As satellite population surges, so does the impact on astronomy

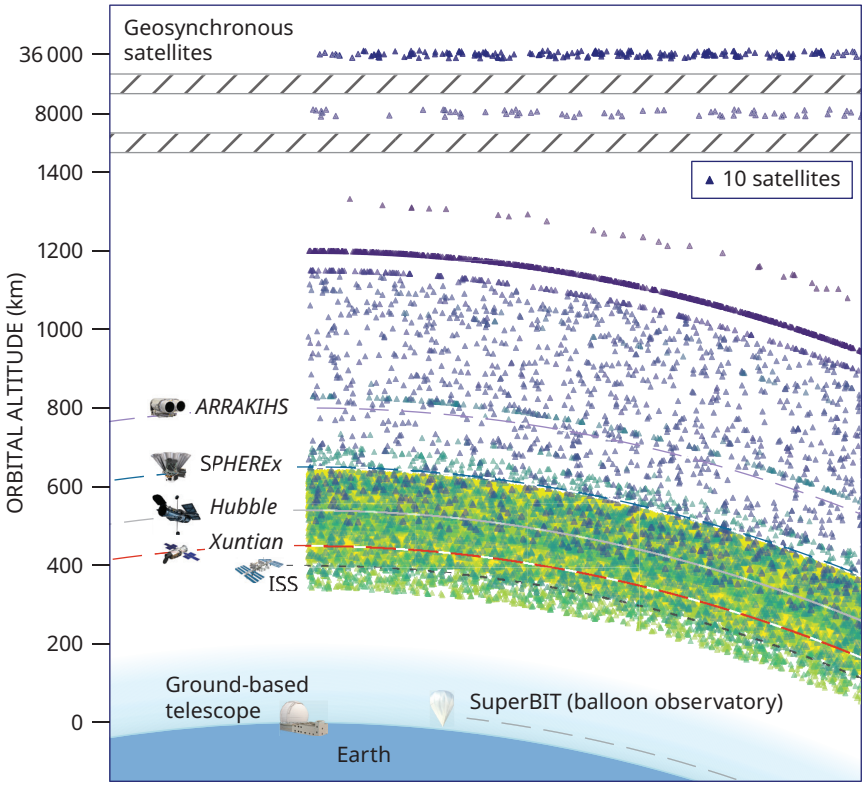
Images captured by ground telescopes are getting contaminated by sunlight reflected off satellites. Space telescope data can get compromised too.

By Sarah Wells

Fewer than 2700 active satellites were orbiting Earth in early 2020. That number grew to more than 7500 by 2023, and today it stands at about 15 000. The sharp rise in the orbital population stems in part from the launches of telecommunications satellites by companies like SpaceX, OneWeb, Amazon, and Guowang. Aided by factors such as decreasing launch costs, the companies are rapidly sending up satellites and trying to sell internet access subscriptions to remote areas. The satellites can also be used for GPS navigation and for military intelligence collection. If companies follow through on the plans they have filed with the US Federal Communications Commission and the International Telecommunication Union, then half a million satellites or more could be orbiting Earth by 2040.

The continuing crowding of space is rife with unintended consequences. (See, for example, *PT*'s 2022 news story "Ballooning satellite populations in low Earth orbit portend changes for science and society.") Ground-based telescopes that take long and wide exposures of the sky have already had their data affected by the trails of reflected sunlight from passing satellites. They can leave marks on telescope images and make some of the data unreadable. Although space telescopes orbit above some telecommunications satellites, as shown in figure 1, and generally have narrower fields of view than ground-based survey telescopes, they are not immune to image contamination from satellite trails. Alejandro Borlaff at NASA's Ames Research Center and colleagues explored how an increased number of satellites would affect four space-based missions: the *Hubble Space Telescope*, NASA's *SPHEREx*, and two still under development—the European Space Agency's *ARRAKIHS* and China's *Xuntian*.[1]

The researchers created a simulation in which four cameras—stand-ins for the space telescopes—orbit Earth. The team then intro-



◀ **Figure 1.** A visualization of the potential satellite population in 2040. Each triangle represents 10 satellites. Tens of thousands of telecommunications satellites could soon orbit at similar and even greater altitudes than those occupied by space telescopes. (Image adapted from NASA and ref. 1.)

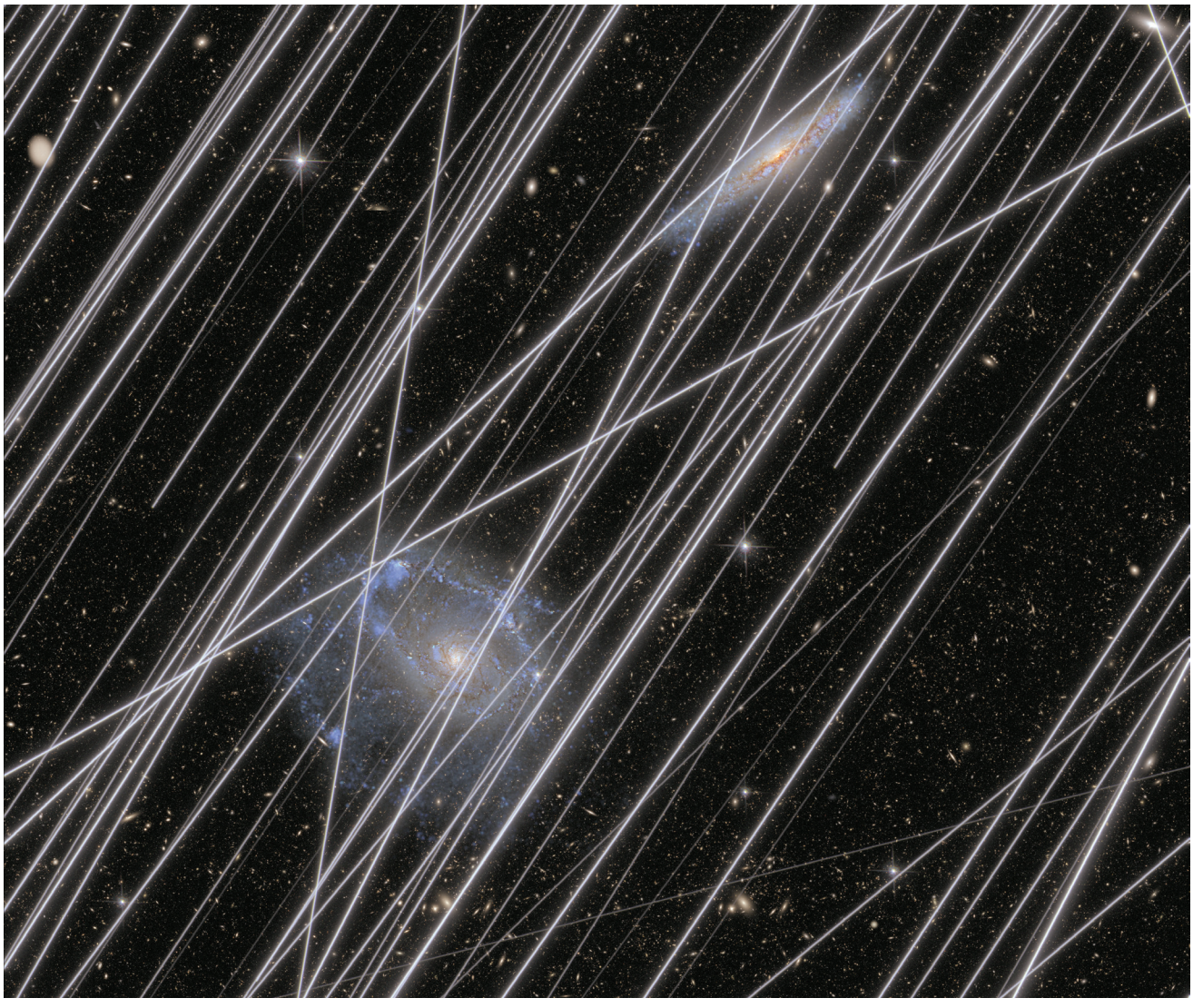


Figure 2. This simulated image for a spacecraft at *ARRAKIHS's* proposed altitude illustrates the potential effect of satellite light trails. Even a handful of streaks can result in the loss of important data. (Image from NASA and ref. 1.)

duced satellites as points of light and recorded how many times they passed each camera. The researchers found that if all the proposed satellites make it to orbit, then 30% of *Hubble*'s images and 96% of the images from the other three space-based observatories would contain at least one satellite trail. The differences between telescopes can be attributed mainly to *Hubble*'s smaller field of view. A simulated streak-filled exposure at the planned altitude of *ARRAKIHS* is shown in figure 2.

There's still a lot of uncertainty about how satellites will affect astronomical observations going forward. As examples of hard-to-predict factors, Borlaff cites how many of the proposed satellites will reach orbit, how effectively the satellites will reflect sunlight, and where the telescopes will be looking. If even a fraction of the predictions come true, however, it would still be a major blow. "The pixels themselves are lost," Borlaff says.

No single authority regulates the satellites in orbit around Earth. But that doesn't mean that nothing can be done. For example, astronomers are educating their industry partners on their work and needs. In 2024, the International Astronomical Union's Centre for the Protection of the Dark and Quiet Sky published a report with a list of recommendations, including launching satellites to lower-altitude orbits and limiting satellite reflectivity with techniques like applying light-absorbing coatings. PT

Reference

1. A. S. Borlaff, P. M. Marcum, S. B. Howell, "Satellite mega-constellations will threaten space-based astronomy," *Nature* **648**, 51 (2025).