



## Mechanics/Machinery

### ⚙️ Robust Tensioned Kevlar Suspension Design

**A suite of compact design elements improves the reliability of Kevlar suspension systems.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

One common but challenging problem in cryogenic engineering is to produce a mount that has excellent thermal isolation but is also rigid. Such mounts can be achieved by suspending the load from a network of fibers or strings held in tension. Kevlar fibers are often used for this purpose owing to their high strength and low thermal conductivity. However, Kevlar presents challenges since it expands on cooling and tends to creep after initial tensioning, causing reductions in the resonant frequencies and a shift in the position of the suspended element, which can lead to misalignment and thermal short circuits. With existing designs, such as the Kevlar suspension used on the Herschel SPIRE instrument, it is difficult to re-tension the Kevlar or measure the tension because parts of the Kevlar string are staked with epoxy. Non-cryogenic designs used on a larger scale,

such as tensioning reels on sailboats, use turnbuckles and fixed eyebolts that cannot be scaled down to a small-scale structure without a significant addition of mass.

A suite of compact design elements has been developed to improve the reliability of suspension systems made of Kevlar. The Kevlar is anchored to the load via a pair of tensioning stars whose arm stiffness is optimized to ensure that the Kevlar spans remain sufficiently taut during and after thermal cycling. All other anchor points for the Kevlar are designed to have much higher stiffness to maintain the optimal geometry when under load. Pulleys are used at each anchor point allowing the tension to equalize between all spans. The resulting symmetry allows the load to remain fixed in space even as the suspension elements undergo thermal strain, and the tension buffering provided by the tensioning

stars reduces the concomitant changes in the structure's resonant frequencies.

The tension is adjusted by means of a capstan made of an array of stainless steel dowel pins to which the Kevlar string is belayed. Each pin has a large diameter compared to the Kevlar string so there are no machined corners that might initiate fraying of the Kevlar. The capstan is locked with an integrated mechanical clamp, so no epoxy is needed to secure the Kevlar or the capstan in place. Thus, the tension of the Kevlar can be adjusted after the initial creep or easily reworked if needed. The tension can be measured in situ by measuring the flexure of a single arm of the tensioning star.

*This work was done by Joseph B. Young, Bret J. Naylor, and Warren A. Holmes of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47940*

### ⚙️ Focal Plane Alignment Utilizing Optical CMM

**This approach will eliminate all requirements on positional tolerances.**

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In many applications, an optical detector has to be located relative to mechanical reference points. One solution is to specify stringent requirements on (1) mounting the optical detector relative to the chip carrier, (2) soldering the chip carrier onto the printed circuit board (PCB), and (3) installing the PCB to the mechanical structure of the subsystem. Figure 1 shows a sketch of an optical detector mounted relative to mechanical reference with high positional accuracy. The optical detector is typically a fragile wafer that cannot be physically touched by any measurement tool.

An optical coordinate measuring machine (CMM) can be used to position optical detectors relative to mechanical reference points. This approach will eliminate all requirements on positional

tolerances. The only requirement is that the PCB is manufactured with oversized holes. An exaggerated sketch of this situ-

ation is shown in Figure 2. The sketch shows very loose tolerances on mounting the optical detector in the chip car-

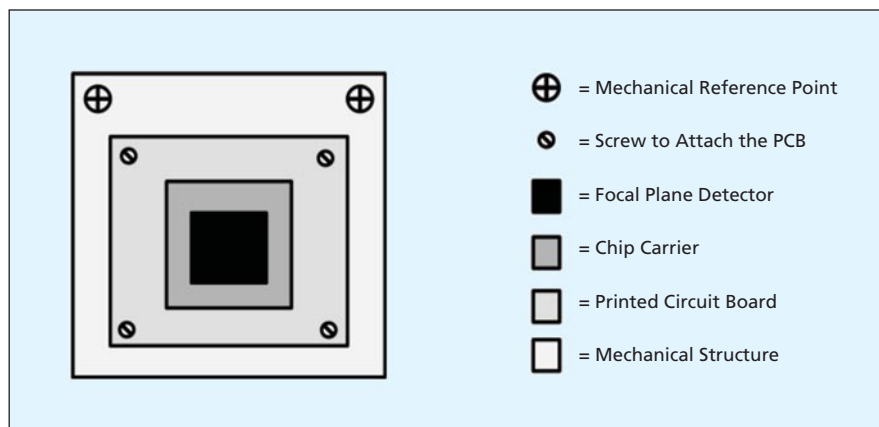


Figure 1. Sketch of an Optical Detector.