The rotor wing project was initiated to investigate the root causes of brownouts and the wobbling effect observed on helicopter’s flight which occurs during takeoff and landing phases. Micro-rotors also have are highly impacted by the separation bubble at low Reynolds number conditions. The long-term goal of the research is to help to minimize these problems seen in the field.

Approach
• Flow visualization of micro-rotor at varying RPMs and blade angle-of-attack.
• Particle image velocimetry (PIV) to measure flow field surrounding a micro-rotor.
• Quantify thrust and torque using force balance sensors.

TEST CHAMBER AND TEST MODEL
• A closed test chamber allows for measuring forces and imaging without interruption of ambient flow.
• Test chamber was built on a heavy-duty optical bread board for isolating vibration and mounting optical parts (laser, lens, mirror, etc.)
• Pitching angle of the blade can be adjustable from 5° to 15°.

PARTICLE IMAGE VELOCIMETRY
Smoke particles
Smoke rake
Laser Sheet
Micro-Rotor
PC for Post-Processing

Schematic of PIV and flow visualization setup

FORCE MEASUREMENTS
• Thrust and torque were measured to evaluate rotor blade performance at different pitching angles.
• Two load cell sensors were used, the tensile load cell and torque cell.

SMOKE VISUALIZATION
Laser with 532 nm wavelength (green) shining into the test chamber

CONCLUSIONS
An increase in the rotor’s rpm caused an increase in strength of wingtip vortices. The flow near the eye are seen to be laminar, however it induces a greater vorticity at farther distance which causes larger instability in the flow. These vortices are seen pairing up with the ones formed before as they move down to the ground. This pairing phenomena causes the vortices to be bigger in dust. The pairing is seen as a contribution to the movement of dust particles.

The authors would like to thank Undergraduate Research Office for financial support through the Ignite Grant, as well as past efforts to the project from Emanuel Marrero, Frank Garriga, Adam Stenger, Alex Michalik, Kiefer Savoie, and Javan Roussel.