New power generation and propulsion system for satellites

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This system could be useful for satellites orbiting the Earth such as the Sentinel-1. Credit: ESA/ATG medialab

Researchers at the Universidad Carlos III de Madrid (UC3M) and the Universidad Politécnica de Madrid have designed and patented a new propellantless system for satellites that allows generation of electric

power and on-board thrust. This innovation, which has led to two national patents, has attracted the interest of the European Space Agency and of the space industry.

The system is based on what is known as a low-work-function tether, a thin, km-size aluminum tape of a few centimeters width with enhanced electron emission properties on receiving sunlight and heat. The tape, which is rolled up in a reel during the launch, is deployed once in orbit.

Via electromagnetism, the tether can generate power passively as the altitude of the satellite lowers. Conversely, if there is available power for on-board use, the tether can be used to produce a thrust force that increases the altitude of the orbit. Inventor Gonzalo Sánchez Arriaga, Ramón y Cajal researcher at the Bioengineering and Aerospace Engineering Department at UC3M, says, "This is a disruptive technology because it allows one to transform orbital energy into electrical energy and vice versa without using any type of consumable.

"Unlike current propulsion technologies, the low-work function tether needs no propellant and it uses natural resources from the space environment such as the geomagnetic field, the ionospheric plasma and the solar radiation."

The two patents "System for generating electrical power in orbit by means of floating conductor cables," and "System for in-orbit propulsion via floating conductor cables," are based on an electrodynamic effect known as the Lorentz drag.

Lorentz drag can be easily observed by letting a magnet fall inside a copper tube. "Space tethers have been investigated for decades and have flown in more than 20 space missions. Our contribution to this technology comes from a strikingly simple design in which two lightweight aluminum tape deployed from a satellite without any active

electron emitter are able to supply power and/or propulsion to a spacecraft. Besides, to make things more efficient, we thought about exploiting the photoelectric effect of the tapes exposed to sunlight. We believe that this is an extremely important simplification which can boost tether technology," states the other patent author, Claudio Bombardelli, from the UPM Space Dynamic research group.

Possible applications

The system provides useful power in orbit while the satellite de-orbits, that is, its altitude is decreased until reentry and burning in the atmosphere. For this reason, the technology is ideal for eliminating space debris. In addition, if the satellite has onboard power, the tether can work the other way around and generate thrust to increase altitude.

"This could be an interesting application for the International Space Station (ISS), for instance. Nowadays, a large amount of propellant must be used to reboost the ISS altitude to compensate for the action of the atmospheric drag," Gonzalo Sánchez Arriaga notes. "With a low- work function tether and the energy provided by the solar panel of the ISS, the atmospheric drag could be compensated without the use of propellant," he adds.

Due to its simplicity, passive operation, and lack of consumables, the low-work-function tethers represent a promising technology for in-space power and thrust generation, according to the researchers. They have provided information about low-work-function tethers to the European Space Agency and are in touch with experts in the USA and Japan. In addition, important stakeholders in the space sector, such as the Spanish company SENER, showed their interested in this innovation.

The next steps include the extension of the patents to the European area and to start the manufacturing of small-scale prototypes. "The biggest

challenge is its manufacturing because the tether should gather very specific optical and electron emission properties," says Sánchez Arriaga." "We have been awarded very recently a small research grant by the Ministry of Economy, Industry and Competitiveness of Spain to investigate promising materials. We are also coordinating an international consortium and submitted a FET-OPEN R&D proposal to the European Commission. The FET-OPEN project would be foundational because it considers the manufacturing and characterization of the first low work function tether and the development of a deorbit kit based on this technology to be tested on a future space mission. If funded, it would be a stepping stone to the future of low-work-function tethers in space," he concludes.

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