PROPOSED CONSTRUCTION OF AN UNMANNED RESEARCH VEHICLE

Naqib Daneshjo - Cristian Stratyinski – Andreas Kohla - Christian Dietrich

The main scope of this article is to describe the structural design of unmanned reconnaissance vehicle up to 90kg. Apart from the design and technical and visual documentation, the work also provides a detailed description of each component.

K e y w o r d s: CATIA, GPS module, UAV, 3D structure

1 INTRODUCTION

The main objective of this work is to plan the construction of an unmanned vehicle with a mass limited to 90kg. At present, unmanned aerial vehicles (UAV's) are currently in use by almost all national defence forces. This work proposes a suitable design for a simplified UAV system which promotes the autonomous movement of an UAV and includes the optimal selection of its components (avionics), such as a (Javelin Stamp) processor, GPS module, motors, gyroscopes and manoeuvring equipment for an optically remote controlled drone.

In the proposal, the most important part is the selection of the profile's wings, because it imparts its aerodynamic characteristics and as a result, its lift. This allows us to create a wing dependent on the dimensions of the aircraft. When calculating the lift and resistance coefficient, the course of pressure around the wing depends on the angle at which it strikes the wing and the results of the calculation of the Reynolds number. The Catia V5 program was used to model the 3D structure. Unmanned technology is playing an increasingly important role in modern armies. Unmanned aircraft take pride of place as they can conduct surveillance, identify targets and eliminate them.

2 PROPOSED CONSTRUCTION OF AN UNMANNED FUSELAGE

The fuselage requires a bearing assembly which consists of parts necessary for a stable and controlled-flight. The airframe houses the power plant which is responsible for carrying the load. This simple fuselage consists of the following main parts: airframe, fuselage, tailfin, control system and landing gear.

The optimal shape places the propeller and engine at the rear of the hull with simple rectangular wings attached to the fuselage, but remarkably the tail is detached, joined only by connecting beams which is unlike most modern aircraft. The main load-bearing members consist of simple rectangular wings with transverse rudders. The wings are connected to the hull with a varying profile. The internal combustion engine is located in the rear of the fuselage. Stabilizers are not directly attached to the hull, because of the location of the engine. The tailfins act as stabilizers which are located in the same plane and consist of a horizontal tail surface, which is located above the two vertical tail fins. The horizontal tail consists of a lateral surface that houses the elevator rudder supported by two vertical surfaces that house the yaw rudders.

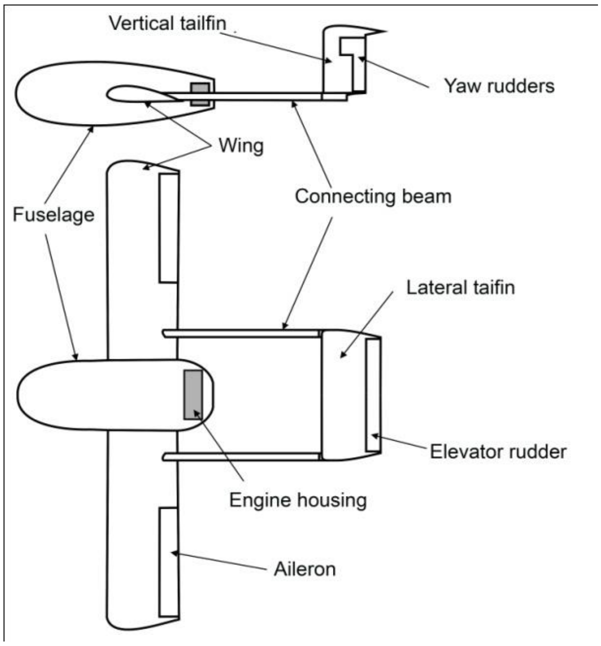


Fig. 1 Preliminary design of the aircraft shape

Calculation of the dimensions of the aircraft should be based on its designed take-off weight. For this particular case, the take-off mass is m = 80kg. The maximum takeoff weight is defined as the limit at which an aircraft is able to take off with (empty aircraft, crew, cargo and fuel weight).

The profile of the airfoil (wing cross-section in the vertical plane) depends on its geometrical dimensions and aerodynamic characteristics. The basic dimensions of the wing include the calculation of the chord length, its relative thickness, the relative curvature, the radius of the leading edge and trailing edge thickness. Relative profile thickness has a considerable effect on the degree of aerodynamic characteristics of the profile, especially the drag coefficient.

$$\bar{c} = \frac{c_{\max}}{b} \qquad (1)$$

where c- [-] relative profile thickness
c max - [mm] max profile thickness
b - [mm] length of profile chord

The calculation of the wing area is based on the calculation of the minimum airspeed. A minimum flight speed of 60 kph was selected-1 (16.667 ms-1).

$$v_{\min} = \sqrt{\frac{G}{\frac{1}{2} \cdot \rho \cdot c_{L\max} \cdot S}}. \qquad (2)$$

$$S = \frac{G}{\frac{1}{2} \cdot \rho \cdot c_{L\max} \cdot v_{\min}^{2}} \qquad (3)$$

S –wing area, G - mass of aircraft, ρ - air density, c_{Lmax} – maximum coefficient of lift for a given profile, v_{min} –- minimum flight speed

The shape of the wing is a simple rectangle.

Calculation of the optimal flight speed:
The optimal lift coefficient is based on the NACA profile 4421. The polar profile corresponds to the optimal value of the maximum strike angle, 6°, where the lift coefficient cL = 1.0758. It is then possible to calculate the flight speed using the relation:

$$v_{let} = \sqrt{\frac{G}{\frac{1}{2} \cdot \rho \cdot c_{L} \cdot S}} \qquad (4)$$

Proposed fuselage structure, wing attachment and engine fitting:

The fuselage which is constructed around the aircraft's frame plays a very important function. In terms of design, the wings, tail, landing gear, management, power train parts and equipment and weapons are integrated into a single unit. Certain requirements are placed on the fuselage which needs to be considered from the outset. These include: aerodynamics (optimal aero-dynamic characteristics of the fuselage, regarding the reduction of drag caused by the unfavourable effect created were the fuselage joins the wing, tail, and possibly other parts of the aircraft), strength, design, manufacture and service.

Aerodynamic requirements call for optimal fuselage aerodynamic characteristics, especially the minimization of resistance due to an adverse effect on the body where it joins with the wing, tail, and possibly other parts of the aircraft. This can be avoided by shaping the body and using a well-designed transition between the wing, fuselage and tail.

A well-designed structure should have a minimum weight in relation to its size and use advanced materials and manufacturing technologies. An optimal solution is to preferably implement a circular cross section or circular parts.

The supporting structure of the fuselage has undergone various forms of organization over the years. At present, two forms are used. Rod (rarely used) and semi shell hull structures which house the load-bearing part of the transverse and longitudinal direction and cover the carrier). The wing will be constructed from two load bearing beams and exhibit a circular cross section. The mountings consist of two aluminium tubes with an outer diameter Ø50mm and thickness of 5 mm. The Limbach L 275 E engine was selected.

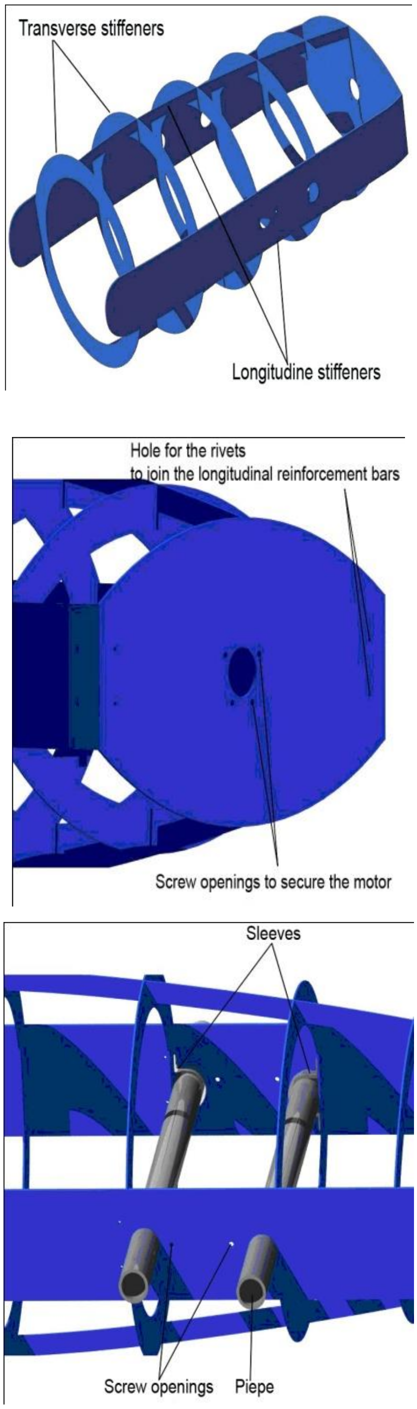


Fig. 2 Supporting structure of the fuselage, wings and engine mount

Proposed wing construction:

The whole wing beam design requires suitably spaced supporting parts, reinforced using longitudinal stiffeners and ribs. The main beam withstands substantial bending moment induced by normal forces.

The wings are composed of one auxiliary beam, three longitudinal stiffeners, one of which performs as the leading edge and eight ribs. The main and auxiliary beams are made of tubes with an outer diameter of Ø40mm and a thickness of 3 mm.

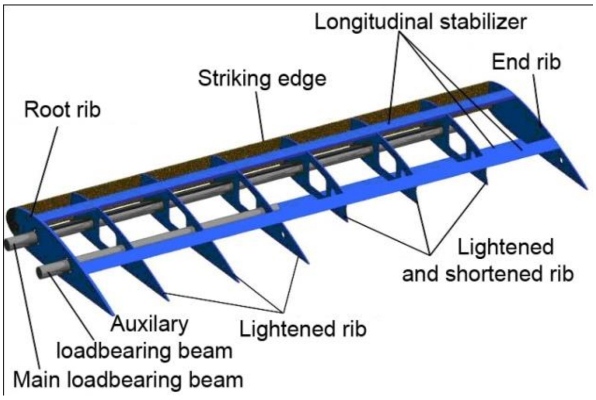
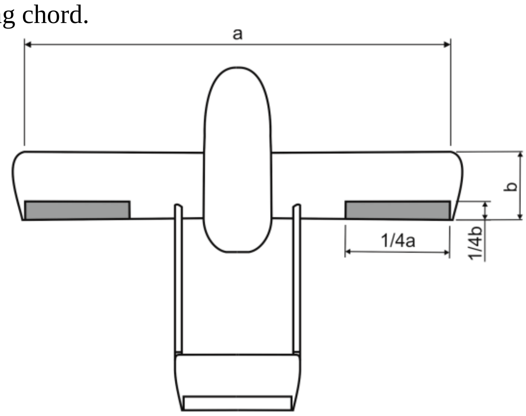


Fig. 3 Wing structure

Lateral control rudders (ailerons) are control surfaces which generate a momentum about the longitudinal axis of the aircraft, causing the aircraft to roll. The most common type of wings currently used are normally designed as deflective and located at the end of the trailing edge. Frequent use of an aileron is justified, because it is structurally similar to wing structure. Besides shortcomings in the momentum, there are also limitations due to the torque which is created by momentum. Lateral control is provided by one aileron deflecting upwards, while the other deflects downwards.

The ailerons have the same plan outline as the main rectangular wing. Its dimensions differ from the wings through simple relative values, where the length of the wings, is ¼ the wingspan and the width is ¼ of the wing chord.



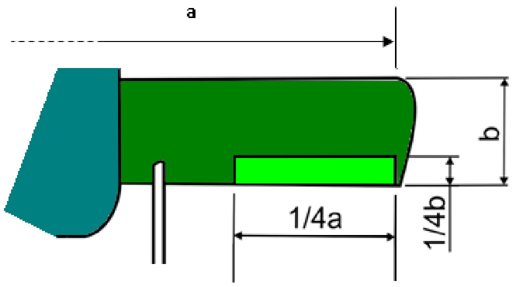


Fig. 4 Ratio values of ailerons

Length of aileron: $$a_k = \frac{1}{4} \cdot a \qquad (5)$$

where a_k – [m] length of aileron[m]
a –wingspan[m]

Width of aileron: $$b_k = \frac{1}{4} \cdot b \qquad (6)$$

where b_k –width of aileron[m]
b –width of aileron[m]

Length 1m and width 0,165m, which results in an aileron area of 0,165m2

Proposed connections of stabilizers and wings:

The aircraft's fuselage is independent to the stabilizers which are anchored to the supporting surface (wings):

- wing rib attachments
- connecting beam (cylindrical)
- stabilizer attachment

Proposed stabilizer:

Stabilizers are usually separated into horizontal and vertical wing segments which are located at the end of the fuselage. Horizontal tail surfaces provide longitudinal stability and manoeuvrability of the aircraft, while the vertical tail surfaces provide directional stability and manoeuvrability of the aircraft. Both areas consist of fixed and flexible parts. The fixed horizontal surface act as the stabilizer and the movable surface acts as the elevator. The fixed vertical part acts as a fin and the movable part is used to change direction (yaw).

A. Vertical tail area:

The vertical tail surface area is 0.066 times the wing area.

$$A_{zp} = 0{,}066 \cdot S \qquad (7)$$

A_{zp} – area of vertical tail fin [m^2], S – area of load bearing wing [m^2]

$$b_{zp} = \frac{A_{zp}}{a_{zp}} \quad (8)$$

A_{zp}– vertical tail area [m^2],
a_{zp}– width of vertical tail surface [m]
b_{zp} – height of vertical tail surface [m]

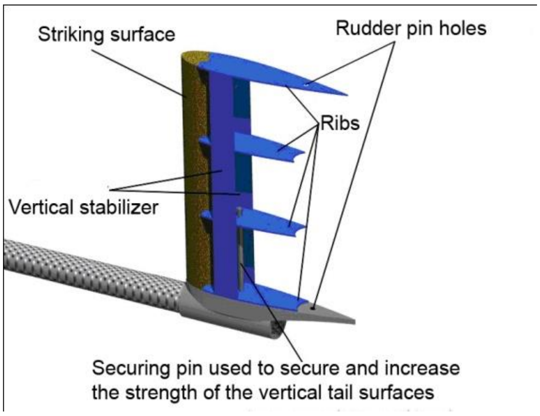


Fig .5 Vertical tail surface construction

B. Yaw rudders:

When calculating the directional yaw) surface area we used the same ratio values that were used previously which is ¼ of the vertical tail surface area.

$$A_{sk} = \frac{1}{4} \cdot A_{zp} \quad (9)$$

where
A_{sk} – area of the yaw rudders [m^2]

The rudder height bs is determined by the height of the construction of the vertical tail surface and will therefore be equal to its height, ie:

$$b_{sk} = b_{zp}$$

The width of the yaw rudder should be calculated according to the equation:

$$a_{sk} = \frac{A_{sk}}{b_{sk}} \quad (10)$$

where: a_{sk} – width of yaw rudder [m],
b_{sk} – height of yaw rudder [m],

C. Horizontal tail surface:

The calculation of the tail area is based on the ratio of the values that were previously calculated. The horizontal tail surface area is 0.2 times the wing area.

$$A_{vp} = 0{,}2 \cdot S \quad (11)$$

where:
A_{vp}– horizontal surface area [m^2], S– area of load bearing wing [m^2]

The width of the a_{vp} must be calculated according to the equation:

$$a_{vp} = \frac{A_{vp}}{b_{vp}} \quad (12)$$

where a_{vp} – width of the horizontal tail surface [m]
b_{vp} – length of the horizontal tail surface [m]

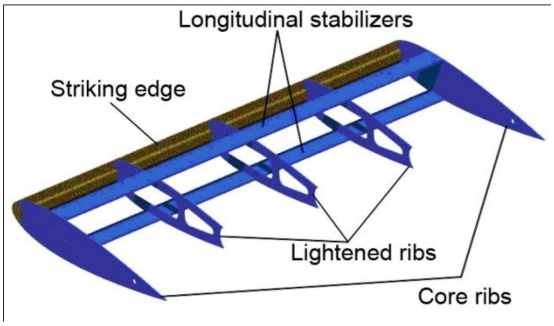


Fig. 6 Construction of horizontal tail surface

D. Elevator rudder:

When calculating the area of the elevator rudder, the same ratio values were used as for the calculation of yaw and transverse rudder (aileron) which is ¼ the horizontal tail surface area.

$$A_{vk} = \frac{1}{4} \cdot A_{vp} \quad (13)$$

where:

A_{vk} –area of the elevator [m^2]

The length of the elevator bvk is determined by the construction of the horizontal tail surface and is therefore equal to its length, ie:

$$b_{vk} = b_{vp}$$

Width of the elevator rudder is calculated as:

$$a_{vk} = \frac{A_{vk}}{b_{vk}} \quad (14)$$

where: a_{vk} – width of horizontal [m]
b_{vk} – length of horizontal [m]

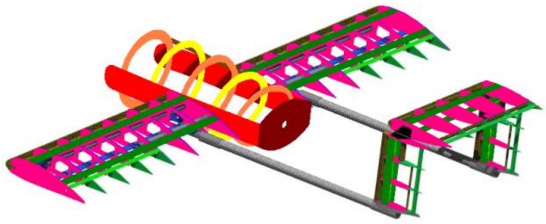


Fig .7 Complete construction of the drone (UAV)

The flow diagram illustrates the results of the calculations.

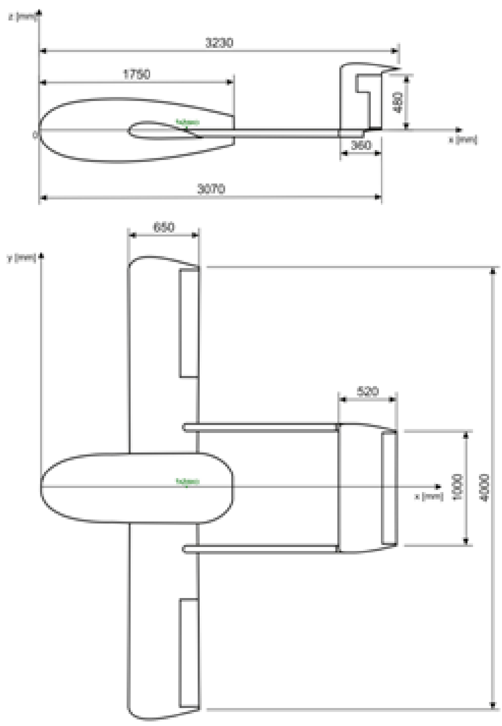


Fig.8 Proposed and calculated dimensions of the drone (UAV)

3 CONCLUSION

The work deals with UAVs. It clarifies current issues regarding UAVs, their use and continuous development. The work proposes a step by step structural design for an aircraft and provides descriptions and pictures, which can also be used as a guide in designing new types of UAVs. Special effort was paid to create an interesting and simple design. The structural design is not final and may be further modified and extended.

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AUTHORS´ ADDRESSES

Daneshjo Naqib, doc. Ing., PhD.
Faculty of Aeronautics of Technical University
Rampová 7, 041 21 Košice, Slovakia
e-mail: naqib.daneshjo@tuke.sk

Cristian Stratyinski, Ing.
Faculty of Aeronautics of Technical University
Rampová 7, 041 21 Košice, Slovakia
e-mail: cristian.stratyinski@gmail.com

Andreas Kohla, Dipl.-Ing.
Papengatt 21
47533 Kleve, Germany

Christian Dietrich, Dipl.-Ing. MBA
Saarstrasse 12
06779 Raguhn. Germany