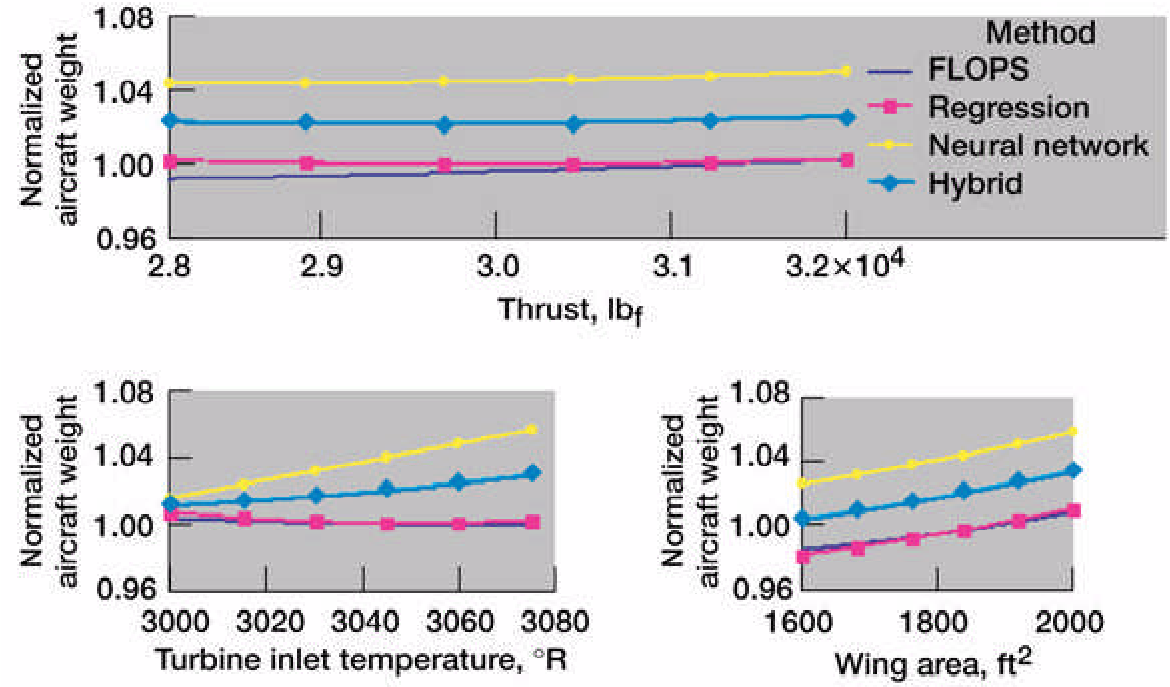
Neural Network and Regression Methods Demonstrated in the Design Optimization of a Subsonic Aircraft

The neural network and regression methods of NASA Glenn Research Center's COMETBOARDS design optimization testbed were used to generate approximate analysis and design models for a subsonic aircraft operating at Mach 0.85 cruise speed. The analytical model is defined by nine design variables: wing aspect ratio, engine thrust, wing area, sweep angle, chord-thickness ratio, turbine temperature, pressure ratio, bypass ratio, fan pressure; and eight response parameters: weight, landing velocity, takeoff and landing field lengths, approach thrust, overall efficiency, and compressor pressure and temperature. The variables were adjusted to optimally balance the engines to the airframe. The solution strategy included a sensitivity model and the soft analysis model. Researchers generated the sensitivity model by training the approximators to predict an optimum design. The trained neural network predicted all response variables, within 5-percent error. This was reduced to 1 percent by the regression method.

The soft analysis model was developed to replace aircraft analysis as the reanalyzer in design optimization. Soft models have been generated for a neural network method, a regression method, and a hybrid method obtained by combining the approximators. The performance of the models is graphed for aircraft weight versus thrust as well as for wing area and turbine temperature. The regression method followed the analytical solution with little error. The neural network exhibited 5-percent maximum error over all parameters. Performance of the hybrid method was intermediate in comparison to the individual approximators. Error in the response variable is smaller than that shown in the figure because of a distortion scale factor. The overall performance of the approximators was considered to be satisfactory because aircraft analysis with NASA Langley Research Center's FLOPS (Flight Optimization System) code is a synthesis of diverse disciplines: weight estimation, aerodynamic analysis, engine cycle analysis, propulsion data interpolation, mission performance, airfield length for landing and takeoff, noise footprint, and others.



Performance of neural network and regression methods for a subsonic aircraft. Top: Normalized aircraft weight versus thrust. Bottom left: Weight versus turbine inlet temperature. Bottom right: Weight versus wing area.

Glenn contact: Dale A. Hopkins, 216-433-3260, Dale.A.Hopkins@nasa.gov **Ohio Aerospace Institute (OAI) contact:** Dr. Surya N. Patnaik, 216-433-5916, Surya.N.Patnaik@grc.nasa.gov
Authors: Dale A. Hopkins, Thomas M. Lavelle, and Dr. Surya N. Patnaik
Headquarters program office: OAT
Programs/Projects: Propulsion Systems R&T