University of Minho
School of Engineering

Hangar 9 Solo Trainer Aircraft Structure Restoration

Master's in Aerospace Engineering

Projeto Aeroespacial

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1. Main Mission Definition

The group's main mission is to physically restore the UAV (Unmanned Aerial Vehicle) structure, ensuring optimal flight conditions in all phases.

2. Requirements & Restrictions

Requirements:

- Maintain the initial center of mass of the UAV. It should be located at ⅓ of the wing chord, from the leading edge;
- Structural Stability: ensure that all components of the UAV are properly recovered and that they will behave mechanically appropriately when requested, also ensuring its durability;
- UAV landing gear: Ensure that the landing gear of the UAV is stable so that the aircraft can land stably and smoothly;
- The coating must ensure the waterproofing of the UAV;
- Preserve the aerodynamic behavior of the UAV: ensure that the changes and repairs we make do not negatively affect the aerodynamic performance of the UAV;
- Document the repairment process: Keep detailed records of the repairs performed on the UAV, this includes which components were repaired, how were they repaired and which materials/techniques were used.

Restrictions:

- The UAV can’t be exposed to water/humidity, otherwise its structural materials may get damaged/weakened;
- Materials: Keeping in mind that the team may not have access to the exact same materials that were used to produce the UAV in the first place, the materials that will be used to repair/replace damaged components must have similar properties to the previous materials, in order to preserve the UAVs mass center and structural integrity;
- Budget: the team shall keep the expenses to a minimum, without compromising the success of the UAVs restoration;

- Flight tests must not be done near active airports or aerodromes without communicating our intent to do so to the competent authorities.

3. Tasks Timeline

Task 1: UAVs previous **cover removal**.

Task 2: UAVs **disassembling**.

Task 3: **Identify** the aircraft damaged components.

Task 4: **Sanding** components to remove residues from previous operations.

Task 5: Study of the **structural optimization** possibilities.

Task 6: **Topological optimization**, regarding the wing's structural components: spars & ribs.

Task 7: **Substitution components** manufacture.

Task 8: **Implementation of the new components**, on the UAV structure.

Task 9: UAV **validation**.

Task 10: **Final Tests**

Table 1 – Gantt's Diagram

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Task 1													
Task 2													
Task 3													
Task 4													
Task 5													
Task 6													
Task 7													
Task 8													
Task 9													
Task 10													

4. Description of the *Hangar 9 Solo Trainer* aircraft model

The *Hangar 9 Solo Trainer* aircraft model is composed of three main components, namely (A) fuselage, (B) wings, and (C) tail. Each subsystem will be described in the following sections.

A. Fuselage

The fuselage comprises a reinforced central section responsible for connecting the three primary sources of stress in an aircraft: the tail, the wing, and the landing gear. It is crucial to ensure the structural integrity of this central section, as it is where all other aircraft components are connected.

Additionally, the servomotors that control the ailerons, the landing gear, and the tail stabilizer are placed inside the fuselage.

The fuselage results from assembling four panels, whose geometry and dimensions are presented in Figure X.

B. Wings

The main structural elements of the wings are the ribs, spars, and leading and trailing edges.

Ribs, which run from the wing's leading edge to its trailing edge, are the components that transmit the forces from the skin to the spars and grant an aerodynamic shape while supporting the covering material.

On the other hand, the spar, or main beam, is responsible for withstanding the forces experienced during the flight and runs spanwise the wing.

The aircraft model *Hangar 9 Solo Trainer* has two wings (Figure X) with one spar (Figure X) and X ribs (Figure X) each. The shape of the ribs matches the curved profile of the skin, presenting a cutout in the middle. Such geometry provides the required structural support while reducing the overall weight of the structure and enhancing performance (Figure X).

Both wings present one aileron (Figure X), which are surfaces mounted on the wing's trailing edge, moving differentially to control the roll: when one aileron moves up, the other moves down, causing the aircraft to roll in the desired direction. Such components grant the aircraft model enhanced maneuverability and better performance.

The leading and trailing edges (Figure X) represent the wing's front and rear parts. Both are critical in controlling the airflow over the wing and the lifting and drag coefficients.

C. **Tail**

The tail assembly is paramount in controlling the aircraft model attitude and stability, including the horizontal and vertical stabilizers and rudder.

The horizontal stabilizer (Figure X) is placed at the rear of the fuselage, parallel to the wings, and provides stability along the pitch axis, offering resistance to the changes in the aircraft model's pitch attitude – nose-up or nose-down. The vertical stabilizer (Figure X), also mounted at the rear of the fuselage, grants stability along the yaw axis, thus resisting the side-to-side movements of the aircraft model's nose and maintaining its directional stability. Additionally, the vertical stabilizer houses the rudder.

The rudder (Figure X) is a moving control surface attached to the trailing edge of the vertical stabilizer that controls the aircraft model's yaw by deflecting left or right: when the rudder deflects to the left, it creates a yawing motion to the left, and when it deflects to the right, it creates a yawing motion to the right.

The tail assembly, wings, and control elements, such as the ailerons and rudder, provide stability and control during the flight.

Landing system

The landing system of the *Hangar 9 Solo Trainer* aircraft model features a single front landing gear (Figure X) – nose gear – and two main landing gear assemblies (Figure X) placed under the wings, close to the aircraft model gravity center.

The nose gear is located at the front of the aircraft, under the nose section, providing support and stability during ground operations, takeoff, and landing. As it is a steerable gear (Figure X), it can be controlled to steer the aircraft model on the ground, granting directional control and maneuvering performance.

The main landing gear system supports the aircraft's weight during landing and taxiing.

The analysis showed that there are no shock absorption mechanisms to dampen the impact forces experienced during landing.

5. Main Concerns

The proposed project has some challenges.

The main thing is to ensure that the model flies in the final tests.

To this end, and given the tasks described and programmed in point 3, the problem that raises the greatest concerns is a hole in the left wing: we need to guarantee its repair, or we will have to replace the entire upper structure of the wing.

Another concern is to ensure the maintenance of the equipment's center of mass and that the structure is adequate so that the Engine and Avionics Group can achieve their objectives. Based on this, our schedule leaves "room for maneuver" in the final weeks for readjustments to be made.

In short, guarantee the integrity of the original structure, and that the stipulated repairs can optimize the model's lifespan.