



## **Welcome to the 18<sup>th</sup> Australian Space Research Conference**

and to the Gold Coast in Queensland! This will be the Twelfth ASRC jointly sponsored and organised by the National Committee for Space and Radio Science (NCSRS) and the National Space Society of Australia (NSSA). The ASRC is intended to be the primary annual meeting for Australian research relating to space science. It welcomes space scientists, engineers, educators, and workers in Industry and Government.

The 18<sup>th</sup> ASRC has over 150 accepted abstracts across Australian space research, academia, education, industry, and government.

We would like to thank Gold Coast Events for sponsorship of the conference. Special thanks also go to Mars Society Australia (MSA) for its programming support – and Australian Defence Magazine (ADM) for its media support.

We look forward to an excellent meeting!

Iver Cairns  
Co Chair ASRC 2018  
University of Sydney

Wayne Short  
Co Chair ASRC 2018  
President, NSSA



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## About the NSSA



The National Space Society of Australia is the coming together of like-minded space advocates who share a vision for the future in which there is an ambitious and vigorous space program leading to eventual space settlement.

To this end the National Space Society (worldwide) promotes interest in space exploration, research, development and habitation through events such as science and business conferences, speaking to the press, public outreach events, speaking engagements with community groups and schools, and other pro-active events. We do this to stimulate advancement and development of space and related applications and technologies and by bringing together people from government, industry and all walks of life for the free exchange of information.

As a non-profit organisation, the National Space Society of Australia draws its strength from an enthusiastic membership who contributes their time and effort to assist the Society in pursuit of its goals.

For more information, and to become a member:

<http://www.nssa.com.au>

Ad Astra!  
Wayne Short  
NSSA President 2018

## About the NCSRS



The National Committee for Space and Radio Science (NCSRS) aims to foster the space and radio sciences in Australia, to link the Academy to Australian space and radio scientists and relevant scientific societies, and to serve as a link between Australian and overseas space and radio scientists, primarily through the [International Union for Radio Sciences](#), the [Scientific Committee on Solar-Terrestrial Physics](#) and the [Committee on Space Research](#).

A vision for space science and technology: [Securing and advancing Australia's interests through space research in Australia](#) was published in September 2017 and presents the strategic vision for an Australian space sector and space industry. The plan outlines strategies to lead Australia into a future that embraces a vibrant space sector and space industry, underpinned by space science and technology, and in due course supported by a national space agency. The National Committee for Space and Radio Science consulted extensively with broad a representation of researchers and organisations to create this plan.

The NCSRS web page can be reached at

<https://www.science.org.au/committee/space-and-radio-science>

## Conference Code of Conduct

It is the policy of the Organising Committee that all delegates at the conference are able to participate in its activities and are able to enjoy an environment that is free from discrimination and harassment. The Organising Committee is committed to making this meeting and all associated events productive and enjoyable for everyone, regardless of race, gender, sexual orientation, disability, physical appearance, body size, nationality or religion. Harassment of any form will not be tolerated and might result in the perpetrators being permanently removed from the conference or reported to relevant authorities.

The code of conduct outlined in this document applies to all Australian Space Research Conference delegates, guests (e.g., media, service staff), and accompanying people, without exception. Anybody who enters the premises in which the meeting and associated activities are held and engages with the conference delegates at any level, is bound by this code of conduct. Participation in any of the activities related to the conference constitutes implicit acceptance and understanding of the code of conducts by the participants. Ignorance of the code will not be considered an attenuating circumstance in dealing with any type of infringement of the code as outlined.

Everybody associated with the Australian Space Research Conference is expected to:

- Behave professionally.
- Be considerate and respectful to others. To not insult or put down other attendees. To Critique ideas, not individuals.
- Open discussion is promoted and encouraged, but the copying, recording or broadcasting of any presentation, material, or idea presented or emerging from scientific discussions, is not permitted. This includes (but is not limited to) posting images of data presented in talks and posters on social media.
- All communication must be appropriate for a professional audience that includes people of many different backgrounds. Inappropriate use of sexist, racist or ageist language and imagery, and / or any other commentary that is or can be perceived to be discriminatory in any way, is not permitted. Inappropriate language or behaviour include (but is not limited to) jokes, sustained disruption of talks or other events, inappropriate physical contact, sexual attention or innuendo, deliberate intimidation, stalking, and photography or recording of an individual without consent. Offensive comments

about race, gender, sexual orientation, disability, physical appearance, body size or religion, will not be tolerated.

Individuals engaging in behaviour prohibited by this policy as well as those making allegations of harassment in bad faith, will be subject to disciplinary action by the conference organisers. Such actions may range from a verbal warning, to permanent ejection from the activity disrupted by the behaviour or the entire meeting, without refund of the registration fees. Repeat offenders may be banned from participating in future conferences. Serious offences will be reported to the relevant authorities.

Anyone who wishes to report a violation of this policy is asked to speak confidentially to the conference cochairs.

## **2018 ASRC Program Committee**

Fred Menk (National Committee Space and Radio Science),  
Program committee chair

Elias Aboutanios (University of NSW)

Jeremy Bailey (University of NSW)

Duncan Blake (University of Adelaide)

Melrose Brown (UNSW, Canberra)

Gordon Cable (University of Adelaide)

Iver Cairns (University of Sydney)

Graziella Caprarelli (Hypatia Scientifica)

Brad Carter (University of Southern Queensland)

Brett Carter (RMIT University)

Christopher Capon (UNSW, Canberra)

Jonathan Clarke (Mars Society of Australia)

Alina Donea (Monash University)

Kerrie Dougherty (University of NSW)

Brad Evans (University of Sydney)

Yanming Feng (Queensland University of Technology)

Duane Hamacher (Monash University)

Jason Held (Saber Astro)

Lucyna Kedziora-Chudczer (University of NSW)

Trevor Harris (Defence Science and Technology Group,  
Department of Defence)

## **2018 ASRC Program Committee – continued**

Jonathan Horner (University of Southern Queensland)

Karen Li (CSIRO)

Murray Parkinson (Bureau of Meteorology)

Chris Rizos (University of NSW)

Wayne Short (National Space Society of Australia)

Michael Smart (University of Queensland)



## **2018 ASRC Organising Committee**

Cheryl Brown  
ACSER, UNSW Sydney, secretariat

Iver Cairns  
Co Chair ASRC 2018  
University of Sydney

Graziella Caprarelli  
Hypatia Scientifica

Jonathan Clarke  
Mars Society Australia

Jonathan Horner  
University of Southern Queensland

Fred Menk  
Chair, Program Committee  
National Committee for Space and Radio Science

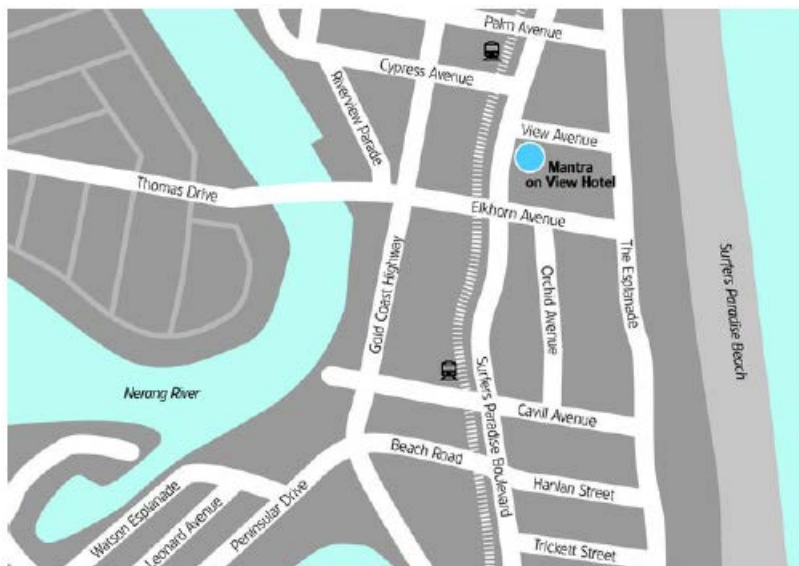
Wayne Short  
Co Chair ASRC 2018  
President, NSSA

## Conference Venue – Mantra on View

Mantra on View Hotel

22 View Avenue

Surfers Paradise, Queensland



## **Location of conference facilities**

The conference secretariat will be in the Lobby area on level 2 of the hotel – just outside the rooms booked for the conference.

All Plenary sessions will be held in Boulevard 2.

Morning / afternoon Teas will also be served in the Lobby area.

Buffet Lunches will be served in the NOSH Restaurant on level 1.

Room usage by Stream is as follows:

Stream 1 – Boulevard 2, Level 2

Stream 2 - Boulevard 3, Level 2

Stream 3 - Boulevard 1, Level 2

### Day 1: September 24

Cocktail function – Lobby area, Level 2

Public MSA talk – Boulevard 2, Level 2

Posters - Lobby area outside session rooms

### Day 2: September 25

Women in Space Lunch - Boulevard 1, Level 2

## **Gala Dinner**

Tuesday September 25

6:50 pm for a 7:00pm start

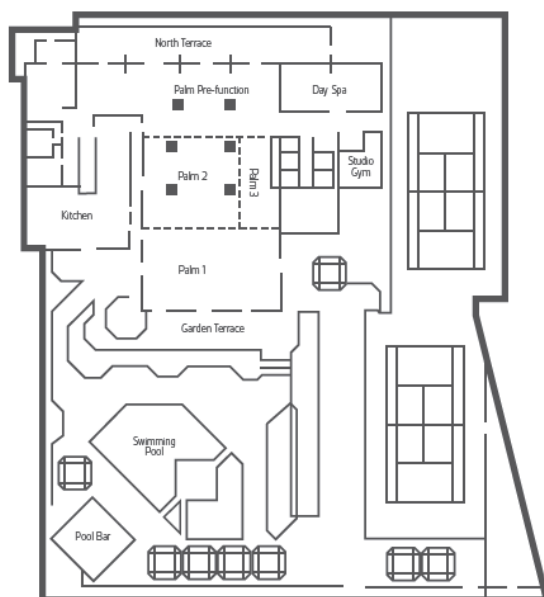
Dress: Smart casual

Location: Palm Ballroom, Level 4

## Level 2



## Level 4



## Session Overview

## September 24 to 26

Time	DAY 1 - MONDAY		
7:45: am	Registrations		
9:00am - 10.30 am	Plenaries - Australian Space agency; Earth observations (Boulevard 2)		
Morning Tea			
11:00 am- 1:00 pm	National Context (Boulevard 2)		
Lunch			
2:00 pm - 3:30 pm	Earth Observations / Space Physics I (Boulevard 2)	Space Engineering I (Boulevard 3)	Aerospace Medicine I (Boulevard 1)
Afternoon Tea			
4:00 pm - 6:30 pm	Posters / Cocktail function		
7:00 pm - 8:30pm	MSA David Cooper Memorial Lecture (Boulevard 2)		

Time	DAY 2 - TUESDAY		
8:00: am	Registrations		
9:00am - 10.30 am	Plenaries - Aerospace medicine & life sciences; Space physics; Space law (Boulevard 2)		
Morning Tea			
11:00 am- 1:00 pm	GNSS (Boulevard 2)	Space Missions I (Boulevard 3)	Space Law / Prof Development (Boulevard 1)
Lunch			
1:15: pm			Women in Space Seminar
2:00 pm - 3:30 pm	Space Physics II (Boulevard 2)	Space Business & Industry (Boulevard 3)	Space Law Prof Development (Boulevard 1)
Afternoon Tea			
4:00 pm - 6:00 pm	Space Medicine II / Stars .. Astrobiology (Boulevard 2)	Space Engineering II (Boulevard 3)	Space Law Workshop (Boulevard 1)
7:00 pm - 9:30 pm	Gala Dinner		

Time	DAY 3 - WEDNESDAY		
8:15: am	Registrations		
9:00am - 10.30 am	Plenaries - Education; Mars; Space Business (Boulevard 2)		
Morning Tea			
11:00 am- 1:00 pm	Education , Culture and History (Boulevard 2)	Space Engineering III (Boulevard 3)	Mars (Boulevard 1)
Lunch			
2:00 pm - 3:30 pm	Space Physics III (Boulevard 2)	Space Entrepreneurs (Boulevard 3)	Space Missions II (Boulevard 1)
Afternoon Tea			
4:00 pm - 6:00 pm	Town Hall Discussion / Closing Remarks (Boulevard 2)		

## Detailed Program

### Monday - Stream 1 (*Boulevard 2*)

Time	Speakers Name	Title
<b>7:45-9:00</b>	<b>Registration</b>	
9:00-9:30	Iver Cairns, Wayne Short	Welcome to ASRC
9:10-9:20	Science Minister, Hon Karen Andrews	Conference welcome / Launch of new of CSIRO space plan
9:20-9:30	Dr Larry Marshall, CEO CSIRO	New CSIRO Space plan

### Plenary Session I

9:30-10:00	Dr Megan Clark, Australian Space Agency	Australia's Strategic Priorities in Space
10:00-10:30	Stuart Phinn, University of Queensland	Linking Upstream and Downstream Using Australia's Earth Observation Capabilities
<b>10:30-11:00</b>	<b><i>Morning Tea</i></b>	

### National Context

11:00-11:15	Dr David Williams, CSIRO	CSIRO's Space Activities and the CSIRO Space Roadmap
11:15-11:30	Prof Frederick Menk, Australian Academy of Science	National Committee for Space and Radio Science update
11:30-11:45	Trent Kershaw, Geoscience Australia	Digital Earth Australia - From Satellites to Insights
11:45-12:00	Julia Mitchell, FrontierSI	FrontierSI and SBAS Test-bed Project Update
12:00-12:15	Dr David Lingard, Defence Science and Technology Group	Update on the Space Science and Technology Strategy for Australian Defence
12:15-12:30	Dr Michael Terkildsen, Bureau of Meteorology Space Weather Service	Australian Bureau of Meteorology Aviation Space Weather Services
12:30-12:45	Prof Russell Boyce, University of New South Wales	UNSW Canberra Space Program
<b>13:00-14:00</b>	<b><i>Lunch</i></b>	

Time	Speakers Name	Title
<b>Earth Observations and Space Physics I</b>		
14:00-14:15	Dr John Le Marshall, Bureau of Meteorology	New Generation Earth Observations from Space - Current and Future Benefits and Opportunities
14:15-14:30	Dr Eriita G. Jones, University of South Australia	A Recipe For Improving the Automated Detection of Vineyards From Space.
14:30-14:45	Prof Iain Reid, ATRAD Pty Ltd and University of Adelaide	Ground based observations of the near space environment
14:45-15:00	Aidan O'Brien, Saber Astronautics	Autonomous recreation of missing data in space weather sensors
15:00-15:15	Prof Iver Cairns, University of Sydney	Beam Speeds and Source Longitudes for Type III Solar Radio Bursts from Magnetic Mapping Analyses
15:15-15:30	Dr Alina Donea, Monash University	Modelling Magnetic-Polarities of Active Regions Using Helioseismic Data: impact into space weather prediction research
<b>15:30-16:00</b>	<b><i>Afternoon Tea</i></b>	
16:00-18:30	<b>Poster Session &amp; Cocktail function</b>	
19:00-20:30	<b>MSA "David Cooper memorial lecture" by Dr Mitch Schulte (NASA)</b>	

### **Monday - Stream 2 (*Boulevard 3*)**

Time	Speakers Name	Title
<b>Space Engineering I</b>		
14:00-14:15	Matthew Richardson, University of Tokyo	Integrated System-level Modelling of a Reusable LH2/LOx-fed Expander-bleed Cycle Rocket Engine

Time	Speakers Name	Title
14:15-14:30	Sholto Forbes-Spyratos, University of Queensland	Mission Design and Simulation of a Rocket-Scramjet-Rocket Launch System
14:30-14:45	Fabian Zander, University of Southern Queensland	Rocket Manufacturing in South-East Queensland
14:45-15:00	Damian Curran, University of Queensland	Numerical Investigation of a Fixed-Geometry Scramjet Inlet across an Accelerating Trajectory for Access to Space
15:00-15:15	Nick Mclean, Gilmour Space	Hybrid Rockets
15:15-15:30	Robert Brand, Thunderstruck Aerospace	The Jump2 Launch System
<b>15:30-16:00</b>	<b><i>Afternoon Tea</i></b>	

### **Monday - Stream 3 (*Boulevard 1*)**

Time	Speakers Name	Title
13:00-14:00	Lunch	
Aerospace Medicine and Life Sciences I		
14:00-14:15	David Keenan, HDR	Designing the The Human Health and Performance (HHP) Laboratory
14:15-14:30	Vienna Tran, University of Adelaide	How does the spacecraft environment increase host susceptibility to infectious diseases?
14:30-14:45	Natalie Rens, Spaceport AI	Towards an intelligent biometric device for holistic astronaut health
14:45-15:00	Julie Hides, Griffith University	Changes in trunk muscle size in response to microgravity: possible implications for low back pain research
15:00-15:15	Dr Jonathan Clarke, Mars Society Australia	A survey of medical questions facing crewed Mars missions
15:15-15:30	Prof. Brian J. O'Brien, University of Western Australia	Risk Management Of Dust On The Moon: 2018 Updated Measurement-Based Case Studies
15:30-16:00	Afternoon Tea	



## Tuesday - Stream 1 (*Boulevard 2*)

Time	Speakers Name	Title
<b>8:00-9:00</b>	<b>Registration</b>	

### Plenary Session II

9:00-9:30	Dr Gordon Cable, University of Adelaide	Australia's Contribution to Space Life Sciences
9:30-10:00	Dr Mark Cheung, Stanford University	Physics and Diagnostics of the Solar Drivers of Space Weather
10:00-10:30	Prof Melissa de Zwart, University of Adelaide	Commercialisation of space: innovation versus domestic legislation?

### **10:30-11:00** *Morning Tea*

### GNSS

11:00-11:20	Matt Higgins, President IGSS Society	Recent Developments and Future Trends in Satellite Positioning – Increasing Ubiquity and Increasing Risk
11:20-11:40	Yanming Feng, Queensland University of Technology	Determination of GNSS positioning integrity and timeless requirements for connected and automated vehicle safety applications
11:40-12:00	Robert Norman, RMIT University	Ionospheric features causing anomalous GNSS radio occultation results
12:00-12:20	Kirco Arsov, Australian Bureau of Meteorology, Space Weather Services	Geomagnetic storm impact on GNSS performance; case study Australia
12:20-12:40	Eamonn Glennon, University of New South Wales	UAV Reflectometry for Sea State Estimation
12:40-13:00	Zahra Bouya, Australian Bureau of Meteorology, Space Weather Services	Method for estimating foF2 from GPS/TEC

### **13:00-14:00** *Lunch*

### Space Physics II

14:00-14:15	Timothy Kodikara, RMIT University	Numerical Investigation of the Density-Temperature Synchrony in the Thermosphere
14:15-14:30	Joshua Williams, University of Newcastle	The modulation of EMIC waves in the inner magnetosphere

Time	Speakers Name	Title
14:30-14:45	Liam Warden, University of Newcastle	Ultra-Low Frequency wave correlations between Van Allen E-B measurements and conjunct ground magnetometer data.
14:45-15:00	Changyong He, RMIT University	Impact of the equatorial mass anomaly and midnight density maximum on the low Earth orbit dynamics
15:00-15:15	Andong Hu, RMIT University	Using an Artificial Neural Network (ANN) to Model Global hmF2, NmF2 and VSH Based on Long- Term Ionospheric Radio Occultation Measurements
<b>15:30-16:00    <i>Afternoon Tea</i></b>		

### **Aerospace Medicine, Life Sciences, Astrobiology and Planets**

16:00-16:15	Dr Tim Squire, Canberra Hospital & University of Notre Dame Australia	Mars radiation exposure risks - The shielding effect of a graphene space suit and a storm shelter during transit.
16:15-16:30	Meg O'Connell, University of Queensland	Strategies for reducing Astronaut Radiation Exposure
16:30-16:45	Dr Shane Usher, University of Melbourne	Radiation Shielding: Novel use of scattering phenomena
16:45-17:00	Dr Aditya Chopra, Australian National University	What can AI tell us about life in the universe?
17:00-17:15	Christopher Tylor, University of Southern Queensland	The Implications of the Orbital Dynamics of Jupiter's Satellite System on the Habitability of Exomoons
17:15-17:30	Dr Lucyna Kedziora- Chudczer, University of New South Wales	Effects of Hazes and Clouds on Exoplanetary Spectra
17:30-17:45	Prof Jonti Horner, University of Southern Queensland	MINERVA-Australis: An Update
19:00-21:30	<b>Gala Dinner.</b> Presentation by Prof. Brian O'Brien	

## Tuesday - Stream 2 (*Boulevard 3*)

Time	Speakers Name	Title
10:30-11:00	<b>Morning Tea</b>	

### ***Space Missions I***

11:00-11:30	Andreas Antoniadis, Saber Astronautics	Australian Space Weather Satellite: A Proposal for a National Collaborative Spacecraft Mission.
11:30-11:50	Dr Kimberley Clayfield, CSIRO Astronomy and Space Science	CSIRO's Small Satellite Initiatives
11:50-12:10	James Harpur, University of Sydney	The 'Training Centre for CubeSats, UAVs and Their Applications', and it's first satellite, CUAVA-1
12:10-12:30	Iver Cairns, ARC Training Centre for CubeSats, UAVs, and Their Applications,	Status of INSPIRE-2 and Evidence for Space Weather Effects
12:30-12:50	Chris Peck, Defence Science Technology Group	Buccaneer Risk Mitigation Mission – DST Lessons Learned
13:00-14:00	<b>Lunch</b>	

Time	Speakers Name	Title
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### ***Space Business and Industry***

14:00-14:20	Prof Phil Bland, Curtin University	FireOPAL: Toward a Low-Cost, Global, Coordinate Network of Optical Sensors for Space Situational Awareness
14:20-14:40	Greg Madsen, Lockheed Martin	FireOPAL: Technical Performance and First Results
14:40-15:00	Mark Ramsey, Sitael Australia	Australian Space Missions: Thinking Bigger
15:00-15:20	Timothy O'Sullivan, Defence Export Controls, Department of Defence	Export controls and the Australian space research sector
15:20-15:40	Jannene Kyytsonen, University of Technology Sydney	A Space Narrative

### ***15:40-16:00 Afternoon Tea***

### ***Space Engineering II***

16:00-16:15	Dr Hideaki Ogawa, RMIT University	Analysis of Effects of Magnet Configurations for Downscaled Cusped Field Thruster via Surrogate Assisted Evolutionary Algorithms
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Time	Speakers Name	Title
16:15-16:30	Prof. Iver Cairns, The ARC Training Centre for CubeSats, UAVs & Their Applications	Spectral investigations of the Charge Exchange Thruster
16:30-16:45	Joshua Kahn, University of New South Wales	Structural Analysis of Varying Joints used for a Hexagonal Solar Sail Concept via FEM
16:45-17:00	Alexander Ryan, University of New South Wales	Particle-in-Cell Analysis of Ion Detachment from Ambipolar Propulsion Devices with Differing Magnetic Nozzle Geometries
17:00-17:15	Peter Anastasiou, Inovor Technologies	Development of a CubeSat Star Tracker
17:15-17:30	Dominic Albertson, University of Sydney	A Study into the Effects of Stray Light Pollution in Wide-Field-of-View Star Trackers
17:30-17:45	Julian Guinane, University of Sydney	Assessing the Viability of a Smartphone-Based Wide Field of View Stellar Gyroscope
19:00-21:30	<b>Gala Dinner.</b> Presentation by Prof. Brian O'Brien	

## Tuesday - Stream 3 (*Boulevard 1*)

Time	Speakers Name	Title
10:30-11:00	Morning Tea	
Space Law		
11:00-11:15	Dr Elias Aboutanios, ACSER, UNSW Sydney	On the Liability Requirements of The Australian Space Legislation
11:15-11:30	Dr Stacey Henderson, University of Adelaide	Exploring a legal framework for the colonisation of Mars
11:30-11:45	Duncan Blake, University of Adelaide	Between a Rock and an Asteroid: Australia's Legal Position in respect of Off-Earth Mining
Space Law Professional Development Series		
11:45-12:00	Dr Stacey Henderson, University of Adelaide	International legal framework for space activities
12:00-12:15	Bora Kaplan, Sydney Bar	National legal framework for space activities
12:15-12:30	Prof Melissa de Zwart and Dr Stacey Henderson, University of Adelaide	Protection of intellectual property for space activities
12:30-12:45	Timothy O'Sullivan, Defence Export Control Office	Export control laws

12:45-13:00	Dr Maria A Pozza, GQ Law - New Zealand	Space Law: Lessons for Australia and New Zealand
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<b>13:00-14:00</b>	<b><i>Lunch</i></b>	
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### **Space Law Professional Development Series II**

14:00-14:15	Joel Lisk, University of Adelaide	Comparative regulatory approaches and competing for global sales opportunities
14:15-14:30	Duncan Blake, University of Adelaide	Regulation of military and government procurement in relation to space activities in Australia
14:30-14:45	Bora Kaplan, Sydney Bar and Tunc Kaplan, Western Sydney University	Legal/business structures for space activities in Australia
14:45-15:00	Tyson Lange, Clayton Utz	Contracting for space activities in Australia
15:00-15:15	Karina Galliford, International Aerospace Law & Policy Group	Space applications: hybrid aerospace vehicles
15:15-15:30	Tunc Kaplan, Western Sydney University	Space applications: active debris management
<b>15:30-16:00</b>	<b><i>Afternoon Tea</i></b>	

### **Space Law Professional Development Workshop**

16:00-17:00	Duncan Blake, International Aerospace Law and Policy Group	Subordinate Rules under new Space Activities (Launches and Returns) Act 2018
19:00-21:30	<b>Gala Dinner.</b> Presentation by Prof. Brian O'Brien	

## Wednesday - Stream 1 (*Boulevard 2*)

Time	Speakers Name	Title
<b>8:30-9:00</b>	<b>Registration</b>	
<b>Plenary Session III</b>		
9:00-9:30	Danielle Shean, VSSEC	Space Science: Empowering STEM learning
9:30-10:00	Katarina Miljkovic, Curtin University	Exploring Mars with InSight
10:00-10:30	Adam Gilmour, Gilmour Space Corporation	A New Space paradigm for Australia
<b>10:30-11:00</b>	<b>Morning Tea</b>	
<b>Education, Culture &amp; History</b>		
11:00-11:20	Kerrie Dougherty, University of New South Wales	The Role of Museums and Science Centres in Informal STEM Education
11:20-11:40	David Platz, University of Southern Queensland	The Online College of Advanced STEM: Delivering Astronomy, Astrophysics, Data Science
11:40-12:00	James O'Connor, University of Southern Queensland	Why would Australia need astronauts?
12:00-12:20	Carla Guedes, University of New South Wales	Exploring Cultural Competence for Astronomers
12:20-12:40	Robert Fuller, University of New South Wales	Songlines and Dreaming Tracks in the Night Sky
12:40-13:00	Kerrie Dougherty, University of New South Wales	From the Weapons Research Establishment to the Australian Space Office: Precursors to the Australian Space Agency
<b>13:00-14:00</b>	<b>Lunch</b>	
<b>Space Physics III</b>		
14:00-14:15	Dr Brett Carter, RMIT University	On the characterisation of the day-to-day occurrence of Equatorial Plasma Bubbles using the Rayleigh-Taylor growth rate calculated using the TIEGCM
14:15-14:30	Dr Julie Currie, RMIT University	The Effect of Sporadic E on Prediction of Equatorial Plasma Bubbles
14:30-14:45	Prof Frederick Menk, University of Newcastle	HF radar observations of periodic ionospheric irregularities at middle latitudes

Time	Speakers Name	Title
14:45-15:00	Dr David Netherway, Defence Science and Technology	Modelling the Received Power of Multipath HF Signals Propagated via the Ionosphere
15:00-15:15	Dr Michael Turley, Defence Science and Technology	Performance Bounds on HF Backscatter Leading Edge Inversion
15:15-15:30	Dr Kenneth Lynn, Ionospheric Systems Research	Morning and afternoon peaks in electron density near the magnetic equator contrasted with a similar phenomenon of different origin occurring at middle latitudes
15:30-16:00	Afternoon Tea	
Townhall Discussion		
16:00-17:00	Australia's future space science plan	
17:00-17:15	Iver Cairns, Wayne Short	Closing remarks

### Wednesday - Stream 2 (*Boulevard 3*)

Time	Speakers Name	Title
10:30-11:00	Morning Tea	
Space Engineering III		
11:00-11:15	Joon Wayn Cheong, University of New South Wales	Progress and Update of UNSW- ECO: Australia's First Cubesat Trio in Orbit
11:15-11:30	Natalie Stevens, DST Group	Buccaneer Risk Mitigation Mission – Ground Station
11:30-11:45	Hao Duong, DST Group	Power Budget Analysis and Verification
11:45-12:00	Garland Hu, DST Group	On-orbit performance of the Namuru GPS Receiver, and other results from the SHARC mission.
12:00-12:15	Paul Alvino, DST Group	On-orbit dynamics of the deployable high frequency antenna on the Buccaneer Risk Mitigation Mission
12:15-12:30	Gavin Conibeer, University of New South Wales	Integrated Patch Antennas and Solar Cells for Cubesats – Optimising solar cell efficiency and antennae gain
12:30-12:45	David Gozzard, Australian National University	Integrated optical phased arrays for spacecraft communications and sensing
12:45-13:00	Robert Eldridge, University of Queensland	Rapid Prototyping in Instrumented Hypervelocity Testing

Time	Speakers Name	Title
13:00-14:00	<b>Lunch</b>	

### Wednesday - Stream 2 (*Boulevard 3*)

Time	Speakers Name	Title
<b>Space Entrepreneurs</b>		
14:00-14:15	Noor Taofiquel Huq, Spiral Blue	Spiral Blue - Stopping maritime piracy from space
14:15-14:30	William Crowe, High Earth Orbit Robotics	Nanosatellites in High Earth Orbit
14:30-14:45	Conrad Pires, Picosat Systems	SAR: The right information at the right time
14:45-15:00	Benjamin Koschnick, Spectral Aerospace	Spectral Aerospace: Hyperspectral Satellite Remote Sensing Solutions
15:00-15:15	Bryce Prior, Leo Aerospace	Leo Aerospace: A balloon launch startup
15:15-15:30	John Weir, University of Southern Queensland	Characterisation of Near Earth Asteroids - An Asteroid Mining Perspective
15:30-16:00	<b>Afternoon Tea</b>	

### Wednesday - Stream 3 (*Boulevard 1*)

Time	Speakers Name	Title
10:30-11:00	Morning Tea	
Mars		
11:00-11:30	Mitchell Schulte, NASA Headquarters	The Mars 2020 Rover Mission
11:30-11:45	Robert Brand, Mars Society of Australia	The MEDIAN Mars Mission Using Impactors – The Search for Life
11:45-12:00	Eriita Jones, University of South Australia	A Neural Network's Search For Polar Spring-time Fans On Mars.
12:00-12:15	Jeremy Bailey, University of New South Wales Sydney	Polarization of Mars during the 2018 Dust Storm
12:15-12:30	Graziella Caprarelli, Hypatia Scientifica Pty Ltd	Geological interpretation of ground penetrating radar reflector in the subsurface of Lunae Planum, Mars.
12:30-12:45	Devyani Devidas Gujar, SRMIST Institute of science and technology, India	A Novel Integrable System for Martian Approach, Mapping and Energy Extraction
12:45-13:00	Steven Hobbs, Mars Society of Australian and UNSW	Mobility Trials and Testing of Micro and Nano-Scale Rovers for Planetary Science Applications.



Time	Speakers Name	Title
13:00-14:00	<i>Lunch</i>	

### Wednesday - Stream 3 (*Boulevard 1*)

Time	Speakers Name	Title
<b>Space Missions II</b>		
14:00-14:20	Simon Barraclough, University of New South Wales Canberra	M1 Readiness for Launch: UNSW Canberra – Royal Australian Air Force Space Situational Awareness and ISR Pathfinder Mission
14:20-14:40	Stevie Nuss- Soeharto, RMIT University	Possible Near-Term Mission Architecture to Measure Lunar Polar Regolith Water Content
14:40-15:00	Brett Carter, RMIT University	RMIT University's Robotic Optical Observatory (ROO) Telescope for Space Situational Awareness Research
15:00-15:20	Ray Stott, SpaceRayStott	Recruitment Challenges for the Australian Space Industry
15:30-16:00	<i>Afternoon Tea</i>	

## Poster Presentations

The presenters at the poster session on September 24 are:

Dr Brett Addison, University of Southern Queensland: Probing the Origins of Hot Jupiters & Spin-Orbit Misaligned Exoplanets -

Stephen Bathgate, University of Sydney: A thruster using magnetic reconnection to create a high-speed plasma jet for spacecraft propulsion

Nahid Kermani, University of NSW: The Effect of Splitter Plate(s) Attached with Square Cylinder in Turbulent Flow

Professor Bradley Carter, University of Southern Queensland: Mt Kent Observatory: A Queensland Facility for Astronomical and Space Sciences

Dr Shuai Chen, Nanjing University of Science and Technology: Applying a Master-slave Filter to Vector Tracking GNSS Receiver for Robust

Dr Julie Currie, RMIT University: On the identification and removal of ground scatter in SuperDARN radar data

Dag Evensberget, University of Southern Queensland: The solar wind in time from young stellar proxies

Kenneth Gillan, DigitalGlobe: Space, Spatial, Machine Learning for Business Benefit

Yanming Feng, Queensland University of Technology: GNSS-driven Accurate Time Synchronization for VANET

Volker Hessel, The University of Adelaide: Tiny Spaces for the Infinite Space: Flow Chemistry Mini-Labs as Assets of Space Manufacturing

Steven Hobbs, Mars Society Australia: Eyes on the Ground: Trialling Remote Sensors for Small Planetary Rovers.

Jonathan Horner, University of Southern Queensland : Preliminary Astrocladistical analysis of the Jovian Trojan swarms

Jonathan Nalder, FirstonMars.net: First Kids on Mars - Future-ready skills program

Behrooz Karamiqucham, University of NSW: Near-Infrared atmospheric modelling of Jupiter's Southern Equatorial Belt (SEB) observed with AAT/IRIS2

Dr Vasily Lobzin, Bureau of Meteorology: Solar Wind Predictions Based on SDO/AIA and DSCOVR Data

Shaun Moss: Arcadia: the First Settlement on Mars

Edwin G. W. Peters, UNSW Canberra Space: A GPU based doppler and code search for the reception of satellite signals

Danielle Shean, Victorian Space Science Education Centre: STEM and the realm of hands-on constructivism

Nam Nghiep Tran, University of Adelaide: Tiny Spaces for the Infinite Space: Flow Chemistry Mini-Labs as Assets of Space Manufacturing?

Nam Nghiep Tran, University of Adelaide: Guardian Satellite-based Flow-Chemistry System Producing Quantum Dots as Counter Measure to Divert Missile Attack

Baptiste Trotabas: Design of a Deployable Lightweight Nanosatellite Antenna

Ivan Voropaev, Wave Power Engineering: Satellite propulsion system

Dr Kehe Wang, Bureau of Meteorology: The Accuracy of Space Weather Services Automatically Scaled foF2 Data

## Conference Plenary Speakers



**Dr Megan Clark**

Australian Space Agency

*"Australia's Strategic Priorities in Space"*

Dr Clark is currently Head of the Australian Space Agency and a director of Rio Tinto, CSL Limited and CARE Australia. She is a member of the Australian advisory board of the Bank of America Merrill Lynch. Dr Clark recently chaired the Expert Working Group into the Review of Australia's Space Industry Capability. She was Chief Executive of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) from 2009 to 2014. Prior to CSIRO, she was a Director at NM Rothschild and Sons (Australia) and was Vice President Technology and subsequently Vice President Health, Safety and Environment at BHP Billiton from 2003 to 2008.

Dr Clark holds a BSc from the University of Western Australia and a PhD from Queen's University, Canada and is a Fellow of the Australian Academy of Technology and Engineering, a Fellow of the AusIMM and a Fellow of the Australian Institute of Company Directors. In 2014, she was appointed a Companion of the Order of Australia.

**Dr Gordon Cable**

Australasian Society of Aerospace Medicine  
*"Australia's Contribution to Space Life Sciences"*

Dr Gordon Cable is a specialist in aerospace medicine and a Senior Aviation Medical Officer for the Australian Defence Force. He has been a consultant to the Royal Australian Air Force since 1996 and is an aviation medical examiner for Australia's Civil Aviation Safety Authority (CASA). He is the current secretary and an honorary member of the Australasian Society of Aerospace Medicine (ASAM), as well as Chair of the Space Life Sciences Committee, and a past president. He also holds Fellowships with the Australasian College of Aerospace Medicine, the Aerospace Medical Association, the Royal Aeronautical Society and the International Academy of Aviation and Space Medicine. Additionally, Dr Cable is a Clinical Associate Professor in the School of Medicine at the University of Adelaide, and the author of many scientific publications. His professional interests include altitude physiology of hypoxia and hypobaric decompression illness, hypoxia awareness training of military and civilian aircrew, space medicine, and postgraduate education in aerospace medicine for medical professionals.

**Dr Mark Cheung**

Lockheed Martin/Stanford University, USA

*"Physics and Diagnostics of the Solar Drivers of Space Weather"*

Dr. Mark Cheung is a Staff Physicist at Lockheed Martin Solar & Astrophysics Lab in Palo Alto, California and a Visiting Scholar at Stanford University. He is the Principal Investigator for the Atmospheric Imaging Assembly (<http://aia.lmsal.com>) on NASA's Solar Dynamics Observatory (<http://sdo.gsfc.nasa.gov>), which has been monitoring the Sun since 2010. He is an advisor to NASA's Frontier Development Lab, where machine learning and artificial intelligence techniques are applied to accelerate space science discovery and exploration. He obtained his undergraduate degree at the University of Adelaide and did graduate research at the University of Göttingen, Germany and the Max Planck Institute for Solar System Research.



**Professor Melissa de Zwart**

University of Adelaide

*"Commercialisation of space: innovation versus domestic legislation?"*

Professor Melissa de Zwart is Dean of Adelaide Law School and Deputy Director, Research Unit on Military Law and Ethics.

Having developed a keen interest in the regulation and commercialisation of cutting edge technology as Manager, CSIRO Corporate Legal Service, she has published widely on internet law, intellectual property, online intermediaries, social media and online communities, surveillance, privacy and the law of outer space. She is a Member of the Advisory Council, Space Industry Association of Australia, a Member of the International Institute of Space Law, and Director of the Woomera Manual on the International Law of Military Space Operations.



**Mr Adam Gilmour**

GilmourSpace

*"A New Space Paradigm for Australia"*

Adam Gilmour is the CEO and Founder of Gilmour Space Technologies, a leading rocket company in Australia that is developing next-generation hybrid propulsion technology. A former banker, Adam is now driven to lower the cost of rocket launches for small satellites, thus enabling Australia to play a bigger role in New Space paradigm.



**Dr Katarina Miljkovic**

Curtin University

*"Exploring Mars with InSight"*

Dr Miljkovic is an ARC DECRA Fellow at the School of Earth and Planetary Science at Curtin University. Initially an astrophysicist, her expertise now includes planetary geoscience, especially focused on impact processes. Dr Miljkovic analyses data from space missions and plays an active role in international planetary exploration teams such as the lunar gravity NASA mission GRAIL until recently, and currently the Martian geophysical NASA mission InSight, now on its way to Mars.





**Professor Stuart Phinn**

University of Queensland

*"Linking Upstream and Downstream Using Australia's Earth Observation Capabilities"*

Stuart Phinn is a professor of Geography at the University of Queensland where he teaches remote sensing and directs the Remote Sensing Research Centre [www.rsrc.org.au](http://www.rsrc.org.au) , which includes programs recognised as world's best practice, to support government agencies across Australia using EO data [www.jrsrp.org.au](http://www.jrsrp.org.au). Stuart's research and teaching interests use airborne and satellite data sets for measuring and monitoring environmental changes and publishing/sharing ecosystem data. This work is done in collaboration with other environmental scientists, government environmental management agencies, NGO's and private companies. Most recently he chaired the Committee that produced Australia's first Earth Observation Community Plan – 2026 [www.eoa.org.au](http://www.eoa.org.au) . He publishes extensively with his collaborators, and currently has 190 papers in refereed international journals, 1 book, and on-line textbook, and 12 book chapters. A large part of this work also involves training the next generation of scientists and managers who effectively use remote sensing, and has graduated 42 PhD students.



**Ms Danielle Shean**

Victorian Space Science Education Centre  
*"Space Science: Empowering STEM learning"*

Danielle Shean has a Bachelor of Science degree and a Masters in Palaeontology. She began work at the Victorian Space Science Education Centre in 2008, during the final year of her post-graduate research, during which time she very quickly developed a love of Space Science. Working with young learners, she took many exciting and stimulating trips to Mars. These experiences fed an obsession with developing STEM curriculum, in particular a commitment to constructivism as a learning tool. This defines her current role at the Centre.

## **MSA David Cooper Memorial Lecture**

Monday September 24

6:45 pm for a 7:00pm start

Venue: Boulevard 2 (Level 2)  
Mantra on View Hotel

Speaker: Dr Mitchell Schulte

NASA Headquarters, Washington, USA

### **“The Past, Present and Future of Mars Exploration”**

NASA has been systematically exploring Mars for decades. Through a series of orbiter, lander, and rover missions and funding of data analysis and basic research programs, great strides have been made in understanding a number of scientific aspects of the Red Planet. NASA has followed a series of strategies to understand Mars as a planetary system, and to determine whether Mars may have once been inhabited (and whether it may be today). The strategies having included determining the presence of liquid water at or near the surface and the habitability of Mars in the past and present, and is now actively seeking signs of life in the surface materials present on Mars. During this presentation, information will be presented on the numerous missions flown to Mars, and highlights of the scientific discoveries that have resulted from the approach NASA has taken. We will also discuss missions currently in development (including our numerous collaborations with international partners), and the prospects for these mission to answer a number of outstanding scientific questions remaining about Mars. Of particular interest are the InSight mission, the first geophysics mission, currently en route to Mars, and the Mars 2020 rover, now being built for a July 2020 launch. Finally, NASA has also increased activity related to returning samples from Mars (for which Mars 2020 is the first step), and the architecture for Mars sample return will be presented.



### **Speaker Biography**

Dr Mitchell D. Schulte is a Program Scientist with the Mars Exploration Program at NASA Headquarters in Washington D.C. He is a geochemist currently working on the Mars 2020 and the US contribution to the European Space Agency's ExoMars 2020. Schulte focuses on the formation of organic compounds in hydrothermal environments and the microorganisms that inhabit them, as well as the implication of water-rock reactions for the emergence of

life on early Earth and other planetary bodies. He is a member of the editorial board for the journal *Astrobiology* and a board member of UNSW Science's Big Questions Institute.

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## **On the Liability Requirements of The Australian Space Legislation**

Elias Aboutanios  
*ACSER, UNSW Sydney*

In this work we will examine the risk to the Australian Government arising from the activities of Australian space players. This issue has recently come to the fore as part of the reform of the Australian Space Activities Act 1998 (the Act-1998). Whereas the Act-1998 stipulates that applicants for an authorisation for a space activity must indemnify the Government for the lesser of the Maximum Probable Loss (MPL) or \$750M, the proposed new bill has capped this financial requirement at \$100M. Furthermore, the new bill provides for the actual insurance requirement to be set in the legislative instruments, which are adaptable. This brings the Australian requirements in line with international best practice and provides a more favourable environment for Australian space actors. Previously, we have analysed the risk to the Australian government under the Act-1998 and showed that the insurance requirement is excessive. We have also shown that reducing the requirement will not lead to excessive risk to the Australian Government. In this talk we will discuss the liability of the Australian Government associated with Australian space activities and present modelling of the additional risk to the Government that arises from the change in the legislated insurance requirement. Furthermore, we will discuss methods for setting the actual insurance requirement in the legislative instruments.

*Presented by: Elias Aboutanios*

## Probing the Origins of Hot Jupiters & Spin-Orbit Misaligned Exoplanets

Brett Addison<sup>1</sup>, Rob Wittenmyer<sup>1</sup>, Jonti Horner<sup>1</sup>, Duncan Wright<sup>1</sup>,  
Songhu Wang<sup>2</sup> and Chris Tinney<sup>3</sup>

<sup>1</sup>*University of Southern Queensland,*

<sup>2</sup>*Yale University*

<sup>3</sup>*University of New South Wales*

The discovery of giant planets on  $<10$  day orbits (hot Jupiters) was one of the most unexpected results of early exoplanetary discoveries. Despite decades of inquiry, the origin of hot Jupiters remains a mystery. The standard paradigm holds that these behemoths were not born in situ, but rather that they formed beyond the proto-stellar ice line by core-accretion (where raw materials are plentiful) and on nearly coplanar orbits that are well-aligned to the spin axis of their host star. They then migrated inward via disk-migration mechanisms, or dynamical-migration mechanisms, including: planet-planet scattering, Lidov-Kozai cycling with tidal friction, and secular chaos.

The successful migration scenario must explain at least two observed properties of hot Jupiters: 1. Hot Jupiters are frequently observed to have orbital planes that are misaligned with the equators of their host stars. This is particularly true for stars hotter than the Kraft break, at  $T_{\text{eff}} \sim 6250\text{K}$ . 2. Hot Jupiters tend to be alone.

To probe the processes involved in the formation and migration of exoplanets, I have initiated the Stellar Obliquities and Planetary Alignments (SOPA) project to measure the sky-projected spin-orbit angles (i.e., the angle,  $\lambda$ , between the spin angular momentum vector of a host star and the orbital angular momentum vector of its planet) of exoplanets by observing the Rossiter-McLaughlin effect.

I will discuss some of the recent and interesting results from the SOPA project. Additionally, I will discuss the importance for carrying out additional spin-orbit measurements using several telescopes including the upcoming MINERVA-Australis telescope array, the Anglo-Australian Telescope, the Keck Telescope, and others. In particular, spin-orbit measurements of the least explored parameter space such as sub-Jovian, long-period, and multi-planet systems are especially important.

*Presented by: Brett Addison*

## **BETWEEN A ROCK AND AN ASTEROID: Australia's Legal Position in respect of Off-Earth Mining**

Jordan Aitken  
*Space Law Interest Group (ANZ)*

Duncan Blake  
*University of South Australia*

The exploitation of resources on Earth has been central to the development and progress of humankind for centuries. Now, as commercial space activity becomes increasingly common, we are at the precipice of a new 'frontier' of resource exploitation; in outer space. In fact, near Earth asteroids alone provide potentially boundless commercial opportunities for future exploitation. Yet, due to the ambiguity of Article II of the Outer Space Treaty, the current international legal framework fails to provide the certainty that the emerging industry requires in order to attract the private investment it desperately needs. Several countries have sought to address this gap by passing domestic legislation that grants citizens (and companies) the right to own resources extracted from outer space. However, such an approach is not sustainable for abundant reasons, none more prominent than the notion that outer space is the 'province of all humankind'. Add to this near certain conflicts between jurisdictions, and the inevitable challenges with dispute resolution, and it is obvious that only an internationally agreed regulatory solution can achieve an outcome that would be satisfactory and sustainable. Yet international solutions carry their own difficulties, as the past forty years of space law would attest. Because of Australia's ratification of the Moon Agreement and analogies with our position on Antarctica, it finds itself in a challenging position ('between a rock and a hard place') in relation to the development of an international regulatory regime. Nevertheless, there are significant opportunities for Australia to take a carefully calibrated leadership role.

*Presented by: Jordan Aitken/ Duncan Blake*



## **A Study into the Effects of Stray Light Pollution in Wide-Field-of-View Star Trackers**

Dominic Albertson  
Iver Cairns  
Xiaofeng Wu  
Joshua Critchley-Marrows  
Nicholas Barbara

*University of Sydney*

Rising capability and demand of small satellites, including cube satellites, has led to increasing demand for miniaturised high accuracy attitude determination systems, in particular, the Star Tracker. Previous research has shown low cost COTS (commercial-off-the-shelf) camera systems to be very promising for use in small satellite star trackers, due to their low cost, low mass and volume, wide FOV (field of view), and high radiometric and spatial resolution. This study is part of an ongoing research project at the University of Sydney, researching and developing a small satellite, multi-camera, Wide-FOV Star Tracker. The wide-FOV aspect ( $\sim 40$  degrees) in particular, offers a new paradigm in star tracking, detecting more stars per image, and only identifying “bright” stars ( $\sim$  mag 3). This is in contrast to traditional methods, typically ranging from 5 - 25 degree FOV imaging  $\sim$ mag 5 stars. However, the increase in FOV leads to increased susceptibility of the system to detrimental stray light from the Sun, Earth and Moon. This study characterises the effect of these stray light sources on the system, using smartphone camera technologies as an analog for the final system. Blinding angles from camera boresight to the centre of the Sun, Earth and Moon, are calculated through laboratory and ground experiments, and the percentage of random, “Lost in Space” orientations, for which the camera can operate, is determined through a Monte Carlo simulation. Experimentation showed the effect of stray light to be very significant, with exclusion angles of  $>85$  degrees,  $>85$  degrees and  $<5$  degrees for the Sun, Earth and Moon respectively. However, the results show that with implementation of typical stray light attenuation methods, particularly baffling, there is potential to increase system operability above that of commercially available systems.

*Presented by: Dominic Albertson*

## **On-orbit dynamics of the deployable high frequency antenna on the Buccaneer Risk Mitigation Mission**

Paul Alvino  
*DST Group*

One of the primary mission goals for the Buccaneer Risk Mitigation Mission (BRMM), a collaborative Australian mission between UNSW Canberra Space and DST Group, was the deployment of a High Frequency (HF) antenna for calibration of the Jindalee Operational Radar Network (JORN). Given the low TRL of the antenna design and the practical obstacles in conducting flight representative tests of the deployment in a terrestrial 1-g environment, the BRMM provided flight heritage on this technology ahead of the Buccaneer Main Mission. The open bow-tie HF antenna with four elements approximately 1.7m long each was successfully deployed from a stowed configuration using a twelve-staged burn wire release. This paper presents the on-orbit data describing the attitude dynamics of the spacecraft in response to the twelve antenna deployment stages, and demonstrates, through hardware-in-the-loop simulation results, the physical cause of this behaviour. The data, best-fit modelling, and simulation of the impact of the antenna deployment on spacecraft dynamics provide useful insight for future deployable structure designs.

*Presented by: Paul Alvino*

## **Development of a CubeSat Star Tracker**

Peter Anastasiou and Matthew Tetlow  
*Inovor Technologies*

This paper describes the design and development of the Inovor Technologies CubeSat star tracker. Star trackers are used in satellites to provide high accuracy attitude estimates by imaging the sky and analysing the stars in the image. The Inovor Technologies star tracker module is designed to have low power consumption and small volume and mass compared to other commercially available star trackers with equivalent accuracy.

This paper covers all aspects of the star tracker design, including the selection of the lens and image sensor, as well as electronics and software design. A discussion and evaluation of approaches to the star tracker lost-in-space problem is presented. Algorithms are developed for each of the main processing stages of centroiding, star identification and attitude estimation. The algorithms were initially developed and tested using simulated star images from a star catalogue. A prototype printed circuit board and frame incorporating the image sensor and lens was developed.

Results from the prototype star tracker are presented to validate the system design. The results demonstrate the identification of stars from live images captured from within the atmosphere. A flight version of the star-tracker will be launched on board an Inovor Technologies developed CubeSat at the end of 2019 for in-orbit demonstration and evaluation.

*Presented by: Peter Anastasiou*

## **Australian Space Weather Satellite: A Proposal for a National Collaborative Spacecraft Mission.**

Andreas Z. Antoniadis and Dr. Jason Held  
*Saber Astronautics*

Space Weather impacts our national infrastructure. Solar storms can degrade both commercial and Defense communications, reduce GPS quality, add charging on electric power grids at low latitudes, and can even increase cancer rates in certain regions. Space weather also adversely affects spacecraft, reduces their longevity, degrades instruments and even results in complete mission failure in certain circumstances. Smaller, less protected satellites such as CubeSats are particularly vulnerable, and are currently of interest to Australian industry.

Most of Australia's space weather data comes from a series of NASA or EU owned spacecraft, providing near-instantaneous snapshots of solar conditions in position they are orbiting. Analysis of service provided by these satellites indicate that Australia is largely isolated from direct coverage, with geostationary/synchronous spacecraft such as SDO, SOHO, GOES-15 and GOES-16 not covering the Asia-Pacific region. For spacecraft that provide early-warning, such as NASA ACE or DISCOVER, coverage to Australia is sporadic, and often unavailable as ground stations are located in the US or EU.

This research presents an Australian-built space-weather satellite as a possible and important collaborative project to demonstrate the country's growing capability, and to provide vital telemetry and early-warning for the Asia-Pacific region. This paper will outline the mission design to include vital space-weather payloads, satellite design, business case, and an orbit plan which maximises access to vital space weather data.

Design focuses on providing service for reasonably low mass and low cost, suitable for manufacturing and launching via local supplying Australian space companies. A 'demonstration' class space vehicle is an ideal national project to test the strength of the supply chain and give Australia a unique asset of national need.

*Presented by: Andreas Z. Antoniadis*

## **Geomagnetic storm impact on GNSS performance; case study Australia**

Kirco Arsov<sup>1</sup>, Michael Terkildsen<sup>1</sup>, German Olivares<sup>2</sup>, Balwinder Arora<sup>1</sup>

<sup>1</sup>*Australian Bureau of Meteorology*

<sup>2</sup>*Cooperative Research Centre for Spatial Information (CRCSI)*

This presentation deals with the impact of Geomagnetic storm on GNSS performance over Australian Territory. As GNSS performance indicators we choose scintillation behavior together with PPP (RTK ) positioning accuracy and ambiguities resolving rate and baseline classical GNSS computations. In addition to this, correlation with different physical parameters is going to be performed and assessed. We will present the new BoM scintillation service and monitor its performance during geomagnetic storm period. Its correlation with other geophysical parameters and indices (such as Kp-index and post fit ionosphere modeling residuals and rms. etc. will be shown).

Furthermore, we will show performance of Precise Point Positioning under storm conditions and monitor the positioning accuracy together with the Ambiguities fixing rate and success over this period. We will also present pure GNSS 2-points baseline positioning and will observe the baseline and positioning accuracy behavior. All the above will help us understand better what GNSS component is mostly affected by the geomagnetic storm. The impact on ionosphere modeling, especially the input coming from GNSS system will be also presented and explained.

*Presented by: Kirco Arsov*

## **Polarization of Mars during the 2018 Dust Storm**

Daniel Cotton and Lucyna Chudczer  
*UNSW Sydney*

We have observed the whole-disk polarization of Mars beginning on 2018 Jun 14 and through opposition using the UNSW 35 cm telescope and the Anglo-Australian 3.9m Telescope. The observations cover the global dust storm in June and July. They were made with our high precision polarimeters in several different wavelength filters. We use the phase-angle dependence of the polarization to constrain the properties of the airborne dust particles.

*Presented by: Jeremy Bailey*

**ANZSLIG Professional Development series –  
Space applications: Space Situational Awareness**

Jackson Balme  
*RAAF*

Part of proposed 'space law professional development' series of short presentations for benefit of researchers and start-ups

*Presented by: Jackson Balme*

## **M1 Readiness for Launch: UNSW Canberra – Royal Australian Air Force Space Situational Awareness and ISR Pathfinder Mission**

Simon Barraclough  
*UNSW Canberra*

UNSW Canberra Space has undertaken a three-year research and development programme with the Australian Defence Force to implement and operate two nano-satellite (cubesat) missions. The programme aims to support and enhance ADF capabilities and activities in Space Situational Awareness (SSA), and to support the ADF's ability to develop and operate affordable miniature-satellite-based ISR capabilities that can provide a level of space self-reliance and resilience to support ADF operations. Additionally it will underpin UNSW's fundamental SSA research and provide education and training opportunities for ADF, and in particular the Royal Australian Air Force (RAAF) in relation to the development and operation of a nanosatellite.

The programme consists of two missions, launched approximately 1 year apart. The first mission, M1, has been design, built, verified and delivered to the launch service provider, following a rapid design and development programme. It is scheduled to launch in the first half of October 2018.

The M1 spacecraft is a 3U Cubesat form factor with a nadir facing deployable payload module and two deployable solar arrays. As well as monitoring and recording AIS and ADS-B signals from ships and airplanes, the mission will demonstrate a number of new developments; bespoke mechanical design supporting a large deployable model, a custom UNSW Canberra flight computer, custom deployable antennae, custom software defined radios and a photo-optical payload to support the activities of the Space Environment Research Centre. The programme demonstrates that a system such as this can be developed under a rapid design and development programme.

The paper will provide an overview of the M1 mission, the objectives and the concept of operations. The experiences and lessons learnt during the assembly and verification campaign will be discussed, leading to successful delivery for launch.

*Presented by: Simon Barraclough*



## **A thruster using magnetic reconnection to create a high-speed plasma jet for spacecraft propulsion**

Stephen N. Bathgate, Marcela M.M. Bilek, David R. McKenzie  
*Applied and Plasma Physics, School of Physics, University of  
Sydney*

Iver H. Cairns  
*Space Physics, School of Physics, University of Sydney*

Plasma thrusters propel spacecraft by the application of Lorentz forces to ionized propellants. Despite evidence that Lorentz forces resulting from magnetic reconnection in solar flares and Earth's magnetopause produce jets of energetic particles, magnetic reconnection has only recently been considered as a means of accelerating plasma in a thruster. Based on theoretical principles, a pulsed magnetic reconnection thruster consisting of two parallel-connected slit coaxial tubes was constructed.

*Presented by: S. N. Bathgate*

**ANZSLIG Professional Development series - Regulation of  
military and government procurement in relation to space  
activities in Australia**

Sasha Bellamy  
*Chief Information Officer Group, Department of Defence*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Sasha Bellamy*

**ANZSLIG Professional Development series - Space  
applications: communications**

Sasha Bellamy  
*Chief Information Officer Group, Department of Defence*

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**ANZSLIG Professional Development series - International  
legal framework for space activities**

Duncan Blake  
*International Aerospace Law & Policy Group*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Duncan Blake*

**ANZSLIG Professional Development series - National legal  
framework for space activities**

Duncan Blake  
*The University of Adelaide*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Duncan Blake*

## **Subordinate Rules under new Space Activities (Launches and Returns) Act 2018**

Duncan Blake

*International Aerospace Law and Policy Group*

This session is intended to facilitate a discussion with conference attendees about the Rules that the Australian Space Agency will draft, subordinate to the new Space Activities (Launches and Returns) Act 2018. The speaker will introduce the new legislation and explain the changes it makes to the pre-existing regulatory regime. In particular, the speaker will explain the significance of the Rules that the ASA will draft under the new legislation, as well as the prospective content of those Rules. The ASA will seek input from the Australian space community in respect of the drafting of the Rules and this conference is an opportunity to empower participants in the Australian space community to contribute to the drafting of the Rules. The speaker will facilitate a discussion with conference attendees about the prospective content of the Rules and consolidate their feedback subsequent to the conference.

*Presented by: Duncan Blake*

**ANZSLIG Professional Development series - Space  
applications: remote sensing**

Duncan Blake and Addy Tandoh

Part of proposed 'space law professional development' series of short presentations for benefit of researchers and start-ups

*Presented by: Duncan Blake and Addy Tandoh*

## **FireOPAL: Toward a Low-Cost, Global, Coordinate Network of Optical Sensors for Space Situational Awareness**

Phil Bland<sup>1</sup>, Greg Madsen<sup>2</sup>, Matt Bold<sup>2</sup>, Robert Howie<sup>1</sup>, Ben Hartig<sup>1</sup>,  
Trent Jansen-Sturgeon<sup>1</sup> and Jim Mason<sup>2</sup>

<sup>1</sup>*Curtin University*

<sup>2</sup>*Lockheed Martin*

FireOPAL is a new, distributed network of standalone, optical sensors that is designed to monitor a large number of artificial satellites simultaneously, providing wide area surveillance and precision tracking in near real time. FireOPAL observatories are fully autonomous intelligent imaging systems, taking high resolution images every few seconds, and capable of operating for 24 months in a harsh environment without maintenance. An onboard processing system delivers thousands of measurements each night of angles, range, and light curves for objects in LEO, MEO, and GEO. The results are reported within seconds of the observations, with all imagery and other data products stored onboard. The observations are synchronised over a distributed geographic network - this enables range estimation through triangulation, significantly reducing uncertainties in orbit determination and catalogue maintenance. The network reports measurements to a central server capable of providing alerts of anomalous behaviour and other warnings within minutes of the observations. FireOPAL traces a direct engineering heritage to the Desert Fireball Network (DFN), an Australian planetary science observational facility designed to track meteoroids entering the atmosphere, determine pre-entry orbits, and pinpoint fall positions for recovery by field teams. FireOPAL observatories are the end result of 6 years development of hardened optical systems for the DFN. Each unit is designed to maximise sensitivity and functionality within a cost effective package that minimises build, maintenance and servicing costs. Networked together, the result is a system that can easily be scaled to arbitrary size, allowing for persistent observation with a high level of disruption tolerance.

*Presented by: Phil Bland*



## **Method for estimating foF2 from GPS/TEC**

Zahra Bouya, Vickal. Kumar, Michael Terkildsen, Phillip Maher,  
Garth Patterson

*Australian Bureau of Meteorology, Space Weather Services*

This paper proposes a new approach to investigating the possibility of estimating foF2 from Total Electron Content(TEC). In this work, GNSS measurements which provide another measure of ionosphere characteristics will be incorporated to augment foF2 modelling and forecasting applicable to geographic locations where measured data are not readily available. A Canonical correlation Analysis (CCA) model using archived TEC, foF2 data and updated with real time GPS observations was used. This study commenced with three stations around Australia; Darwin, Canberra and Hobart with promising results and will be applied to other stations. By performing this analysis, it will be possible to addresses the issues of outliers, missing information and fill in gaps in foF2 data.

*Presented by: Zahra Bouya*

## **UNSW Canberra**

Prof Russell Boyce, University of New South Wales  
*UNSW Canberra Space Program*

*Presented by: Russell Boyce*

## **The Jump2 Launch System**

Robert Brand  
*Mars Society of Australia*

Australia, despite its proximity to the equator is severely lacking in suitable land to build efficient low cost launch facilities. Possible locations are either remote or have issues such as land rights, eco-sensitivity, expensive land, indigenous land issues and much more. Australia's northern coastline is still 12 degrees below the equator and misses out on many of the huge benefits of an equatorial launch. The Jump2 system (short for Jump to Space) is able to launch at the equator using an air launch system.

The system uses a Hercules C130 aircraft to transport a 3 stage solid fuel rocket internally. It is removed from the aircraft by a drogue parachute and launched vertically at about 25,000 feet or 7.6Km. It can be launched over the equator when required or in open water if an equatorial launch is not needed. Launching over open water helps greatly with mitigating the onerous risks assessments of any launch.

Payloads of between 10Kg and 50Kg can be launched to 600Km Low Earth Orbit (LEO) with the unmodified Hercules. The entire operation will be located in a regional NSW town and low cost is achieved by using the aircraft for cargo deliveries within Australia when not launching rockets. A runway of less than 1Km length is all that is needed making most regional airports suitable for use. Private property with a runway, a fuel mixing building and a Vehicle Assembly Building is all that is required. A hanger for the aircraft is optional.

Larger aircraft would be needed to take larger payloads to LEO or to even take large payloads to Geostationary Transfer Orbit. The initial use of a Hercules is expected to create the lowest price to orbit of any system and the fastest turnaround to relaunch.

*Presented by: Robert Brand*

## **The MEDIAN Mars Mission Using Impactors – The Search for Life**

Robert Brand  
*Mars Society of Australia*

The Mars MEDIAN Mission (Methane Detection by In-Situ Analysis with NanoLanders) is proposed as a secondary payload to a NASA Mars lander mission and is progressing within NASA being championed as an experiment that “ticks all the boxes”. As a secondary payload, it needed a landing method that did not use stored energy for the safety of NASA’s primary mission – a future mars lander. A non-traditional landing had to be adopted. That is, by impactor probes. The surviving probes that land on Mars will produce a network capable of triangulating the position of any methane vents in the vicinity. A rover may be sent to locate the methane vent and test for the ions and trace gases in the methane that would indicate it came from either life or chemical origins.

This study tests G-force reduction by shock suppressing systems. This will build on desktop studies completed in the UK. Physical testing will be done by a gas gun with a target chamber utilising a variety of Mars simulated soil and temperatures. 4Kg test probes 1m long will initially be impacted at 100m/s with a set of XYZ sensors on board, high speed cameras will view the impact. Future testing will be at 200m/sec, above the expected impact velocity.

The Australian Defence Force Academy will jointly participate in the tests and investigate spinoff technologies.

The successful landing of MEDIAN experiments on Mars with solar power will create a long term Australian, British presence on mars and long term monitoring above and below ground. Data relay will be via Satellite and direct. NASA classify this as citizen science as it has come this far without a company structure. Funding for 50 impact tests has been secured.

*Presented by: Robert Brand*

## **Australia's Contribution to Space Life Sciences**

Gordon Cable

*Australasian Society of Aerospace Medicine*

In September 2017 the Australian Government announced its intention to establish an Australian Space Agency based on the recommendations of an appointed Expert Reference Group (ERG) chaired by Dr Megan Clark AC. Although initially overlooked, biomedical science has now been recognised as a key element of Australia's future space industry and has been specifically noted as a priority of the new Agency. Australia has always had a strong track-record of high quality biomedical research and has already been contributing productively to the field of space medicine. This paper summarizes the background and current status of the Australian Space Agency, some of the current Australian capabilities in space life sciences, future global plans for human space exploration, and outlines some niche areas in which Australia could contribute to future missions.

*Presented by: Gordon Cable*

## Beam Speeds and Source Longitudes for Type III Solar Radio Bursts from Magnetic Mapping Analyses

Iver Cairns<sup>1</sup>, Bo Li<sup>1</sup>, Daniel Graham<sup>2</sup>, Vasili Lobzin<sup>3</sup>, Graham Steward<sup>3</sup> and David Neudegg<sup>3</sup>

<sup>1</sup>*University of Sydney*

<sup>2</sup>*Swedish Space Research Institute*

<sup>3</sup>*Bureau of Meteorology*

Energetic electrons accelerated during solar flares can form an electron beam and generate type III solar radio bursts while streaming along open magnetic field lines. The electron beams are rarely measured in situ and estimating the beam speed from the frequency drift rate of the type III emission is indirect and has several issues. A new method is presented that combines the electron paths obtained from maps of the large-scale magnetic field lines with the release of electrons at the onset times  $t_0$  of type III bursts. Electron energy losses are neglected, so the beam speed at a distance  $L$  along a field line from the source varies with time as  $v_b(t) = L / (t - t_0)$ . The method is applied to 21 type III bursts for which the STEREO spacecraft observed beam-driven Langmuir wavepackets in situ and the beam speeds were independently estimated from observations and theory of the nonlinear electrostatic decay process for Langmuir waves. The two methods yield estimated beam speeds that: (1) range from 0.03c to 0.28c, decreasing with time within each event; (2) agree within better than  $\sim 10\%$  for the first and last wavepackets in all 21 events, and (3) agree better than 10% for each of over 14 groups of Langmuir wavepackets during an unusually long-lived event that lasted almost 75 minutes and clearly demonstrates the hyperbolic relation above for  $v_b(t)$ . Finally, tracing the field lines from STEREO back to the Sun yields source longitudes that are within 10 degrees and 20 degrees of the associated flare's active region for 6 and 17, respectively, of the 21 type IIIs considered. These results provide strong arguments in favour of the model and against this paper's Langmuir wavepackets being driven by beams faster than 0.3c.

*Presented by: Iver Cairns*

## **Spectral investigations of the Charge Exchange Thruster**

Charlotte Pouwels  
A\prof. Joe Khachan  
Prof. Iver Cairns

*The ARC Training Centre for CubeSats, UAVs and Their  
Applications*

The Charge Exchange Thruster (CXT) is a low power, self-neutralizing plasma thrust device that shows promise as a propulsion system for Cube Satellites. This type of thruster can be used for low Earth orbit corrections and to counteract atmospheric drag. Initially conceived as a hydrogen fuelled device, early prototypes produced limited thrust due to hydrogen's low mass. Fuel X, a prospective liquid fuel, contains carbon, hydrogen, and oxygen which can form high mass molecular fragments inside the CXT. Acceleration of these fragments can result in a larger thrust. Optical spectroscopy and residual gas analysis were used to assay the molecular species and ions in the thruster plasma plume for fuel X, as well as speeds. Experiments were also done when one hydrogen atom was replaced by a deuteron. Research was conducted into the plasma resistance in the "abnormal" glow discharge region. The results constrain the characteristics of the plasma and are important for the Charge Exchange Thruster.

*Presented by: Prof. Iver Cairns*

## **Status of INSPIRE-2 and Evidence for Space Weather Effects**

Iver Cairns, Anthony Monger, Ron Maj and  
The INSPIRE-2 Team

*ARC Training Centre for CubeSats, UAVs, and Their Applications,  
University of Sydney*

The INSPIRE-2 CubeSat was deployed into space on 26 May 2017 as part of the European Union's QB50 Project. INSPIRE-2 has now survived over 1 year in orbit. The satellite is in good health, reliably transmits its beacon signals, and is expected to continue in orbit for at least another 3 months. These are major achievements. However, just over 1 month after deploying its antennas and entering communications with groundstations the CubeSat went radio-silent again. This occurred just after a large space weather event. Subsequently the satellite was recovered but now has a damaged Comms board and poor uplink capability. Evidence is presented that this damage occurred due to space weather.

*Presented by: Iver Cairns*



## **Geological interpretation of ground penetrating radar reflector in the subsurface of Lunae Planum, Mars.**

Graziella Caprarelli<sup>1</sup>, Roberto Orosei<sup>2</sup>, Andrea Cicchetti<sup>3</sup>, Marco Mastrogiuseppe<sup>4</sup>, Marco Cartacci<sup>3</sup>

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<sup>4</sup>Dipartimento di Ingegneria dell'Informazione, Elettronica e Telecomunicazioni, Università La Sapienza, Via Eudossiana 18, 00184 Roma, Italy.

Here we report the results of our ongoing study of Lunae Planum, a Martian plain approximately 1,500,000 km<sup>2</sup> in areal extent, centered at coordinates 294°E - 11°N, bounded by Echus Palus (west), Sacra Mensa and Kasei Valles (north), Xanthe Terra (east), and the northernmost chasmata of Valles Marineris (south). Overall, Lunae Planum appears to be morphologically uninteresting when compared to other geological features in the region. The presence of wrinkle ridges, grabens and impact craters with fluidized ejecta however, indicates that Lunae Planum had a complex geological history. Over the past two years we explored the subsurface of Lunae Planum by Mars Express (MEX) Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) to detect evidence of structures and to determine the geophysical properties of the materials forming the plain. Standard MARSIS radargrams provided no results, but acquisition and processing of super-frame (SF) data along MARSIS orbits 17590, 17597 and 17604, led to the observation of time-delayed echoes. The absence of similar echoes in surface clutter simulations suggests the presence of a real subsurface reflector with a time delay of 11  $\mu$ s along one of the SF tracts of orbit 17597 [1]. Based on this evidence, we present and discuss possible geological interpretations consistent with the data and with the tectonic context of this Martian region. Our work sheds new light on the planetary scale processes that occurred during the Hesperian period (3.7-3.0 Ga) of Mars's geological history.

[1] Caprarelli et al. (2018) *COSPAR* **42**, B4.1-0015-18.

*Presented by: Graziella Caprarelli*

## **Mt Kent Observatory: A Queensland Facility for Astronomical and Space Sciences**

Bradley Carter  
*University of Southern Queensland*

USQ operates Mt Kent Observatory at a dark-sky site about 20 km southwest of Toowoomba in southern Queensland (28S, 153E). The facility is currently used to complement a range of USQ astronomical research projects, including exoplanet detection and characterization, stellar activity, magnetic field and wind studies, and dynamical studies of solar system bodies and exoplanetary systems. The site hosts a PlaneWave Instruments CDK20 telescope, a CDK700 telescope, and a wide-field Takahashi camera all provided by the Shared Skies Partnership with the University of Louisville, USA. Mt Kent also now hosts a growing MINERVA-Australis CDK700 telescope array supporting NASA's Transiting Exoplanet Survey Satellite (TESS) mission. Forthcoming developments include a SONG telescope array for asteroseismology studies, a DLR SMARTnet geostationary space debris survey telescope, and a support role for the forthcoming Twinkle Space Observatory's planned exoplanetary and other studies.

*Presented by: Bradley Carter*

## **On the characterisation of the day-to-day occurrence of Equatorial Plasma Bubbles using the Rayleigh-Taylor growth rate calculated using the TIEGCM**

Brett Carter<sup>1</sup>, J. L. Currie<sup>1</sup>, M. Terkildsen<sup>2</sup>, K. Groves<sup>3</sup> and R. Caton<sup>4</sup>

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<sup>2</sup>*Space Weather Services, Bureau of Meteorology, Australia*

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<sup>4</sup>*Space Vehicles Directorate, Air Force Research Laboratory, USA*

The prediction of Equatorial Plasma Bubbles (EPBs) on a daily basis is an ongoing scientific challenge, despite decades of observations and research. While the Generalised Rayleigh-Taylor (R-T) plasma instability is well understood to be the physical mechanism that is responsible for the generation of EPBs, the daily variability exhibited by the terms within the R-T growth rate – particularly the upward plasma drift – is not completely understood, and is thus prohibiting the development of reliable EPB forecasts, which are currently needed for users of Satellite Communications and GPS. Recent works have revealed that global coupled ionosphere-thermosphere modelling is capable of reproducing a high degree of observed daily variability in the upward plasma drift after sunset, and in the subsequent development/suppression of EPBs. More specifically, it was shown that EPB suppressions during peak EPB seasons were captured well by the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM) R-T growth rate. However, in order for these advancements to be transitioned into an operational EPB prediction capability, knowledge of the best R-T growth rate thresholds and the expected reliability of such predictions is required. In this contribution, the outputs of the TIEGCM are used to calculate the R-T growth rate for multiple GPS and VHF receiver station locations around the geomagnetic equator for an entire year. The stations used cover the South American sector, West Africa, Southeast Asia and the Western Pacific longitude sectors. The appropriate metrics for quantifying EPB prediction success are explored and the shortcomings identified are discussed.

*Presented by: Brett Carter*

## **RMIT University's Robotic Optical Observatory (ROO) Telescope for Space Situational Awareness Research**

S. Gehly<sup>1</sup>, B. A. Carter<sup>2</sup>, Y. Yang<sup>2</sup>, H. Cai<sup>2</sup>, S. Le May<sup>2</sup>, B. Adamos<sup>2</sup>,  
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Earth's orbit is populated with many thousands of artificial objects, including active and inactive satellites, rocket bodies, collision fragments and slag. The number of objects in orbit is set to significantly increase due to the advancement and uptake of cubesat technology, which has improved the affordability of access to space. Subsequently, the large number of objects in Earth orbit poses significant challenges in Space Situational Awareness (SSA) and Space Traffic Management (STM) given the limited number of sensors, and organisations that operate them, on the ground.

In an effort to join the international research efforts in SSA and STM, RMIT University has built the Robotic Optical Observatory (ROO) at its Bundoora campus, approximately 20 km north of Melbourne, Victoria, Australia in late 2017. ROO consists of a 16 inch aperture telescope on a robotic mount that is housed within a fully automated 3m dome. The optical setup includes a focal reducer that alters the focal ratio from f/7.3 to f/5.25, which effectively halves the required exposure times for the 16 megapixel CCD camera. The ROO telescope setup can be used for several research applications, but its primary use will be for SSA research, particularly in the areas of sensor tasking, tracklet correlation, orbit determination, orbit prediction and object characterisation. In this contribution, RMIT University's ROO telescope will be introduced and the results from a joint observation campaign with the Falcon telescope at University of New South Wales Canberra will be presented. In this campaign, simultaneous observations of active satellites, inactive satellites and a rocket body in geosynchronous and geosynchronous transfer orbits were collected at both sites and compared. Future plans for the full automation of ROO and the potential for spin-off projects that ROO facilitates will also be outlined.

*Presented by: Brett Carter*

# **Applying a Master-slave Filter to Vector Tracking GNSS Receiver for Robust**

Shuai Chen, Changhui Jiang and Yuming Bo

*Nanjing University of Science and Technology, China*

Vector Tracking Loop (VTL) is a recently developed method to enhance the performance of GPS receiver. VTL employs a center navigation filter to complete signal tracking and navigation computation together. In this way, all channel are processed by a single navigation filter to acquire performance improvement. However, the time-varying measurement noise will affect VTL reliability and positioning accuracy. In this paper, a master-slave adaptive filter is designed and its application to VTL is investigated. In this design, the master filter estimates the dynamic states, the slave filter estimates the measurement noise statistics using the master filter residuals. Master and slave filter exchange information and operate simultaneously. Simulation is implemented in VTL software running in Matlab. Simulation results show that the master-slave filter is able to enhance the robustness of VTL and improve positioning accuracy.

*Presented by: Shuai Chen*

## **Progress and Update of UNSW-ECO: Australia's First Cubesat Trio in Orbit**

Joon Wayn Cheong, Benjamin J Southwell, Eamonn Glennon, and  
Andrew G Dempster  
*Australian Centre for Space Engineering Research, UNSW Sydney*

Elias Aboutanios  
*School of Electrical Engineering and Telecommunications,  
UNSW Sydney*

UNSW-ECO was launched into orbit in May 2017 and has been operational since July 2017. We will present preliminary data from the mission and present unforeseeable issues that complicated mission operations, then step through the problem solving process. We will highlight lessons learnt and indicate how issues can be circumvented in follow-up missions.

*Presented by: Joon Wayn Cheong*

# **Physics and Diagnostics of the Solar Drivers of Space Weather**

Mark Cheung

*Lockheed Martin Solar and Astrophysics Laboratory, Stamford University*

Solar magnetism drives space weather in the near-Earth environment and the solar system. In this talk, we review the physical mechanisms responsible for heating of the solar corona, the solar wind and the generation of solar eruptive phenomena such as flares and coronal mass ejections. We show how remote sensing data from NASA's Solar Dynamics Observatory mission is used to model the state of the Sun, and how big data and machine learning is being used to improve our ability to understand and predict space weather. We discuss how studying the Sun impacts our understanding of other astrophysical objects and the search for habitable exoplanets.

*Presented by: Dr Mark Cheung*

## What can AI tell us about life in the universe?

Aditya Chopra  
*Australian National University*

Aaron Bell  
*University of Tokyo*

William Fawcett  
*University of Cambridge, CERN*

Rodd Talebi  
*Georgia Tech Research Institute*

Anamaria Berea  
*University of Central Florida*

Chris Kempes  
*Santa Fe Institute*

NASA FDL Team

Astrobiology is increasingly a part of the primary science goals of remote and in situ planetary exploration missions. However, a common concern with research in astrobiology are the limitations inherent to Earth-centric methods of understanding life in the universe and searching for biosignatures within the solar system and exoplanets. Artificial intelligence (AI) offers a powerful avenue to better understand life on Earth and beyond, particularly by efficient analyses of large datasets, and by assisting to fill the sparseness of existing datasets.

In 2018, a novel applied artificial intelligence research accelerator, NASA Frontier Development Lab (FDL), was established to prototype methods using the latest AI technologies to address current challenges in astrobiology. Supported by state-of-the-art computing resources from the Google Cloud, we explored two research questions to better understand “what is universally possible for life”.

To characterise the potential role of biological regulation of planetary atmospheres, we simulated a wide range of atmospheric compositions. This led us to infer the landscape of the multi-parameter space, such as the abundances of biological mediated gases and stellar types that would yield stable (non-runaway) planetary atmospheres. The derived estimates of the biological



mediated atmospheric gas fluxes could help constrain the type and the extent of exobiology on exoplanets based on the atmospheric compositions that will be revealed by upcoming telescopes such as JWST and GMT.

We also coupled a Metabolic Theory of Ecology that models the fluxes associated with communities of organisms in a wide range of environmental conditions to understand the minimal set of metabolisms that would be fundamental for extraterrestrial life and to extract universal principles of biological thermodynamics.

Our work demonstrates the potential of AI to discover new planetary and biological evolutionary pathways. The rapidly advancing landscape of machine learning methods and AI optimised hardware promises to revolutionise the exploration of life and its environment on Earth and other habitable worlds.

*Presented by: Aditya Chopra*

## **A survey of medical questions facing crewed Mars missions**

Jonathan Clarke  
*Mars Society Australia*

A considerable body of data has been generated about long duration spaceflight since 1971, gathered from over 4600 crew-days spread over 107 missions, 57 of them as long or longer than a Mars transit. Thirty seven space farers have accumulated for than a year's time in orbit, five more than two years, three of them with five long durations flights. We also have more than two centuries of expeditions to both polar regions, numerous Mars mission simulations of various fidelity levels, and data from people living in locations with radiation levels equivalent or higher than experienced by a crew on Mars. Despite this experience a commonly expressed opinion in both the medical and popular literature is that not enough is known regarding issues facing crewed Mars missions. This talk endeavours to separate the ongoing search for better understanding of space biomedical problems from what level of knowledge is sufficient for the first missions. A "human readiness level" concept is introduced, analogous to the "technology readiness level" used in engineering, to assess the questions. Audience participation in the discussion will be sought.

*Presented by: Jonathan Clarke*

## **CSIRO's Small Satellite Initiatives**

Dr Kimberley Clayfield, Dr Alex Held and Ms Laura Brindle

*CSIRO Astronomy and Space Science*

CSIRO is home to two of Australia's national space facilities, the Australia Telescope National Facility and the Canberra Deep Space Communication Complex. CSIRO also has world-leading capabilities in Earth observation data analytics, applications development and satellite data calibration and validation. In 2018 CSIRO Astronomy and Space Science (CASS) established the CSIRO Centre for Earth Observation, which oversees several new initiatives to develop capability in relation to small satellite technologies and operations. This presentation will give an overview of CSIRO's new small satellite activities, which include:

- a 10% stake in the NovaSAR satellite (access to which will be operated as a national facility)
- the acquisition of CSIRO's first CubeSat, which will focus on Earth observation applications, and will be launched within the next two years, and
- CSIRO's partnership on the DMTC High Altitude Sensor Systems Program, which is focused on the development of enhanced sensor components and on-board processing of sensor data for CubeSats and other Unmanned Aerial Systems with a payload capacity of up to 5kg.

*Presented by: Dr Kimberley Clayfield*

## **Integrated Patch Antennas and Solar Cells for Cubesats – Optimising solar cell efficiency and antennae gain**

Gavin Conibeer , Joon Wayn Cheong and Nicholas Ekins-Daukes

*UNSW Sydney*

Failure of mechanically deployed antennae on Cubesats is a common occurrence and is mission threatening. Use of omnidirectional patch antennae, at least for receiving signals, largely avoids this issue. But the surface area available for patches on Cubesats is very limited and must be shared with the solar arrays that provide the satellite's power. The integration of the patch antenna on top of the solar cell array is a potential solution. There are two designs for such integration. Either an Indium Tin oxide (ITO) patch antenna which is optically transparent but electrically conducting. Or a patch made from a metal mesh, which is also partially transparent and conducting. Transparency and conduction are a compromise that must be optimised to give both reasonable performance for the patch (high patch conductivity) and a reasonable power output for the solar array (high patch transparency). Modelling indicates surprisingly little attenuation of the solar cell output behind such a transparent patch. This will be discussed in the context of the fabrication requirements for multijunction space solar cells. The radiation patterns for the ITO and conventional patch antennae are also modelled. At present these show a depressingly large reduction in the antennae gain due to reduced conductivity. This will be discussed as will the potential to improve gain through further optimisation of patch transparency and conductivity. More advanced possibilities for full integration of the patch directly into the structure of the solar cell will also be discussed and its potential assessed.

*Presented by: Gavin Conibeer*

## **Nanosatellites in High Earth Orbit**

William Crowe, Hiranya Jayakody and Graziella Caprarelli  
*High Earth Orbit Robotics*

High Earth Orbit Robotics plans to provide satellite operators up-close imagery of their satellites, allowing them to understand anomalies on their asset and the surrounding environment. We do this by building and operating nanosatellites that are optimised for use beyond Low Earth Orbit. In this presentation, we will discuss future plans, some design details and our deployment strategy.

*Presented by: William Crowe*

# **Numerical Investigation of a Fixed-Geometry Scramjet Inlet across an Accelerating Trajectory for Access to Space**

Damian Curran, Vincent Wheatley, Michael Smart and Rowan Gollan

*Centre for Hypersonics, The University of Queensland*

At The University of Queensland, a three-stage launch system is being developed, with the first two stages being reusable; the second stage being powered by a scramjet engine. This will allow cheaper and more flexible access to space for small satellites [1]. One of the key challenges for a scramjet vehicle to operate across an accelerating trajectory is the design of the inlet; this must not unstart at any point, and provide sufficient conditions for combustion. This is difficult for a fixed geometry inlet. A shape transitioning inlet can meet these requirements.

This paper will numerically investigate such an inlet; the CREST (CRescent to Elliptical Shape Transition) inlet, as designed using the methodology in [2]. As the conical vehicle changes angle of attack and speed throughout the trajectory, the flow conditions will change at the end of the inlet, which must be understood to design a suitable combustion system. For illustrative purposes, Figure 1 presents a RANS (Reynolds-Average Navier-Stokes) simulation of the CREST inlet for a freestream condition of Mach 8 and an angle of attack of 4 degrees. This is half of the inlet, positioned on a conical forebody, which is not shown. The presentation will detail the performance between Mach 5 and 10.

## References

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- [2] Gollan, R. J. and Smart, M. K. Design of modular shape-transition inlets for a conical hypersonic vehicle Journal of Propulsion and Power, American Institute of Aeronautics and Astronautics, 2013, 29, 832-838

*Presented by: Damian Curran*

## **On the identification and removal of ground scatter in SuperDARN radar data**

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The Super Dual Auroral Radar Network (SuperDARN) is comprised of over 30 High Frequency (HF, 3-30MHz) Over The Horizon (OTH) radars designed for studying ionospheric dynamics. The HF radiowaves transmitted by the radar may be reflected from field aligned irregularities in the ionosphere or from the ground. It is common practice for ground scatter to be removed prior to analysing SuperDARN data to ensure the backscatter is correctly mapped onto the ionosphere. Typically, a simple threshold algorithm is applied to the Doppler velocity and spectral width data to identify ground scatter. However, this also removes ionospheric scatter with similar characteristics, thereby affecting results in statistical studies.

In this work, the limitations of current ground scatter detection methods are discussed. Spectral width data from different fitting processes are compared in order to investigate whether spectral width selection has an effect on ground scatter identification. Finally, geomagnetic storm time data are compared to quiet time data to determine if the thresholds should change with respect to geomagnetic activity.

*Presented by: Dr Julie Currie*

## **The Effect of Sporadic E on Prediction of Equatorial Plasma Bubbles**

J. L. Currie<sup>1</sup>, B. A. Carter<sup>1</sup>, R. Pradipta<sup>2</sup>, R. Caton<sup>3</sup>, K. Groves<sup>4</sup> and M. Terkildsen<sup>5</sup>

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Equatorial Plasma Bubbles (EPB) are large ionospheric disturbances that commonly occur in the post sunset equatorial ionosphere. These EPBs can cause amplitude and phase scintillation of radio waves, such as those used by Global Navigation Satellite System (GNSS) satellites. The generation of EPBs is controlled primarily by the uplift at the ionosphere after sunset, which occurs due to an ExB drift. The climatology of EPBs can be well parameterised by the angle between the magnetic field and solar terminator, which controls the strength of zonal electric fields and thus the upward plasma drift. The field of EPB research has moved towards gaining an understanding the day-to-day variability in EPB occurrence.

The presence of sporadic E in the post sunset region affects the generation of EPB with large Pedersen conductivities reducing the linear growth rate of the instability. However, during July 2014, unseasonable EPBs over the South-East Asian sector occurred on evenings with strong sporadic E. This work further investigates the effect of sporadic E using TIEGCM outputs to calculate the effect on the linear growth rate of the Rayleigh-Taylor instability in the post sunset sector. The E region density was artificially increased during the linear growth rate calculation, isolating the effects on the terms in the linear growth rate. This work also considers the implication of strong E regions on detecting EPBs and how this has affected our ability to understand day-to-day variability. A complete understanding of Sporadic E influences on EPB generation is important for the development of EPB prediction services.

*Presented by: Dr Julie Currie*



## **Commercialisation of space: innovation versus domestic legislation?**

Melissa de Zwart  
*Adelaide Law School, University of Adelaide*

The 2018 OECD Report, Space and Innovation notes the specific and inherent tensions that lie at the heart of innovation in the space sector:

Since the beginning of the space age, space systems have been paradoxical technological beasts: they lead to the emergence of revolutionary technologies during their exploratory and development phases, but once they are operational, the focus often turns to reliability, durability and cost, stifling further innovations by risk averseness. (OECD (2018) Space and Innovation, OECD Publishing, Paris, <http://dx.doi.org/10.1787/9789264264014-en>, 15)

That Report makes a number of recommendations for domestic policy makers regarding policy and legislative responses which may stimulate space innovation. These include:

- Reviewing national policy instruments that support space innovation: including a review of domestic space and intellectual property laws;
- Participation in downstream space activities: including identification and support of specialist or niche capabilities; and
- Capturing spin-offs and technology transfers: recognising the value of new commercial products and services which have evolved from space-related research, such as, medical, communication and mining technologies, and protecting that investment.

The specific issues with risk and reliability in the space sector and the lack of opportunities for diversification, create a particular need for continued government intervention or continued support in this sector. However, new entrants to the space technology industry are creating challenges to the existing paradigm. This paper will consider how domestic laws may be used to encourage and support innovation and commercialisation of technology.

*Presented by: Melissa de Zwart*

**ANZSLIG Professional Development series - Liability and  
insurance for space activities in Australia**

Joel Dennerley  
*ASG Group*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Joel Dennerley*

**ANZSLIG Professional Development series - Protection of  
intellectual property for space activities**

Melissa deZwart  
*The University of Adelaide*

Annabel Griffin  
*King & Wood Mallesons*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Melissa deZwart and Annabel Griffin*

## **Modelling Magnetic-Polarities of Active Regions Using Helioseismic Data: impact into space weather prediction research**

Alina Donea  
*Monash University, Victoria, Australia*

Charlie Lindsey  
*NorthWest Research Associates, Boulder, Colorado*

A very useful algorithm in local helioseismology, named "computational helioseismic holography" (CHH) has a broad range of diagnostic applications mainly for magnetic regions on the nearside surface of the Sun as well as on the Sun's far hemisphere. The Stanford University's Joint Operations Science Center now uses this algorithm to compute routine synoptic maps of the Sun's far hemisphere, posting them on <http://jsoc.stanford.edu/data/farside>. The early detection of seismic maps of large active regions in the Sun's far hemisphere is extremely useful to trigger a warning sign early enough, to prepare the Earth's satellite army for a possible solar storm impact. As such, our seismic monitor of the Sun's far hemisphere, then, fulfils the role of a much needed supplement to direct observations of the Sun's near hemisphere for space-weather forecasting on times scales ranging from about a day up to about three weeks.

There are some major adaptations of far-side seismic monitoring for space-weather that have yet to be developed. In this work we report progress on one of these new developments: the need for identifying signed magnetic flux distributions in the Sun's far hemisphere. This work is essential for computing projections of the global coronal magnetic field, and for the assessment of flare potentialities when the magnetic flux recognised rotates into the Sun's near hemisphere.

I will discuss the starting problem for such a complex task: the helioseismic maps, while they are clearly sensitive to magnetic flux, are insensitive to the sign of the polarity. However, the Hale Polarity Law and the use of theoretical and empirical our understanding of CHH do help us to formulate an algorithm that realistically derives the needed polarities!

*Presented by: Alina Donea*

# **From the Weapons Research Establishment to the Australian Space Office: Precursors to the Australian Space Agency**

Kerrie Dougherty  
*University of NSW*

Australia's first space agency came into formal existence on July 1, 2018. However, at the beginning of the Space Age, the Weapons Research Establishment, which managed the Woomera Rocket range, acted as a de facto national space agency, while the Australian Academy of Science put forward the first submission to government for the establishment of an Australian space program in 1959. These were the first of several attempts over the ensuing decades to establish a national civil space program and a formal space agency.

This paper will present the various proposals put forward in the latter half of the Twentieth century for the establishment of an Australian space program and a space agency to manage the country's civil space activities. It will also examine the complex reasons underlying the failure of these attempts, despite Australia's ongoing participation in space activities.

*Presented by: Kerrie Dougherty*

# **The Role of Museums and Science Centres in Informal STEM Education**

Kerrie Dougherty  
*University of NSW*

to be supplied

*Presented by: Kerrie Dougherty*

## Power Budget Analysis and Verification

Hao Duong  
*DST Group*

The Buccaneer Risk Mitigation Mission (BRMM) is a 3U cubesat developed by Defence Science and Technology Group in collaboration with UNSW Canberra. The spacecraft relies on electrical power generated through solar panels and stored in lithium ion batteries. Similar to many spacecraft missions, careful planning goes into the power budget and the availability of electrical power during operations before the satellite is even launched. DST Group and the UNSW Canberra had developed a CONOPS that would put Buccaneer in its most optimal state energy wise and had conducted thorough analysis to show that the electrical power system would be sufficient in maintaining power to all relevant subsystems even in the worst case scenarios. These calculations and margins were produced using theoretical data combined with laboratory experimentation to construct software models.

With the data collected from Buccaneer since its launch in November 2017, it is now possible to validate these models. Data will allow the optimisation of the margins to ensure that the spacecraft is working as efficiently as possible, reducing degradation and maximising the longevity of the BRMM cubesat. This will provide useful insight to guide planning for future missions.

*Presented by: Hao Duong*

## **Rapid Prototyping in Instrumented Hypervelocity Testing**

Robert Eldridge, Chris James, Steven Apirana and Richard Morgan

*University of Queensland*

Additive manufacturing, or more colloquially 3D printing, is a recent technology that has been applied to many disciplines to increase both design freedom and speed. These are both necessary characteristics for designing hypervelocity vehicles, however, it has yet to see widespread use in ground-based testing.

This study sought to analyse the use of resin-based 3D printed models under a variety of high enthalpy flows - simulating both ESA's IXV and Japan's Hayabusa return conditions. Such models were not only suited to being internally instrumented, but also ablated under high shock speeds allowing for heat transfer losses of cold wall ablation to be directly measured.

Both axisymmetric and asymmetric designs were tested, the latter of which is extremely difficult to produce through traditional manufacturing techniques. These 3D printed models were then used to compare flow characteristics across actual geometry spacecraft with their 2D analogues (the use of which has been standard for many years due to difficulty machining full models). These designs, due to the unique nature of 3D printing, were able to be produced cheaply and rapidly with a high dimensional accuracy. Additionally, duplicates of these designs were easily produced, allowing for each test to be conducted with an undamaged model. This was imperative for conditions that induced high ablation, where the shape of the model changed after every test.

Overall, this method of producing models was found to be desirable and was easily adaptable for different design and test conditions. The cold wall ablation affected heat transfer measurably at high thermal loadings, and therefore demonstrated that using 3D printed models is a way of experimentally determining these impacts. Additionally, the models did not ablate noticeably at flow speeds under 4 km/s, suggesting they are suited for lower velocity CFD validation and test conditions.

*Presented by: Robert Eldridge*



## **The solar wind in time from young stellar proxies**

Dag Evensberget, Bradley Carter, Stephen Marsden and Leigh Brookshaw

*University of Southern Queensland*

The stellar winds produced by young, Sun-like stars are believed to be orders of magnitude more powerful than those of the present-day Sun. These strong winds affect the stars themselves through angular momentum loss, and they potentially reduce the habitability of orbiting planets by eroding their atmospheres.

The University of Southern Queensland Starwinds project aims to extend understanding of the Solar wind in time by presenting a collection of stellar wind maps for young, Sun-like stars, based on published surface magnetic measurements from the TOUPIES study. The wind maps lets us calculate stellar parameters such as mass loss, angular momentum loss, and high-energy radiation. We characterise the wind ram pressure, a key parameter determining atmospheric erosion, at a range of distances including 1 AU.

The Starwinds project intends to produce the largest atlas of three-dimensional wind maps of young, Sun-like stars to date. We expect that the results should improve understanding of the young Sun's behaviour and have relevance to models of planetary evolution in our Solar system and beyond.

*Presented by: Dag Evensberget*

# **Determination of GNSS positioning integrity and timeless requirements for connected and automated vehicle safety applications**

Yanming Feng, Andy Bond and Charles Wang  
*Queensland University of Technology*

Connected and automated vehicle safety applications depend on communication and position and velocity information to function. However, road users may have different vehicle communicating and positioning capabilities with Global Navigation Satellite System (GNSS). Further, the performance of communicating and GNSS positioning could vary from time to time and location to location. It is important for the vehicle safety system to be fully aware of the performance of vehicle positioning outputs and warn the drivers when the positioning system cannot be used for intended level of safety applications. However, unlike aviation and Maritime navigation, minimum operational performance standards about positioning have not been established in the road community. In this presentation, we review and develop the required navigation performance parameters for vehicle positioning capability in terms of accuracy, integrity, and timeliness of positioning solutions. We attempt to adjust the integrity performance parameters for vehicle safety positioning and provide the analysis for integrity risk, protection level and different alert limits. We also discuss the requirement for velocity and acceleration states and covariance information. The results from a vehicle experiment demonstrate how well different levels of vehicle positioning capabilities meet the different integrity alarm limits, and how the data rate affect the positioning and acceleration accuracy. The results emphasize that the positioning system can inform the protection level achievable at any time instant and serve the safety application at that level accordingly.

*Presented by: Yanming Feng*

## **GNSS-driven Accurate Time Synchronization for VANET**

Khondokar Fida Hasan, Yanming Feng, Yu-Chu Tian

*Queensland University of Technology*

Time synchronization is a recognized tool to attain accurate time throughout the networks. VANET is a unique distributed network with high mobility, short range, and outdoor based communication nature. Physical time plays important roles in performing data fusion on board for various real time applications in VANET. VANET is principally an open air based network where GNSS signal is feasible to receive. GNSS based navigation system is already popularly integrated with modern vehicles to enable road guiding and positioning support. Therefore, GNSS based time synchronization has the potential to enable accurate and precise timing services on VANET. In this paper, we analyze and argue the feasibility and benefits of GNSS based time synchronization in VANET and implement an application layer GNSS time integration. In our experiments, we bind our mobile nodes with UTC time at a maximum deviation of  $2.16\mu\text{s}$ , implying that the achievable accuracy of synchronization under  $4.5\mu\text{s}$ . Our result prospects that GNSS enabled time synchronization in VANET can achieve higher accuracy with high precision over existing synchronization techniques in the family of Mobile Ad Hoc Networks.

*Presented by: Yanming Feng*

## **Mission Design and Simulation of a Rocket-Scramjet-Rocket Launch System**

Sholto Forbes-Spyratos, Michael Smart, Michael Kearney,  
Alexander Ward and Ingo Jahn

*The University of Queensland*

A partially-reusable rocket-scramjet-rocket launch system is under development by The University of Queensland and Hypersonix. This launch system will provide unique capability in the dedicated, flexible and reliable launch of small satellites at reduced cost. The scramjet-powered stage, designated the SPARTAN, is designed to fly back to the initial launch site for re-use.

This work simulates the trajectory of this launch system, in order for its capabilities to be assessed. Aerothermodynamic simulations consisting of an inviscid computational fluid dynamics solver and boundary layer calculations were used to compile a comprehensive, medium fidelity aerodynamic database. The launch system is simulated in six degrees of freedom, and optimised for maximum payload-to-orbit using the pseudospectral method of optimal control.

The launch system is simulated as being launched into an 566km sun synchronous orbit, from the launch site in East Arnhem Land being developed by Equatorial Launch Australia. It is found that the launch system is able to place a satellite of 160kg into orbit, while successfully returning the SPARTAN to the initial launch site. The aerodynamic controllability of the SPARTAN is found to allow for banking and 'skipping' manoeuvres to be utilised to maximise the efficiency of the launch system.

*Presented by: Sholto Forbes-Spyratos*

## **Songlines and Dreaming Tracks in the Night Sky**

Robert Fuller  
*University of NSW*

New research and sharing by knowledge-holders is starting to reveal to non-Aboriginal people the complexity and stunning originality of Australian Aboriginal songlines and Dreaming tracks. For many years, Aboriginal people have been asserting that Australia is criss-crossed with these pathways, which are used for navigation, for keeping cultural stories, and for trading. The connection between these pathways and the night sky has only recently begun to be understood by non-Aboriginal people, as knowledge-holders have begun to share the non-sacred aspects of their culture. This presentation will draw on knowledge from across Australia, and in particular, from research with the Euahlayi people of Northwestern New South Wales, and over 20 Aboriginal Saltwater communities along the NSW coast. Examples include the use of the night sky to teach routes of travel along songlines (star maps), Dreaming tracks that encode a story that connects to the night sky, and songlines and Dreaming tracks that traverse great swathes of the Australian continent. I'll also demonstrate that songlines and Dreaming tracks are important in our daily lives, as they are increasingly becoming understood as the basis for much of Australia's road network.

*Presented by: Robert Fuller*

**ANZSLIG Professional Development series - Space  
applications: hybrid aerospace vehicles**

Karina Galliford  
*International Aerospace Law & Policy Group*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Karina Galliford*

## **Space, Spatial, Machine Learning for Business Benefit**

Kenneth Gillan  
*Peter Kinne*

The Fourth Industrial Revolution represents the integration of cyber-physical systems, the Internet of things, cloud computing and cognitive computing into our personal and professional lives. We are blurring the line between physical and digital environments. Location Intelligence has emerged as a critical enabler in managing the challenges of data Velocity, Veracity, Volume and Variety of Industry 4.0.

For data creators like DigitalGlobe, these developments demand a transition in focus and business strategy to manage the increasingly competitive market around empowering innovation within the location intelligence community while still maintaining our traditional client base.

Innovation empowerment is about providing access to multiple sources of data and the tools to derive information from them. How do analysts manage hundreds of petabytes of data and leverage artificial intelligence to derive knowledge? How do we translate results at massive scale into effective decision making?

Emerging companies are already creating solutions that require petabytes of Geospatial Big Data to implement. Together, we are part of a unique ecosystem working to create solutions in automotive, insurance, and telecommunications industries, to better understand how we mitigate disasters and improve lives, and to leverage artificial intelligence to its full potential in extracting knowledge from spatio-temporal data sources.

*Presented by: Kenneth Gillan*

## **A New Space paradigm for Australia**

Adam Gilmour  
*Gilmour Space Technologies*

New Space, or Space 2.0, is more than just building smaller/cheaper satellites and enabling it with lower cost launches. We will show how New Space technologies and applications (including launch) could be orders of magnitude cheaper, allowing governments to radically reassess their current/future spending and investments into space projects in Australia.

*Presented by: Adam Gilmour*



## **UAV Reflectometry for Sea State Estimation**

Eamonn Glennon, Benjamin Southwell and Andrew Dempster

*Australian Centre for Space Engineering Research, UNSW Sydney*

Satellite navigation (e.g. GPS) signals reflected from the Earth's surface can be used as a passive radar system to estimate sea state (wave height, wind speed, wind direction), classify land types, detect changes in ground cover and possibly other surveillance tasks such as detecting objects on the open ocean, floods on land and to track environmental incidents such as oil spills. UAV reflectometry technology being developed by Seaskip/UNSW represents a considerable improvement over existing sea condition measurement solutions currently available in terms of both spatial and temporal resolution.

This project aims to develop a working prototype GNSS reflectometry sensor payload for deployment on UAVs.

This project is part of the DMTC's High Altitude Sensor Systems (HASS) Program, which will enhance Australian defence capability and build industrial capacity in sensor and on-board data processing technology for unmanned aerial systems and small-satellite platforms. See the DMTC website for more information: <https://www.dmtc.com.au/our-activities/sensor-systems/>

*Presented by: Eamonn Glennon*

## **Integrated optical phased arrays for spacecraft communications and sensing**

David R. Gozzard<sup>1</sup>, James T. Spollard<sup>1</sup>, Paul Sibley<sup>1</sup>, Lyle E. Roberts<sup>1</sup>, Mirko Lobino<sup>2</sup>, David E. McClland<sup>1</sup> and Daniel A. Shaddock<sup>1</sup>

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Optical phased arrays (OPA) provide a way to manipulate the distribution of optical power in the far-field without the use of mechanical beam-steering technology. They work by stabilising the phase of individual, spatially separate emitters which are interfered in the far-field to form a coherent and contiguous optical wavefront. By controlling the phase of each emitter in the array, it is possible to ‘steer’ the coherently combined beam in the far-field. The solid-state nature of OPAs reduces risks associated with mechanical degradation and failure in space-based applications.

These qualities make optical phased arrays a potentially valuable technology in applications including near-earth and deep-space laser communications, satellite interferometry, adaptive optics, target acquisition and tracking, and light detection and ranging. Here, we present the ongoing development of an integrated ‘on-chip’ optical phased array using silicon waveguide technology. This monolithic on-chip architecture improves scalability and robustness to shock, vibration and other environmental effects compared to optical fibre-waveguide optical phased arrays.

A demonstrator OPA constructed from discrete components was used to demonstrate MHz bandwidth steering and sub-milliradian pointing precision. The integrated OPA comprises electro-optic modulators (EOMs) embedded in a silicon waveguide. This technology is readily scalable, able to achieve ~100 channels, and at a much lower cost-at-scale than the equivalent number of discrete EOMs. The design uses a wavelength of 1550 nm which allows us to capitalise on the advanced state and availability of telecommunications-grade components.

Phase sensing and feedback control is performed on a field-programmable gate array using a technique called digitally

enhanced heterodyne interferometry which effectively transfers complexity from the optical setup into digital signal processing.

The ultimate goal of this research is to demonstrate agile beam-steering from a solid-state millimetre scale optical phased array.

*Presented by: David Gozzard*

## Exploring Cultural Competence for Astronomers

Carla Guedes  
*University of NSW*

This presentation focuses on the intersecting domains of cultural competence, astronomy, Indigenous knowledge, and the implications thereof for ethnographic theory and practice. This research has the potential to provide a better theoretical and practical understanding of astronomy, Indigenous cultural competence, and scientific approach to the Indigenous communities and their land. The aim of this study is to present a systematic approach to gaining cultural competence for astronomers who wish to work with Indigenous people or develop research facilities on Indigenous lands. This Master by Research thesis will propose a new cultural competence model – MICCA (Model of Indigenous Cultural Competence for Astronomers). I will argue that this new model can help astronomers before, during and after either ethnographic research, the implementation of telescopes facilities projects, and designing protocols between astronomers and indigenous for various projects. Is it possible to significantly increase the Astronomer's Cultural Competency, protecting Indigenous peoples culture and interests while improving the astronomers' scientific research? To answer this research question I will present two case-studies: a) The possible lack of Cultural Competency observed in the case of Hawai'i's sacred mountain and the contentious Thirty Meter Telescope (TMT). The dormant volcano is Hawai'i's most sacred place, where in ancient traditions only the Ali'i (high chiefs) were allowed to climb to its summit where their most sacred ancestors are buried. And this is where astronomers are trying to build research facilities; b) The Square Kilometer Array (SKA) project, in South Africa and Australia, where astronomers gained a deeper understanding of a different perspective of the sky from working closely with the Indigenous, opening up new areas of opportunity, education and vocation for these communities. This is why this project seems to be culturally competent. That resulted in a peaceful project in terms of Indigenous feedback and acceptance. Normally, Cultural Competency is applied to different areas such as Education, Indigenous Health, Indigenous Rights, Psychology and Environment, but my main objective in this research is to apply the Cultural Competency concept to Astronomy, proving that it could be one of the strongest tools to improve the ethnographic work of Astronomers whom easily can fall into a negative process

of cultural appropriation in the name of science in general, and Astronomy in particular.

*Presented by: Carla Guedes*

## **Assessing the Viability of a Smartphone-Based Wide Field of View Stellar Gyroscope**

Julian Guinane, Iver Cairns, Xiaofeng Wu, Joshua Critchley-Marrows, Benjamin Jarvis and Matthew Suntup

*University of Sydney*

In this study, a stellar gyroscope system is proposed, designed, and its accuracy evaluated, using a smartphone. The stellar gyroscope operates by imaging at prolonged exposure times and measuring the position and size of smeared stars to determine a spin axis and slew rate. Past work on optical gyroscope systems has focused on measuring relative positions of known stars, which lacks robustness at high slew rates and in lost-in-space scenarios. An interesting and valuable feature of the smartphone camera is a wide field of view, which is also investigated. Utilising the smartphone's on-board MEMS gyroscopes, accessible and reasonable validation of the proposed stellar gyroscope may be completed. Images and real gyroscopic data were captured for comparison, and the effects of user-defined parameters on the accuracy and robustness of gyroscopic predictions were examined. Findings of the study showed a median spin axis determination error of 10 degrees and a median slew rate error of 3 percent. Significant improvements to the test apparatus and algorithms used to predict gyroscope measurements may increase the overall accuracy of the system.

*Presented by: Julian Guinane*

## **A Novel Integrable System for Martian Approach, Mapping and Energy Extraction**

Devyani Devidas Gujar.

*Graduate student, department of aerospace engineering, SRMIST  
Institute of science and technology*

Vikram Ramanan

*Project officer, national centre for combustion development and  
research, IIT Madras, chennai, India.*

The present work is addressed towards conceptualization and design of an integrated system, that can serve the twin purpose of orbit attitude transfer and extraction of Carbon-dioxide rich Martian soil for energy generation. The generated energy can be exploited for surface exploration and return to Earth. The core of the integrated system is the indigenous fuel-cell-capacitor assembly (FC), whereby an alkaline fuel cell is the power source for a Radio-frequency oscillator coupled with Tesla coil (RFTC). The novel RFTC coil will enable higher mass fraction of Xenon plasma owing to both electromagnetic oscillation and high voltage. The hot plasma is effectively accelerated by electrode-less cyclotron and a geometric nozzle to utilize the high thermal energy. The electrons generated by plasma will be isolated to charge the capacitor in the FC assembly. The higher energy density and efficiency of alkaline fuel cell combined with RFTC is expected to significantly reduce the attitude transfer time and will be used to power laser spectrometer to measure fluorescence of CO<sub>2</sub> to map the concentration contour of CO<sub>2</sub> across the surface and subsequently exploit regions of high CO<sub>2</sub> for energy. This is also achieved by the FC assembly, whereby the voltage stored across the capacitor is used to electrolyze CO<sub>2</sub> whereby the products will be combusted to produce large amounts of energy as well as to initiate the Sabatier cycle, whereby Methane can be generated by reacting the CO<sub>2</sub> with H<sub>2</sub>. The twin source of energy- 1. Oxidation of products of electrolysis and 2. generation of more potential fuel ( CH<sub>4</sub>) will significantly augment any known sources of energy generation used in contemporary Mars exploration. The proposed FC-RFTC assembly is thus seen to perform operations that are faster, more durable and energy intensive than current systems, in an integrated manner.

*Presented by: Devyani Devidas Gujar.*

## **The 'Training Centre for CubeSats, UAVs and Their Applications', and it's first satellite, CUAVA-1**

James Harpur and Iver Cairns

*University of Sydney*

Initiated late of 2017, born out of support from the Australian Research Council and a collaboration between the University of Sydney, UNSW, commercial partners and government, the 'Training Centre for CubeSats, UAVs and Their Applications' Centre will (a) train the next generation of workers in cutting edge advanced manufacturing, entrepreneurship, and commercial space and UAV applications, (b) develop new instruments, technology and products to solve crucial problems, and (c) develop a world-class Australian industry in CubeSats, UAVs, and related products.

The Centre aims to launch one CubeSat and one UAV project per year for the next five years. The first satellite of the centre will be CUAVA-1; a 3U CubeSat developed by the centre to be launched late 2018/early 2019. The satellite will house a number of payloads, including an innovative communications payload from commercial partner Air@Wave aiming to demonstrate world record gigabit/sec data rates, as well as a nanophotonic spectrograph and a novel GPS payload. The satellite will be a big step forward for the centre and Australia's CubeSat capability furthering development of scientific payloads in space, training Australia's next generation of space engineers and increasing interest nationally in space.

*Presented by: James Harpur*



## **Impact of the equatorial mass anomaly and midnight density maximum on the low Earth orbit dynamics**

Changyong He [1,2], Brett Carter [2], Yang Yang [1,2], Haibing Ruan [3], Florent Deleie [4], Jiuhou Lei [3], Wang Li [2], Kefei Zhang [2,5], Robert Norman [2]

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In low Earth orbit (LEO, 200-1000 km), satellites experience a significant atmospheric friction force, also named atmospheric drag, which is the largest error source in orbit prediction. The equatorial mass anomaly (EMA) and midnight density maximum (MDM) are two important but not completely understood variations in the thermospheric mass density in the altitude range of 200-500 km. Only few empirical thermospheric models after 2010 can capture the EMA and MDM and, more importantly, their impact on the LEO dynamics has not been fully explored.

The EMA is an anomalous geomagnetic latitudinal variation at 10-20 local time (LT) with two crests in the geomagnetic latitudes of ~30 degree and a trough near the geomagnetic equator. The mass density around crests is 6% higher than that near the trough. Due to the magnetosphere-ionosphere-thermosphere coupling, electron density in the ionosphere also shows a similar equatorial structure except that the positions of two crests are located around the geomagnetic latitudes of 15 degree. These equatorial features in mass density, electron density and neutral temperature are collectively termed as the equatorial thermosphere anomaly. Lei et al. (2012) found the trough and crests in the EMA during solar maximum are mainly caused by the field-aligned ion drag and

collision heating between neutral and charged particles, respectively.

The MDM is an enhancement of mass density within 20 degree of equator during 0-2 LT, which generally accompanies a midnight neutral temperature maximum. Arduini et al. (1997) noted a significant dependence of MDM on solar cycle and season. Ruan et al. (2014) reproduced the MDM structure by adding the upward migrating terdiurnal tide into the National Center for Atmospheric Research Thermosphere Ionosphere Electrodynamics General Circulation Model (NCAR-TIEGCM). His study revealed an equatorial mass density enhancement in the MDM that peaked 2 LT with a magnitude of 10-30% higher than the surrounding atmosphere.

This study investigates the impact of the EMA and the MDM on orbit prediction simulations of LEO satellites. The NCAR-TIEGCM is used to reproduce the EMA and MDM during solar maximum and minimum and around two equinoxes and solstices. Their impact is quantified by the difference between the predicted orbits with and without the EMA and MDM. Some recommendations for the thermospheric mass density modelling are also formulated.

*Presented by: Changyong he*

## Exploring a legal framework for the colonisation of Mars

Stacey Henderson  
*The University of Adelaide*

As SpaceX pushes ahead with its plan to build a thriving city and eventually a self-sustaining civilisation on Mars, there are many legal issues that need to be considered before colonisation of Mars occurs. This paper explores some of the legal consequences, including ownership and intellectual property protection for inventions created on Mars, which flow from the current space law treaties which regard outer space as terra communis rather than terra nullius. The current international space law treaties never contemplated human habitation beyond Earth and are notably silent on what happens when humans dwell among the stars.

*Presented by: Stacey Henderson*

## **Tiny Spaces for the Infinite Space: Flow Chemistry Mini-Labs as Assets of Space Manufacturing?**

Volker Hessel & Nam Nghiep Tran  
*School of Chemical Engineering, The University of Adelaide,  
Australia, SA 5005*

Space Manufacturing is by no means anymore a vision of a Jules Verne novel or a Kubrick science-fiction movie. It is silently, yet consistently underway and much further developed than public perception is aware. Recently, some experiments have been conducted at the International Space Station (ISS) opening up an opportunity for space chemistry and space manufacturing. This study is to give a perspective contribution on the motivation and technological capability of the use of flow chemistry for space manufacturing. These fields have not yet been brought together in an experimental proof-of-concept, so a think-tank is provided for showing up opportunities.

Giving feasibility and cost-effectiveness, what may drive chemical and pharmaceutical synthesis and manufacture in the outer space?

- (a) Understanding fundamental questions of outstanding importance such as the origin of chirality which is relevant in the context of the origin of life
- (b) Performing experiments and chemistries not possible on earth
- (d) Preparing ultra-pure pharmaceuticals, crystals, and alloys
- (e) Flow bio-nanonization for increased bioavailability of drugs
- (f) Anti-satellite weapon countermeasure by flow-made nanodots as radiation profile decoy
- (g) Space mining of rare-earth and expensive transition metals from dwarf planets, asteroids, and other near-earth objects: flow extraction following hydraulic fracturing or hydrofracking?
- (h) Onboard fuel production for the energy supply of space stations or future colonies/stations on planets and moon
- (i) Production of at-site fertilizers and space farming using the resources of our planet neighbors and the moon

Obviously, such an ambitious endeavor in the harsh space environment (i.e. vacuum, coldness, intense irradiation, and a low degree of logistics) is only possible with the most advanced process chemistry. A very compact format is required and the processing needs to be automated, seeing the high transport costs and remote location. Indeed, flow chemistry has been considered as an enabler for space explorations.

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## **Changes in trunk muscle size in response to microgravity: possible implications for low back pain research**

Julie Hides  
*Griffith University*

Gunda Lambrecht  
*Wyle GmbH*

Volker Damann  
*European Space Agency Space medicine Office*

**Background:** In microgravity, muscle atrophy is known to occur in the intrinsic muscles of the spine. Astronauts perform exercises on the International Space Station and following their return to Earth to remediate these effects. Similar changes in trunk muscles have been observed in people on Earth in prolonged bed rest studies and in those with low back pain (LBP). The aim of this case report was to examine the effects of microgravity, exercise in microgravity and post-flight rehabilitation on the size of the multifidus and anterolateral abdominal wall muscles.

**Methods:** Ultrasound imaging was used to assess the size of the multifidus, transversus abdominis and internal oblique muscles at four time points: pre-flight and after daily rehabilitation on day one (R +1), day 8 (R + 8) and day 14 (R +14) after return to Earth (following 6 months in microgravity).

**Results:** Exercises in microgravity maintained multifidus size at the L2–L4 vertebral levels, however, after spaceflight, the size of the multifidus muscle at the L5 level was reduced. The size of the internal oblique muscle was increased and the size of transversus abdominis was reduced. Rehabilitation post-space flight resulted in hypertrophy of the multifidus muscle to pre-flight size at the L5 vertebral level and restoration of anterolateral abdominal muscle size.

**Conclusions:** Exercise in space can prevent loss of spinal intrinsic muscle size. The effectiveness of the exercises varied at different levels of the spine for the multifidus muscles. Post-mission rehabilitation targeting specific motor control restored muscle balance between the anterolateral abdominal and multifidus muscles, similar to results from intervention trials for people with LBP.

*Presented by: Julie Hides*

## **Recent Developments and Future Trends in Satellite Positioning – Increasing Ubiquity and Increasing Risk**

Matt Higgins  
*President IGNSS Society*

Satellite Positioning continues to develop at an increasing pace. The deployment of the EU's Galileo and China's BeiDou systems are accelerating with both expected to join the USA's GPS and Russia's GLONASS as fully operation global systems in the next 2 or 3 years. Regional Systems from India and Japan are also adding important additional capabilities for users in the Asia-Pacific. A current hot topic centres on plans for several system providers to deliver so-called Precise Positioning Services directly from their satellites.

At the other end of the supply chain, recently released mass market chipsets are capable of multi-system, dual-frequency measurements enabling accuracies of 30 centimetre for key mass market applications such as automated vehicles. In recent months we have even seen the release of a smartphone with those capabilities.

Closer to home, the 2018-19 Australian Federal Budget has allocated \$225 million over the next 4 years to Geoscience Australia (GA) for a major boost to our National Positioning Infrastructure (NPI). This will see an improved national network of Continuously Operating Reference Stations, enhanced capability for GA's GNSS data analysis and development of a Space-Based Augmentation System to deliver enhanced positioning capability to all Australian users.

This presentation will outline all of these developments and then move on to examine some of the implications. The environmental, economic and societal benefits from all of these enhancements will be outlined. However, it is not all good news so the presentation will also explore the growing levels of international concern about risks from intentional and unintentional interference and signal spoofing. The presentation will close with some thoughts on possible research activities that all of this will either enable or require.

*Presented by: Matt Higgins*

## **Eyes on the Ground: Trialling Remote Sensors for Small Planetary Rovers.**

Steven Hobbs  
*UNSW Canberra, Mars Society Australia*

David Paull  
*UNSW Canberra*

Jon Clarke  
*Mars Society Australia*

Trent McDougall  
*Mars Society Australia*

John Haythorpe  
*Mars Society Australia*

Jean-Luc Stevens  
*Mars Society Australia*

Mars Society Australia continues to research and develop micro and nano-rover class vehicles for planetary science applications. Such a small vehicle uses open source electronics and sensors to make the project more affordable. In this work open source sensors were trialed to determine their utility in sampling environments analogous to Mars. One such experiment investigated the utility of conducting thermal inertia measurements at surface level. Although conducted from Martian orbit, no lander mission has ever undertaken thermal inertia measurements on the Martian surface. In this work, thermal inertia experimentation using non-contact thermometer measurements of basalt was trialed over a 24 hour period. Additionally, reflectance experiments using a low-cost spectrometer was conducted and results compared with a laboratory-grade instrument. The data returned from these experiments will assist in optimizing the science package of small roving vehicles.

*Presented by: Steven Hobbs*



## **Mobility Trials and Testing of Micro and Nano-Scale Rovers for Planetary Science Applications.**

Steven W. Hobbs  
*MSA, UNSW*

D.J. Paull  
*MSA*

J.D.A. Clarke  
*MSA*

T. McDougall  
*MSA*

J. Stevens  
*MSA*

Mars Society Australia continues to research and develop micro and nano-rover class vehicles for planetary science applications. Such a small vehicle could be carried as a secondary payload on larger surface missions, or be launched and operated as an affordable payload in its own right. We tested two versions of an A4 sheet of paper- (29.5 X 21 cm) sized rover under controlled conditions, as well as on surfaces likely to be found on Mars. This was conducted in order to compare the benefits of a four wheel rocker bogie suspension versus a spring designed system. We found that although the rocker bogie enabled most working parts to be contained within a thermally insulated chassis, the spring suspension provided greater mobility. The rovers were also used to test and characterize obstacle avoidance maneuvers and science return from sensors, including a camera. In addition, initial testing of smaller (20 cm) sized rovers was conducted in order to determine the minimum size a vehicle can be and still return useful science.

*Presented by: Steven W. Hobbs*

## **MINERVA-Australis: An Update**

Jonti Horner, Rob Wittenmyer, Duncan Wright, Brett Addison and  
The MINERVA-Australis Consortium

*University of Southern Queensland*

On 18th April, 2018, NASA launched the Transiting Exoplanet Survey Satellite, TESS - a mission that in the coming years will discover a vast number of planets orbiting other stars. To confirm those planets, and to learn more about them, requires a significant ground-based effort, requiring the construction of facilities dedicated to the follow-up and characterisation of the worlds that TESS will uncover. To that end, the University of Southern Queensland (USQ) has led an international collaboration to build the multi-million dollar MINERVA-Australis observatory at USQ's Mt Kent Observatory. In this talk, we present an update on the progress of the new facility, and describe some of the exciting ancillary observational work that we will be able to carry out in addition to studying TESS' strange new worlds.

*Presented by: Jonti Horner*

## **Preliminary Astrocladistical analysis of the Jovian Trojan swarms**

Timothy R. Holt  
*University of Southern Queensland*

Jonathan Horner  
*University of Southern Queensland*

David Nesvorny  
*Southwest Research Institute*

Brad Carter  
*University of Southern Queensland*

Christopher Tylor  
*University of Southern Queensland*

The Jovian Trojans are two swarms of asteroids in Jupiter's orbit, one leading and one trailing the gas giant. These objects provide a suitably sized population to extend the use of astrocladistics. Astrocladistics is a technique of classification, based of cladistics, which is traditionally used in the Biological sciences, the 'Tree of Life'. The dynamical situation of the Jovian Trojans has also made traditional classifications systems problematic. Modern dynamical analysis of the Jovian Trojans has identified a total of seven families, representing only a fraction of the swarm population. In this paper we expand the use astrocladistics in the planetary sciences, specifically the Jovian Trojan asteroid population. With a history of other taxonomic methods, these populations form a test case for the general expansion of cladistics as a tool for comparative planetology. In investigating the astrocladistical methodology, we use a subset of the Jovian Trojans, in order to maximise the robustness of the trees. The characters selected for the analysis include the proper elements, geometric and WISE albedos, as well as the UBV and SDSS colour ratios. The subset was created from the intersection of these databases. We also separate the swarms into L4 and L5 databases. The resulting taxonomic trees are then hypotheses for the relationships within the Jovian Trojan swarms. We can expand the current families and offer potential new groups within the swarms. This study will provide insights into the history of the Jovian Trojans as well as incorporate astrocladistics further into the narrative of our Solar system.

*Presented by: Jonathan Horner*

## **On-orbit performance of the Namuru GPS Receiver, and other results from the SHARC mission.**

Garland Hu  
*DST Group*

SHARC is a 6U CubeSat mission built and operated by the United States Air Force Research Laboratory (AFRL). Deployed from the ISS in May 2017, it achieved full mission success during its one year of operations. One of its missions was to characterise the performance of the Australian developed Namuru GPS Receiver in the Low Earth Orbit environment, and validate its results against other ephemeris solutions.

As an example, the SHARC CubeSat was equipped with a retroreflector, allowing a Laser Ranging Facility in Australia, operated by EOS Space Systems, to track it and generate highly accurate position and velocity data. This paper will present these results, as well as other on-orbit data from various Namuru experiments.

This paper will also present some other general insights and lessons learnt from the SHARC mission, and how these lessons can be integrated into future missions.

Contributors: E. Glennon (ACSER, UNSW Sydney), K. Parkinson (General Dynamics Corporation Limited, New Zealand), J. Bennett (EOS Space Systems), I. Cartwright (Myriota), G. Hu (DST Group), K. Kemble (AFRL), C. Jacka (AFRL), D. Voss (AFRL)

*Presented by: Garland Hu*

## **Using an Artificial Neural Network (ANN) to Model Global hmF2, NmF2 and VSH Based on Long-Term Ionospheric Radio Occultation Measurements**

Andong Hu, Brett Carter, Julie Currie and Kefei Zhang  
*SPACE Research Centre, School of Science, RMIT University*

An advanced machine learning method, Artificial Neural Network (ANN), for the modelling of global hmF2, NmF2 and Vertical Scale Height (VSH) is developed and tested in this study. The sample data are obtained from 163051 electron density profiles measured by almost all available GNSS Ionospheric Radio Occultation (IRO) missions (including Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC), Gravity Recovery and Climate Experiment (GRACE) and CHALLENGING Mini-satellite Payload (CHAMP)) from 2001-2017. The performance of the new model is substantially improved compared to previous models and the current International Reference Ionosphere (IRI) model (IRI-2016). The contribution of each model variable/input is also investigated in this study. The characteristics of the variations of the model-derived hmF2, NmF2 and VSH during the St Patrick's Day (March 17) geomagnetic storms in both 2013 and 2015 are also investigated in order to further verify the new model. A substantial increase in hmF2 during the storms and a simultaneous decrease in NmF2 across most of the world are captured with the new ANN model results. In the equatorial region, a decrease in hmF2 and increase in NmF2 during the storm is shown by the model. In addition, the VSH shows a clear geomagnetic equatorial peak during the storm time in the ANN results and IRO observations, which does not exist in previous model results. Finally, it is revealed that some of the independent variables may not be necessary for constructing these models. In conclusion, the results suggest that the proposed ANN technique could be used to update or improve the empirical models, such as the IRI, in future.

*Presented by: Andong Hu*

## **Spiral Blue - Stopping maritime piracy from space**

Noor Taofiqui Huq  
*Spiral Blue*

Spiral Blue is a startup aimed at solving terrestrial issues using satellite data, starting with the problem of maritime piracy. Maritime piracy is an ongoing problem costing the maritime industry billions every year, with over 100 sailors kidnapped in 2017. Spiral Blue makes shipping through piracy hotspots cheaper and safer by identifying pirate ships long before they have the opportunity to conduct attacks on customer ships. Initially, satellite images delivered from Planet's constellation of earth observation CubeSats will be used. Eventually, Spiral Blue will develop its own satellites for higher resolution and superior revisit rates.

*Presented by: Noor Taofiqui Huq*

## **Hayabusa 2 at Ryugu**

Trevor Ireland  
*Australian National University*

Hayabusa 2 has arrived at asteroid Ryugu! On 3 June the ion engines were turned off and by June 27, Hayabusa 2 had manoeuvred to Home Position, only 20 km above the surface. Ryugu is shaped like a top with a diamond shaped aspect. This suggests that Ryugu either formed with this shape, or regolith redistribution caused a build up of material at the equator. Resolving this issue will likely require an accurate shape model and mass so as to determine density and likely porosity. Ryugu's surface comprises boulders, craters, troughs and other surface features. With arrival at Home Position, a program of imaging and remote analysis will commence. Key aspects of this will be LIDAR, which will allow an accurate shape model to be produced, and IR spectroscopy, which might give an indication of variations in composition across the surface. The Science Team will also be looking to start using images to find appropriate landing sites on the surface with several experiments to be delivered to the surface later this year. These experiments will also be used for selecting possible sampling locations. Ryugu goes behind the Sun later this year and so there is some urgency to get as much information as possible back to Earth before radio contact is lost. Hayabusa 2 will leave Ryugu later in 2019 and get back to Earth in 2020.

*Presented by: Trevor Ireland*

## **A Neural Network's Search For Polar Spring-time Fans On Mars.**

Eriita G. Jones

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*Computational Learning Systems Laboratory, School of IT and Mathematical Sciences, University of South Australia, Mawson Lakes, Australia; Consilium Technology, Adelaide, Australia*

Dark fans are a seasonal spring-time occurrence in Mars' south polar region. These features are thought to be produced by carbon dioxide jets breaking through a thawing seasonal ice cap. The jets bring dust and dirt from below the ice up to the surface, which is then distributed by the local surface winds. Understanding these features – their spatial dimensions, density, distribution and temporal frequency – provides important constraints on atmospheric conditions (such as local dominant wind direction), and ice composition and thickness, which give valuable clues to the characteristics of past Martian climate cycles. Given the vast area covered by these seasonal fans during southern spring and summer, combined with large numbers of these features (hundreds of thousands) captured in satellite imagery, it is a significant undertaking for researchers to map the size, dimension,



and shape of individual fans. Machine learning techniques however – in particular, neural networks – have provided significant advancements in recent years in the areas of image segmentation, classification, and object detection. The performance of a neural network is crucially dependent on large amounts of labelled data for training, testing and validating the network and its output. In this work a convolutional neural network (CNN) is utilised to detect and segment fans and blotches within crowd-labelled imagery from the Mars High Resolution Imaging Science Experiment (HiRISE) camera. The fan catalog used as training input by the CNN was produced by the Planet Four project (<http://www.planetfour.org>), an online citizen science project which enlists the public to map the seasonal fans visible in HiRISE color mosaics [Aye et al. submitted]. This talk will present the initial output of the CNN in the form of fan predictions, discuss some of the hurdles faced thus far, and share some derived attributes of the detected features with their scientific relevance.

*Presented by: Eriita G. Jones*

## **A Recipe For Improving the Automated Detection of Vineyards From Space.**

Eriita G. Jones

*Computational Learning Systems Laboratory, School of IT and Mathematical Sciences, University of South Australia, Adelaide, Australia*

Sebastien Wong

*Consilium Technology, Adelaide, Australia*

Anthony Milton

*Consilium Technology, Adelaide, Australia*

Joseph Sclauzero

*Consilium Technology, Adelaide, Australia*

Kristijan Ramesa

*Consilium Technology, Adelaide, Australia*

Mark D. McDonnell

*Computational Learning Systems Laboratory, School of IT and Mathematical Sciences, University of South Australia, Adelaide, Australia and Consilium Technology, Adelaide, Australia*

Precision viticulture (PV) is the application of technologies to enable winemakers and grapegrowers to adapt to, and effectively manage, the variability of their vineyards - rather than needing to utilize a 'one-size-fits-all' approach. PV relies on having high-resolution and accurate vineyard information, including precise geo-referenced vineyard boundaries and vinerows. It is of great benefit if this information can be derived from remote sensing, without a priori knowledge of vine parcel locations. Vineyard detection using satellite based remote sensing enables efficient, and potentially automated, derivation of spatial measures such as length and area of crop, and hence required volumes of water, fertilizer and other resources, as well as derived vegetation attributes such as vigor, health and yield forecasting (when multispectral information is available). This talk will discuss some of the important decisions that must be made when undertaking vineyard detection from space. Considerations include the initial choice of input imagery (considering spatial and spectral resolutions), the type of processing, the role of derived spectral indices, and some confounding variables in vineyard detection (e.g. orchards). Examples from Australian vineyards in Digital Globe Worldview 2 and Worldview 3 imagery will be presented, and initial quantitative results on the impact of these choices on

vineyard detection and segmentation accuracy using a deep convolutional neural network (CNN) will be discussed. Much of the results discussed will be applicable to other types of agriculture from space.

*Presented by: Eriita G. Jones*

# **Structural Analysis of Varying Joints used for a Hexagonal Solar Sail Concept via FEM**

Joshua Kahn  
*University of New South Wales*

Solar sails are spacecraft that utilise solar radiation pressure for both propulsion and control. Due to the small magnitude of this pressure, large solar sails that can easily deploy in space are required, which can be

difficult. One concept that responds to this issue utilises hexagonal solar sail frames that are assembled in orbit, rather than deployed. This presentation covers the analysis and results of a 20m solar sail frame concept using Finite Element Methods to determine how different joining methods affect the deflection and stress of the structure, and which method of joint is the most effective in securing it together.

*Presented by: Joshua Kahn*

**ANZSLIG Professional Development series - Legal/business  
structures for space activities in Australia**

Bora Kaplan  
Tunc Kaplan  
*Sydney Bar*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Bora Kaplan and Tunc Kaplan*

## **Near-Infrared atmospheric modelling of Jupiter's Southern Equatorial Belt (SEB) observed with AAT/IRIS2**

Behrooz Karamiqucham, Jeremy Bailey, Lucyna Kedziora-Chudczer  
and Daniel Cotton  
*School of Physics, UNSW*

The low resolution ( $R \sim 2400$ , H and K bands) spectra of Jupiter's Southern Equatorial Belt have been modelled using VSTAR (Versatile Software for Transfer of Atmospheric Radiation) and ATMOF (ATMOSpheric Fitting) codes through observation of the Anglo-Australian Telescope's Infra-Red Imaging Spectrograph 2 (AAT/IRIS2). By creating a line-by-line radiative transfer model with the most latest ammonia and methane line lists (HITRAN 2016) we derived the best models in the Jupiter's Southern Equatorial Belt. Using different cloud and haze opacities and distributions resulted from our modelling outputs, we were able to fit our models to the spectra of the planet in the observed region. Our findings enable us to use and define the resulted parameters to uncover the cloud and haze pressure heights and opacities in the spectral H and K bands of Jupiter's troposphere and stratosphere. The modelled spectra fit the observations remarkably well at H and K bands except for extremities around 2.11, 2.16 and 2.19  $\mu\text{m}$  for K band and high-pressure window peak around 1.6  $\mu\text{m}$  for H band.

*Presented by: Behrooz Karamiqucham*

## **Effects of Hazes and Clouds on Exoplanetary Spectra**

Lucyna Kedziora-Chudczer  
*University of New South Wales*

Clouds form in every substantial atmosphere of the Solar System planets and are also present in cool brown dwarfs. Clouds are likely to be common in atmospheres of extra solar planets as well. They affect propagation of incident stellar radiation in planetary atmospheres and also have an effect on emitted thermal emission. A combination of these factors provides the feedback that defines global climate and planetary albedo. I will discuss the properties of clouds that can be expected in atmospheres of extra solar planets with the different atmospheric composition and physical conditions. I will give examples of observations and measurements, which allow detection of such clouds and hazes.

*Presented by: Lucyna Kedziora-Chudczer*

## **Designing the The Human Health and Performance (HHP) Laboratory**

David Keenan and Graeme Spencer  
*HDR*

Research revolving around the International Space Station that focuses on human physiology, specifically on astronauts both in-flight and back on Earth, will play a big role in NASA's next great mission: sending a crewed mission to Mars in the 2030s. Accomplishing this feat, which has been named the Orion mission, involves a myriad of exploration technologies like autonomous refueling of spacecraft, advanced life support systems, and human robotic interfaces. And it also requires crews who will thrive in deep space, for two to three years at a time—far longer than ever before. The Human Health and Performance (HHP) Laboratory at the Johnson Space Center (JSC), home to the astronauts, is designed specifically to support these space pioneers.

The HHP Laboratory is a human health and environmental sciences laboratory, think tank, inventors' workshop, and outreach center all rolled into one. It is a place dedicated to maintaining human health—on Earth, in low-Earth orbit, traversing deep space, and landing on Mars. With the unifying and inspiring goal of maintaining human health and performance, the design of the HHP Laboratory puts people at the center, enhancing interdisciplinary integration by bringing together groups that had formerly been distributed across campus in different buildings. By co-locating scientists, clinicians and engineers, and by fostering an integrated approach to studying the human system, the facility is the physical vehicle for advancing a highly collaborative and innovative research era at NASA's JSC.

In this session, David Keenan will discuss the design and planning of this one-of-a-kind facility and share the key learnings that can be applied to other aerospace facilities with similarly complex and ambitious programs and goals.

*Presented by: David Keenan*



## **The Effect of Splitter Plate(s) Attached with Square Cylinder in Turbulent Flow**

Nahid Alemi Kermani and Prof. Con Doolan  
*University of New South Wales*

Bluff bodies are commonly used in many various engineering applications, such as cars, ships, aircrafts, tall towers, high speed trains etc. When a bluff body interacts with flow, different flow induced phenomena, such as high pressure drag and unsteady aerodynamic loading, may occur. In order to modify the bluff body wake structure, presenting a secondary body in the wake of the bluff body has been a successful approach.

The aim of this study is to investigate the effect of using flat splitter plate(s) for passive bluff body wake control. A square cylinder as the primary bluff body is used and thin flat plate(s) attached with the cylinder, as the secondary body, is placed at upstream, downstream and both upstream and downstream of the cylinder. The plate length,  $L$ , is varied in relation with the square cylinder side length,  $D$ , over the range  $0.5 \leq L/D \leq 3.2$  to determine the optimal length of the plate for the least aerodynamic loading. This study has two parts, numerical and experimental. For the numerical study, the flow over twenty-seven models are simulated using two-dimensional models in ANSYS fluent at a Reynolds number  $1.4 \cdot 10^4$  and the behaviour of the flow over plain cylinder and with attached plate(s) is studied. The results from the simulation were used to calculate the Strouhal number, root mean square of lift coefficient and mean drag coefficient. The numerical study has shown the indication of transition into a new flow regime when downstream plate is  $L_2/D > 1.5$  and when  $L_1/D = L_2/D > 1.5$ . Also, this study showed that the upstream splitter plate has great impact on drag and lift reduction of the cylinder, while has higher vortex shedding frequency (compared to other cases). A 44.7% reduction in drag is observed when the square cylinder is attached with an upstream splitter plate ( $L_1/D = 2.5$ ).

The experimental study was performed by using a bench-top wind tunnel and 3D printed of twenty-three models. The obtained results from the tunnel were used to calculate drag coefficient. The experimental study agreed with the significant impact of upstream splitter plate on drag reduction in turbulent flow however, inconsistency in the results, mainly in double plate models, was

considerable. Also, a 51.9% reduction in drag is observed for the case where two splitter plates are used ( $L_1/D=L_2/D=1.5$ ).

*Presented by: Nahid Kermani*

## **Digital Earth Australia - From Satellites to Insights**

Trent Kershaw  
*Geoscience Australia*

In the 2018-19 Budget, the Australian Government announced an ongoing, multi-million dollar investment in Digital Earth Australia (DEA) to provide government and businesses unprecedented access to satellite imagery tailored for Australia.

From helping to manage water in the Murray-Darling Basin through to helping farmers increase the productivity of their land - the potential uses of DEA are almost unlimited. This talk will showcase how DEA is already being used to identify and manage environmental changes across our vast continent as well as outlining how this innovative digital infrastructure will be used by businesses to develop new applications for sectors across the entire Australian economy.

*Presented by: Trent Kershaw*

## Numerical Investigation of the Density-Temperature Synchrony in the Thermosphere

Timothy Kodikara<sup>1,2</sup>, Brett Carter<sup>1</sup>, Robert Norman<sup>1,2</sup>, Kefei Zhang<sup>1</sup>

<sup>1</sup>SPACE Research Centre, RMIT University, Melbourne, Victoria,

<sup>2</sup>SERC Limited, AITC2 Mount Stromlo Observatory, Canberra, ACT,

An analysis of the neutral density-temperature ( $\rho$ -T) synchrony in the thermosphere is described through numerical simulations with the National Center for Atmospheric Research Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM). The  $\rho$ -T synchrony follows from the dynamical theory for a hydrostatic atmosphere, which states that the pressure at a given height varies in response to T variations at lower heights and hence the  $\rho$  variations are roughly in-phase with the T variations at approximately 1–2 scale heights below.

First, it is demonstrated that the previously discovered  $\rho$ -T synchrony begins at about 250 km altitude and is correlated with a difference in the neutral winds between the different altitude layers in the thermosphere. The tidal spectrum (modulated via an empirically formulated global scale wave model) entering the thermosphere near 97 km seems to have only a marginal effect on the synchrony patterns, which are more noticeable during the equinox-months. The study demonstrates that the longitudinal shift in synchrony (i.e. phase lag) is dominant in the high latitudes of the summer hemisphere. The dominant response in the high latitudes evolves through the day and is attributable to ion drag and temperature fluctuations via soft particle precipitation; essentially, the roughly in-phase signature between the east-to-west diurnal trend in  $\rho$  at a given altitude and the T variations at a substantially lower altitude, changes (i.e.  $\rho$  leading or lagging T) in the high latitudes in response to amplified neutral winds and localised T variations. In addition, it is demonstrated that the phase lag is significantly affected by geomagnetic activity; the underlying mechanism is hypothesised to be related to temperature enhancements via Joule heating and associated nonlinear interactions. This is shown through an analysis of  $\rho$  response at 400 km with respect to T at 300 km during times of relatively high geomagnetic activity in four different seasons. The large variability in the phase lags correlates with relatively high amplitude change in geomagnetic activity. While the phase lags attributable to different solar activity levels are modest, the solar heating is the main source that maintains the  $\rho$ -T synchrony in the mid/low latitudes via upward propagating thermal 20 tides (i.e. the T wave propagating upward and westward).

*Presented by: Timothy Kodikara*

## **Spectral Aerospace: Hyperspectral Satellite Remote Sensing Solutions**

Benjamin Koschnick and Ryan Hofer  
*Spectral Aerospace*

Spectral Aerospace aims to change the way we see our world, utilising hyperspectral technology to provide satellite remote sensing solutions to a variety of under serviced markets. We have identified gaps in the market for pipeline monitoring, precision agriculture, river system management, mining and a wide variety of other markets that we can service with our technology. With our emphasis being on the flexibility of hyperspectral technology we aim to provide a comprehensive array of innovative remote sensing solutions to governments, industries and other organisations.

*Presented by: Benjamin Koschnick*

## **A Space Narrative**

Jannene Kyytsonen  
*UTS*

### **A Space Narrative**

How will the Australian Space Agency survive in the competitive space industry? What is our comparative advantage? Can we take advantage of the terrain in central Australia of the Eromanga Sea region of the Great Artesian Basin, that so approximates that of Mars?(1) Coober Pedy(SA), White Cliffs and Lightning Ridge(NSW), already represent contained biospheres where communities are living just as they would if they were under the surface of Mars or indeed The Moon. Can we expand those communities with high technology habitats where educators and tourists can imagine the future of life off planet? The benefit of the habitats is that they can also be “living Labs” where sustainable dwellings are designed and engineered for the world’s smart cities. Many people wonder what their futures will be, what kind of work will they have? These underground communities will allow visualization of skills and knowledge sets that will be needed. Economies exist to provide for the populations needs, from agriculture to the digital economy. In these Australian underground communities people can come and learn how to live sustainably in a confined space, and the Universities can move from classrooms to living spaces needing architecture, construction, utility services, health and so many other domain knowledge sets. Doing is knowing, and so many will benefit from a hands on education or tourist experience.

The survival of the Australian Space Agency will lie in embedding itself in the everyday life of all. The financial backing of the education and tourism industries can sustain the agency, affording through innovations, a connection to the wider economy, and then, facilitate the collaboration with actors in the other sectors of the space industry.

(1)P.Rey2013

*Presented by: Jannene Kyytsonen*

**ANZSLIG Professional Development series - Contracting for  
space activities in Australia**

Tyson Lange  
*Clayton Utz*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Tyson Lange*

## **New Generation Earth Observations from Space - Current and Future Benefits and Opportunities**

John Le Marshall, Bureau of Meteorology, Australia  
Norman, Robert<sup>2</sup>, RMIT University, Australia  
David Howard, Bureau of Meteorology, Australia  
Yi Xiao, Bureau of Meteorology, Australia  
Susan Rennie, Bureau of Meteorology, Australia  
Chris Tingwell, Bur

There have been significant benefits to meteorological analysis and forecasting in the southern hemisphere deriving from new generation Earth Observations from Space (EOS). In the southern hemisphere these space based observations extend the length of a high quality global numerical forecast by a factor of four when the forecast is verified using analyses incorporating satellite and conventional (all) data. Several instruments have recently been placed in earth orbit for use in Numerical Weather Prediction (NWP) and others are soon to follow. These include the Advanced Himawari Imager (AHI) on Himawari-8/9, the Advanced Baseline Imager and the Geostationary Lightning Mapper on GOES-16, CrIS on JPSS and soon the wind lidar ADM Aeolus and the COSMIC-2 constellation of satellites. Of note is that the COSMIC-2 constellation of satellites has a command and data acquisition station in northern Australia hosted by the Bureau of Meteorology . The important contributions some of these new instruments have and will make, particularly in the southern hemisphere and in relation to extreme weather will be discussed in detail. For example, the generation and assimilation of locally generated, near continuous wind data from Himawari-8 for operational forecasting are described, as is the use of GNSS Zenith Total Delay data. The EOS data are also being examined in relation to prediction of extreme weather. This will also be discussed.

Overall, EOS data have provided great social and economic benefit to Australia and these benefits can be maintained or expanded at the moment, in many cases by application of smaller satellites with comparatively inexpensive payloads. An example of this is the case of atmospheric sounding using radio occultation, which improves both general and severe weather forecasting. As a result, there is now a noteworthy opportunity to expand the current EOS related capability in Australia with attendant economic and social cost benefit.

*Presented by: John Le Marshall*



**ANZSLIG Professional Development series - Space  
applications: position, navigation and timing**

Bin Li  
*University of Newcastle*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Bin Li*

## **Update on the Space Science and Technology Strategy for Australian Defence**

Dr Nick Stacy  
*Defence Science and Technology Group*

Australia is reliant on services provided by space-based capabilities and this is recognised in the Australian Defence White Paper. Further, the barriers of entry into space are lowering resulting in increased opportunities for new and existing Australian enterprises to deliver cost-effective niche capabilities and compete in the global space market. With these new and existing opportunities and recognition of the reliance on space, Australian Defence has been developing a space science and technology strategy to guide its research and development over the coming decade seeking to foster and leverage the new prospects to develop Australian capability. This presentation will provide an update on the Space Science and Technology Strategy for Defence and its main goals.

*Presented by: Dr David Lingard*

**ANZSLIG Professional Development series - Comparative  
regulatory approaches and competing for global sales  
opportunities**

Joel Lisk  
*The University of Adelaide*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Joel Lisk*

## **Solar Wind Predictions Based on SDO/AIA and DSCOVR Data**

Vasily Lobzin and Graham Steward  
*Bureau of Meteorology*

This presentation describes an empirical model for solar wind predictions based on data provided by the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO) spacecraft and by the Faraday Cup on board the Deep Space Climate Observatory (DSCOVR) spacecraft monitoring solar wind near the L1 point. Adapting linear functions are used to predict the solar wind speed for the next UT day by using the solar wind speeds measured during the previous solar rotation and the numbers of dark pixels in an image slice centred at the solar central meridian. The current version of the algorithm has been tested for DSCOVR observations from 26 July 2016 to 4 June 2018. The correlation coefficient for measured versus predicted values of the solar wind speed is 0.63. This technique will be implemented and used in the Bureau of Meteorology's Space Weather Services Australian Space Forecast Centre.

*Presented by: Vasily Lobzin*

**Morning and afternoon peaks in electron density near the magnetic equator contrasted with a similar phenomenon of different origin occurring at middle latitudes**

K.J.W.Lynn

*Ionospheric Systems Research*

S. Sripathi

*Indian Institute of Geomagnetism*

R.S. Gardiner-Garden

*Defence Science and Technology Group*

A.Heitmann

*Defence Science and Technology Group*

A paper (Lynn et al, 2014) has described the existence of morning and afternoon peaks in ionospheric density at middle latitudes which was postulated as due to changing meridional wind patterns possibly of tidal origin. A similar phenomenon in electron density can be seen by ionosondes near the magnetic equator, the example shown being from the Indian site of Tirunelveli. The middle latitude twin peaks are associated with falling F2 layer height and an associated compression of the ionosphere. In contrast, the equatorial twin peaks arise from the day-time action of the equatorial electrojet in pumping electrons from the F2 ionosphere to great heights thus producing a midday minimum. These electrons subsequently fall down magnetic field lines to form the well-known day-time equatorial anomaly. The minimum at midday in F2 electron density which produces the equatorial twin peaks is associated with a smooth rise and fall in F2 height which reach's a maximum at midday when the bite-out in electron density is greatest. Thus, although the twin peak patterns in foF2 appear quite similar at equatorial and middle latitudes, their origin and associated changes in height are quite different

*Presented by: Kenneth J.W. Lynn*

## Detailed Technical Performance of the FireOPAL system

Greg Madsen<sup>1</sup>, Phil Bland<sup>2</sup>, Matt Bold<sup>1</sup>, Robert Howie<sup>2</sup>, Ben Hartig<sup>2</sup>,  
Trent Jansen-Sturgeon<sup>2</sup> and Jim Mason<sup>1</sup>

<sup>1</sup>*Lockheed Martin*

<sup>2</sup>*Curtin University*

An overview of the FireOPAL system is provided elsewhere at this conference. Here we describe the technical performance and first results of the near real time data processing onboard each unit. For each 5 second image, we find that FireOPAL measures apparent angular coordinates with an accuracy of a few arcseconds. The system measures absolute time within milliseconds, absolute flux to within 10%, and detects point sources with visual magnitude of around 16 or brighter. Each unit has sufficient computational resources to completely process an image onboard within seconds, reports measurements to a central server in near real time, which are then used for orbit determination and catalogue maintenance. The data from our prototype network across Australia is used to calculate accurate orbits for hundreds of objects per clear night. When orbits for both LEO and GEO objects are propagated forward more than one day, the predictions match the observations to better than one pixel. In addition, the system has recorded more than one million light curves of satellites which are used to deduce properties such as size, tumbling, composition, pattern of life, etc. Finally, we report on the capture rate of objects of different sizes and in different orbital regimes, and discuss ongoing plans to improve the performance of the network.

*Presented by: Greg Madsen*

## Hybrid Rockets

Nick Mclean  
*Gilmour Space*

Gilmour Space has worked with a number of Australian research institutions on technology development of our launch vehicle. This includes research and development of our catalyst pack, thermal work on high temperature parts such as nozzles and nose cones, aerodynamic analysis of high speed flight, GPS navigation instruments etc.

This talk will focus on the companies' early engine development work with hybrid motors and areas of further research with CSIRO and other research institutions.

*Presented by: Nick Mclean*

## **HF radar observations of periodic ionospheric irregularities at middle latitudes**

Frederick Menk

*University of Newcastle, NSW, Australia*

Colin Waters

*University of Newcastle, NSW, Australia*

John Devlin

*La Trobe University, Vic, Australia*

Jim Whittington

*La Trobe University, Vic, Australia*

Peter Dyson

*La Trobe University, Vic, Australia*

The ionosphere forms the lower boundary of the magnetosphere and couples to the thermosphere. The international SuperDARN consortium of high frequency over-the-horizon radars has been used for over three decades to investigate dynamics of the high latitude ionosphere. More recently a network of mid-latitude radars has been added to SuperDARN to provide extended coverage at times of enhanced magnetic activity. These include the TIGER and Unwin radars in Tasmania and New Zealand respectively, both located at  $-55^\circ$  magnetic latitude. In 2014 a new design of HF mid-latitude radar was deployed at Buckland Park, near Adelaide, with a field of view overlapping TIGER and Unwin and extending from near the magnetic pole to around  $-40^\circ$  magnetic latitude. The Buckland Park radar detects a variety of ionospheric irregularities including MSTIDs and ionospheric perturbations driven by the electric fields of magnetospheric plasma waves. The TIDs may propagate equatorward away from a higher latitude source region and can also be detected with optical imagers and other radio sounders at lower latitudes. The plasma waves produce oscillation features with periods of a few minutes or less over a range of scale sizes. This presentation gives examples and discusses propagation properties and impacts for ionosphere users.

*Presented by: Frederick Menk*



## **National Committee for Space and Radio Science update**

Frederick Menk  
*Australian Academy of Science*

The National Committee for Space and Radio Science is one of 22 national committees for science within the Academy of Science. Its purpose is to (i) link and promote relevant discipline areas nationally and internationally, (ii) advise on relevant developments, and (iii) formulate strategic plans to assess the current state of the discipline, identify and set priorities, and outline strategies to achieve them. This presentation outlines some of the main developments over the past year, and future priorities.

*Presented by: Frederick Menk*

## Exploring Mars with InSight

Katarina Miljkovic  
*Curtin University*

The InSight (Interior exploration using Seismic Investigations, Geodesy and Heat Transport) Mission will reveal what lies under the red planet's surface so that we can understand the formation and evolution of Mars and other rocky planets in the inner solar system, such as Earth. The robotic stationary lander is now Mars-bound, after a successful launch on May 5. It will be the first thorough check-up Mars has had since it formed 4.5 billion years ago and will measure interior structure via seismic (SEIS), heat flow (HP3), and radio experiments. Focus in this talk will be on meteoroid bombardment on Mars that causes impact-induced marsquakes. Marsquakes will help understand the structure of the crust and interior of Mars by constraining the material properties associated with the impacts.

*Presented by: Katarina Miljkovic*

## FrontierSI and SBAS Test-bed Project Update

Julia Mitchell  
*FrontierSI*

FrontierSI brings the best people together to solve the most complex spatial problems. Why? Because the power of where is growing rapidly and we are committed to asking how spatial information can be better used to understand what is happening around us. We have been bringing people together and asking this for over 15 years.

This SBAS Test-bed is a satellite based positioning infrastructure that is currently available until January 2019. In simple terms, SBAS provides a cost effective way to improve GPS signals from around five metres in accuracy to sub-metre. This trial is supported by a \$12 million investment from the Australian Government with a further \$2 million from the New Zealand Government. FrontierSI (formerly the CRC for Spatial Information) is coordinating and undertaking user testing of SBAS in Australia and New Zealand in conjunction with a benefit analysis of SBAS technology.

FrontierSI partners, Geoscience Australia (GA) and Land Information New Zealand (LINZ) together with three global companies GMV, Inmarsat and Lockheed Martin are implementing the SBAS test-bed to evaluate three positioning signals for improved accuracy and integrity over Australia and New Zealand.

The positioning signals for evaluation are:

- The current L1 Legacy service similar to that available in the United States (WAAS) and Europe (EGNOS).
- A second-generation Dual Frequency Multi Constellation signal which will provide improvement over the legacy signal in a number of areas. This signal has not been tested anywhere in the world.
- Precise Point Positioning (PPP) corrections with expected decimetre accuracies at user level.

Projects are currently running in Australia and NZ trialling the SBAS technology addressing applications in one or more of the following key sectors: agriculture, aviation, construction,

consumer, maritime, rail, resources, road, spatial and utilities. Julia will provide an update regarding FrontierSI and on the SBAS test-bed project.

*Presented by: Julia Mitchell*

**ANZSLIG Professional Development series - Space  
applications: active debris management**

Paul Monaghan  
*NSW Law Society*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Paul Monaghan*

## **Arcadia: the First Settlement on Mars**

Shaun Moss

*Mars Society Australia and National Space Society of Australia*

Since the dawn of the Space Age, numerous ideas have been proposed that could provide an economic motivation for the development of the space industry and economy. Examples include space solar power, space tourism, and asteroid mining.

Another business opportunity, which may have the potential to lead to large-scale human settlement of Mars, is the development of residential and commercial real estate on the Red Planet. This would hopefully entice many people and businesses to move to Mars, in order to participate in the development of the new frontier.

Mars has greater potential to support large numbers of people than anywhere else in the inner Solar System, due to its similarities to Earth and abundance of key resources such as water, oxygen, carbon, and nitrogen.

It seems that many people would move to Mars if doing so can be made safe, healthy, and affordable. Assuming that technological evolution will eventually cause this to be true, we may also assume that eventually a viable business case could be made for constructing a settlement on Mars.

For this plan to work, the barrier to entry associated with moving to Mars must be lowered as much as possible. The cost of transportation must be reduced as a priority. In addition, we must also work towards producing as much as possible of our energy, propellant, life support resources, materials, and manufactured goods from local resources. This will also reduce the settlement's vulnerability, maximise its long term survivability, and stimulate greater innovation.

The plan for Arcadia primarily emphasises aesthetics, development of local industry, and health and safety, with the goal of offering an ultra-modern, premium lifestyle at the human frontier, which will become progressively more affordable and accessible as the settlement grows into a city.

*Presented by: Shaun Moss*

## **First Kids on Mars - Future-ready skills program**

Jonathan Nalder  
*First on Mars*

### **First Kids On Mars - Future-ready skills program**

To solve tomorrow and today's big problems like succeeding in space, students need as much of a head start with big picture skills like creativity, team-work, project delivery and storytelling as they can get to augment their technical knowledge.

Its no secret that AI and automation are already impacting the workplace as full time employment drops to record lows and experts predict 30-70% of todays jobs will be impacted by 2030. At First on Mars our educators see that schools are so busy delivering curriculum that the next level of skills that are in demand by industry are not being delivered.

Since 2017 the founder of First on Mars Jonathan Nalder has been working with students to turn this around, and using Space and the engaging interest in Mars to do so. Along the way schools have had their first chance ever to chat with Astrobiologists and Astrogeologists (like Dr Jonathan Clarke), hold flown metal and meteorite pieces, grow space radish seeds that have been to the ISS, work with Space Nation and connect with Gilmour Space technologies and Spaceport AI.

In the program, which is now endorsed by the Mars Society of Australia, students (and teachers) go on an imaginative journey to solve what does Mars need first if it is to be a thriving community where people will actually want to live beyond the initial survival and research heavy phase. The journey sees them experience VR, AR, build solutions in Minecraft, learn agile practices, play drama games, and engage with how to pitch the story of their solution to a Mars base commander.

Our poster will set out how the program works, and what results have been obtained so far as a way of educating the broader space community about our grass-roots efforts, especially with students in primary school.

As was shared by a Gilmour Space Tech engineer at the TAFE Gold Coast Space 2.0 event, softer skills like team-work are just as crucial to the success of Space companies as other kinds of knowledge - and at First on Mars we want to share the how of seeing this occur in schools today so that as many students as

possible can grow up to succeed and support the burgeoning Australia Space industry the fullest range of skills possible.

*Presented by: Jonathan Nalder*



# **Modelling the Received Power of Multipath HF Signals Propagated via the Ionosphere**

David Netherway, Manuel Cervera, Robert Gardiner-Garden

*Defence Science and Technology Group*

For applications that use HF propagation, particularly where there are multiple paths of propagation, it is desirable to estimate the power of all modes that could be received. This is particularly important for radar applications where the number of possible paths is the product of the number of inbound and outbound paths. Models of the ionosphere, propagation paths and propagation losses allow for reasonable average estimates but there is still a significant residual power variance that needs to be accommodated and/or better modelled.

This presentation will focus on two ionospheric phenomena that impact on received power estimation and path evaluation: sporadic E (Es) and absorption. Typically we use models based on Sinno et al, 1976 to estimate partial reflection and transmission from Es layers and models based on George and Bradley, 1974 to model absorption.

Gardiner-Garden, 2018 recently introduced a new model for working with multiple Es layers in which, based on measurements from a network of bottom side ionospheric sounders, there is a deterministic model of the heights of Es layers and a probabilistic model for the spatial variation of the strength of their strength (foEs).

In this presentation these models will be reviewed with regard to power estimation based on sounder measurements from the Jindalee Operational Radar Network.

*Presented by: David Netherway*

## **Ionospheric features causing anomalous GNSS radio occultation results**

Robert. Norman<sup>1,2</sup>, Brett. A. Carter<sup>1,2</sup>, Sean. B. Healy<sup>3</sup>, Ian. D. Culverwell<sup>4</sup>, Axel. von Engeln<sup>5</sup>, John. Le Marshall<sup>6</sup>, Joel. P. Younger<sup>7</sup>, Ara. Cate<sup>1</sup> and Kefei. Zhang<sup>1,8</sup>

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<sup>5</sup>EUMETSAT, Satellite group, Darmstadt, Hessen, DE

<sup>6</sup>Science and Innovation group, Bureau of Meteorology, Australia

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The Global Navigation Satellite System (GNSS) Radio Occultation (RO) is a space-based technique for sounding the Earth's atmosphere with global coverage. The data retrieved using this technique has been demonstrated to deliver unprecedented advantages in terms of improving operational weather analysis and forecasting and assisting in regional and global reanalysis and climate monitoring. The GNSS RO technique is becoming more widely used in operational applications, however it still has limitations. An investigation by EUMETSAT and the United Kingdom Meteorological Office (UKMO) revealed that there are regions in the Earth's atmosphere where up to 60 % of GRAS (GNSS Receiver for Atmospheric Sounding) RO measurements exhibit anomalous bending angle results. GRAS forms part of the payload on the LEO Metop series of meteorological satellites. In these regions the anomalous RO measurements consist of cases when the calculated bending angle of the GPS L1 signal frequency is greater than that of the corresponding L2 signal frequency path. This is also shown in COSMIC data with very similar characteristics. In this investigation the ionospheric features in these regions causing the anomalous RO measurements have been identified and the reasons for these anomalous results explained using ray tracing simulations based on geometrical optics.

*Presented by: Robert Norman*

## **Possible Near-Term Mission Architecture to Measure Lunar Polar Regolith Water Content**

Stevie Nuss-Soeharto, Nathan Long and Graham Dorrington

*School of Engineering, RMIT University*

A possible follow-on to NASA's LCROSS mission is described. It is argued that, prior to lunar resource exploitation, it is necessary to better constrain the lunar regolith water-ice content and distribution in the southern pole region, to improve confidence that water can be found in sufficiently large quantities and to better inform the siting of future in-situ production facilities. A novel mission architecture solution is proposed comprising of three segments: a cis-lunar polar orbiter, a set of six impactors, and a low lunar polar orbiting spacecraft. On successive orbits the cis-lunar orbiter releases an impactor such that it strikes a different designated lunar polar target site with an impact velocity of  $\sim 2.5$  km/s. Each impactor (Fig. 1) comprises of a  $\sim 0.3$  m diameter hollow copper sphere fitted with a cold-gas micro-propulsion system to permit trajectory modification. Despite its poor structural properties, copper is selected to minimise measurement contamination. The ejector plume resulting from each impact is sampled by the orbiter, at a perilune altitude of  $\sim 50$  km, using a mass spectrometer (MASPEX) and the impact site recorded using a thermal imager. In this manner, it is proposed that a robust measurement of the regolith-to-water ratio at multiple sites could be obtained. A preliminary mass and cost breakdown estimate of the proposed system is offered. It is concluded that the mission described might be achieved for  $\sim \$500\text{M USD}$  (FY18), which is deemed lower cost than other possible architectures employing landers/hoppers/rovers. The overall mission risk is also characterised as being low, given that it builds directly on LCROSS experience and the use of existing scientific instrumentation.

*Presented by: Stevie Nuss-Soeharto*

## **60 Years of Glorious Entertainments Exploring Space: From Antarctic Auroras to Apollos to (hopefully) Far Side of the Moon**

Prof. Brian J. O'Brien  
*University of W.A.*

Our purposes are to stimulate audiences with samples of many real-world experiences as an Australian after a richly-mentored PhD and to credit my school teachers.

Successes, and some failures, came from pursuit of enjoyment of excellence and good luck in glorious entertainments of global discoveries in exploration of space between 1958 and 2018. A prime example was being idea-ready for opportunities with flexible total system responses, as with 40-pound satellite Injun 1 built in 4 months to hitchhike in 1961 from my vision since 1958 as the only sensible way to investigate causes-and-effects of gloriously "divine signalling" of auroras.

Injun 1 discoveries included (i) first satellite with digital transmission, (ii) proof original estimates of van Allen radiation were 1000-fold too large, (iii) evidence geomagnetically-trapped radiation was not the source but a consequence of auroral radiation, and (iv) the first satellite evidence of diurnal distortion of the magnetosphere at 1000km. The only survivor of 9 satellites from radiation from Starfish thermonuclear device, Injun 1 providing the only before-and-after measurements of that uniquely devastating man-made radiation.

Although Injun 2 blew up, Injun 3 was a magnificent idea-ready follow-up to jointly measure Starfish in a higher orbit and discover new VLF phenomena.

Many other delights included 40 years of seamless transition into innovative governance and strategies for environment in Australia as part of Spaceship Earth..

The only experiment to measure key movements of dust on the Moon was our serendipitous invention of 4 Apollo Dust Detectors. Those successes led to current co-operative studies with designers of Chang'e-3 and -4 spacecraft.

Keys to successes include small dedicated teams sharing TLC cultures, innovation plus high alertness for synergies of engineering and science. After 60 years, major sustainable outcomes include Don Gurnett and Jim Burch, world's leading

space scientists who began in two such teams. Add thrift in everything but imagination and hard mental and physical work.

*Presented by: Prof. Brian J. O'Brien*

## **Autonomous recreation of missing data in space weather sensors**

Aidan O'Brien, Jalal Elwazze and Jason Held  
*Saber Astronautics*

Saber Astronautics liberally uses space weather data as a key input for satellite diagnostics, orbital permutation modelling, and space situational awareness. Reliability and consistency of time series space weather data is important for many of these techniques. Most of the industry is familiar with space weather satellites such as NASA ACE, DSCOVR, etc. However ACE has not been monitored consistently since 2015 when the DSCOVR spacecraft was launched. Whilst DSCOVR has the same scientific mission as ACE and also located at L1 Lagrange point DSCOVR also has data inconsistencies which impact models relying on time series inputs. With both satellites in the same location gap filling technique are possible to allow space weather operations and research to continue uninterrupted.

Data was collected from the Faraday Cup onboard the DSCOVR spacecraft and the SWEPAM sensor from NASA ACE and stored on a Saber Astronautics space weather cloud server. Relationships between the sensors were trained using Machine Learning for a model relating the heterogeneous sensors. We measured the accuracy of the model with time series cross validation and mean squared percentage error.

This presentation reports on the model's accuracy at recreating ACE data showing the potential to use data streams from one satellite to now-cast the measurements for another satellite in the same approximate volume of space which allows operators to have longer duration of service and more consistent service picture of the space environment.

*Presented by: Aidan O'Brien*

## **Risk Management Of Dust On The Moon: 2018 Updated Measurement-Based Case Studies**

Prof. Brian J. O'Brien

*School of Physics and Astrophysics, University of Western Australia*

The purpose here is to assist operational risk management of movements of fine dust during future human and robotic expeditions in the vacuum and dusty plasmas on the surface of Moon and large airless asteroids. Reliable simulation is not possible on Earth or near-Earth orbit of lunar dust movements in lunar daytime environments. So future expeditions must rely on past experiences and previous measurements on the lunar surface. We show that key official NASA Manned Spacecraft Center (MSC) dust reports can mislead.

Here we show Case Studies (CS) summarising 14 published measurement-based quantitative measurements of movements of dust, primarily from our 1966 invention, Apollo Dust Detector Experiment (DDE) deployed by Apollo 11, 12, 14 and 15.

CS1- Rocket exhausts: Moon Villages will involve dozens of rocket landings and ascents. Powerful rocket exhausts of Lunar Modules (LMs) ascending to lunar orbit caused (a) large and damaging contamination during Apollo 11 deployed at 17 m whereas (b) Apollo 12 at 130m caused cleansing and cooling, and (c) Apollo 14 at 180m caused smaller cleansing.

CS2 - Apollo astronaut experiences, qualitative but expert: Gene Cernan summarised Debriefings as "We can overcome other physiological or physical or mechanical problems except dust".

CS 3 - Hardware and equipment: Gaier (2005) catalogued 9 varieties of major operational problems caused by dust during Apollo 11 to 17. 23

CS4 - Sunrise-driven dust storms, measured only by Apollo 12 DDE.

CS5 - Amelioration of mining effects on Moon: from Case study 4.

CS6 - Dust adhesion to vertical versus horizontal surface: 1 example only.

CS7- Dust possible cause of immobilisation of Chang'e-3 Yutu: uncertain, co-operative analyses with CAST specialists continue as of July 2018.

While our simple 5-step measurement-based model of dust transport published in 2015 appears consistent with explaining decades-old mysteries, including (i) Horizon Glow, (ii) levitation of fine dust and (iii) smoothness of many lunar surfaces, it articulates no equations as yet and to our knowledge has not been assessed by theorists.

*Presented by: Prof. Brian J. O'Brien*



# Strategies for reducing Astronaut Radiation Exposure

Meg O'Connell  
*University of Queensland*

Reducing radiation exposure is a difficult but essential task in order to enable further manned spaceflight beyond low earth orbit. Radiation exposure can come from high-energy galactic cosmic rays, solar proton events and the radiation belts. Radiation poses not only short term sequelae of acute radiation sickness and CNS disturbances, but also long term issues of multi-system soft tissue degeneration and radiation carcinogenesis. This study aimed to explore the current strategies and models planned to mitigate radiation exposure.

Methods: A literature review was undertaken of Medline, Pubmed and Google Scholar. The Search terms "radiation", "exposure", "near earth orbit asteroids", "Orion", "MPCV", and "Lunar Orbital Platform Gateway", in order to quantify the current strategies for radiation exposure reduction.

Results: The majority of studies were conceptual. Physical shielding was the most commonly mentioned strategy, but one study mentioned also a mini magnetosphere could also be employed for active radiation shielding. Additionally, crew behaviours, pharmacological prevention and dietary countermeasures were all found to potentially reduce radiation on conceptual level.

## Conclusion:

Further research is required in this field, in particular, research to determine an appropriate model to conduct radiation exposure experiments in order to benefit manned spaceflight. The upcoming Orion missions will provide a unique insight into radiation exposure levels in the current Orion MPCV design.

*Presented by: Meg O'Connell*

## **Why would Australia need astronauts?**

James O'Connor

*University of Southern Queensland MSc Research student*

The recent formation of an Australian Space Agency (ASA) has fostered public reporting and discussion of an Australian astronaut program, a notable absence compared to many other nations. The ASA's stated roles mostly relate to policy, strategy, coordination and the development of Australia's space industry, but includes "inspiring the Australian community and the next generation of space entrepreneurs", suggesting a role for an Australian astronaut program in enhancing national pride, STEM education and the pursuit of space-related careers. This presentation surveys and analyses relevant research and media reports and online discussions to outline the possible national benefits of an Australian astronaut program.

*Presented by: James Hamish O'Connor*

# **Analysis of Effects of Magnet Configurations for Downscaled Cusped Field Thruster via Surrogate Assisted Evolutionary Algorithms**

Suk Hyun Yeo and Hideaki Ogawa  
*RMIT University*

Electric propulsion (EP) is a propulsion technology that offers promise for satellite and space missions owing to advantages over chemical propulsion in various aspects including fuel consumption hence launch cost. The cusped field thruster (CFT), in particular, is advantageous over other classes of EP such as the gridded ion thruster and Hall-effect thruster, featuring enhanced electron confinement enabled by magnetic mirror and reduced particle loss effects at the dielectric wall.

Growing interest and demand in high-performance EP for small payload applications in the latest space development has driven the endeavour devoted to physical modelling and performance characterisation of downscaled CFT suitable for microsatellite class platforms. Preceding research efforts have predominantly investigated the thruster performance and physical behaviour of CFT comprising three magnets. Research on downscaled CFT with an additional magnet ring hence cusp region, on the other hand, has rather been sparse, although it would represent a value in consideration of the uncertainties and complexities associated with the thruster design and physics.

This paper presents the results and insights obtained from a study undertaken by applying a state-of-the-art methodology combining high-fidelity simulations comprising modified power distribution calculations coupled with evolutionary algorithms assisted by surrogate modelling. Multi-objective design optimisation has been performed to maximise the thrust, efficiency, and specific impulse simultaneously, with the anode voltage and current, mass flow rate, magnet radii, and magnet and spacer thicknesses employed as decision variables. The results for CFT with four magnets have been analysed to investigate the influence of an additional cusp region in comparison with the three-magnet configuration. Covariance-based sensitivity analysis is performed to identify key design variables and their interactions and interdependencies for physical characterization and modelling of downscaled CFT.

*Presented by: Hideaki Ogawa*

**ANZSLIG Professional Development series - Export control  
laws**

Timothy O'Sullivan  
*Defence Export Control Office*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Timothy O'Sullivan*

## **Export controls and the Australian space research sector**

Timothy O'Sullivan

*Defence Export Controls, Department of Defence*

Australia's system of export controls exists to enable the responsible transfer of military and dual-use goods and technologies. We ensure that Australian exports don't damage our national interests - from supporting foreign terrorist organisations, to facilitating human rights abuses, to contributing to the proliferation of nuclear weapons and their means of delivery. Our regulations of course apply to arms sales, but also extend to numerous aspects of non-military space technology currently being developed and produced in Australia.

In this presentation, Timothy from Defence Export Controls will give an overview of the export controls that are relevant to the Australian space research sector and explain how Australia's regulations fit into the global export control regime and support Australia's prosperity in an international context. In particular, he will discuss the regulations on launch vehicles, payloads, subsystems, and broader international collaboration in space system development, and how these regulations apply to companies, universities and individuals. He will also explain how you can engage early with Defence Export Controls so that we can work together towards a regulatory solution that supports your needs.

*Presented by: Timothy O'Sullivan*

## **Buccaneer Risk Mitigation Mission – DST Lessons Learned**

Chris Peck  
*DST Group*

The Buccaneer Risk Mitigation CubeSat Mission was launched on 18th November 2017. It is a joint mission between University of New South Wales (UNSW) Canberra and Defence Science and Technology Group (DST Group). The BRMM is a risk mitigation mission for the future Buccaneer Main Mission (BMM) and is one of only a small number of Australian Defence-developed satellites. The key objectives of BRMM are (i) to undertake and monitor the complex commissioning of a high frequency receiver and antenna to be used for the Jindalee Operational Radar Network (JORN) calibration; (ii) to acquire accurate flight dynamics data for Astrodynamics and Space Situational Awareness models; (iii) to further develop Australian expertise in small-satellite development and operations.

DST Group developed their own ground station hardware infrastructure, software infrastructure, processing chain and operating procedures.

The Buccaneer team present the lessons they learned from operating the spacecraft and ground station in conjunction with UNSW for nearly a year.

*Presented by: Chris Peck*

## **A GPU based doppler and code search for the reception of satellite signals**

Edwin G. W. Peters and Craig Benson  
*UNSW Canberra Space*

We present a real-time GPU based algorithm to aid in the reception of satellite signals. The algorithm non-causally estimates Doppler, code rate and code phase. We utilise a bank of matched filters, all covering a few symbols (e.g. 5) and each representing a different code-word. Using this, the algorithm can be used for signals that do not utilise synchronisation sequences. The Doppler search is then performed by cross correlating frequency shifted versions of the filters with blocks of the received signal.

The cross correlation is done using FFTs and reduction sums on a GPU. This allows for a high resolution search or a search over a wide frequency range.

After finding the Doppler offset, the code-rate and code phase can be found directly from the cross correlation sequence.

Due to the use of matched filters for the Doppler, code rate and code delay search, different modulation schemes can be supported by merely replacing the filters.

The advantage of this approach is that besides the modulation scheme and a course estimate of the centre frequency, and code rate, no knowledge of the signal is required.

The computational efforts that are required for the presented method are however significant. In fact, a Matlab CPU based algorithm could not perform the Doppler search in real time for a low earth orbit satellite transmitting at a 9600 Hz symbol rate. However, the CUDA based GPU implementation resulted in significant performance gains which allow real-time Doppler search on entry level GPU's such as the Quadro K620.

The algorithm is currently in use for communications with an in-orbit satellite.

*Presented by: Edwin G. W. Peters*

## **Linking Upstream and Downstream Using Australia's Earth Observation Capabilities**

Stuart Phinn

*University of Queensland, Earth Observation Australia*

Australia's ability to significantly develop the upstream and downstream sectors of its space industry can be significantly improved by building our earth observation capacity. In this presentation we outline a strategy that allows Australia to build on several of its unique capacities in several select space industries. Earth Observation (EO) – the use of satellite based instruments to map and monitor the earth, is presented as an essential linking element. We are not suggesting the Australia's development of space capability is based solely on EO, but that it offers one strategy with a high chance of success. Complete end to end EO systems, in addition to the central people components, require design and build of satellite sensors, integration with a suitable satellite platform, launch of the system, operation of the satellite from ground facilities, and development of systems to collect, process and deliver information from the sensor. Each of these activities relates to a separate business or industry capability within the upstream and downstream sections of our space industry. Several examples from Australia are presented showing the use of this sequence of activities to deliver earth and non-earth observing satellite systems that built significant space capabilities.

*Presented by: Stuart Phinn*



## **SAR: The right information at the right time**

Conrad Pires  
*Conrad Pires*

The resources industry is an essential part of the Western Australian economy. As a Perth-based start-up, Picosat Systems has been investigating how to improve the industry's efficiency. We've discovered that mining companies require accurate, timely and cost-effective environmental information to help them plan and conduct exploration activities. This is not something exploration geologists easily have access to today. Our solution is to provide them this using synthetic aperture radar (SAR). SAR provides high-resolution, topographical imagery, allowing geologists to: use elevation information to calculate potential ore tonnage; determine optimal access paths for transporting exploration equipment; and characterise land structures to understand mineralogy. Using SAR based information from satellites, we're able to allow mining companies to make informed decisions to conduct exploration activities more safely, at a lower cost and with a lower environmental impact. Additionally, SAR is not impacted by clouds or night-time and we can capture information 24 hours a day.

Further investigation showed that this accurate, timely and cost-effective SAR-generated information has additional uses, such as: monitoring the environmental impact of deforestation; tracking ships and ocean-based oil spills; managing agriculture; managing assets in the resources industry; and conducting urban planning including traffic management. This SAR-based information has the ability to impact and improve the economics of industries.

Our proposal is to launch a constellation of small satellites to provide SAR information with a high-resolution and high-revisit time of ground locations. While there is significant value in selling the imagery generated, we will add further value by using AI and machine learning to determine patterns and relationships within the SAR information to meet our ultimate goal, which is to help our customers make the right decisions at the right time. We are looking for initial funding to develop and test our SAR prototype satellite.

*Presented by: Conrad Pires*

## **The Online College of Advanced STEM: Delivering Astronomy, Astrophysics, Data Science and Coding to High Capability High School Students**

David Platz  
*University of Southern Queensland*

Australian students entering university studies in Science, Technology, Engineering and Mathematics (STEM) appear to be increasingly unprepared by their high school education, with a particular problem being that many gifted students are not enabled to pursue high school STEM studies that lead to the university degrees and careers needed for Australia's future. To address this problem, advanced STEM courses for high capability high school student have been developed and delivered online, with the initial focus being The School of Astronomy & Astrophysics (TSAA). Strong enrolment growth and evidence of student success for TSAA graduates has led to the formation of a more broadly-based Online College of Advanced STEM (OCAS). As of 2018, OCAS enrolments have grown to over 100 high capability STEM students from across Queensland, Australia and the world, and this upward trend is continuing, with plans to offer a wide range of mathematics and science studies. OCAS also continues to demonstrate the effective delivery of a school STEM online learning experience, with partner universities and industries now able to provide extension and research activities.

*Presented by: David Platz*

## **Space Law: Lessons for Australia and New Zealand**

Dr Maria A Pozza  
*GQ Law - New Zealand*

New Zealand enforced the Outer Space and High-altitude Activities Act 2017 on 21 December 2017 as a result of increasing interest in New Zealand from geo-location and economical perspectives, as a nation that might be able to facilitate launch services of satellites in Low Earth Orbit. Foreign interest in New Zealand's progressing space-services market has seen an increase in foreign direct investment into the industry. Whether New Zealand is ready or not, it has officially become an 'emerging space-faring nation'. However, is New Zealand ready or sufficiently equipped to fully exploit its new title and, is it able to learn from the tough lessons experienced by Australia in order to side-step similar and problematic hurdles? During the Act's legislative process, the Author proposed several changes to the Select Committee that were adopted into the Act based on the Australian experience, and this presentation speaks to those changes. In this way, the presentation will consider the strengths and weaknesses of the New Zealand Space Act and offer a comparative analysis between the Australian Space Activities Act 1998 and the Space Activities Amendment (Launches and Returns) Bill 2018 in its present form.

There are a number of pertinent lessons that both New Zealand and Australia may learn from the other in order to ensure a solid space legal-policy framework, enhanced national and trans-Tasman security, and better consistency between the two approaches, that will serve to avoid a conflict of national space laws in the not-so-distant future.

*Presented by: Dr Maria A Pozza*

## **Leo Aerospace: A balloon launch startup**

*Leo Aerospace*

The emerging small satellite economy is hindered by a single outstanding problem: Access to space.

Microsatellite developers—whether they are established companies, researchers, or independent interest groups—are impacted by the current launch market. They are constrained to rideshare on large launch vehicles, meaning they cannot choose to which orbit their satellite is delivered. Furthermore, these launches are delayed on average by 6 months. Speaking to executives of small satellite companies, this has devastating consequences on their business models which rely on timely operation of satellites.

There is a plethora of other technical issues faced by these satellite developers—from launch frequency to pricing and launch availability—but everything can be represented as a symptom of a larger ailment:

**The Microsatellite Launch Problem Is Being Approached With a Big Satellite Mindset.**

*Presented by: Bryce Prior*

## **Australian Space Missions: Thinking Bigger**

Mark Ramsey  
*Sitael Australia*

Australia is having a resurgence in interest in Space, and the broader benefits that it can achieve for the nation. With a newly established Space Agency, and increased Defence spending, the time is right to start to think big about what Australia can achieve in future missions and the Space Economy. Locally, Australia has had recent success in cubesat development and technology missions, particularly with organisations such as DST Group, Skykraft, Inovor, Myriota and Fleet. However, the time is coming when Australia can move beyond the cubesat paradigm and think bigger. Sitael Australia plans to design, build, integrate and test mini and micro class satellites (50kg-300kg) locally, leveraging European platform technology to deliver Australian missions. Sitael Australia also plans to establish an Australia earth station, to support missions globally. In doing so, Sitael Australia wants to support Australia take the next big step in our Space journey.

*Presented by: Mark Ramsey*

## **Ground based observations of the near space environment**

Iain Reid

*Atradi Pty Ltd and Adelaide University*

Recent improvements in analysis techniques and the availability of long data sets together with better instrument coverage have enabled insights into coupling between the Sun and the Earth's mesosphere lower thermosphere (MLT) region. We report on data from several meteor radars that have been used to demonstrate the influence of short term and periodic solar variations on the density, temperature and winds of the MLT region.

*Presented by: Iain Reid*

## **Towards an intelligent biometric device for holistic astronaut health**

Natalie Rens  
*Spaceport AI*

Bahareh Nakisa  
*Queensland University of Technology*

Mohammad Naim Rastgoo  
*Queensland University of Technology*

Oluseun Aremu  
*University of Queensland*

Individuals on long space flight missions are going to face a number of extreme challenges in terms of medical, psychological, and social health. This is heightened by the loss of real-time communication to mission control as the distance to Earth increases, with a communication lag of 4-24 mins for a future Mars settlement. Rather than acting in response to events, it will become critical to proactively monitor health in order to prepare for and, ideally, mitigate emergencies.

Wearable technologies in combination with artificial intelligence presents a strong solution for real-time monitoring and prediction of human states. At Spaceport AI, we are aiming to develop a fully-embedded biometric device that could provide a continuous holistic measure of health. To do so, we are engaging in a series of smaller commercial projects using smart wristbands as well as wireless electroencephalogram (EEG) devices that together record electrophysiological responses and brain activity.

Using lightweight physiological sensors in combination with deep learning (ConvLSTM), we have demonstrated a fast and accurate system that can detect and predict mental states, such as stress, fatigue, and emotional states. We have validated these in contexts such as watching movies and driving. Our focus is now on developing these systems in real-world applications, especially in health care.

*Presented by: Natalie Rens*

## **Integrated System-level Modelling of a Reusable LH2/LOx-fed Expander-bleed Cycle Rocket Engine**

Matthew Richardson  
*The University of Tokyo*

Hiroaki Kobayashi, Satoshi Nonaka and Yoshifumi Inatani  
*Japan Aerospace Exploration Agency (JAXA)*

The Japan Aerospace Exploration Agency (JAXA) is currently developing the RV-X – a flight test vehicle for demonstrating Reusable Launch Vehicle (RLV) technologies and operations. The RV-X is a single-stage VTVL suborbital rocket, powered by a single reusable LH2/LOx-fed expander-bleed cycle rocket engine. The engine has a reusability design requirement of 100 flight cycles, which has been verified through ground testing. While a reusability rate of 100 flight cycles represents state of the art in reusable rocket engines, to achieve true “aircraft-like” operations, future RLV engines will be required to significantly exceed this rate.

The combustion chamber is a primary life-limiting component in this engine. Reducing combustion temperature by changing the oxidizer-to-fuel mixture ratio has been proposed as a service life extension method. Reducing combustion temperature in turn reduces thermal loading on the combustion chamber walls, decreasing the severity of low-cycle fatigue. However, changing the mixture ratio in a LH2/LOx-fed expander-bleed rocket engine could have wide-ranging flow-on effects. For example, thrust, specific impulse and turbopump performance could be impacted.

To investigate the above-mentioned issues, an integrated system-level model of a rocket engine has been developed, using the JAXA engine as a baseline. CFD models of the combustion chamber and cooling system have been established. Analytical models based on design data have been developed for other components, such as turbopumps, valves, propellant manifolds and the fuel mixer. The analytical models are scalable, to reflect potential design changes required to operate at non-normal mixture ratios. The models are integrated together through appropriate data flows and control inputs. The integrated model is solved iteratively, with heat transfer between the combustion chamber and cooling system serving as a convergence metric. The model has been verified through comparison of outputs to reference data for the JAXA engine operating at 100%, 70% and 40% thrust levels.

*Presented by: Matthew Richardson*



# **Particle-in-Cell Analysis of Ion Detachment from Ambipolar Propulsion Devices with Differing Magnetic Nozzle Geometries**

A. Ryan  
*University of NSW*

M. Bilek, I. Cairns, D. McKenzie, J. Olsen  
*University of Sydney*

Particle-in-Cell simulation is a kinetic particle modelling technique that has become an increasingly effective utility for the analysis of high energy plasma discharges. The Particle-in-Cell code V-Sim has been demonstrated to accurately simulate ambipolar acceleration through a magnetic nozzle, and provides a valuable source of data for the optimisation of similar devices.

This research analyses the incidence of ion detachment from the magnetic nozzles of two distinct ambipolar propulsion systems, thus ensuring net thrust. This is achieved by determining the regions within the simulation domain that have a plasma beta exceeding unity during quasi steady state flow, where the plasma beta is determined using the ratio of ion and Alfvén speeds. The data presented endeavours to distinguish the region beyond which the plasma is considered detached. Results are further scrutinised by analysing the varying axial and perpendicular energies of a series of test ions, relative to the displacement from the throat of the magnetic nozzle.

*Presented by: Alexander Ryan*

## **The Mars 2020 Rover Mission**

Mitchell Schulte  
*NASA Headquarters*

The next rover mission to Mars represents the culmination of almost two decades of strategic missions in the exploration of Mars. Our understanding of the Red Planet has evolved from a global frozen desert to a dynamic world that once was warmer, wetter, and may have supported microbial life. The series of missions reflects this evolution, moving from global reconnaissance, to following the water, to seeking the signs of life. The Mars 2020 rover will be outfitted with seven sophisticated payload elements to conduct remote sensing and in situ science, demonstrate exploration technology, and cache samples for potential return to Earth. The instrument suite includes a combination of a zooming, binocular, multi-spectral camera; a telescopic imager; two Raman spectrometers with different wavelength lasers; a visible/near-infrared spectrometer; a Laser-Induced Breakdown Spectrometer; an X-ray fluorescence spectrometer, a microscopic imager, and ground-penetrating radar. Together, they will enable the science team to establish the geological context of the landing site area, assess whether past or present environments could support microbial life, search for potential biosignatures, and use this information to identify samples for caching. The Mars 2020 Rover Mission is the first step in bringing samples of known provenance from Mars back to Earth for study, and the mission will be collecting approximately 20 core samples for eventual return during its prime mission. To prepare for future human exploration, the payload includes the ability for in situ resource utilization, converting CO<sub>2</sub> from the martian atmosphere to O<sub>2</sub>, the ability to assess physical characteristics of the dust, and environmental monitoring of the temperature, pressure, humidity, wind, and radiation at Mars' surface. The Mars 2020 mission will pave a significant portion of the path to Mars for scientific understanding and future human exploration.

*Presented by: Mitchell Schulte*

## **Space Science: Empowering STEM learning**

Danielle Shean and Michael Pakakis

*Victorian Space Science Education Centre*

A unique characteristic of space science is its holistic nature: it encompasses many fields of science, technology, engineering and mathematics. This, similarly, is the way in which STEM (Science, Technology, Engineering and Mathematics) education in secondary and primary schools should be approached. STEM is not a new concept to education, but it is an increasingly important one in the light of today's demand for technical expertise, both digital and analogue. There exists a set of 'soft' skills which run parallel to this demand and which are becoming more and more relevant: skills such as cooperation, critical evaluation and thinking, creativity and communication. Here, space science as a teaching tool comes into its own. Its use in STEM is pedagogically powerful: it inspires, generates curiosity and engages. Key programs such as the Victorian Space Science Education Centre's (VSSEC) Mission to Mars, Surviving Mars, Primary Mars Base, Robotic Mission to Mars and What are Stars? demonstrate the collegiate nature of space science in their stress on the importance of every aspect of the 'mission'. These programs give students agency over their own learning, place them in the real world and stimulate them to make educated diagnoses and evaluations based upon their own understanding and experience. Space science can also impart an important truth to today's learners: there is no one direct way to reach a conclusion. Not everything is correct the first time; it is the very mistakes and errors made on the way that inform decisions and lead to real depth of understanding. Further, as all space scientists, technicians, engineers and mathematicians know, research and collaboration are not conducted in a vacuum.

*Presented by: Danielle Shean*

## **STEM and the realm of hands-on constructivism**

Danielle Shean  
*Victorian Space Science Education Centre*

It is generally accepted that the importance of students undertaking STEM programs cannot be stated too highly; but what is not articulated as strongly are the engagement and agency created by constructivism and engineering with purpose. The importance of creating with purpose lies in the blending of science, mathematics, engineering and technology. Creating with purpose increases students' confidence, their ability to communicate ideas, their creative and critical thinking and their capacity to collaborate and cooperate with their peers. These are the 21st Century skills that employers and researchers so keenly desire. Constructivism also allows students to approach difficult tasks with confidence, to persevere in the face of adversity and, in moving themselves deliberately out of their comfort zones, to increase their understanding of the world around them.

*Presented by: Danielle Shean*

## **Mars radiation exposure risks - The shielding effect of a graphene space suit and a storm shelter during transit.**

Tim Squire

*Canberra Hospital & University of Notre Dame Australia*

With NASA planning a mission to Mars a significant amount of research is being performed investigating the health risks associated with a deep space mission. The number one health risk posed to astronauts is radiation exposure. This risk must be understood prior to a mission beyond Earth's protective magnetosphere. Galactic cosmic radiation (GCR) consists mostly of protons and a small amount of biologically significant heavy charged particles which are difficult to shield against. Spontaneous particle events (SPE) are mass ejections of protons from the sun. Strategies exist to mitigate effects from radiation including optimisation of shielding against heavy charged particles with large volume and heavy materials being impractical due to their limitation on spacecraft launch.

The purpose of this research was to employ radiobiological principles and incorporate tools provided by NASA to develop a spacesuit and design a "storm shelter" which minimized radiation exposure to astronauts during a mission to Mars and improve the chances of successful interplanetary travel.

Access was granted from NASA to utilize the OLTARIS space radiation modelling tool to investigate thirty potential shielding materials. Their ability to decrease equivalent and effective radiation dose received by a computerized phantom was assessed during GCR and SPE.

Thirty materials were tested for their shielding efficiency during a simulated 360 day return trip to Mars. Promising materials were those that were light-weight and maximised fragmentation. The optimal suit was composed of a single layer of carbon atoms known as graphene. The graphene suit reduced effective dose compared with a standard spacesuit by 32% (453mSv/yr vs 660mSv/yr). This equates to a relative cancer risk reduction from stochastic effects by 1% (2.5% vs 3.5%). The most effective shielding mechanism during a SPE was achieved by modelling a "storm shelter" where a large water/fuel tank was positioned to create a barrier surrounding the astronauts. The water barrier reduced effective dose by 98.8% (44mSv vs 3614mSv).

A graphene based space suit can decrease astronaut exposure to harmful radiation during transit to Mars facilitating interplanetary travel. A storm shelter using liquid as a barrier also decreased radiation dose during a SPE.

Access was granted from NASA to utilize the OLTARIS space radiation modelling tool to investigate thirty potential shielding materials. Their ability to decrease equivalent and effective radiation dose received by a computerized phantom was assessed during GCR and SPE.

Thirty materials were tested for their shielding efficiency during a simulated 360 day return trip to Mars. Promising materials were those that were light-weight and limited nuclear fragmentation. The optimal suit was composed of a single layer of carbon atoms known as graphene. The graphene suit reduced effective dose compared with a standard spacesuit by 68.6% (453mSv/yr vs 660mSv/yr). This equates to a relative cancer risk reduction from stochastic effects of 28.6% (2.5% vs 3.5%). The most effective shielding mechanism during a SPE was achieved by modelling a "storm shelter" where a large water/fuel tank was positioned to create a barrier surrounding the astronauts. The water barrier reduced effective dose by 98.8% (44mSv vs 3614mSv).

A graphene based space suit can decrease astronaut exposure to harmful radiation during transit to Mars facilitating interplanetary travel. A storm shelter using liquid as a barrier also decreased radiation dose during a SPE.

*Presented by: Tim Squire*

## **Buccaneer Risk Mitigation Mission – Ground Station**

Natalie Stevens and Rob Earl

*DST Group*

The Buccaneer Risk Mitigation CubeSat Mission (BRMM) was launched on 18th November 2017. It is a joint mission between University of New South Wales (UNSW) Canberra and Defence Science and Technology Group (DST Group). The BRMM is a risk mitigation mission for the future Buccaneer Main Mission (BMM) and is one of only a small number of Australian Defence-developed satellites. The key objectives of BRMM are (i) to undertake and monitor the complex commissioning of a high frequency receiver and antenna to be used for the Jindalee Operational Radar Network (JORN) calibration; (ii) to acquire accurate flight dynamics data for Astrodynamics and Space Situational Awareness models; (iii) to further develop Australian expertise in small-satellite development and operations.

DST designed and built a ground station and mission control system at their DST Edinburgh site in South Australia to support the operation of Buccaneer. Manual, automatic and semiautomatic operations are supported and extensive mission planning capabilities are available to the user. The DST Group ground station hardware includes a custom-designed UHF antenna and a 1.8m S-Band dish with automated tracking from 10 degrees elevation and in 360 degrees azimuth. A software defined radio (SDR) and GNU-radio processing chain allow rapid development of processing algorithms. The Buccaneer team present the details of their ground station, operations and options for future missions.

*Presented by: Natalie Stevens*

# **Recruitment Challenges for the Australian Space Industry**

Raymond Stott

*SpaceRayStott ,*  
*<https://www.spaceraystott.com>*

This oral presentation will cover the following issues:

- Introduction and status of space/satellite situation in Australia (Australian Space Agency white paper etc.)
- market opportunity (upstream and downstream)
- Expected job numbers, typical job descriptions and roles
- Typical projects current, planned and future
- Coordination with Aerospace/Defence sector
- Barriers to growth/implementation
- Coordination with STEM/University/Colleges/Higher Education
- Australian diaspora and attraction mechanisms for future workforce
- Salary compensation and packages
- Immigration and Visa assistance for overseas talent
- Problem areas and critical subjects/jobs for next 5 years
- Lessons learned from UK and other recent country examples that are relevant to Australia
- Global competition for the NewSpace workforce
- Work/Life balance
- spaceraystott and space specialist assistance in recruitment, training and consultancy services worldwide
- Summary



**ANZSLIG Professional Development series - Regulation of  
the electromagnetic spectrum**

Matthew Stubbs and Stacey Henderson

*The University of Adelaide*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Matthew Stubbs & Stacey Henderson*

## **Australian Bureau of Meteorology Aviation Space Weather Services**

Michael Terkildsen, Balwinder Arora, Kirco Arsov, Phillip Maher,  
Vickal Kumar and Murray Parkinson  
*Bureau of Meteorology*

This presentation will introduce our efforts to become an International Civil Aviation Organisation (ICAO) recognised provider of space weather services for regional and international aviation.

Space weather impacts aviation in various ways including:

- The availability and accuracy of GNSS positioning and timing systems.
- The availability and quality of satellite communication systems.
- The availability and quality of HF radio communication systems.
- The cosmic radiation environment impinging avionics and humans.

The products and services developed to mitigate these impacts will be discussed.

*Presented by: Michael Terkildsen*

## **Guardian Satellite-based Flow-Chemistry System Producing Quantum Dots as Counter Measure to Divert Missile Attack**

Nam Nghiep Tran<sup>a</sup>, Quy Don Tran<sup>a</sup>, Shaokun Shen<sup>a</sup>, Hung Nguyen<sup>b</sup>, Volker Hessel<sup>a</sup>

<sup>a</sup>*School of Chemical Engineering, The University of Adelaide, Australia, SA 5005*

<sup>b</sup>*Teletraffic Research Centre, The University of Adelaide, Australia, SA 5005*

Protection systems for the growing number of satellites and other space assets against hostile threats and collisions should have the ability to precisely replicate the spectral signature of the target to act as an effective decoy. Quantum dots are well known for their size-dependent electro-optical properties, and by controlling the geometrical size, shape and the strength of the confinement potential, they can be easily tuned to emit radiation at desired wavelengths. This study introduces an on-board flow chemistry-based counter measure system employing quantum dots to divert the missile attack from a spacecraft or a satellite. The space asset that is to be protected is monitored for threats by a ground tracking system which sends early warnings about a detected missile to the space control centers which in turn can activate the guardian satellite (a nanosatellite of less than 100 kg) orbiting in the co-orbit of the space asset. Upon activation, the guardian satellite releases the cloud of quantum dots so as to trick the missile into seeking the decoy instead of the protected asset.

The key innovation of this study is the quantum dots are produced by a flow chemistry system on board and in real-time (within seconds) with unrivaled quality regarding size, size distribution, and shape. Thus intensity and quality of their optical (luminescent) properties are on best standard which means maximal effect in acting as decoy to divert the missile attack. It will be aimed to engineer quantum dots to produce any kind of spectral signature by mixing different kinds (InSb, PbTe, HgTe, HgSe, CdTe, CdSe and CdS) and sizes in the required ratio so as to mimic the exact spectral signature of the target.

The research will be performed under simulated outer space conditions and the effect of hard UV, x-ray radiation, etc. will also be tested.

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## **How does the spacecraft environment increase host susceptibility to infectious diseases?**

Vienna Tran  
*The University of Adelaide*

This paper will review current literature and discuss how spaceflight impacts an astronaut's in-flight susceptibility to infectious diseases. Both the astronaut and the microbe are affected by spaceflight, as shown by studies both in-flight and on Earth. Stress, microgravity, and the isolated nature of the spacecraft have been found to compromise the immunity of the astronaut, while microbes have demonstrated rapid adaptation to their unfamiliar environment, including genetic mutation and increased virulence. Further research into infectious diseases and effective countermeasures are essential for the future of human space travel.

*Presented by: Vienna Tran*

# **Design of a Deployable Lightweight Nanosatellite Antenna**

Baptiste Trotobas

The nanosatellite business is constantly increasing, their missions become more and more complex, however, their communication systems have remained stagnant. This paper talks about a new generation of lightweight and deployable antenna (LDA) to improve the efficiency and usability of nanosatellites.

Based on the Astromesh® concept developed by NASA, the LDA system has been designed as an assembly of rigid beams where two nets are attached onto it. Those nets are linked by tensile ties in order to balance the tension force. That configuration has been demonstrated as being the most efficient for yielding the best results possible.

This paper presents two parts – design and simulation. The design concerns mostly the deployable ring and the antenna shape which the last one has been performed by using a new algorithm following the principle of the Force Density Method (FDM). The FDM can ensure a uniform tension at the surface, which is needed for its manufacturing.

The simulations have been undertaken to ensure the Space Qualification of the LDA (by considering a Thermal & Mechanical studies). Thermally, the purpose is to ensure that radiation and space temperature range will not modify the structure of the ring, but especially of the Antenna, in order to continue to send and receive signals. Mechanically, studies are vibratory, to test its withdraw during the launch. In both of case, final results are promising.

*Presented by: Baptiste TROTABAS*

## **Performance Bounds on HF Backscatter Leading Edge Inversion**

Michael Turley and David Netherway  
*Defence Science and Technology*

In this contribution we calculate the performance bounds on estimating an ionospheric electron density height profile from inversion of a high frequency backscatter sounder ionogram. Backscatter sounders (BSS) are instruments that measure ionospheric propagation support between the instrument location and remote down range locations. Ionograms are constructed of the returned signal power as a function of carrier frequency and group range. Receive arrays permit azimuth discrimination. BSS ionograms thereby provide a continuous observation of the ionosphere over a vast and remote area.

BSS ionogram inversion offers an estimation of the ionospheric profile for this area. Unfortunately uncertainties in many of the factors that determine the ionogram make this task problematic. Instead the process typically focuses on extraction and inversion of the ionogram one-hop leading edge (LE) feature.

The ionospheric profile complexity is reduced by assuming a multi-layer quasi-parabolic (QP) parameterisation with three principal layers (E, F1 and F2) together with joining segments. The inversion from a BSS ionogram LE to a QP ionospheric profile is an ill-posed problem, leading to the need for further model assumptions or severe regularisation (smoothing) of the solution. Researchers have indicated this problem without quantification. By performing a Cramer-Rao Lower Bound (CRLB) analysis, we calculate the performance bounds on estimating each of the QP parameters from the BSS LE observations. The bounds scale with the BSS LE observation variance for which distributions are measured. The minimum variances of the QP F2 layer parameters are derived and shown to depend on the number of LE samples and their frequency span. Frequency span is shown to be the most significant factor but breaks-down with ionospheric spatial heterogeneity; this leads to the need for smooth solutions or reliance on supplementary joint information.

Finally we introduce the concept and performance of ionospheric mapping based on multiple overlapped BSS coverages.

*Presented by: Michael Turley*

## **The Implications of the Orbital Dynamics of Jupiter's Satellite System on the Habitability of Exomoons**

Christopher Tylor, Brad Carter, Jonti Horner, Stephen Kane and  
Stephen Marsden

*USQ*

In recent years, astrobiologists have begun to seriously consider the possibility that suitable conditions for life to develop might be found on planetary satellites, as well as on planets themselves. For this reason, the moons of planets around other stars (Exomoons) provide a fascinating route by which astrobiological studies can move beyond the search for habitable-zone planets. Habitability fundamentally depends on the reliability of the energy supply (astrophysical, geophysical or geochemical) for life, and the local environment. The icy moons of the outer Solar System already provide targets for the search for subsurface oceanic life. Given that such satellites rely on tidal heating to provide a stable environment for life, a key factor in Exomoon habitability would be the long-term orbital stability of a given moon around the host exoplanet. In this project, the long-term orbital stability of the Jovian moons is explored using numerical modelling with the REBOUND N-body integrator code to assess the potential for significant orbital changes on timescales of tens to hundreds of millions of years. The results to date indicate that the Jovian satellite system is characterised by an extremely stable orbital configuration, and hence provides a thermally stable environment to within one part in 100,000 in energy input into any subsurface oceans present over timescales of at least tens of millions of years. As a result, those moons could provide a stable environment for life to develop and survive. These results can be used to speculate that a range of stable Exomoon orbital configuration and environments could exist that expand the potential number of habitable worlds well beyond the estimates made on the basis of classical habitable-zone exoplanets alone.

*Presented by: Christopher C.E. Tylor*



## **Radiation Shielding: Novel use of scattering phenomena**

Shane P. Usher

*Department of Chemical Engineering, The University of Melbourne*

Space crew launch rates have been curtailed by safety considerations for decades. Now, there is optimism that the transport problem is being solved with improved rocket launch reliability that will bring crew to space in large numbers. Establishing an enduring human presence in space looks to be within reach. That success will bring the next challenges to the fore.

The primary sources of radiation in the solar system are the Sun and cosmic radiation. External radiation is prevented from reaching the surface of Earth by a magnetic field and atmospheric absorption, equivalent to metres of lead. These natural protective barriers are absent in outer space and on planetary bodies that lack a significant atmosphere or magnetic field. Minimising radiation exposure in space, on the Moon, Mars and beyond is essential to establishing an enduring human presence in space.

On the Moon and Mars, in the absence of a magnetic field or sufficient atmosphere, the expected solution is to bunker down under metres of regolith. Under normal circumstances, relatively thin spaceship walls aren't as effective, but can shield radiation so that crew exposure is within arguably safe limits. Unfortunately, solar flares and emissions from galactic events can produce radiation levels that exceed the wall shielding capacity, requiring emergency procedures that maximise the mass between the source and crew.

There is a complementary solution to the shortcomings of radiation absorption, namely scattering the radiation with an object a reasonable distance before it reaches the surface or spaceship. This scattering significantly reduces the intensity of radiation to be absorbed. The use of scattering for radiation shielding is introduced for the following five case studies:

1. Spaceship Fleet Configuration
2. Shield Satellites
3. Sun Shade Drones
4. Elevated Sun Shade Structures
5. Divergent Lenses

*Presented by: Shane P. Usher*

## **Satellite propulsion system**

Ivan Voropaev  
*Ivan Voropaev*

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Satellite propulsion system converts electricity into the satellite's motion.

We built laboratory prototypes and tested them in different conditions.

We recorded stable impulses. The force correlates with input.

In the pool, prototypes move smoothly. We controlled prototype's direction and speed.

Our drive can be used as a main drive or for orbit correction and for other simple manoeuvres on an orbit.

We have recorded test data and video.

*Presented by: Ivan Voropaev*

## **The Accuracy of Space Weather Services Automatically Scaled foF2 Data**

Kehe Wang, Colin Yuile, Garth Patterson, Murray Parkinson and  
Vickal Kumar

*Space Weather Services, Bureau of Meteorology*

Scaled ionospheric foF2 data is used in ionospheric foF2 mapping, T-Index (ionospheric index) calculation, ionosphere research and HF communication services. In previous decades, the Australian Bureau of Meteorology, Space Weather Services (SWS; formerly named IPS) relied on the manual scaling (parameterisation) of ionograms. With the development of the IPS 5A digital ionosonde, the autoscaling software "Autoscale" was developed and put into production in the early 90's. It has since become essential for the near real-time analysis of ionograms, and for the creation of SWS HF products. SWS ceased full manual scaling of ionograms in 2014.

The accuracy of autoscaled ionospheric data has been verified through extensive comparison between manual (valid) and autoscaled foF2 data. However, it is still necessary to comprehensively evaluate the accuracy of the autoscaling software with ionograms from different geophysical locations with different altitudes, longitudes and times. This paper will thoroughly compare all available manual scaled and autoscaled foF2 data for all SWS IPS 5D ionosondes between 2000 and 2014. The results of this study will be useful in improving the autoscaling software, providing researchers with more accurate autoscaling results in the future.

In order to conduct this comparison, two intranet webpages were developed within the SWS WDC Intranet. The result shows that the accuracy of autoscaling of low-mid latitude stations is generally better than high latitude stations. This study demonstrated that SWS autoscaling software compared favourably with manual scaling, and that the accuracy of the results indicates that autoscaling is an acceptable alternative to manual scaling in most cases. The use of autoscaling within SWS saves time and human resources. Most importantly, the software makes near real time foF2 mapping and HF forecasting possible. This comparison of autoscaled and manually scaled foF2 data will be used as the basis for analysis of other ionospheric parameters, such as foE, H'F2 and M(3000)F2, etc.

*Presented by: Kehe Wang*

## **Ultra-Low Frequency wave correlations between Van Allen E-B measurements and conjunct ground magnetometer data.**

Liam Warden  
*University of Newcastle, Australia*

Electrons within the radiation belts of the magnetosphere can be energised to relativistic (MeV) energies. These energised electrons are capable of causing large-scale damage to communication satellites and networks. Although the exact energisation method is not known, a potential theory links the electric field amplitude of Ultra Low Frequency (ULF) waves in the Pc3–5 range, as an energisation mechanism. Suitable in situ measurements of the ULF field amplitudes are difficult to obtain due to a lack of satellite coverage. Ground magnetometers provide a much wider spatial coverage and are particularly useful when coupled with computational models that could accurately map ULF wave propagation between the equatorial region of the magnetosphere, through the ionosphere, to the ground. This mapping would allow for remote sensing of electric field amplitudes of ULF waves in the equatorial region based on ground based magnetic field amplitudes. Previous studies are few, with one case using an  $e/b$  ratio from the Polar satellite and Canadian CARISMA ground stations, giving an estimated equatorial electric field as 1.7 mV/m compared to 1.5 mV/m recorded by the Polar satellite. However, this methodology used excluded important inductive effects of the ionosphere, over simplified assumptions on wave spatial structure and ULF wave propagation mode. Only one case has been presented in the literature so far. In this presentation, several addition events are presented and discussed, using ground magnetometer and electric field data from the Van-Allen Probe.

*Presented by: Liam Warden*

## **Characterisation of Near Earth Asteroids - An Asteroid Mining Perspective**

John Patrick Weir  
*University of Southern Queensland*

With the advancement in our understanding of celestial bodies that travel near Earth it has become clear that asteroids and comets are well within our reach to use for the harvesting of resources. These resources will involve uses both on Earth as well as in orbit around the Earth. There is also the potential for asteroids and comets to provide the off-Earth fuel and launching stations required for true deep space exploration. Resources of interest include water for use as fuel in space (including the potential use in commercial and government satellites in Earth orbit) and precious metals and minerals.

A range of facilities are currently in place to view near Earth objects and the majority of these take images that provide a snapshot of an instant of the asteroid or comet's brightness and position. Telescopic systems coming online over the next couple of years will take the number of near Earth objects that have been catalogued in this way from tens of thousands to millions. This dramatic increase in the knowledge of location and orbital path of these bodies leads to a need for a vast amount of follow up research to allow for a complete understanding of the commercial feasibility of mining targeted asteroids and comets.

This follow up work can be completed using a range of methods which would be designed specifically for the task at hand. This proposal explores the structure and potential scientific and economic success of one such method which comprises of a reasonably low cost global telescope network allowing for long term imaging of the asteroids and comets of interest.

*Presented by: John Patrick Weir*

**ANZSLIG Professional Development series - Space  
applications: launch**

Anthony Wicht  
*Bain & Company*

Part of proposed 'space law professional development' series of  
short presentations for benefit of researchers and start-ups

*Presented by: Anthony Wicht*

## **CSIRO's Space Activities and the CSIRO Space Roadmap**

Dr David Williams  
*CSIRO Astronomy and Space Science*

Dr Sarah Pearce and Mr Warren Flentje  
*CSIRO Strategy and Market Vision*

CSIRO is home to two of Australia's national space facilities, the Australia Telescope National Facility and the Canberra Deep Space Communication Complex (CDSCC). A new national facility in the NovaSAR satellite will be added this year through an investment with Surrey Satellite Technology Limited. CSIRO also has world-leading capabilities in earth observation data analytics and applications development, and is currently establishing several new initiatives to develop capability in relation to small satellite technology. This presentation will give an overview of CASS's current role and capabilities, and provide an update on Australian involvement in the international Square Kilometre Array (SKA) radio-astronomy project, the status of the Australian SKA Pathfinder, current and future activities at CDSCC, CSIRO's Centre for Earth Observation, and other recent developments.

This presentation will also discuss the opportunities for space industry growth in Australia identified in a new Space Roadmap from CSIRO. The roadmap introduces promising opportunity areas for Australia for a mainstream audience by combining industry trend analysis with Australia's natural comparative advantages, consultation with industry from multinational space primes to start-ups and a review of recent industry analyses and submissions to the (Space Agency) Expert Reference Group report. The roadmap identifies three opportunity themes for the growth of Australia's space industry: Space-derived services, Space object tracking and Space exploration systems. It suggests short-term and long-term technology developments that will unlock these opportunities for Australia alongside key enablers and R&D priorities.

*Presented by: Dr. Sarah Pearce*

## **The modulation of EMIC waves in the inner magnetosphere**

Joshua Williams, Brian Fraser, Colin Waters and Murray Sciffer

*Center for Space Physics, School of Mathematical and Physical  
Sciences, University of Newcastle, NSW, Australia*

Electromagnetic Ion Cyclotron (EMIC) waves in the Pc1-2 (0.1-5Hz) range are formed in Earth's magnetosphere by the anisotropic temperature of the ring current interacting with cold plasma populations in the outer plasmasphere. A subset of these waves are observed to modulate in amplitude, forming discrete packets and are known as 'pearl' pulsations. The free energy for the growth of these waves is well known to come from the temperature anisotropy instability. The process responsible for the modulation of the growth rate is much less understood.

This packet structure was once thought to be due to bouncing of one or a few wave packets along geomagnetic field lines between conjugate ionospheres. Observations of the bounce time and the unidirectional nature of the wave Poynting flux above 11 degrees magnetic latitude make this explanation unlikely. As a result, several competing theories now exist. One theory involves the direct or indirect modulation of the Pc1-2 wave growth rate by longer period Pc3-5 (2-100mHz) waves via the wave magnetic field, cold plasma density perturbations, and/or changes in the ring current density or temperature anisotropy. Evidence supporting this theory has previously been observed on earlier spacecraft (e.g. CRRES). This talk will present observations of Pc3-5 signatures concurrent with pearl Pc1-2 waves from the recent Van Allen probes mission and discuss their properties in the context of this model.

*Presented by: Joshua Williams*



## **Rocket Manufacturing in South-East Queensland**

Fabian Zander

*Mechanical and Electrical Engineering, University of Southern  
Queensland*

Philip Teakle

*Teakle Composites*

David Buttsworth

*Mechanical and Electrical Engineering, University of Southern  
Queensland*

Richard Morgan

*Centre for Hypersonics, The University of Queensland*

A rocket manufacturing capability has been under development in south-east QLD since 2000. The program started with the manufacture and testing of high performance solid propellant at the Centre for Hypersonics at The University of Queensland. It expanded to include the filament winding of lightweight rocket motor casings, tanks, nosecones and nozzles, becoming a complete rocket manufacturing capability. The later stages of this were supported by 'Smart State' funding, allowing the capabilities to be scaled up so that batches of approximately 20kg of high performance solid propellant could be manufactured.

By 2011, several high performance (high propellant mass fraction and high specific impulse) solid propellant rockets up to 200mm in diameter and with 60kg propellant had been manufactured and tested. These used filament wound carbon fibre casings and nozzles lined with an EPDM insulation layer. A propellant slurry was mixed in a remotely operated heated vacuum mixer then cast directly into the casing under vacuum. After curing for 7 days the propellant casting tooling was removed by remotely operated equipment. The motor assembly was completed and they were stored in an explosives magazine until static testing. Additionally, large (up to 600mm diameter) lightweight hypersonic nosecones were produced for several scramjet flight tests conducted by the Defence Science Technology Group; and large filament wound pressure vessels were produced for hybrid rocket and non-rocket applications.

Future plans include further development of the 20kg rocket motor into an upper atmosphere sounding rocket and affordable hypersonic test vehicle. The former application would involve launching an instrumented dart to altitudes over 100km and plans

to utilise the launch services of the German DLR Mobile Rocket Base. The latter would involve free flight testing of small payloads at speeds in excess of Mach 5. We are also discussing other applications for this capability with partners from research organisations and industry.

*Presented by: Fabian Zander*