Master's Degree in Aeroespace Engineering

Integrated Avionics Systems

# TCAS implementation


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# 1 Global System

This report will describe the implementation of a TCAS system in a simulated environment. For this first part the goals to achieve will be stated for both the simulated environment and aircrafts. As its name so thoroughly suggests, a Traffic Collision Avoidance System is designed to avoid collisions mid-air between aircrafts. As such, it will be the main goal during the implementation of the simulated environment. For this task a server receiving simulated data from several clients representing aircrafts will be set in place. Comparing data from different clients the server will return a response based on the position of other virtual aircrafts, thus allowing for these to actuate and avoid an eventual collision. A more in-depth description of this system will be made below.

We shall firstly list the goals for the implementation of the simulated environment (server side)

- **Aircraft Trajectories** After receiving the data from clients, it will be stored in a data log for each. This will allow the server to keep track of the trajectories of the virtual aircrafts and their flight plans.

- **Aircraft Control** From the previous point, the server shall have all the information, both flight plans and positions. From these the server will me able to send TCAS status messages to its clients, this way controlling and avoiding possible collisions.

- **Aircraft Control** The third and final goal will consist of implementing a GUI allowing for the visualization of the simulated environment.

Note that it is imperative that the implementation of this server is transversal to all groups. Its details must therefore be discussed with the remaining groups.

For the simulated aircraft we have:

- **Information Broadcast** The information to be broadcast by the clients will contain its id, position and velocity, the last two in all 3 dimensions. It also broadcasts the TCAS resolution information

- **Information Reception and Processing** The server-side information is processed by the client to determine resolution actions and actuates.

The planned system is described in the following block diagram

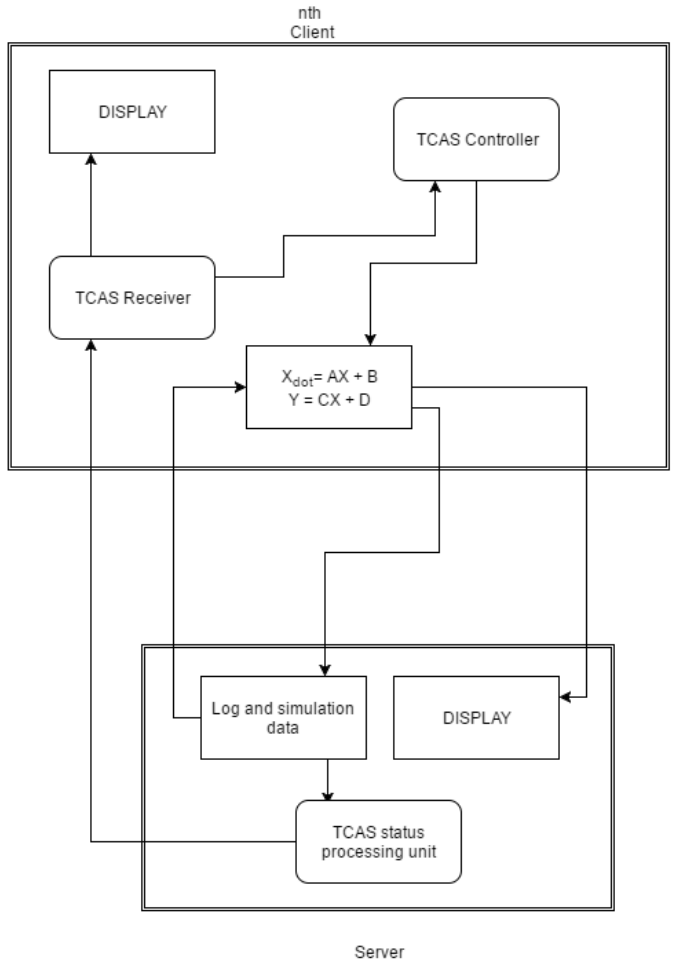


Figure 1: Global System architecture

## 2 Data flow

As shown in the previous section, the TCAS system operates as a sub-system in every aircraft. However, it operates globally as a distributed system, in a sense that all aircraft fly safely by ensuring constant monitoring and communication between every individual TCAS system. That being said, each aircraft must provide to the central server its position (WGS84 XYZ coordinates) and its velocity vector, along with their ID, for trajectory tracking. Furthermore, a TCAS status message must be sent from the server to each available client describing the current level of threat (or step in the resolution process). Additionally, the ID of the (one) possibly conflicting aircraft (we exclude the 3 aircraft collision scenario) must also be provided by the server, together with the available resolution (qualitative: climb, descent, turn, etc.) and the corresponding resolution value (quantitative: climb/descent distance/rate, turn rate, throttle push-up, etc.).

The mentioned data, their units (if applicable), format and flow direction are presented in Table 1.

| Data | Units | Format | Flow |
|---|---|---|---|
| AC ID | - | unit64 | Bidirectional |
| Pos_x | m | IEEE 754 Double (64 Bit) | Client → Server |
| Pos_y | m | IEEE 754 Double (64 Bit) | Client → Server |
| Pos_z | m | IEEE 754 Double (64 Bit) | Client → Server |
| V_x | m/s | IEEE 754 Double (64 Bit) | Client → Server |
| V_y | m/s | IEEE 754 Double (64 Bit) | Client → Server |
| V_z | m/s | IEEE 754 Double (64 Bit) | Client → Server |
| TCAS Status | - | 16-char Null-terminated ASCII string | Server → Client |
| Conflicting AC ID | - | unit64 | Server → Client |
| TCAS Resolution | - | 16-char Null-terminated ASCII string | Server → Client |
| Resolution Value | SI units | IEEE 754 Double (64 Bit) | Server → Client |
| CRC32 | - | uint32 | Bidirectional |

Table 1: Data shared by the Client-Server interface

The CRC32 message is aded to provide robustness to the communication system.

# 3 Network

First of all, after our first meeting, it was decided that the aircrafts would change information using broadcasting.

In order to choose the best network available, first we must understand what are our possibilities and the pros and cons of each one.

We have two main options:

1. Transmission Control Protocol (TCP)

2. User Datagram Protocol (UDP)

The first protocol, TCP is known for:

- Slower but Reliable Transfers

- Typical Applications:

  - E-mail

  - Web-Browsing

- Operates via Unicast (sends messages to a single network destination identified by a unique address)

On the other hand, the second protocol UDP, is known for:

- Fast Transfers
- Non-Guaranteed Transfers
- Typical applications:
  - Music Streaming
  - VoIP
- Operates via Unicast, Multicast and Broadcast

Apparently the best protocol to be used in this project is the UDP. Let us present some advantages of using UDP:

1. Broadcast transmission is available with UDP;
2. Startup latency in distributed applications is much lower, as this protocol does not restrict you to a connection based communication model;
3. All flow control is up to user programs, one only needs to implement and use the features he needs;
4. The recipient of UDP packets gets them unmangled.

To further support our argument, we present some of the TCP disadvantages:

1. TCP cannot conclude a transmission without all data in motion being explicity acked;
2. TCP cannot be used for multicast or broadcast transmission;
3. TCP has no block boundaries, one must create its own.

In conclusion, the protocol chosen for this project is the UDP, so that **each message is sent by UDP broadcast**.

Every aircraft can, at any moment, broadcast its information. Similarly, the same aircraft can receive the information broadcasted by any other aircraft.