

# Technical Approach

*Please find attached a very rudimental design in the form of a 3D PDF which is used to help illustrate some concepts.*

## Sponsor Relationship

To fully define the technical approach more information will need to be gathered from the sponsor. The relationship with the sponsor will be more pertinent in the beginning and final stages, the middle development stages will be done independently, with the need to access some of their facilities for information gathering purposes and concept testing.

On that note a closer relationship with the sponsor will always yield beneficial results for both the developer and the client.

## Aerodynamic Design

The chosen aerodynamic design will be a rotorcraft for manoeuvrability and control. To reduce the amount of actuators the rotors will be fixed pitch. The exact configuration will be explored during the project and will be selected based on a few factors like power distribution (electrical and aerodynamic), as well as control algorithms and space requirements.

Therefore no exact sizes of the aircraft are available yet, but will be designed to fit into a 14000cm3 sphere (Radius = 15cm).

## Collision Protection

*The cage described below is not represented in the 3D PDF, the Gimbal concept is attached.*

For collision protection we propose placing the full rotorcraft in a polyhedral cage which will generate an even and safe bounce off, as to avoid loss of control.

The cage will surround a two-axis gimbal set, and using inertial sensors we will keep the inner frame stable. This will allow the cage to roll around the device, while the core remains stable. Thus giving more accurate camera feeds and navigation, as well as allowing the drone to roll on floors, walls and other obstacles.

## Explosion Protection

*The colour references made below are represented in the attached 3D PDF.*

To ensure full explosion protection we have proposed a modular design, using the three most common methods of protection.

Designing intrinsically safe circuits would only be applicable to the control circuitry (Light Grey Box). Since the motor drivers (Orange Box) will be running at much higher powers, we will be encapsulating those circuits. Encapsulation for obvious reasons can’t be applied to moving parts so the motors will need to be contained in their own explosion proof containers (Red Box). The battery (Yellow Box) will be encapsulated and will source power to the other modules through the interlinking connecting shafts (Black Thin Square Tubes).

## Sensor Packs

To try and locate the higher power consumption areas, encapsulated with the motor drivers are the illumination components (White Hemispheres), Cameras (Blue Hemispheres) as well as some sort of object detection/proximity sensor (Green Hemispheres).

Placing a camera on each quadrant of the device will help the user navigate the device, while one of the cameras will be dedicated for inspection purposes.

In the control box we will include accelerometers and gyroscopes to determine the devices orientation and assist with generating maps of the inspected areas as well as stability.

The working environment needs to be assessed further to develop the appropriate wireless communication protocols, but a possible approach is to place an explosion protected transmitter inside the tank (or other possible environment) to create a signal hub inside, which we can then use as an extension to the outside user.

## Material Selection

The cage will be made from lightweight materials. Potentially carbon fibre for the frames and propellers to ensure light weight designs and that no sparks are generated with a collision. The explosion proof containers will be made from Carbon Fibre or some form of polycarbonate.

## Power consumption and Endurance

To obtain maximum flight time, battery selection becomes very pertinent. A high density battery such as lithium ion polymers or a battery pack of a similar chemistry will need to be used. These batteries unfortunately can be unstable so a very careful battery monitoring circuit will need to be introduced. Luckily we will never charge the battery inside the volatile environment.

Due to the principles of flight, weight will directly affect power consumption, thus the importance of the material selection.

From previous experience, flight time can be estimated to sit between 15-30 minutes.

# Budget

The budget and timing is available for the first three phases and is estimated below. Aspects of the later phases are difficult to evaluate at this point in time and can be reassessed with the sponsor further down the line.

Phase 1 – Proof of technical concept

Expected Time: ±3 Months

HR Costs: R688 589

Running Costs:

Phase 2 – Development and optimisation against the intended application.

Expected Time: ±6 Months

HR Costs: R1 377 173

Running Costs:

Phase 3 – Prototype construction and laboratory testing

Expected Time: ±3 Months

HR Costs: R688 589

Running Costs:

# Team Experience

The proposed team is a joint collaboration between South Africa’s Council of Scientific and Industrial Research (CSIR) as well as The University of Stellenbosch (US).

## CSIR ~ Mechatronics and Micro Manufacturing (MMM)

The Council of Scientific and Industrial Research in South Africa is seen as the innovation hub of the country. The Mechatronics team is dedicated to the design of autonomous robotic systems, as well as a variety of different electronic devices. The MMM team is also responsible for the innovations behind mining technologies at the CSIR.

We have existing expertise in image processing, communications, electronic and mechanical design and embedded software.

## US ~ Electronics Systems laboratory (ESL)

The University of Stellenbosch is renowned for having one of the top engineering programs in the country. The ESL group specializes in both the design and control of aircraft, both fixed wing and rotary. More information can be seen at: <http://www.esl.sun.ac.za/wp/>

## Team Members

*Please find attached the CV’s of the individuals mentioned below.*

### CSIR

John Dickens – Electronic engineer with a background designing products and sensor packs for use in mining environments.

Thegaran Naidoo – Computer engineer with experience in automation, control systems and machine learning. As well as a background in computer vision and image processing.

Danny Naicker – Electronic and software engineer with experience in designing military grade communication systems and other robotic systems.

Angus Steele – Mechatronic engineer with experience in electronic design and robotics. Currently conducting a master’s research project on the development of a, close quarter, explosion protected, aerial robot.

Peter Bosscha – International experience in both electronic engineering and product development. Has a background in Engineering project management as the co-founder and current research group leader of the MMM unit.

### University of Stellenbosch

Johannes Treurnicht – Electronic and control systems engineer with a background in aerospace design. Currently a lecturer in control systems and is doing PhD research in quadrotor aerodynamics.

# Attachments

## CSIR Projects

## Stellenbosch Projects

## CVs

## Concept Designs

### Gimbal

### CEPAR