Preventing outer space from becoming a hazardous junkyard

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Credit: AI-generated image (disclaimer)

As the number of objects launched into orbit grows, the EU is working to prevent debris from getting out of hand.

An upsurge in worldwide rocket and satellite launches into space means collisions are an increasing danger that EU research projects are seeking

to curb.

The number of satellites in space may exceed 100,000 by 2030, according to forecasts. Small satellites are increasingly being sent into low orbits 500 to 1,000 kilometers above Earth to do everything from improve remote communications to guide driverless cars.

Collision alarm

"There is an increasing amount of debris in space," said Anthony Caron, future programs manager at a French space-observation company called Share My Space. "More and more debris implies more and more collision probability—and the problem is real now. There are lots of events where you have to perform maneuvers to avoid collisions."

Toulouse-based Share My Space leads a research project that received EU funding to compile the first independent catalog of 100,000 pieces of space debris measuring under 10 centimeters. The two-year initiative, named CASSIOPEE, runs until the end of January 2024.

Organizations that launch satellites and rockets need information to avoid spacecraft collisions and currently have a limited amount to rely on besides U.S. data, according to Caron. Such information is also important for developing largely absent rules on activities in space and preventing it from becoming a lawless frontier.

The downstream market of the Global Navigation Satellite System, or GNSS, will grow from €199 billion in 2021 to €492 billion in 2031, according to the EU.

In 2009, the first known accidental collision between two satellites presaged a potentially perilous future. The crash involving an Iridium 33 and Cosmos 2251 satellite released thousands of pieces of debris into

space.

Even tiny fragments could have a catastrophic impact because they travel at about 10 times the speed of a bullet.

Crowding-out risk

Such "space junk" includes no-longer-operational spacecraft, abandoned sections—or stages—from rockets, fragments from anti-satellite missile tests and even paint flecks that have eroded from an object over time.

Caron cited a possible scenario outlined in 1978 by an American astrophysicist named Donald Kessler: with growing debris, a collision triggers a cascade of further crashes that render space useless.

"The worst-case scenario is this Kessler syndrome where you cannot use space anymore," said Caron.

Fragments as tiny as 1 cm across or less are enough to knock out a satellite, according to Caron. The US National Aeronautics and Space Administration estimates there are half a million fragments of at least 1 cm and 100 million with a minimum size of 1 millimeter.

Telescope stations

Share My Space has set up its first multi-telescope station at an as-yet undisclosed location in Europe and is installing observation equipment there that the company previously tested in Paris. More stations are planned elsewhere.

The system comprises four telescopes that rotate in coordination with objects' transit time in the field of view. Software processes data to

generate collision alerts for space operators.

As the catalog of objects expands and the detectable fragment size falls with advances in Share My Space's technology, the ultimate aim is to be able to track items as small as about 2 cm, according to Caron.

He said the system seems to have worked well so far.

"We are seeing objects which are known from the U.S. catalog while we are also seeing non-catalogued objects," said Caron. "The goal is to be able to predict their orbits based on our own observations and add this information to our catalog."

The raw data can then be used to gauge risk-collision probabilities as well as to help organizations trying to clean up space junk. Share My Space, for example, has signed a contract with a Japanese company—Astroscale—that is developing services for debris removal.

Rules of the game

Another EU-funded project, Stardust-R, has also been plotting a path towards a sustainable future in space. This research initiative ended in June 2023 after four and a half years.

The coordinator, Professor Massimiliano Vasile, argues for a far-reaching approach for preventing collisions even before delving deeper into debris removal.

"You don't just want to mitigate the risk of a collision but also have a sustainable space economy," said Vasile, a space-systems engineer at the University of Strathclyde in the U.K.

Stardust-R developed technological tools to help optimize the

commercial and scientific opportunities of space and to predict and mitigate collisions of objects.

"The problem is increasing much faster than what people might have expected," said Vasile. "And it has grown largely unregulated, as airspace on Earth can be confined quite easily but you don't have territorial space in space. Institutions are trying to catch up."

He said another difficulty with space warrants better tracking: when satellites or other space vessels malfunction, it's hard to know whether the cause was a collision with a tiny object.

In addition, big extra costs can be incurred when inaccurate information causes a spacecraft to make an unnecessary maneuver, according to Vasile.

Lasting impact

Aided by data from partners including the European Space Agency and France's National Center for Space Studies—whose involvement highlights the capacity of EU research to pool resources, foster cross-border collaboration and tap local expertise—the Stardust-R team explored a range of mitigation instruments.

These included an artificial-intelligence system to forecast when spacecraft need to maneuver. This was tested on past actual scenarios and on made-up ones.

"In these scenarios, we know that the algorithm is working because it responded with maneuvers that avoided a collision," said Vasile.

Stardust-R also produced computational models for tracking the likelihood of collisions and the origin of debris. Furthermore, it looked

at ways to use lasers for removing debris and algorithms and artificial vision in robots for conducting in-orbit repairs or satellite removal.

Vasile is counting on the work of Stardust-R researchers to have an impact long after the project.

"My hope is that some of these technologies are adopted in the future," he said. "We need more investment and development, but I think we're on the right track."

More information:

- CASSIOPEE
- Stardust-R

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