

# UC Rocketry history

- Started in 2009/2010 – UC summer project, Malcolm Snowdon and Avinash Rao, 2 launches (Ellen 1 and Lisa I)
- > 50 launches from 2009-2017 (Kaitorete Spit, Tekapo, Mangakahia), Waikaia Southland (planned)



STACY SQUIRES/The Press  
ROCKET MEN: Avinash Rao, left, and Malcolm Snowdon launched their rocket about 700 metres into a clear blue sky above North Canterbury yesterday.

Malcolm



Malcolm

Launch into orbit  
by Rocket Lab  
(Mahia peninsula)



# Student training/employment

- UC Rocketry (since 2011) → 5 Masters students, 4 PhD students, 3 undergraduates
- Several postgraduates in key leadership roles for propulsion, GNC and avionics
- A number of other UC undergraduate engineers have also been hired at Rocket Lab



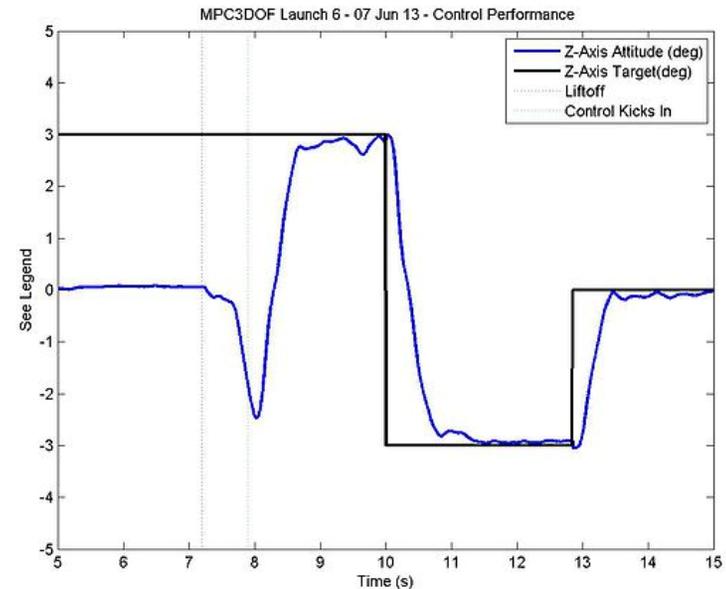
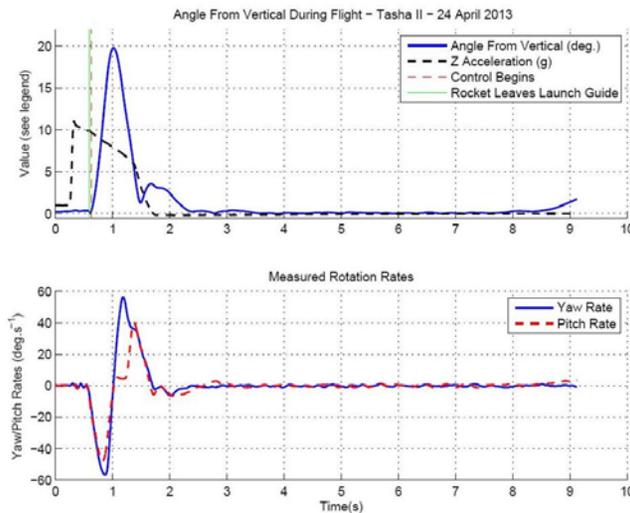
# Launch operators

- 5 launch operators at Mahia Peninsula
- 4 in charge of teams:
  - Avinash Rao (PhD) – Director of Mission Delivery and Planning
  - Lachlan Matchett (ME) – VP of propulsion
  - Adam Slee (ME) –Launch Conductor
  - Hoani Bryson (ME) – Team Leader in Avionics



# Research highlights

- Control capability =  $\sim 0.1$  deg (pointing)
- Successfully stabilized aerodynamically unstable vehicle
- Research foundation for GNC on Electron



- Developed orbital trajectory optimization capability for Rocket Lab
- Designed original orbital trajectory of Electron from Birdlings Flat
- Passed knowledge on to students (Callaghan)

# Satellite propulsion and ADACS research

- The NZ Government, Ministry of Business Innovation and Employment are looking to fund space research in NZ
- Robinson Institute at Victoria University Wellington, University of Auckland and University of Canterbury are placing a combined bid for a project titled:  
**“High-magnetic-field plasma propulsion systems enabling next generation small satellite missions”**
- Idea is to use propulsion system elements like dynamo and magnetic field to develop an ADACS without using any excess energy
  - ➔ Could either significantly reduce the mass of existing satellite ADACS for an existing torque
  - ➔ Or significantly increase the torque for the same mass
- The use of Astrobeer would help de-risk the mission in case there is a launch or satellite failure during the final launch with Rocket Lab. Proving the concept of the thruster on Astrobeer would enable investors to have confidence to further develop the project.

# Astrobee proposal

## Ground tests – Simulator, Astrobee Micro Gravity Test Facility and Granite table labs

- Software-in-the-loop thruster + astrobee hardware: multiple thrusters to simulate impact of both the dynamo's and magnetic field dynamics
  - Develop model that maps astrobee thruster actuation dynamics onto dynamo/magnetic field actuation dynamics, apply in both simulator and hardware
  - Also program astrobee thruster responses to simulate a 6U cubesat response including inertia (that is, essentially changing the effective inertia of the Astrobee)
- Implementation of thruster prototype in the astrobee payload bay
  - Dynamos only (turn off magnetic field) and simulate magnetic field from thrusters
  - turn off astrobee ADACS and use payload to perform ADACS (totally self-contained)
  - interface payload commands to thrusters to mimic smaller inertia for 6U cubesat compared to Astrobee

## ISS

- Apply software-in-the-loop + astrobee hardware onboard ISS
  - Compare results with ground tests and update software as required (iterate)
- Implement thruster prototype as ADACS of astrobee (dynamos on/magnetic field off and dynamos on/magnetic field on)

# Control testing (ground tests and ISS)

- Attitude step responses with disturbances simulated by Astrobee thrusters:
- Guidance maneuver to change orbit trajectory slightly.
- De-tumbling tests
- Characterise maximum torques available and limitations of actuation
- Analyse experiments and design improvements including updating model parameters

## **Research questions:**

- Can astrobee thrusters be programmed to mimic a 6U cubesat response?
- Are the thrusters suitable for simulating magnetic field changes over time at the required speed?
- What impact do time-lags in the astrobee actuation system have on the simulation of the 6U cubesat?
- Can the new thruster system control the astrobee?