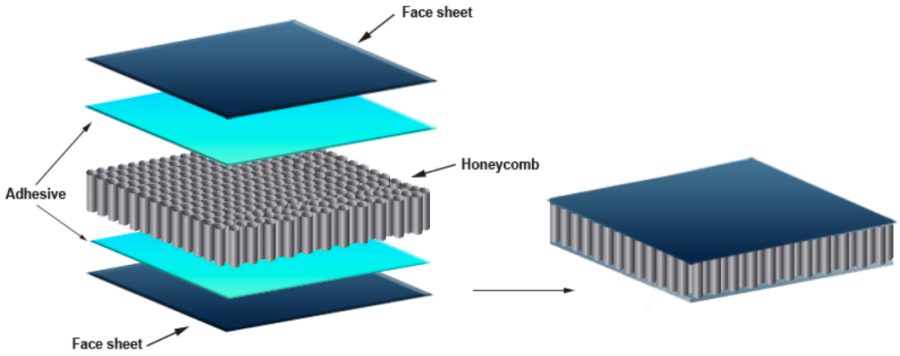
Prioritized multi-objective optimization of the structural strength of a sandwich panel under bending loads and blast

Sandwich elements are well-known for their remarkable mechanical performance



Physical model: analytical model derived from global energy and momentum conservation laws in terms of 4 sizing variables (3 thicknesses, 1 aspect ratio, all 4 subject to interval constraints); one functional constraint on total thickness.

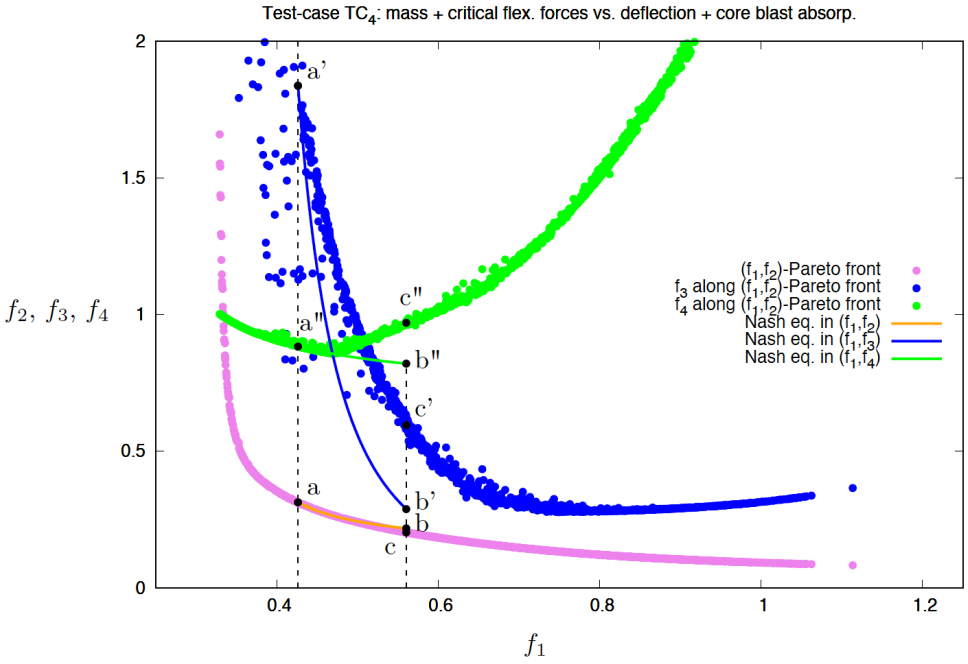
Optimization objective associated with the following prioritized cost functions:

1. Primary (mechanical strength): mass and a blend of (inverse) critical failure forces under bending loads (first two modes considered).
2. Secondary (blast mitigation): core energy absorption and deflection at element center.

Method: "Prioritized multi-objective optimization method"

1. First phase: Quasi-Riemannian MGDA applied to optimize concurrently the primary cost functions under constraint (`https://hal.inria.fr/hal-01417428`).
2. Second Phase: reducing the secondary cost functions while quasi-maintaining the Pareto-optimality of the primary ones by calculating the continuum of Nash equilibria via the MGDA software platform (`https://mgda.inria.fr`).

Result: four cost functions accounted for and a solution far superior in performance than all those provided by the design points of the Primary Pareto Front (PPF; magenta) determined in the first optimization phase. The continuum of Nash equilibria (in yellow), determined in the second optimization phase, nearly coincides with the PPF but largely outperforms it in efficiency w.r.t. the secondary cost functions (b' outperforms c', and b'' outperforms c'').



Legend:
1st optimization phase: Strength under bending loads
PPF of mass concurrently with a blend of two inverse critical failure forces (magenta)
2nd optimization phase: adaptation to blast mitigation
Colors: blue for deflection at center; green for inverse core energy absorption
Symbols: dots for values at PPF design-points; solid lines for values along the continuum of Nash equilibria.

Refs.: J.-A. Désidéri, P. Leite, Q. Mercier. Prioritized multi-objective optimization of a sandwich panel [Research Report] RR-9362 (2021) `https://hal.inria.fr/hal-02931770v1`
J.-A. Désidéri, Springer Proceedings in Mathematics and Statistics, 372, 2021. `https://hal.inria.fr/hal-03430972`

Contrary to a common practice in engineering, evaluating secondary cost functions at design-points on the Primary Pareto Front, is a risky strategy to guide the final selection of a design-point. The continuum of Nash equilibria may provide a far superior solution.