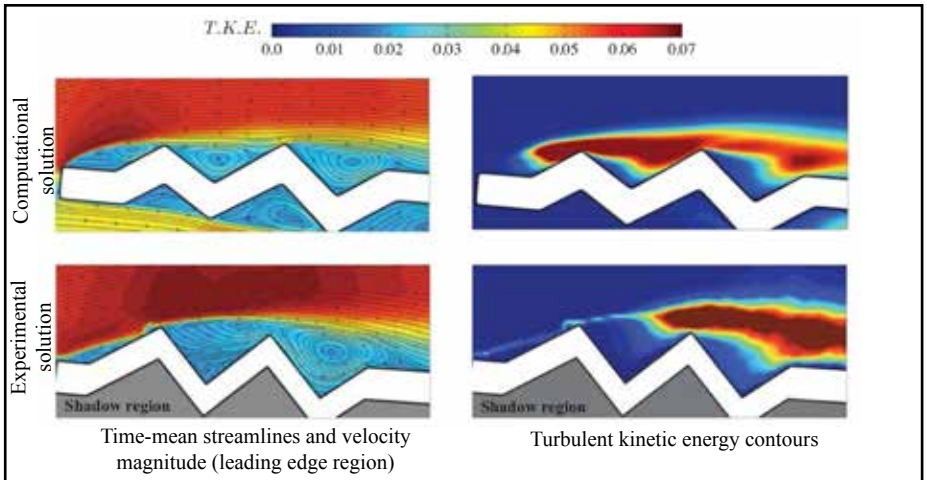
Bio-Inspired Simulations Study Flight Dynamics for MAVs

Project Purpose: *Use High Performance computing resources to simulate the physics associated with the structure and flapping motion of a dragonfly wing.*

Designing from Nature:

Researchers Caleb Barnes and Miguel Visbal at Wright-Patterson Air Force Base are using numerical simulations on AFRL's Cray XE6 Supercomputer to study and predict the flow characteristics of a dragonfly wing. Their goal is to exploit the corrugated nature of a real dragonfly wing and apply its structure to small-scale, unmanned air vehicles or micro air vehicles (MAVs).

Their biologically-inspired numerical simulations demonstrate that due to the unusual geometry of the corrugated wing surface, unusual effects result which not only improves lift but reduces drag. They also show that the wing's behavior is highly sensitive to the shape of the wing's leading edge. Slightly changing the leading edge's configuration can optimize flow at higher angles of attack. They indicate that these behaviors can be further improved if the wing could change shape during flight.



Time-mean streamlines and velocity magnitude (leading edge region)

Turbulent kinetic energy contours

Comparison of time-mean streamlines and turbulent kinetic energy between computation and experiment at $Re_c = 3.4 \times 10^4$ and angle of attack= 5°

The corrugated cross-section of a dragonfly wing used in the simulation

Graphic scene of a field-deployed robotic system blending in with its environment. Configured with video and remote sensors to gather intelligence.

IMPACTS:

- *Decreases the cost of building and testing prototypes*
- *Decreases development time*
- *Improves the performance and efficiencies of similar technologies*

Caleb Barnes and Miguel Visbal, Aerospace Systems Directorate, AFRL Wright-Patterson AFB, OH, utilized 700,000, hours on the AFRL DSRC HPC System, Hawk. In addition, this project has performed many successful runs using HPC code FDL3DI.