1. Purpose: identification of the mechanical properties of structural adhesives for bond of space electronics. The unknowns are Young’s modulus, Poisson’s ratio and modal damping of the investigated adhesive.

2. Application: structural adhesives (EC2216, CV2946, Trabond 8.2, etc.) are employ in reinforcing solder joints of space electronics. This is due to high stress generated at interconnections from high levels of vibrations during critical phases such as the launch.


4. Experimental set-ups: the resonant structure consists of an aluminum top mass adhesive bonded to a base aluminium part attached directly or through an adaptation part to the head of an electrodynamic shaker. The adhesive bond consists of four joints dispensed beneath corners of the top mass.

5. Measured transmissibilities: The assembly is tested separately under sweep sine and random excitations in peel and shear set-ups. Transmissibilities of the adhesive joints are computed using the first estimator $H_k(f)$ from accelerations of the top mass and the base, $s_\text{t}(t)$ and $s_\text{b}(t)$, respectively.

$$H_k(f) = \frac{S_{bc}(f)}{S_{bb}(f)}$$

$S_{bc}(f)$ is the cross-spectrum between the acceleration of the base and the acceleration of the top mass. $S_{bb}(f)$ is the auto-spectrum of $s_b(t)$.

6. Analytical approach: the adhesive joint can be modelled by means of peel and shear stiffness, $K_\text{ac}^p$ and $K_\text{ac}^s$ respectively. Stiffness of the base and the component should be taken into account in the determination of the peel and shear resonance frequencies of the test prototype. This is done by resolving eigenvalue problems defined in shear by

$$\begin{align*}
\lambda_\text{c} x_\text{c} &= K_\text{ac}^s (x_\text{b} - x_\text{c} + \frac{h_c}{2} \theta_\text{c}) \\
m_\text{c} \ddot{x}_\text{c} &= K_\text{ac}^s (x_\text{c} - x_\text{b}) + K_\text{ac}^s (u - x_\text{b}) \\
I_\text{c} \ddot{\theta}_\text{c} &= \frac{h_c}{2} K_\text{ac}^s (x_\text{b} - x_\text{c}) + K_\text{ac}^p \omega_c^2 \theta_\text{c}
\end{align*}$$

and in peel by the following equations of motion:

$$\begin{align*}
\lambda_\text{c} x_\text{p} &= K_\text{ac}^p (x_\text{b} - x_\text{p}) \\
m_\text{p} \ddot{x}_\text{p} &= K_\text{ac}^p (x_\text{p} - x_\text{b}) + K_\text{ac}^p (u - x_\text{b})
\end{align*}$$

$K_\text{ac}^s$ and $K_\text{ac}^p$ represent the respective shear and peel stiffness of the base. $K_\text{ac}^p$ and $K_\text{ac}^s$ are the equivalent peel and shear springs of the adhesive-component.

7. Updating the mechanical properties of the adhesive joint: the tuning of $E_\text{a}$ and $\nu_\text{a}$ is performed through a numerical optimization based on a constrained non linear multi-variable function able to vary $(E_\text{a}, \nu_\text{a})$ until the following error function is minimized.

$$\varepsilon(E_\text{a}, \nu_\text{a}) = \sum_{i=1}^{n} \left( \frac{f_{\text{exp}}^i - f_{\text{fin}}^i}{f_{\text{exp}}^i} \right)^2$$

By supposing the thickness of the adhesive constant, the optimization procedure yields calibrated values of $E_\text{a}$ equal to 3.3 GPa and $\nu_\text{a}$ of 0.49 for Trabond 8.2 adhesive.

8. Conclusion: the present work assessed an original test prototype able to identify Young’s modulus, Poisson’s ratio and modal damping of any adhesive. We argue that this prototype allies simplicity of use and accuracy of results: it conducts to smooth single-mode transmissibilities making the identification of the adhesive properties straightforward and rapid.