Increasing Hazards of Orbital Debris: Cause, Effect, and Mitigation

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More than half a century of human space exploration has introduced large quantities of debris on orbit; to the extent that it has become a serious threat to active satellites. Impact of even a small 50 g debris with a satellite moving with a relative velocity of 10 – 15 km/s (energy equivalent of about a kg of TNT) can be fatal. A recent study by the US National Research Council concluded that we are at the tipping point for collisional cascade to exponential growth of small orbital debris while another article argues that we are already over the tipping point. It may soon be difficult to utilize the space environment, which has been identified as one of the major issues of US national significance. We propose a concept for elimination of small individually untrackable debris by deploying micron-scale dust to artificially enhance the drag on the debris. Key physics that makes this technique viable are: (i) the natural atmospheric drag can be exploited to decay the deployed dust orbits and simultaneously using the dust to induce enhanced drag on the orbital debris. By choosing the dust characteristics, for instance, mass density, size, etc., it is possible to synchronize the rate of dust and debris descent. This offers the possibility to clear a very large volume of small debris by deploying a modest amount of dust in a narrow layer and "sweeping" of the debris volume by the dust layer, and (ii) the possibility of large momentum boost realized through hypervelocity dust/debris collision that can slow the debris speed more than the usual elastic collision. By deploying high mass density micron scale dust in a narrow altitude band it is possible to significantly enhance drag on precessing debris spread over a large volume and force rapid reentry. Most of the deployed dust as well as the small orbital debris will incinerate while reentering the Earth's dense atmosphere.