Derad

ADS-B scalability solution & Flight data processing

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Overview

Air travel has become an indispensable part of people's lives. Not only for its convenience but also because it is the fastest way to travel to distant countries, sometimes covering distances that would take days or even months by other means of transportation. Because of this, increased competition in the aviation industry and reduced flight costs have made air travel more affordable, enabling it to reach a wider audience. By 2023, the global airline industry had served approximately 4.5 billion passengers. According to data from 2021, the estimated number of planes in the air at any given time is between 15,500 and 17,500. As the aviation sector has grown and global flight numbers have increased, the necessity for better aircraft tracking and security has become more critical. The need to ensure passenger safety has driven the development of new technological advancements. This is where ADS-B (Automatic Dependent Surveillance-Broadcast) technology comes into play, which enhances aircraft tracking and improves the efficiency of air traffic management.

ADS-B technology helps by providing real-time data on an aircraft's speed, altitude, and position, making it possible to track aircraft more accurately and securely. Despite its benefits, achieving global ADS-B coverage remains a significant challenge. Traditional deployment methods are often hindered by high costs and logistical barriers, particularly in rural and underserved areas where ground stations are scarce. Currently, for-profit companies dominate the ADS-B ground station infrastructure, resulting in slow scalability and high recurring costs, such as land rent and maintenance. This coverage gap not only impacts aviation safety but also limits the ability to leverage ADS-B data for broader use cases, including logistics, research, and intelligence gathering. Yet, a vast untapped potential lies in decentralizing this infrastructure and incentivizing individuals to contribute to expanding ADS-B coverage. Derad Network steps in at this point and empowers individuals to establish and operate ADS-B ground stations using inexpensive and easy-to-install equipment. Participants are incentivized with DRD tokens, creating a mutually beneficial system where contributors earn rewards while enhancing global aviation safety.

By decentralizing ADS-B infrastructure, Derad Network overcomes the inefficiencies of traditional systems, enabling faster scalability and lower costs. This model improves aviation safety and creates opportunities for innovative applications of ADS-B data. For instance, researchers, journalists, and logistics firms can access a decentralized marketplace for real-time flight data, unlocking new possibilities in tracking and analysis. Derad Network transforms a complex, centralized system into an accessible, scalable solution, setting a new standard for global air traffic management

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1. Introduction to Derad Network

To understand the foundation of **Derad Network** and what it aims to accomplish, it is important first to grasp the role of **ADS-B** in modern aviation. ADS-B, or **Automatic Dependent Surveillance-Broadcast**, is a technology used in aviation that allows aircraft to determine their precise location using satellite navigation. The periodic broadcasts from ADS-B include the position, speed, and planned movements that are available to air traffic control and other aircraft equipped with an ADS-B receiver. Such real-time data allows enhancement of situational awareness, which can add to the safety of flights and assistance in more effective air traffic control management.

Despite its critical importance, ADS-B ground stations face significant challenges, particularly in rural and underserved areas. A lack of coverage in these regions poses a major obstacle to ensuring comprehensive aviation safety. However, currently, there is no incentive mechanism for ordinary people to run ADS-B ground stations. An important share of the ADS-B coverage is provided by for-profit companies. This results in some common drawbacks, such as slow scalability, high maintenance costs, and high recurring costs, such as rent for station area and UPS. Overall, there are many more drawbacks, but we can say traditional ways of deploying ADS-B ground stations are not cost- and time-efficient.

The implementation of Automatic Dependent Surveillance-Broadcast represents a critical building block for modern aviation surveillance, making the tracking of aircraft possible in real time. Building upon this technology, Derad Network looks to expand **ADS-B coverage** in underserved areas through a decentralized, community-driven approach, supported by an **incentive mechanism** that encourages participation and data sharing. This approach not only enhances coverage but also motivates individuals to contribute to improving aviation safety and efficiency.

2. Diving into the Depths of ADS-B

ADS-B stands for Automatic Dependent Surveillance-Broadcast:

- It is **automatic** because it does not require any input from the pilot or air traffic controller.
- It **depends** on gathering data such as position and speed from airplanes' GPS and other systems.
- It is used to detect and track the location of aircraft in the airspace, their altitude, and the direction they are moving, which represents **surveillance**.
- **Broadcast** refers to the transmission of data from each aircraft that can be received by air traffic control, other aircraft, or anyone with an ADS-B receiver.

2.1 ADS-B Message Structure

The ADS-B message content is 112 bits and divided into five parts. The first 8 bits indicate the data format, the next 24 bits indicate the aircraft's unique and fixed International Civil Aviation Organization (ICAO) address, the next 56 bits transmit the ADS-B surveillance data, and the final 24 bits are a cyclic redundancy check block. The 56-bit ADS-B data are subdivided into a 5-bit message type (TYPE) field, a 3-bit message subtype (SUBTYPE) field, and a 48-bit message content. The message content is an important carrier of aircraft flight status and ground target information parameters, carrying the position information, altitude information, and aircraft airspeed information of air or ground targets.

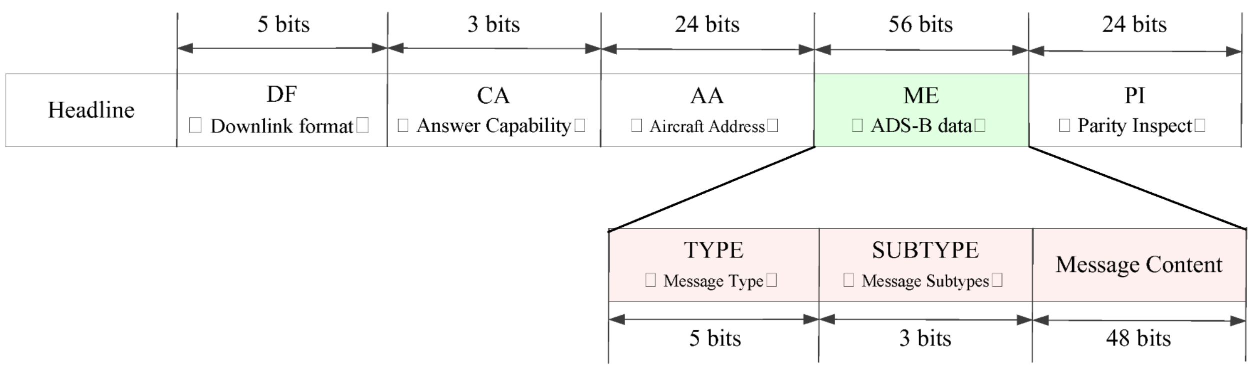

Figure 2.1: ADS-B Message Structure
(Source: https://www.mdpi.com/2076-0825/12/4/165#)

2.2 How Does ADS-B Work?

ADS-B uses equipment on an airplane to transmit information. Most airplanes are equipped with an ADS-B transponder. This device broadcasts the precise location of the aircraft every half second. ADS-B ground stations capture this information and share it with air traffic controllers.

This information can also be received by other aircraft in the sky. This real-time data enhances situational awareness, improves flight safety, and helps air traffic controllers manage airspace more efficiently. ADS-B has two modes: ADS-B In and ADS-B Out. ADS-B In enables aircraft to receive broadcasts from ground stations and other aircraft. It helps pilots build better situational awareness by allowing them to access TIS-B and FIS-B data and information directly from nearby aircraft. On the other hand, ADS-B Out enables aircraft to broadcast information such as aircraft's GPS location, altitude, and ground speed to ground stations, air traffic controllers, and other aircraft once per second.

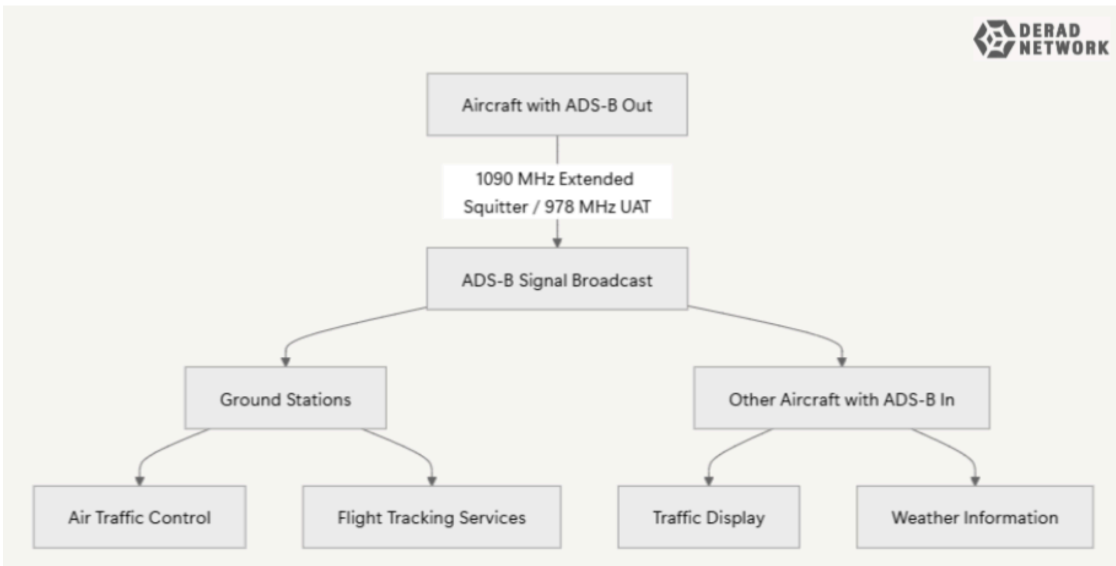

Figure 2.2: ADS-B Out System Flow

ADS-B (Automatic Dependent Surveillance-Broadcast) systems come in two types: one that uses a 1090 MHz Extended Squitter (1090ES) transponder and another that uses a 978 MHz Universal Access Transceiver (UAT). Aircraft equipped with 1090ES transponders are authorized to fly at all altitudes, whereas 978 UAT transponders are not permitted above 18,000 ft. Commercial and international flights primarily use the 1090ES (1090 MHz) system because it is mandatory for commercial aircraft and aligns with global ADS-B standards. UAT is not widely used outside of the U.S. A study conducted by the FAA (Federal Aviation Administration) stated that ADS-B technology is 30% more efficient in tracking aircraft than traditional radar systems. Because ADS-B provides coverage in areas where radar might be limited or unavailable. Compared to radar signals, which are limited to line of sight and unable to overcome obstacles like mountains, ADS-B has a simpler infrastructure; its ground stations are smaller, more adaptable, and can be placed without obstacles, providing wider and better coverage. In brief, ADS-B is a more economical, accurate, and efficient tracking technology than radar.

The best part is that **anyone can detect** ADS-B transmissions, which contain permanently assigned codes to identify aircraft, by using inexpensive equipment that can be easily installed at home. That's where **Derad Network** comes in.

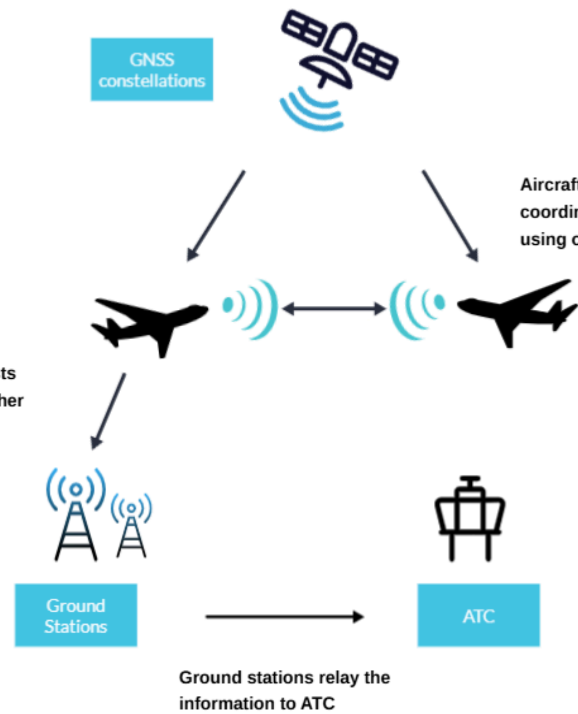

Figure 2.3: ADS-B System Diagram

2.3 Growing Scale of ADS-B Market

ADS-B is an essential technology for the aviation industry, so its market size gradually increases yearly. This system, which allows aircraft to transmit real-time information is crucial in enhancing safety and optimizing air traffic management. With its growing adoption in both commercial and general aviation sectors, the demand for ADS-B technology continues to rise. Here is some statistical data about the global market growth of ADS-B technology and analysis of its increasing significance over the years:

- The Automatic Dependent Surveillance-Broadcast (ADS-B) Market is expected to grow USD 27.86 Billion at a CAGR of 20.61% by 2020-2030

(Source:https://www.marketresearchfuture.com/reports/automatic-dependent-surveillance-broadcast-market-8420).

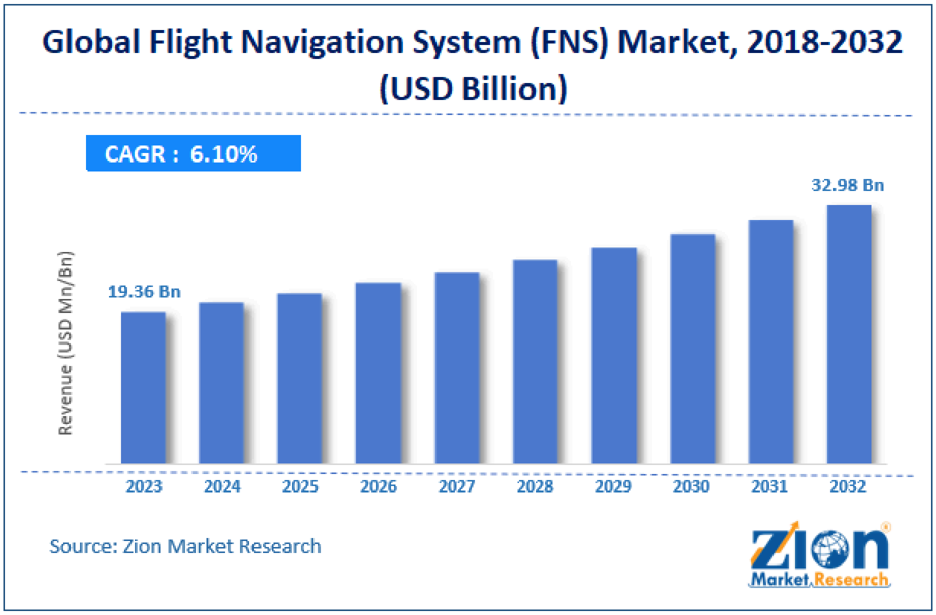

Figure 2.4: Global Navigation System Market, 2018-2032

(Source:https://www.zionmarketresearch.com/report/flight-navigation-system-market)

- According to the report published by Zion Market Research, the global Flight Navigation System (FNS) Market size was valued at USD 19.36 Billion in 2023 and is predicted to reach USD 32.98 Billion by the end of 2032. The market is expected to grow with a CAGR of 6.10% during the forecast period.

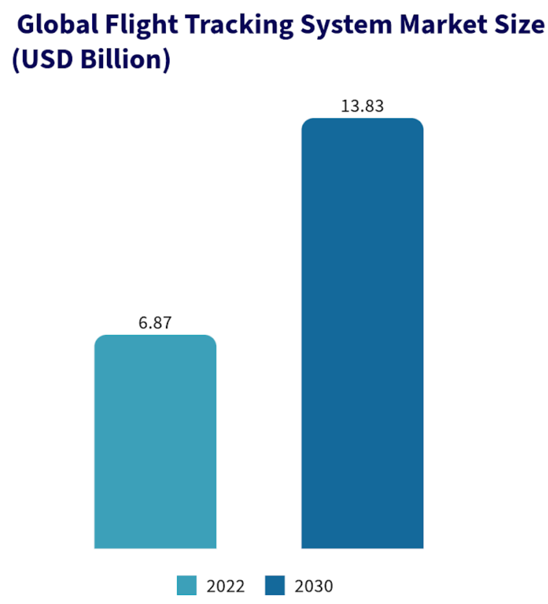

Figure 2.5

- The Global Flight Tracking System Market size was valued at USD 6.87 billion in 2022 and is projected to reach USD 13.83 billion by 2030, growing at a CAGR of 9.3% from 2024 to 2030 (Source:https://www.marketsizeandtrends.com/report/flight-tracking-system-market/).

The value chain of the Automatic Dependent Surveillance-Broadcast (ADS-B) market involves several key stages, starting with component suppliers who provide essential parts such as transponders, antennas, and GPS receivers. System manufacturers assemble these components into ADS-B devices, which then undergo stringent testing and certification processes to ensure compliance with regulatory standards. The receiver market is estimated to experience the highest CAGR growth between 2021 and 2028. Similarly, the antenna market size is expected to demonstrate remarkable growth in the future. Since ADS-B technology is a whole with its parts, the market size of these parts will directly affect ADS-B's market growth.

2.3.1 Unmanned Aerial Vehicles (UAVs) and ADS-B

The increasing integration of UAVs into airspace is driving the need for robust surveillance solutions. Hence, the development and implementation of ADS-B solutions specifically designed for UAVs will result in the growth of the ADS-B market. These solutions will ensure the safe and seamless integration of UAVs into current air traffic management systems.

The UAV volume is projected to grow from 5.24 million units in 2024 to 7.51 million units in 2029. The overall UAV(drone) Market to be USD 30.2 billion in 2024 and is projected to reach USD 48.5 billion by 2029, at a CAGR of 9.9% from 2024 to 2029 (Source:https://www.marketsandmarkets.com/Market-Reports/unmanned-aerial-vehicles-uav-market-662.html).

2.3.2 Regulatory Mandates Driving Growth in the Global ADS-B Market

The European Commission (EC) mandated that all aircraft be equipped with ADS-B Out avionics starting from December 7, 2020. In Europe, increasing investments by countries such as the U.K., Germany, and France, for airport infrastructure and air traffic management are contributing to the growth of the ADS-B market. Similarly, government regulations in regions such as the UAE, Saudi Arabia, and other countries have made it mandatory to install automatic dependent surveillance-broadcast systems on all aircraft, further driving market expansion. Additionally, the extensive helicopter fleet in Brazil is playing a significant role in boosting the ADS-B market across South America. These global regulatory mandates are driving the adoption of ADS-B technology, contributing to the growth of the ADS-B market worldwide.

2.3.3 Greener Air Travel with ADS-B

The increasing focus on reducing aviation's carbon footprint creates significant opportunities for ADS-B technology to enhance sustainability. It enables optimized flight paths, minimizing unnecessary fuel consumption and emissions, and contributing to greener and more efficient air travel. This capability not only aligns with global environmental goals but also offers cost savings to airlines, making ADS-B a critical tool in the pursuit of eco-friendly aviation.

3. What is Derad Network?

The Derad Network is a community-driven initiative focused on creating the largest and most advanced ADS-B transmission and processing system by encouraging individuals to contribute through ground stations. Unlike traditional models that typically depend on for-profit companies, Derad Network allows community members to establish and manage their own ADS-B ground stations. This decentralized approach removes the need for costly land rental and equipment expenses, making it easier and more scalable for everyone involved.
We believe that cryptocurrencies can sometimes be more effective in creating an incentivized model rather than solely focusing on decentralization, and we adopt this approach in the Derad Network. Using cryptocurrency and Layer 1 technology, we have developed an incentivized model to encourage participation. The primary goal of the **Derad Network is not merely to create a decentralized ADS-B coverage system but to address the challenge of ADS-B coverage**, particularly in rural or underserved areas, by establishing reliable and consistent coverage.

ADS-B signals have become an important source of information not only for commercial vendors and others providing flight tracking information, but also for researchers and journalists tracking aircraft movements, and firms specializing in corporate intelligence gathering. **Derad Network** takes on the aggregation and processing of ADS-B signals, creating a decentralized platform where miners contribute real-time ADS-B data to a global marketplace. Data on aircraft locations, altitudes, speeds, etc. can be bought and sold by third parties, such as airlines, air traffic controllers, or logistics companies. Derad Network offers an **incentivized mechanism** for users who host ground stations and provide the data infrastructure, to receive compensation through DRD tokens for their contributions. Users can earn income by simply setting up inexpensive equipment that collects and shares ADS-B data, creating an appealing opportunity for expanding aviation data coverage.It is important to have a large number of ADS-B ground stations for the continuity of data received from aircraft. Derad Network solves this problem by enabling people worldwide to become active contributors to air traffic while implementing this in a cheap and easy-to-install way. Community involvement is crucial for expanding ADS-B coverage, particularly in rural areas lacking traditional infrastructure. As mentioned before, radar is not cost effective and cannot be installed everywhere but this is possible with ADS-B technology. Derad Network seeks to revolutionize aircraft tracking by using decentralized **community involvement** and introducing new, advanced technologies to develop a much safer aviation environment with **better coverage**. This way, every user of this system automatically becomes a contributor to further develop this mission, which will empower aviation safety.

4. Understanding the Derad Network: Cathedral and Bazaar Models

In the context of the Derad Network, it is appropriate to recall the work “The Cathedral and the Bazaar,” written by Eric S. Raymond. The author eloquently discusses two schools of thought in the development of software. The first is the Cathedral, which stands for a closed and monolithic system because everything happens behind a closed door. The second is the Bazaar, where it is open and where communities are encouraged to participate.

The Derad Network perfectly fits within the Bazaar model. It enables people to build their own ground stations and to distribute data, making it open and decentralized. This type of participatory model encourages creativity and enables quick growth – anybody can take part without the restrictions of conventional profit-based models.

In contrast, the Cathedral model that many mainstream ADS-B providers operate within often limits participation primarily to those who own or control the system. Cathedral model is based on huge amounts of capital and controlling the processes which in most cases hinders innovation and development.

In this case, by adhering to the spirit of Bazaar, the Derad Network not only improves the coverage of ADS-B but strengthens the community as well. Trust is formed through activity, sharing of resources, and openness, consequently allowing a strong and flexible network to the needs of aviation safety.

4.1 Building the Future of ADS-B: The Need for New Models

Currently, there are two main different models: Cardinal (traditional) and Bazaar (community-based). As we mentioned above, the traditional model is used by companies. The community-based model is mostly adopted by enthusiasts and hobbyists.
There are some existing **community-driven approaches** to ADS-B today. These models are scalable but not reliable enough and future-proof. In these models, members of specific organizations run DIY/small ground stations on their properties. The main drawbacks of these models are that they lack a clear business model, fail to meet aviation authority standards, and are often not seen as reliable enough for widespread use in aviation. This model is mostly a hobby rather than a product or business, lacking a **zero-trust approach**.

4.2 Incentivized Model of Derad Network

The Derad Network Model is similar to the Bazaar model but with some very important improvements. In the Derad Model, all stations are provided by community members. The Derad Network does not own any land, rent, or devices. Instead, the Derad Network provides an incentivized mechanism, software support, and a DAO for users who want to support ADS-B coverage and create passive income. For this, they only need to install the software provided by the Derad Network on any device capable of receiving signals from 1090 MHz and sending that data via TCP. This kind of device is really easy and cheap to make. A $5 antenna can receive a wide range of signals, including 1090 MHz ADS-B. A $15 Raspberry Pi Zero has enough power to process and send that data to a decentralized network.

4.2.1 Unique Zero-Trust Approach

Trust the code, the chain, and the Chainmaker. Chainmaker (in this scenario: Derad Network) is the ultimate source of trust. It develops the code, which is open source. Code rules the system, and the system rules the data. In this trust chain, you only need to verify the code, not the data you receive at the other end. This is unique to the Derad Network. Currently, there is no ADS-B data provider that can take this kind of approach. Because participants do not need to verify each other's data individually, this approach minimizes human error and prevents malicious interference, creating a safer and more robust ADS-B network. The zero-trust model allows the network to grow organically while maintaining the integrity and security of the system.

5. Derad Network Hardware Design Philosophy

The Derad Network hardware design philosophy is heavily influenced by the KISS (Keep It Simple, Stupid) principle, emphasizing simplicity, efficiency, and accessibility. The installation and operation of ADS-B receivers can be technically demanding. This is a major problem for ADS-B coverage scalability because not everyone is tech-savvy and capable of setting up and maintaining ground stations. The issue becomes even more pronounced in rural areas, where access to emerging technologies is often limited. The development of plug-and-play ADS-B receivers is essential to address this issue. These devices' installation process must be easy and require minimal steps. For example:

1) Power up the device.
2) Connect the device to the internet.
3) Create an account in the web interface and claim the device location.

That's it. This kind of simple installation process can help us to increase coverage in rural areas and can help us reach people who don't have technical knowledge.
The device must be monolithic in design and equipped with a graphical user interface (GUI), ensuring ease of use. Additionally, the device will feature multilingual support to cater to a global user base. The antenna must be integrated into the device. The total cost of the device should not exceed 50 dollars, making it affordable for widespread use. It should be small to reduce shipping costs, ensure portability, and enable easy placement in various locations. Its compact size will allow it to be conveniently installed in different environments, making it adaptable for use in both urban and rural areas. Depending on the location and energy infrastructure, some device models may be equipped with an internal battery and 3G/4G/5G connectivity. This device model can help people run their devices during prolonged power shortages. As we mentioned, the device must come with a built-in antenna; however, the device must also have a connector to attach an external STR antenna. This is because some people may choose to dive deeper into ADS-B technology, and after learning about this technology, they may want to increase their coverage by installing a more powerful antenna. In this scenario, advanced users can expand their setup without having to purchase entirely new hardware; they can simply buy a new, powerful antenna and connect it to our existing Derad Network node. This design model ensures flexibility and scalability while contributing to increasing ADS-B coverage.
Our research into existing solutions revealed several shortcomings in the market, particularly on the hardware side. Most available hardware is sold in separate components, requiring users to purchase, assemble, and configure the system themselves. After that, users need to install the software manually to run that hardware which often involves multiple drivers and additional components. Even the more integrated software solutions on the market fail to provide a complete system, leaving users to handle the hardware setup independently.

In the Derad Network hardware design philosophy, we offer a complete solution. Hardware and software are pre-configured and bundled together. Users will only need to power up the device and connect it to the internet to contribute to the network. This seamless integration eliminates the complexity of traditional setups and lowers the barrier to entry for new users.
The Derad Network focuses on simplicity, accessibility, and integration. This approach not only empowers individuals to participate but also ensures that aviation safety and monitoring can reach even the most remote and underserved areas of the world. By addressing the pain points of existing solutions and embracing a user-first approach, we aim to revolutionize ADS-B adoption and expand global coverage, ensuring safer skies for everyone.

6. Components of Derad Network

The Derad Network is built on a foundation of interconnected components that work harmoniously. These components are essential to ensure that the network operates efficiently, provides accurate data, and delivers advanced aviation tracking and safety solutions.
The collaboration between ground stations, data processing nodes, network partitioning resilience and proof-of-accuracy mechanisms creates a robust and adaptable framework capable of extending coverage to underserved areas while ensuring reliable data and real-time insights. This integrated approach increases the overall performance of the network and turns out to be a future-proof and highly reliable solution for aircraft tracking around the world.

6.1 Ground Stations

Ground stations are one of the core components of Derad Network's infrastructure and play an important role in gathering and sharing ADS-B data. By hosting ADS-B receivers at home, users actively participate in the network, earning rewards for their contributions while enhancing aircraft tracking capabilities, especially in underserved areas.
In the first stage, the Derad Network will collect and process ADS-B data through its ground stations. Currently, ADS-B data holds significant value. A ground station with a small antenna can capture a wide range of signals. Derad Network ground stations can receive any signals within the 100 MHz to 1.8 GHz range, including LoRaWAN signals.
Ground stations set up by users are designed to passively collect ADS-B signals from over 30,000 commercial flights daily. The approach guarantees operational safety and data integrity while securely transmitting the data via IP/TCP to the Derad Decentralized Network.
Each ground station within the Derad Network is irreplaceable in its importance for enhancing aviation safety. These stations contribute by capturing and processing ADS-B transmissions, extending coverage to areas with insufficient infrastructure, and ensuring data reliability in rural and high-traffic regions.

Ground stations function as decentralized nodes that work collaboratively to create a robust and scalable network, capable of adapting to the dynamic demands of the aviation industry. This way, the distributed architecture of Derad Network allows for unparalleled flexibility and robust performance.
Derad Network develops a strong global infrastructure through a decentralized network of ground stations. This innovative architecture provides comprehensive global coverage, built-in redundancy, and exceptional resilience, thus ensuring a reliable data acquisition and processing system.

6.2 Data Processing Nodes

The Derad Data Processing Network uses a decentralized network of nodes for analysis, validation, and processing of the ADS-B data. The nodes, hosted by users around the world, transform raw data into meaningful insights. Using cutting-edge algorithms combined with distributed computing, the nodes make sure the data is accurate, consistent, and redundant.
This decentralized approach not only enhances the overall reliability and security of the data but also provides real-time insights that are essential for optimizing flight operations, enhancing aviation safety, and supporting a wide range of applications, from regulatory compliance to logistics management. Moreover, participants hosting these nodes are rewarded for their contribution, fostering a collaborative ecosystem that drives innovation and expands global aircraft tracking capabilities.

6.3 Proof of Accuracy Mechanism

To verify and guarantee the reliability of the data gathered among ground stations, Derad Network uses proof of accuracy mechanisms. These mechanisms play a crucial role in maintaining the integrity and trustworthiness of the network by verifying that the ADS-B data is both accurate and tamper-proof before it is processed or transmitted.

6.3.1 Integrating Proof of Accuracy with Zero-Trust

The concept of proof of accuracy directly complements the unique zero-trust approach within the Derad Network. The zero-trust approach ensures that users can trust the system by verifying the integrity of the code and the chain, rather than the data source itself. Both mechanisms work together to establish a framework of trust and reliability without relying on centralized authorities or intermediaries.
In this context, the proof of accuracy mechanism becomes a critical implementation layer, operationalizing this trust by verifying that the ADS-B data collected from decentralized ground stations is accurate and consistent.

Together, these methodologies eliminate the need to trust individual contributors or stations, perfectly aligning with Derad Network's decentralized architecture and vision for transparent, reliable ADS-B data sharing. By leveraging open-source protocols and cryptographic validation processes, the proof of accuracy reinforces the zero-trust principle: trust lies in the system's verifiability rather than in external participants. This integration ensures that the Derad Network can scale globally while maintaining the integrity and quality of its data, setting it apart from conventional ADS-B providers. To measure the accuracy of the data collected from decentralized ground stations, we use comprehensive formulas that account for both consistency and the continuity of the data provided. In this way, we ensure that the collected data meets the required standards of trust and validity.

The following formula helps us determine the overall accuracy of the system, which is crucial for ensuring data integrity and supporting the network's transparency:

$$A_{\text{score}} = \frac{\sum_{i=1}^{n} (w_i \cdot f_i)}{\sum_{i=1}^{n} w_i} \times 100$$

- *wi* represents the reliability of a ground station's data, determined by its frequency and consistency. Stations with continuous and frequent data have a higher *wi* score, while intermittent or sparse data results in a lower *wi* score.
- *fi* represents the accuracy of data from the *i*-th ground station, calculated by comparing it with data from other stations. The *fi* score uses a sigmoid function to reflect varying levels of consistency across the network:

$$F_i = \frac{1}{1 + e^{-k \cdot (\text{consistency}_i - b)}}$$

Consistency between ground stations is essential for calculating *fi*. It measures how closely a station's data aligns with others and is mathematically expressed as:

$$\text{Consistency}_i = 1 - \frac{1}{n} \sum_{j=1}^{n} |F_i - F_j|$$

- Where *fi* represents the accuracy score of the *i*-th station, *fj* represents the accuracy scores of the other stations, and *n* is the total number of stations.

6.4 Network partitioning resilience

Network partitioning resilience refers to the system's capability to continuously work smoothly and reliably even when parts of the network become disconnected due to technical failures, communication issues, or other disruptions. This way, the system will keep running without losing valuable data or compromising security.

For the Derad Network, this resilience is crucial. Since it relies on a distributed network of community-driven ground stations, some of these stations may occasionally be cut off or isolated from the larger system (e.g., due to internet connectivity problems or network outages). Despite this, the network must still be able to process and transmit ADS-B data from other stations, ensuring that the flow of real-time aviation data continues as smoothly as possible.

In this case, network partitioning resilience ensures that, in case of temporary problems occur, the system can:

- Maintaining data integrity by ensuring that the data collected from operational stations is consistent and reliable.
- Automatically adapt by re-routing data from active stations to cover the gaps left by temporarily disconnected stations.
- Minimize the impact on the larger system by ensuring that other parts of the network continue to contribute and function without major disruption.

This capability is especially important for the Derad Network's decentralized approach, as it ensures that the network can keep running, even if parts of the infrastructure become temporarily unavailable. To quantify this resilience, we propose a Network Partitioning Resilience (NPR) formula, which measures the network's ability to remain functional despite disruptions:

$$NPR = \frac{1}{n}\sum_{i=1}^{n}(A_i \cdot C_i \cdot R_i)$$

- n represents the total number of ground stations in the network. A_i represents the availability of the i-th ground station. This value depends on whether the station is operational. If the station is active, A_i=1; if it is not, A_i=0. This ensures that non-operational stations do not affect the network's resilience score.

- C_i denotes the importance of the i-th ground station within the network. This score is influenced by the station's coverage area and strategic significance.

For example, a station located in a rural area may have a higher *Ci* value since the main purpose of the Derad Network is to increase the ADS-B coverage area, especially in these areas. This way, Derad Network emphasizes the importance of ADS-B coverage with *Ci* in the NPR formula.

- *Ri* measures the redundancy of the *i*-th ground station, evaluating how well other stations can compensate for its absence. A high *Ri* indicates that the network has strong redundancy, meaning other stations can effectively cover the gap left by the missing station.

A high NPR score signifies the resilience and uninterrupted operation of the network. It indicates that stations are functioning effectively, critical areas are covered, and the network is capable of withstanding potential disruptions. That's why Derad Network aims to ensure the protection of aviation security by keeping the NPR score customized with this formula always high. By doing so, the system self-monitors and ensures that coverage and resilience are always maintained.

7. Derad Network Use Cases

ADS-B data serves diverse needs across various sectors. In the aviation industry, ADS-B data is needed to monitor the operational status of aircraft fleets and optimize flight routes. Media organizations can use ADS-B data to track and report on aviation incidents, such as accidents and emergencies. Similarly, cargo and logistics companies utilize this data to monitor cargo aircraft and streamline delivery processes for greater efficiency. Most importantly, governments and defense industry companies benefit from this data for detecting potential threats and ensuring airspace security. Apart from these, ADS-B data can be used in data analytics and technology companies, aviation insurance and legal firms, research and educational institutions, the tourism and travel sector, and many other industries.

Derad Network aggregates ADS-B data from **ground stations** set up by people around the world, ensures the accuracy of the data using a **proof-of-accuracy mechanism**, and leverages **network partitioning resilience** to maintain reliable operations even in the event of partial network disruptions. These components work in tandem with **data processing nodes** to transform raw data into real-time, actionable insights that are both meaningful and tradable, providing a robust and scalable solution for global aviation needs.

Besides these, during emergencies, access to real-time ADS-B data in Derad Network's infrastructure allows rescue teams to locate and track aircraft in distress quickly, reducing the critical time window and increasing safety. ADS-B's highly precise GPS-based surveillance provides more accurate information about the last reported location of the aircraft, which helps take the "search" out of search and rescue.

Derad Network has an important role in regulatory and compliance monitoring. Aviation regulators can monitor compliance with airspace regulations in real time. They can make sure aircraft are following flight paths, altitudes, and no-fly zones, and violations are logged automatically using blockchain. This real-time monitoring system not only enhances safety but also simplifies regulatory enforcement and auditing processes, providing a robust solution for maintaining compliance in the airspace.

8. Future Developments

8.1 zBAF AI

zBAF AI (Zero Buffer Advanced Flight AI) is a state-of-the-art system designed to revolutionize real-time flight intelligence by aggregating data from ground stations, local weather stations, and other key sources. Using this data, zBAF AI provides highly accurate real-time insights into flight operations to optimize decision-making processes across the aviation ecosystem.
Its decentralized architecture enhances surveillance capabilities, bringing unparalleled coverage and resilience. This architecture will make available the most critical information accessible and safe, even in the case of localized disruptions. zBAF AI's insights serve a wide range of applications, from offering governmental bodies support in airspace compliance surveillance to offering private aviation operators guidance on route optimization and safety enhancement. Moreover, the system's real-time data analysis capabilities enable predictive analytics, allowing end users to anticipate and address potential issues before they escalate. Whether it is improving air traffic flow, mitigating weather-related risks, or enhancing overall aviation safety, zBAF AI is at the forefront of developing efficiency and reliability in the aviation industry.

9. Conclusion

We are in an exciting era of technological transformation, where advancements in aviation safety, communication systems, and data processing have become more critical than ever. The demand for reliable, scalable, and efficient systems continues to rise sharply as the aviation industry gradually depends on data-driven insights. However, many centralized solutions face high costs, limited coverage, and performance vulnerabilities in underserved areas.
With the rise of decentralized technologies and advancements in ADS-B data processing capabilities, the foundation for building a new generation of aviation data networks has emerged. Derad Network leverages decentralized contributions from ground stations to create a reliable and cost-effective solution for improving ADS-B coverage, especially in rural and underserved areas. By empowering contributors to establish and maintain ground stations

Derad Network ensures a fair cost structure and leverages the strength of community-driven innovation to revolutionize global airspace monitoring. By addressing the limitations of centralized solutions, Derad Network is poised to redefine aviation safety and data transmission, ultimately delivering a superior experience for all aviation industry stakeholders.