YREF PROPOSAL

ANGUS STEELE

DECEMBER 2015

SUMMARY INFORMATION

Proposal Title	Development of a Close Quarter Intrinsically safe Aerial Platform, for use in underground mines or search and rescue
Name of Applicant	Angus Steele (303884)
Lead Operating Unit/Centre	MSM - MMM
Other Operating Units/Centres	University of Stellenbosch – Electronic Systems Lab
Ethics Approval Required (Yes/No)	No

BACKGROUND AND MOTIVATION

The project proposed is to develop an aerial platform that can be used in a close quarter environment. This includes but is not limited to mapping or inspections in an underground mine or search and rescue missions in disaster zones. Currently there are no aerial platforms being deployed in similar situations.

Research into the project has already begun and is a collaboration between the CSIR and The University of Stellenbosch. Johann Treurnicht is a lecturer at Stellenbosch and a supervisor in the Electronic Systems Lab (ESL). ESL focuses on the control aspects of system design and has done extensive research into aerial platforms. Johann is currently busy with his PHD which is based around quadcopters.

Angus Steele is a permanent employee at the CSIR in MSM registered as a student at the University of Stellenbosch and is busy completing his Masters under the supervision of Johann Treurnicht. The topic of which is to develop an aerial platform that can navigate in a close quarter environment.

Dawid Oosthuizen is a senior design engineer and project leader in the mechatronics research group at MSM. Dawid has mentored Angus since he began at the CSIR and has agreed to help **supervise the project.**

The proposed project will cover **key gaps in knowledge** of micro unmanned aerial systems (MUAS) that have not been solved for before. Included in this is the ability to fly into or close to walls, ceilings and floors without losing its orientation. The ability for a MUAS to stably navigate in a close quarter environment has numerous industrial applications. Inspections of mines and containers are currently been done by placing human lives at risk and can take a long time. The use of legged robots is rendered near impossible in some cases as they cannot navigate these complex terrains effectively or quickly. An aerial platform however will be able to complete these missions with haste, while eliminating human risk.

The **key research question** will be whether or not an aerial platform is suitable for use in a close quarter environment. Entwined in that question includes which platform configuration is best suited for the application as well as what sensing requirements are needed. Once the platform has been validated through research the control system around negating these effects and disturbances will become the focus of the project.

This project is taking on a **novel approach** by not using standard rotor configurations but rather developing a new unique platform that is best suited for this application. This includes the capability to nullify the disturbances of being in close proximity to walls as well as the ability to have a substantial flight time while carrying a sensor payload. The control systems used to stabilise the craft near the walls or post collision will also be a **novel approach.**

One of the **CSIR's strategic objectives** is to constantly try and improve South African technologies and methods. Since mining is such a core national business for South Africans, any improvements in the field will increase South African productivity. MMM has been given the mandate to explore mining technologies and this platform will be an extremely powerful tool for the use in mining.

An aerial drone that can navigate through these areas without being influenced by its surrounding environment is an incredibly powerful tool with a huge variety of applications. The **long term impacts** of such a system are countless, including a much safer mining environment for all workers,

with more detailed maps of the regions. The platform will also increase effectiveness of search and rescue missions and teams by equipping them with the right tools to do their job quickly. Any situation that requires robotic translation in an indoor environment will benefit from this system.

OBJECTIVES

The **project's key objectives** aim to develop an aerial platform that can be used in a close quarter environment. The end result of which will be an extremely robust platform that can navigate any area that legged robots or humans previously did not have access to.

By completing this objective, the project will also have solidified new knowledge and applications for rotorcraft. Recent advances in computing requirements have made aerial platforms a more accessible platform and the project plans on establishing CSIR in the forefront of these technologies

IMPLEMENTATION PLAN

PROJECT PLAN

	WP1 - 2015	WP2 - 2016	WP3 - 2017	WP4 – 2018
YREF Funding	Not Funded by YREF	1st Year YREF Funding	2nd Year YREF Funding	3rd Year YREF Funding
Planned Major Tasks	Major components of literature review completed.	1st Half Year Platform can fly stably with payload. 2nd Half Year Platform can negate the disturbances of near wall effect.	1st Half Year Platform can restabilise itself after collisions 2nd Half Year Start providing sensing capabilities. Mapping etc.	Once the platform is built and validated we can begin to focus on different applications and demos to various industry partners.
Proposed Outputs	Publications surrounding the literature. Review papers of the technologies.	The initial configuration of the drone complete. Including all hardware. Provides potential for a Technology Demonstrator Publications surrounding the design, including the novel approach to the configuration and control method.	A new novel platform that can handle the disturbances and collisions. Provides potential for a patent. Publications around the advanced control systems. Masters project completed.	New novel applications for aerial platforms could provide partnerships with industry. Publications based around the novel use of the aerial platform.

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 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 some of the innovations behind mining technologies at the CSIR.

The team has 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

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. Will be responsible for the development of the system.

Dawid Oosthuizen – Senior Design engineer at CSIR and proposed supervisor for the project. Dawid has a Masters degree in engineering management as well as extensive experience in software and electronic design. Will help with technical advice and project management.

UNIVERSITY OF STELLENBOSCH

Johann 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. As Angus's supervisor Johann will be assisting with the platform development.

BUDGET

The main components of the budget will be HR costs around the development of the system. This also includes travelling to and from Stellenbosch to utilise their facilities and knowledge.

There will also be conferences that will be beneficial to attend as it may help gather an understanding of concepts and provides a platform to demonstrate the work we are doing.

The first year of YREF funding will include running costs based around procurement of the system parts. Including all of the components required for flight

The second year will include some procurement of additional sensing modules that are needed.

The third year we will be exploring various application options, so different sensor packs will need to be purchased to explore these options

WP1	Not funded by the YREF Grant	
WP2	HR Costs Travelling and conferences Procurement	R150 000 R20 000 R30 000
WP3	HR Costs Travelling and conferences Procurement	R160 000 R25 000 R15 000
WP4	HR Costs Travelling and conferences Procurement	R150 000 R20 000 R30 000

On acceptance of the YREF grant, MSM has agreed to co-fund the project to the value of R150 000. This will be used to increase amount of HR resources allocated to the project.

OUTPUTS

The research will include various aspects of aerial platforms that have not been tackled before. This opens up potential for journal articles and conference papers. The topics of which will include:

- Review of standard rotor configurations
- The novel control system behind counter acting the near wall effect

- Restabilising the platform after a collision
- Underground navigation without GPS
- New applications for aerial drones

The project scope is to design and build the platform and will therefore be eligible for a Technology Demonstrator. Since the technology we will be demonstrating is novel and has not been done before there is also potential for a patent.

PROBABILITY OF TECHNICAL SUCCESS AND KEY RISKS

In any novel design there is always risk that the proposed outcomes will not be met. In the case of this project I see the **probability of technical success** as quite high. Research has been done into similar systems that have produced good results [1][2].

The Stellenbosch lab that is assisting with the project has extensive experience in the development of aerial vehicles, especially around controlling these systems. The combination of this knowledge with MMM's experience in robotics, automation and sensor integration creates a lasting partnership that will be able to handle the technical difficulties expected along the way.

The need for the platform has been well established with Chevron Oil releasing a RFP earlier this year into the development of such a platform. There has also been a recently published paper that is investigating the requirements for such a system [3]. With this in mind the project has a greater chance of success as there is interest from multiple parties and industries which will speed up research and progress in the field.

One of the **key risks** is the limited amount of research that has been done on nullifying these disturbances as it has not been done before.

CVS

CVs for Angus Steele, Johann Treurnicht and Dawid Oosthuizen have been attached.

REFRENCES

[1] A. Klaptocz, A. Briod, J. Zufferey, and D. Floreano, “An Indoor Flying Platform with Collision Robustness and Self-Recovery,” pp. 3349–3354, 2010.

[2] A. Briod, D. Floreano, P. Kornatowski, and J.-C. Zuffery, “A Collision-resilient Flying Robot,” *J. F. Robot.*, vol. 31, no. 4, pp. 496–509, 2014.

[3] J.Green, A Marnewick and JHC Pretorius, "Prototyping during the requirements elicitation process in the development of an underground unmanned aerial system." PRASA-ROBMECH 2015