

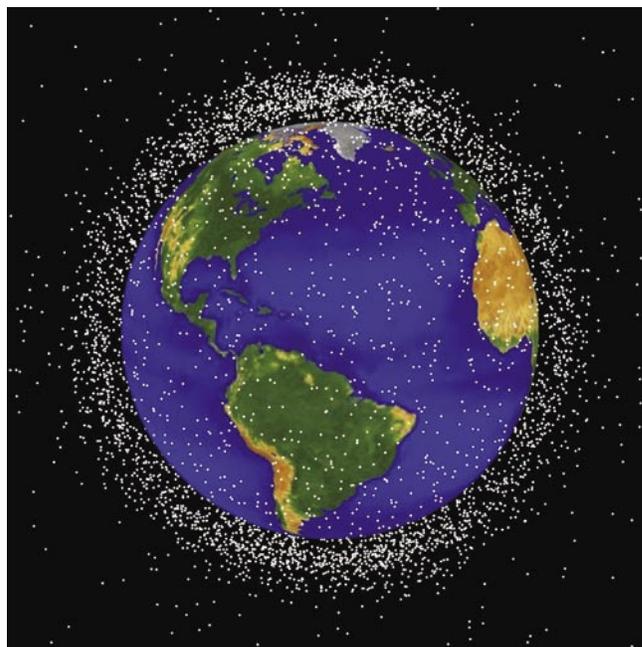
The Evolution of the Earth's Satellite Population

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Since the beginning of the Space Age, more than 4,300 missions from around the world have placed human-made objects into orbit about the Earth. Although the majority of these objects, primarily spacecraft and launch vehicle upper stages, have already fallen back to Earth, the number of objects in Earth orbit continues to grow at a steady pace. In addition to the placement of new vehicles into orbit, a significant portion (~40%) of the official worldwide satellite catalog is comprised of debris from spacecraft and launch vehicle explosions. A collision with any of these cataloged objects could result in the destruction of an operational spacecraft.

Orbital debris research in Astromaterials Research and Exploration Science (ARES) includes the investigation of potential trends of the Earth's satellite population into both the near term and the far term—within the next few decades and over periods of hundreds of years. This research is vital to evaluating the efficacy of proposed orbital debris mitigation measures. In the 1980s, the Orbital Debris Program Office identified the prevention of launch vehicle upper-stage explosions as the best means to curtail the near-term growth of orbital debris. Subsequently, all the major space agencies of the world revised launch vehicle designs or operations.

Complex computer models are used extensively to aid in understanding the principal drivers of the future Earth satellite population. In 2003, a multiyear effort within ARES culminated in a new NASA satellite evolutionary model called LEGEND, (low Earth orbit to geosynchronous orbit environment debris model). The model has already confirmed previous analyses that the long-term Earth orbital environment will likely be driven by the accidental collisions of large (>10-cm-diameter) objects. Consequently, the accelerated removal of large objects from orbit is a vital element in environment preservation efforts. Such analyses have led NASA and the international aerospace community to adopt guidelines recommending the removal of



Depiction of orbital debris population.

objects within 2,000 km of the Earth's surface from orbit within 25 years of the end of their missions. LEGEND represents a new high-fidelity tool to examine these and other factors affecting the near-Earth environment and the future safety of operational spacecraft.