Aerospace Engineering Thesis Defense

Revisiting the Transonic Area Rule for Conceptual Aerodynamic Design

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Abstract

The Transonic Area Rule, developed by Richard T. Whitcomb in the early 1950s, revolutionized high-speed flight because its insight allowed engineers to reduce and/or delay the transonic drag rise. To this day, it is the rationale behind "coke-bottle" sculpturing (indenting the fuselage of aircraft at the wing-fuselage junction) to alter the cross-sectional area development of the body. According to Whitcomb, this indentation is meant to create a smoother transition of cross-sectional area development of the body and consequently would reduce the number of shocks on the body, their intensity, and their shock pattern complexity. Along with this, modeling of a geometry's transonic drag rise could be simplified by creating a comparable body of revolution with the same cross-sectional area development as the original geometry. Thus, the Transonic Area Rule has been advertised as an aerodynamic multitool.

This new work probes the underlying mechanics of the Transonic Area Rule and determines just how accurate it is in producing its advertised results. To accomplish this, several different wave-drag approximation methods were used to replicate and compare the results presented in Whitcomb's famous 1952 report14. These methods include EDET (Empirical Drag Estimation Technique)2, D2500 (Harris Wave Drag program)4, and CFD analysis through SU23. Overall drag increment data was collected for comparison with Whitcomb's data. More in-depth analysis was then done on the flow conditions around the geometries using CFD solution plots.

After analysis of the collected data was performed, it was discovered that this data argued against Whitcomb's comparable body of revolution claim as no cases were demonstrated where the comparable body and original body yielded similar drag rise characteristics. Along with this, shock structures and patterns were not simplified in two of the three cases observed and were instead complicated even further. The only exception to this observation was the swept wing, cylindrical body in which all shocks were virtually eliminated at all observed Mach numbers. For the reduced transonic drag rise claim, the data argued in favor of this as the drag rise was indeed reduced for the three observed geometries, but only for a limited Mach number range.

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Zoom Link: https://asu.zoom.us/j/84209719191