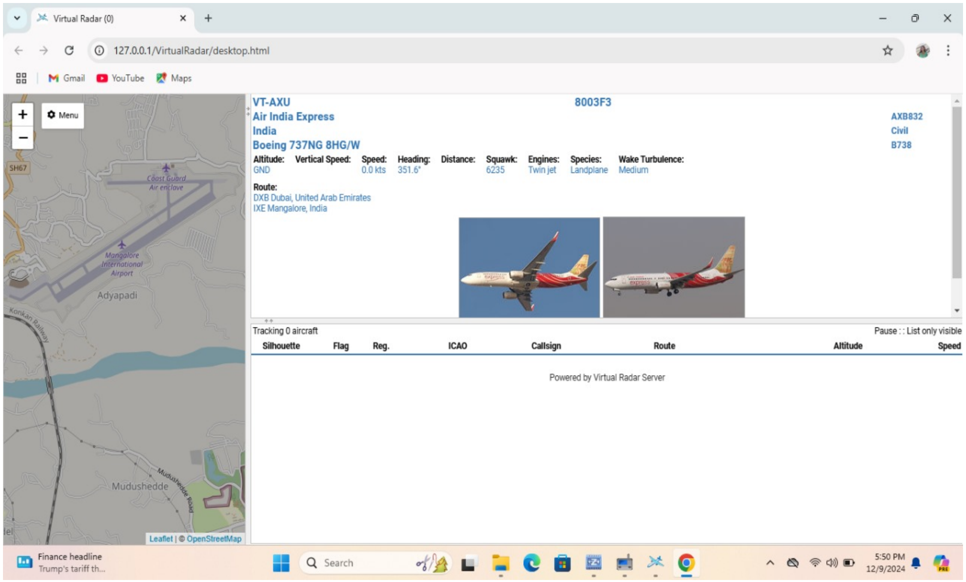


Figure 6.2: Virtual Radar Server running locally

The above image Virtual Radar Server running locally and tracking aircraft operated by Air India Express. The displayed aircraft is registered as VT-AXU, a Boeing 737NG 8HG/W - a twin-engine jet categorized as a land plane under medium wake turbulence classification. Under civil aviation, it falls under the ICAO type code B738. The Mode-S Hex Code of the aircraft is 8003F3: that is its unique identifier for tracking purposes. This flight, operating under the call-sign AXB832, is a scheduled operation from Dubai International Airport (DXB) in the United Arab Emirates to Mangalore International Airport (IXE) in India.

The available data would indicate that the aircraft is currently on ground (GND), with a 0.0-knot recorded speed, indicating it was not moving. Also, it has a heading of 351.6°, pointing somewhere else, and the transponder squawk code is set to 6235. The information provided shows no vertical movement, reinforcing that the plane is either waiting for departure, is being serviced, or has just completed its flight. This aircraft is the Boeing 737NG which has proved to be a very reliable and efficient workhorse and is commonly used for flights to and from medium-haul distances. The Virtual Radar Server provides real-time processing of ADS-B data, offering live details on aircraft speed, altitude, heading, and position. The interface enhances the tracking experience by showcasing images of Air India Express Boeing 737, with its distinct red, white, and golden livery, helping users easily identify the aircraft. The map on the left displays Mangalore International Airport, with runway markings and nearby places, powered by OpenStreetMap for real-time location data. This geographic visualization allows users to track aircraft, such as VT-AXU, currently on the ground, and monitor its operational phase and journey.

6.2 Summary

The helical unit did an efficient capture of the airborne aircraft communications channel signals of 1090 MHz. The structure of this helical antenna enabled the reception of circularly polarized waves irrespective of aircraft attitude. It gave the best measurement of weak signals of dynamic areas with its high gain and broad bandwidth.

Given the RTL-SDR dongle, the whole setup now understood the decoded ADS-B message, which included crucial data such as position, altitude, speed, and heading. By feeding such information through SDR along with Virtual Radar Server, one could visualize these signals live over an interactive map complete with detailed flight information.

Testing was conducted on an Air India Express Boeing 737NG (VT-AXU) to analyze its live status using its Mode-S Hex Code via Virtual Radar Server. The analysis revealed that the flight was stationary on the ground, with a recorded speed of 0.0 knots.

Such a simple yet inexpensive scalable system provides portability in current radar systems and makes indoor air traffic monitoring feasible anywhere for aviation enthusiasts and professionals. Such a system also demonstrates that the price of the components does not always need to cost much to offer reliability.

Chapter 7

Conclusions and Future Work

7.1 Conclusion

The helical antenna is a practical and flexible option for aircraft communications because of its high gain, broad bandwidth, and circular polarization. These features make them ideal for airborne communication applications, primarily when minimizing such mismatches between signal strength and polarization is necessary. In addition, its very simple design and fabrication make it a advantageous and competent solution for long-distance communication at high frequency. Not only helical antenna is a cost-effective solution, but it is also very high in performance. All of these advantages make it an optimum antenna for aircraft communication systems.

The installation of helical antennas has the ability to improve reliability of communications in the aircraft and satisfy the demands of currently emerging technology in high advanced aviation. Because of the endless development of aviation, the necessity for even better and dependable communication systems could be somewhere around the corner. These features and advantages of helical antennas make them an efficient solution for superior air travel by making communications safe and efficient. Therefore, the use of helical antennas will ensure that the aviation industry maintains reliability in communication, lower costs, and overall enhanced safety. It is compact and lightweight, which makes it easy to install on different types of aircraft, including unmanned aerial vehicles (UAVs).

7.2 Future Work

- Optimization of Design Parameters: Refine the sound pitch angle, wire diameter, and number of turns, among others, to enhance performance for aviation-specific frequencies.
- Miniaturization: Design small, lightweight antennas for fixing into limited spaces on aircraft without compromising efficiency.
- Integration with Advanced Materials: Use new materials such as meta materials and flexible substrates to enhance durability, as well as mechanical and electrical performance.
- Beamforming Capabilities: Incorporate adaptive beam-steering to enhance signal quality and improve robustness in dynamic conditions.
- AI-Driven Performance Monitoring: Use artificial intelligence to monitor antenna performance as it occurs and predict possible failures for smooth operation.
- Environmental Adaptation: Design an antenna that withstands extremely high and fluctuating temperatures in altitudes for reliable operation.
- Cost-Effective Fabrication: Develop efficient and scalable manufacturing methods to produce antennas for widespread adoption in commercial and military aviation.
- Testing and Validation: Conduct extensive real-world testing on aircraft to validate the antenna's performance and identify areas for improvement.
- Modern System Integration: Future-proof functionality with modern avionics and satellite communications systems to provide connectivity.

References

[1] M. A. Alzabidi et al. “Broadband High Gain Helical Antenna for Satellite Communication Applications”. In: *2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (AP-S/URSI)*. IEEE. 2022, pp. 2038–2039.

[2] A. R. Djordfevic et al. “Optimization of helical antennas [antenna designer’s notebook]”. In: *IEEE Antennas and Propagation Magazine* 48.6 (2006), pp. 107–115.

[3] F. Firdaus et al. “Rectangular Monopole Antenna Design for ADS-B Application”. In: *Proceedings of the 11th International Applied Business and Engineering Conference, ABEC 2023*. Presented on September 21st, 2023, in Bengkalis, Riau, Indonesia. Feb. 2024.

[4] A. H. Kelechi et al. “The recent advancement in unmanned aerial vehicle tracking antenna: A review”. In: *Sensors* 21.16 (2021), p. 5662.

[5] S. D. Keller and S. J. Weiss. “Quadrifilar helix antenna for enhanced air-to-ground communications”. In: *2015 USNC-URSI Radio Science Meeting (Joint with AP-S Symposium)*. IEEE. 2015, pp. 336–336.

[6] S. H. Lee et al. “Protection method for data communication between ADS-B sensor and next-generation air traffic control systems”. In: *Information* 5.4 (2014), pp. 622–633.

[7] H. Malik et al. “Performance Analysis of ADSB Signal Receiver SDR for Low Cost ADSB Mini Radar”. In: *2024 International Electronics Symposium (IES)*. IEEE, Aug. 2024, pp. 245–250.

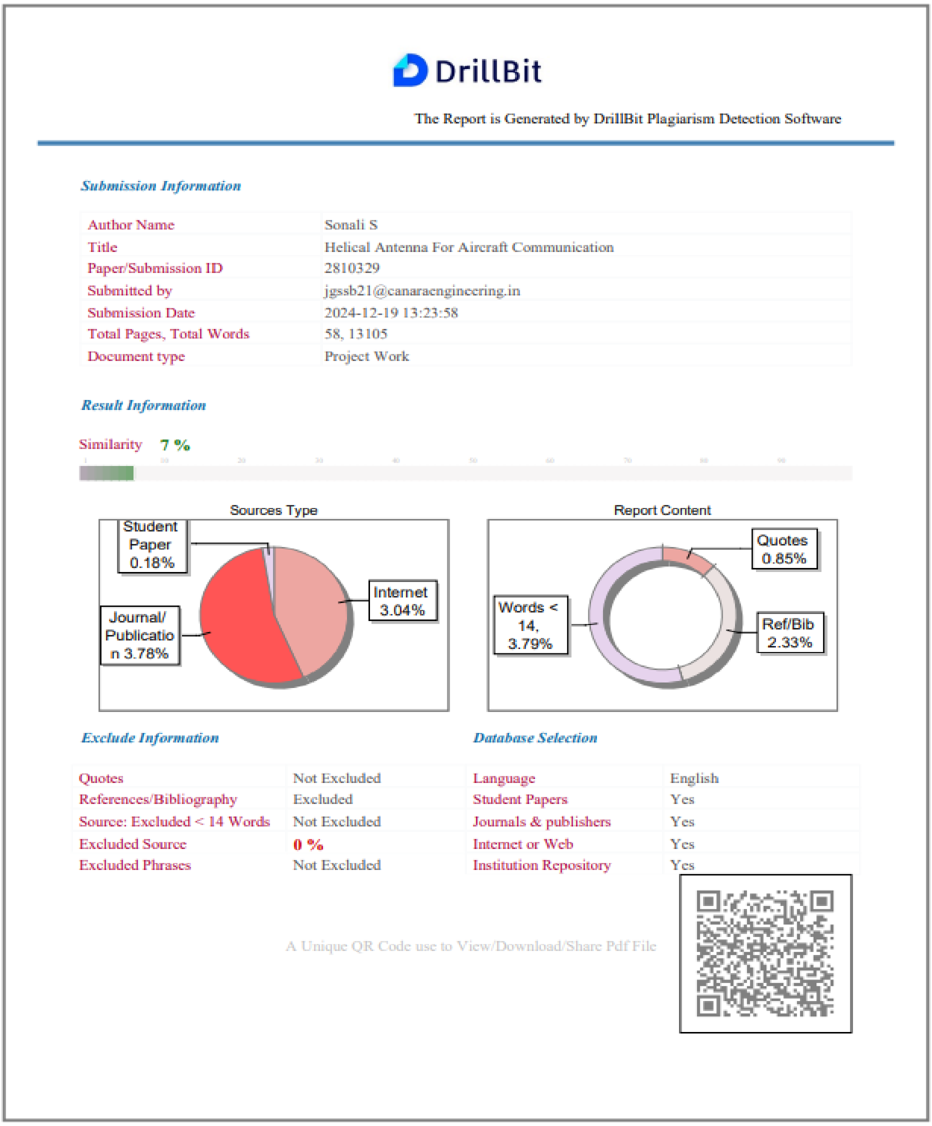
[8] X. Wang. “Receiving and processing ADS-B signals for aircraft tracking”. Bachelor’s thesis. Universitat Politècnica de Catalunya, 2019.

[9] Z. Wu, T. Shang, and A. Guo. “Security issues in automatic dependent surveillance-broadcast (ADS-B): A survey”. In: *IEEE Access* 8 (2020), pp. 122147–122167.

[10] X. Zhang et al. “Aircraft monitoring by the fusion of satellite and ground ADS-B data”. In: *Acta Astronautica* 143 (2018), pp. 398–405.

Appendix A

Drill-bit/Trunitin Plagiarism Report


DrillBit

The Report is Generated by DrillBit Plagiarism Detection Software

Submission Information

Author Name	Sonali S
Title	Helical Antenna For Aircraft Communication
Paper/Submission ID	2810329
Submitted by	jgssb21@canaraengineering.in
Submission Date	2024-12-19 13:23:58
Total Pages, Total Words	58, 13105
Document type	Project Work

Result Information

Similarity 7 %

Exclude Information

Quotes	Not Excluded
References/Bibliography	Excluded
Source: Excluded < 14 Words	Not Excluded
Excluded Source	0 %
Excluded Phrases	Not Excluded

Database Selection

Language	English
Student Papers	Yes
Journals & publishers	Yes
Internet or Web	Yes
Institution Repository	Yes

A Unique QR Code use to View/Download/Share Pdf File

Figure A.1: Plagiarism Report

Appendix B

Project Expo Details

Figure B.1: Technovation

The Project team has successfully attended Technovation : Project Exhibition of 2024-25 conducted by Canara Engineering College on 10/12/2024.