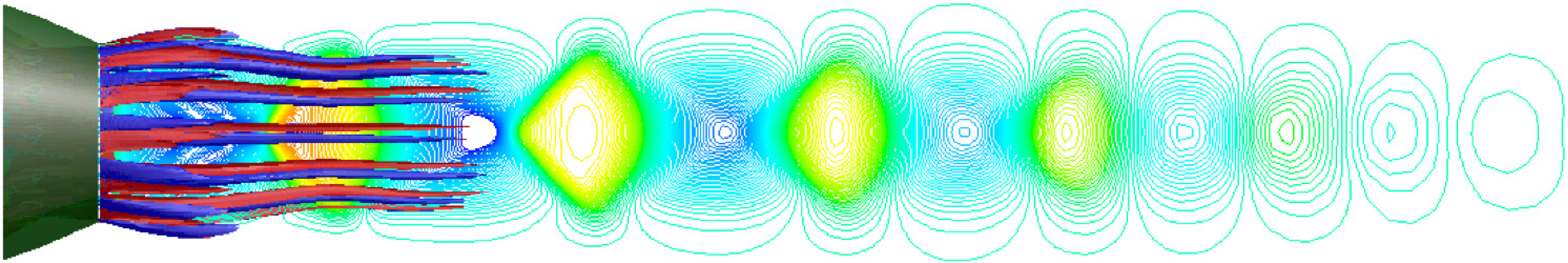
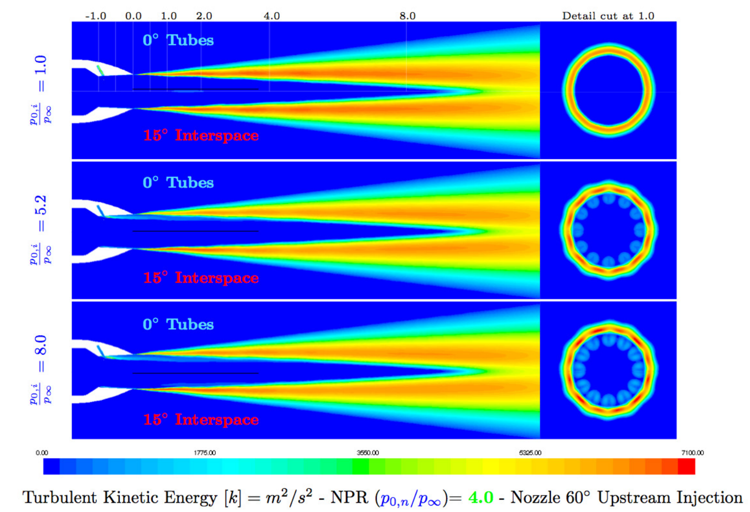


*A qualitative image of the supersonic flow field exhausting the convergent-divergent nozzle with fluidics on.*




*The effect of injection on the turbulent kinetic energy levels for an upstream injection (near-by the nozzle throat) at 60 degrees angle.*

# OPTIMIZED FLUIDIC CONTROL

## *Gutmark analyzes aircraft noise suppression techniques*

*The roar of jet engines is the major source of noise created by commercial and military aircraft, which are bound by numerous stringent noise regulations. A research team led by Ephraim Gutmark, Ph.D., D.Sc., at the University of Cincinnati, is leveraging both experimental and computational tools to optimize existing aircraft noise suppression techniques and to develop new ones.*

One method for decreasing noise levels is to enhance the turbulent mixing in the shear layer of the jet just downstream of the nozzle exit. This is accomplished by using fluidic injection ports or flow mixing enhancement devices called chevrons. The positioning, number, geometry of the device, inclination angles and injection-pressure (for fluidics) of the applied system affect the efficiency of noise suppression. Gutmark's team is working to identify the best combination of these parameters to achieve optimal results.

Gutmark has employed detailed flow analyses of factors, such as flow variables gradients, turbulent quantities and stream-wise vorticity, to expose information about the location and strength of the acoustic sources. The analyses also inform Gutmark's team on how the selected noise suppression methodology affects flow behavior. With this data, correlations between flow and acoustic data can be performed.

"Since running physical flow and acoustic experiments for all possible configurations is time consuming and very expensive, we use compressible steady-state Reynolds averaged Navier-Stokes (RANS) models with correspondent turbulence closures as a fast-screening procedure," explained Gutmark, an Ohio Eminent Scholar and professor of aerospace engineering and engineering mechanics at the University of Cincinnati.

"For each configuration, we quantify flow variables, such as turbulent kinetic energy, stream-wise vorticity, pressure and density gradients," he said. "Using computational fluid dynamics software on Ohio Supercomputer Center systems, we obtain 3-D flow data in regions or at locations where experiments cannot be performed (e.g., inside the nozzle) or other parameters that are difficult to measure."

Aware of drawbacks of steady-state RANS models, Gutmark uses them in this parameter study to identify trends in the flow behavior. Identified cases that have shown a potential for reducing the jet noise without significant thrust penalties are considered for transient flow calculations using the more expensive, but more accurate, Large Eddy Simulation (LES) approach. Information about the near-field acoustics is computed directly from the compressible LES solution, while far-field noise predictions are obtained using acoustic analogies.


**Project lead:** Ephraim Gutmark, University of Cincinnati
**Research title:** Fluidic control on high velocity jets; optimization by CFD
**Funding source:** Swedish Defence Materiel Administration
**Web site:** http://bit.ly/OSC-RR-Gutmark