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Technical Notes

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Development of a Java-Based Framework for Aircraft Preliminary Design and Optimization

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I. Introduction

THE conceptual and preliminary design phases play a very important role for the development of the future transport aircraft. A computational framework capable of finding an optimal configuration satisfying several basic requirements would be an essential tool for industrial aircraft designers. Such software should be developed around all those basic principles and approaches to aircraft preliminary design well described in several textbooks on the subject [1–9].¶

A modern preliminary aircraft design tool should be characterized by a certain level of accuracy and reliability (albeit using fast and simple semi-empirical procedures), the capability to perform multidisciplinary analyses, and reasonably short computational times. Because of the particular relevance of production costs, noise, emissions, maintenance, and operative costs in the commercial success of a transport aircraft, a modern software framework should be developed with a multidisciplinary optimization (MDO) approach in mind. Another important aspect is the user-friendliness of the interface that should allow the user to interact with the design framework in an easy, fast, and efficient way. Of the same or even of more importance is the possibility to include in the software multiple fidelity analysis methods or to modify and develop new semi-empirical models to achieve better accuracy. It should also be possible to export the aircraft configuration geometry (e.g., as a CAD model or a surface mesh) in one or more standard formats and to execute high-fidelity analyses with external tools (e.g., computational fluid dynamics or Finite Element Method (FEM) solvers).

Many aircraft design computational tools have been developed by several universities, companies, aeronautical industries, and research centers in the past and recent years [10–17]. In many recent papers [18–21], the importance of including a knowledge-based engineering approach in modern aircraft design tools is highlighted.

The present note introduces the ongoing development of the Java Program Toolchain for Aircraft Design (JPAD), a Java-based desktop application for aircraft designers. The aim of JPAD, which eventually will be released as open-source software, is to provide a library and a set of companion tools based on modern software technology as a support for typical preliminary design studies. The software has been conceived to be used in an industrial environment across conceptual and preliminary design phases. In these phases, a lot of different configurations have to be considered, and so the proposed software relies mostly on semi-empirical analysis methods and is capable to quickly provide results. A comprehensive study of the methods available in the literature has been first carried out to improve the accuracy of the results; each method has been tested against experimental data (produced in house or drawn from literature) so that statistical quantities (e.g., standard deviation) could be estimated either to find the best method currently available or to make a merger of different methods.

The use of middle- and high-fidelity methods (e.g., in aerodynamics, numerical lifting line, vortex lattice method, or computational fluid dynamics) is beneficial in preliminary studies, provided that their computational time is reasonably short. In this respect, the development of new semi-empirical methodologies or improved analysis approaches (especially for innovative aircraft configuration) is an important item that has been extensively reported in several recent works [21–26]. The aircraft design research group at the University of Naples has matured in the past two decades experience in design of light and turboprop transport aircraft [27,28]. Recent aircraft design activities carried out by the authors on a commuter 11-seat aircraft has been described and illustrated in some recent papers [29,30]. The matured know-how in aircraft aerodynamic designs has also found confirm through specific flight-testing research [31,32].

II. Main Features of the Proposed Software Framework

The main challenge in developing from scratch a computational ecosystem to be used by aircraft designers is the choice of the programming language and its related software technology. On the domain modeling side, another challenge is the abstraction of the aircraft with all its

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