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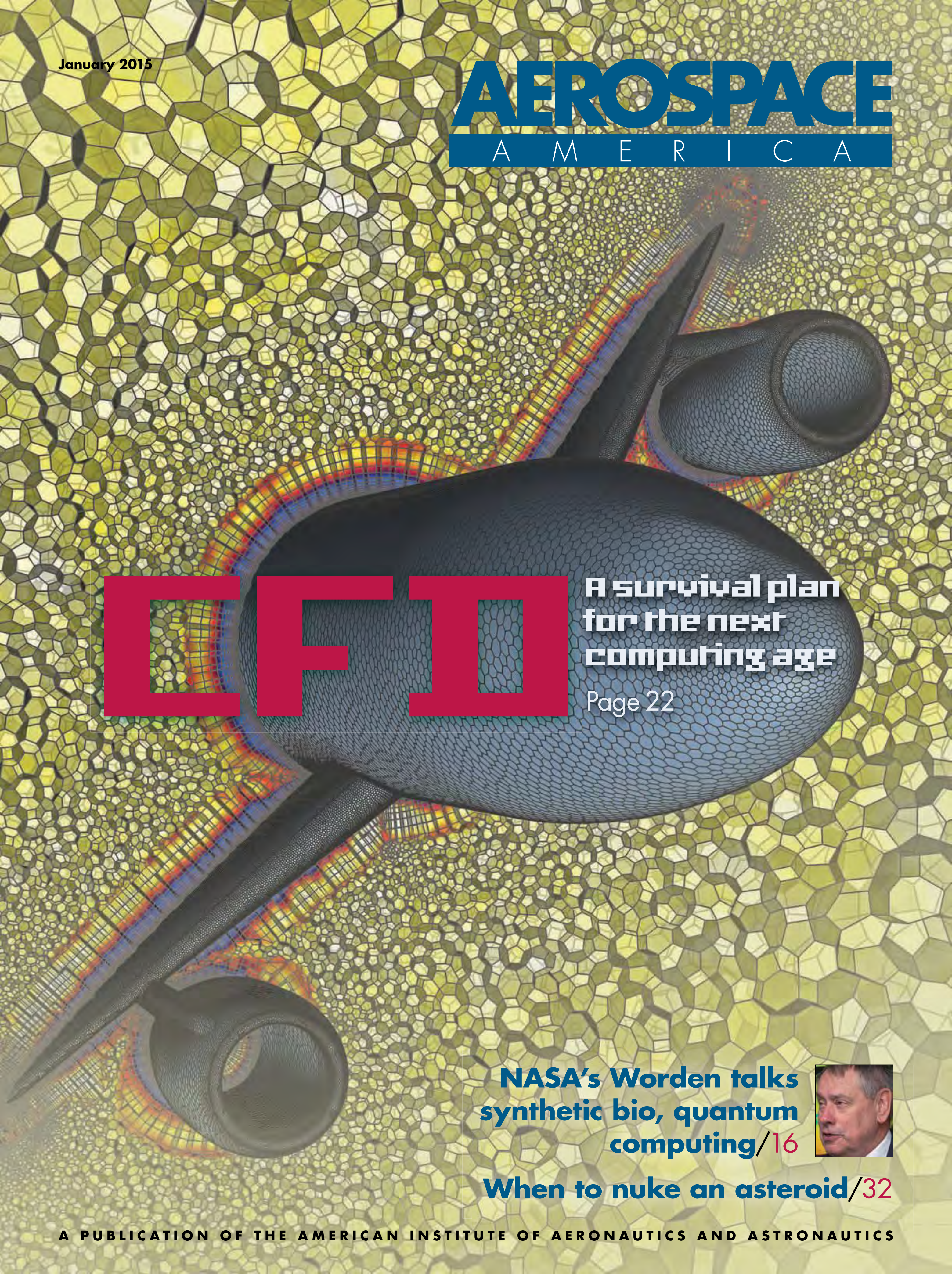
# AEROSPACE AMERICA



# CFD

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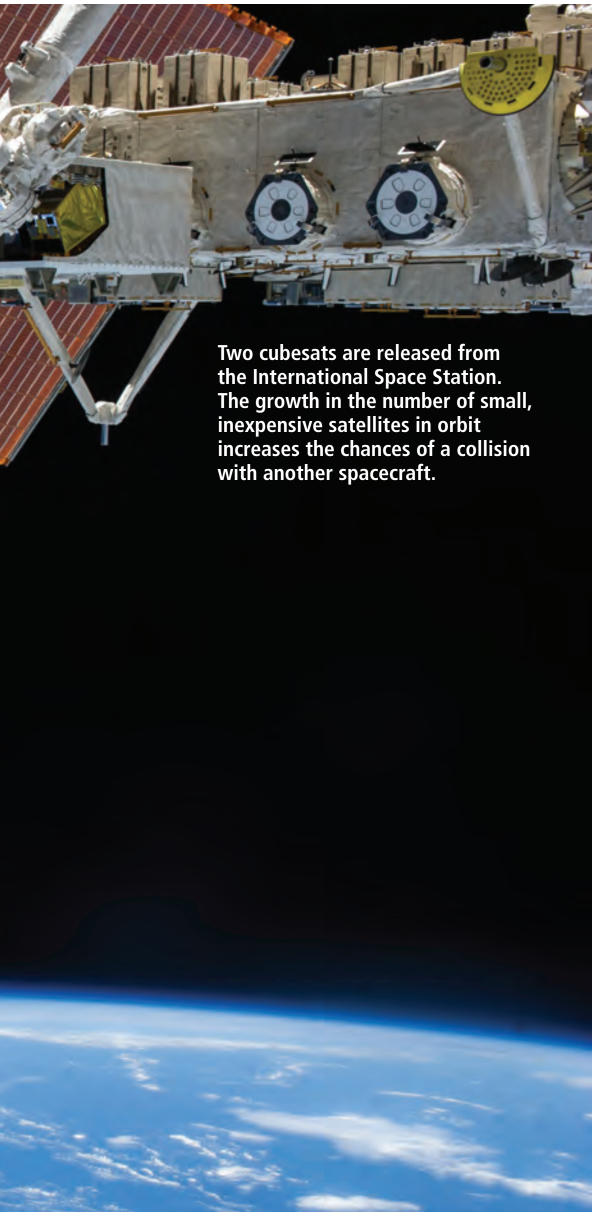
# Collaborating against *space debris*

Space debris provides an incentive for commercial satellite operators, governments and universities to collaborate toward more effective use of the space environment, because all are at risk unless all participate.

Consider the biological world. When creatures spread to new locations, either on their own accord or with the help of humans, they disrupt the ecological balance and force new and often undesirable equilibria.

Invasive species can't be stopped, but their impacts can be controlled. We should adopt a similar philosophy for managing the space environment. Collaboration on space debris will mean distributing tasks among institutions to avoid redundant experiments and the tendency to do what is accessible rather than what is necessary. We also need an agreement on a more useful definition of debris. The Inter-Agency Space Debris Coordination Committee, or IADC, defines space debris as "all man-made objects...that are nonfunctional." This definition is too expansive. Only those objects that could diminish the beneficial use of space should be considered debris.

When objects do pose a risk, spacefaring nations, satellite operators and other



Two cubesats are released from the International Space Station. The growth in the number of small, inexpensive satellites in orbit increases the chances of a collision with another spacecraft.

NASA

***Satellite operators and space-faring nations have a long to-do list when it comes to space debris, from understanding exactly how spacecraft break apart to updating the definition of what constitutes debris. Dave Finkleman, formerly of the North American Aerospace Defense Command, examines the issues and the potential for collaboration.***

stakeholders must understand the nature of the potential impairments. Collisions and explosions that disassemble spacecraft and create more intrusions are the most serious occurrences, though extremely rare. We must assess the unavoidable and unalterable background fragment population, analyze the fragmentation consequences of any destructive events, whether accidental or deliberate, and assess the degree of potential perturbation and risk these introduce. We have not yet achieved this capability.

All satellites face the risk of collisions with the natural meteoroid background that races toward Earth at a rate of millions of kilograms per day. Every spacecraft encounters neutral and charged particles, and sometimes this alone impairs a spacecraft, no matter how diligent we are about shielding and protection. At sea, severe storms sometimes sink seemingly unsinkable vessels. We cannot prevent everything. The more satellites we launch, the more risk of failures and collisions we create. The only real solution would be to keep our presence in space low enough to minimize the risk of the most dangerous scenarios. Simply

VIEWPOINT
BY DAVE FINKLEMAN

put, there is a balance between how much we launch and how much worse we make matters.

Thankfully, we are nowhere near having to stop launching satellites, but the population of objects in orbit will need to be managed eventually. Even then, we can't prevent orbital debris any more than we can prevent the introduction of environmentally invasive species. We can only mitigate the risk and diminish the probability of serious consequences.

We have a hard time defining the risk right now, partly because we do not understand how satellites disassemble through either explosions or collisions. This is not surprising, since we hardly understand how aircraft, automobiles or ships break up. The unfortunate demise of Malaysia Airlines flight 370 illustrates this. We can achieve some control with structural modifications, but more structure is more unproductive mass. Mission capability may be compromised more by excess mass than by collisions.

The explosive growth of cubesats complicates matters, partly because there are so many of them but also because their size almost doesn't matter. If a small thing hits a big thing, it's a big problem. We can add some predictive understanding by blowing up satellite mockups in controlled environments, but not much. The community must collaboratively seek greater insight.

Removing satellites at end of mission is one effective step. If a satellite isn't in orbit, it cannot explode or hit anything. An IADC guideline states that satellites should remain in low-Earth orbit for no more than 25 years after their missions end. This guideline should be reassessed. It may be too long for many orbits, while no limit may be appropriate for other orbits. In any case, estimates of orbital lifetimes for our satellites are notoriously imprecise. The atmosphere is dynamic on several time scales, not just solar cycles, which are themselves marginally predictable. As a result, there are many ways to estimate lifetime and just as many different estimates. Designers can easily underestimate how long a satellite will remain in orbit. Second, the longer a satellite is in orbit, the greater the probability of collision over its lifetime. It is wise, therefore, at the end of a mission to purge most energy stored in the satellite. This could mean residual propellants, batteries, or even flywheels that keep spinning or the tension in the outer sphere of a balloon structure. A challenge is that we often do not know how much energy remains. Residual propellant mass measurements grow very imprecise the more propellant is expended. Batteries retain latent chemical energy even when voltage is apparently low. A reason for concern about a complete purge of energy is that without energy, all control and communication would be lost.

It is also costly in terms of energy to avoid collisions. We typically don't know that a maneuver is necessary until shortly before the collision would be inevitable. Our collision estimates improve with time and more frequent observations, but the longer we wait to maneuver, the more energy we will expend and the greater the impact on the overall mission lifetime. We don't like to maneuver satellites unless we know we must. Our threshold of concern is a 1-in-10,000 chance of collision. Therefore, there is a 99.99 percent probability that there would be no collision. If there is no collision, we could never prove that it was because of the maneuver. This does not mean that we should not maneuver. It does mean that maneuver decisions are very complex and do not depend only on collision probability percentages.

We need much greater international collaboration in observing satellites and estimating their future states. Operators know much better than others where their satellites are, but they have little knowledge of where everyone else is. These are a small fraction of the challenges of space debris. We can address them only collaboratively. Technical, diplomatic and economic collaboration are all necessary. Any who resist data sharing or mutual understanding are threats to all others, and others are a threat to them.

*Retired Air Force Col. Dave Finkleman is a former chief technical officer at NORAD and the former U.S. Space Command. He has a Ph.D. in aerodynamics and gas dynamics from MIT and is an AIAA lifetime fellow.*