AirCargoChallenge 2022

Technical Report

Team #26

HAWings

See the Regulations for details on the report. E.g. 4.5.2.

Send the complete Report as PDF to teamcontact@acc2022.de (the standard mail address). You will get a confirmation within 2 days max. If not, ask in the signal team leaders group or directly via email.

If you used a different program (e.g LaTeX) you can either recreate this template or just add the front page afterwards. (Helpful tool is e.g. PDFSAM - PDF Split and Merge)

We are currently still looking how to get the video files from you.

Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

Air Cargo Challenge 2022 – #26 HAWings

Technical Report

1sth May 2022

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Table of content

List of symbols

Symbol	Meaning	Unit
b	Wing span	mm
c	chord	mm
c_{root}	Root chord	mm
c_{tip}	tip chord	mm
C_D	drag coefficient	-
$C_{D,0}$	Zero drag coefficient	-
$C_{D,i}$	Induced drag coefficient	-
$C_{D,tot}$	Total drag coefficient	-
C_L	lift coefficient	-
C_P	Pressure coefficient	-
E	Glide ratio	-
g	earth acceleration mm/s2	$\frac{mm}{s^2}$
m	Mass	kg
S	wing area	mm²
T	thrust	N
V	velocity	$\frac{mm}{s}$
Λ	Sweep angle	°
ν_w	Dihedral	°
ε_t	twist	°
i_w	Incidence angle	°

List of abbreviations

Abbreviations	Meaning
PDR	Preliminary Design Report
TR	Technical Report
CFRP	Carbon fibre reinforced polymer
A	Ampere
V	Volt
W	Watt
CG	Center of gravity

1. Introduction

As already mentioned in the Preliminary Report, the HAWings team continues to pursue the participation in the Air Cargo Challenge 2022 in Munich.

2. Project management

1. Financial budget

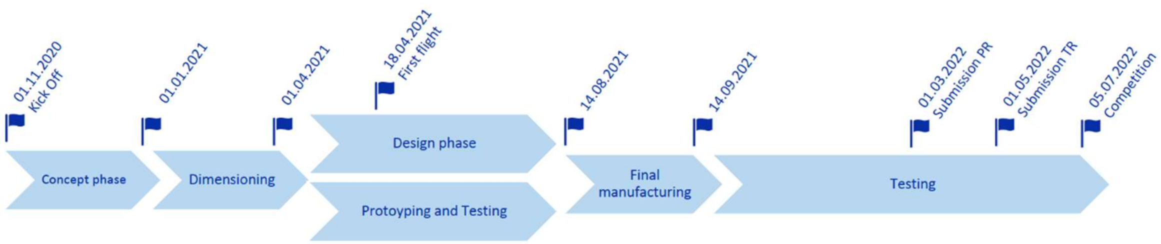
For the project we tried to use as much material we already had in our facilities as possible. Beyond that we had budget of 1000€. A detailed financial plan is given in the following:

Name	Cost [€]
Propulsion	200
Batteries	50
Wood*	50
CFRP parts*	100
Other electronics	100
Other material	100
Registration fee**	200
Total	800

Table 1: financial plan [*=material from facilities; **= fee we did not get sponsored]

The remaining budget is planed to pay our travel cost to Munich.

2. Time schedule



3. Overall aircraft design

All calculations were made with XFLR5. With this program we were able to compare different wing and empennage combinations. The fuselage was not included. In

Figure 1 the GUI and a calculation result are showen.

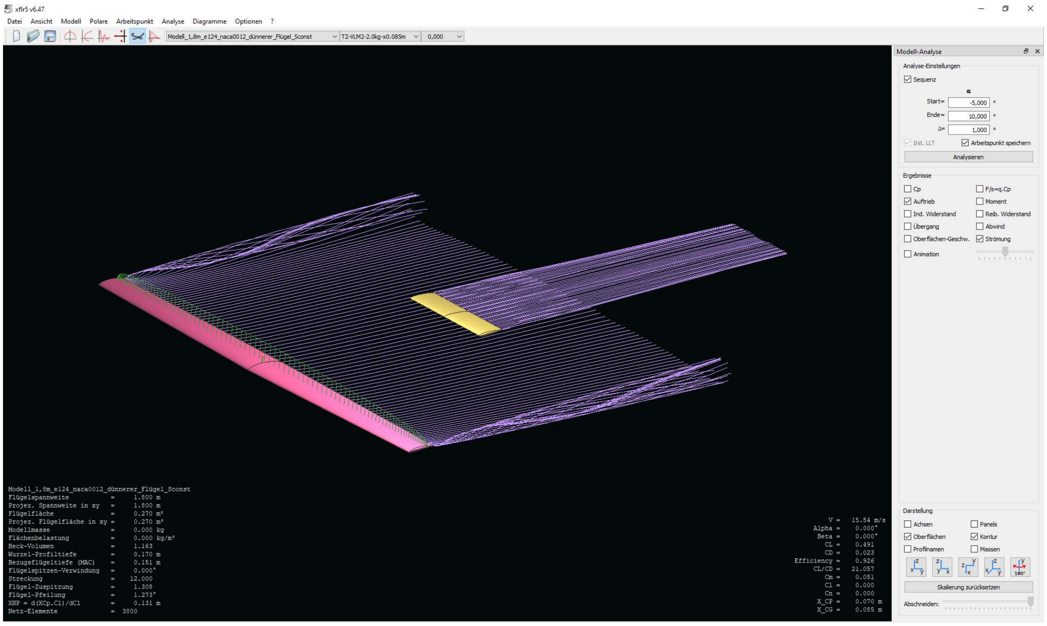


Figure 1: GUI of XFLR5

The geometrical parameters of the components are presented in the following:

Wing Parameters

Name	Symbol	Value
Wing area	S	0,27 m²
Wing span	b	1800 mm
Root chord	c_{root}	170 mm
Tip chord	c_{tip}	130 mm
Incidence angle	i_w	0°
Dihedral	ν_w	0°
Twist	ε_t	0°
Sweep	Λ	1,27°
Airfoil	-	Eppler 214

Table 2: Geometrical wing parameters

Empennage parameters

Name	Symbol	Value
Empennage area	S	0,05 m²
Empennage span	b	400 mm
Root chord	c_{root}	120 mm
Tip chord	c_{tip}	120 mm
Incidence angle	i_w	0°
Dihedral	ν_w	0°
Twist	ε_t	0°
Sweep	Λ	0°
Airfoil	-	NACA 0012

Table 3: Geometrical canard parameters

Calculated values for chosen parameters

name	symbol	XFLR 5
Lift coefficient	C_L	0.4913
Induced drag coefficient	$C_{D,i}$	0,0692
Total drag coefficient	$C_{D,tot}$	0,02333
Glide ratio	E	21
Cruise speed	V_{cruise}	15,54 m/s
Stall speed	V_{stall}	9,5 m/s
Static margin		30%

Table 4: Parameters from chosen dimensions

3.1. Structure

In the following the different components and their method of construction will be described in more detail. All solutions were designed to be as simple and economical as possible.

3.1.1. Fuselage

The main structural part of the fuselage comprises two CFRP Tubes. As shown in Figure 2 the tubes are starting from the engine holder and going through the hole fuselage.

Figure 2: Fuselage structure made out of two CFRP Tubes and wooden frames and stringer

The outer contour is given by stringers and film. The frames and stringers are laser-cutted and have cut-outs to make the assembly easier.

The engine holder as well as the wing connector and payload container connectors are 3D printed. PLA is used as material. The engine holder is glued to the CFRP tubes and screwed to the second wooden frame.

The payload container is assembled with lasercutted wooden parts and has one part of the connector glued on (see Figure 3). The second part is connected by a M3 screw and encloses the two CFRP tubes. To unload the container no other part except the aerodynamic top cover has to be removed.

Figure 3: Cargo box

3.1.2. Wing

As for the fuselage the scope for the wing realisation pursued an uncomplicated assembly and economical design. To fit this scope the wing is made out of a CFRP beam and wooden rips that are covered by film. To save some weight the CPRP beam is a square tube (8x8mm outside and 7x7mm inside). Under a 3g force with a safety factor of 2 this would lead to maximum bending tension of 253 N/mm² which left a safety factor of 1.58 (see Figure 4). Additionally, the beam is filled in the inner part of the wing, to support it.

Profil:	Vierkantrohr	
Material	CFK	
b	8	mm
t1	0,5	mm
Masse Hauptholm (pro Seite)	**21,6**	g
Flügelkoordinate [m]	**Sicherheit**	**Spannung [N/mm²]**
0,900	∞	0
0,855	352,82	1,1
0,810	87,38	4,6
0,765	38,58	10,4
0,720	21,58	18,5
0,675	13,73	29,1
0,630	9,49	42,2
0,585	6,93	57,7
0,540	5,28	75,7
0,495	4,17	95,9
0,450	4,14	96,6
0,405	4,00	99,9
0,360	3,78	105,9
0,315	3,49	114,5
0,270	3,18	125,9
0,225	2,86	140,1
0,180	2,55	157,0
0,135	2,26	176,8
0,090	2,01	199,5
0,045	1,78	225,1
0,000	1,58	253,6

Figure 4: Structural calculation for the wing beam

To make the assembly easy the wooden rips and stringers have out cuts that fit into each other. With this concept no assembly mould is needed. The leading edge is closed with 1mm Balsawood (see Figure 5).

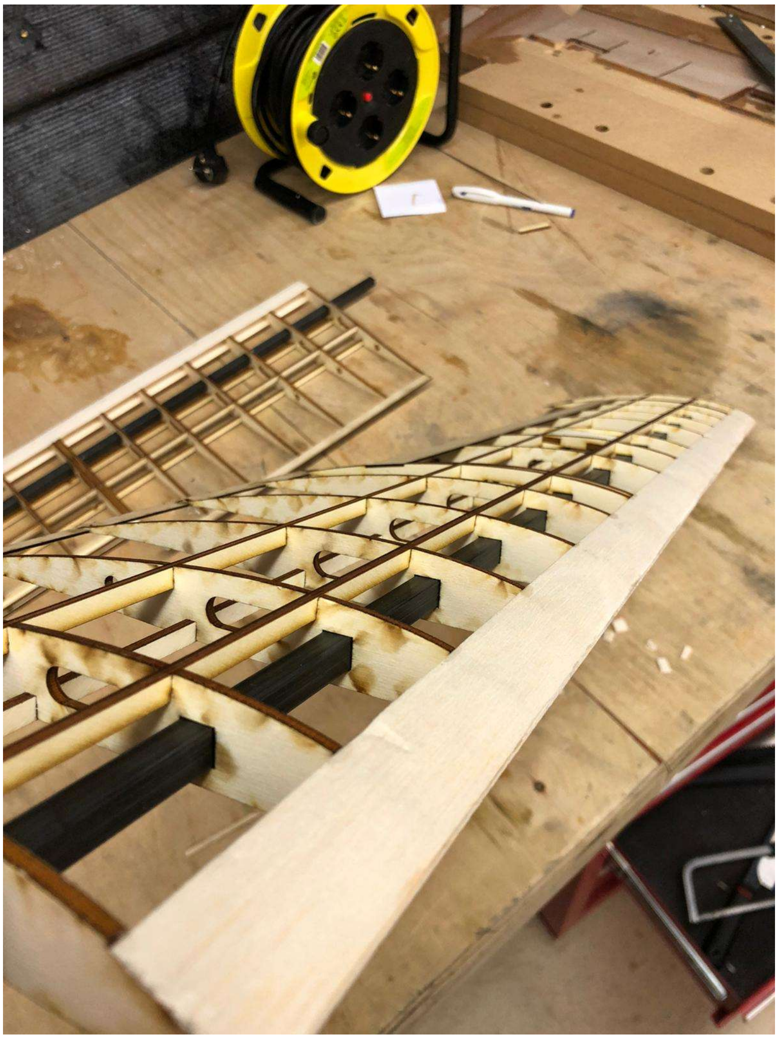


Figure 5: wing without cover

For the ailerons rips and 1mm plywood is used. They are covered with two different coloured film to make it easier seeing the airplane orientation while flying (see Figure 6). Tape is used as hinge.

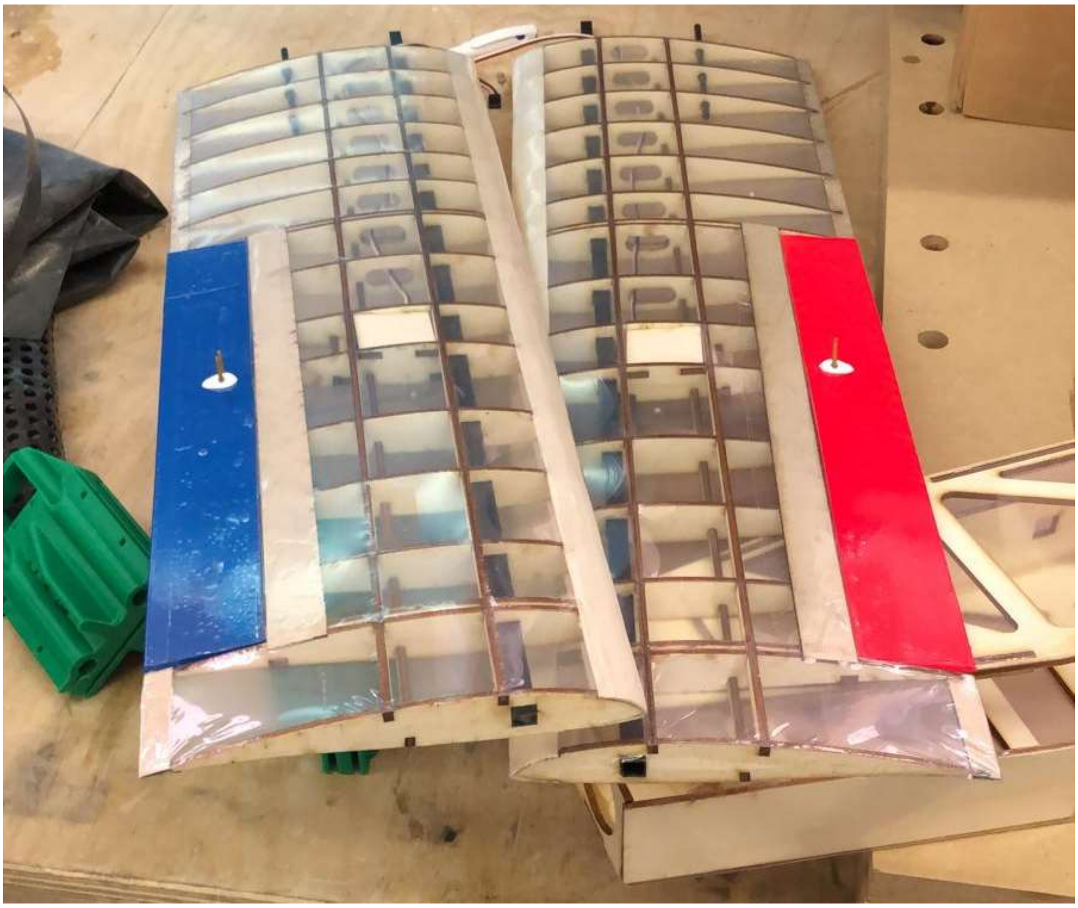


Figure 6: Different coloured ailerons

3.1.3. Empennage

In our aerodynamic calculations we used an NACA0012 for the empennage. As the main scope of our aircraft is to keep it as simple as possible, the empennage is made out of a plate without a defined profile. As a structural support a CFRP bar is implemented. The plate has some out cuts to save some weight. These out cuts are covered with film. The elevator is made of a film covered plate. It makes 80% of the empennage wingspan and approximal 30% depth. The controllservo is implemented into the connector.

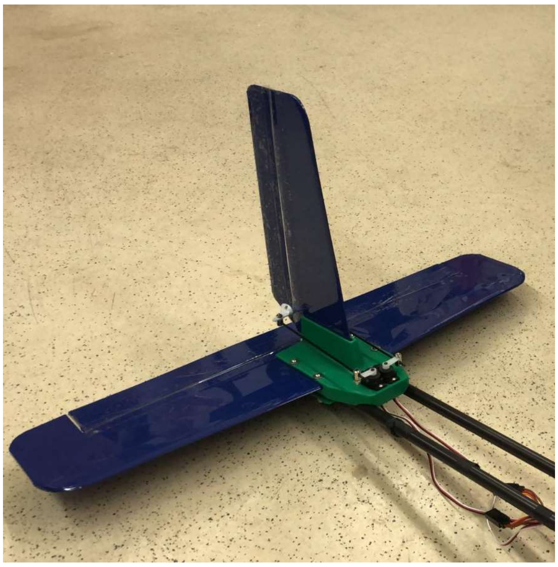


Figure 7: 3D-printed empennage connector

Figure 8: wooden empennage connector

The connector for the empennage is glued to the CFRP tube that are the main structural part of the fuselage. The first prototype of this connector was 3D-printed (see Figure 7). To save some weight we designed a new one out of wood (see Figure 8). The lower part of the connector is supported by fiberglass and is used as a grinding point.

3.1.4. Vertical tail

The vertical tail is made the same way as the empennage. The rudder goes over the entire length und about 40% depth. The control servo is also implemented into the connector.

While testing the airspeed sensor is attached to the vertical tail (see Figure 8).

3.1.5. Payload prediction

Our payload is calculated after the following:

$$\text{payload}\ (\rho) = 900\text{g} * \frac{\rho}{1{,}225\ \frac{kg}{m^3}}$$

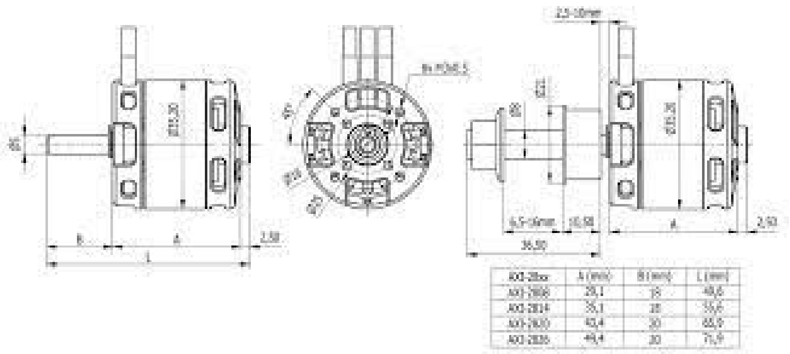
3.2. Avionics

3.2.1. Energy supply

Based on the motors maximum current rating (43A) and a given flight time of 3 minutes, the necessary battery capacity is:

$$43A * \frac{3\,minutes}{60} = 2150\,mAh$$

Therefore, we will use a 2200mAh LiPo battery (30C) in the competition flight.



3.2.2. Propulsion system

The main propulsive engine consist of one AXI 2826/10 GOLD LINE V2, equipped with a Aeronaut CAMcarbon Light 10”x6” propeller, as given in the regulations.

3.2.3. Electronic Speed Controller

To control the engine, a Hacker MasterBasic 70SB ESC is used.

3.2.4. Miscellaneous components

Radio control receiver: FrSky GR8
Servos: Master s2112

3.2.5. Flight testing Hardware

During Flight-testing the following components were used to evaluate and improve the flight characteristics:

- Flightcontroller (Mateksys f405-wing) with INAV firmware
- GPS
- Aispeed Sensor
- 433mHz telemetry

These components will not be part of the competition aircraft.

3.3. 3-view-drawing

The 3-view-drawings are attached.

4. Team management & encountered problems

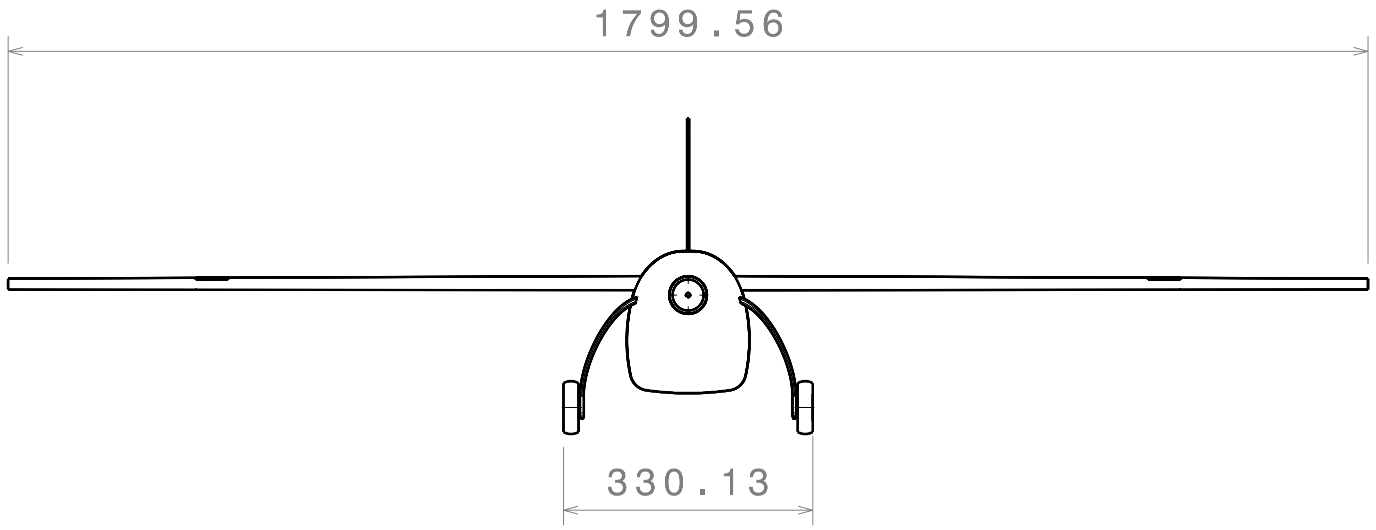
The HAWings team consists of 25 members and a hand full of occasional supporters, who have contributed to the team in various ways. The team includes students of the disciplines aeronautical and automotive engineering, mechanical engineering as well as computer sciences. The team mostly consists of bachelor students from first to seventh semester as well as three master students.

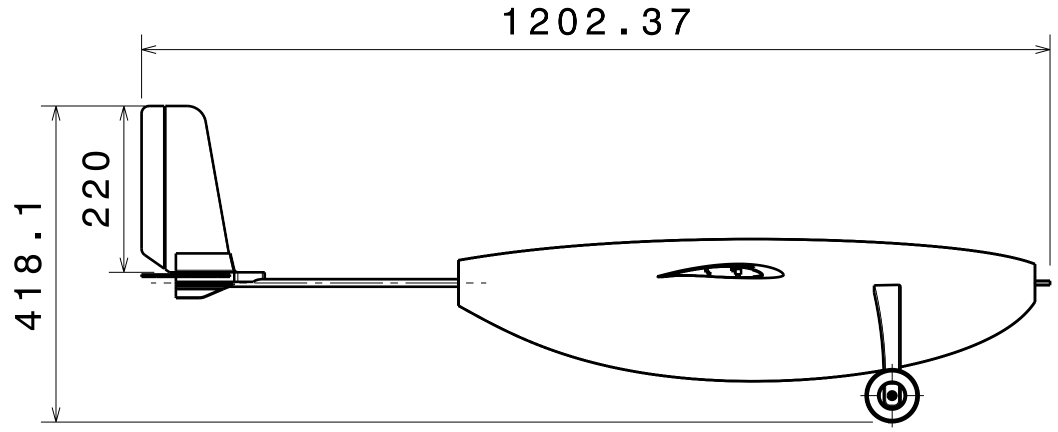
As it took a long time for some of our members to build up a lot of experience, our first approach at the ACC is used to shear this experience. Under this point we tried to do the most tasks in bigger groups. During the COVID-19 pandemic this lead to a lot of online meetings. Also, we decided to not build a complex airplane in aerodynamic and structural point of view. This decision is also influenced by the participation in the New Flying Competition 2022 that we are taking part in, and which has been taking up almost the entire capacity of the team for months now.

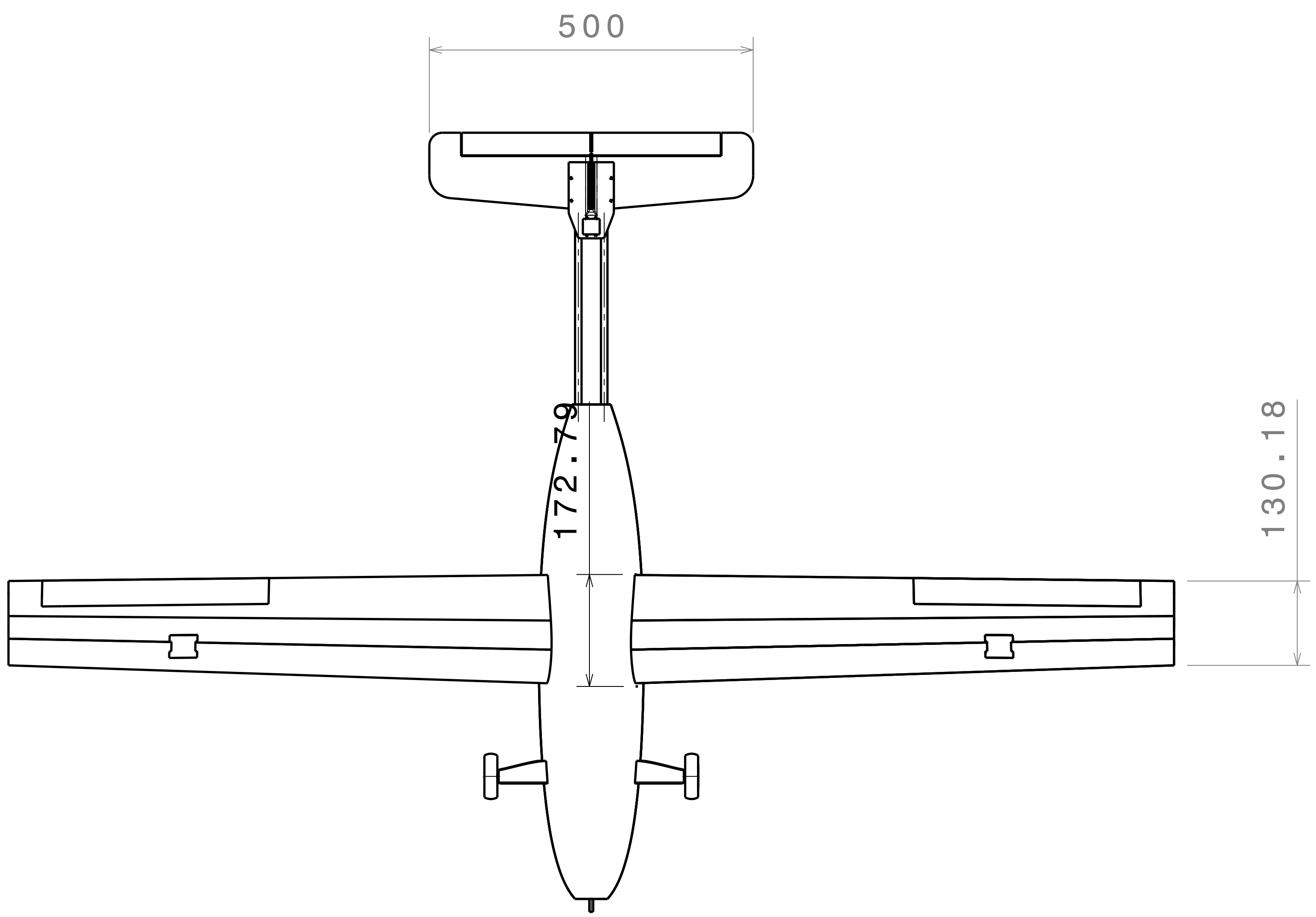
Our first iteration was built with a minimised fuselage to check out calculations. After first successful tests we designed a second iteration with an adapted wing and a fuselage able to carry 1kg of payload. From that point we focused on optimising smaller part as our wing-fuselage-connectors.

We will use our time left till the competition to train our pilots. We do not plan major updates anymore, as most of our team is focused on building our NFC22 aircraft. But we are looking forward to the competition.

5. Appendix







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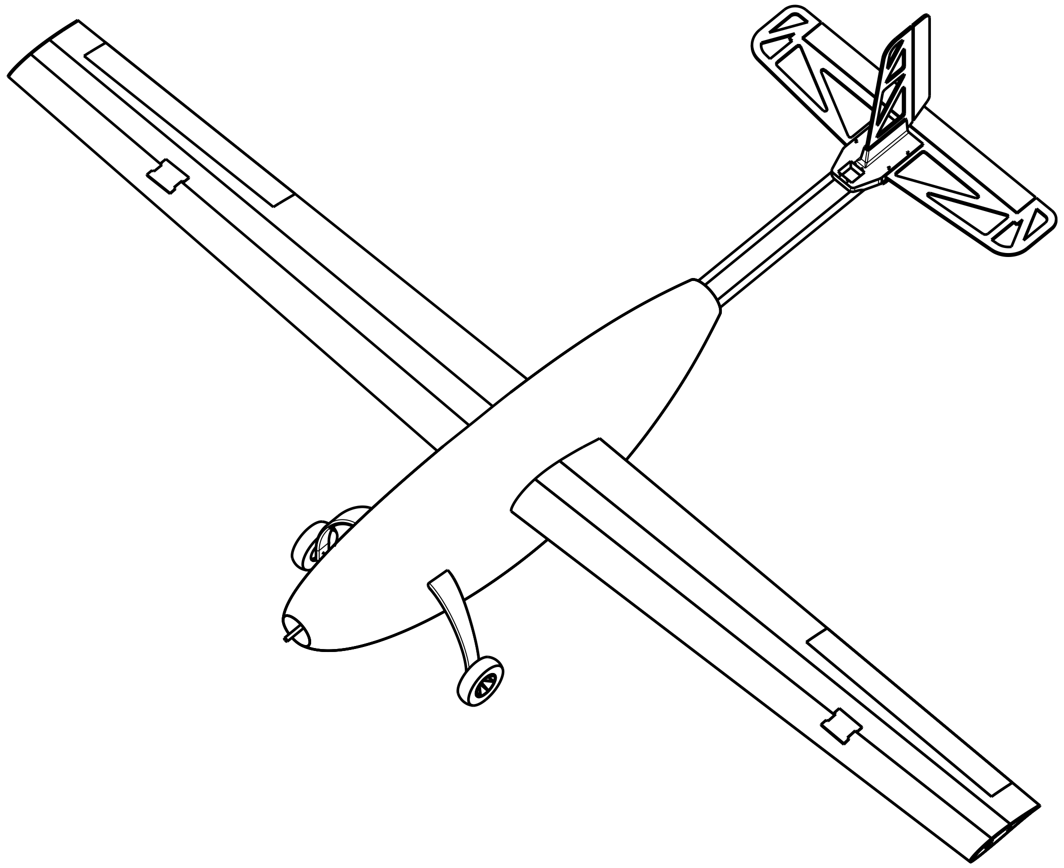

Isometric view
Scale: 1:10

Designed for	Air Cargo Challenge 2022	Title	Moby Dick
Date	01.05.2022	Team	HAWings
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