Enhancement of an Aircraft Design Environment for the Design of Fighter Aircraft

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1. INTRODUCTION

Without a doubt, aircraft design is a complex process where the smallest change in a particular value affects the overall result. Consequently, new aircraft are designed on different computer-based software with rapid estimation capabilities to investigate – among others – the effect of parameter variations. Up to the preliminary design stage, several public computing tools are available for purchase or freeware. Nevertheless, at the Institute of Aircraft Design of the Technical University of Munich, a conceptual and early-stage preliminary aircraft design environment, the Aircraft Design Box (ADEBO), is under development. In contrast to the commercially available design environments, the requirements for ADEBO were, among others, the possibility to use various tools of different fidelity, the utilization of already existing software with uniform application procedures, and consequently the existence of a central data model as a single data source [1]. The initial version of ADEBO was designed for the preliminary layout of fixed-wing manned and unmanned subsonic aircraft. The presented work's main objective is to extend these existing aircraft design capabilities to fighter aircraft design.

2. METHODOLOGY

In the ADEBO design environment, an aircraft design starts with defining the flight performance requirements. A predefined required mission contains not only supersonic and subsonic flight phases but optionally a total deployment of the onboard armament in the form of the sudden drop in payload mass as well. As a result of flight in supersonic condition or the requirement of increased maneuverability, the methods for estimating the aerodynamic coefficients are tailored for these altered conditions (specifically describing aerodynamic properties of low aspect ratio wings). Furthermore, the flight at supersonic speeds fundamentally affects the airfoil selection and the fuselage's shape due to effects such as transonic zero-lift drag increase. Methods are implemented to address relaxed stability fighter layouts (horizontal tail sizing). The equations for the mass estimation of the aircraft components are adapted for fighter aircraft configurations. A more detailed description of the fighter aircraft design process and the used methods will be provided in the full paper.

3. PRELIMINARY RESULTS

As an example, the established fighter aircraft design process has been used to re-design the F-16 fighter aircraft. Preliminary results show sufficient similarity concerning area loading (AL) and thrust loading (TL) as can be seen in TABLE 1 and FIGURE 1, respectively.

		Original	ADEBO
Geometry	S_w [m^2]	30.61	33.15
	AL [kN/m^2]	5.33	4.66
Propulsion	BPR [−]	0.78	0.82
	TL [−]	1.05	1.12

TABLE 1: Comparison of preliminary results of the F-16 re-design in ADEBO with the original F-16 data

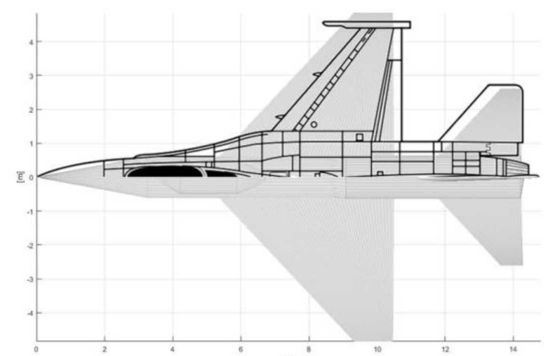

FIGURE 1: Geometrical comparison between the F-16 and the result of the preliminary design process in ADEBO

4. CURRENT WORK

To further improve the fighter aircraft design, the conceptual aerodynamic modeling is currently being refined with two different methods: a more detailed handbook method based on formulas for preliminary estimation of nonlinear lift [2] and the penalization method of Paniszczyn [3], and the NASA Ames Wing-Body Panel Program's early mean surface panel code, usable for both subsonic and supersonic estimations [4]. In this way the currently used equations for linear aerodynamics will be replaced; enabling a more accurate design process of a fighter aircraft in ADEBO.

5. REFERENCES

[1] Herbst, S., *"Development of an Aircraft Design Environment Using an Object-Oriented Data Model in MATLAB,"* Dissertation, Technical University of Munich, Munich, Germany, 2018.

[2] Staudacher, W., *"Die Beeinflussung von Vorderkantenwirbelsystemen schlanker Tragflügel,"* Dissertation, University of Stuttgart, Stuttgart, Germany, 1992.

[3] Paniszczyn, T. F. (ed.), *Prediction of lift and aerodynamic center for variable sweep wings.,* American Institute of Aeronautics and Astronautics, New York, United States of America, 1967.

[4] Woodward, F. A., Carmichael, R., Kawaguchi, A., Tinoco, E., Larsen, J., et al., *NASA Ames Wing BodyPanel Programm*, Ver. 0.95, Public Domain Aeronautical Software, 1959.