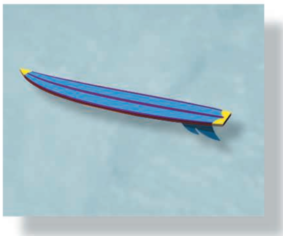

Microwave Surfing

The Sky Is Falling!

■ Rajeev Bansal

Longtime readers of this column will recall that the proliferation of space debris in near-Earth orbits is an issue that I have previously expressed concern about. Last May, the inevitable happened when a piece of space debris too small to be tracked has hit and damaged part of the International Space Station, namely, the Canadarm2 robotic arm [1]. The object punctured the thermal blanket and damaged the boom underneath, but fortunately, the instrument is still operational [1].

Space debris has been a growing problem since the launch of the first Sputnik in 1957. Some 23,000 orbiting pieces are being tracked by radar to protect satellites, but they are all about the size of a softball or larger [1]. However, smaller objects can still inflict serious damage because of the high velocities involved. The European Space Agency (ESA) estimated that 130 million fragments of man-made material smaller than a millimeter are currently orbiting the Earth. Tim Florer,

head of the ESA's Space Debris office, warns [1]

> To continue benefitting from the science, technology, and data that operating in space brings, it is vital that we achieve better compliance with existing space debris mitigation guidelines in spacecraft design and operations … It cannot be stressed enough—this is essential for the sustainable use of space.

Editor's Note: An earlier version of this column originally appeared in the October 2021 issue of *IEEE Antennas and Propagation Magazine*.

Researchers from the Australian National University at Canberra are exploring the use of an artificial guide star to improve the monitoring of space debris. The guide star laser is a tool in adaptive optics, a field that eliminates the haziness caused by turbulence in the atmosphere. The laser is fired into space and illuminates atoms within the atmosphere. A wavefront sensor measures the level of atmospheric distortion, which then sends a signal to correct the angle of a deformable mirror [2]. Although the technique has been used for studying stars and planets, applying it to objects in near-Earth orbits is much more challenging because the adaptive optics must make corrections much faster than when observing stars [2].

Even though our atmosphere may make debris monitoring more challenging (because of its turbulence), it has also proved to be a natural ally in reducing the space junk. Collisions with air molecules create frictional drag, drawing debris particles back into the lower atmosphere where most objects burn up in fewer than 10 years. However, climate change may be compromising this natural decay process.

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Figure 2. *A view of the old town of Ulm next to the Danube River.*

parallel sessions with presentations from the broad technical areas of "electronics and active circuits," "passives, electromagnetics, and antennas," and "systems and sensors." Further, we are proud to present four invited keynote talks given by renowned speakers: G. Chattopadhyay of the NASA Jet Propulsion Laboratory in Pasadena, California; J.C. Hwang of Cornell University, Ithaca, New York; G. Kahmen from Leibniz-Institut für innovative Mikroelektronik; and A. Neto from the Technical University of Delft, The Netherlands. Last but not least, we will have a social evening event to get together with colleagues, offering perfect conditions for networking within the microwave community.

Ulm can be reached easily by car and train from within Germany and by plane for our international attendees flying to the nearby international airports of Stuttgart, Munich, or Frankfurt and then by train directly to Ulm. If we caught your attention, you can find more information at www.gemic2022.de. We very gladly welcome all of you to GeMiC 2022!

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According to a recent conference paper described in *The New York Times* [3], increasing carbon dioxide levels in the lower atmosphere may reduce the density of the upper atmosphere, reducing the effectiveness of the process. The study estimates that the atmosphere, at an altitude of 250 mi, has lost 21% of its density [3]. The worst-case analysis [3] by the Intergovernmental Panel on Climate Change foresees a doubling of carbon dioxide levels by 2100, which (according to the paper) may reduce the upper atmospheric density by 80%. Even in a best-case scenario, where carbon dioxide levels stabilize or even reverse, the amount of space junk would still be expected to double [3]. A Federal Communications Commission (FCC) spokesperson told *The New York Times* [3]:

> We do not know at this time if there are any plans … to address the changes in atmospheric composition predicted in the paper. The FCC periodically reviews its rules and regulations and updates them consistent with developments in the marketplace and in scientific knowledge.

Stay tuned.

References

[1] M. Starr, "Space debris has hit and damaged the International space station," Science Alert. https://www.sciencealert.com/space-debris-has-damaged-the-international-space-station (accessed July 1, 2021).

[2] "Adaptive optics keep an eye on space junk," Photonics. https://www.photonics.com/Articles/Adaptive_Optics_Keep_an_Eye_on_Space_Junk/a66969 (accessed July 1, 2021).

[3] J. O'Callaghan, "What if space junk and climate change become the same problem?" NY Times. https://www.nytimes.com/2021/05/12/science/space-junk-climate-change.html (accessed July 1, 2021).