Biomimicry of the Boxfish: A Computational Analysis and Wind Tunnel Study of Aerodynamic Drag Reduction of Class 8 Heavy Vehicle Trailers

Srinivas, Vedant (School: Eastlake High School)

In August 2021, the Environmental Protection Agency (EPA), through its Clean Truck Plan, proposed new standards to promote clean air and reduce pollution from heavy-duty vehicles starting in model year 2027. One of the recommended approaches is for heavy-duty vehicles to improve fuel economy by 40% by the year 2027. Class 8 trucks achieve fuel economy in the range of 6-8 miles per gallon of diesel. At speeds of 70 mph, 65% of the energy is spent in overcoming aerodynamic drag (McCallen et al., 1999), making aero-drag the largest opportunity for improving efficiency. A truck consists of a cab in front and a trailer in the back. Cab aerodynamics is well understood and modeled as is evident with the near-airplane-looking cabs on the roads with aero hoods, aerodynamic bumpers, streamlined mirrors, and roof extenders. The trailer has remained as cubical containers that are designed more for stacking and storage than being aerodynamic. Inspired by the Boxfish hydrodynamics, different add-on shapes were used in CFD simulations to provide a streamlined shape to the trailer and its corresponding drag measured. A 3D-printed model of the cab and trailer with add-on attachments was tested in a wind tunnel to validate the simulation. When comparing the bio-inspired to a standard trailer, a drag reduction of 13.8% in computational and 16.7% in the wind tunnel experiments was achieved. These results translate to 14%-16% efficiency gains of Class-8 trailers by bio-mimicking the Boxfish. Keywords: class 8 vehicles, tractor trailer; aerodynamic drag; Boxfish; wind tunnel; CFD;

Awards Won:
Third Award of $1,000
Air Force Research Laboratory on behalf of the United States Air Force: Glass trophy and USAF medal for each recipient
Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Regeneron ISEF Category, FOR 2023 ONLY: EBED WILL HAVE TWO
Long Island University: Presidential Scholarships
Serving Society Through Science: Second Award of $500