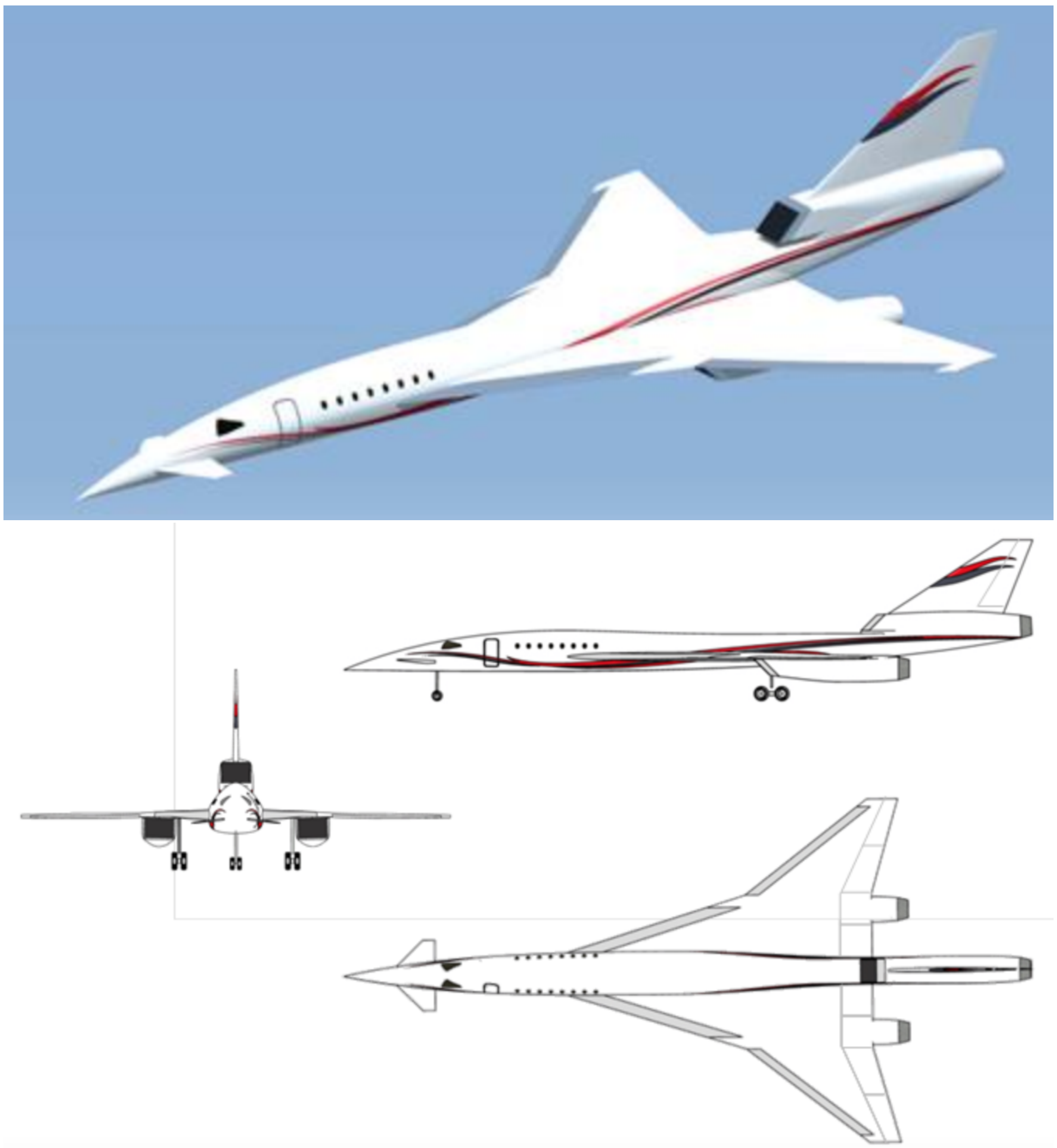
# Prioritized multi-objective optimization of the flight performance of a SuperSonic Business Jet (SSBJ)



*(Courstesy of Dassault Aviation)*

Fifteen sizing parameters defining a generic geometry of a Super Sonic Business Jet (SSBJ) all subject to interval bounds (see Table 1 below) have been optimized concurrently to maximize flight performance in terms of mass at take-off (to be minimized), range (to be maximized), approach speed (to be reduced) under a bound constraint on take-off distance. This optimization was conducted within the ANR Project "OMD" on multi-disciplinary optimization. The generic geometry was also utilized in the European Project HISAC.

Physical model: Breguet's laws permitting to calculate analytically the aircraft flight performance in terms of 15 sizing variables subject to interval bounds (software by courtesy of Dassault Aviation).

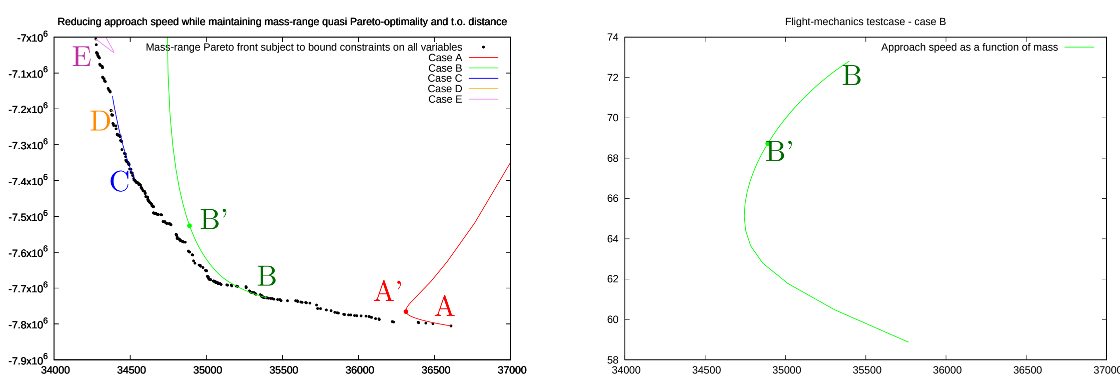
| symbol ($X_i$) | significance (unit) | lower bound $X_{i,\min}$ | upper bound $X_{i,\max}$ |
|---|---|---|---|
| z | cruise altitude (m) | 8000 | 18500 |
| xmach | cruise Mach number | 1.6 | 2.0 |
| S | wing reference surface ($\mathrm{m}^2$) | 100 | 200 |
| phi0w | wing leading-edge sweep angle ($^o$) | 40 | 70 |
| phi100w | wing trailing-edge sweep angle ($^o$) | -10 | 20 |
| xlw | wing taper ratio | 0.05 | 0.50 |
| t_cw | wing relative thickness | 0.04 | 0.08 |
| phi0t | vertical-tail leading-edge sweep angle ($^o$) | 40 | 70 |
| phi100t | vertical-tail trailing-edge sweep angle ($^o$) | 0 | 10 |
| xlt | vertical-tail taper ratio | 0.05 | 0.50 |
| t_ct | vertical-tail relative thickness | 0.05 | 0.08 |
| dfus | fuselage diameter (m) | 2.0 | 2.5 |
| wfuel | fuel mass (kg) | 15,000 | 40,000 |
| alpha | landing maximum angle of attack ($^o$) | 10 | 15 |
| xfac | mlw/tow, landing to take-off mass ratio | 0.85 | 0.95 |

Table 1: Physical design variables in the flight-mechanics test-case and their specified bounds

Optimization objective via ‘Prioritized multi-objective optimization method”:

1. First phase: minimize take-off mass and maximize range subject to a bound constraint on take-off distance by Pareto Archived Evolutionary Strategy (PAES); elect a Pareto-optimal solution $\mathbf{x}_A^\star$.
2. Second phase: construct a continuum of Nash equilibria as a path originating from $\mathbf{x}_A^\star$ tangent to the above Pareto front (in function space) to reduce approach speed via the MGDA software platform (`https://mgda.inria.fr`).

Result: reduced approach speed while quasi maintaining the mass-range Pareto optimality[1].




Left: Primary mass-range Pareto front and five continua of Nash equilibria (abscissa: mass in kg; ordinate: -range in m); right: reduced approach speed along the green continuum path..

[1]Ref.: Prioritized optimization by Nash games : towards an adaptive multi-objective strategy , J.-A. Désidéri and R. Duvigneau, ESAIM: Proceedings and Surveys, EDP Sciences, 2021.
`https://hal.inria.fr/hal-03430912`