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Optimal sensor placement in high-speed transitional boundary layers[1] MELISSA KOZUL, Norwegian University of Science and Technology (NTNU), DAVID A. BUCHTA, TAMER A. ZAKI, Johns Hopkins University — Predictions of the mechanism and location of boundary-layer transition from limited wall observations are an important challenge in high-speed flow experiments and flight tests. We have developed a framework whereby we infuse available observations in our simulations, to determine the precise flow conditions, transition mechanism and its location. However, the quality of the estimated flow field depends on the available number of sensors and their placement, which in turn may be restricted by practical considerations such as the leading-edge geometry. For a transitional boundary layer at Mach 4.5, we seek the optimal arrangement of a limited number of wall pressure probes. An ensemble of planar and oblique second-mode instabilities is used to represent environmental uncertainty. Direct numerical simulation of each inflow is used to acquire wall-pressure data, which form an observation matrix. The optimal sensor placement is then identified by a gradient-based optimization of matrix invariants. Using the predicted sensor configuration, we then perform observation-infused simulations whereby we attempt to reconstruct an independent flow state from wall observations. The accuracy of our predictions is contrasted to a traditional sensor placement.

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