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Conceptual Design Level Airframe/Propulsion Integration Using the Generic Synthesis Framework AVDS.

Application to Supersonic and Hypersonic Aerospace Vehicles

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ABSTRACT

In the past few decades there has been a significant growth in commercial aerospace transportation encompassing both atmospheric and space flight. In fact, the aircraft industry has seen several generations of engines and vehicles developed. While the space launch sector has switched from exclusively expandable rockets systems to including reusable rocket systems. Now, the current push in the industry is to develop a reusable in-atmosphere hypersonic transportation system. The development of any aircraft entails communicating the interactions among the principal design disciplines (aerodynamics, propulsion, structures, materials, etc.). For hypersonic vehicles, the interdependence of these interactions is enhanced to a level not present at lower speeds. For example, an increase in wing size would require an increase in engine size, which would lead to more fuel required, which then leads to more volume, etc. With all of this known, the goal is to size the smallest possible vehicle.

With hypersonic vehicle design embracing a focus on reusability, high flight rates, and benefit to civilian transportation systems, the understanding of propulsion and airframe integration becomes a key to a sufficient design. Achieving good aero-propulsion performance can lead to a promising design which may reduce the significance of the material chosen has on the design. Generally, the aero-propulsion interactions are considered later in the preliminary design phase when the airframe and the engines are already decided. Until that point, each component is analyzed separately by the corresponding disciplines. This does not necessarily lead to the optimum design. For an accurate prediction of the design, and reduction of the cost to change the design, if necessary, these propulsion airframe integration effects should be considered in the early design phase (conceptual design).

It is the hypothesis of this research that the propulsion airframe integration has classically been reserved for high-fidelity analysis (level 3-4) and its effects not considered at low fidelity (level 0-2). This is especially apparent in mainstream synthesis systems. Being restricted to higher fidelity approaches often leads to the advancement of inadequately designed aircraft through the design cycle. This can be fixed by sizing engines and considering its basic effects on vehicle geometry in addition to other disciplines within an automated synthesis system. In pursuit of this solution, a generic synthesis tool, AVDS (Aerospace Vehicle Design Synthesis), is modified to capture the effects of airframe/propulsion integration.

This dissertation presents the review of propulsion airframe integration documents and synthesis process, and the development and demonstration of the generic methodology that will support the conceptual design level propulsion-airframe integration process utilized within the synthesis system AVDS. Two different integration processes are developed and discussed in detail along with disciplinary analysis methods and method verification.

Three vehicle configurations, Concorde, XB-70 and Sänger, have been selected to serve as case studies for verification of the proposed processes. The applicability of the process to produce hundreds or thousands of converged vehicles with a quick turnaround time is also discussed along with proper comprehension of the produced solution space that occurs before selecting the final baseline design that could progress further along the design process.