Differential Drag for Collision Avoidance
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Introduction
Small satellite operators need a coherent response to the question of space debris, and many designers can’t afford the volume, weight, and/or cost of a propulsion system.

Small satellites provide the most likely platform to make use of differential drag due to their characteristically high surface-area-to-mass ratio, as well as volume constraints that can preclude the use of an on-board propulsion system. Planet Labs has proven that differential drag can be used for tasks such as constellation phasing, and the research presented here demonstrates its use for collision avoidance as well.

Current Debris in Orbit

Objects In Orbit >1cm 14000
2700
1300
732000

Unmonitored Object Large Enough to Monitor Inactive Spacecraft Active Spacecraft

Form Factor Effectiveness

High drag = Lower orbit = Higher velocity

Low drag = Higher Orbit = Lower velocity

More effective

Less effective

Dove

Planet Labs Dov

Astro Digital Corvus HD

Conjunction Frequency

Using data from Perseus-M (620 km orbit), there are:
1.89 conjunctions of 300 meters or less per year
3.78 conjunctions of 500 meters or less per year
7.87 conjunctions of 1000 meters or less per year

Risks:
- Mission-killing impacts
- Functional degradation from small impacts
- Increased regulation on satellite launches (More costs)
- Worst case: Regulatory refusal to launch objects that can’t maneuver

Avoidance Maneuvers

Maneuvering capability for Corvus BC form factor at 600 km altitude

Time to shift predicted position by 1 kilometer and differential acceleration for various form factors at 600 km altitude

Collision Avoided Normal Operations Resume Operations All SSM Maneuver Warning Received SC 2 Maneuvers Resume Operations SC 2 Resyncs Warning Received

Operational Interruption

A method of collision avoidance that requires the satellite to be constantly maneuvering is not viable. The table below shows the expected loss of operations time various constellation designs would experience using different methods of collision avoidance if all conjunctions under 500 meters were avoided.

As expected, propulsion results in the least lost operations time. However, SSM is fairly reasonable for larger constellation sizes and low altitude orbits. SCM is more effective for small constellations (<4 satellites).

These two methods can be used to maintain relative phasing between spacecraft in a constellation.