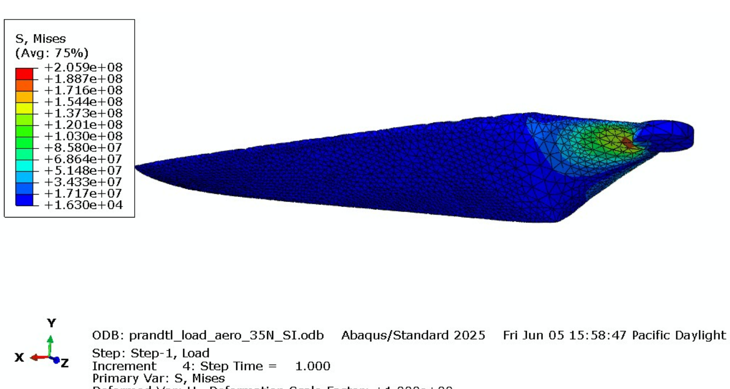
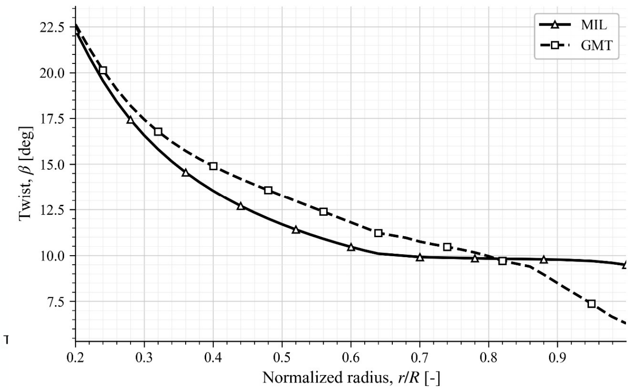
Aerodynamic Design and Structural Evaluation of a Global Minimum Torque Multirotor Propeller

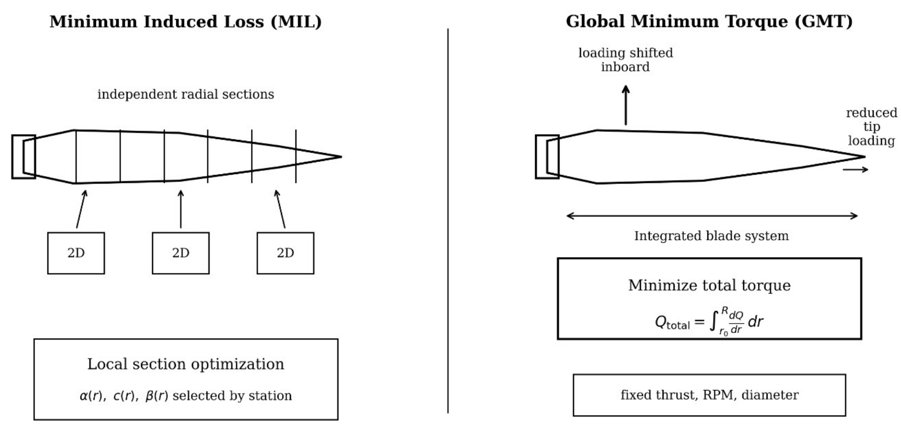
A Master's Thesis Defense in Mechanical Engineering

Presented by: Zeke Bukovansky
Committee Members: Dr. Eltahry Elghandour (Chair, ME), Dr. Xi Wu (ME), Dr. Nandeesh Hiremath (AERO)

Date and Time: Thursday, June 11th, 2:10-3:30 PM
Location: 13-124B







(a) (b)

Multirotor aircraft rely on propellers to produce lift, control motion, and carry payload. Because these aircraft must continuously produce thrust during hover, even small reductions in propeller torque and power demand can improve overall performance. Conventional propellers are commonly designed using minimum induced loss (MIL) methods, which optimize local blade-section performance, but this approach does not directly minimize torque for the complete rotating system.

This thesis investigates a global minimum torque (GMT) propeller design approach inspired by Prandtl bell-spanload concepts and applies it to a 22-inch multirotor propeller. The design workflow generates MIL and GMT propeller geometries while controlling diameter, blade count, chord distribution, airfoil schedule, rotational speed, and target thrust. The final designs were evaluated using BEMT/XFOIL aerodynamic postprocessing, built in CAD, evaluated with finite element analysis, and planned composite manufacturing. The modeled GMT case maintained the 35 N static-hover thrust target at 4000 rpm while reducing predicted torque by 1.50 percent compared with the MIL case. Structural results identified the blade root and hub transition as the primary design concern, while the manufacturing work established a path for future prototype fabrication, thrust testing, acoustic characterization, and flight validation.