



# **ANTI COLLISION SECURITY SYSTEM, RECENT INNOVATIONS IN ENGINEERING AND TECHNOLOGY**

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**Abstract-** This paper is focused on the anti-collision system for the aircraft using IOT technology over the big data, by using some sensors like infrared sensor, Ultrasonic sensor, altimeter etc. and Positioning System. We can determine the location of each flying object and can determine the probability of their collision. We can also save the aircrafts from collision by using the proper algorithms and dynamic location tracing techniques. We are in an era of machine learning and the artificial intelligence, and hence we can use such technologies to give us a better way of safety and decision-making ideas.

This combination of proposed sensors and data base technology aims to optimize the remote measurements, and the development of such technology that can help to build a sustainable future where anybody can fly without any danger.

**Keywords** –IOT, Infrared sensor, Ultrasonic sensor, Positioning System, Anti-collision system, Aircraft, Artificial intelligence, Machine learning.

## **1. INTRODUCTION**

The anti-collision system that is explained in this paper is a combination of big data, highly designed algorithms, positioning system and specific sensors. By using modern microchips and specially designed technologies of positioning system such as GPS by America, GLONSS by Russia, IRNSS by India etc. The system is capable of determining the location of anything with a precision of around 1-2m. The system also includes some sensors like infrared sensor, ultrasonic sensor, altimeter etc. to determine the more precise location of the aircraft in the air. This determined location will include the values of longitude, latitude and height from the sea level. So after determining the exact location of each aircraft, it will be in need to store the data temporarily of their locations to compare the locations of each aircraft with other aircrafts in that cell or block, which can be done using big data and then comparing the data of locations over very advanced computers and algorithms to check the probability of collision. Once the probability of the collision is known then by using the artificial intelligence we can determine the different ways of avoiding the collision. As a result, in such a way we can save the aircrafts from being collide and this technology can also be helpful in this rapidly increasing air traffic to save the future collisions with limited ground duty.

## **2. HISTORY**

During 1950 air travel was became a common criterion of traveling. Before that air traffic was so less that to develop an anti-collision system was of no use. In 1956 a mid-air collision resulted in 128 deaths over the Grand Canyon[1]. Due to such an accident FAA was established in 1958(Federal Aviation Administration)[2].

After the establishment of FAA there were many improvements had been done on the design of the aircrafts and the air traffic. To ensure the safety of flights as heights of the aircrafts flying in different directions was set.

For example, if an aircraft has to fly in west, it will fly at a certain height and the other aircraft that has to fly in east, must have to fly at a certain height that is different from the height of other three directions[3].

Such rules and regulations designed by the FAA, actively decreased the mid-air accidents and collisions. But there was still need of more advanced system to ensure the safety. Still after making so many attempts for the improvements in the safety of the air traffic, a very disastrous accident occur in 1978 resulting in death of 144 people over the san-dingo.

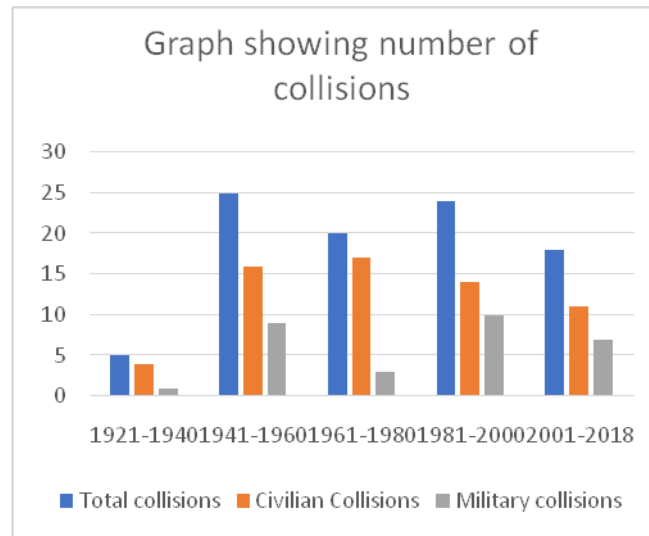
Another air collision occurred in 1986 which made the people to think again about the development of a more rigid and advanced anti-collision system, this collision caused 80 casualties.

Such air collisions convinced that aircrafts need a more advanced and accurate system that can protect against human errors, visual limitations, mechanical problems or even weather conditions, A system that can not only detect the future collision while can also suggest the techniques to avoid them.

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Years	Civilian collisions	Military collisions	Total collisions
1921-1940	4	1	5
1941-1960	16	9	25
1961-1980	17	3	20
1981-2000	14	10	24
2001-2018	11	7	18
Total	62	30	92

### 2.1 Positioning systems

A positioning system is a system that tells the location of something anywhere in its range.

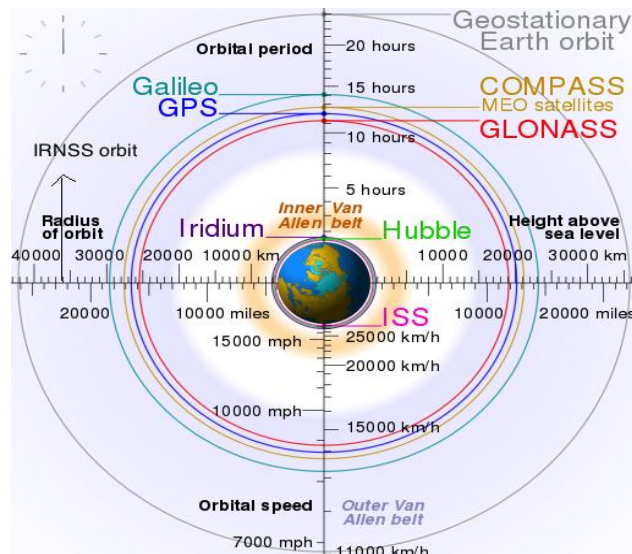


Fig 1[18]

Available positioning systems are:

Global Positioning System (GPS)

Global Navigation Satellite System (GLONASS)

Galileo

BeiDou

## IRNSS

### Quasi-Zenith Satellite System

#### 2.2 Internet of things

The Internet of things is an advance technology that can perform the connection of two or more electronic devices, such as embedded system, sensors, actuators, computers etc. Such connection lets these devices to exchange data. This technology allows to control the devices (sensors and actuators) from any remote location over the existing network infrastructure, say internet. It creates many opportunities for the future development of these type of devices that can be controlled remotely. Such technology helps in identifying each device uniquely. It not only gives the remote access to the devices, while it makes the control so faster that the lag in response is minimal or negligible. It is estimated that nearly 20-30 billion devices will be connected through this technology in the next decade.

#### 2.3 Infrared Distance Sensors

An infrared distance sensor requires very low power to operate and is used to detect some nearby objects, and also the distance from it [6]. It is a short-range sensor which makes it less useful for detection of longer distance objects. The working of IR sensor is very simple, it consists Infrared waves transmitter and a receiver. By calculating the time lap between the transmitted and the received wave, the distance between the sensor and the object is known[5].

#### 2.4 Anti-collision System

Anti-collision system is a system capable of finding the probability of the collision of two vehicles or aircrafts. This system increases the safety of and decreases the chances of percentage of human error as it can ensure the safety even in the absence of involvement of human or people[7].

Anti-collision system is not only being useful for vehicles, while it is also useful for aircrafts and the drones too. Such technology requires many hardware and software requirements to implement as a system, such as radar, GPS, Altimeter, Ultrasonic and infrared sensor etc.

#### 2.5 Altimeter

An altimeter is an instrument, which is widely used in the aircrafts to determine the height of the aircrafts from a fixed level say sea level[8].

Altimeter measures the atmospheric pressure, by using a simple principle, the higher the altitude and lower the pressure. The calibration of the altimeter uses the equation.

$$Z = cT \log(P_0 / P)$$

Where,

c is constant (depends on acc. of gravity and molar mass of air) T is absolute temperature.

P is pressure at that altitude.  $P_0$  is pressure at sea level.

#### 2.6 Ultrasonic Sensor

An Ultrasonic sensor is a device which is used to measure the distance of an object by sending sound waves and receiving it[9]. It calculates the time of flight between the sending and receiving of the sound waves sent at some fixed frequency, by determining the time of flight it calculates the distance between the sensor and the object by recording the elapsed time.

Since, the sound waves travel the distance between sensor and the object two time (once from sender to object and second from object to sender). Therefore, multiplying by half, we can get the required distance between sender and object.



Fig 2[10]

$$D = 344 * T / 2$$

Where D=Distance and T=Time

#### 2.7 Time of flight

The Time of flight is a method to measure or calculate the distance between the two objects. It measures the time delay between the round trips of the particles or waves sent by the sensor to the object [13]. As time taken by the waves is double due to the round trips, since it is divided by 2. Then the time is multiplied with the speed of waves to calculate the distance between the sensor and the object.

Formula used :-

$$D=ST/2$$

where,

D is distance, S is speed of waves, T is time taken by waves to fall back.

### 2.8 Dgps

DGPS stand for Differential Global Positioning System. It is an advancement over the existing Global Positioning System that provides better location accuracy, from the 10-15-meter nominal GPS accuracy to about 10 -12 cm in case of the best implementations[14].

DGPS technology uses a network of ground-based stations to find the difference between the positions calculated by the GPS and the known fixed positions. These ground-based stations broadcast the difference between the satellite measured ranges with the internally calculated by the ground-based stations. Then the receiver stations correct the pseudo-ranges by the calculated amount.

### 2.9 Data security and advancement in networks

As the whole system is designed to avoid the collision between the aircrafts and the system is working over the internet, therefore it also increases the probability of getting hacked or the chances of conspiracy of data.

Data security is a term used for the protection of digital data, that is stored in the database or the data warehouse from getting stolen or getting used for the destructive measures by the unauthorized users, such as cyberattack and hacking etc.

With the advancement in the recent technologies of computing and communication such as Internet of Things, Cloud computing, Web 3.0, 4G and upcoming 5G, LTE etc. and also the increasing number of security attacks like hacking, data breach etc. We are in an era where the advancement in the networks and communication technology is must.

By making a separate or new communication node of network only for the aircrafts and the ground duty having no interference of the existing local internet that is common to everyone. We can develop a new network of communication only for the communication between authorized people of the aircraft world. "Airnet" a term comprising of two separate words 'Air' short for aircraft and the 'net' for network, can be a name given to such a network that will help in developing two types of network, peer-to-peer (aircraft to aircraft) or (ground-duty to aircraft) and one-to-many (ground-duty to all aircrafts). Such a network will be completely controlled by an international organization so that there will be a global control on the air traffic and also the safety of air transport. Such a new network will provide a network of robust communication between the aircrafts and hence increasing the security by multiple times that is nearly impossible to hack.

## 3. TYPES OF COLLISION AVOIDANCE SYSTEMS

TCAS I

TCAS II

TCAS III

TCAS IV

ACAS X

ACAS X

ACAS X is the advancement over the previous systems made on the level 1 to 4. It provides better collision avoidance protection with better performance for the aircrafts[16].

There are four variants of ACAS

- ACAS Xa (active)

It incorporates new and advanced surveillance sources that provides global protection against aircrafts.

- ACAS Xo (operation)

It is designed for particular operations where ACAS Xa can prove unstable or unsuitable. Such as closely spaced parallel approaches. It also provides operation specific alerts during intentional procedures.

- ACAS Xu (unmanned)

It is an advanced aircraft system that is specifically designed for unmanned aircraft systems such as drones

- ACAS Xp (passive)

It is most relied on ADS-B system to track other aircrafts and it doesn't makes any interrogation too. It is developed for such a class of aircrafts that are not fitted with TCAS II or higher collision avoidance systems.

Diagram showing the working of IOT to detect collision

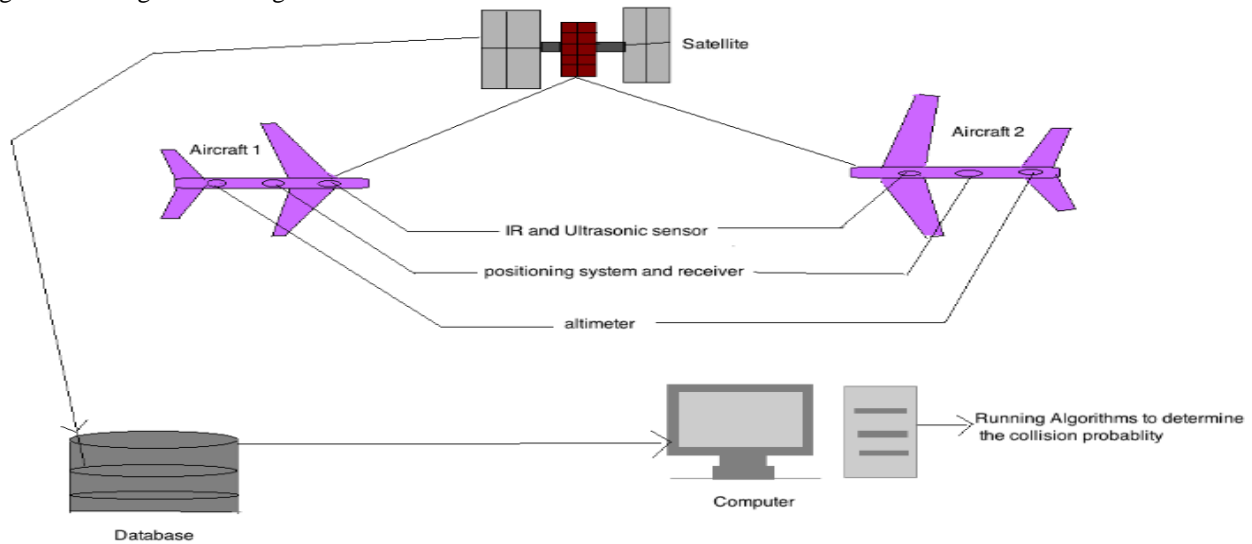
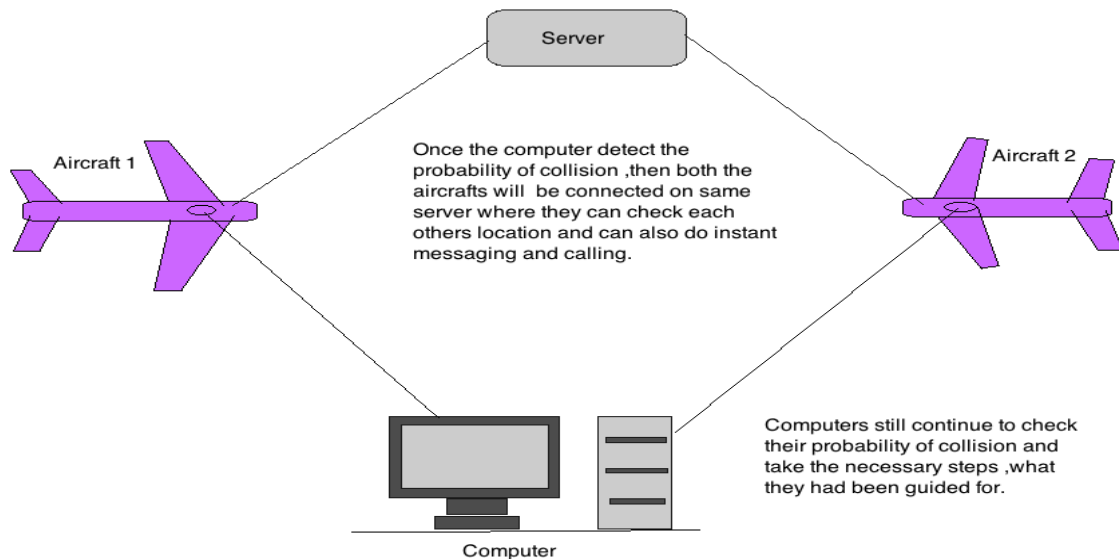


Diagram showing the steps taken after the collision is detected



#### 4. ALGORITHM

#Algorithm for the aircraft

Initialize Height.

Initialize latitude.

Initialize longitude.

Initialize degree of rotation.

Initialize speed.

Initialize Unique ID (of aircraft)

While (1) (start an infinite loop.)

Determine the coordinates of the aircraft in space for next 10 minutes with samples of 30 seconds each. (Height from sea level, latitude, longitude, degree of rotation, Aircraft unique ID)

Upload the latest data to server and delete the old data.

# Algorithm for the server

Initialize Time

Initialize Height.

Initialize latitude.

Initialize longitude.  
 Initialize degree of rotation.  
 Initialize Unique ID  
 Make a dynamic array for every aircraft in that cell.

While (1) (start an infinite loop.)  
 Compare all the data of aircrafts at some specific UTC.  
 If the heights of two or more aircrafts are equal.  
 And if the latitude or longitude are also equal.  
 And if degree of rotation along that latitude or longitude is also same  
 Call collision avoidance function ()  
 Else If the height of aircraft is equal to some peak or building or less than some desired height at that location. (To save aircraft from crashing during bad visibility)  
 Call the collision avoidance system ()

# Algorithm for collision avoidance system.

Initialize Time  
 Initialize Height.  
 Initialize latitude.  
 Initialize longitude.  
 Initialize degree of rotation.  
 Initialize Unique ID

While (i==100) (Start a loop that will compare 100 times.)  
 Compares the Height, latitude, longitude, and degree of rotation.  
 If it still predicts collision  
 Then collision probability = true  
 Else collision probability = false  
 Delay of 1 second.  
 When collision probability is true (after 100 comparisons)  
 Connect all the aircrafts on the same server having collision probability. (so that every pilot can see or check the command given to each other pilots)

The R.A developed with A.I (chat-bot) will communicate with the pilots and provide the solutions for the collision avoidance.

If any of the pilots is/are not following the RA, then the new solutions will be offered to remaining pilots.  
 For added security the Autopilot will be connected to the server to control the aircraft wirelessly in case of pilot is unable to respond. (To take control on the aircraft by ground duty and saving it from collision or crash)

Once the collision is avoided.  
 All the pilots will be disconnected from that server.

Comparison Table

TCAS 1	TCAS 2	TCAS 3	TCAS 4	Anti-collision security system
Working	Working	Not working	Not working	---
It is cheaper.	It is costly.	---	---	It is moderate.
Range is 40 miles	Range is up to 30/40 miles	---	---	Range is around 50-100 N miles
It only warns with "Traffic-traffic" and "clear of conflict".	It has a resolution advisory(RA) and warns with "descend-2","climb-2", "adjust vertical speed" etc.	It has a resolution advisory(RA) and warns with "descend-2","climb-2", "adjust vertical speed" etc.	It has a resolution advisory(RA) and warns with "descend-2","climb-2", "adjust vertical speed" etc.	It has a resolution advisory(RA) which warns with A.I (natural language).
---	Provides vertical manoeuvre..	Provides vertical manoeuvre.	---	---

---	---	Provides horizontal manoeuvre advisories.	---	---
---	Version 7.1- Provides reversal in coordinated encounters.(when one is not following commands)	---	---	Provides reversal in coordinated encounters. (when one is not following commands)
---	---	---	Mode s transponder	---
---	---	---	---	Can be adjusted for any size of cell (area).
---	---	---	Uses GPS or inertial navigation system.	Uses GPS or inertial navigation system.
---	---	Horizontal advisories- "Turn right climb" , "turn left descend" etc.	---	---
---	---	---	---	Plots a 3d image of all objects in that cell on the screen.
---	---	---	---	Connects pilots on same server for one to one talk and personal messaging.
---	---	---	---	Uses A.I to communicate with pilots, a better alternative for RA.
---	---	---	---	Encryption of communication channel to increase security for false command from hijackers.
---	---	---	---	Prediction modelling for future paths.
---	---	---	---	Auto-pilot can be controlled with this system in case of pilot in cockpit is unable to proceed.
---	---	---	---	Overlapping cells provides better results.
---	---	---	---	Three communication channel for better security. Military-military Military-civilian Civilian-civilian

## 5. CONCLUSION

This paper is all about the need of safety in future air traffic and to increase smoothness among the automation so that the human interaction will decrease as much as possible. Resulting in less accidents and less complications for transportation. In theory this seems practically possible but needs a setup on the world level so that we can make this system available for everyone.

Nearly every person has their dream to fly, and research in personal flying machine technology such as drones or flying cars is increasing rapidly and hence we are also in an era where we need to develop such a system that can cope up with this upcoming future problem.



## 6. REFERENCES

- [1] Tech notes (2015) "Airborne Collision Avoidance System X".
- [2] Federal aviation administration (FAA): History and Function- <https://study.com/academy/lesson/federal-aviation-administration-faa-history-function.html>
- [3] Federal aviation administration -<https://www.faa.gov/>
- [4] Thomas B. Billingsley, Mykel J. Kochenderfer, and James P. Chryssanthacopoulos (2011) "Collision avoidance for general aviation".
- [5] Teach Engineering "Hands-on Activity:Measuring Distance with Sound Wave"-  
[https://www.teachengineering.org/activities/view/nyu\\_soundwaves\\_activity1](https://www.teachengineering.org/activities/view/nyu_soundwaves_activity1)
- [6] Infrared IR Sensor Circuit Diagram and Working Principle- <https://www.elprocus.com/infrared-ir-sensor-circuit-and-working/>
- [7] Risk management in a vehicle anti-collision system - <https://www.google.com/patents/US20130278442>
- [8] Altimeter- <https://en.wikipedia.org/wiki/Altimeter>
- [9] What is ultrasonic sensor? -[http://education.rec.ri.cmu.edu/content/electronics/boe/ultrasonic\\_sensor/1.html](http://education.rec.ri.cmu.edu/content/electronics/boe/ultrasonic_sensor/1.html)
- [10] Fig 2 - What is ultrasonic sensor? -[http://education.rec.ri.cmu.edu/content/electronics/boe/ultrasonic\\_sensor/1.html](http://education.rec.ri.cmu.edu/content/electronics/boe/ultrasonic_sensor/1.html)
- [11] Time complexity, Space complexity - <http://www.leda-tutorial.org/en/official/ch02s02s03.html>
- [12] Database(DB)-<http://searchsqlserver.techtarget.com/definition/database>
- [13] Mykel J. Kochenderfer, Jessica E. Holland, and James P. Chryssanthacopoulos (2012) "Next-generation airborne collision avoidance system".
- [14] Differential Gps-[https://en.wikipedia.org/wiki/Differential\\_GPS](https://en.wikipedia.org/wiki/Differential_GPS)
- [15] Traffic collision avoidance system - <https://www.scribd.com/document/363272400/Traffic-Collision-Avoidance-System>
- [16] Tech notes-anti-collision avoidance system X[https://www.ll.mit.edu/publications/technotes/TechNote\\_ACASX.pdf](https://www.ll.mit.edu/publications/technotes/TechNote_ACASX.pdf)
- [17] Ajit Kumar, Ankit Jaiswal, Neha Jaiswal, Rahul Sharma (2014) "Vehicles Anti-collision system".
- [18] Fig1-[https://upload.wikimedia.org/wikipedia/commons/thumb/b/b4/Comparison\\_satellite\\_navigation\\_orbits.svg/250px-Comparison\\_satellite\\_navigation\\_orbits.svg.png](https://upload.wikimedia.org/wikipedia/commons/thumb/b/b4/Comparison_satellite_navigation_orbits.svg/250px-Comparison_satellite_navigation_orbits.svg.png)
- [19] Janeks Ahrens (2017)" development of v2v and gps based collision warning algorithm for uncontrolled intersections" Electronic ISBN: 978-1-5386-0394-9.