Autonomous Nanosatellites: Satellites that Make Up Their Mind

By Alexander Hellemans

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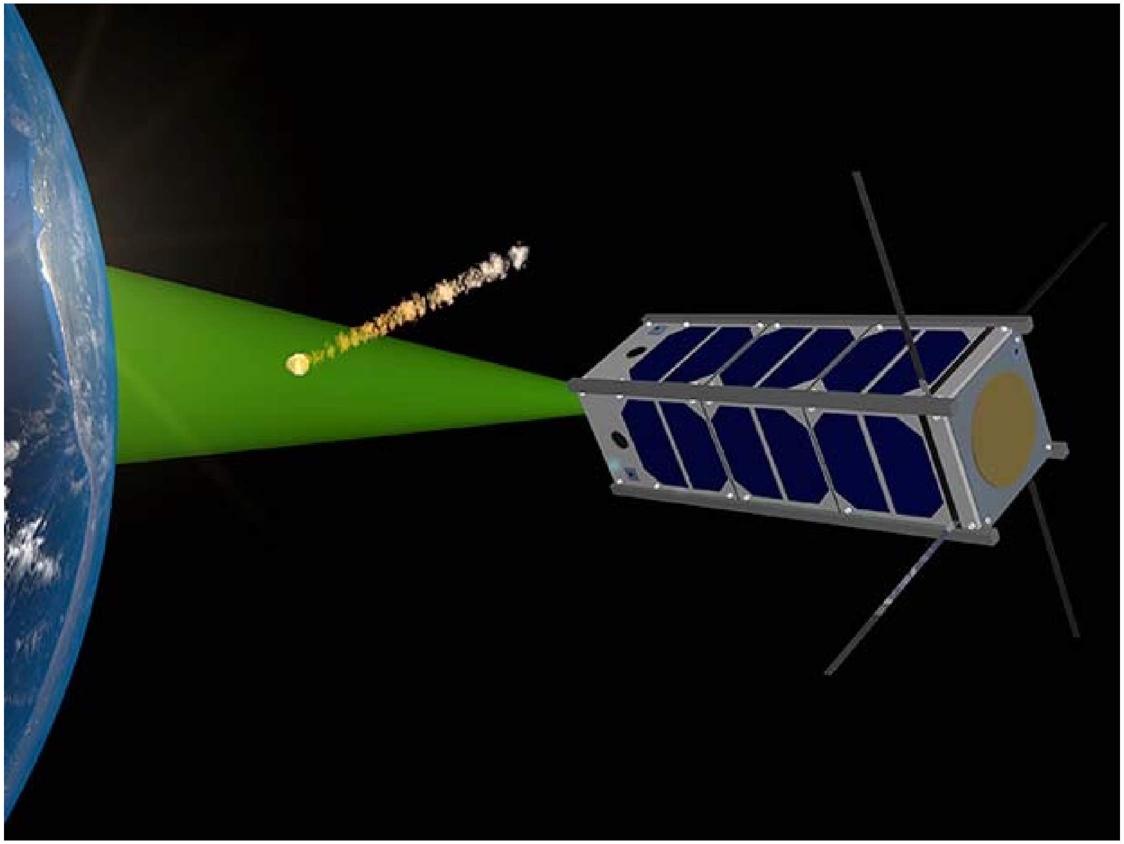

Illustration: Hakan Kayal

Nanosatellites, small satellites with sizes ranging from a shoe box to a small suitcase are popular because they are cheap–just some communication gear and a few instruments, and because they can piggyback onto other space missions. NASA is now preparing to launch in orbit around Mars two CubeSats (http://spectrum.ieee.org/tech-talk/aerospace/space-flight/first-cubesats-planned-for-mars), small satellites that will piggyback on InSight (http://www.nasa.gov/insight) (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport), NASA's mission to understand the interior structure of Mars, now likely to be launched in 2018.

The CubeSats, in orbit, will communicate with the lander and with NASA's Mars Reconnaissance Orbiter (http://mars.nasa.gov/mro/) (MRO), which will relay communication with ground control on Earth. Sending a message to Earth can take up to 20 minutes, too long to transmit and then receive urgent corrections or adjustments for such things as the misalignment of solar panels or antennas.

To avoid such mishaps in space, the satellites should be equipped with autonomous fault correction, something already available in certain drones or autonomous driverless cars, argues Hakan Kayal (http://www8.informatik.uni-wuerzburg.de/en/staff/kayal0/), a researcher at the University of Würzburg (https://www.uni-wuerzburg.de/en/new/) in Germany, whose expertise combines both space technology and computer science. “These technologies, as found in smartphones with their apps, are more advanced than what we normally find in space,” says Kayal, who adds that in space one turns to more secure devices and software. “We thought it would be a good idea to develop this technology for nanosatellites, allow them to functions autonomously, and allow error correction and autonomous control of mission scenarios,” says Kayal. And in future planetary missions such autonomous satellites will be able to focus their cameras and instruments on transient events without having to wait for ground control.

The Würzburg scientists have now started up two space projects, technology missions that will lead to the development and testing of autonomous nanosatellites. The first project is the construction of a nanosatellite called SONATE for “Solutus (independent) Nano Satellite” that will incorporate two systems as payload, an “Autonomous Sensor and Autonomous Planning system” or ASAP and an “Autonomous Diagnosis System for Satellites” or ADIA. Strictly a technology mission, it will be launched in an Earth orbit in 2019. By simulating faults in the satellite’s system, the researchers will test how ADIA will make a diagnosis, in order to find the root cause of the problem. It will also be able to find possible future errors by analyzing the trends within the satellite. We hope in a follow-up step or project, to be able to better correct the error; but this is not yet part of the project, remarks Kayal.

A second project, called NACOMI, “Nano Satellite Communication Interplanetary,” will focus on advanced communications technologies for nanosatellites that will be orbit around moons and planets. “NACOMI will be a prototype study in a laboratory setting; we will look at different techniques and decide which are the most promising,” says Kayal.

For planetary astronomers, the autonomous operation of instruments, such as cameras, aboard the nanosatellites will open up exciting new possibilities. “The cameras will be analyzing the scenery all the time, trying to detect changes or movements, such as meteor impacts, lightning, geysers, chemical eruptions, and transient lunar phenomena,” says Kayal. Typically, a satellite will catch these events—many shorter than a second—and store them on board. Communication bottlenecks will not allow sending images and video continuously. The satellite will have to autonomously analyze these records and decide what to do with each of them—for example, keep recording and then tweet to Earth: “What do you want to do with this recording?”.