Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 204 (2017) 500–507

Procedia Engineering

www.elsevier.com/locate/procedia

14th Hypervelocity Impact Symposium 2017, HVIS2017, 24-28 April 2017, Canterbury, Kent, UK

# Orbital debris momentum transfer in satellite shields following hypervelocity impact, and its application to environment validation

Joel Williamsen[a]*, Steven Evans[a]

[a]*Institute for Defense Analyses, 4850 Mark Center Drive, Alexandria VA, USA*

**Abstract**

This paper describes a technique for estimating the momentum enhancement (K factor) after impact of orbital debris into dual wall shields using the SPHC hydrocode by measuring the velocity in the plates following impact after various normal and oblique impact conditions. By understanding the mass and shield characteristics of a satellite, the technique can be used to compare actual satellite altitude changes to changes predicted by the orbital debris environment, and thus validate the environment.
© 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 14th Hypervelocity Impact Symposium 2017.

*Keywords:* Orbital debris; spacecraft shielding; meteoroid and debris environment; momentum enhancement

## 1. Approach

NASA recently released a new orbital debris environment (ORDEM 3.0) that included an increase in the orbital debris population for many satellites in low earth orbit [1]. In the light of this increased environment, the NASA Engineering and Safety Center (NESC) sponsored an independent assessment of the expected risk to satellites in low Earth orbit in 2015-2016, comparing this expected risk to observed anomalies [2]. Part of this assessment was an

**Nomenclature**

| | |
|---|---|
| mo | Original mass of orbital debris particle impacting normally to plate, typically expressed in grams |
| Vo | Original velocity of orbital debris particle impacting normally to plate, typically expressed in km/sec |
| mi | Mass of particle i emerging from crater, typically expressed in grams |

* Corresponding author. Tel.: +1 703-994-6551.
*E-mail address:* jwilliam@ida.org

1877-7058 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 14th Hypervelocity Impact Symposium 2017.
10.1016/j.proeng.2017.09.747

| | |
|---|---|
| Vni | Normal component of velocity for particle i emerging from crater, typically expressed in km/sec |
| Mp1 | Mass of plate 1 moving in direction of original particle, typically expressed in grams |
| Vp1 | Velocity of plate 1 moving in direction of original particle (typically expressed in grams) |
| K | Momentum multiplier, usually > 1 for non-penetrating hypervelocity impacts |
| v | Orbital velocity (m/s), |
| Ve | Escape velocity from Earth (11,300 m/s) |
| r | Spacecraft altitude expressed in units of the earths radius |
| a | Spacecraft semi-major axis expressed in units of the earths radius (r = a for circular orbits) |
| M | Mass of satellite (kg) |
| dV | Satellite velocity change (m/s) |

effort to correlate observed satellite rotation rates and orbit changes to the expected orbital debris momentum-inducing environment. This paper describes the hypervelocity impact momentum transfer processes commonly experienced by spacecraft employing Whipple shields. It describes how the level of these transfers varies with orbital debris sizes, velocities, and obliquities, and discusses how spacecraft employing these protection systems may be used as a means of measuring the momentum distribution of the impacting orbital debris environment.

When a satellite is impacted by orbital debris, some fraction of the momentum of the impacting particle is imparted to the satellite, and may in fact be "multiplied" by a factor K due to the ejection of some portion of the impactor and satellite mass in a direction opposite to the original direction of the particle (see Figure 1).

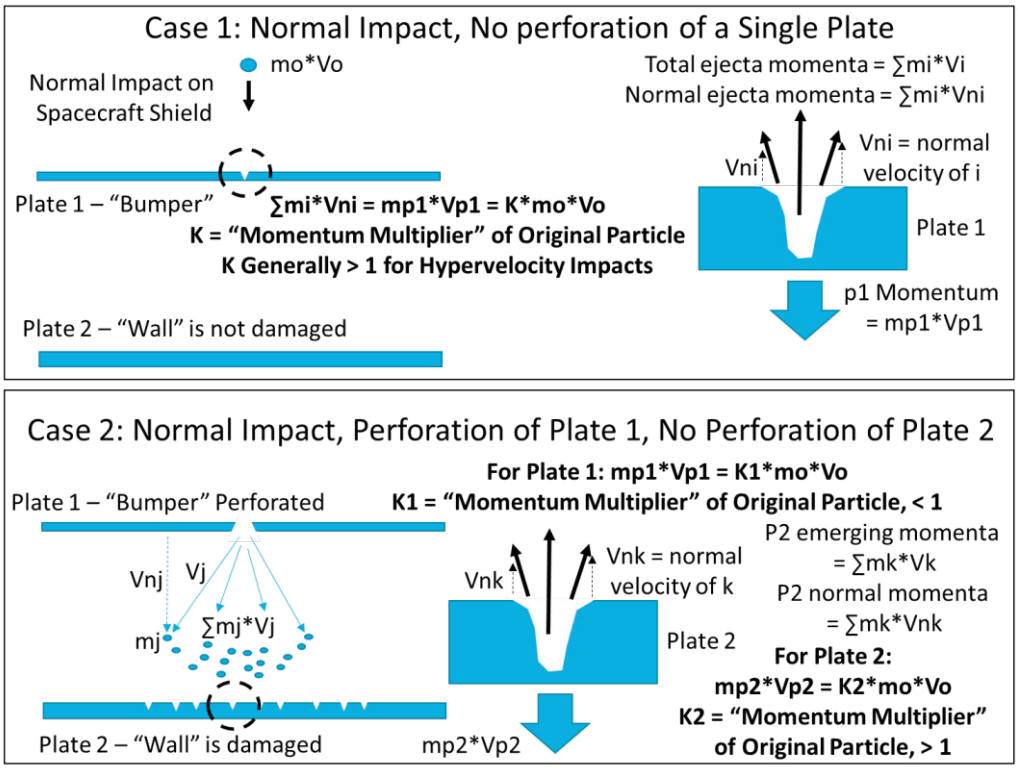


**Figure 1.** Momentum Multiplication in Single Plate (Case 1) and Dual Plates (Case 2)

Download English Version:

https://daneshyari.com/en/article/7228036

Download Persian Version:

https://daneshyari.com/article/7228036

Daneshyari.com