Air Cargo Challenge 2024

Participation Handbook

Version 1.3

22.04.2024

ADDI

AACHEN DRONE DEVELOPMENT INITIATIVE

Changelog:

Date	Change
07.08.2023	Version 1.0
09.08.2023	V1.1: minor changes, clarifications propeller
31.08.2023	V1.2: minor changes
22.04.2024	V1.3: corrections, more details fly-off

Changes since Version 1.0:

Section	New in version	Change (green new, ~~red~~ old)
2.5	1.1	~~Euroavia~~ EUROAVIA
3.5.5	1.1	Folding propellers are allowed. Variable pitch propellers are not allowed.
3.7.2	1.1	Lowest energy consumption per distance ~~and payload~~
3.7.4	1.2	Changed efficiency calculation to avoid regular 0 points
3.7.	1.2	Corrected section numbers
3.7.7	1.2	The current penalty is active for the total flight.
2.6	1.3	~~Dinner~~
2.7	1.3	Updated information regarding insurance, competence certificate and eID
3.3.8	1.3	(= nothing allowed in this area)
3.3.8	1.3	The box must be oriented with the XT-60 input and output connectors facing forward as shown in the appendix.
3.4.2	1.3	~~We will provide a template for the front page.~~
3.5.1	1.3	The allowed flight area is depicted in the appendix 5.2.
3.7.6	1.3	~~180s~~ 120s (in the denominator of the formula)
3.7.7	1.3	you receive ~~1~~ 0.5 points penalty for the current flight
3.7.10	1.3	points of one round can never be higher than ~~1176~~ 1113 points
3.9.	1.3	maximum of ~~1476~~ 1413 points
5.1	1.3	CAD drawing of Measurement Box added
5.2	1.3	Allowed flight area picture added

INTRODUCTION

The competition Air Cargo Challenge was originally initiated in 2003, inspired by the North American DBF (design-build-fly) aircraft university competitions. Since then, the competition was held every two years and, from 2007, the challenge gained a European projection. In 2024, the competition is organized by the Aachen Drone Development Initiative (ADDI), which won the competition in 2022. It is a competition for university students and postgraduates in the engineering or science area and was created to stimulate interest in the fields of aeronautics. In this competition, each team gets the chance to test and improve their skills by competing with other teams in a design-, build- and fly competition.

ADDI is exclusively managed by students and former students of RWTH Aachen University. They work as non-political and non-profit associations to promote and spread Aeronautical Engineering. The Air Cargo Challenge offers students the unique opportunity to develop a multidisciplinary and challenging project from its beginning to the finished product. By participating at ACC, the teams can test their knowledge and, at the same time, get involved with a wide range of challenges that students will find in their future professional careers: technical, interpersonal, and financial challenges as well as strict deadlines. To participate in the Air Cargo Challenge competition, the team should design, document, build and fly a radio-controlled aircraft with the best and highest combination of large payload, excellent efficiency, and high speed. The aircraft must comply with the following competition's regulations, including design restrictions such as pre-defined motor and transport box dimensions.

CONTENTS

1 NOTIFICATION, NEWS AND CONTACT

All news will be posted on our website https://www.aachen-drone.de/acc-24/ . We suggest visiting the website regularly. This is the binding source for news as well as changes in the regulations and organization.

For press inquiries please contact acc2024@addi.rwth-aachen.de.

Some updates will be announced additionally on our Instagram page (https://www.instagram.com/aachendrone/).

If you have any questions concerning regulations or organization, please contact teamcontact@addi.rwth-aachen.de. PLEASE use your team number and team name as the first words in the subject line. (e.g. "04 ADDI - Question about motor") This contact is for all questions by the teams (organizational, financial, regulations, etc.). If necessary, the answers will be made public to every team.

There will be two WhatsApp groups:

1. “ACC2024 all Participants”: for all participants (unmoderated) to increase the communication between the teams before the competition. You will get the invitation link after your registration. All team members may join. Don't expect us to read all posts!

2. “ACC2024 team leaders”: for team leaders only! You may ask questions regarding Organization or Regulations. Please keep this group short and informative. Please use this only for small inquiries, everything else via e-Mail. (teamcontact@addi.rwth-aachen.de)

The competition regulations may be changed by the organizing committee in order to fix errors or omissions that are found in the existing regulations. The organizing committee may contact the team leaders by e-mail about more or less urgent subjects. All teams are considered to be notified from the moment the information is available on the official website of the competition.

2 ORGANIZATION HANDBOOK

Section 2 of the handbook will deal with all organizational and general matters.

The technical parts of the competition will be in Section 3.

2.1 Nomenclature

Shall = This is a requirement that should be kept. Please consult with us EARLY if you can't realize any of these rules to find a solution.

Must = This is a hard rule. Not keeping it will definitively lead to a penalty up to disqualification!

2.2 Participation

A team consists of 4 to 7 people. All team members shall be over 18 years old during the competition. One team member is the designated pilot. If you don't have a pilot, please contact us before applying.

The pilot may be a "non-student". (e.g. pilot at your local RC club,…)

Except for the pilot, all other team members shall be students, professors, or research associates of the higher education institution that they are representing. In case the organizing committee finds some of the team members are not from the university or other irregular actions occurred, the team will be disqualified.

A professor in charge is required when the team represents a university or different higher education school. He may also be a team member. A written declaration is required in which the professor states that the team is representing the university and confirms that all team members are students or employees of the university.

2.3 Application

The application period will begin on 01.09.2023 at 12:00 UTC. It ends on 01.11.2023 at 24:00 UTC or if all available spots are full. The application form can be downloaded during this period at https://www.aachen-drone.de/acc-24/.

We have to stop the application if 30 Teams have applied. If the limit is exceeded, the application will be accepted on a first come first serve manner. Every team is allowed to participate with a maximum of 7 team members. Due to this limitation, there are no guests possible in the initial application. If we still have free capacities after November 1st, it might be possible to bring guests and additional team members. Otherwise, everyone is free to visit the ACC as a visitor. Each university can participate with one team. The application is valid after the organizer receives the following items:

- Application that is fully and correctly filled out

- Copies of documents proving that all team members are eligible (ex: Student card, etc.)

- Professor in charge statement

All this information must be sent to teamcontact@addi.rwth-aachen.de with the declaration of the team name in the subject line of the e-mail. (e.g. "Team Daedalus – Application) Applications made before 01.09.2023 12:00 UTC or after 01.11.2023 24:00 UTC will not be accepted. The teams will be contacted via e-mail after processing, to confirm successful registration. A provisional list of the teams will be published one week after the application stop. The application will become effective with the

first bank transfer of the team application fee. You will get a bill after the application with important information regarding the bank transfer.

2.4 Financial

The first transfer has to take place until 01.02.2024 with 150€ per team member. Please use your team number and the name of your university as reason of payment. The second transfer has to be made by 01.04.2024 with 150€ per team member. Banking fees have to be covered by the participating team. We can only process received funds. If you/your university wishes, you can transfer the total amount by the first deadline.

Transfer	Amount per team member	Deadline
1st	150 €	01.02.2024
2nd	150 € (additional)	01.04.2024

ADDI e.V. will make all efforts to provide the teams with the greatest comfort and support possible. Accommodation, meals, and transportation during the competition are provided in the application fee. For each team member, including the pilot, the participation fee must be paid. The fee for the team members does not cover all expenses of the organizing committee. The deficit will be covered by sponsors. We are still trying to reduce the amount of the second payment through additional sponsors.

In case of a cancelation, we will try to give back as much money as possible. The teams are responsible for fulfilling all application fee deadlines. The receipt of payment is the relevant date.

2.5 EUROAVIA

We were asked by EUROAVIA IB if we could report what local EA groups join the ACC2024. We are happy to help EA to continue the Air Cargo Challenge in the future and will report to EUROAVIA IB what EA groups registered for the competition.

2.6 Competition program

The competition will take place in Aachen on 09.07- 13.07.2024

This is a preliminary schedule. We will update the schedule regularly and release the final version via our website.

Timetable (preliminary)

Day	Tue	Wed	Thu	Fri	Sat
Date	09.07	10.07	11.07	12.07	13.07
Morning		Technical inspection, Test flights	Competition flights Day 2	Competition flights Day 3	Departure until 9:45!
Afternoon	Arrival Check-in beginning at 15:00	Competition flights Day 1	Competition flights Day 2	Competition flights Day 3	
Evening				Final Dinner	

2.7 Insurance and pilot registration and certificate

The pilot needs to have insurance for model airplanes by German law. It must cover at least 1.000.000 €. Every pilot is responsible for his aircraft during flight. We are still discussing with the club of the airfield if a DMFV insurance is mandatory (would be free for 3 months but might be difficult for non German residents).

All pilots must have a proof of competency certificate from the DMFV (https://kenntnisnachweisonline.dmfv.aero/en/) No other certificates are accepted by the club which thankfully allows us to use their airfield.

By law you must have a label with the eID of the pilot. You can find Links to the registration at https://www.easa.europa.eu/en/domains/civil-drones/naa.

We advise all participants to travel with health insurance and with a European Health Insurance Card.

2.8 Deadlines

The important deadlines for the participation are summarized in the table below.

Application period	01.09.2023 12:00 UTC – 01.11.2023 24:00 UTC
First bank transfer	01.02.2024
Second bank transfer	01.04.2024
Preliminary report	01.03.2024
Technical report and drawings	01.05.2024
Competition	09.07.2024

2.9 Jury

The jury consists of university professors, industry representatives, and members of ADDI e.V.. They will be announced in the near future. They will score the reports submitted by the teams.

2.10 Location and program

This section will be filled later with general information about our location and program.

3 REGULATIONS HANDBOOK

3.1 General

We consider the ACC regulations as “open”, meaning that everything that is not forbidden is allowed. Of course, this is limited by safety concerns. If you are not sure about something you thought of, you can always contact the organizer to clarify if it is allowed.

The powertrain providing thrust to your aircraft is partially “closed”, giving only a limited number of options to provide fair and equal conditions for every team.

3.2 Flight goal overview

The task of the ACC 2024 is to transport as many ‘passengers’ (pool billiard balls) as fast and efficiently as possible. Each flight consists of a take-off, 90s of ‘efficiency’ flight, 90s of ‘distance’ flight, and a safe landing. Additional points are given for a shorter runway length and fast loading and unloading. To exclude the influence of the motor selection a specified motor must be used. The choice of propeller and ESC is free but exceeding a given current limit results in penalty points. To simplify travel for the teams the aircraft must fit in a defined transport box. The flight will be automatically measured and does not require a specific flight path. Thus, the results depend less on the skill of the pilot (no sharp turns).

First, the aircraft requirements are outlined before the deliverables are described. Following a detailed description of the competition procedure, the scoring system is presented.

3.3 Aircraft Requirements

3.3.1 General

You are tasked to design an aircraft that is powered by an electric propulsion device, and which generates lift by aerodynamic forces acting on surfaces remaining fixed in flight, except control surfaces. The remotely piloted aircraft must be controlled by the pilot on the ground using radio control. Any variation of geometry or area must be actuated at distance by radio control.

The aircraft must not be rotary wing or lighter-than-air (for example, helicopters, autogyros, dirigibles, and balloons are excluded). No form of externally assisted take-off is allowed. All energy for take-off must come from the onboard propulsion battery pack(s). The only means of aircraft propulsion is the prescribed electric motor.

3.3.2 Transportation Box

Each team must use a transportation box for the aircraft. The box is limited in size and must not exceed a maximum length + width + height of 1400 mm (inside dimensions). All parts required for the mission (wing, tail, fuselage, landing gear, motor, propeller, ground mission loading tool...) must fit into this box at one time. The transmitter and the battery are not regarded as part of the aircraft. The batteries must be transported in a special protective container. (See section 3.3.5 Propulsion) The total mass of the box including all items above must not exceed 23 kg. The Transportation box must be used during the transfer between the hostel and the airfield and is also well suited to travel as luggage in an airplane. It is also recommended that each transportation box has handles on both ends.

3.3.3 Size Restrictions

The size of the aircraft is not limited except for the requirement to be transported in the transportation box.

3.3.4 Identification

Every aircraft must have unique identification symbols. This identification shall be the team number and the name of the university. Other logos, for example from sponsors, are also allowed.

The team number must be visible on the aircraft:

- In figures with at least 10cm height (if this is not possible, please contact us)

- On both the top and bottom of the wing

- On both sides of the fuselage or vertical stabilizer.

The university logo shall be visible on the wings or the fuselage. The university initials can be used if they are unique and recognizable or if the logo is too complex.

By law, you must have a label with the eID of the pilot on the aircraft.

3.3.5 Propulsion

To ensure fair and equal conditions during the competition, certain parts of the powertrain are prescribed for all teams.

Only the prescribed parts are allowed in the powertrain. All parts except the ESC have to be commercially available and in unmodified condition.

Motor

The motor must be an unmodified T-Motor AT2826 900KV. The aircraft must be driven by a single motor and single propeller. The motor must be fixed to the airframe of the aircraft. The motor must be easily accessible from all sides to allow for inspection (recommended to mount the motor outside of the fuselage). The motor must be commercially available and in unmodified condition. You may solder the motor to the ESC or use connectors.

Transmission

The rotational speed of the propeller must always be the same as the rotational speed of the motor. -> e.g. only 1:1 Gears are allowed as long as they keep the motor rpm unchanged toward the propeller.

Propeller

The selection of the propeller is free to all teams. Only one propeller is allowed. The propeller must be commercially available off the shelf. Only the tip may be painted or covered with strips of tape to balance the propeller. No other modifications to the propeller are allowed. Commercially available ducted fan units are allowed. Folding propellers are allowed. Variable pitch propellers are not allowed.

The propeller must be fastened to the power train in a secure way (photograph/drawing in the final report). A common motor spinner or airscrew nut is ok (e.g. the one shipped with the motor). The propeller must be demountable to allow a test run without a propeller during technical inspection.

Keep in mind that it is your responsibility to avoid overheating or damage to the motor.

ESC

You may use your choice of ESC. The ESC may be developed and built by the team. The ESC is not allowed to increase the voltage of the battery in any way.

Main Battery

You may use LiPo-, LiIon- or LiFePo-based batteries. You may use up to 3 cells in series. The maximum voltage for the pack is 12.6V (LiIo and LiFePo have a lower maximum Voltage, according to their datasheet). The maximum continuous discharge rate must be at least 40A. The maximum voltage per cell as specified in the datasheet must not be exceeded. Multiple battery packs in parallel are allowed. Serial connection is allowed as long as the entire pack does not exceed 3s. The energy capacity per battery pack must not exceed 100 Wh.

Voltage, capacity, and maximum discharge rate shall be clearly printed on the battery. The cells/packs must keep their factory look and condition and may not be altered except for the plugs. If the required data is not printed on the pack/cells you must provide the datasheet from the manufacturer.

To allow for inspection of the voltage, the battery must have a (female) balancer connector of the single cell voltages with a spacing of 2.45mm pitch of the pins. (e.g. Standard EH or XH connectors)

Be careful with Lithium batteries, they can be dangerous. Also, check with your airline on how to transport them. (https://www.rcgroups.com/forums/showthread.php?209187-Complete-Guide-to-Lithium-Polymer-Batteries-and-LiPo-Failure-Reports)

Each team can choose to use batteries with larger capacities (in case a second start is necessary or for other reasons). Each team is responsible to have their batteries charged before each flight. It is recommended to bring more than just one battery.

All batteries must be stored and transported in a LiPo safety bag or container and not mounted in the aircraft. Usually, you can buy these safety bags at your LiPo battery dealer. If you notice a damaged LiPo battery, notify the organizational committee immediately!

Not confirmed yet: At the airfield, electric power (230V AC German Type F plug and 12V DC) will be available to enable the teams to charge their batteries.

Connectors

The battery connector must be an XT60 female plug to enable connection to the data recording box. The connector to the ESC must be an XT60 male plug.

The connection between ESC and motor may be realized by connectors or soldering.

3.3.6 Radio Requirements

The radio control is used to fly and operate the aircraft. The servos must be capable of withstanding the aerodynamic loads the aircraft is going to be subjected to during the flight. The flight will occur under any given weather conditions as long as the limits given in section 3.5.2 Bad Weather are not exceeded, either sunny, rainy, or windy. Therefore, the teams shall be prepared to protect their radio equipment.

All radios must comply with the frequencies for model aircraft in Germany. An independent avionics/servos battery pack is mandatory, with a minimum capacity of 600 mAh (2s LiPo recommended). No power supply from the main propulsion battery (Battery eliminating Circuit, BEC) is allowed. If your ESC has a BEC, you must disconnect the positive wire of the RC system or use an optocoupler module. The aircraft must have an externally accessible switch to turn on the radio control system. It must not be internal or under a panel or hatch.

Only 2.4GHz Systems are allowed since it reduces the risk of multiple teams having the same frequency channel. The system may have an 866 MHz backup channel. Please be aware that with some manufacturers your radio must have an EU firmware installed to comply with German radio regulations. (e.g. Taranis EU Firmware). Please read the manual on how to put the transmitter into range-check mode. The fail-safe function in the receiver must be activated and set up the following way:

Motor off

Full up elevator

Full right rudder

Full right aileron

Full flaps (if existing) down

3.3.7 Autopilots/'Fly-by-wire'

Fully automated flight is not allowed. Gyros, either integrated inside RC receivers or as an external gyro are allowed as long as no navigation/position/route control is done. Flight stabilization/'Fligh-by-wire' is allowed.

GNSS systems are only allowed as part of a telemetry system. If a GNSS is used must be directly connected to the receiver and not to the flight controller.

3.3.8 Automated Measuring Equipment

To make automated measurements of your flights, we developed a small box with all the measurement equipment. It uses a Unilog GPS Logger 3 (https://www.sm-modellbau.de/GPS-Logger-3) to get the altitude and GPS Data and a UniSens-E Sensor (https://www.sm-modellbau.de/UniSens-E-XT60) to record the voltage and current. This logger is approved and tested by several model aircraft competitions.

For safety, the box contains an arming plug that is used to arm the aircraft when it stands on the runway and disarmed directly after the flight.

The logger will be provided by the organizer and must be mounted in the aircraft by the team. The loss of the logger will result in zero points for the flight. It is your responsibility to fly in a way that the GPS receiver will point to the sky. Avoid steep bank angles (>40°) and high G-loads (>3-4g). Loss of GPS

signal will not be a reason to get an additional new flight. The measurement box must be placed in the model with an unobstructed vertical view of the sky (= nothing allowed in this area). We added two lines in the drawings to indicate an angle of 20° from the horizontal. Additionally to the vertical requirement we recommend not place any component over this line to ensure good visibility of the sky.

The box will be handed to you before takeoff and must be given back after landing. In case there is a problem with our logging equipment, the flight manager will give you a reflight.

You can find the size of the box in Appendix 5.1 Automated Measuring Equipment. The box will be screwed into your aircraft with two M3 screws. Every aircraft must have two M3 nuts directly under the box to safely and reliably mount the box. We suggest using M3 drive-in nuts in the aircraft. The box has one XT 60 Male connector to plug in the battery and one XT 60 Female connector for your ESC. The box must be oriented with the XT-60 input and output connectors facing forward as shown in the appendix. It is your responsibility that the cables are long enough that they can be connected to the measurement box. If required you can extend the cables either by soldering additional cable between your components and the connector or using extension cables. The box will have a mass of 150g. We will give you one opportunity per team to compare the measurements of current and voltage of the box with your own equipment (e.g. telemetry).

3.3.9 Payload

You are transporting pool billiard balls representing passengers. The payload must be fully enclosed within the aircraft's structure. Each ball must be securely held in position without touching another ball. The cargo bay must accommodate at least two balls. The diameter of the balls is 57 (+/-1) mm and the mass is 170 (+/-5) g.

Be aware that the payload might affect the center of gravity (CG) of the aircraft. The stability and controllability have to be calculated for all extreme CG positions. (see section 3.3.11 Longitudinal Stability of the Aircraft).

Because the loading and unloading time is part of the scoring, additional tools and devices are allowed for this task. However, all additional tools and devices must not be part of the aircraft (= not onboard during the mission).

3.3.10 Maximum Take-off Mass

To stay within the regulations of the airfield, a maximum take-off mass of 25 kg must not be exceeded.

3.3.11 Longitudinal Stability of the Aircraft

To ensure a safe flight of your aircraft, the correct position of the CG is important.

Calculation of the correct CG has to be executed by using corresponding formulas. The chosen calculation method must be described in the preliminary report for review by the organizing committee. To calculate the derivatives of the airfoils for the CG calculation, only the following methods or calculations by software are allowed:

- Wind tunnel measurements
- XFOIL
- XFLR5

- AVL
- Eppler
- Javafoil
- OpenVSP
- Other methods only after checking with the organizing committee.

A sufficient stability margin for stable flight must be demonstrated in a calculation for the most extreme (positive and negative) CG positions due to changes in the payload (for example, but not necessarily, maximal and minimal payload). The value of the intended stability margin must be delivered in the preliminary design report.

3.3.12 Aircraft Production

The aim of the Air Cargo Challenge is to learn and understand the challenges of the aircraft design process. Therefore, you must not only design the aircraft but you shall manufacture as many components of the airframe as possible by yourself. You will experience problems arising from your design decisions and learn from them. Especially the production of the wings shall be done by the team. Evidence that the manufacturing had been carried out by members of the participating team has to be provided (e.g. time-lapse video recording, Photos,...)

Some components are specifically excluded from this rule. Please use reliable commercially available off-the-shelf parts for:

- RC components (transmitter, receiver, servos)

- Screws, fittings, and connectors

- Powertrain (propellers, batteries)

3.3.13 Proof of Flight

An aircraft that has never flown before the competition and/or has no proof of flight will not be allowed to fly during the competition. A proof of flight video must be presented during the technical inspection.

3.3.14 Technical Inspection

During the technical inspection, all aircraft will be checked to meet these regulations and the minimum quality for a safe flight.

You will get a maximum of one hour time to set up your aircraft for the technical inspection. It has to be complete and ready for take-off, except for the batteries that are not connected until instructed and the payload that is provided on the flight days.

Inspection will comprise at least the following items:

• Dimensions

• Verification that all components are adequately secured to the vehicle

• Visual inspection of all electronic wiring to ensure adequate wires and connectors are used

• Verification that the propeller is attached safely

• Motor test

• RC-Check, range test with the motor off and motor on (read the manual of your equipment before the competition to make sure you know how to activate the range check)

• Servo test

• Linkages (correct mechanics, backlash, strength)

• Payload installation (fixation)

• Check of Center of Gravity (must be marked at the aircraft)

• Build quality

• Secure attachment of components

This list is not complete and we reserve the right to ground an aircraft we deem not airworthy.

3.3.15 Static Load Test

In addition to the technical inspection, there will be a static load test of the aircraft with payload before take-off.

A maximum of 2 team members are allowed to lift the aircraft on its wingtips by hand. (the thumb of the hand has to touch the outermost point of the wingtip) The aircraft has to withstand this load to be allowed for take-off. The aircraft must be held at the wing with the biggest wingspan for the load test.

Clarification:

Especially for swept wings, multiple wings, or wingtips, which do not allow easy support with the hands, a support structure may be used. For this support structure, the following rules apply:

- The thumb of the hand must touch the outermost point of the support structure, which must not reduce the effective wingspan.
- It must not reach further inside the wing than 20cm from the wing tip.
- The support structure may protrude forward or backward to compensate for any pitch tendencies due to the wing sweep.
- When connecting multiple wings, the structure must not carry any moments in between them.
- The support structure must be easily attachable and must be removed before take-off.
- The support structure and its functionality must be presented during the tech inspection.

Alternatively, a third team member is allowed to stabilize the aircraft by pushing either the nose or tail DOWNWARDS.

3.3.16 Spare Parts and Reserve Aircraft

You are allowed to have as many spare parts and additional aircraft as you want. All parts and aircraft must be equal to the primary competition aircraft. Everything must be presented during tech inspection. One primary competition aircraft must be declared and will be marked. Only in case of damage to the aircraft you are allowed to re-declare parts.

3.4 Deliverables

The evaluation of the designs will be made in several disciplines:

1. Technical Report

2. Drawings

3. Flight Competition.

All submissions must be in English. All submissions may be published on the internet or other media by the organizing committee.

3.4.1 Preliminary Report (PR)

The preliminary report is an update for the organizer. It consists of a written document that does not exceed one A4 page and eight additional pictures. It shall give a summary of the progress of the aircraft design and how you organized your team. It shall also show what is not developed yet and what difficulties you encountered.

Please don't forget to include your stability analysis formula as well as your aimed stability margin in the Preliminary Report.

There will be no scoring on the Preliminary Report, but there are penalties if you miss delivering it within the deadline. Delivery is via e-mail in PDF format. The maximum allowed file size is 20 MB.

3.4.2 Technical Report (TR)

The technical report sums up all your thoughts during the design of the aircraft and shows the final aircraft with its details.

The TR may have up to 30 pages (without attachments). It must be in A4 format with font Calibri (or similar) size 12. Delivery is via e-mail in PDF format. The maximum allowed file size is 20 MB.

To have better comparability between the different reports, the report shall contain at least the following chapters:

Introduction

- Project management (including financial budget and time schedule)

- Aerodynamic design

- Structural design

- Payload prediction

- Outlook

- Drawings

More content is requested and necessary to get the full score for the Report.

The drawings must be included in every report.

3.4.3 Drawings

Each copy of the report must include a set of four detailed drawings of the aircraft. These drawings consist of A3 size sheets included in the technical report. The drawings do not count toward the page limit.

One of the drawings must be a 3-view drawing of the aircraft using European projection, that is:

- front view at the top left corner

- top view below

- starboard view on the right of the front view

The views must contain the main aircraft dimensions:

Wingspan

wing root chord

wing tip chord

aircraft length

aircraft height

distance between the wing and stabilizer leading edge at the center line

span of the horizontal stabilizer

root chord of the horizontal stabilizer

tip chord of the horizontal stabilizer

height of the vertical stabilizer

root chord of the vertical stabilizer

tip chord of the vertical stabilizer

position of center of gravity

These 12 parameters will be used to verify the aircraft has the same dimensions as the drawing.

Below the starboard view, there must be a table containing other dimensional information such as relevant areas and/or volumes, used airfoil, etc. The second drawing must be an isometric perspective view of the aircraft. The third drawing shows the cargo bay, its location, and dimensions, as well as the location of the RC receiver and the measuring equipment The content of the fourth drawing are up to each team. Summary:

1. 3-view drawing

2. Isometric drawing

3. Cargo bay, RC receiver position, position of measuring equipment

4. Free choice

A standard scale for each drawing must be properly chosen. The 3-view and isometric perspective drawings may not display hidden lines. All dimensions must be in SI units except for linear lengths which shall be in millimeters and plain angles which shall be in degrees. All the drawings must have a label in

the right bottom corner containing the team logo or university logo, the team's name and number, a short description, and other pertinent information. If the aircraft is changed after the technical report is sent in, a new copy (called corrected drawing package) with remarks identifying the changes must be e-mailed to the organization committee or presented during the technical inspection. A missing or incorrect corrected drawing package receives penalties (not required if the initial drawing package represents the actual aircraft correct).

3.4.4 Poster

Since there are no on-site presentations, every team will bring a poster (size A0, 841 mm × 1189 mm, portrait) with details of their design. These posters shall be easily understandable to give spectators of the event a glimpse of the work you put into this project. The poster shall at least contain the following:

- Header: ACC2024 logo (left side), Team number, Team name, 3-letter country code(right side; https://en.wikipedia.org/wiki/ISO_3166-1_alpha-3)

- Team/University logo

- Basic aircraft parameters (for each missing information a penalty of 5 points will be given)

    Wingspan

    Total length

    Wing area

    Empty mass

    (max.) payload mass

    Airfoil used

- Image, isometric view, or rendering of the entire plane to identify it during the competition.

- Special features of the aircraft

A missing poster will be penalized with 50 points.

3.4.5 Deliverables Scoring

The following points can be achieved:

$S_{report} = max. 250\ points$

$S_{drawings} = max. 50\ points$

Points are given by our jury.

3.5 Competition

3.5.1 Flightfield

Our take-off and landing field is made of grass. The allowed flight area is depicted in the appendix 5.2. It will be lawn mowed before the competition. You can have a first look at the airfield using google maps: https://goo.gl/maps/kPACDboBS3pUJDiV7. We are thankful for the MFG Würselen to allow us to use their field for the Air Cargo Challenge Competition!

3.5.2 Bad Weather

The contest will be interrupted if the wind, measured at approx. 2 metres above the ground at the starting line, is stronger than 9 m/s for at least 20 seconds (8m/s if the wind is more than 45° from the starting direction). We will try to avoid rain, but you have to be prepared for high humidity conditions or even light rain.

The flight manager can interrupt the competition earlier if there are safety concerns.

3.5.3 Protest

The teams have the right to protest against the decisions made by the organizing committee. The applicable rules and the decisions of the jury cannot be the subject of protests. The protests must be presented in writing in English to the judges by the team's leader. The organizing committee is available to accept any suggestions or criticism aiming at improving any aspect of the competition. We remind you that unjustified (=not accepted by the jury) protests will end in a penalty.

3.5.4 Pilot, Helper, and Flight Manager

The pilot is allowed to have one helper with him on the runway. All other team members must be in the safety area during the flight. The pilot is required to follow the German laws. This includes, that he must not be under the influence of alcohol, drugs, or other illegal substances.

There will be a flight manager directly next to the pilot. He is the authority on the field and helps you to stay within the flight area. There will be no take-off attempt without his specific call. The flight manager is also allowed to demand an abort of flight and immediate landing.

3.6 Mission Procedure

The process for each flight round is described in the following.

3.6.1 Time Slots

A queue for the flight will be posted before each flight round. Bevor the round starts, you must inform the responsible judge how many payloads you want and which runway length you chose (we will give you forms to fill in your payload and runway length).

After your team's name is called you have 5 minutes to show up at the staging area. You must have the aircraft prepared and all materials and tools you need with you. At the staging area you will receive the billiard balls and the measurement box.

3.6.2 Loading and Pre-flight Check:

In the staging area, only two people are allowed. You have a maximum of 5 minutes to install the measurement box and prepare your aircraft (and tools if needed) for loading the payload. Neither any tools nor any payload is allowed to touch the aircraft. The positioning of all parts is up to the team. During the loading, the aircraft sits on the ground and only one team member is allowed to touch the aircraft, the payload, and any tools. The loading and the time measurement starts with the callout of the jury. After the loading, no changes to the aircraft are allowed except for plugging the ESC into the measurement box.

After loading the aircraft is lifted by the same two team members at the wingtips as a structural test. If a third person is required as described in section 3.3.15 Static Load Test, this person may then enter the staging area.

3.6.3 Take-off

The entire aircraft has to be inside the runway and no team member is allowed to touch the aircraft after line-up. If you touch anything outside this runway during take-off, there will be a red flag indicating that you violated the take-off distance. In that case, you are allowed to return your aircraft to the start line with a maximum of three team members and try again as soon as the helpers are in the safety area. You have three minutes to complete your take-off.

After advancing the throttle for a successful take-off attempt you have 30s time to climb.

3.6.4 Flight Mission Task

After the take-off and climb follows the efficiency task. The measuring equipment will automatically log the (2D projected) distance covered within the 90s time window and the electric energy required for it. After this, the speed task must be flown. You must cover as much (2D projected) distance as possible within 90 seconds. This distance is logged as well. You are allowed to trade altitude gained during the climb phase for speed as long as you stay within the altitude limits given in the following.

3.6.5 Restricted Areas

If you land or fly outside the flight area, the flight will be scored with zero points. The flight area will be published prior to the competition and will we explained during the pilot briefing. The minimum flight altitude during the flight mission tasks is 10m. The maximum altitude during all phases of the flight is 100m.

As safety for participants and visitors is our highest priority there will be a penalty up to disqualification if any person is endangered by the aircraft. Please inform your pilots that the highest priority is the well-being of people, not the aircraft.

3.6.6 Flight Pattern

You may fly at will during your entire flight time.

You must ensure to stay within the flight area. The bounds will be indicated to you by the flight manager during the flight and in the pilots briefing before the competition.

3.6.7 Landing

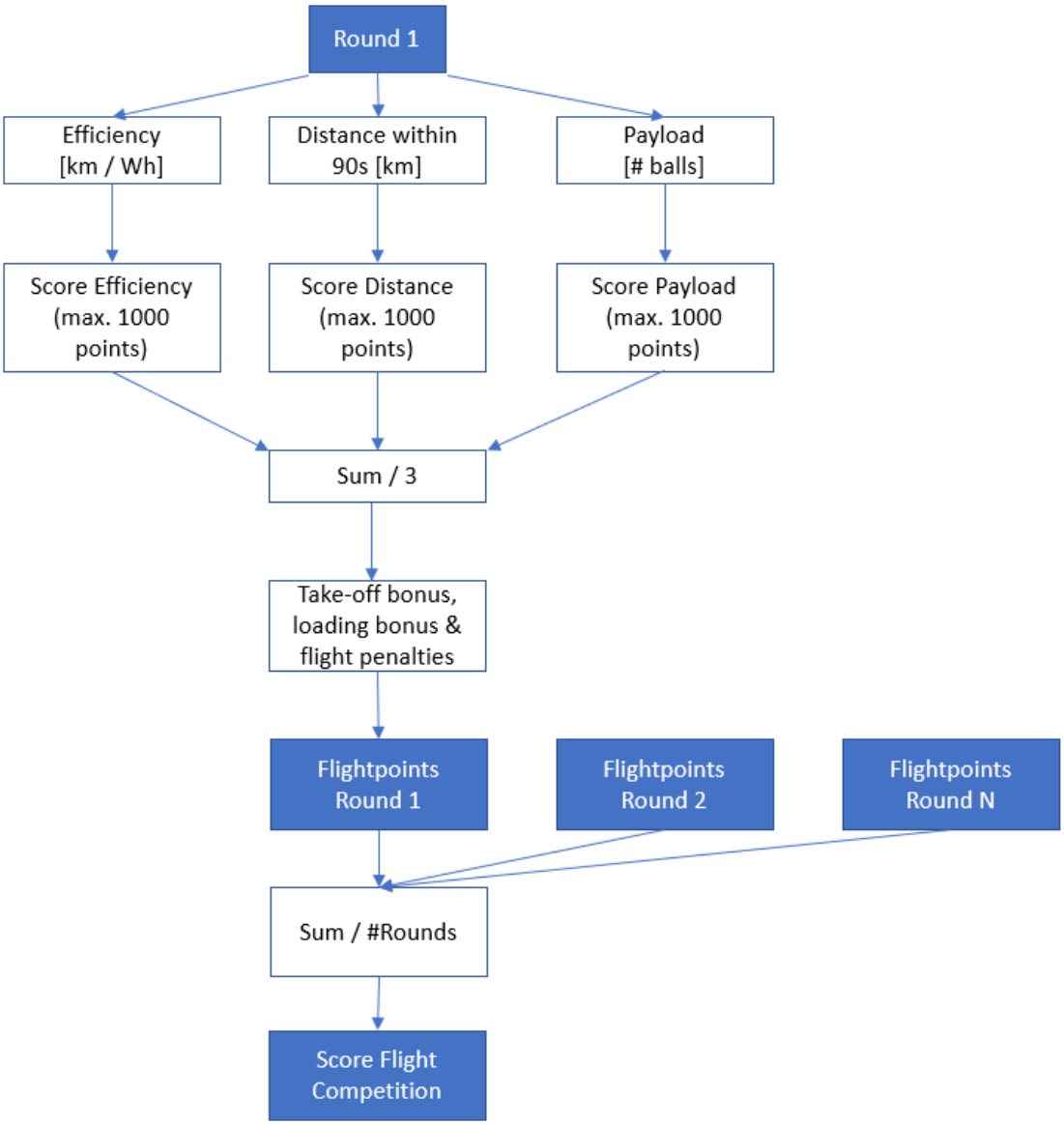
The landing must take place within the flight field. Landing within means that the first contact with the ground or any object (high grass, crop, or similar outside the landing area) must be within the landing area. After touchdown, the aircraft may roll or slide off the runway. It must not bounce off the runway. If you lose any parts during landing or damage the aircraft (status after landing not equal to the status before take-off) you will get a deduction to your score.

3.6.8 Definition Flight Time

The flight time starts when the current exceeds 5 A for more than 3 seconds or the aircraft reaches 5 km/h GPS-speed (whichever is earlier) in the logged data and the take-off is valid. After 30 seconds, the 90s efficiency task starts which is directly followed by the 90s distance flight. This results in a total flight time of 210 seconds plus time for landing. (Keep in mind you may need more than one or two tries for landing)

3.7 Flight competition scoring

3.7.1 Overview



3.7.2 Partial Scores

In reality, you don't get a fixed formula to assess your aircraft. You must do some research on competitors, comparable existing aircraft, or the physical effects that limit the performance of aircraft.

We will fly several rounds. Every team gets the chance to fly once during each round.

Partial scores will score the flight performance for each round independently for three features:

1. Payload transported during the flight
2. Lowest energy consumption per distance
3. Travelled (2D projected) distance within 90 seconds

The team with the best result in each category will get 1000 points. The other teams partially less.

In the end, all achieved points will be added up for the ranking.

3.7.3 Payload Scoring

The payload score for each flight is determined as follows:

$S_{payload} = 1000 * P_{Team}/P_{max}$

$P_{Team} = \#balls$ transported during your flight

$P_{max} = maximum\ \#balls$ transported by any team during this round

3.7.4 Efficiency Scoring

The efficiency score for each flight is determined as follows:

$S_{efficiency} = 1000 * E_{Team}/E_{max}$

$$E_{Team} = \frac{(distance\ traveled\ efficiency\ flight\ [km])^2}{2\frac{Wh}{km} * distance\ traveled\ efficiency\ flight\ [km] + consumed\ electrical\ energy\ [Wh]}$$

$$E_{max} = max\left(\frac{(distance\ traveled\ efficiency\ flight\ [km])^2}{2\frac{Wh}{km} * distance\ traveled\ efficiency\ flight\ [km] + consumed\ electrical\ energy\ [Wh]}\right)$$

during this round

3.7.5 Distance Scoring

The "Score Distance" for each flight is determined as follows:

$S_{distance} = 1000 * D_{Team}/D_{max}$

$D_{Team} = Distance\ travelled\ during\ your\ flight\ [km]$

$D_{max} = Maximum\ distance\ flown\ by\ any\ team\ during\ this\ round\ [km]$

3.7.6 Loading and Unloading Bonus

For each flight, the team must put the payload into the aircraft. The shorter the amount of time a team needs for loading the payload, the more points can be gained. The aircraft shall be prepared for take-off completely before the loading. After the payload is mounted, no more changes to the aircraft are allowed.

After the flight, the main battery is disconnected and the aircraft is transported to a safe location on the ground by the team for the unloading of the payload.

The relationship is the following:

$$B_{loading} = 60 * \left(1 - \frac{t_{loading} + t_{unloading}}{120s}\right) for\ t < 120s, 0\ points\ for\ t \geq 120s$$

$$t_{loading} = time\ needed\ for\ loading\ the\ payload\ and\ prepaing\ aircraft\ for\ flight\ [s]$$

$$t_{unloading} = time\ needed\ for\ unloading\ the\ payload\ [s]$$

3.7.7 Current Penalties

A short take-off requires a high-power loading of the propulsion system. However, it also reduces the life span of the motor. To reflect this trade-off a current penalty is applied for exceeding the current limit of 30 Ampere. The current is recorded with 10 Hz and mean value calculated every 0,5s. The penalty calculates to

$$P_{current} = 0.5 * \int current\ above\ 30A\ dt$$

(so per second and ampere you exceed 30 ampere you receive 0.5 points penalty for the current flight round). The current penalty is active for the total flight.

3.7.8 Take-off Bonus

If your team decides to only use 40 meters instead of the available 60 meters of runway you will get an additional 5% bonus to your flight points.

You must announce this option together with your payload before the round starts. All rules apply for 40m instead of 60m, e.g. if you can't start within 40m the flight is invalid and you may try again if the remaining time allows it.

$$B_{take-off} = 0\ for\ vioaliting\ runway\ limit, 1\ for\ 60m\ runway, 1.05\ for\ 40m\ runway$$

3.7.9 Flight Penalties

If any part of the aircraft gets lost during the flight attempt, the flight will be scored with zero points due to safety concerns. "Lost" means that a part has no more physical connection to the aircraft.

If you damage the aircraft during landing in a way that it is not capable or safe to fly directly again (as stated in the tech inspection section 3.3.14 Technical Inspection) your mission score is multiplied by 0.5. The rules for landing as given in section 3.6.7 Landing must be fulfilled to be regarded as a landing.

If the recorded battery voltage exceeds 12.75 V at any time the flight will receive zero points.

If you are flying below 10m (except for take-off and landing) or over 100m altitude during the flight you will receive zero points for the round. If you are violating a no-fly zone you will receive zero points for the round. The first violation results in 200 global penalty points. The second violation of the flight areas results in disqualification.

3.7.10 Score for one Round

Using the results from 3.7.3 Payload Scoring to 3.7.9 Flight Penalties we now calculate the total points for the team for one round.

$$S_{round,N} = \left(\frac{S_{payload} + S_{efficiency} + S_{distance}}{3} + B_{loading} - P_{current} \right) * B_{take-off} - P_{flight}$$

(Therefore, the total points of one round can never be higher than 1113 points.)

3.7.11 Score for the Flight Competition

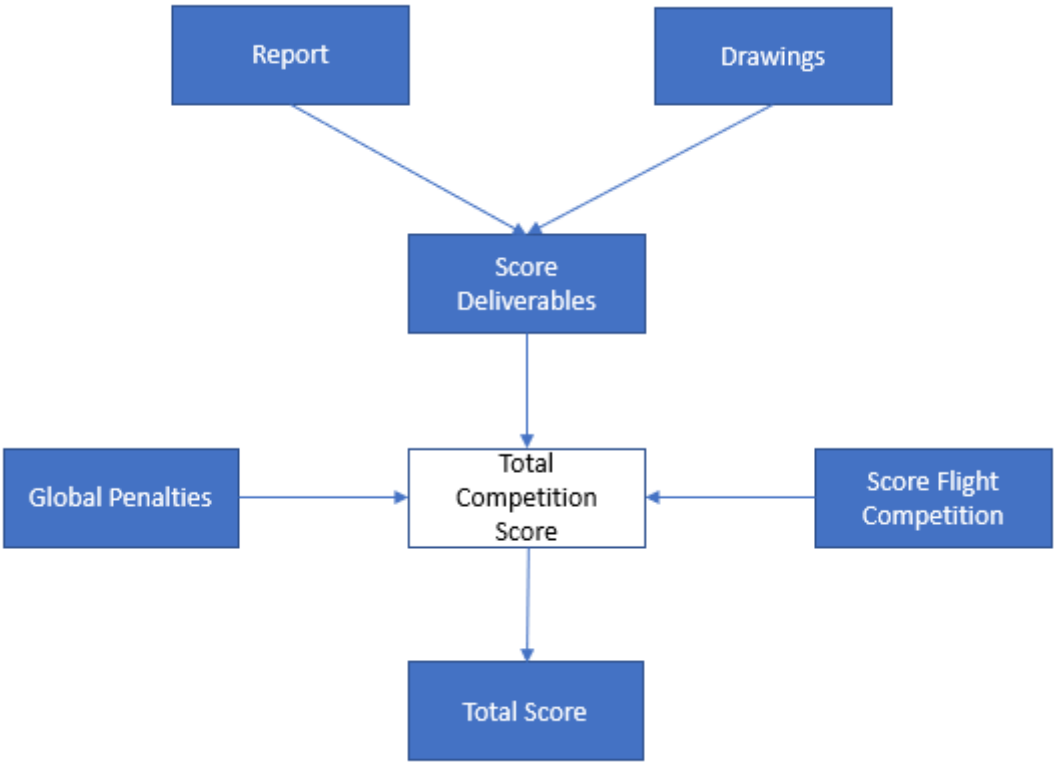
The flight competition score ($S_{flight\ competetion}$) is the weighted average of all round scores. In case of two flight rounds, the worser round score will be weighted only 50%. In case of three or more rounds the worst score will be weighted 25% and the second worst 50%.

3.8 Global Penalties

These points will be deducted from your final competition score.

Delay in delivering Preliminary report	30 points per day, max. 100 points, disqualification after 30 days
Poster missing	50 points
Delay in delivering technical report/drawings	30 points + 30 points per day, no acceptance after 15 days delay
Delay or not being present at the technical inspection (e.g. over 60 min set-up-time)	50 points
Delays during competition	5 points per minute, after 10 minutes your attempt for this round is forfeited
Replacement of parts without notifying the organization committee	50 points
Aircraft dimensions changed compared to the technical report drawing package. A tolerance of +/- 2 cm is allowed.	Every additional cm of difference is 5 points. (the difference is rounded to full centimeters)
Missing or incorrect corrected drawing packaged	30 points
Disregard of regulations	Disqualification
Flying outside the flight area	200 points penalty + flight with 0 Points 2nd offender: disqualification
Flying over the spectator area	Disqualification
Disregard of flight manager/Jury/Organizing committee	200 points up to disqualification
Unjustified protest (the jury does not agree with your protest)	First time: 20 points Next times: 50 points

3.9 Total Score / Final Ranking



All given points will go into the final ranking.

$$S_{total} = S_{flight\ competition} + S_{report} + S_{drawing} + \sum global\ penalties$$

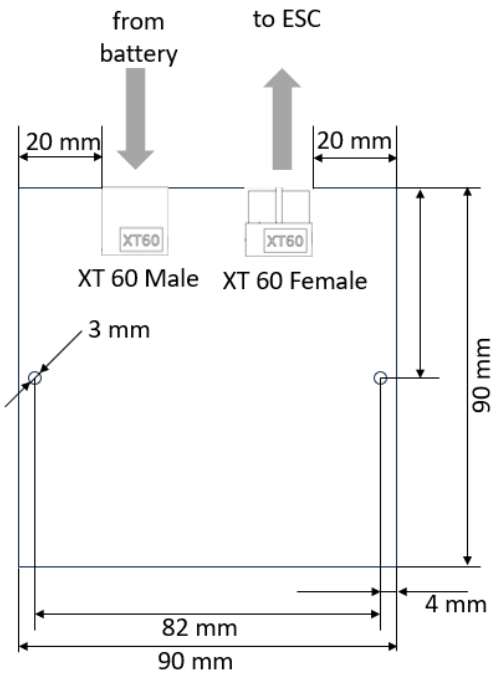
$$S_{flight\ competetion} = Score\ of\ the\ team\ in\ the\ flight\ competetion$$

(A maximum of 1413 points can be achieved in the entire competition theoretically.)

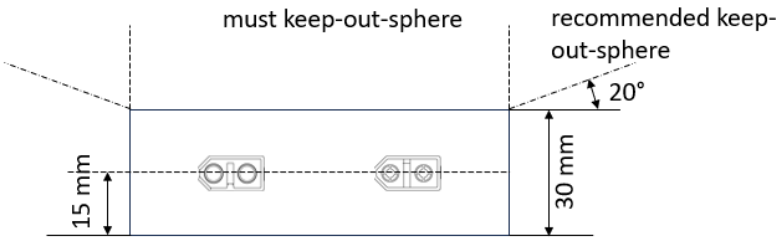
The final ranking is based on this score.

5 APPENDIX

5.1 Automated Measuring Equipment

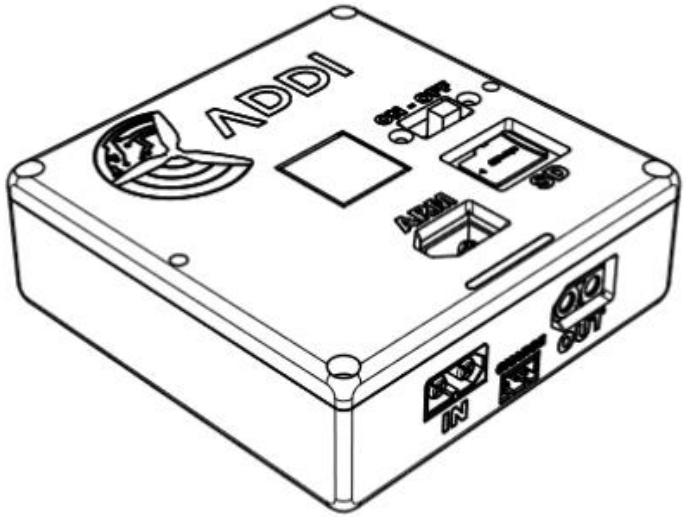


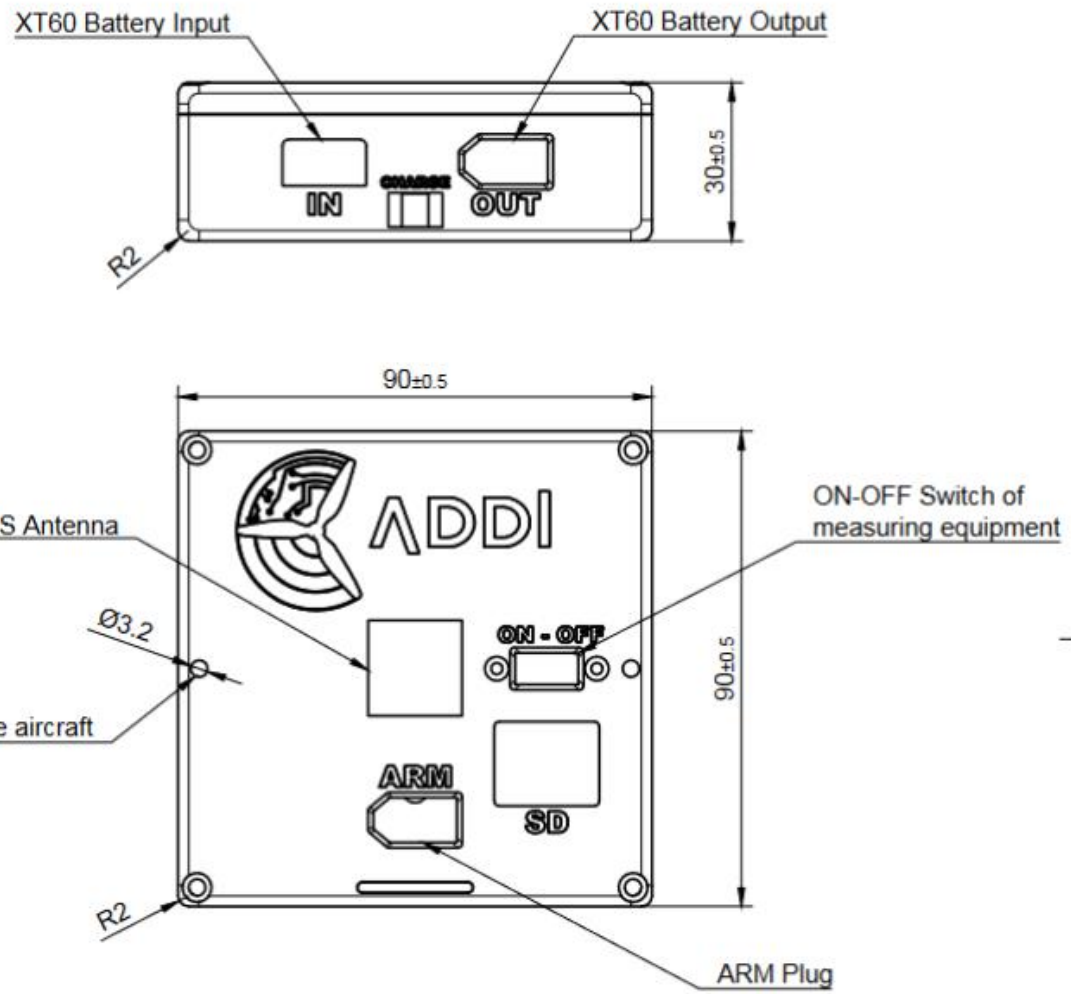
Top view



Front view

mass = 150 g





Important Notes:

As the device is 3D printed, make sure you allow for some deviation from nominal dimensions, as stated by the dimensions above.

Make sure ARM plug and ON-OFFswitch are reachable at any time.

The keepout zones as stated in the rules still apply.

Dept.	Technical reference	Created by: Maximilian Fries 20.04.24	Approved by
		Document type	Document status
		Title: Messbox	DWG No.
			Rev. / Date of issue / Sheet: 1/1

5.1 Airfield

Location of the airfield:
https://www.google.com/maps/place/Condor+e.V.+W%C3%BCrselen/@50.8333722,6.1432928,261m/data=!3m1!1e3!4m6!3m5!1s0x47c09f496d948419:0xbeeec57d9af70b53!8m2!3d50.8333486!4d6.1441893!16s%2Fg%2F12hsg7z9n?entry=ttu

Allowed flight area shown below: