# NTU Singapore successfully launches its fifth and sixth satellites

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NTU Singapore Assoc Prof Low Kay Soon (center) working with two of his researchers to prepare the Velox-II for launch. Credit: NTU Singapore

Nanyang Technological University, Singapore (NTU Singapore)

successfully launched two satellites: a climate monitoring and navigation satellite, and the university's first satellite with a commercial payload.

These two latest satellites are the fifth and sixth respectively from NTU Singapore since 2011.

The 123-kg climate monitoring and navigation satellite, named VELOX-CI, will orbit the Earth for the next three years. Its mission is to study Asia's tropical climate and to test a new navigation system. The smaller 12-kg VELOX-II is carrying an experimental "communication-on-demand" technology that will be tested over one year.

The two NTU satellites were launched from India's Satish Dhawan Space Centre on the Indian Space Research Organisation's Polar Satellite Launch Vehicle (PSLV-C29) rocket, together with Singapore's first commercial earth observation satellite TeLEOS-1 and three other Singapore satellites.

TeLEOS-1 is built by ST Electronics (Satellite Systems) Pte Ltd, a joint venture between ST Electronics (Satcom & Sensor Systems) Pte Ltd, NTU and DSO National Laboratories.

Shortly after the successful launch, NTU established radio contact with VELOX-II and VELOX-CI during their first ground pass. The telemetry data showed that both satellites had deployed their solar panels and communication antennas successfully.

Associate Professor Low Kay Soon, Director of NTU's Satellite Research Centre, said: "Our satellite team has worked very hard over the last few years to advance satellite science and technology, and we are proud to see our two new satellites in space. What makes us so unique is that we have the capability to complete the design and development of satellites in different classes - from micro-satellites (20-150kg) to nano

(1-20kg) and pico satellites (less than 1kg).

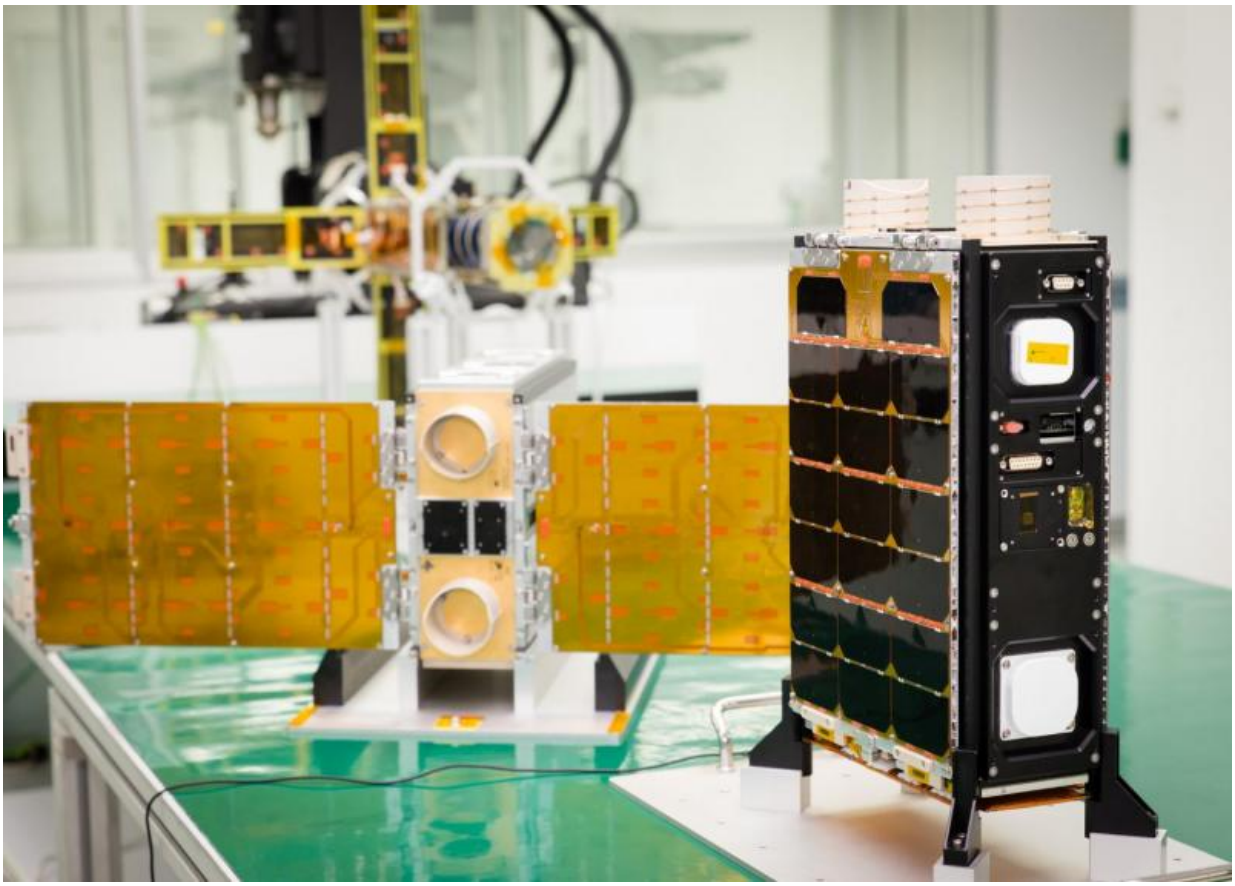
"Besides training our students for a career in the aerospace and space industry, we have also implemented various advanced concepts and new technologies into the present and future satellites in the pipeline. This will further strengthen NTU's reputation as a centre for excellent and credible satellite technology."

NTU Singapore is the first university in Singapore to develop a satellite programme for undergraduates and boasts one of the most advanced satellite research facilities in Asia.

The university's position at the forefront of satellite research and development is supported by its strengths in engineering. With one of the largest engineering colleges in the world, NTU Singapore is ranked 6th globally for Engineering and Technology in the 2015 World University Rankings by Quacquarelli Symonds.

## New satellite technologies in VELOX-CI and VELOX-II

Supported by Singapore's Economic Development Board, the VELOX-CI is a micro-satellite the size of a mini fridge. It is designed to observe climate in the tropics and also test out an experimental navigation system over the next three years.



NTU Velox-II, which carries an experimental inter-satellite data relay system. Credit: NTU Singapore

The satellite uses a special technique known as radio occultation and advanced algorithms to obtain weather data such as the upper atmospheric temperature, humidity and pressure, which are useful for long term climate studies.

Radio occultation makes use of radio signals transmitted from the GPS satellites flying 20,000km above the Earth. Using specially-designed GPS receivers, VELOX-CI can detect these signals even without line of sight and detect the changes in the signals caused by them passing

through the atmosphere.

Its second mission is to test NTU's newly developed GPS hardware and software, which can determine the satellite position and velocity more accurately in the sub-metre and millimetre range.

Besides providing real-time orbit position, it also allows accurate reconstitution of the satellite trajectory. In addition, this new navigation system can allow NTU scientists to determine the satellite's orientation by applying an advanced signal processing technique.

The main mission of VELOX-II is to test an innovative data relay technology developed by Addvalue Innovation Pte Ltd.

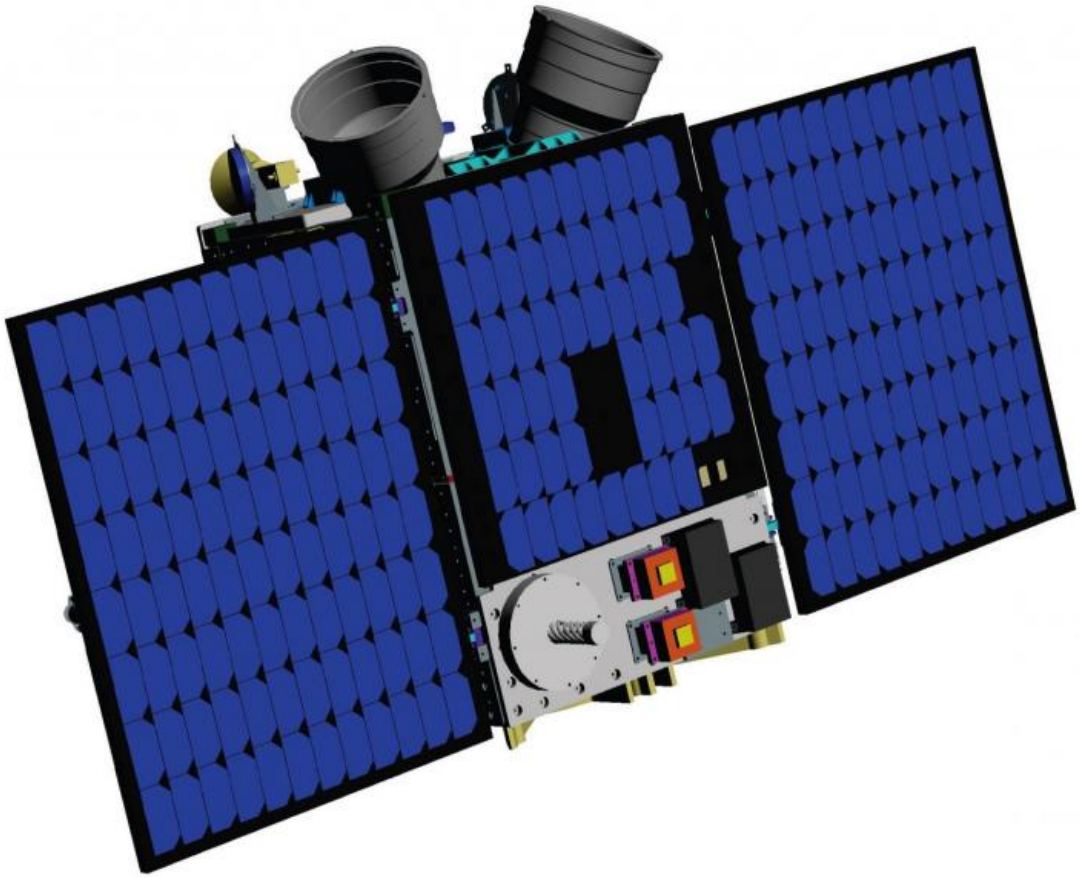
The traditional modes of communication via radio signals will require a line of sight, which means the satellite can only link to NTU when it flies near Singapore.

However, VELOX-II carries a space-qualified data relay terminal, a key component of Addvalue's Inter-Satellite Data Relay System keeps VELOX-II in contact with NTU at anytime and anywhere in space. The satellite also contains a fast GPS tracking algorithm developed by NTU that determines the VELOX-II position accurately within a minute.

Chief Operating and Technology Officer of Addvalue, Mr Tan Khai Pang, highlighted that it was a huge technical challenge to design and develop a data relay terminal that can fit space and weight constraints, as well as the power budget of a very small satellite like the VELOX-II.

"Our proprietary terminal was built without using any expensive space-hardened or export-controlled components, and yet it could pass the stringent space environment tests," Mr Tan added. "Once VELOX-II is on its orbit, it will be exciting to see how our data relay terminal will

perform according to its test plan, since this inter-satellite communication system is the first of its kind for low-orbit satellites."



New 3-D-model of NTU Singapore's climate satellite, the VELOX-CI, which was successfully deployed in space. Credit: NTU Singapore

VELOX-II is also testing out a new radiation-resistant hardware designed at NTU. The new hardware aims to protect the critical data stored in the memory of the satellite, which may be subject to various energetic particles found in space caused by solar flares and cosmic rays. These energetic particles could cause some memory loss in satellites,

causing errors that would lead to a mission failure.

Assistant Professor Chen Shoushun, who co-led the design of the new radiation-hardened integrated circuit, said it can detect and correct small errors in the satellite's memory, making it more robust.

"Our NTU design features a much higher resistance to radiation compared to conventional electronics, and can provide a robust and reliable performance over a wide temperature range. Once we prove our technology in space, we can then apply it to many other mission-critical systems."

## Other NTU satellites in space

NTU has four locally-built satellites currently orbiting in space:

- X-SAT, Singapore's first locally built satellite launched in April 2011. The fridge-sized micro-satellite weighing 105kg is built by NTU and DSO National Laboratories
- VELOX-PII, an NTU student-built pico-satellite satellite launched in November 2013. It is the size of a 10cm cubic box weighing 1.3kg.
- VELOX-I, a 4.5-kilogramme satellite built by students and research staff to demonstrate advanced satellite technologies designed by NTU. These technologies include a radiation-tolerant camera sensor; an actuator for controlling the orientation of the satellite; and an inter-satellite communication system that could communicate with the 193-grams VELOX-PIII which it piggybacked. These two satellites were launched in June 2014.

## NTU's expanding fleet of satellites

Under the NTU's satellite road map for 2020, the satellite team is now working on a series of nano-satellites. The next satellite slated for space is named AOBA VELOX-III, which will be launched by the Japan Aerospace Exploration Agency via the International Space Station.

VELOX-III will test an NTU-built micro thruster which compensates for atmospheric drag, enabling the satellite to continue flying in space twice as long as it would without a thruster.

Provided by Nanyang Technological University