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MULTI-OBJECTIVE OPTIMIZATION OF AIRCRAFTS FAMILY AT CONCEPTUAL DESIGN STAGE

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Conceptual Design is the very first step of aircraft design project during which the general arrangement of the aircraft is defined, selecting the overall positions and shapes of various component, as well as the most suitable technologies. These choices are crucial for the project progress and its profitability while wide range of uncertainty is attached to most of the assumptions and evaluation processes. The economical viability of a given project of a new airplane is even more difficult to assess as it has to be put in the perspective of the competition landscape.

Actually, in order to make the largest feedback on R&D investment and to maximise the product attractiveness it is usual to consider the production of a family of aircrafts of different capacities rather than an aircraft alone. With highly similar products, this allows covering a more important market part than a single aircraft. All the members of this family of aircrafts have different fuselage lengths and characteristic weights but they have in common a maximum number of elements which may reduce drastically airliners maintenance and operational costs.

Generally, there is a central configuration from which are taken the other members of the family. These are usually realized adding or removing fuselage sections, adapting engine rating thrusts or changing engines and optimising structural reinforcements of a limited number of components. This will result in airplanes with different nominal ranges and characteristic weights. To give an example, Fig. 1 shows the market place covered by a family of three aircrafts. It is important to notice that each aircraft in this type of graphic is facing existing, or projected, competitor airplanes.

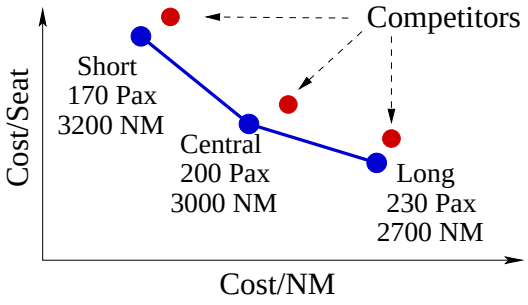

Figure 1. Market place covered by 3-aircraft family.

Being inside slightly different market segments, each member of the family has its own operational requirements but also its own cost criteria which makes the family optimisation a basic multi-criteria problem. Some of the design parameters (as the wing design parameters) are common to all members of the family but some others (as the engine maximum thrust) are specific to each member. Due to coupling through family parameters, any design parameter (family or member specific) can be sized by any member specific constraints. To complicate a little bit the picture, it is usual to put in concurrence several criteria as Cash Operating Cost (COC), Maximum Take Off Weight (MTOW) and Mission Fuel in order to assess some robustness of the optimum.

Due to business strategic considerations, aircraft family optimisation requires that several possible solutions be exhibited in order to let freedom to decision making. The Pareto Front in the criteria space and its associated Pareto Set in the parameter space is probably one of the most relevant mathematical tool to capture most of possible compromises.

The following study illustrates this approach. AIRBUS in-house simulation toolbox was used to evaluate design criteria and constraints. MACROS Generic Tool for Optimization developed by DATADVANCE was used to perform multi-objective optimization.

Complexity of proposed formulation is challenging and it seems that none of conventional methods are able to solve it properly. Here the advantages of MACROS Generic Tool for Optimization proved to be invaluable to exhaustively solve the problem. Using MACROS we were able to find not only the designs with greatly improved performances (from 10 to 20 percent), but to investigate the fine structure of Pareto frontier as well.