EXTENDING FIVE-HOLE PRESSURE PROBE CALIBRATION ACROSS PROBE GEOMETRIES USING A GEOMETRY-BASED CORRECTION FACTOR

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ABSTRACT

Five-hole pressure probes require independent calibration for each probe geometry, increasing calibration effort and limiting transferability of calibration methodologies. Recent work has developed CFD-based calibration maps for an L-shaped five-hole pressure probe and identified experimental validation as the next step toward evaluating the accuracy of the numerical predictions.

The present work represents the experimental continuation of that study by validating the CFD predictions and investigating whether observed geometric effects can be incorporated into existing straight-probe calibration framework. By comparing pressure responses of the straight and L-shaped probes, this study aims to determine whether geometry-induced differences can be represented mathematically and incorporated into the existing calibration framework.

INTRODUCTION

Five-hole pressure probes are widely used for aerodynamic measurements because they provide accurate measurements of flow direction and pressure while remaining practical where optical measurements may be incompatible due to cost or experimental constraints [1,2]. Their ability to perform non-nulling measurements enables simultaneous measurement of flow direction, velocity components, and total and static pressures without requiring probe nulling [2,3,4,5]. Early calibration approaches relied on empirical polynomial relationships and lookup-table interpolation [4,6], while later work introduced local interpolation algorithms and improved procedures to increase prediction accuracy and reduce sensitivity to experimental noise [2,7,8,9]. Automated calibration systems and data-driven modeling techniques have further improved calibration efficiency through Symbolic Regression and Gaussian Process Regression [10,11,12].

Recent computational work within the GIMAS laboratory developed CFD calibration maps for an L-shaped five-hole pressure probe and identified experimental validation as the next step toward extending the methodology to practical applications [13]. Building upon this work, the present study investigates whether a geometry-based correction factor can enable calibration transfer from a straight to an L-shaped five-hole pressure probe.

PRELIMINARY RESULTS AND DISCUSSION

Experimental calibration of the L-shaped five-hole pressure probe is currently underway. The facility employs computer-controlled positioning to obtain repeatable probe locations during calibration experiments [14]. The probe is positioned using LabVIEW-controlled stepper motors for precise pitch and yaw positioning [15,16], while pressure measurements are acquired using a high-accuracy DSA3217 Scanivalve pressure scanner [17]. Calibration data are being collected over the same operating conditions used for the straight probe to enable direct comparison between the two probe geometries.

Based on the previous CFD study, it is anticipated that the experimental calibration maps will reproduce the trends observed numerically, with the most significant deviations occurring in the yaw calibration coefficients due to the influence of the L-shaped stem on the surrounding flow field. Agreement between computational and experimental calibration maps would provide confidence in the numerical methodology, while discrepancies will help identify geometric effects that are not fully captured by the CFD [13].

If successful, the proposed framework in Figure 1, could reduce the need for independent calibration of every probe geometry and improve the efficiency of future aerodynamic testing.

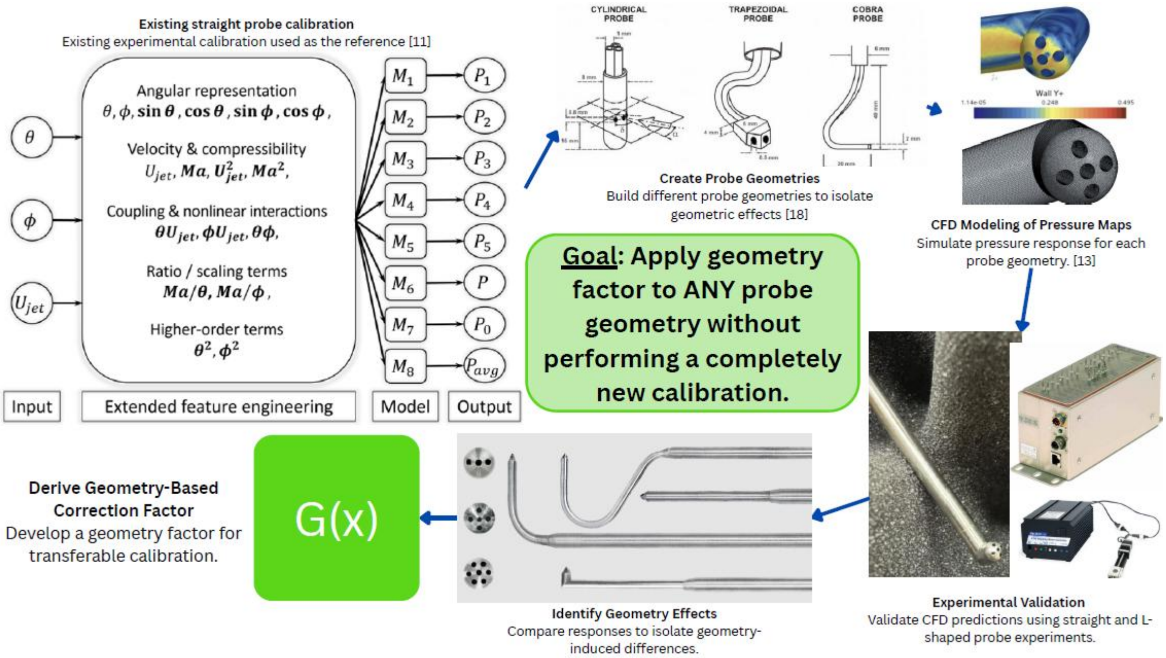

Figure 1. Overview of proposed geometry-based calibration transfer methodology for pressure probes.

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