

SPACE-BASED DATA CENTERS ROADMAP: THE CASE FOR CAUTION

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Text Box 2-1:

Ground Damage and Casualties

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WORKING PAPER

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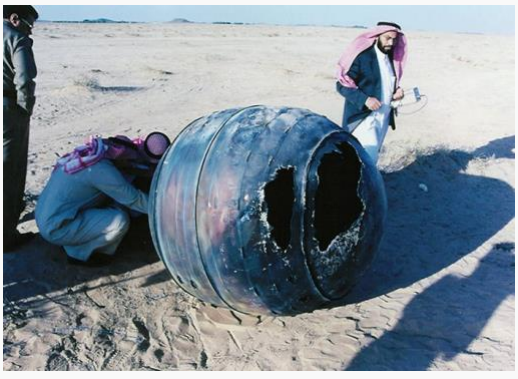
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Satellites in low Earth orbit (LEO) gradually lose altitude because of atmospheric drag, unless operators take steps to counteract it. Some satellites can be designed to burn up on re-entry, depending on their size and materials. (This is known as design for demise.[1,2]) Other satellites are designed for controlled re-entry, often over remote ocean areas.

Constellations with hundreds of thousands of satellites, such as those proposed for space-based data centers (SBDCs), would create risks of damage and casualties as satellites return to Earth. Some SBDC components might survive re-entry. Controlled re-entry of many thousands of satellites each year would significantly exceed historical experience, increasing the likelihood of some failures.[3,4]

International law places responsibility for ground damage and casualties from satellites on states. Under the 1972 Liability Convention, a launching state is absolutely liable for damage its space objects cause on the surface of the Earth or to aircraft in flight.[5] The Inter-Agency Space Debris Coordination Committee's (IADC's) international guidelines recommend 10^{-4} as the upper limit for expected casualties per re-entry and call for minimizing cumulative re-entry risk from constellations.[6]

National and space-agency standards with respect to these risks vary. In the United States, the Federal Communications Commission (FCC) requires applicants to disclose whether the probability that a collision with small debris or meteoroids would cause loss of control and prevent disposal is 1 in 100 or less.[7-9] For covered satellites in LEO, the FCC requires disposal as soon as practicable and no later than five years after mission end.[10,11] Applicants planning atmospheric re-entry must also demonstrate a calculated casualty risk below 1 in 10,000 per spacecraft.[7] For large constellations of at least 100 spacecraft, the European Space Agency (ESA) requires either fewer than 10^{-6} expected casualties per re-entry or controlled re-entry. Controlled re-entries are subject to ESA's general limit of fewer than 10^{-4} expected casualties per re-entry.[12]



A Payload Assist Module – Delta 2's casing landed in Saudi Arabia upon spacecraft re-entry, Jan 2001. Source: NASA ARES

Small per-satellite risks can add up to a substantial cumulative risk across a very large constellation. If 300,000 satellites each had an expected casualty number just below 10^{-4} on re-entry, the combined expected number of casualties would approach 30.

Controlled re-entries are typically targeted at remote ocean areas, frequently the South Pacific. Managing large numbers of re-entries could become a continuing operational challenge for SBDC constellations. Surviving fragments would enter the ocean, accumulating in large numbers on the ocean floor.

The ground risk from space debris is not theoretical. In March 2024, a piece of metal from the International Space Station (ISS) struck a home in Naples, Florida.[13] In November 2022, Spanish authorities closed airspace over four regions during the uncontrolled re-entry of a Chinese rocket, delaying some 300 flights.[14]

A. References

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