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NASA, industry weigh the dilemma

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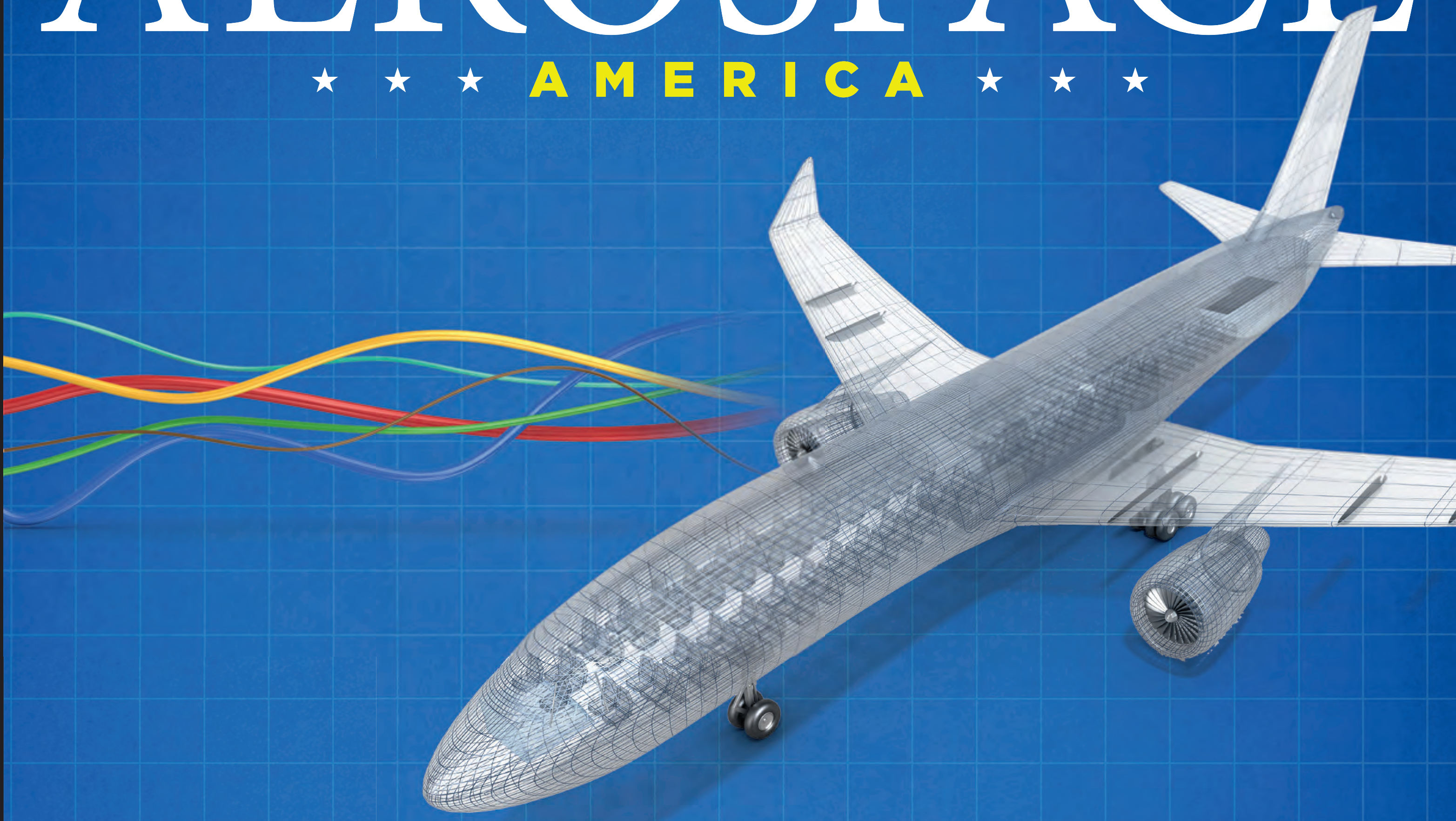

War on wiring

Your smart TV doesn't need data wires, so why do airliners need tons of them? Meet the researchers who don't think they do.

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MAY 2017 | A publication of the American Institute of Aeronautics and Astronautics | www.aerospaceamerica.org

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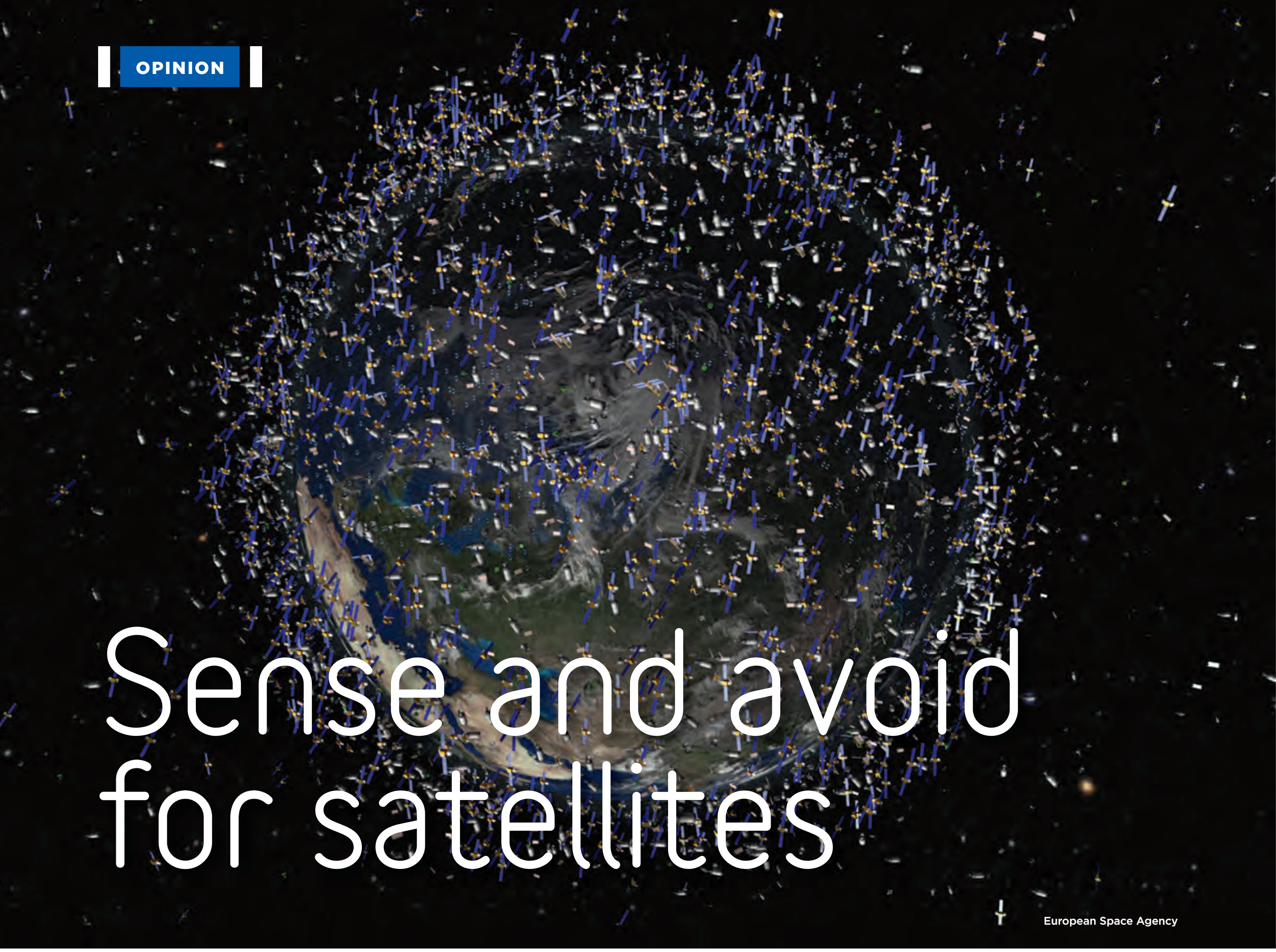


Sense and avoid for satellites

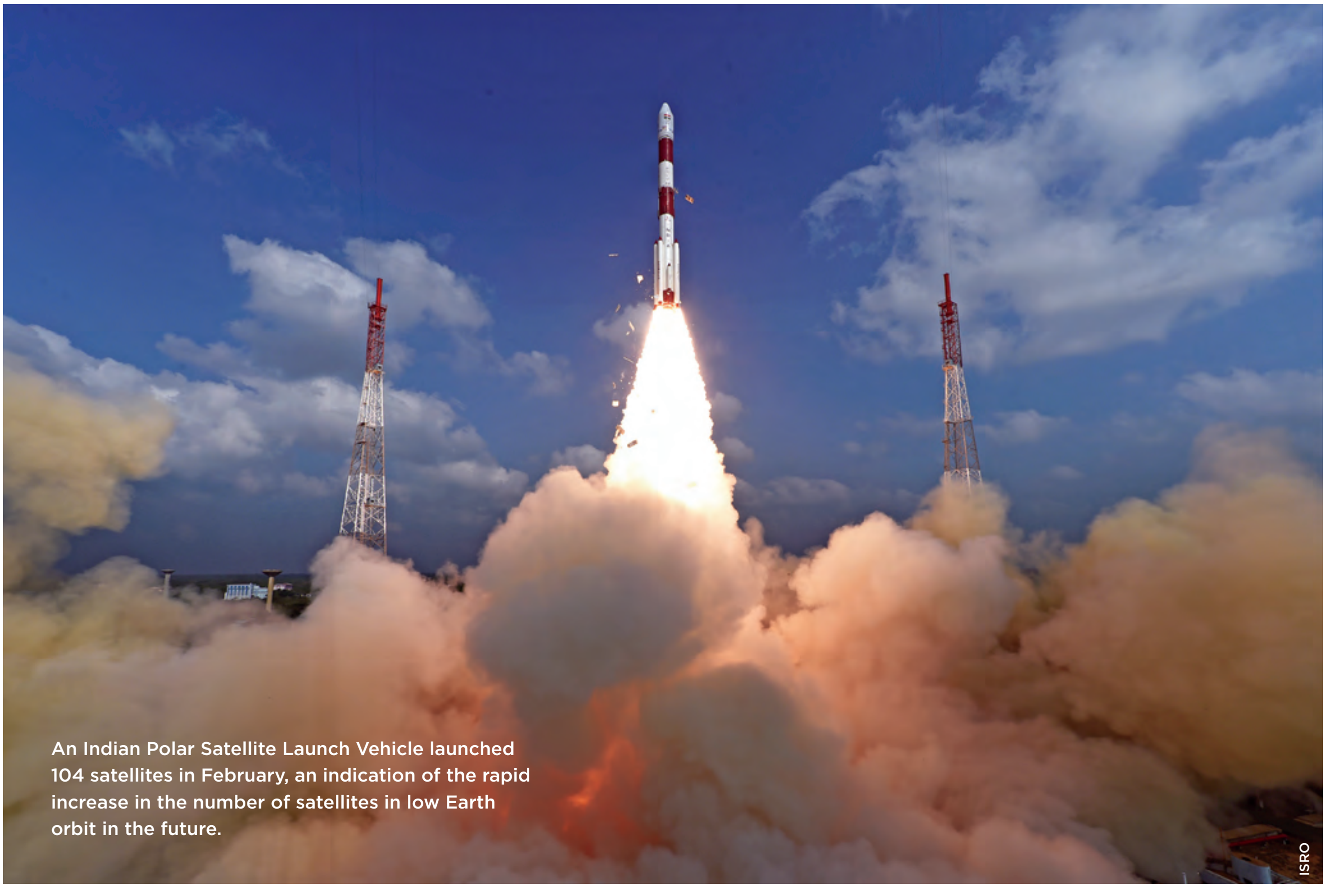
European Space Agency

▲ The debris field in this artist's rendering is based on actual density data. However, the sizes of the debris and satellites are exaggerated.

The conventional approach to avoiding collisions in space centers on estimating where satellites and debris will be relative to each other on subsequent orbits. Technologists are also working on concepts for removing dead satellites and spent rocket stages from orbit. Given the plans private companies have for launching thousands of satellites, these strategies may not suffice. Space expert Dave Finkleman says it's time to consider an alternative approach.

Given the scope of the space-debris problem and the small satellite revolution, technologists are considering active debris-removal options ranging from nets to sophisticated large object capture and deorbit devices. As innovative as these concepts are, there will soon be too many satellites to mitigate risk of collisions through this sweeping-sand-from-the-beach approach. This will be particularly true in low Earth orbit (below 2,000 kilometer maximum altitude).

More than 8,000 satellites in low Earth orbit are seriously planned soon, and the numbers are already growing fast. A significant milestone was reached in February when India launched the most satellites ever on a single launch vehicle, including 88 imaging satellites for the California company Planet. China announced intent to deploy even more with a single launch. No matter how well small satellites are designed, some will always fail in short order. As of March 2017, of the 685 nanosats (spacecraft weighing less than 10 kilograms) launched since the late 1990s, 405 remain in orbit, and only 321 remain operational, per the nanosatellite database maintained by Estonian satellite expert Erik Kuku. The rest are now debris. Lacking guidance and propulsion, many will remain in orbit for 25 years or longer.



An Indian Polar Satellite Launch Vehicle launched 104 satellites in February, an indication of the rapid increase in the number of satellites in low Earth orbit in the future.

ISRO

The debris mitigation industry should consider alternatives to traditional strategies for reducing the risk of debris-causing collisions. Instead of trusting our ability to track objects from the ground and mathematically estimate possible conjunctions, manufacturers might equip their spacecraft for obstacle avoidance. Satellites might be able to sense and avoid dangerous encounters, returning to their operational trajectories autonomously with very little mass or volume impact. Research has demonstrated that the probability of a collision between two objects closing in on each other at kilometer-per-second relative velocities can be reduced to insignificance by imparting relatively little maneuvering energy on one of them. This maneuver would have to be executed only about one revolution ahead of the estimated time of closest approach. Arrival at this estimated closest approach would only need to be accelerated or delayed by milliseconds (or the estimated separation adjusted by meters) for the objects to miss each other. The greater the relative velocity, the easier it would be to mitigate risks of collision.

Sense and avoid technologies are mature. They are in practice for automobiles, unmanned aircraft, and on some ships. Even hobbyist quadcopters now sense and avoid obstacles autonomously. No doubt, there are issues of range and bandwidth, but similar difficulties were overcome in orbit 30 years ago in the U.S. Strategic Defense Initiative's Delta Star missile-tracking experiment.

Satellites will become so numerous that the launching country may not be able to meet its responsibilities within the 1972 Convention on International Liability for Damage Caused by Space Objects International Liability Convention. Even when a launch vehicle and satellites are privately owned, governments are responsible for the consequences of launches from their territories.

Another question is whether those who plan to establish these vast constellations would voluntarily agree to include obstacle avoidance and propulsion systems on their spacecraft. There are paradigms in maritime navigation. While there are command and control sites ashore, no one expects these sites alone to prevent collisions. It is up to the captain of the ship to maintain situational awareness of the locations of other vessels and avoid collisions with prescribed rules of engagement. Similar satellite rules of the road have been suggested.

We will likely never be able to track every active or threatening object in space, and certainly not with the precision required for timely and relatively assured maneuver. We need not and could not sweep all the sand off the beach or clear the passages of every dynamic obstacle. Onboard sense and avoid is feasible and arguably essential.★

Dave Finkleman is an AIAA Lifetime Fellow, a retired Air Force colonel and chief engineer of Sky Sentry LLC in Colorado. He is a former chief technical officer of the North American Regional Aerospace Defense Command, U.S. Space Command and U.S. Northern Command, and was the senior scientist at Analytical Graphics Inc. for 10 years. He has a Ph.D. in aeronautics and astronautics from MIT.