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MULTIDISCIPLINARY ANALYSIS OF THE DLR SPACELINER DESIGN CONCEPT BY DIFFERENT OPTIMIZATION TECHNIQUES

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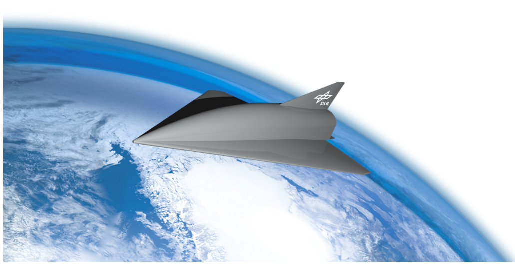
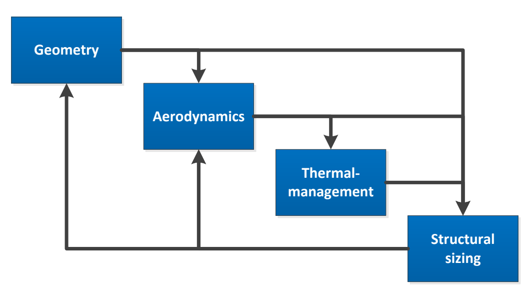
The DLR SpaceLiner [1], depicted on Fig.(a), is a concept study between aviation travel and space travel for ultra fast passenger transport. A flight from Europe to Australia would take only 90 minutes. As one can imagine, many challenges have to be faced when designing new space transportation vehicles. So far, research has been carried out on several aspects of the SpaceLiner concept separately. The aerodynamic performance of the flight vehicle has been investigated in hypersonic flow regime which represents the major part of the trajectory [2]. A finite element model of the SpaceLiner structure has been generated and analyses of the structural loadings have been executed [3]. When designing spacecraft, one of the major issues is to devise its thermal protection systems needed during atmospheric re-entry. Beside passive thermal management techniques through heat sink elements consisting of materials with extremely high heat conductivity and forced radiation cooling, active cooling procedures like transpiration cooling using liquid water evaporating through a porous ceramic are in the focus of DLR research [4].
In this paper, the goal is to find the optimal preliminary SpaceLiner design considering all these disciplines together in one single optimization problem. As the considered disciplines



(a) DLR SpaceLiner concept study



(b) Involved disciplines in MDO problem

together build a coupled system (see Fig.(b)) and a change of input in one simulation tool affects also the output of several other ones, multidisciplinary optimization (MDO) techniques have to be applied. We decided to use the sequential Individual Design Feasible (sIDF) approach. The objective of the formulated MDO problem is to locate the design with the minimal mass including liquids subject to a lower bound on the glide ratio, an upper bound on the pitching moment and to several geometrical constraints.
As most of the involved physical phenomena cannot be computed analytically, they have to be approximated by different numerical simulation tools of the mentioned disciplines. These distinct tools are integrated in a design process chain inside the workflow integration platform RCE [5] to be able to efficiently analyze and optimize the overall system. Furthermore, most of the integrated engineering simulation tools do not provide derivatives of the objective and constraint functions such that only optimization methods which do approximate or do not need derivatives at all can be applied in our case. The described optimization problem is solved using several publicly available software codes (COBYLA, APPS and SOLVOPT) which we compare in terms of quality of the solution. Our experiments show that SOLVOPT [6], a modified version of Shor's r-algorithm, is able to find a feasible solution of the described MDO problem in our optimization framework.
Many more details will be given in the forthcoming paper.

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