

## FSS - Flight Safety System

### AIM

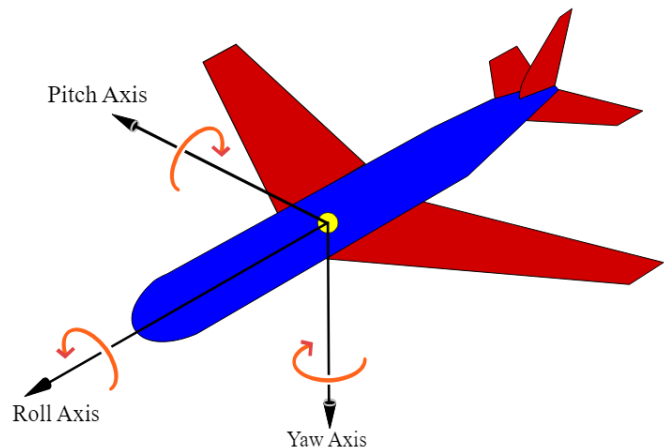
The FSS aims to automate some aircraft's maneuvers while it is in flight, so that its safety is increased.

### DEVICES

This system will control the following sensors:

- **Joystick** (Gyroscope): indicates the movements that the pilot wants to make in relation to the position of the aircraft: Pitch (up/down) and Roll (right/left turns) maneuvers.

To do this we will use a gyroscope that will give us the Joystick rotation in the X and Y axes (Rx, Ry). Each of the two axes provides us with measurements between  $-90^\circ$  and  $+90^\circ$



- **Altimeter**: indicates the current flight altitude in meters (values between 0 and 10,230m). In the laboratory we will simulate it using a potentiometer that is connected to the system through an ADC. The potentiometer gives values between 0..1023, which we will multiply by 10 to obtain the altitude value in meters. .

- **Mode**: Button to select whether the FSS is in “automatic” or “manual” mode. The system alternates from one mode to another each time the pilot presses the button. In the case of “manual mode”, the system does not intervene and is controlled entirely by the pilot.

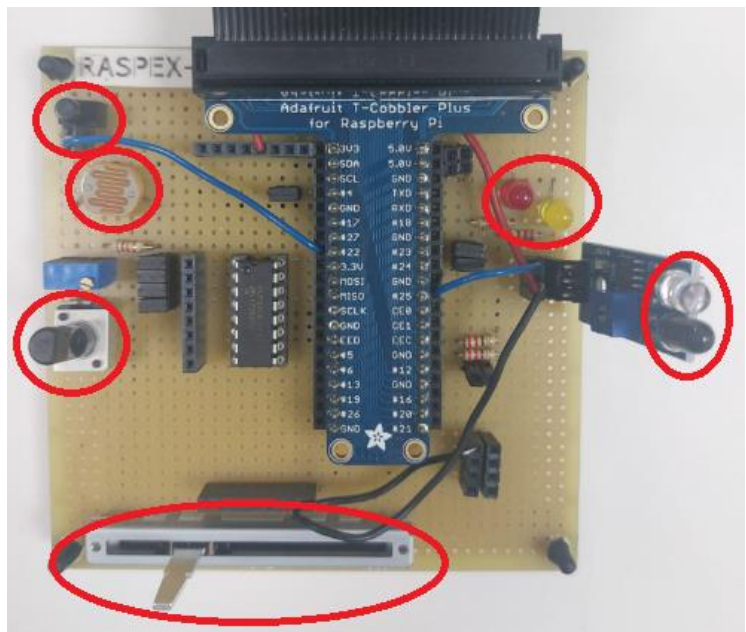
- **Engine\_Power**: indicates the power that the pilot is giving to the engines. In the laboratory it is simulated with a rotation potentiometer, with values between 0..1023.

- **Visibility**: measures the visibility that the pilot has from the cockpit. In the laboratory it is simulated with a light sensor that gives values between 0..1023.

- **Obstacle\_Detector**: tells us if any obstacle is being detected in the plane's path. In the laboratory we will simulate it with an infrared cell.

- **External Red and Yellow LEDs** to give warning signals.

- **Display**: for data visualization. In the laboratory we will use the screen connected to the Raspberry.



## SYSTEM FUNCTIONALITY

The functions that the system must perform are described below. These specifications are based on the Master's Thesis "Documentation and development of a high integrity system using the DO-178 standard" carried out by Juan Gutiérrez González-Román.

### 1- GENERAL

- 1.1.- The system shall monitor the position of the control joystick to determine the pitch and roll angles.
- 1.2.- The aircraft will only be able to turn 15 degrees down and up (pitch) and 45 degrees right and left (roll). If the joystick exceeds the previous inclination, the system will transmit the maximum (15 or 45 degrees) to the aircraft.
- 1.3.- The system must keep the aircraft horizontal (0° pitch, 0° roll) if the joystick is between the margins +3 and -3°.

### 2- AUTOMATIC/MANUAL SYSTEM MODE

- 2.1.- The tasks that are programmed in the FSS will be permanently running since the system boot, that is, they will be continuously reading the sensors and analyzing the data.
- 2.2.- The system will not perform any control action on the aircraft (engine power and trajectory) while the system is in **manual mode**.
- 2.3.- Control actions over the speed and trajectory of the aircraft will only be carried out in **automatic mode**. If the pilot presses the button again to put the manual mode, tasks will continue running, but they will stop acting on the aircraft trajectory.
- 2.4.- Pilot warnings will be activated in both, manual and automatic mode.
- 2.5.- The yellow LED will indicate whether the system is in automatic or manual mode.

### 3- PITCH CONTROL

- 3.1.- The system must decrease the pitch angle when the joystick is tilted forward (negative values) and must increase it when the joystick is tilted backward (positive values).
- 3.2.- The pitch angle of the aircraft will be equivalent to the angle of inclination of the joystick with a tolerance of +1/-1°.
- 3.4.- The maximum pitch angle of the aircraft must not exceed +15/-15 degrees. If the joystick exceeds these values, the FSS should not reflect them in the aircraft position.
- 3.5.- The system must alert the pilot when descending if the altitude is 2500 m.
- 3.6.- The system must keep the aircraft in horizontal position if an altitude equal to or less than 2000 m is detected in the altitude sensor.
- 3.7.- The system should ignore the joystick input if the altitude is equal to or less than 2000 m and the pilot attempts to continue descending.
- 3.8.- The system must keep the aircraft in horizontal position if an altitude equal to or greater than 8000 m is detected.
- 3.9.- The system must ignore the joystick input if the altitude is equal to or greater than 8000 m and the pilot attempts to continue going up.

### 4- ROLL CONTROL

- 4.1.- The system will consider positive roll angles when the joystick is tilted to the right and negative angles when it is tilted to the left.

- 4.2.- The roll angle of the aircraft will be equivalent to the tilt angle of the joystick.
- 4.3.- The system must alert the pilot if the roll angle exceeds +35/-35 degrees.
- 4.4.- The maximum roll angle cannot exceed +45/-45 degrees. If the joystick exceeds these values, they will not be transferred to the aircraft position.

## 5- ENGINE CONTROL

- 5.1.- The system must transfer the power level indicated by the pilot with the potentiometer to the aircraft engines. The values of the potentiometer are between 0 and 1023 (will be interpreted as km/h).
- 5.2.- If a pitch increase maneuver is initiated the engine power will always be increased by 150 units.
- 5.3.- If a roll maneuver is initiated and the engine power is below 600, the power will be increased by 100 units.
- 5.4.- If a maneuver to increase simultaneously pitch and roll is initiated the engine power will always be increased by 250 units.
- 5.5.- The system must alert the pilot if the engine power is below 500 km/h.
- 5.6.- If the speed is reduced below 400 km/h, the system must increase the speed to 600 km/h
- 5.7.- If the speed exceeds 900 km/h the system will reduce the speed to 800 Km/h.

## 6- OBSTACLE DETECTION

- 6.1.- The system will detect the presence of obstacles in the aircraft trajectory (in the laboratory it will be done using the infrared cell). If the cell is activated it indicates that there is an obstacle in the middle distance.
- 6.2.- If an obstacle is detected and the visibility is above 600, the system will only warn the pilot
- 6.3.- If an obstacle is detected and visibility is below 600, the system automatically initiates a maneuver to avoid the obstacle:
  - 6.3.1 If the altitude is lower than 6000 m, increase the pitch of the aircraft for 5 s.
  - 6.3.2 If the altitude is greater than 7000 m, the pitch will decrease for 5 s.
  - 6.3.3 If the altitude is between 6000 and 7000 m, perform a roll to the right for 5 s.
  - 6.3.4 At the end of the 5 s period, the system will stabilize the pitch or roll.

## 7- VISUALIZATION

- 7.1 The system will display the following data on the monitor once per second
  - Altitude
  - Engine power indicated by the pilot
  - Engine power transferred to the aircraft
  - Joystick position: Jx, Jy
  - Aircraft position: Nx, Ny