

# NUS SEDS

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February to July 2020

National University of Singapore  
Students for the Exploration and Development of Space



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NUS SEDS



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# About NUS SEDS

Students for the Exploration and Development of Space (SEDS) is a chapter-based non-profit promoting space exploration and development through student-led engineering projects, events and programmes. It is the largest student-run space organization in the world, with a presence in more than 20 countries.

Prominent SEDS alumni include Jeff Bezos and Steve Wozniak.

NUS SEDS was founded on 14 January 2019 and was officially launched on 20 July 2019, in commemoration of the 50th anniversary of the moon landing. It is a constituent chapter of SEDS Earth and SEDS Singapore, along with sister chapter SEDS-NTU. Our vision at NUS SEDS is to be the rallying youth force that ushers in a new space age in Singapore and the South East Asian region. To that end, our mission is to inspire and empower young people in NUS and beyond to participate and make an impact in space exploration.

NUS SEDS seeks to accomplish this by providing a platform for NUS students interested in space to come together and share experiences. We educate people about the benefits of space and the progress the sector has seen in recent years, and support and inspire a community of interested students in their space endeavours by involving them in projects

relating to space. We recognize that those seeking to expand the frontiers of space will need decisiveness and a pioneering spirit as well, and so we also seek to cultivate that wherever practical by maintaining a strong student-run philosophy, installing enthusiastic members in key leadership roles to train their soft skills.

*We've got students that run the gamut from biomedical engineering to geography, and everything in between. In part it's because space is so broad that attracts people of all academic backgrounds. We've got tinkerers and thinkers, writers and coders, and dreamers and doers. We're a young and growing community, and definitely one that is determined to make a dent in the universe.*

Our longer term goals would include preparing members for work in the space industry or further studies in space-related graduate programs, and building a network of industry, government and academic contacts for internship, job, scholarship and research opportunities.

All current NUS students (both graduate and undergraduate) are eligible for membership, regardless of their faculty and year of study. NUS SEDS has a current membership of 70 students within NUS and a reach of 200 students across tertiary institutions in Singapore.

The core team offers direction and administration for the substituent projects and events. It assists with publicity, recruitment, fund-raising and financial management. Funds raised according to the yearly budget are centrally held by NUS SEDS and disbursed to individual projects and events on a claims basis.

# Events



New Frontiers is a talk series that aims to impart to students technical insight into the various areas of space exploration and development. It doubles up as a regular meet-up for students to connect with the local space industry and other space enthusiasts within NUS. Our talks are held on Thursday evenings on campus with an estimated audience size of 20-30 attendees mainly from the faculties of engineering, computing and science. We have hosted speakers from Infinite Orbit, Transcelestial Technologies, Alien, Astropreneurs Hub and Singapore Power among others. This event is open to the general public.

New Horizons is a workshop series that aims to equip students with skills that would allow them to contribute to space industry effectively. Our basic premise is that learning together is easy and fun. We wish to help people get past the initial hurdle through classes. In the spirit of keeping our workshops accessible to all, we have made them free of charge for attendees. This semester we hosted engineers from Analytical Graphics Inc. to run Systems Tool Kit (STK) courses on orbital manoeuvres and propagation, conjunction analysis, and CubeSat mission design.



Outreach Events include showcasing at NUS Engineering Fair, Student Life Fair, Welcome Tea and sharing sessions for younger students from around Singapore. We recently hosted disadvantaged youth from Hatch SG with the goal of exciting them about the field of robotics and its applications. We also encourage our members to participate in local and international conferences, workshops and competitions to gain exposure. Our members have participated in events like the International Astronautical Congress 2019 held in Washington DC, the Space Generation ASEAN Workshop 2019 held in Bangkok, as well as the Singapore Space Challenge 2019.

# NUS Rover Team

The NUS Rover Team was formed as an engineering initiative of NUS SEDS. The team designs and builds Remotely Operated Vehicles (ROV) that can accomplish a variety of tasks with some autonomous capabilities. Rover technology has applications beyond space exploration, such as warehouse management, disaster search & rescue and explosive ordnance disposal.

## University Rover Challenge

The Rover Team plans to participate in the University Rover Challenge (URC) from November 2019 (registration) to May 2020 (competition). This is an annual competition held by The Mars Society at the Mars Desert Research Station in Utah, USA, where teams and their rovers are tasked with the completion of 4 mission requirements:

**1**

*A Science Mission to investigate a site for the presence of current or past life.*

**2**

*A Delivery Mission to deliver a variety of objects to mock astronauts in the field across rugged terrain.*

**3**

*An Equipment Servicing Mission to perform dexterous operations on a mock lander using a robotic arm.*

**4**

*An Autonomous Traversal Mission to autonomously travel to a site and locate a marker.*

These missions demand a well-designed and capable rover. Focus areas include communications, sample analysis using an assay, localization and mapping, path planning and navigation, structures and mobility system, testbeds and robotic arm manipulation among others. Funds raised will be used to design and construct the rover and its various subsystems, and to transport the rover and a select team of students to Utah and accommodate them for the length of the competition, where they will be competing against the likes of Stanford, Cornell and the IITs.

## Accomplishments

To date, the team has built a fully functioning prototype, New Spirit, to gain experience in rover construction. It took a small, dedicated workforce just 2 months and S\$500 to complete, and incorporates many industry-standard features for planetary exploration vehicles. The rover features a rocker-bogie suspension akin to that on the Curiosity rover, as well as independently powered wheels employing Ackermann-steering. It also incorporates many exciting independently-designed features such as a mast camera, Bluetooth-controlled robot arm, and Wi-Fi-enabled remote-control through a custom-made app.

The NUS Rover Team is the only team from South East Asia to have cleared the URC's Preliminary Design Review (announced [here](#), submission can be viewed [here](#)). The team is getting ready for their next submission for the System Acceptance Review by 28 February 2020



## Ongoing Work and Future Plans

The team has shortlisted over 30 highly talented individuals to work on the challenge rover for URC, called New Opportunity. Development of the vehicle is in full swing with strong collaboration between the subsystem teams. At this point, most subsystems have passed the evaluation stage, and designs are being finalized. The actual construction, testing, and implementation of the rover is contingent on further funding.

Team members come from a diverse set of majors and years of study with a common passion for space exploration. The team promotes a culture of collaborative learning through various sessions and workshops. For instance, the team conducted a boot camp covering Robot Operating System, CAD modelling, fabricating techniques and the use of micro-controllers in electrical systems, all key elements in designing and building New Spirit and future rovers. This was done to bring new team members up to speed with regard to their technical skills, as well as to ensure project continuity.

# Rover Team Leadership



## Rachiket Arya Project Manager

Rachiket pursues a bachelor's degree in mechanical engineering with a second major in Innovation and Design at NUS. Through his experience of working at a startup and having led multiple project groups in university, he brings his managerial expertise to the team along with his strong technical background. He has also had experience in developing an electric scooter and an autonomous dustbin. His team was the winner for ActInSpace 2018 Singapore, and was the recipient of Airbus Innovation Award for pitching an innovative idea to solve a space-related problem. Rachiket is also a co-founder of Terran Space Technologies, which aims to develop innovative technologies that will democratize space.

## Harsh Goel Project Team Lead

Harsh majors in mechanical engineering with a minor in computer science. Through his work on human-robot collaboration techniques, he has gained extensive research and industrial experience in the field of robotics. With his experience in path planning for lunar rovers and developing control algorithms for robotic arms by using haptic devices and computer vision, he is a strong asset to the team. Having worked on attitude and orbit control systems for swarms at Thales Singapore, he has a comprehensive overview of the subsystems of the rover.



## Asyraf Abbas Mechanical Team Lead



Asyraf is a mechanical engineering undergraduate at NUS and holds a diploma in aeronautical engineering from Singapore Polytechnic. Through his work at the Aircraft Maintenance and Engineering Corporation (AMECO Beijing), he has gained substantial experience in the aerospace field. Asyraf brings valuable technical and leadership skills to the team, having excelled at various other projects such as the mechanization of hummingbirds' flight as well as enhanced electroencephalogram (EEG) headset with control applications. With his strong management skills, he paves the way for the team.



## Jethro Kuan

### Software Team Lead

Jethro is a computer science undergraduate and is specializing in machine learning. He has extensive industry experience, having been involved in roles ranging from full-stack software engineer to data scientist. His substantial contributions to the industry include building the data pipelines and models for image search and price suggestions for Carousell, as well as data engineering and modelling for Twitter's recommendation system. Given his expertise and passion, he is a strong addition to the team as a leader. In addition, Jethro is a coreteam member of NUS Hackers.

## Chin Wei

### Science Team Lead

Chin Wei is currently pursuing a bachelor's degree in Life Sciences with a second major in Innovation and Design and holds a diploma in Biotechnology from Temasek Polytechnic. Not one to underestimate the value of experience, Chin Wei has worked for clinical and research laboratories in the Singaporean healthcare sector, and embarked on an overseas joint research project with the University College Cork on marine research involving invasive barnacles. He is currently interning under the Autodesk Fusion Catalyst programme, where he instructs fellow students in NUS in the use of the Autodesk Fusion 360 3D design software.



## Sambhavi Deepthi

### Electrical Team Lead

Sambhavi majors in electrical engineering with a second major in Innovation and Design. She has extensive industry experience through her work at companies that manufacture Autonomous Mobile Robots. Her work in the mechatronics division of a VR Technology company involved the electrical design, wiring and coding for hardware components. In pursuit of her passion for robotics and mechatronics she has also worked on solar trackers and drink dispensers. Having led a team to successfully build an automated guided vehicle, she is a great asset to the team.

# DARPA Subterranean Challenge Team

A special engineering project of NUS SEDS, the DARPA Subterranean Challenge Team comprises 17 zealous engineering, computer science and science undergraduate students from NUS with significant experience in autonomous robotics. The team's aim is to develop next-generation robotic swarms that can produce a full 3D map of an underground space. The technology will benefit first responders to rapidly map, navigate, and search in high-risk underground environments. The same technology would also have a use-case for exploring and mapping lunar caves in low-light conditions and in the absence of GPS signals.

## DARPA Subterranean Challenge

The team will be participating in the DARPA Subterranean (SubT) Challenge, an annual competition in the US where teams push the frontiers of robotic underground Search and Rescue. The international competition is split into 4 phases based on the type of environment encountered: Tunnel, Urban, Cave, and also all three environments together. Competition is fierce, and the team will be competing in the Urban category against the likes of NASA, CMU and ETH Zurich.

## About the Team

The team at NUS is supervised by three professors and comprises 17 students from the engineering, computer science and science faculties. Over the past year they have been developing a set of unmanned aerial (UAV) and ground (UGV) vehicles which cooperatively map and identify objects and provide a detailed 3D map of the environment.

To date, the team has done an admirable job of fabricating, designing and testing much of their software and hardware in-house. However, as the project ramps up in intensity and scope, the team hopes to enlist the help of sponsors in providing custom equipment, funding transport and accommodation of the vehicles and crew to the US, and also bankrolling vehicle construction.

## Current Progress

The DARPA SubT Team is one of only 17 teams worldwide to have qualified for the Urban Circuit (announced [here](#) in December 2019). The team is currently getting ready to compete in the Systems competition held in Washington D.C. from 18 to 27 February 2020. They will later attend the Cave Circuit challenge in August 2020. The team is also considering participation in the Virtual track, given their strong software background.

The team has designed and developed 4 ground vehicles, of 4.5kg each, which are equipped with LiDAR, thermal and real sense cameras for underground 3D mapping using point cloud. They also have a 21kg track wheeled tank to enable climbing up and down stairs. In addition, the team has a larger drone which they are in the process of building and testing.



*The Ground Vehicles and the Drone*



*A Ground Vehicle and the Tank*

The UAV (drone) is capable of autonomous launch and recovery using a system developed in-house. It carries various navigational sensors, including a self-developed UWB indoor positioning system to maneuver in an underground environment that lacks GPS signals. Plans are to include thermal imaging and optical flow sensors to gather information about the underground environment.

The UGVs are designed to launch, recover, recharge, and coordinate UAVs, and are equipped with unique holonomic drive systems which allows them to navigate in any direction and climb 45° inclined grass slopes while fully loaded. They carry a suite of sensors to help navigate in the underground environment, including a ultra-wide-band indoor positioning system, 3D cameras, and most importantly several UAVs which they will use to probe the underground environment.

# DARPA Team Leadership

## Anushka Gaikwad Project Manager

Anushka is a final year electrical engineering student at NUS. She developed a keen interest in engineering after she was selected to attend the NASA Leadership Challenge Academy in 2015. For the Tech-Factor Challenge 2017 organized by ST Electronics, she was placed as a semifinalist for designing an automated medicine dispenser to increase elderly medical adherence rates. Anushka has also interned at early-stage startup RESync Technologies, where she spearheaded development of their first publicly-released product, and is a co-founder of Terran Space Technologies, which aims to develop innovative tech to democratize space.

Currently, as Project Manager of the team, Anushka handles recruitment, sponsorships, and resource management. She is confident that the team will be successful at the Challenge given their experience and skill.

## Arjo Chakravarty Technical Lead

A year 3 computer engineering student at NUS, Arjo is obsessed with robots and indoor localization. He had previously worked with Project Bumblebee developing the mapping and LIDAR point cloud processing and detection algorithms behind the ASV 2.0 that won first place at Maritime RobotX 2018. He had also worked at a startup that developed BLE-based (Bluetooth Low Energy) indoor location solutions and as a back-end engineer at PayPal.

For the DARPA SubT project, Arjo works on the higher level software functions such as obstacle avoidance, mapping, swarm coordination and localization.

## Xavier Lee Kok Teng

### Technical Co-lead

Xavier is a year 3 computer engineering undergraduate with a passion for robotics. He envisions robotics as a critical aspect of mankind's future, and sees that robotics could have many applications for society such as increasing productivity, industrial automation, biomedical procedures, and even saving lives. This belief led him to participate in the DARPA Subterranean Challenge, where he serves as the team's Technical Co-Lead. He is responsible for developing the control schemes employed by the team's vehicles and a fault-tolerant ultra-wideband (UWB) mesh protocol for vehicle localization.

## Heng Meng Pei

### Mechanical Lead

Meng Pei is a passionate year 4 mechanical engineering undergraduate who has a strong interest in robots. He has developed various projects in the past including Silver Flexor - an arcade game machine for the elderly which went on to win the NUS Makerthon. For his final-year project at NUS he is developing "a unique marsupial indoor semi autonomous drone swarm".

Meng Pei is currently in charge of chassis design for the UGV, and designing a higher-endurance UAV for the SubT Challenge.

# Future Prospects

## Space Policy Unit (SPU)

Recognising the importance of space-friendly policies in space development, NUS SEDS will be setting up a Space Policy Unit, with the goal of allowing students interested in the legal framework of space exploration to understand and participate in the space policy field. The SPU aims to help shape space policy through research, debate, publication, and attendance at events such as the International Astronautical Congress and the International Institute for Space Law Manfred Lachs Space Law Moot Court.

The Geospatial Research Unit aims to develop competency amongst its members in the areas of Geographic Info-Systems (GIS), which deals with the analysis and storage of geographic data, and Remote Sensing and Photogrammetry (RSP), which concerns satellite capture of said data.

GRU is designed to cater towards students interested in geospatial technologies but unable to find outlets for this interest. It aims to be a learning space and project proving ground for these students, and to provide them with opportunities to take part in GIS or mapping competitions under the NUS banner, as well as to cooperate with the wider GIS community in Singapore.

## Geospatial Research Unit (GRU)

The cost of leaving and returning to the atmosphere of Earth is a major bottleneck to space development. A spaceplane appears to be an ergonomic solution to this problem, combining reusability, high turnover time and the possibility of lower operating costs. HRU aims to delve into the research and development necessary to create a small spaceplane capable of performing orbital manoeuvres and returning safely to the Earth.

## NUS Spaceplane Team

### NUS High-Altitude Balloon (HAB) Team

High-altitude ballooning is a readily available means of accessing the stratosphere, and provides an intermediate stepping stone to working in a true space environment. Participants will create a balloon designed to fly to an altitude of 20km, wherefrom the Earth's curvature is clearly visible. The team will submit their project and results as an entry in the Global Space Balloon Challenge. The launch may be done with teams around the world through the Hosted Payloads or Balloon Buddies programmes offered by GSBC.

# Sponsorship

## DARPA Subterranean Challenge Team

Negotiable depending on sponsorship level

Options include:

- Incorporation of sponsor-provided custom sensor equipment in vehicle
- Sale of vehicle pairs (UGV and UAV) to sponsor

&

Band	Benefits
<b>Diamond Sponsor</b> <i>(S\$25,000 and above)*</i>	<ul style="list-style-type: none"> <li>• Fully customized benefits</li> <li>• Exclusive partner</li> </ul>
<b>Platinum Sponsor</b> <i>(S\$18,000 and above)*</i>	<p><b>NUS Rover Team:</b></p> <ul style="list-style-type: none"> <li>• Priority in conducting recruitment drives on NUS Rover Team</li> <li>• Dedicated acknowledgment during official presentations</li> <li>• Tech review of components provided by sponsor (if any)</li> <li>• Largest logo on team apparel^ and presentations</li> <li>• Largest decal on rover</li> <li>• Showcase of vehicle at company events</li> <li>• Featured in team publicity and videos</li> <li>• Access to team members' names and emails^^</li> <li>• Access to team members' resumes and LinkedIn profiles^^</li> </ul> <p><b>NUS SEDS Events:</b></p> <ul style="list-style-type: none"> <li>• Priority consideration for New Horizons workshops and New Frontiers talks**</li> <li>• Dedicated acknowledgment during introduction at all events</li> <li>• Largest logo on sponsors slide at all events</li> <li>• Distribution of sponsor swag at all events</li> <li>• Standing banners (provided by sponsor)</li> <li>• Largest logo on SEDS apparel^ and on website</li> <li>• Logo in official emails</li> <li>• Posts about sponsor on Facebook and Instagram</li> </ul>
<b>Gold Sponsor</b> <i>(S\$12,000 and above)*</i>	<p><b>NUS Rover Team:</b></p> <ul style="list-style-type: none"> <li>• Opportunity to conduct recruitment drive on NUS Rover Team</li> <li>• Dedicated acknowledgment during official presentations</li> <li>• Tech review of components provided by sponsor (if any)</li> <li>• Large logo on team apparel^ and presentations</li> <li>• Large decal on rover</li> <li>• Featured in team publicity and videos</li> <li>• Access to team members' names and emails^^</li> <li>• Access to team members' resumes and LinkedIn profiles^^</li> </ul>

<b>Gold Sponsor (cont'd)</b> <i>(S\$12,000 and above)*</i>	<p><b>NUS SEDS Events:</b></p> <ul style="list-style-type: none"> <li>• Opportunity to run New Horizons workshops and give New Frontiers talks**</li> <li>• Dedicated acknowledgment during introduction at all events</li> <li>• Large logo on sponsors slide at all events</li> <li>• Distribution of swag at all events</li> <li>• Standing banners (provided by sponsor)</li> <li>• Large logo on SEDS apparel^ and on website</li> <li>• Logo in official emails</li> <li>• Posts about sponsor on Facebook and Instagram</li> </ul>
<b>Silver Sponsor</b> <i>(S\$7,000 and above)*</i>	<p><b>NUS Rover Team:</b></p> <ul style="list-style-type: none"> <li>• Tech review of components provided by sponsor (if any)</li> <li>• Opportunity to conduct recruitment drive on NUS Rover Team</li> <li>• Medium logo on team apparel^ and presentations</li> <li>• Access to team members' names and emails^^</li> </ul> <p><b>NUS SEDS Events:</b></p> <ul style="list-style-type: none"> <li>• Opportunity to run New Horizons workshops and give New Frontiers talks**</li> <li>• Medium logo on sponsors slide at all events</li> <li>• Distribution of swag at all events</li> <li>• Medium logo on SEDS apparel^ and on website</li> <li>• Logo in official emails</li> <li>• Posts about sponsor on Facebook and Instagram</li> </ul>
<b>Bronze Sponsor</b> <i>(S\$3,000 and above)*</i>	<p><b>NUS Rover Team:</b></p> <ul style="list-style-type: none"> <li>• Opportunity to conduct recruitment drive on NUS Rover Team</li> <li>• Small logo on team apparel^ and presentations</li> <li>• Small sticker on the rover</li> </ul> <p><b>NUS SEDS Events:</b></p> <ul style="list-style-type: none"> <li>• Opportunity to run New Horizons workshops and give New Frontiers talks**</li> <li>• Distribution of swag at all events</li> <li>• Small logo on sponsors slide at all events</li> <li>• Small logo on SEDS apparel^ and on website</li> <li>• Logo in official emails</li> <li>• Posts about sponsor on Facebook and Instagram</li> </ul>
<b>Starter Sponsor</b> <i>(S\$1,000 and above)*</i>	<p><b>NUS Rover Team:</b></p> <ul style="list-style-type: none"> <li>• Small logo on team apparel^ and presentations</li> </ul> <p><b>NUS SEDS Events:</b></p> <ul style="list-style-type: none"> <li>• Opportunity to run New Horizons workshops and give New Frontiers talks**</li> <li>• Distribution of swag at all events</li> <li>• Small logo on SEDS apparel^ and on website</li> </ul>

Organizations willing to support with less than S\$1,000 will have their company logo displayed at the NUS SEDS website.  
We accept in-kind sponsorship of refreshments for our events.

\* This includes cash or equipment equivalent in value to the amount stated.

\*\* Talks and workshops can either be space-related or relevant to the engineering projects under SEDS.

^ Monochrome logo

^^ On participants' permission

# Principal Contacts

## Dean Su

External Outreach Lead, NUS SEDS

[dean.su@u.nus.edu](mailto:dean.su@u.nus.edu)

+65 8258 6225

## Anisha Joseph

Finance Lead, NUS SEDS

[anisha.joseph@u.nus.edu](mailto:anisha.joseph@u.nus.edu)

+65 9686 4083

## Mission Control

NUS SEDS Core Team

[missioncontrol@nusseds.space](mailto:missioncontrol@nusseds.space)

Learn more about us at [nusseds.space](http://nusseds.space)



