GALLOGLY COLLEGE OF ENGINEERING
SCHOOL OF AEROSPACE AND MECHANICAL ENGINEERING
The UNIVERSITY of OKLAHOMA

UAV Propellor Design Project in 3DEXPERIENCE

Sponsor: The Boeing Company (Dr. Ryan Stoddard and Mike Christian)

Faculty Advisor: Dr. Srikanth Bashetty

BOEING

Introduction



Team (left to right)
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Objectives

- Design a quieter 3D-printed replacement propeller for the DJI Air 2S while maintaining aerodynamic and structural performance.
- Demonstrate a full product lifecycle in 3DEXPERIENCE, from requirements to Verification and Validation (V&V)
- Prove 3DX as a viable end-to-end engineering tool for the aerospace industry



Constraints

- Max mass: 7g | Max wingspan: 7 inches | Min thickness: 1.5 mm
- RPM range: 2,225 – 8,000 RPM | Max altitude: 400 ft
- Compatible with DJI Air 2S
- Maintain sufficient thrust for all flight cases
- Manufacturable using standard FDM 3D printing

Engineering Standards

- FAA Part 107 - Small UAS Regulations
- ISO/ASTM 52910:2018 - Design guidelines for additive manufacturing.
- ISO 3740:2019 - Methods for measuring sound power levels in acoustic testing.
- ISO 6926:2016 - Specifies calibration and performance requirements in acoustic testing.

Material Selection

	Flexural Modulus	Flexural Strength	Density	Printability	Cost (1kg)
PA-12 CF	10000 MPa	140 MPa	1.15 g/cm^3	Low	High
PA-12	1600 MPa	66 MPa	1.04 g/cm^3	Medium	Medium
PLA+	**2882 MPa**	**91.6 MPa**	**1.22 g/cm^3**	**High**	**Very Low**
PETG	1882 MPa	79 MPa	1.27 g/cm^3	High	Low

Sound Dampening Approach

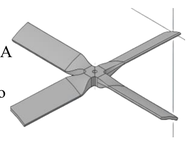
Approach	Benefit	Tradeoff
1. Altered Blade Count	Shifts tonal peaks	↑ thrust, ↑ weight and drag
2. Reduced Diameter	↓ tip Mach number	↓ thrust + drag
3. Toroidal Geometries	Disrupts tip vortices, ↑ rigidity and safety	↓ thrust
4. Enclosed Propellers	Disrupts tip vortices, ↑ rigidity and safety	↑ weight + drag
5. Serrated Trailing Edges	Disrupts vortex formation + pressure pulses along TE	↓ thrust + tolerances
6. Skin Texturing	↑ boundary layer stabilization	Strict manufacturing tolerances

- Printing specifications eliminated bioinspired approaches (5, 6).
- Mass limitations eliminated enclosed approaches (4).
- Interdisciplinary approach balances tradeoffs while combining aero-acoustic benefits (1, 2, 3).

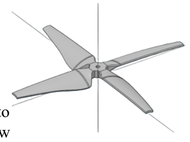
Design

Motor-to-Propeller Interface: To maintain compatibility with the DJI Air 2S platform, the factory motor-to-propeller connection was reverse-engineered. This served as a foundation for all parametric propeller models.
Parametric Modeling: Propeller geometry was created by driving dimensions, constraints, and relationships to keep surfaces intact while altering key blade characteristics. Chord length, blade length, and angle of attack are the driving parameters of the three models below.

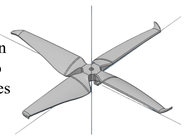
Initial Design
- Constant chord and AOA throughout blade span
- Base for complexities to be added



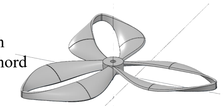
Second Design
- Builds off initial design
- Blade tip features $\frac{1}{3}$ root chord and AOA to optimize for local flow



Third Design
- Builds off second design
- Anhedral swept wingtip added to redirect vortices upward

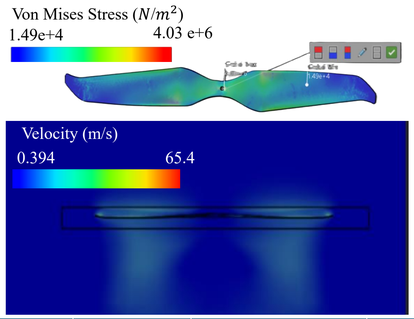


Fourth Design
- Elliptical blade path
- Features variable chord and AOA



Simulations

- CFD and FEA conducted in 3DX SIMULIA
- Hover conditions at 6100 RPM
- 3DX Optimization Process Composer automatically iterates CAD → CFD → FEA

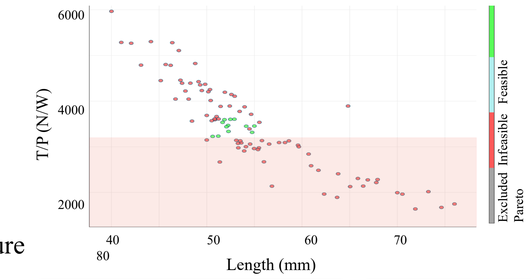


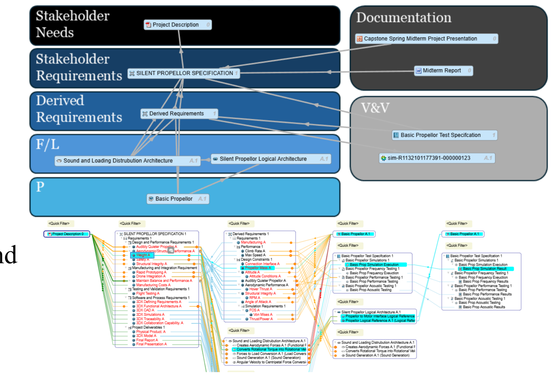
	Thrust (N)	Drag (N)	Shaft Torque (Nm)	T/P (N/W)	Displacement (mm)	FOS
OEM	0.68	0.09	0.01	3260	0.988	21.1
Basic	0.66	0.336	0.015	3315	0.017	131
Variable	0.69	0.032	0.013	4033	0.053	32.2
WT	0.66	0.212	0.009	3415	0.037	35.2
Toroidal	0.66	0.591	0.027	1588	0.049	13.2

3DEXPERIENCE Integration

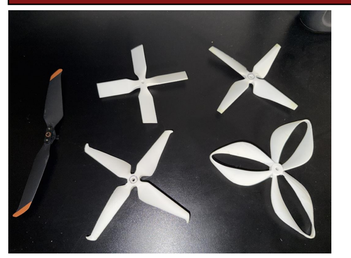
Full implementation done through 3DX Including:
- Tasking
- Requirements
- Functional Architecture
- Logical Architecture
- Traceability
- CAD
- Simulations
- Design Optimization
- Verification and Validation

Allowed for End-to-End traceability with a preserved Digital Thread





Test Results







	dBA	dBC	Hover RPM (RPM)	Max Climb (m/s)	Max Speed (m/s)
OEM	87.0	98.9	6000	6	10.4
Basic	82.9	76.2	8200	1.7	8
Variable AOA	77.7	74.5	8150	1.2	9.6
WT	83.5	75.1	8100	0.7	7
Toroidal	Did Not Fly				

Final Remarks

Findings
- Propeller designed in 3DEXPERIENCE
- CFD/FEA confirm acceptable performance
- Noise reduced with a large aerodynamic tradeoff
- Full engineering VEE encapsulation

Recommendations
- Evaluate advanced materials
- Repeat testing for validation
- Optimize blade geometry

