University of Minho
School of Engineering

Reconstruction of the Avionics System of the Hangar 9 Solo Trainer Aircraft

System Idealization

Master's in aerospace engineering

Projeto Aeroespacial

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1 System architecture and composition

The architecture of the avionics system involves the integration of electronic components such as the flight controller, the receiver, the servos, the telemetry sensors, the radio emissor and the batteries.

The receiver communicates with the radio emissor, relaying pilot commands to the flight controller, which then processes this information to make real-time adjustments to the aircraft.

Telemetry sensors will also be employed, such as the GPS, the lights, and the airspeed sensor, and they should be connected to the flight controller.

Regarding the servos, these will also be connected to the flight controller, and positioned in designated locations in order to control the various control surfaces.

The avionics system will be powered by onboard batteries, and they will be connected to the receiver via a switch, in order to manually control the flow of electrical power.

Each component, besides the radio emissor and its battery, needs to be securely mounted within the aircraft's fuselage or wings. The placement of components like the flight controller, receiver, airspeed sensor, and GPS should be carefully chosen to ensure optimal performance and balance of the aircraft.

Figure 1 presents an illustration of a block diagram, made with draw.io, that illustrates the flow of information and control signals from the pilot's input through the transmitter to the various components of the avionics system.

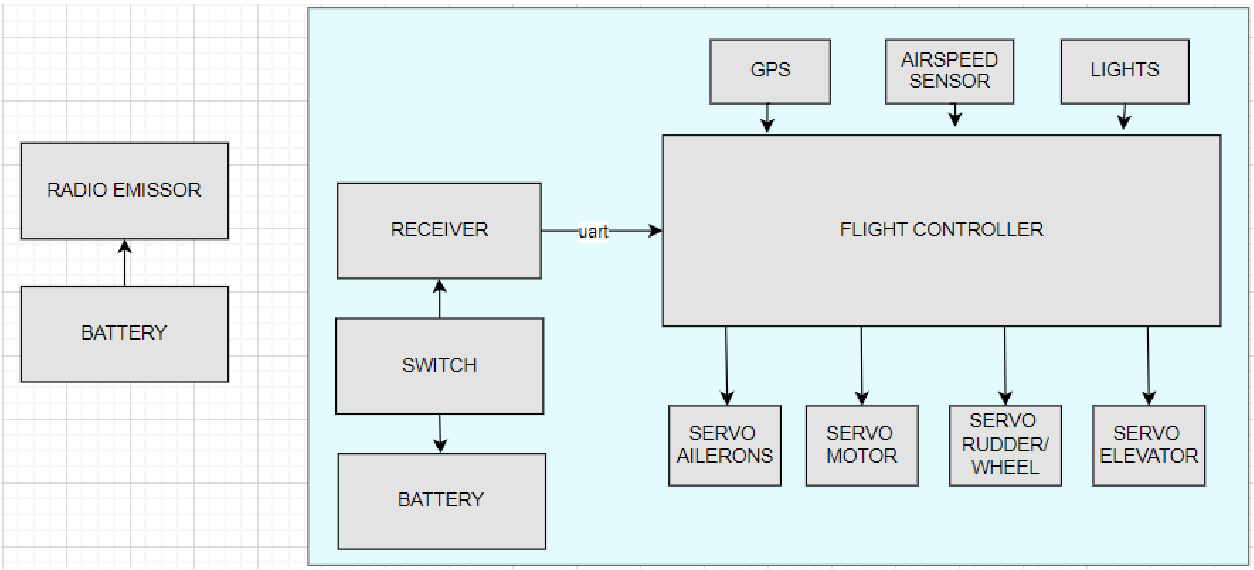

Figure 1. Block Diagram of the Avionics System.

To create a better representation of how the components connect with each other, an illustration with all the electrical wirings was made, as seen in figure 2.

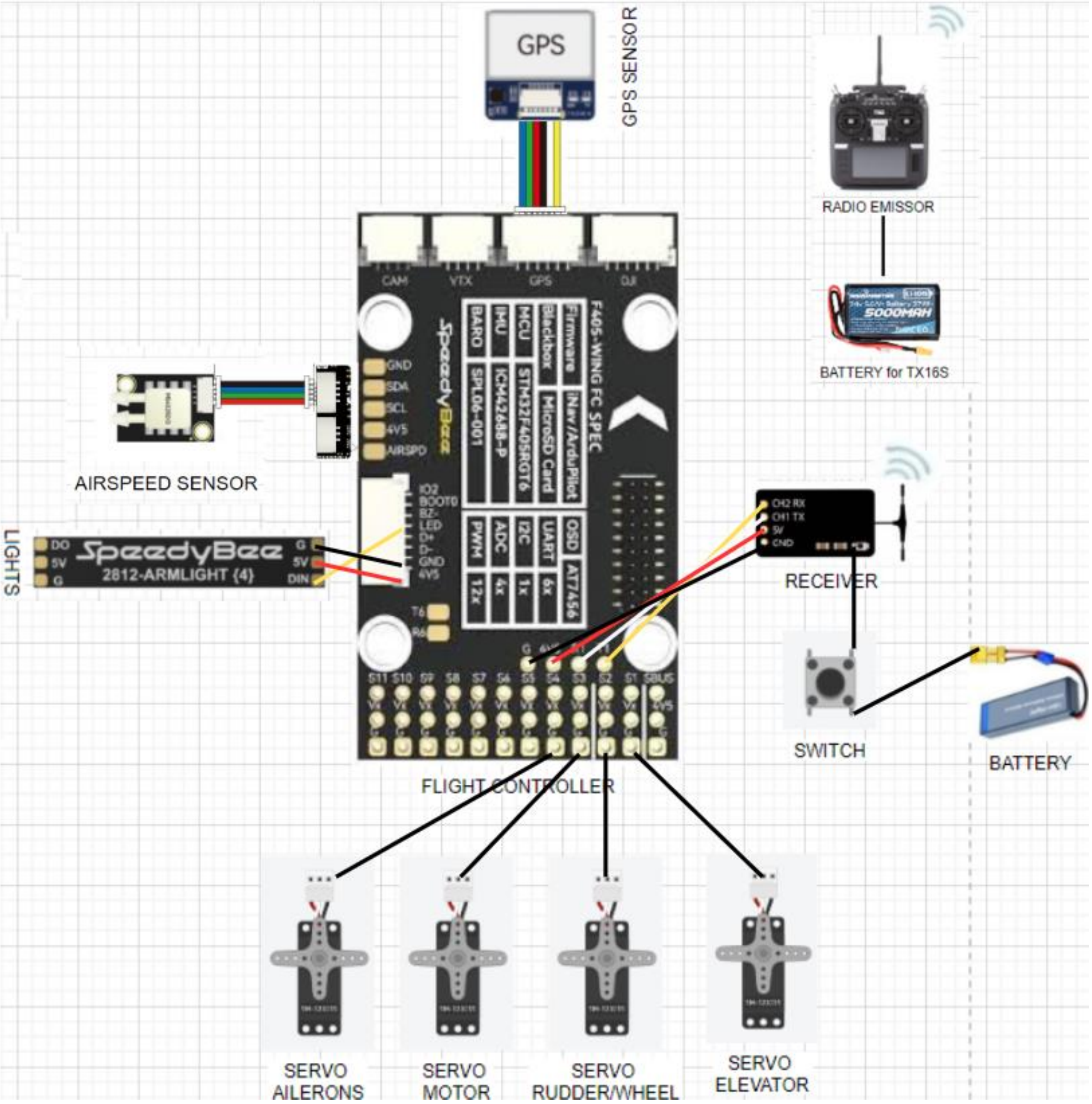

Figure 2. Illustration with the electrical wiring of the Avionics System.

2 Component description

This Avionics system integrates a wide range of components, including:

Servos: Servos are small motors that translate electrical signals from the flight controller into mechanical movement. In this system there will be four servos that are responsible for the movement of the ailerons, the rudder or wheel, the elevator, and the motor:

- **Ailerons:** Ailerons control the roll of the aircraft. By moving the ailerons in opposite directions, the airplane rolls left or right. One servo will be used to control both ailerons.
- **Rudder:** The rudder is located on the vertical stabilizer of the tail, and it controls the yaw of the aircraft. Moving the rudder left or right causes the nose of the aircraft to yaw in that direction. One servo will be used to control the rudder, and also to control the wheel direction during ground movement.
- **Elevator:** The elevator is located on the horizontal stabilizer of the tail, and it controls the pitch of the aircraft. Moving the elevator up or down causes the nose of the plane to pitch up or down. One servo will be used to control the elevator.
- **Motor:** One servo is going to be responsible for feeding the power to the aircraft. It will be connected to the carburetor, and the servo actuation will be responsible to feed more or less fuel to the engine, giving more or less power according to the pilot's desire and needs.

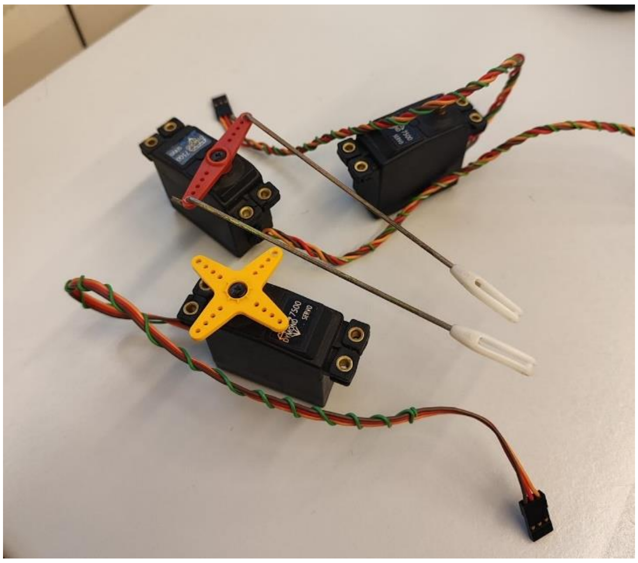

Figure 3. Servos.

Controller: The controller's function is interpreting the inputs from the pilot, and then generating appropriate signals to control the various components of the aircraft. The chosen model was the "*TX16S Mark II Radio Controller*" from Radiomaster, since it has ELRS properties, which refers to a device or component that utilizes ExpressLRS firmware for controlling remote devices, which provides low-latency and long-range communication between the controller and the receiver

Figure 4. "TX16S Mark II Radio Controller" from Radiomaster.

Battery for Controller: The battery of the controller will be responsible for powering the controller. After an in-depth analysis on the subject, it was concluded that the battery should have three fundamental characteristics, namely, to be a LiPo battery, with XT30 connectors and compatible with the radio. It was decided to implement a LiPo battery in the system since it has several advantages such as high energy density and low weight, so the battery model selected was "*21700 5000mAh Battery for TX16S and TX12S MKII*" from Radiomaster.

Figure 5. "21700 5000mAh Battery for TX16S and TX12S MKII" from Radiomaster.

Receiver: The receiver is going to be responsible for receiving control signals from the transmitter operated by the pilot. It decodes these signals and sends them to the flight controller, which then interprets them to adjust the aircraft's control surfaces (ailerons, elevator, rudder, wheel). The selected model was the "*ER6 2.4GHz ELRS PWM*" from Radiomaster since it has a PWM (Pulse Width Modulation).

It is important that the receiver has PWM, which is a method used to encode information in the form of a varying pulse width of a square wave. In PWM, the duty cycle of the square wave is modulated to represent different values or commands. For example, in a remote-control application, different button presses may encode different pulse widths, which the PWM receiver interprets and translates into commands for the controlled device.

A PWM receiver typically consists of a demodulator circuit that converts the PWM signal back into its original form. PWM receivers are commonly used in various applications such as remote controls and communication systems where digital data needs to be transmitted over analog channels efficiently, which is the case of this project.

It is also important that the receiver has six channels, since multiple channels allows a better control of various aspects of the aircraft's movement and functionality

Figure 6. "ER6 2.4GHz ELRS PWM" receiver from Radiomaster.

Onboard Battery: It is essential within the aircraft's electrical system since it is responsible for feeding the electrical system of the aircraft. In this project it would be beneficial to incorporate a LiPo Battery with 2-6S, with XT30 connectors (so it is compatible with the switch), and that is able to feed the entire system. So, the model chosen was the "*2S 7.4V 6200mAh Lipo Battery*" from Radiomaster.

Figure 7. "2S 7.4V 6200mAh Lipo Battery" from Radiomaster.

Battery Charger: The batteries will be recharged between flights using an external charging equipment. In this project, a battery charger that is compatible with the batteries will be used, and the chosen model was the "*S100 1x100W USB-C Smart Charge*r" from Spektrum Smart.

Figure 8. "S100 1x100W USB-C Smart Charger" battery charger from Spektrum Smart.

Switch: In order to manually control the flow of electrical power, a switch will be added. It will be connected to the receiver and to the battery, so the model selected was the "Digital Switch" from SkyRC, since it has XT30 connectors that are compatible with the system.

Figure 9. "Digital Switch" with XT30 connectors from SkyRC.

Flight Controller: This is the principal component of the avionics system. The flight controller receives input signals from the receiver, which is connected to the controller operated by the pilot. The flight controller processes these signals and calculates the necessary adjustments to the control surfaces to achieve desired flight characteristics and stability and sends commands to the servos. In summary, the flight controller plays a crucial role in stabilizing and assisting the pilot in controlling the aircraft, providing a smoother and more manageable flying experience. The selected model was the "*F405 WING APP Fixed Wing*" from SpeedyBee, since it is compatible with the receiver and INav or Ardupilot, and it also allows the connection with various sensors.

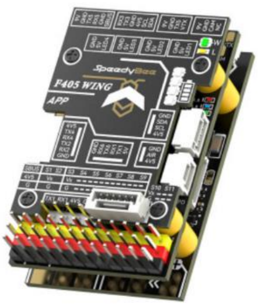

Figure 10. "F405 WING APP Fixed Wing" Flight Controller from SpeedyBee.

Airspeed Sensor: Speed sensors detect and measure the speed of an object relative to its surroundings. In the context of RC aircraft, these sensors measure airspeed, providing crucial data to pilots for monitoring, controlling, and navigating the aircraft. They typically work by detecting changes in air pressure, airflow disturbances, or the time it takes for sound waves to travel through the air. The collected data on airspeed is then transmitted to the flight control system for monitoring and adjustment during flight. It is an essential element for this project once it gives additional and important values for flight monitoring and data. And because the "*ASPD-4525*" Airspeed Sensor from Matek is compatible with the Flight Controller, it will be the model implemented in the system.

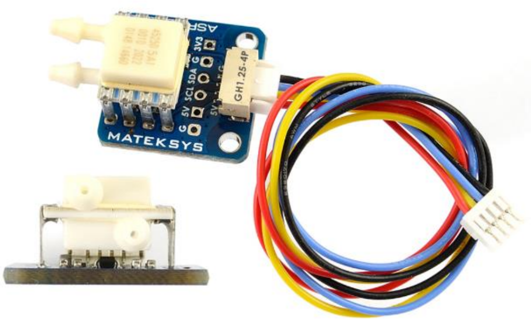

Figure 11. "ASPD-4525" Airspeed Sensor from Matek.

GPS Sensor: The GPS sensor on an RC plane serves various purposes ranging from navigation and flight planning to safety and emergency assistance. The chosen model was the "*BZGNSS BZ-251 GPS with 5883 Compass*" from SpeedyBee since it offers the following key features and benefits: GPS positioning providing accurate location tracking using signals from satellites; compass integration for orientation and heading sensing, aiding navigation. With that, this device enhances navigation, stability, and control of the RC aircraft, providing pilots with essential data for safe and effective flight operations.

Figure 12. "BZGNSS BZ-251 GPS with 5883 Compass" GPS sensor from SpeedyBee.

Lights: In an RC aircraft, lights serve crucial purposes and also aesthetics. Visibility and orientation are a major guidance to the pilot because it helps tracking the aircraft's position, orientation, and direction, especially during low-light conditions. In addition, lights can enhance the aircraft's appearance, especially during night-time flights or airshows, contributing to a visually striking effect. In summary, the addition of lights to this RC aircraft is important considering the fact that enhances visibility, safety, and aesthetics. The lights chosen were the "*Programable 2812 Arm LEDs (4 Pcs)*" from SpeedyBee.

Figure 13. "Programable 2812 Arm LEDs (4 Pcs)" lights from SpeedyBee.

3 Schedule Update

Considering the fact that there were delays in conducting the previous steps, it became necessary to update the schedule. This delay was mainly due to the fact that the component acquisition stage was a longer and more complex process than expected, which involved previously listing the necessary components and requesting a quote for them.

TASK	START	END
Planning and Research		
Define the avionics system requirements	19/02/2024	01/03/2024
Ensure that the servos are working	19/02/2024	01/03/2024
Specify the elements present in the system	19/02/2024	01/03/2024
Market Study		
Research the necessary components, such as sensors, actuators, controllers, etc	04/03/2024	22/03/2024
Component Aquisition		
Ask stores for quotes	18/03/2024	29/03/2024
Order the components of the avionics system	02/04/2024	05/04/2024
Acquire the components and ensure that they are compatible with each other	08/04/2024	12/04/2024
Component Assembling and Testing		
Perform initial tests to verify communication between devices	15/04/2024	19/04/2024
Carry out final tests of the entire avionics system	22/04/2024	26/04/2024
Connect the avionic system with the UAV	29/04/2024	03/05/2024
Solve any remaining issues	06/05/2024	10/05/2024

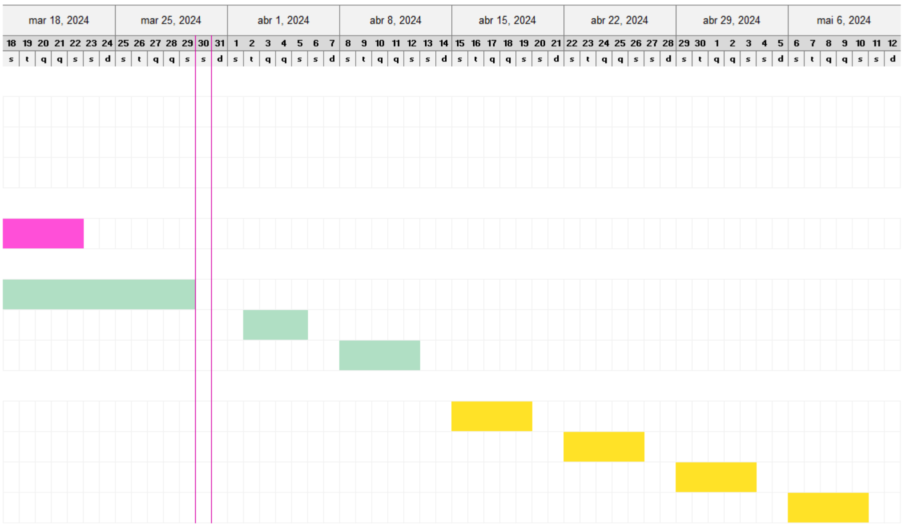

Figure 14. Schedule Update.

https://1drv.ms/x/s!AnaCUtBAxpti3gUNty3qYczapd07?e=mv7q6O