



## Adaptation of Mesoscale Weather Models to Local Forecasting

**Both objective and subjective evaluation methodologies are needed.**

*John F. Kennedy Space Center, Florida*

Methodologies have been developed for (1) configuring mesoscale numerical weather-prediction models for execution on high-performance computer workstations to make short-range weather forecasts for the vicinity of the Kennedy Space Center (KSC) and the Cape Canaveral Air Force Station (CCAFS) and (2) evaluating the performances of the models as configured. These methodologies have been implemented as part of a continuing effort to improve weather forecasting in support of operations of the U.S. space program. The models, methodologies, and results of the evaluations also have potential value for commercial users who could benefit from tailoring their operations and/or marketing strategies based on accurate predictions of local weather.

More specifically, the purpose of developing the methodologies for configuring the models to run on computers at KSC and CCAFS is to provide accurate forecasts of winds, temperature, and such specific thunderstorm-related phenomena as lightning and precipitation. The purpose of developing the evaluation methodologies is to maximize the utility of the models by providing users

with assessments of the capabilities and limitations of the models.

The models used in this effort thus far include the Mesoscale Atmospheric Simulation System (MASS), the Regional Atmospheric Modeling System (RAMS), and the National Centers for Environmental Prediction Eta Model ("Eta" for short). The configuration of the MASS and RAMS is designed to run the models at very high spatial resolution and incorporate local data to resolve fine-scale weather features. Model preprocessors were modified to incorporate surface, ship, buoy, and rawinsonde data as well as data from local wind towers, wind profilers, and conventional or Doppler radars.

The overall evaluation of the MASS, Eta, and RAMS was designed to assess the utility of these mesoscale models for satisfying the weather-forecasting needs of the U.S. space program. The evaluation methodology includes objective and subjective verification methodologies. Objective (e.g., statistical) verification of point forecasts is a stringent measure of model performance, but when used alone, it is not usually sufficient for quantifying the value of the overall contribu-

tion of the model to the weather-forecasting process. This is especially true for mesoscale models with enhanced spatial and temporal resolution that may be capable of predicting meteorologically consistent, though not necessarily accurate, fine-scale weather phenomena. Therefore, subjective (phenomenological) evaluation, focusing on selected case studies and specific weather features, such as sea breezes and precipitation, has been performed to help quantify the added value that cannot be inferred solely from objective evaluation.

*This work was done by John T. Manobianco, Gregory E. Taylor, Jonathan L. Case, Allan V. Dianic, and Mark W. Wheeler of ENSCO, Inc., John W. Zack of MESO, Inc., and Paul A. Nutter formerly of ENSCO, Inc., for Kennedy Space Center. For further information, contact John Manobianco at (321) 853-8202 or via e-mail at manobianco.john@ensco.com or refer to "Evaluation of the 29-km Eta Model. Part I: Objective Verification at Three Selected Stations" and "Evaluation of the 29-km Eta Model. Part II: Subjective Verification over Florida" in Weather and Forecasting, Volume 14 (February 1999), published by the American Meteorological Society. KSC-12241*

## Aerodynamic Design Using Neural Networks

**The amount of computation needed to optimize a design is reduced.**

*Ames Research Center, Moffett Field, California*

The design of aerodynamic components of aircraft, such as wings or engines, involves a process of obtaining the most optimal component shape that can deliver the desired level of component performance, subject to various constraints, e.g., total weight or cost, that the component must satisfy. Aerodynamic design can thus be formulated as an optimization problem that involves the minimization of an objective function subject to constraints.

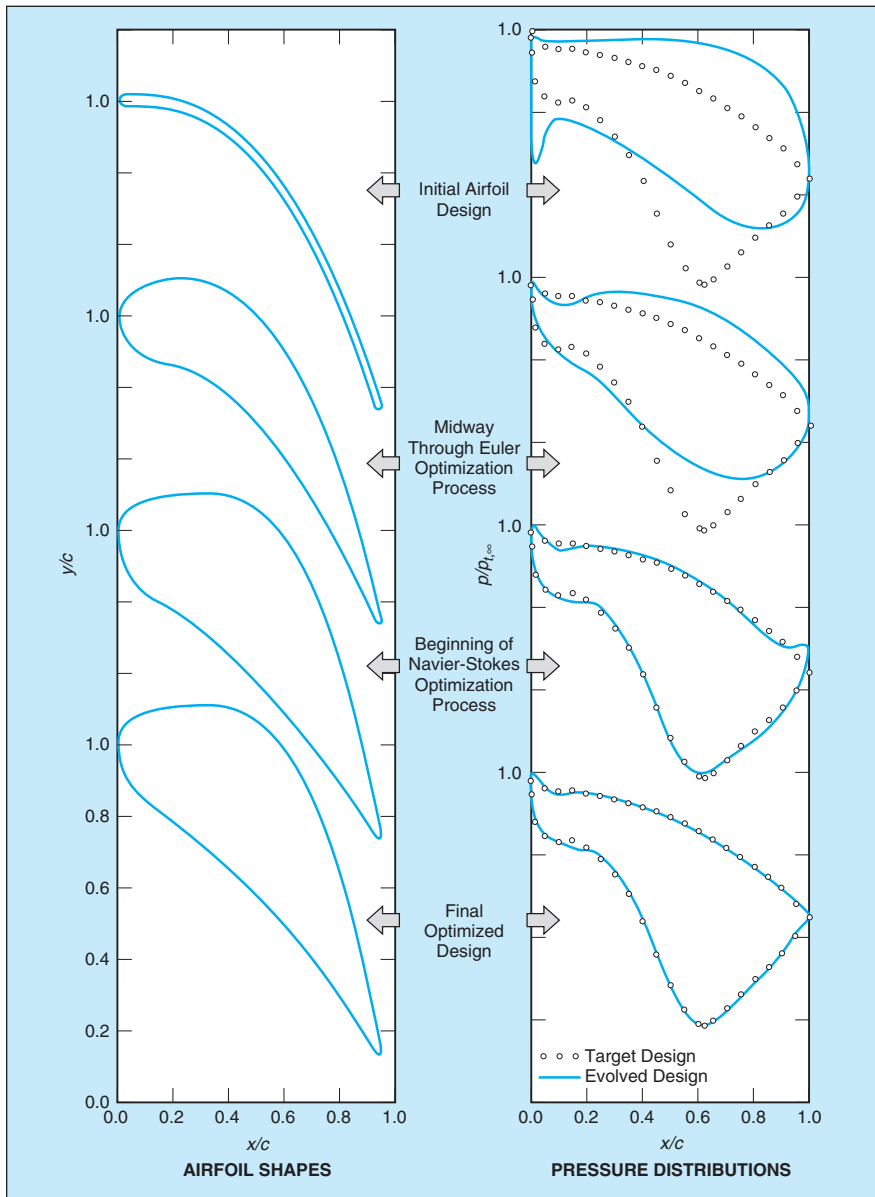
A new aerodynamic design optimization procedure based on neural networks

and response surface methodology (RSM) incorporates the advantages of both traditional RSM and neural networks. The procedure uses a strategy, denoted parameter-based partitioning of the design space, to construct a sequence of response surfaces based on both neural networks and polynomial fits to traverse the design space in search of the optimal solution.

Some desirable characteristics of the new design optimization procedure include the ability to handle a variety of design objectives, easily impose constraints, and incorporate design guidelines and

rules of thumb. It provides an infrastructure for variable fidelity analysis and reduces the cost of computation by using less-expensive, lower fidelity simulations in the early stages of the design evolution. The initial or starting design can be far from optimal. The procedure is easy and economical to use in large-dimensional design space and can be used to perform design tradeoff studies rapidly. Designs involving multiple disciplines can also be optimized.

Some practical applications of the design procedure that have demonstrated



The **Design Procedure** can evolve a generic shape into an optimized airfoil that matches a target pressure distribution. Position coordinates ( $x$  and  $y$ ) are normalized to the chord length ( $c$ ); local pressure ( $p$ ) is normalized to the turbine inlet total pressure ( $p_{t, \infty}$ ).

some of its capabilities include the inverse design of an optimal turbine airfoil starting from a generic shape and the redesign of transonic turbines to improve their unsteady aerodynamic characteristics.

In one practical application, the procedure was used to reconstruct the shape of a turbine airfoil given a desired pressure distribution and some relevant flow and geometry parameters. The shape of the airfoil was not known beforehand. Instead, it was evolved from a simple curved section of nearly uniform thickness. The evolved optimal airfoil closely matched the shape of the original airfoil that was used to obtain the pressure distribution. The progression of the design is depicted in the figure. The airfoil shape evolution is shown on the left, while the corresponding pressure distributions and the target pressure distribution are shown on the right. The surface pressures approach the target distribution as the design progresses until the optimal airfoil shown at the bottom has a pressure distribution that matches closely the target.

The technology developed and implemented in the neural-network-based design optimization procedure offers a unique capability that can be used in other aerospace applications such as external aerodynamics and multidisciplinary optimization, and has potential applications beyond aerospace design.

*This work was done by Man Mohan Rai and Nateri K. Madavan of Ames Research Center. Further information is contained in a TSP (see page 1).*

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14281.*

## Combining Multiple Gyroscope Outputs for Increased Accuracy

**A lightweight, low-power, compact MEMS gyroscope array could perform comparably to a larger more-conventional gyroscope.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A proposed method of processing the outputs of multiple gyroscopes to increase the accuracy of rate (that is, angular-velocity) readings has been developed theoretically and demonstrated by computer simulation. Although the method is applicable, in principle, to any gyroscopes, it is intended especially for application to gy-

roscopes that are parts of microelectromechanical systems (MEMS). The method is based on the concept that the collective performance of multiple, relatively inexpensive, nominally identical devices can be better than that of one of the devices considered by itself. The method would make it possible to synthesize the readings of a single,

more accurate gyroscope (a "virtual gyroscope") from the outputs of a large number of microscopic gyroscopes fabricated together on a single MEMS chip. The big advantage would be that the combination of the MEMS gyroscope array and the processing circuitry needed to implement the method would be smaller, lighter in