Lessons Learned Developing Separation Systems for Small Satellites

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PSC makes separation systems in Silver Spring, MD
- Building our 65\textsuperscript{th} Lightband
- Started in 1998
- 7 People
**What are separation systems?**

- They separate adjoining space vehicles

A 38 inch diameter separation system on a thrust cone
Vibration testing can produce many cycles of very high quasi-static loading on the primary structure. Several methods are available to pre-empt structural failure.
Wiring harnesses are a major element of separation system design. If the net shape of the harness is not predetermined, a substantial risk of the harness not fitting may result.

A minimal wiring harness schematic

Once formed, a 1.0 inch diameter harness can’t be bent!

A fully featured 3.0 lb harness on a 5.2 lb separation system (Lightband)
Engineers should design to the maximum allowable line load of the adjoining structures and ideally, have a design that minimizes the extremes of line loading. Such a design is also structurally efficient.
TIP-OFF AND CENTER OF MASS (CM)

\[ w = \frac{mv_d}{I} \]

- \( w \) is the tip-off rate [angle per unit time]
- \( m \) is the mass of the separating vehicle
- \( v \) is the relative velocity
- \( d \) is the distance between the center of mass (CM) and the resultant location of the separation springs
- \( I \) is the mass moment of inertia about the center of mass of the separating vehicle.

Tip-off is induced by the distance between the CM and the center of the spring force.
VELOCITY AND SEPARATION SPRINGS

Final Stage Mass (M)  Payload Mass (m)

Spring (S)  v

\[ S = \frac{mMv^2}{2(m + M)E} \]

- \( S \) is the number of springs
- \( E \) is the energy in a spring

Springs are lousy rocket engines
Flatness and Preload

- Joining (preloading) stiff warped structures can substantially reduce structural margin
- Finite element models (FEM) often obscure this possibility as they, by default, assume perfectly flat structures

Joining a warped (0.010 inches) thrust cone to a flat cylinder can create high stresses.

In the cross section of a V-band, a warp of 0.004 inches at the interface to adjoining structures is created by preload.

The flatness of the adjoining surfaces directly affects the strength margin of the separation system. Preloading reduces flatness of structures.