Aalto University

Students' mission to get Finland's first satellite into orbit

speedgoat
real-time simulation and testing

Aalto University

Students at Aalto University are developing the first Finnish spacecraft, a low-cost nanosatellite, which will allow universities and small companies to develop their own space systems and instruments, and to perform leading-edge space science

Aalto University was created by a merger of the Helsinki School of Economics, the Helsinki University of Technology, and the University of Art and Design Helsinki. It is strongly future-oriented while at the same time building on the combined 300 year history of three highly regarded universities. Its inspiring learning environment has led to many new student activities including the multi-disciplinary project Aalto-1, a student built satellite.

The Aalto-1 project started in the beginning of 2010, when a group of students carried out a feasibility study of a nanosatellite. Since then the project has generated significant excitement, and reformed teaching and learning in the interdisciplinary area of space technology. Additionally, the project has created an extensive collaboration network of many Finnish and international partners.

Student satellite teams at Irbene Radio Astronomy Center, Latvia

Nanosatellites

Nanosatellites, with a mass between 1 and 10 kg (2 to 22lbs), offer a cost-effective solution for universities and small companies to develop their own space systems and instruments, and to perform leading-edge space science. The growing capability and complexity of nanosatellite systems requires effective verification solutions for prelaunch testing.

HIL Simulation

One of the highly complex and mission-specific systems is the Attitude Determination and Control System (ADCS), which consists of sensors, actuators and a processing unit running control algorithms. To test the control operations and performance of the ADCS within a short time frame, and without extensive test equipment investment, a Hardware-in-the-loop (HIL) solution is used.

With the HIL solution, the attitude and orbit dynamics simulator running on a Speedgoat real-time target machine is connected to the ADCS processing unit. The sensors and actuators are modelled in the simulator with performance and operational characteristics obtained from testing or from the component manufacturer. The same simulator can be used for both the development of the ADCS controller and the analysis of its performance.

Some of the complex mission operations of Aalto-1, such as a 200 deg/s spin-stabilized operation mode required for an electric solar wind sail experiment, would otherwise be nearly impossible to test.

Real-Time Testing

Students use Simulink running on a laptop to model the attitude and orbit dynamics, the space environment, and sensor and actuator models. Then a real-time application is created from the Simulink model using Simulink Real-Time and Simulink Coder, and run on a Speedgoat Performance real-time target machine.

While the real-time application simulates the physical plant, actuators, and sensors, the target machine provides all real physical I/O and communication protocol interfaces, including I2C, SPI, and CAN, to connect with the ADCS.

This flexible setup allows new ideas and scenarios to be tested with the ADCS prototype long before the embedded hardware for the satellite is available.

Launch

The Aalto-1 satellite is launched in 2015. Education and research using nanosatellites will continue at Aalto University with the second satellite Aalto-2 already under design, and more satellite projects to come.

Speedgoat's Value Contribution

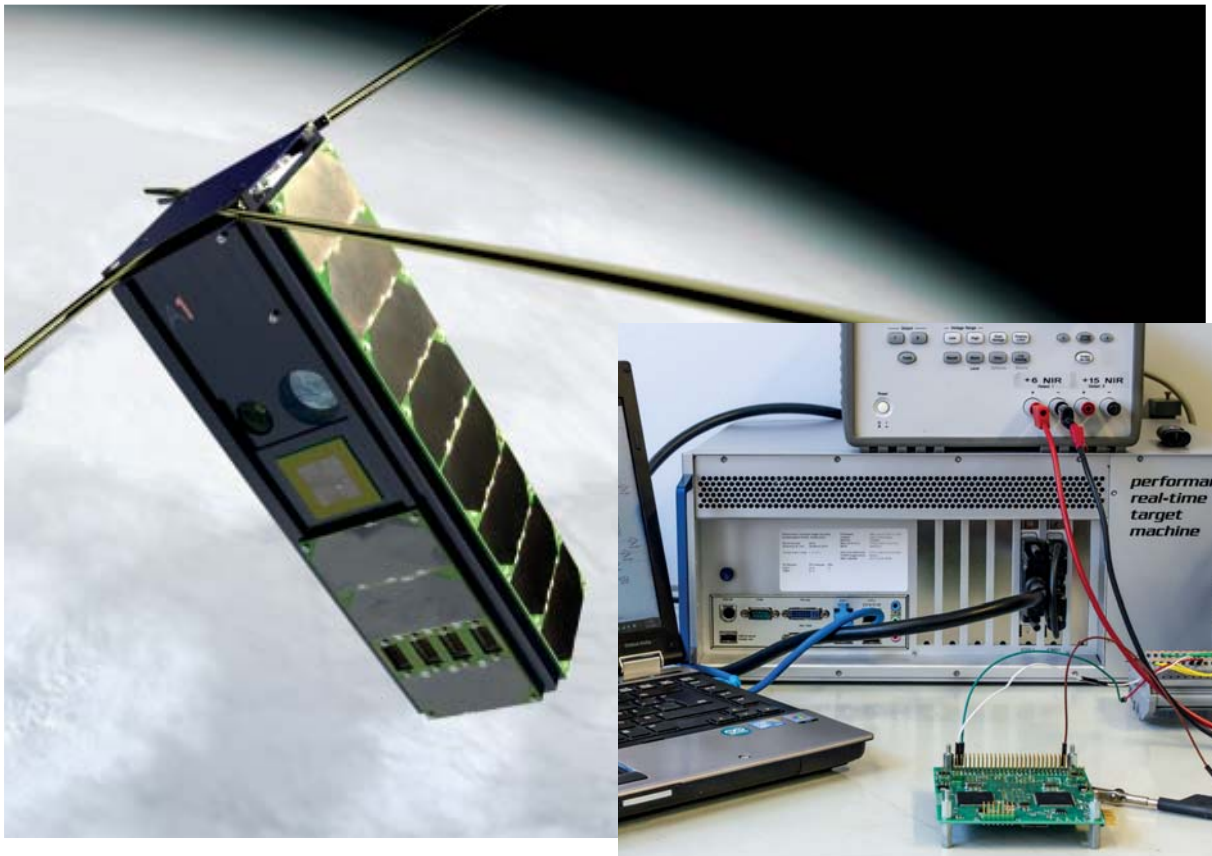
"The cost of setting up and using a HIL solution is very low compared to performing all ADCS tests with a physical test setup emulating the orbit environment." says Mr. Tikka.

"The ability to perform HIL testing allows even the most complex satellite mission operations to be verified on real hardware.

Since the Performance real-time target machine can be used for attitude and orbit dynamics simulation throughout development and testing, large time savings are possible.

Overall the learning curve for performing ADCS testing is much shallower than creating a custom solution in-house."

Tuomas Tikka, Aalto-1 Navigation Team Leader and Quality Manager



Aalto-1 nanosatellite with antennae deployed

Testing the Attitude Determination and Control System (ADCS) module

Aalto University

Helsinki, Finland

www.aalto.fi
Images: Pekka Laurila

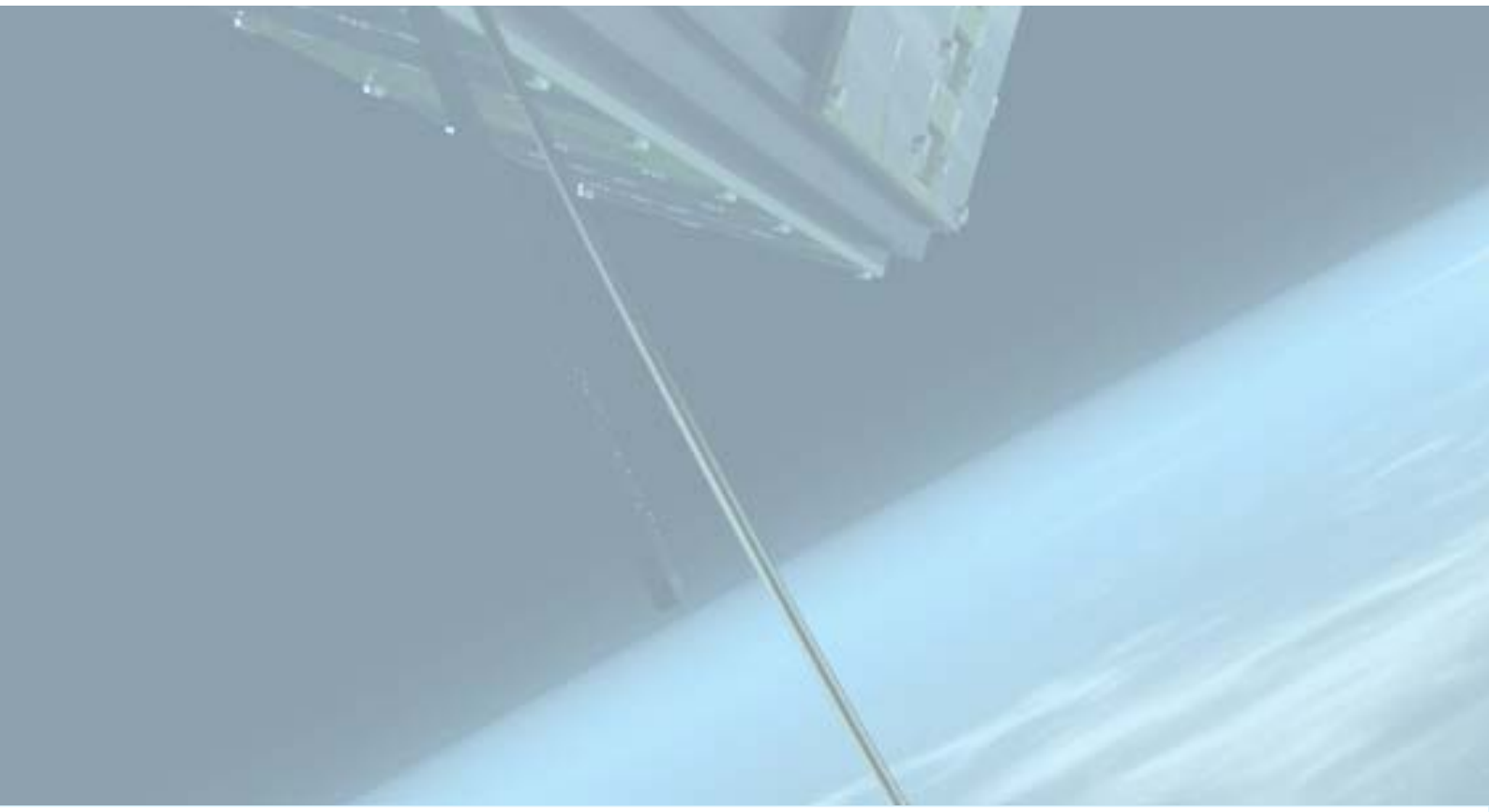
Speedgoat products used

- Performance real-time target machine
- IO311 configurable FPGA I/O module with SPI, I2C and digital I/O
- IO601 CAN I/O module

MathWorks software used

- MATLAB®
- Simulink®
- MATLAB Coder™
- Simulink Coder™
- Simulink Real-Time™

Learn more
www.speedgoat.ch/userstories



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