A COMPARATIVE STUDY OF CRUCIFORM AND ANNULAR PARACHUTES: EVALUATING DRAG AND STABILITY PERFORMANCES

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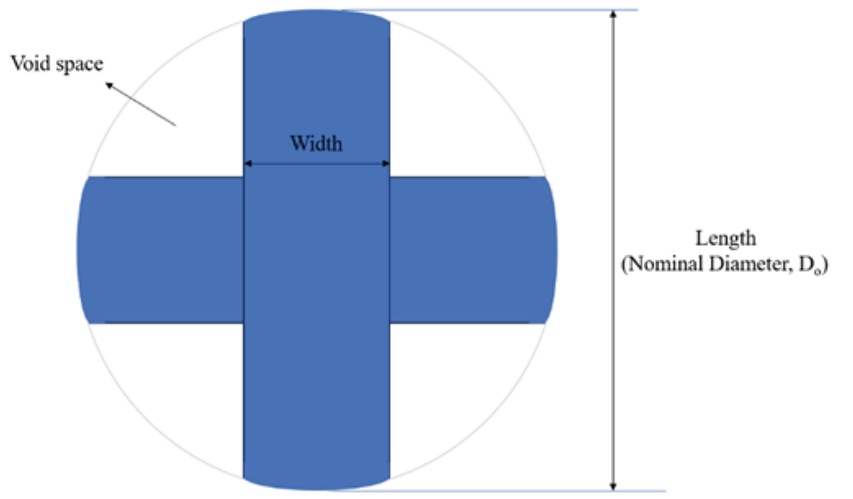
Introduction

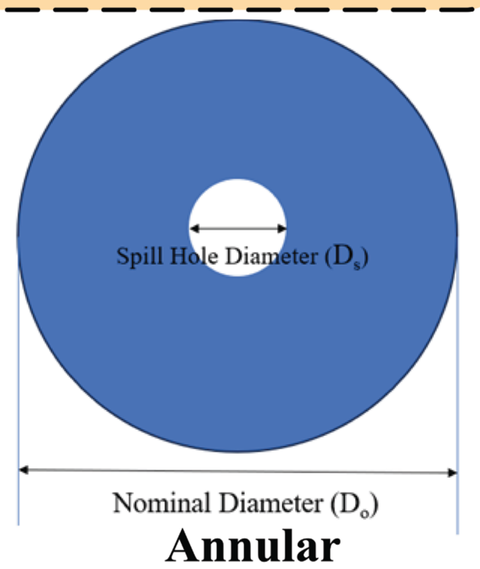
Parachutes play a critical role in aerodynamics and safety engineering. Hence, this study compares two parachute designs—cruciform and annular—focusing on drag efficiency and stability under various conditions.

Methodology

- **Parachute Models**
  - Designed using standard drag equation: for drag and scaled for accuracy
  - Nominal diameters: 0.40 to 0.60 m (Cruciform), 0.348 to 0.522 m (Annular)
- **Computational Fluid Dynamics (CFD) Simulation**
  - Platform: Ansys Student 2024R2 with SST K-omega model
  - Simulations assumed a rigid parachute with steady airflow at 5 m/s, no heat exchange, where density of air is 1.225kg/m³
- **Experimental Drop Test**
  - Conducted with Arduino Nano BLE and ripstop nylon parachute
  - Dropped from ~14 m; data recorded with onboard IMU

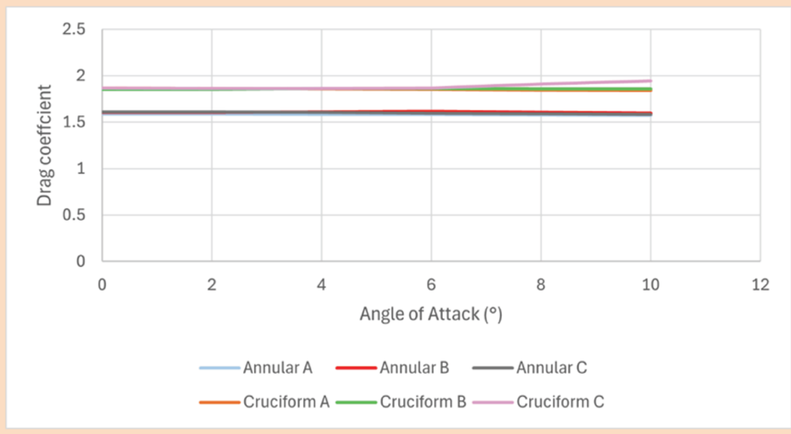


Cruciform

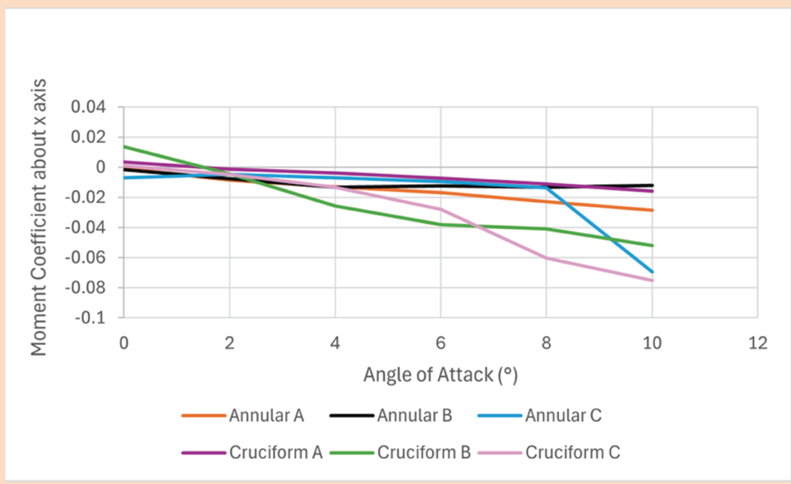


Annular

Results



- **Drag Coefficient**
  - Cruciform: 1.87 (CFD), 1.9 (Experimental).
  - Annular: 1.6 (CFD).
  - Higher drag observed in cruciform due to higher pressure difference



- **Stability**
  - Cruciform parachutes showed superior stability, particularly at larger sizes, due to restoring moments generated by their cross-shaped canopy
- **Validation**
  - CFD and experimental results show a 98.4% agreement

Conclusion

- **Cruciform parachutes generate higher drag and displays higher stability than annular parachutes**
- **Limitations**
  - Rigid canopy assumption in simulations may not reflect real-world conditions
  - IMU drift and inconsistent time intervals impacted data accuracy
  - Initial angle of attack and wind effects during drops were uncertain
- **Future Work**
  - Investigate dynamic stability to understand oscillatory effects
  - Incorporate flexible canopy models and address cloth permeability in simulations

References:
Saim, R, et al. "Computational Fluid Dynamic (CFD) Analysis on ALUDRA SR-10 UAV with Parachute Recovery System." IOP Conference Series: Materials Science and Engineering, vol. 243, Sept. 2017, p. 012014, https://doi.org/10.1088/1757-899x/243/1/012014.

All images are self-generated.