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An I-Optimal Split-Plot Design for EVTOL Tilt-Rotor Performance Characterization

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A growing flock of eVTOL urban air mobility vehicles has hit the market and will play an important role in reducing future ground and air traffic congestion in urban areas. Over 100 vectored thrust eVTOL configurations are in either the design or prototype phase according to the Vertical Flight Society (https://evtol.news/aircraft). The success of eVTOL hinges on battery technology and hence benefits greatly from propeller aerodynamic efficiency. In addition, noise concerns have driven aircraft designers to consider higher propeller blade counts. This talk presents a general testing approach with restricted randomization for aerodynamic performance characterization of propellers at angle of incidence, including empirical model building. The specific aircraft model that is supported by this work is pictured below, the NASA Langley Aerodrome 8 (LA8).

Hard to change factors are common in wind tunnel aerodynamic performance characterization studies. Factors that require aircraft model configuration changes may not support randomization within test entry resource constraints. Split Plot Design (SPD) and analysis techniques are an attractive option for the DOE practitioner to conform to constraints. In this talk, an SPD is applied to a wind tunnel test where subscale three- through six-blade propeller performance tests were conducted in a wind tunnel.

Design-Expert was used to build a constrained I-optimal SPD. In the talk I will describe the process in detail including the development of the constraints, point selection, considerations for prediction variance distribution, FDS, degrees of freedom for the modified cubic model and error. Analysis was performed using ANOVA with REML for significance testing.