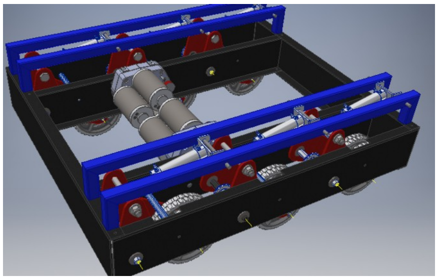
THOMAS BANNERMAN

Aerospace Engineering and Physics | The University of Sydney

tban4122@gmail.com
+61 484 355 788
www.linkedin.com/in/tombannerman

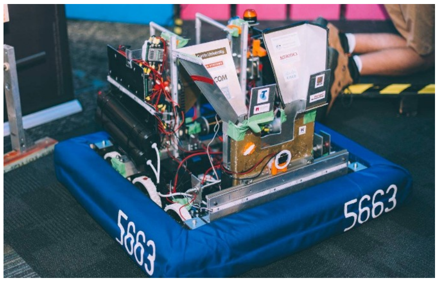
FIRST ROBOTICS COMPETITION

What?



FIRST Robotics is a competition with teams of more than 10 students. The teams are tasked with designing and building a robot in 6 weeks to compete in a unique challenge. I was a member of Curtin FIRST Robotics Team, 5663 Ground Control in **2016, 2017, 2018.** My role was **mechanical design, build and pit crew** for all the years I was involved.

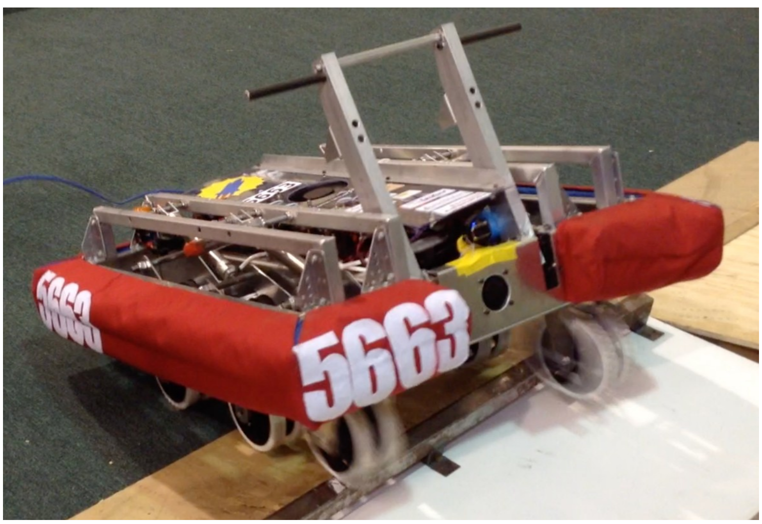
How?

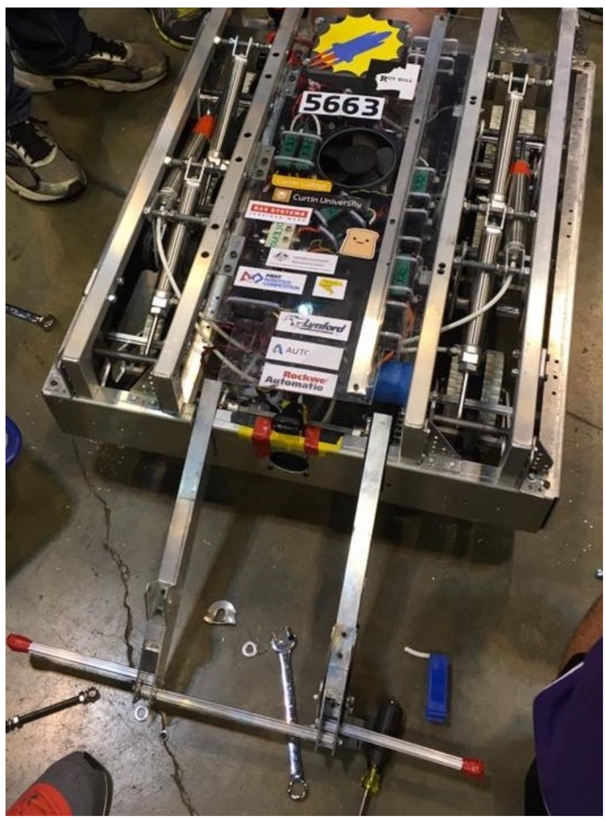


In 2016 I was in the **mechanical team** using **Autodesk Inventor.** We used predominantly **custom sheet metal designs** to ensure low cost and rapid manufacturing. We pioneered a **pneumatic tank suspension system** that outperformed all teams on rough terrain. In 2017 I became **team captain and robot operator,** coordinated design and **pit crew operations.**

Results.

Qualified and competed in the World Championships in 2016 and 2017. This gave me exposure to the best teams, engineering and design philosophy that has made me a better engineer. Team won the Australian regional in 2018 and qualified for the World Championships in Houston, TX.





Above: Pneumatic dog leg suspension. Allowed the robot to traverse high rugosity terrain at high speed with no difficulty. Note the legs actuating under the chassis as it glides over the obstacle.

Right: Robot being serviced in the pits in between matches. Working in this environment taught me how to make **fast critical design decisions** and **effectively coordinate a team.**

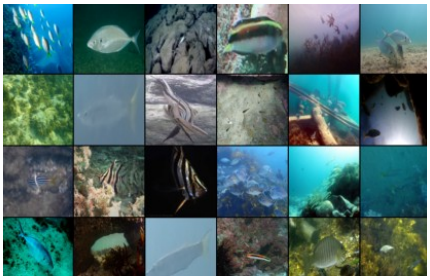
THOMAS BANNERMAN

Aerospace Engineering and Physics | The University of Sydney

tban4122@gmail.com
+61 484 355 788
www.linkedin.com/in/tombannerman

MARINE PARK SURVEY USING MACHINE LEARNING

What?



Taking dive video as an input the algorithm must **detect the fish** and apply a bounding box to crop the image fish and feed into a fish classifier. The classifier will then take this image and **predict which of 6 fish families** it belongs too.

How?

Carangidae

Dinolestidae

Enoplosidae

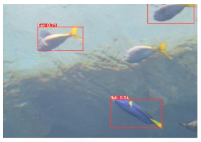
Girellidae

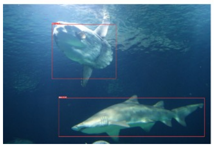
Microcanthidae

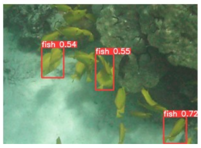
Plesiopidae

The dataset was gathered through videoing fish in the wild and hand classifying fish in each frame. iNaturalist database was also used to boost the number of images. A YOLOv5 model was trained to predict the bounding boxes of fish. I utilised a ResNet model to build a classifier that predicted the fish family.

Results.



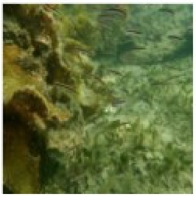




Initial attempts were made for the model to classify up to 40 species of fish. Acceptable levels of accuracy were not achieved for this number of fish. It is believed to be due to insufficient quantity and quality of the training data. Therefore, the scope was reduced to classifying by family.

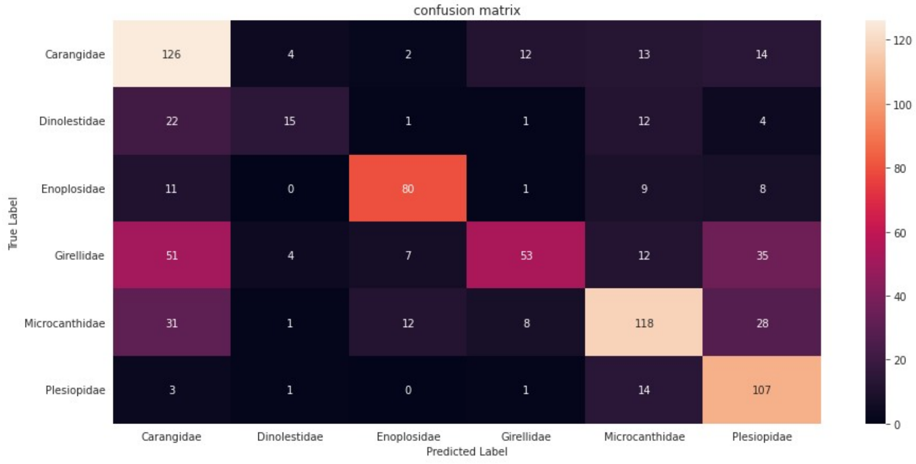
Class	Precision	Recall	F1 Score
Carangidae	0.52	0.74	0.61
Dinolestidae	0.60	0.27	0.37
Enoplosidae	0.78	0.73	0.76
Girellidae	0.70	0.33	0.45
Microcanthidae	0.66	0.60	0.63
Plesiopidae	0.55	0.85	0.66

True: Plesiopidae
Predicted: Plesiopidae



True: Carangidae
Predicted: Carangidae

True: Girellidae
Predicted: Microcanthidae



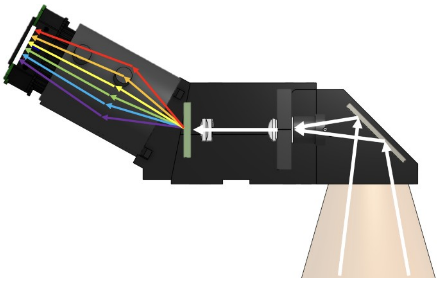
THOMAS BANNERMAN

Aerospace Engineering and Physics | The University of Sydney

tban4122@gmail.com
+61 484 355 788
www.linkedin.com/in/tombannerman

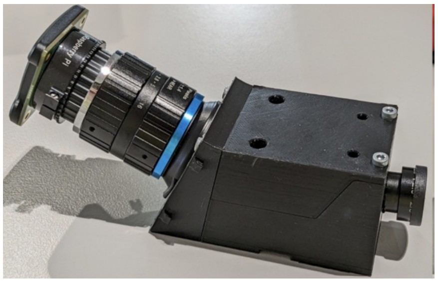
HYPERSPECTRAL IMAGER FOR LEO SATELLITE

What?



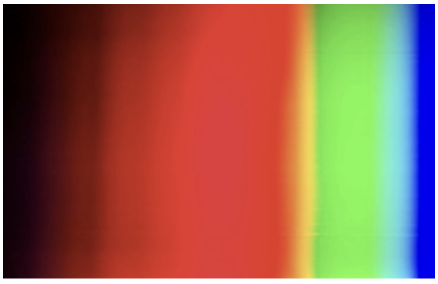
Over **10 weeks**, in a team of **8 students** we designed, built and tested a satellite to perform Earth observation. My role was to **develop the payload, a low-cost hyperspectral imager**. In this project I utilized skills in **system design, CAD, FDM 3D printing, optical design, software (Python, UBUNTU)**, and **methods for systematically testing and validating the performance of subsystems**.

How?



I made **mechanical, optical and electrical modifications** to an open-source optical design that allowed it to operate within a smaller satellite. I **wrote custom software** to in Python to operate the device and compress the data onboard. I followed an iterative approach through rapid design and testing using **FDM 3D printers, laser cutters and optical testing benches.**

Results.



The imager proved the feasibility of a low-cost hyperspectral imager for small satellite platforms. The above image is the raw image taken by the payload. The below image shows a reconstructed spectral image of the team in the 400-900nm range. Unfortunately due to time constrains the image distortion was not removed prior to demonstration.

Hyperspectral team photograph taken by the developed imaging system. The required panorama scanning motion was achieved by utilizing the UR5 Robotic arm.

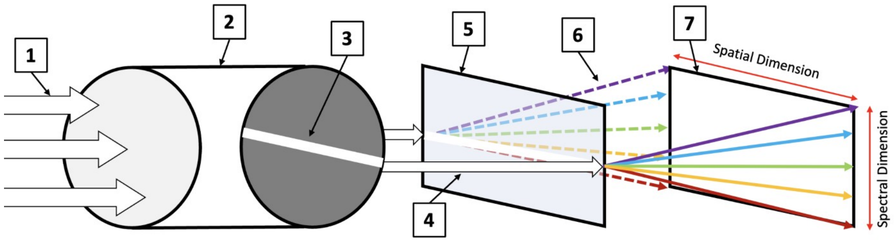
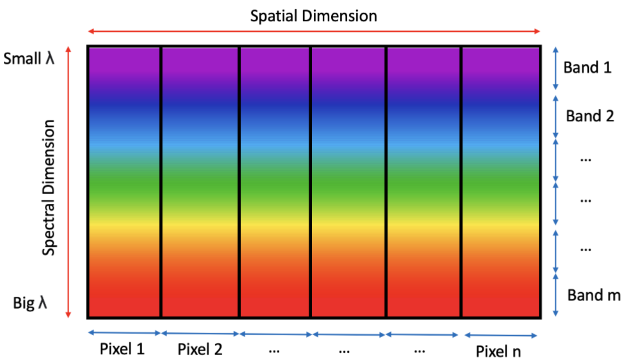
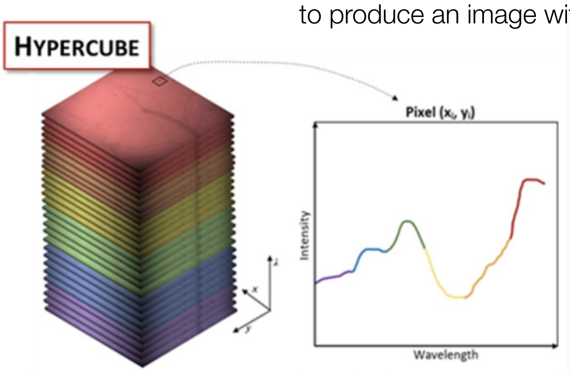


Diagram shows how the incoming image [1], is focused [2] onto a slit [3], collimated [4], diffracted [5,6] and then detected by the image sensor [7]. 1000s of these images are captured over an area of interest and then computationally stitched together to produce an image with





THOMAS BANNERMAN

Aerospace Engineering and Physics | The University of Sydney

tban4122@gmail.com
+61 484 355 788
www.linkedin.com/in/tombannerman

DEPLOYMENT SYSTEM FOR HIGHRISE ROBOTICS

DEFY-HI

What?

The task was to develop a deployment system that suspended a robot over a high-rise glass façade, was transportable between buildings by a team of 2 and allow full access to all building facades.

How?

Myself and another engineer developed the MVP version of the system. I utilised **FEA in SOLIDWORKS** and manual calculations to guide the design and validate the mechanical performance.

Results.

The deployment system was successfully installed and tested on a high-rise building in Parramatta, NSW in 2023. I was involved in the installation and monitored the deployment during the testing period.

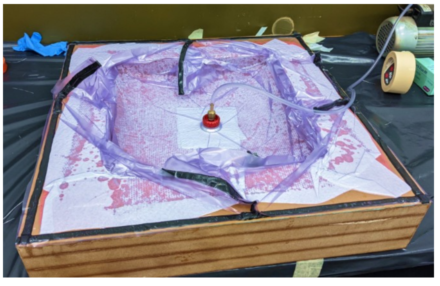
FABRICATION OF FIBREGLASS SHROUD

DEFY-HI

What?

I **fabricated the fibreglass shrouds** used to protect the electronics. The custom moulds were fabricated with MDF panels and CNC'd. We used 3 layers of fibreglass to achieve the desired mechanical and aesthetic properties.

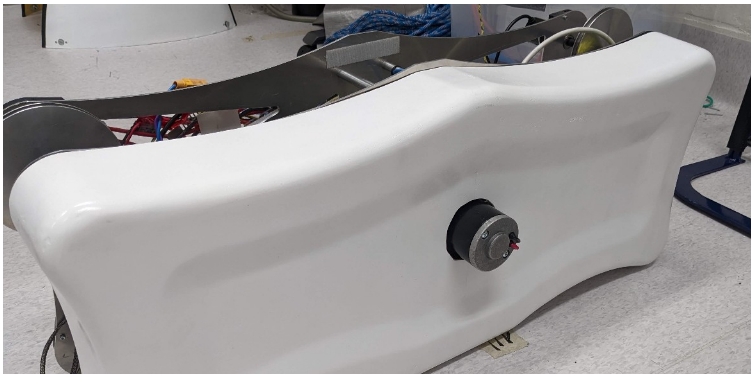
How?



The methodology used for fibre glassing was the same utilised in small scale automotive applications. I smoothed and filled any defects by hand as well as primed and painting each layer myself.

Results.

The final product fulfilled the mechanical and aesthetic requirements. It was installed in the MVP version of the platform and deployed onsite for our first official building deployment in Parramatta in 2023



THOMAS BANNERMAN

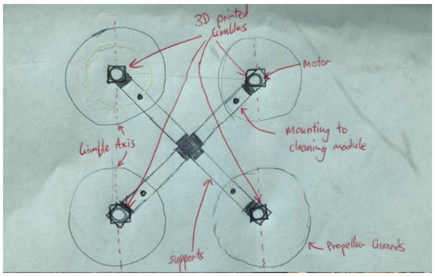
Aerospace Engineering and Physics | The University of Sydney

tban4122@gmail.com
+61 484 355 788
www.linkedin.com/in/tombannerman

FLIGHT CONTROL SYSTEM

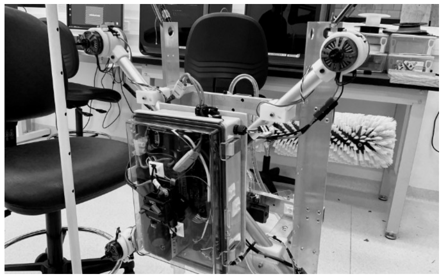
DEFY-HI

What?



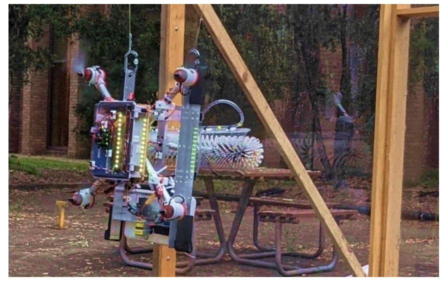
The robot needed to stabilise itself whilst suspended by two dynamic ropes off the side of a high-rise building. This environment was prone to strong gusts of wind from any direction. The robot needed to be positioned range of distances away from the building. A drone style control system was chosen to do this.

How?



I used **SOLIDWORKS** for the CAD and programmed the flight control system using **Arduino**. The system worked by taking a requested pose from the operator and adjusting the propeller thrust and pitch to reach that desired pose.

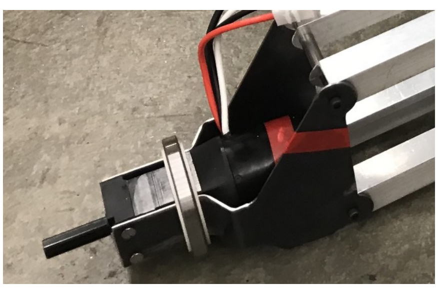
Results.



The control system was implemented on the prototype of the robotic platform and performed at our demonstration day for at investors. Following this we re-evaluated the overall design and decided to reduce the complexity of the design for the MVP to increase reliability of the system.

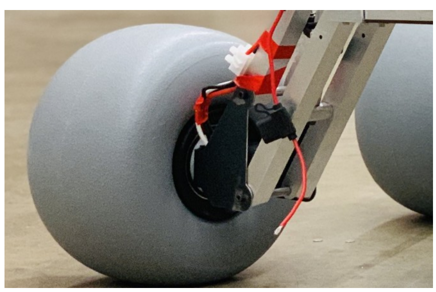
MARS ROVER WHEEL HUB DESIGN & BUILD

What?



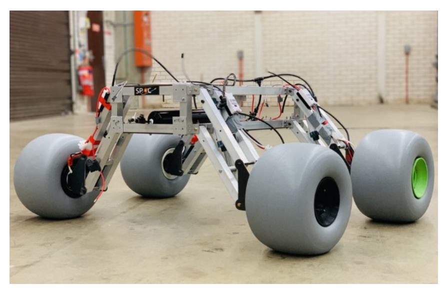
I designed a custom wheel assembly for a student-built Mars rover. I used **SOLIDWORKS, 3D printers, lathes, mills, hand tools.** I also used **CNC steel sheet** for the most demanding parts.

How?

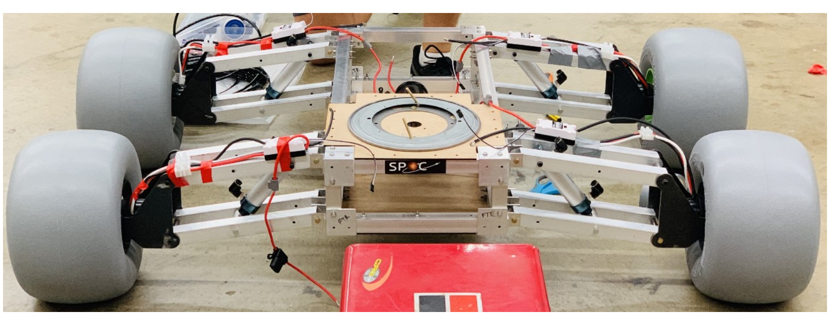


The design included an inflatable wheel, brushless motor and planetary gearbox integrated into a single wheel. The design ensured that the wheel could be replaced within a minute in case of failure.

Results.



This design protected all hardware from damage during operation by shielding it inside the wheel hub. It also significantly lowered the COM improving the stability of the rover on high inclines.



THOMAS BANNERMAN

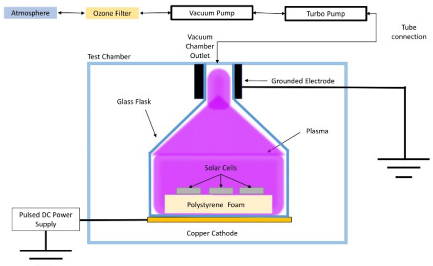
Aerospace Engineering and Physics | The University of Sydney

tban4122@gmail.com
+61 484 355 788
www.linkedin.com/in/tombannerman

SOLAR CELL SPACE ENVIRONMENTAL TESTING

THE UNIVERSITY OF SYDNEY

What?

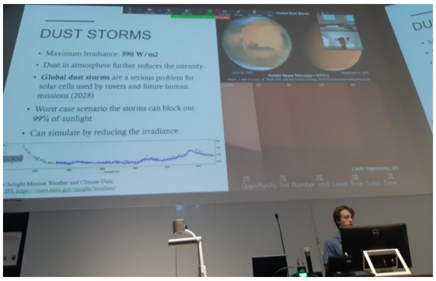


In 2020 I joined Anita Ho-Ballie's Solar Research Group (https://anitagroup-perovskite.sydney.edu.au). My role was to investigate Perovskite Solar Cells (PSCs) ability to operate in extreme space environments. I performed low temperature and atomic oxygen exposure tests with a **cryostat** and a **DBD plasma chamber**.

How?

Environmental exposure tests were performed with a cryostat and temporal performance of the cells were measured. Solar cells exposed to a range of atomic oxygen energies in the DBD plasma chamber were monitored before and after exposure to determine their ability to survive LEO.

Results.

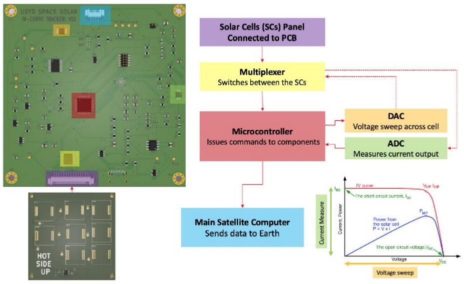


Tests ultimately showed PSCs outperformed silicon cells for low-temperature, mass/weight. The research group expanded, and a research paper published with our results (3rd Author). ***Deployment Opportunities for Space Photovoltaics and the Prospects for Perovskite Solar Cells***. I shared my findings by presenting to the solar cell research group in NSW.

CUBESAT MOUNTED SOLAR TEST MODULE

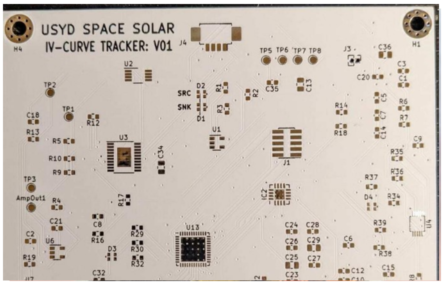
THE UNIVERSITY OF SYDNEY

What?



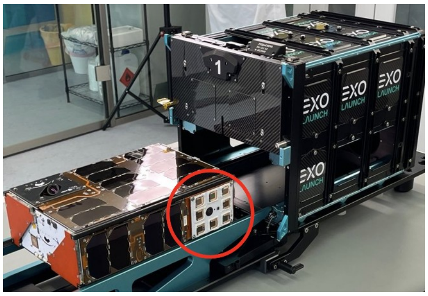
Given the findings regarding perovskite solar cell in space operations the scope was expanded to send solar samples onboard a satellite being built at the University of Sydney. This mission required a custom payload module to mount the cells to the satellite structure and individually measure the simultaneous output voltage and current of the cells.

How?



My role was to work in a team to design the complete system. I worked alongside another student to design the electrical system using the Open Source **PCB development software KICAD**. This along with guidance from electrical engineers in industry we completed the design for the custom perovskite solar cell IV-curve tracking PCB for space environment testing.

Results.

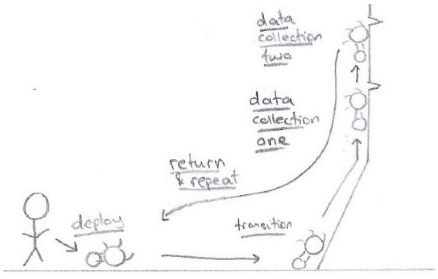


The custom designed PCB for IV-curve tracking 9 individual solar cells exposed to the space environment was manufactured and began integration in the summer of 2021/22. This was the end of my responsibility for the project due to increasing hours at my job at Defy-Hi Robotics. The payload launched as a payload on CUAVA-2 on 16th Aug 2024.

THOMAS BANNERMAN
Aerospace Engineering and Physics | The University of Sydney
tban4122@gmail.com
+61 484 355 788
www.linkedin.com/in/tombannerman

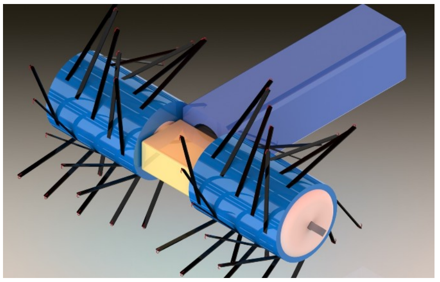
MARS EXPLORATION CLIFF CLIMBING ROBOT

What?



Over 4 weeks, working in a team of 4 students the task was to conceptualise, design, build and test an autonomous system capable of retrieving geological sample from the vertical face of a sedimentary cliff. My role was to **create requirements and testing methods** for this project as well as **design and build the mechanical parts** of the platform.

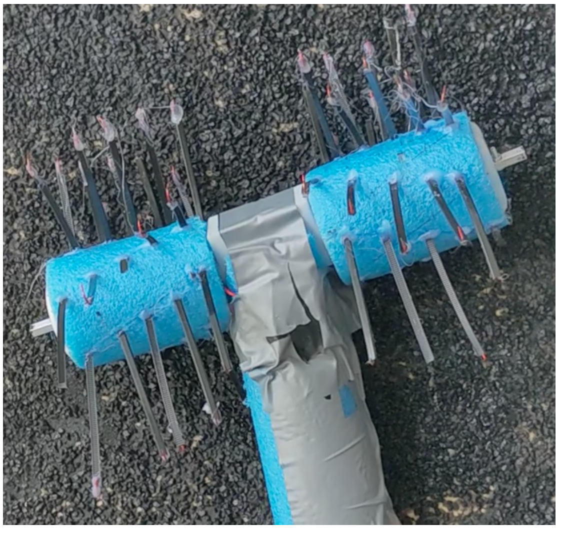
How?

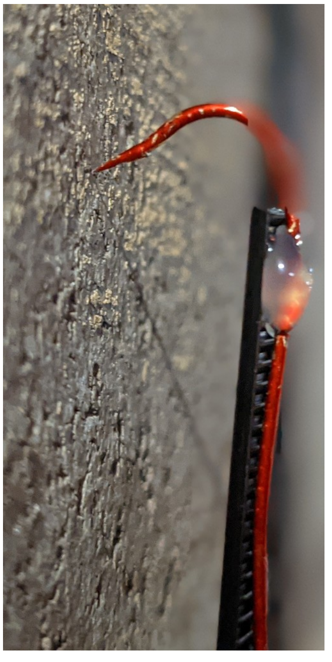


I designed the system through **SOLIDWORKS** and managed the **BOM.** We utilised a Gantt chart and updated it regularly to use **the agile method**. I also contributed heavily to the **electrical and software system development**. Testing was performed at each subsystem development stage to ensure every component performed as expected prior to integration.

Results.

The final version could scale vertical cliffs unassisted. It was durable to falls up to 5m. The ability to climb flat surfaces diminished over time as blunting on the hooks occurred. This could be avoided by using more durable materials and focusing on sedimentary instead of igneous rock faces.





THOMAS BANNERMAN

Aerospace Engineering and Physics | The University of Sydney

tban4122@gmail.com
+61 484 355 788
www.linkedin.com/in/tombannerman

SCUBA DIVING

What?

I have a keen interest in exploration and space technology. SCUBA diving allows me to merge these two passions. I aim to gain the qualifications required to operate rebreathing apparatus within the next 10 years. Rebreathers will allow me to operating similar life support systems used in NASA spacesuits and therefore allow me to push further and explore even more extreme environments like >40m dive sites and caves.

How?

I am currently undertaking training for my **BSAC Twinset diving and BSAC Rescue diving certification.** Following this I aim to become a certified dive instructor. This will help me achieve my goal of operating a rebreather within the next 10 years.

Results.

I currently hold **ISC** qualifications for **Open water 20m**, **Advanced 30m**, **Nitrox** and **40m Deep Diving**. In addition, I also enjoy non-competitive freediving and underwater photography. This paired with regular swimming training, running and gym ensures I maintain optimal fitness for this extreme sport.

FLIGHT TRAINING

What?

I took part in 5 days of flight school training in 2021 at Camden airport with Curtis Aviation. This training involved 5 hours of total flight time in both the Citabria and Cirrus SR22 aircraft.

How?

In addition to flight time I performed an hour of simulator instrument flight training as well as flight theory exams and performed the role of navigator in one of the flights over Sydney harbour.

Results.

In the final flight I performed my first assisted landing at Wollongong's Shellharbour Airport. This flight course has inspired me to pursue my full pilot's licence as soon as possible.