Scientists have found a new way to track space debris falling to Earth.

New research suggests that seismographs could help track space debris falling to Earth more accurately and quickly than radar.

Thousands of man-made objects are being left in Earth's orbit. When this space debris falls back to the surface, it could pose real dangers to humans. To more accurately pinpoint where debris might land, a scientist at Johns Hopkins University has contributed to the development of a new tracking method, leveraging the existing earthquake monitoring network.

This method relies on seismometers already installed on the ground. Compared to current systems, the new approach can provide more detailed information, almost in real time – a factor that helps authorities speed up the search and recovery of debris that may have been burned, broken, or contain hazardous materials.

" *Atmospheric re-entry events are becoming increasingly frequent. Last year alone, several satellites entered Earth's atmosphere every day, but we have no way of independently verifying where they entered, whether they broke into pieces, burned up in the atmosphere, or fell to the ground* ," said Dr. Benjamin Fernando, lead author of the study. " *This is a growing problem and will certainly get worse in the future* ."

Using earthquake sensors to track a falling spacecraft.

Fernando and his colleague Constantinos Charalambous, researchers at Imperial College London, demonstrated this method by analyzing debris from China's Shenzhou-15 spacecraft. The spacecraft's orbital module re-entered Earth's atmosphere on April 2, 2024. With a diameter of about 1 meter and a weight of over 1.5 tons, this object was large enough to pose a danger to people on the ground.

When space debris enters the atmosphere, it travels at speeds faster than the speed of sound, creating sonic booms and shock waves, similar to those produced by fighter jets. As it crashes into Earth, these shock waves transmit vibrations down to the ground and trigger seismometers along its trajectory. By identifying which instruments detected the vibrations and when they occurred, scientists can trace the trajectory, direction of travel, and estimate where the debris will land.

By mapping the areas where seismometers in southern California detected the sonic boom, researchers at Johns Hopkins University and Imperial College London were able to track the trajectory of the Shenzhou-15 orbital module after it re-entered Earth's atmosphere on April 2, 2024.

Reconstruct speed, altitude, and break point.

The research team analyzed data from 127 seismometers in Southern California to calculate the module's speed and trajectory. The debris hurtled through the atmosphere at Mach 25–30, traveling northeast over the Santa Barbara and Las Vegas areas, about 10 times faster than the fastest jet aircraft currently in existence.

The intensity of the seismic signal also helped scientists estimate the object's altitude and determine where it began to break apart. By combining orbital and velocity data, the research team concluded that the module had deviated approximately 40 kilometers north of the orbit previously predicted by the U.S. Space Command, which was based on orbital measurements taken before re-entry.

Health and environmental concerns

During its descent and combustion in the atmosphere, space debris can release toxic particles that remain suspended in the air for hours. Winds can then carry these particles far away, affecting other areas. Knowing the precise trajectory of the debris makes it easier for organizations to track where these substances might spread and who might be exposed.

The near-real-time tracking capability also allows authorities to quickly recover any debris left behind after a fall. This is especially important because some objects may contain hazardous substances.

"In 1996, debris from the Russian Mars 96 spacecraft fell out of orbit. Everyone thought it had burned up, but the spacecraft's radioactive source fell intact into the ocean. At the time, attempts were made to track it down, but its exact location was never determined, " Fernando said. " *More recently, a team of scientists discovered synthetic plutonium in a glacier in Chile and believes this is evidence that the source broke apart during its fall, contaminating the area. We would benefit greatly from having more tracking tools, especially in the rare cases where space debris contains radioactive material* ."

Supplementing radar-based predictions.

Until now, scientists have relied primarily on radar to track objects as they gradually lose altitude in low Earth orbit and predict where they will re-enter the atmosphere. In some cases, these predictions can be inaccurate by thousands of kilometers. Seismic data could become a crucial supplementary tool, helping to track debris after it enters the atmosphere and showing the precise actual flight path.

"If we want to provide effective support, quickly locating the falling debris is crucial – within 100 seconds instead of 100 days, for example ," Fernando said. " *We need to develop as many methods for tracking and assessing space debris as possible* ."