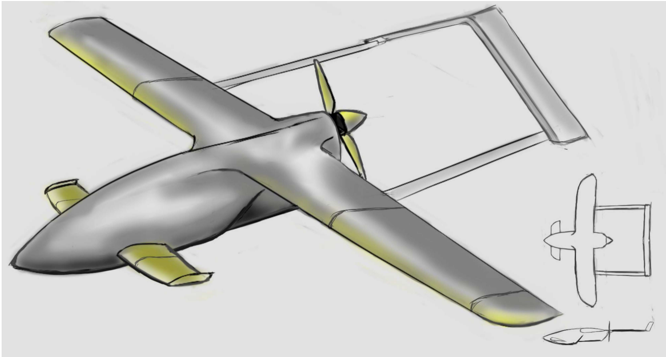

Concept Paper UAS Challenge

Team Number: 14

Technische Universität Dresden

TU Dresden Robotik AG

Position	Person	Signature
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Team Member	Subject	Year of Enrollment
Dominik Braig	Physics	2016
Robert Lange	Computer Engineering	2021
Friedrich Lunacek	Mechatronics	2021
Sebastian Schwabe	Electrical Engineering	2017
Andreas Türke	Mechanical Engineering	2015
Alexander Tutsch	Mechatronics	2021
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Konstantin Wrede	Electrical Engineering	2017
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1 Introduction

We, the TU Dresden Robotik Arbeitsgruppe (TURAG), are a group STEM students at the Technische Universität Dresden, Germany. We offer an interdisciplinary environment for students, mostly studying at the School of Engineering. Students can gather practical experience and network with other students and companies. Our organization has a long tradition in building autonomous mobile robots, mainly for the international robotics competition Eurobot. Since 2006 we have been participating at Eurobot. Now we are looking forward to attend a new challenging competition.
In the following chapters we will give a short introduction to our Unmanned Aerial Vehicle concept for the UAS Challenge 2022. We will describe our design goals and explain our ideas to fulfill these. We will provide more detailed insights into the general aircraft configuration as well as our subsystems for propulsion, control, communication, package carriage and launch.
All abbreviations used correspond to those from the UAS Challenge 2022 Competition Rules, Issue 1.

2 Concept Description

The main goal of our concept is to create an aircraft with high payload capacity and cruise speeds to reach good results at the core task "Cargo Delivery" and the optional task "Endurance". Since our team is not experienced in flight navigation and digital image processing, we will not focus on the optional mission "Area Search".
To approximate the dimensions and weight of the aircraft a mass budget was calculated. It includes specified weights for components like the flight controller, which are already predetermined. Unknown weights for components like wings or airframe were estimated by researching realised vehicles and configurations.

- electronics: 1600 g
- propulsion: 400 g
- structure: 3000 g
- payload: 2500 g

In total this results in 7500 g maximum take-off weight. The payload includes the aid package with 2000 g cargo mass and the ADB Micro System with 500 g mass.

2.1 Aircraft Configuration

To fulfill our mission goals, we will design a fixed wing UAS in a canard configuration. This allows the use of the complete fuselage to store the aid package and other components such as electronics. Furthermore the enlarged wing area with both wings creating lift will allow slower cruising speeds and shorter take-off and landing distances. The propulsion will be located in the rear to improve the weight balance, vertical stability and crosswind sensitivity.
The main wing is planned as a rectangular wing with a rib and spar structure. This construction offers a lightweight and stiff structure and is easy to repair in case of a crash. The wing will be covered with foil. When the aircraft has proven its flight stability and robustness, a more complex wing design might be considered. To improve the lift coefficient distribution in spanwise direction and lift-induced drag a trapezoid wing with multiple segments could be used in future designs. The estimated wing span is 2700 mm with an aspect ratio of 12. The main wing will be top mounted to ensure ground clearance. To avoid further damage in case of a crash each wing half is mounted separately to the fuselage at mountings with predetermined breaking points. The ailerons are actuated by servo motors which are located inside the wing. The force to actuate ailerons are transferred by push rods.

The airframe consists of a supporting structure to bear the loads and an outer shell for aerodynamic efficiency and protection of electronic components. Instead of a conventional landing gear with tires a skid landing gear will be used. Because an auxiliary start device is planned good roll characteristics are not necessary. Therefore braking performance at landing is immproved. This ensures take-off and landing inside the designated area.

2.2 Propulsion System

The thrust will be generated by a single propeller propulsion system. For modern model aircraft applications a thrust-to-weight ratio of at least 75 % is favourable. Therefore a brushless motor with an with 16 inch prop will be used. With this configuration an maximum thrust of 6000 g can be generated. In cruise flight an average current draw of 15 A is planned to allow enough range for a complete mission time. To ensure ground clearance at landing a folding propeller is used.

2.3 Electrical Power System

A lithium polymer battery with the specifications of 6S at a 22.2 V nominal voltage and a capacity of 4000 mAh is used to supply all electronics of the UAS. To provide the nominal voltage of the battery to the on-board electronics as well as to convert it to 12 V and 5 V, a power distribution board is developed. This board will also be capable of current monitoring. In coordination with possible candidates for a motor and the chosen airframe concept, a maximum air time of up to 20 min is estimated. To ensure adequate weatherproofing of the UAS, sensitive electronic components in the UAS's fuselage will be protected by its sealed housing.

2.4 Control System

The Pixhawk 5X is used as the UAS's flight controller. For navigation, integrated sensors such as a GPS module, onboard redundant IMUs and an external airspeed sensor in form of a Pitot tube are used. The design of a real-time control system is supported by the open source software PX4. This software also offers a lot of features for autonomous navigation by means of an autopilot. For example, it is possible to define a Geo-fence, which shall activate the FTS if it is violated. For less real-time critical tasks, a Raspberry Pi 4 Compute Module is provided. Guidance tasks, image recognition and communication to the GCS is perfomed using the ROS 2 framework onboard the compute module.

2.5 Communication System

With a direct connection to the flight controller, a transceiver is provided for the communication to the master controller on the basis of a 2.4 GHz connection via ExpressLRS. For default transmission of telemetry data to the GCS, another transceiver will be connected to the Raspberry Pi, also operating on the 2.4 GHz band. These should ensure reliable operating ranges of more than 500 m via WiFi broadcasting. Both transceivers are 'Spread Spectrum' compliant on the 2.4 GHz band. The communication between the Raspberry Pi and the flight controller will be via an Ethernet interface using MAVLink.

2.6 Imaging System

Regarding a camera system, a Raspberry Pi High Quality Camera can be used. Ground markers can be detected in Open CV using filters that have been basically tested and evaluated. The markers are then interpreted, localized and these information is sent to the GCS. The Raspberry Pi forwards the telemetry from the flight controller in addition to the camera data and the interpreted results.

2.7 Ground Control Station

The setup for a GCS is a consumer notebook (or tablet) together with a transceiver for communication with the UAS on the 2.4 GHz band. On this notebook the open source software QGroundControl is executed, which allows the definition of waypoints and an outer boundary as a Geo-fence.

2.8 Catapult

In order to achieve the UAS's required minimum take-off velocity of approx. 15 $\mathrm{m/s}$, the usage of a launch catapult is considered.

2.9 Package Carriage and Release System

The construction for loading and deploying the aid package will be a half cut tube made of glass fiber or carbon fiber reinforced plastic. After loading the package, the tube will be rotated to allow a rapid loading process. This enables passive keeping without power even in case of a system failure. A fast deployment is made possible by a release mechanism with a preloaded spring, which is actively triggered. Alternatively, a conventional mechanism with a part of the fuselage flapping out synchronized via cable control could be used. A release height of 20 m is planned.

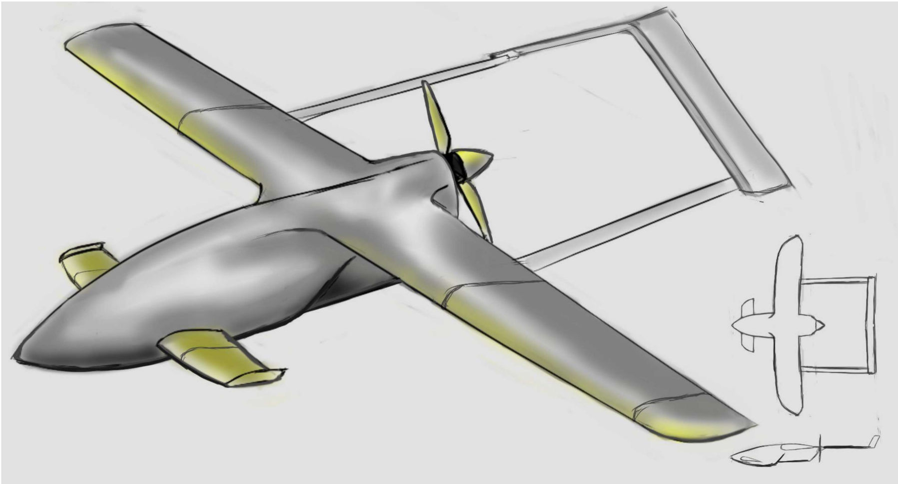
2.10 Flight Termination System

In case of a loss or severe disruption of the data link between the UAS and the GCS as well as the breach of the Geo-fence, the FTS should be triggered. Thereupon the UAS shall safely land as soon as possible after initiation. The throttle will be set to ‘engine off’ and the control surfaces set to initiate a rapid spiral descent. The FTS will be capable of manual selection via the Master Controller.

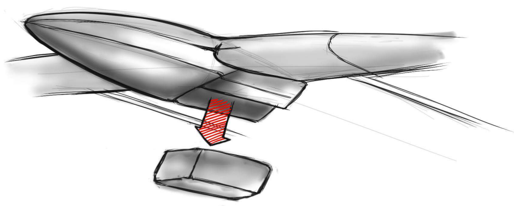
2.11 Storage Container

To protect the UAS from damage during transportation it will be stored in a flight case, which is usually used for event technics for example. The storage container will also include the ground control station and a secured space for batteries.

3 Drawings

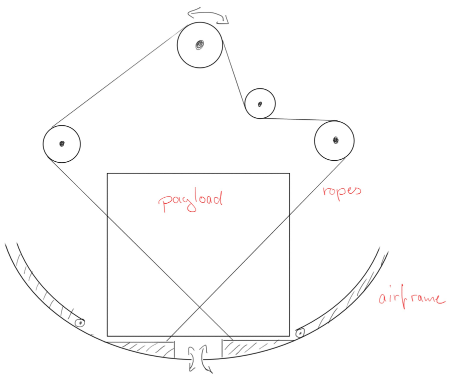


(a) Different perpectives

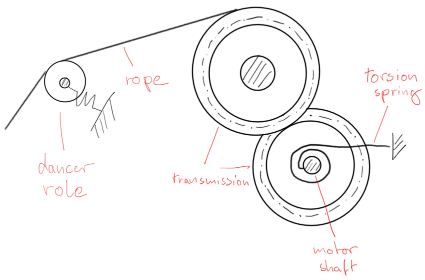


(b) Aid package drop

Figure 1: UAS Concept Drawings



(a) Cargo Doors



(b) Rope Pull System

Figure 2: Conventional Approach for a Package Carriage System

4 Project Plan

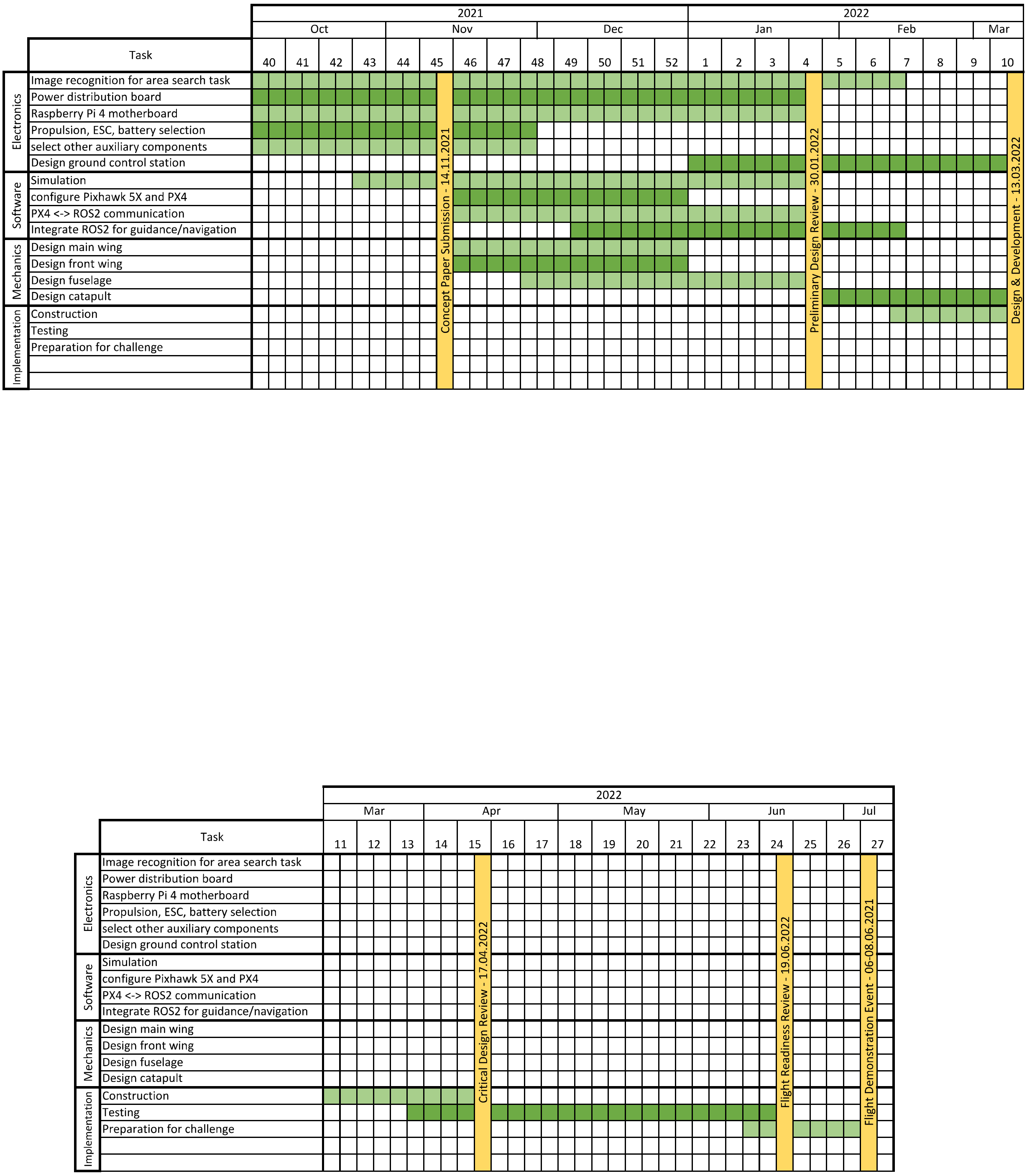


Figure 3: Gantt diagram of the project plan.