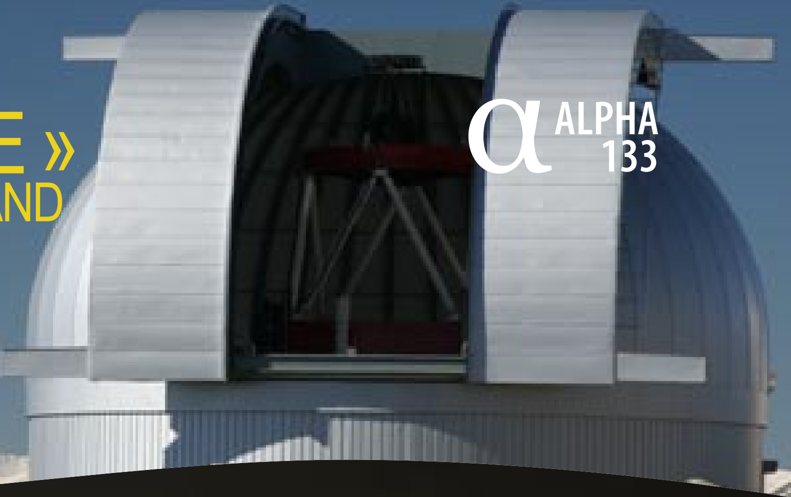
» OUR PLACE IN SPACE »
SPACE RESEARCH IN NEW ZEALAND



» From missions to the International Space Station to discovering new planets, astronomers, scientists, teachers, technicians and engineers around New Zealand are involved in a variety of space-related research, an industry which, because of our geographical location, is set to rocket ahead in this country. »

» The Jules Verne is a space-tug and cargo-carrier which carried approximately 4.6 tonnes of cargo to the International Space Station as it orbits around the Earth. The cargo included experiments, equipment, spare parts, fuel for the space station's engines, as well as food, clothes and tanks containing air and drinking water for the people on board the space station. On future ATV missions, the cargo will be increased to around 7.4 tonnes.

Rocket tracking and working with the International Space Station

Because of our strategic location, New Zealand radio astronomers, engineers and technicians played a vital role in the success of the March 2008 mission to the International Space Station. The mission saw the launch of Jules Verne, the first ever Automated Transfer Vehicle to rendezvous with the space station.

Jules Verne was built in France by an international team of companies, and was commissioned by the European Space Agency (ESA). It was carried into orbit around the Earth by a launch vehicle called the Ariane 5. The launch lifted off from the ESA's spaceport in Kourou, French Guiana, on 9 March 2008.

On 3 April, Jules Verne docked with the station. As the big cargo section is fully pressurized (meaning it contains breathable air like the rest of the space station), astronauts dressed in normal clothing, rather than space suits, could enter the section as soon as it had latched onto the International Space Station.

» DID YOU KNOW?

When an object in orbit about another object, for example a satellite around the Earth, slowly loses altitude and moves closer to the central object (e.g. the Earth), this is known as a degrade in orbit. In the example of a satellite moving about the Earth, a degrade in orbit can be caused by drag from the Earth's atmosphere.

The Ariane 5 and Jules Verne blasts off from the ESA's spaceport in Kourou, French Guiana, on 9 March 2008 at 05:03 CET, 01:03 local time, (5.03pm NZ time).

» » NEW ZEALAND'S ROLE

So Jules Verne could meet with the International Space Station, its launch trajectory passed just to the south of Stewart Island. Important activities, including adjustments to orbits and separation of the space-tug from the launcher, were observed using radio telemetry from a tracking station at Awarua, a remote and radio-quiet area ten kilometres south of Invercargill, at the southern end of New Zealand's South Island. The station includes a specialised 3.5 metre diameter dish tracking antenna, although the ESA plan to fund new equipment for each launch.

⇧ *A rocket tracking antenna at Awarua.*

The ESA is planning between six and ten supply missions to the International Space Station between 2008 and 2016, which will all use the Awarua facility. When not in use for the ESA, the facilities will be available to radio astronomers and students throughout New Zealand.

The Jules Verne will remain attached to the space station for up to six months. During this time the cargo will be removed and the empty cargo section filled with over six tonnes of rubbish. After this, Jules Verne will undock from the space station and perform a controlled re-entry into the Earth's atmosphere; the plan is that Jules Verne will enter at such a speed that it will burn up over the Pacific Ocean and, in the process, dispose of all the waste material.

» » WAG THE DOG

As well as carrying cargo, Jules Verne can control the entire space station's altitude (distance from the Earth). On 25 April the ESA used the engines on Jules Verne to move the space station 4.5 km to a height of 342 km above the Earth's surface. This is to compensate for the degrade in orbit caused by drag on the station by the Earth's atmosphere.

⇧ *Inside the Awarua tracking station, a rocket tracking technician, Leon Korkie, works with the tracking equipment to track Jules Verne as it passes over New Zealand's skies.*

» DID YOU KNOW?

The trajectory is an arc (path) made (or likely to be made) by an object, such as a bullet or a launched rocket, as it moves from its launch position to its point of impact. The moving object has had some force applied to it to set it moving on its path.

⇧ *The Awarua Rocket Tracking Station.*

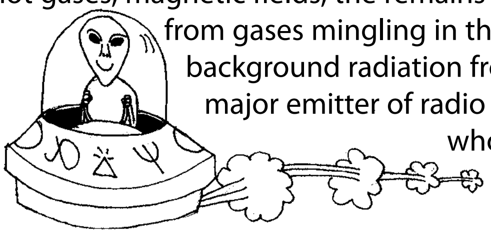
More detailed information about this mission is available in a Royal Society of New Zealand's Gamma at http://www.rsnz.org/education/gamma/SpaceProgramme.php

For more about missions by the European Space Agency see http://www.esa.int.

» MORE ABOUT RADIO ASTRONOMY »

» » WHAT IS RADIO ASTRONOMY?

Radio astronomy is the study of radio waves from space using radio telescopes. It began in 1932 when Bell Telephone Laboratories engineer Karl Jansky began investigating radio interference and found the central region of our Milky Way galaxy to be a noise source. Radio waves are emitted from hot gases, magnetic fields, the remains of supernova explosions such as the Crab Nebula, pulsars, from gases mingling in the birthplace of stars, from quasars beyond our galaxy, and background radiation from the Big Bang – the origin of our universe. Our own Sun is a major emitter of radio waves; this was discovered by radar operators in World War II who found they sometimes mistook the Sun for incoming bombers. We've tried to pick up radio waves from alien intelligence, but no luck so far (at least none publicly known!).



» » WHAT IS A RADIO TELESCOPE?

A radio telescope doesn't look like an optical telescope at all. It is usually made of a large dish antenna, like many people would have to receive satellite TV only very much bigger. The 64 m diameter Parkes Antenna, which featured in the Sam Neil movie, The Dish, is one such antenna. This dish was big enough for the astronomers to play cricket in!

Sometimes radio telescopes are made in a trough shape, or even for low frequency observations, a length of wire. A wire radio telescope can be made with just of a couple of dipoles (a rod aerial usually one half-wavelength or a whole wavelength long) – which is enough to observe strong radio sources such as the Sun and Jupiter, while the largest in Russia looks like a kiwifruit orchard dripping with wires. Radio telescopes receive radio waves. This usually doesn't have anything to do with listening out for aliens as some people may suppose, although if they were broadcasting radio waves we might pick them up. We have radio telescopes to detect radio waves emitted naturally by objects in space.

The dish on a radio telescope collects and focuses the received radio waves as a concave mirror would with light. The dishes are so large because resolution (the closest angular separation that can be discerned) is a function of the observation frequency and the aperture of the observing eye, or telescope. For example, a dish operating at 1.4 gigahertz (20 cm wavelength - radio waves have a much longer wavelength than visible light) would have to be 2 km in diameter to just match a human eye at 550 nanometres (green light). Several dishes can be linked together to form an array - this is like having one giant dish made of many little dishes, the data from the separate dishes is combined using a technique called aperture synthesis. For example, there is a Very Large Array in New Mexico made up of 27 dishes, arranged in a Y-shape. Although each dish is only 25 metres across, the arrangement simulates a single dish with a 27 kilometre diameter! When dishes are used in this way, the combining technique is called interferometry. When the dishes are hundreds or even thousands of kilometres apart, the combining technique is called Very Long Baseline Interferometry (VLBI). We link dishes or aerials together in this way as it improves the resolution through increasing the effective aperture of the telescope. To make it work, data sampled from each antenna must be "timestamped" by a very accurate atomic clock and the data from each antenna is then able to be combined with all the other antenna data using a mathematical operation called deconvolution to create an image with resolution equivalent to the longest baselines. This requires a high performance computer, or even a super-computer.

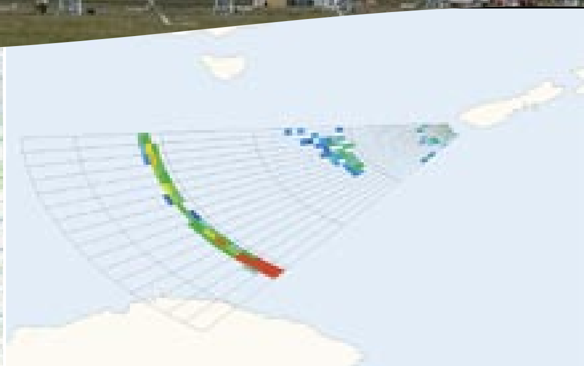
⇧ *The famous Parkes radio telescope, which starred in the movie The Dish.*

» DID YOU KNOW?

Radio telemetry is the process by which information is gathered and recorded at a distance. In the case of rocket tracking, electronic equipment on board the tracked rocket collects and processes data, such as location, altitude, attitude, engineering data, hull conditions, etc., and then relays this data as an encoded signal to receiving stations (rocket tracking stations) back on Earth where the data is decoded, recorded and analyzed.

» THE UNWIN SUPERDARN ARRAY »

⇦ The location of the Unwin SuperDARN array in Awarua, a remote and radio-quiet area ten kilometres south of Invercargill, at the southern end of New Zealand's South Island.



⇦ A sample output from the Unwin Array. The blue and green blocks of colour at the bottom of the fan, closest to New Zealand, represent reflected radio waves from micro-meteorites ionising the ionosphere, the middle band with blue and green is reflected radio waves from the ocean and the band closest to Antarctica with red, yellow, blue and green represents radio waves reflected from the ionosphere.

Awarua's lack of radio pollution and its proximity to the South Pole has attracted the attention of other international space projects. In 2005, the $3 million Unwin Array at Awarua, was commissioned by Australia's La Trobe University. The Unwin facility is a high frequency (8 MHz – 20 MHz – megahertz means one million cycles per second) stereo auroral radar which forms part of an international SuperDARN network to study ionospheric activity (phenomena that occur 100 to 300km above the Earth's surface) such as the Aurora Australis (Southern Lights).

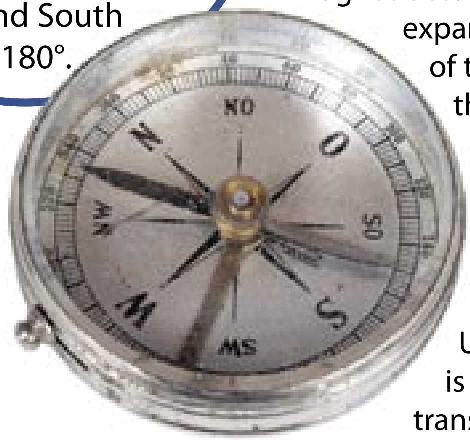
SuperDARN stands for Super Dual Auroral Radar Network, the entire SuperDarn network is made up of nine radar arrays in the Northern Hemisphere which study ionospheric activity over the North Pole region and six radar arrays in the Southern Hemisphere which study ionospheric activity over the South Pole region. Of those in the Southern Hemisphere three of the arrays are located on the Antarctic Continent, one is on Kergeulen Island, one is at the bottom of Tasmania and the last is our array in Awarua.

Extending the coverage away from the pole into what is known as the sub-auroral regions at the bottom of New Zealand and Australia means that the international team of researchers can observe new phenomena and improve the coverage of auroral phenomena during magnetic storms when the aurora expands equatorward of the footprints of the other radars in the SuperDARN network.

Unlike the Australian array, New Zealand's Unwin array radar is a stereo system, transmitting two different set of frequencies simultaneously. Unwin is only one of three stereo radars to be operated in the SuperDARN

»DID YOU KNOW?

The azimuth is a horizontal angle measured clockwise in degrees from a reference direction, for example, if North is the reference point (0°), then East has an azimuth of 90° and South is 180°.



community and the only high frequency stereo radar to be operating in the Southern Hemisphere.

The antennas in the radar are made up of various equipment supported on 15m tall towers shaped like a capital 'T'. The towers are arranged in two arrays, the main or primary array is made up of 16 towers, and the secondary interferometer array has four towers.

Each antenna is fed by a 600W power amplifier and a phasing network is used for beam forming and to electronically steer the radar into one of sixteen different beam directions. These 16 directions represent an array of over 52° of azimuth.

The radar transmits a short sequence of pulses in the high frequency band and samples the returning echoes. The sequence of pulses, referred to as a multi-pulse sequence, is carefully designed to allow the Doppler characteristics of different targets to be determined at multiple ranges. Echoes, representing ionospheric activity such as the Aurora Australis, can be detected from as close as 180km and as far away as 3330kms.

»DID YOU KNOW?

A Doppler radar works by transmitting radio waves into the sky. The radio waves bounce off different targets such as clouds. If the clouds are moving away the returning radio waves are stretched out and become longer as the target moves away. If the clouds are moving towards the radar the returning waves are squeezed and become shorter.

» THE SQUARE KILOMETRE ARRAY »

The success of the Unwin SuperDARN project and the European Space Agency ATV launch also means that New Zealand (as part of an Australasian consortium) is now one of two locations being considered for a NZ$2.4 billion international radio astronomy project called the Square Kilometre Array (SKA).

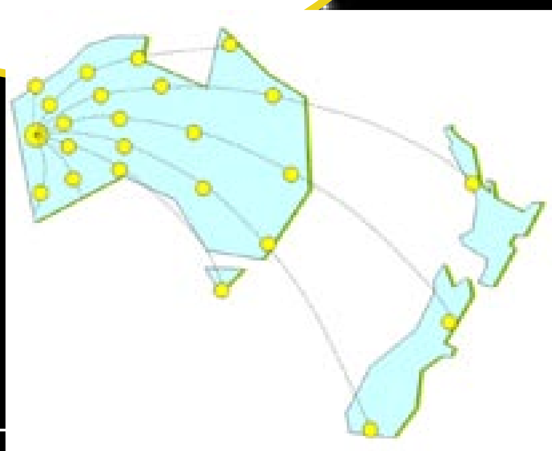
The SKA project is a plan to build the world's largest radio telescope. The project participants are a consortium of space research organisations from 17 countries.

Radio Astronomer, Professor Sergei Gulyaev, is the New Zealand SKA Project Leader for New Zealand's bid to become co-host to part of this giant network making up the telescope. He explains our involvement. "The Square Kilometre Array is not just one giant radio telescope but a set of linked antennas sites spread over a vast area. Despite the vast area, the entire actual collecting area is a square kilometre – hence the name. This giant array of radio transmitters and receivers will be 50 times more sensitive and 10,000 times faster than the most powerful currently in existence, and will be capable of far greater penetration into the depths of the universe."

Modern radio astronomy uses advanced computing and high-speed data communication networks to mimic a huge antenna or radio telescope by connecting a number of much smaller and cheaper, well separated radio telescopes as part of a technique known as electronic Very Long Baseline Interferometry (e-VLBI). This is a vast improvement on the traditional method of VLBI where data is recorded onto magnetic tape and shipped to one location to be processed on a central correlator, which normally took weeks. e-VLBI means that radio astronomers can now make observations in real-time, for example they can observe rapid transient radio sources, such as X-ray binaries, gamma-ray bursts, flaring stellar systems, and supernovae in nearby galaxies.

»DID YOU KNOW?

Very Long Baseline Interferometry is when separate radio telescopes - possibly in different countries, around the world or even in space, observe the same distant object in space from their respective positions. The radio signals received at each telescope are fed into a computer. Because the distance travelled by the waves from a particular radio source are different for each radio telescope, this creates an interference pattern which the computer can analyse to provide as much detail as possible about the source of the radio waves. An interference pattern is created when two or more waves are combined to produce a single wave of larger or smaller amplitude depending on whether the contributing waves are in or out of phase with each other.



⇨ The layout of the square kilometre array, each Australian site will have an array of 15 to 20 dishes. It is likely New Zealand will have two or three sites.

» MICROLENSING - DISCOVERING NEW STARS AND PLANETS »

In late 2007, a team of astronomers at New Zealand's Mt John observatory in Canterbury discovered a small star with its own planet some two to three times larger than Earth, 3000 light years away.
The international team includes New Zealand astronomer Dr Ian Bond from Massey University in Auckland. Software that Dr Bond has developed is used for the analysis of data in the microlensing technique used to discover the star and planet.
Dr Bond says the discovery is significant because it means that even the lowest mass stars can host planets. Dr Bond says in the near future it may be possible to see signs of life on planets like this, when NASA launches a more powerful successor to the Hubble space telescope.

» MORE ABOUT THE SQUARE KILOMETRE ARRAY »

If Australia and New Zealand win the bid to host the SKA, New Zealand will probably have two to three sites, with each site having an array of 15 to 20 dishes. One of these sites would be in the North Island and one or two in the South Island, making the east-west baseline of the entire array over 5500km. Australia would have approximately 100 sites, with most of these being in Western Australia.
"The potential for exciting new discoveries on the origins of our universe is set to revolutionise astronomy, physics and many other areas of science. Such is its importance that it is being hailed as the greatest scientific project of the 21st Century," says Professor Sergei Gulyaev.
Professor Gulyaev says that at present the Australasian bid is battling it out with South Africa to host the Square Kilometre Array. While both sites have suitable radio quiet, sparsely populated, barren areas, Professor Gulyaev feels that Australia and New Zealand may have an advantage, "Australia and New Zealand are both sophisticated societies with stable political and social environments and extensive engineering capabilities. Australia is a world leader in radio astronomy, and we both punch above our weight in internationally recognised astronomical research."

⇧ *A prototype 12 metre radio telescope under construction in Auckland.*

Current work in radio astronomy, VLBI and e-VLBI is centred on the Institute for Radiophysics and Space Research (IRSR) at the Auckland University of Technology. AUT is investing $1million into a prototype radio telescope – a 12 metre dish – which will boost New Zealand's chances of co-hosting the SKA. Installation of this radio telescope began in mid-2008 at a site near Warkworth.

The discovery was made through the new Japanese-funded MOA telescope, the world's largest telescope dedicated to gravitational microlensing and the biggest telescope in New Zealand. MOA stands for microlensing observations in astrophysics. The telescope has a 1.8-metre aperture, and a field of view in excess of two square degrees. It has a large electronic camera mounted at the prime focus. The camera can take photos with 80 million pixels. Many millions of stars can be recorded in a single exposure of dense stellar fields such as in Sagittarius at the centre of the Milky Way.
The newly discovered star has a mass only about 6 percent of our Sun and is so small it may not be able to produce energy by nuclear fusion as our own Sun does (the Sun produces heat and light by the nuclear fusion of hydrogen atoms into helium atoms). The planet is larger than Earth, but has a smaller orbital radius, similar to Venus, and, because its sun is so small, it is likely to be colder than Pluto. The MOA team thinks that the planet could have a thick atmosphere underlain by a deep ocean warmed by internal heating from radioactivity.
The heating of the planet from radioactive decay was likely keeping its ocean liquid, yielding a possible habitat for life.
A paper about the discovery of the star and planet has been accepted for publication in The Astrophysical Journal, and is expected to be published in September 2008.

» MICROLENSING - DISCOVERING NEW STARS AND PLANETS »

⇧ *The camera for the MOA telescope at the Mt John Observatory in Canterbury.*

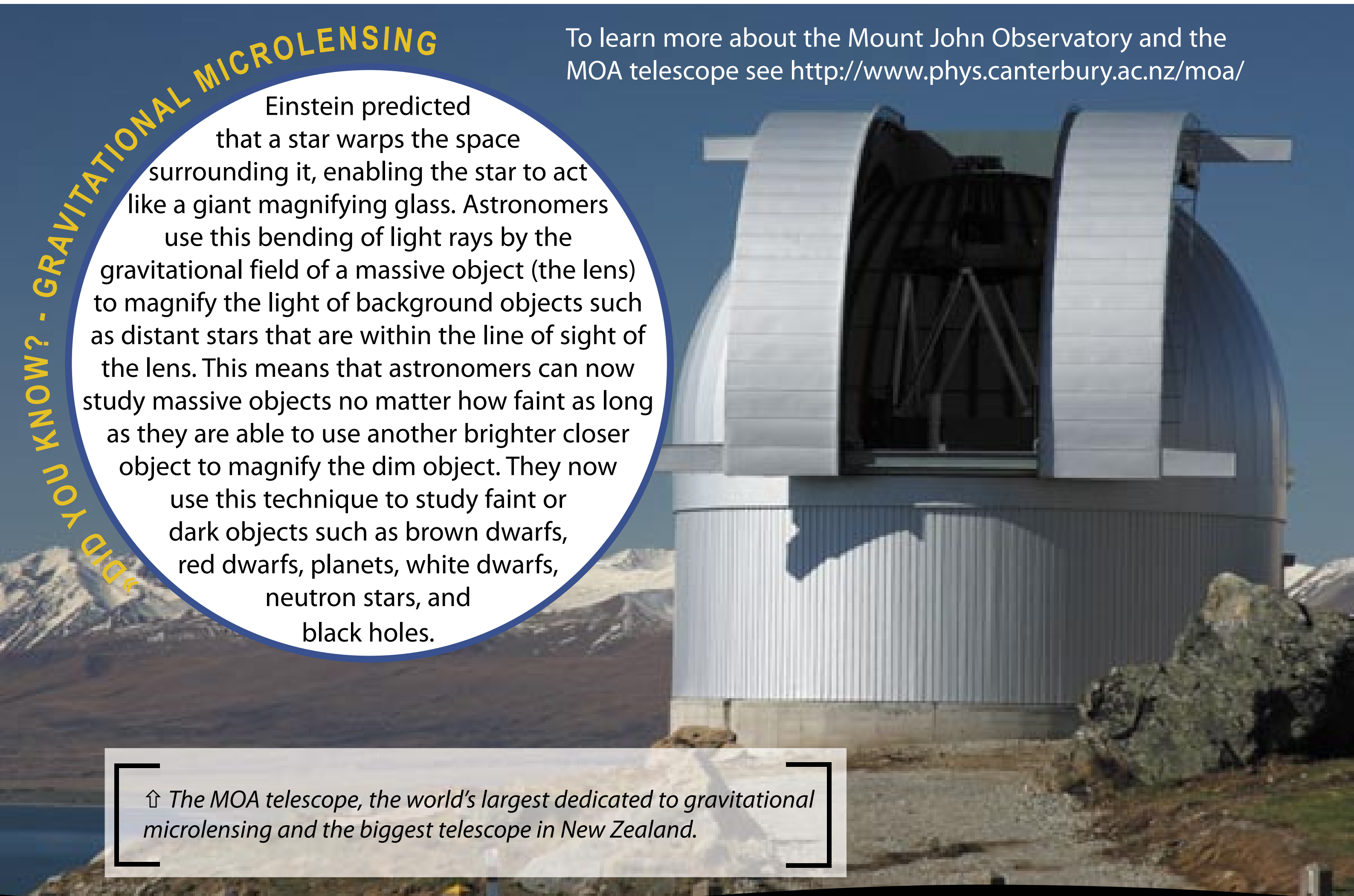
In 2007, also using gravitational microlensing, the international team discovered a solar system that is similar to our own. The astronomers were able to observe a star and two giant planets, but there could be other smaller planets included in the system as well. The observation lends further weight to the idea of there being a larger number of Earth-like planets than previously thought (Kerr, 2008).

The MOA group is made up of astronomers from Nagoya University, Konan University, Nagano National College of Technology, and Tokyo Metropolitan College of Aeronautics in Japan, as well as Massey University, The University of Auckland, Mt John Observatory, the University of Canterbury, Victoria University in New Zealand, as well as Dr David Bennett of Notre Dame University. Additional astronomers include staff from the Warsaw University Observatory in Poland, the Universidad de Concepción in Chile, the University of Cambridge, the Institut d'Astrophysique de Paris, the Observatoire Midi-Pyr´en´ees, the Observatoire de Paris, the European Southern Observatory in Chile, and Heidelberg University.

»DID YOU KNOW? - GRAVITATIONAL MICROLENSING

Einstein predicted that a star warps the space surrounding it, enabling the star to act like a giant magnifying glass. Astronomers use this bending of light rays by the gravitational field of a massive object (the lens) to magnify the light of background objects such as distant stars that are within the line of sight of the lens. This means that astronomers can now study massive objects no matter how faint as long as they are able to use another brighter closer object to magnify the dim object. They now use this technique to study faint or dark objects such as brown dwarfs, red dwarfs, planets, white dwarfs, neutron stars, and black holes.

To learn more about the Mount John Observatory and the MOA telescope see http://www.phys.canterbury.ac.nz/moa/



⇧ *The MOA telescope, the world's largest dedicated to gravitational microlensing and the biggest telescope in New Zealand.*

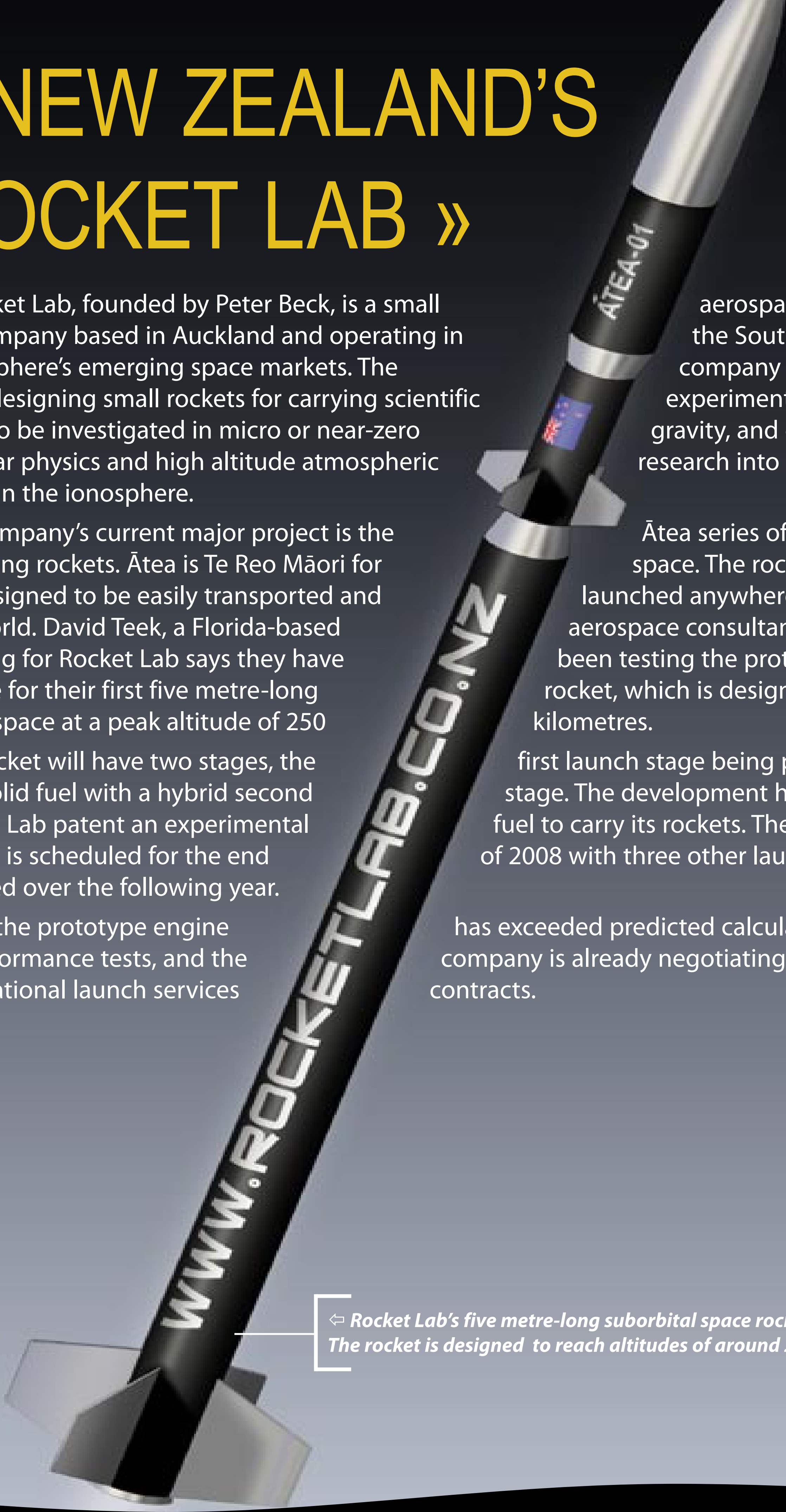
» NEW ZEALAND'S ROCKET LAB »

Rocket Lab, founded by Peter Beck, is a small aerospace company based in Auckland and operating in the Southern Hemisphere's emerging space markets. The company have been designing small rockets for carrying scientific experiments which need to be investigated in micro or near-zero gravity, and equipment for solar physics and high altitude atmospheric research into close orbits in the ionosphere.

The company's current major project is the Ātea series of suborbital sounding rockets. Ātea is Te Reo Māori for space. The rockets are designed to be easily transported and launched anywhere in the world. David Teek, a Florida-based aerospace consultant currently working for Rocket Lab says they have been testing the prototype engine for their first five metre-long rocket, which is designed to reach space at a peak altitude of 250 kilometres.

The rocket will have two stages, the first launch stage being powered by a solid fuel with a hybrid second stage. The development has seen Rocket Lab patent an experimental fuel to carry its rockets. The first launch is scheduled for the end of 2008 with three other launches planned over the following year.

So far the prototype engine has exceeded predicted calculations in performance tests, and the company is already negotiating two international launch services contracts.



⇦ Rocket Lab's five metre-long suborbital space rocket the Ātea. The rocket is designed to reach altitudes of around 250km.

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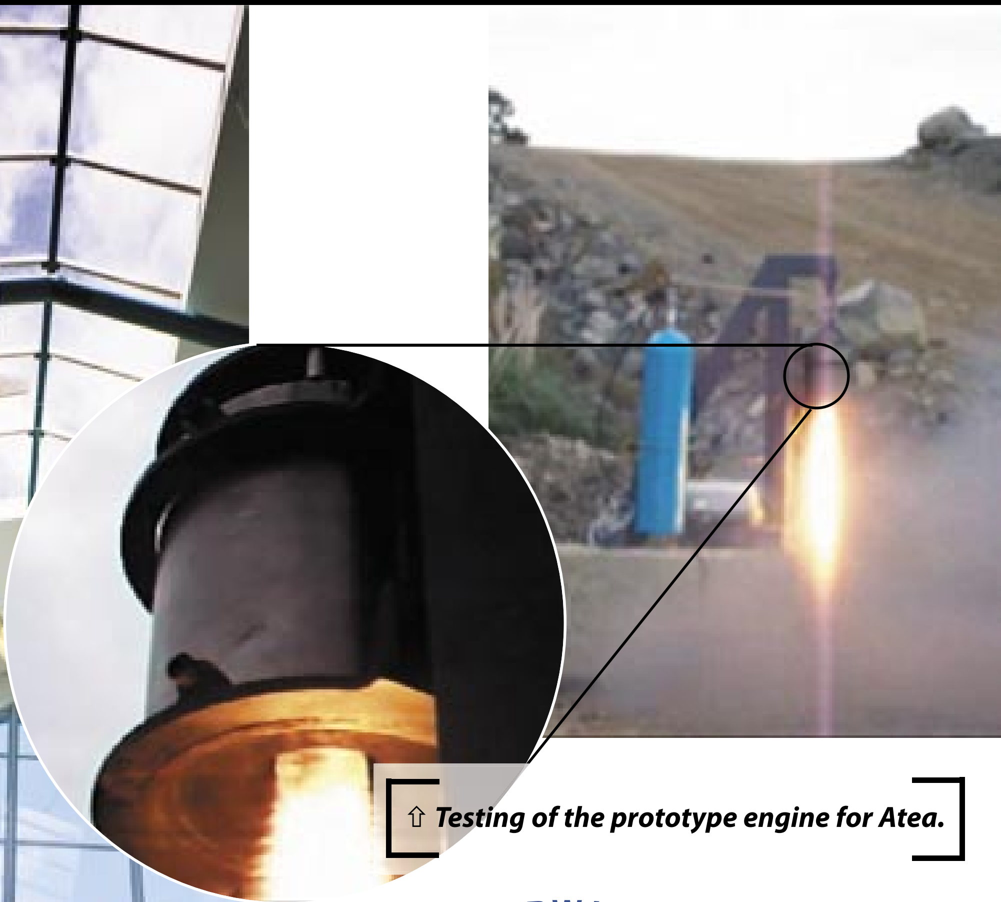


⇧ *Testing of the prototype engine for Atea.*

⇧ *The Ātea under construction.*

»FAST FORWARD - SPACE RACE

David Teek says the goal of Rocket lab is to establish a thriving New Zealand space industry. "The potential for space research in New Zealand is huge. Now, we're taking the first few steps down that road and if we start having scientific vehicles launched from here - does that open the door for more experimental development? What do we need for a launch site? The development of suborbital space passenger vehicles (Virgin Galactic and others) will lead to new operational sites worldwide, and this would be a good fit for New Zealand. In addition to the rich space tourists, the systems are also being designed to support microgravity research."

To learn more about the Rocket Lab see http://www.rocketlab.co.nz

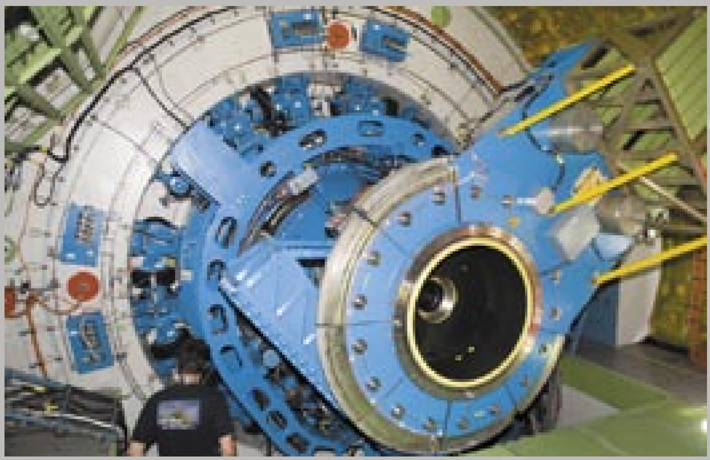
» MORE SPACE RACE »

» NASA to operate the world's largest airborne observatory out of Christchurch »

From 2009, the NASA Science Mission Directorate in partnership with Germany's DLR Deutsches Zentrum fur Luft- und Raumfahrt (German Aerospace Center) is planning to operate the world's largest airborne infrared observatory out of Christchurch for two months of the year. The observatory, dubbed SOFIA (Stratospheric Observatory for Infrared Astronomy), will be carried skyward into the stratosphere onboard a modified Boeing 747-SP, where observations will be made of the radiation of celestial objects at wavelengths from the visual and into the far-infrared. The observations that astronomers expect to make onboard would be impossible for even the largest and highest of ground-based telescopes. The observatory and plane modifications include a gyro-stabilized 2.5 meter infrared telescope; an on board mission control area; a telescope cavity with cavity door; and a cavity environment system.

⇧ *With landing gear extended, the NASA/DLR Stratospheric Observatory for Infrared Astronomy (SOFIA) 747SP cruises over central Texas on its first test flight in April 2007.*

The South Island's strategic location for Southern Hemisphere observations should prove a windfall for New Zealand's astronomers and engineers with NASA offering opportunities for locals to participate in SOFIA operations. NASA's plans also include mention of the possibility to take teachers and classes onboard the observatory although these details would need to be ironed out in further discussions with the partnership.



⇧ *A technician examines the instrument mounting structure and bulkhead of the German-built infrared telescope installed in NASA's SOFIA airborne observatory.*

For the other 10 months of the year NASA plan to operate SOFIA out of its home base at NASA's Ames Research Center at Moffett Federal Airfield near Mountain View, California. SOFIA is expected to operate three or four nights a week for at least twenty years. It will be used to study many different kinds of astronomical objects and phenomena, including star birth and death; formation of new solar systems; planets, comets and asteroids in our solar system; nebulae and dust in galaxies; and black holes.

For more about NASA's SOFIA see http://www.nasa.gov/centers/ames/research/exploringtheuniverse/exploringtheuniverse-sofia.html and http://www.nasa.gov/mission_pages/SOFIA/index.html

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Two Line Elements (TLEs), which can be used to update Wxtrack can be found at:

ISS & Hubble Space Telescope: http://www.aus-city.com/cgi-bin/dada/mail.cgi/list/TLELIST

Space Shuttle: http://www.aus-city.com/cgi-bin/dada/mail.cgi/list/STSTLE_LIST

» ACKNOWLEDGEMENTS »

⇦ *A Square Kilometre Array site.*

Written by Louise Thomas, Wordwise Science Communication

Photos and images

Page 1: Mt John Observatory, Dr Ian Bond; Ariana and Jules Verne lift off, courtesy of ESA.
Page 2: Awarua, dish, and rocket tracking technician, Robin McNeill.
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Page 10: SOFIA, Carla Thomas, courtesy of NASA Dryden Flight Research Centre; Infrared telescope, Tony Landis, courtesy of NASA Dryden Flight Research Centre.
Page 12: SKA site, courtesy of international SKA office; Mount John Observatory complex, Dr Ian Bond.

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Dr Ian Bond, MOA microlensing project, Massey University;
Prof Peter Dyson, Department of Physics, La Trobe University, Australia;
Prof Sergei Gulyaev, Director of the Institute for Radiophysics and Space Research (IRSR) at AUT;
Marilyn Head, Secretary for the Square Kilometre Array New Zealand bid;
Robin McNeill, Venture Southland;
Chris Riley, HOD Physics – Hutt Valley High School;
David Teek, a Florida-based aerospace consultant currently consulting for Rocket Lab.

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⇦ *Mount John Observatory complex with lake in background.*