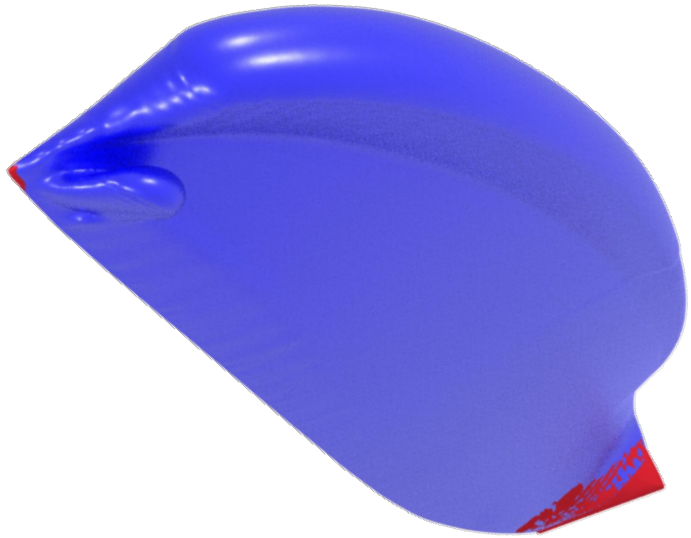
Icing Calculation of a UAV Propeller

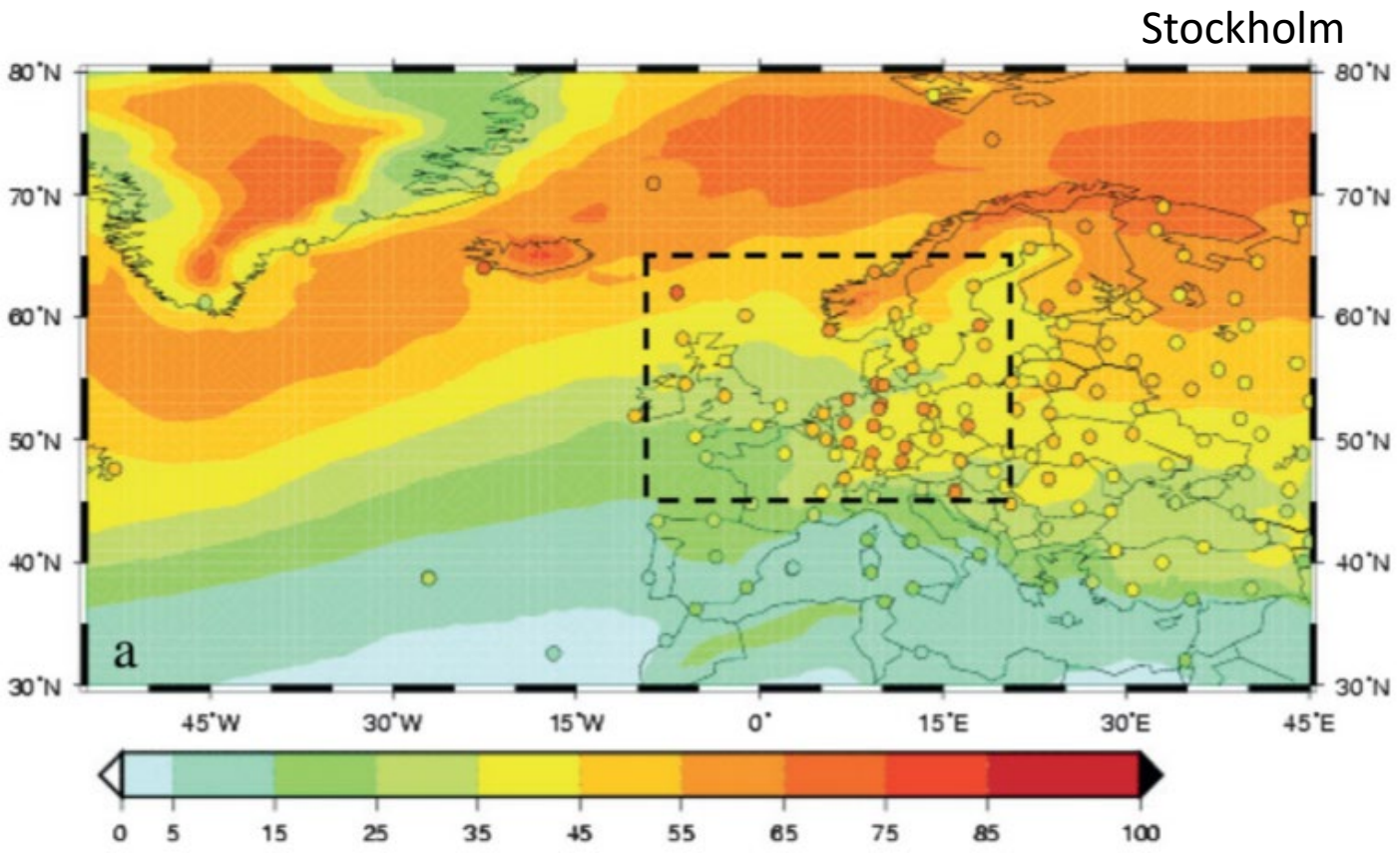


Universität Stuttgart

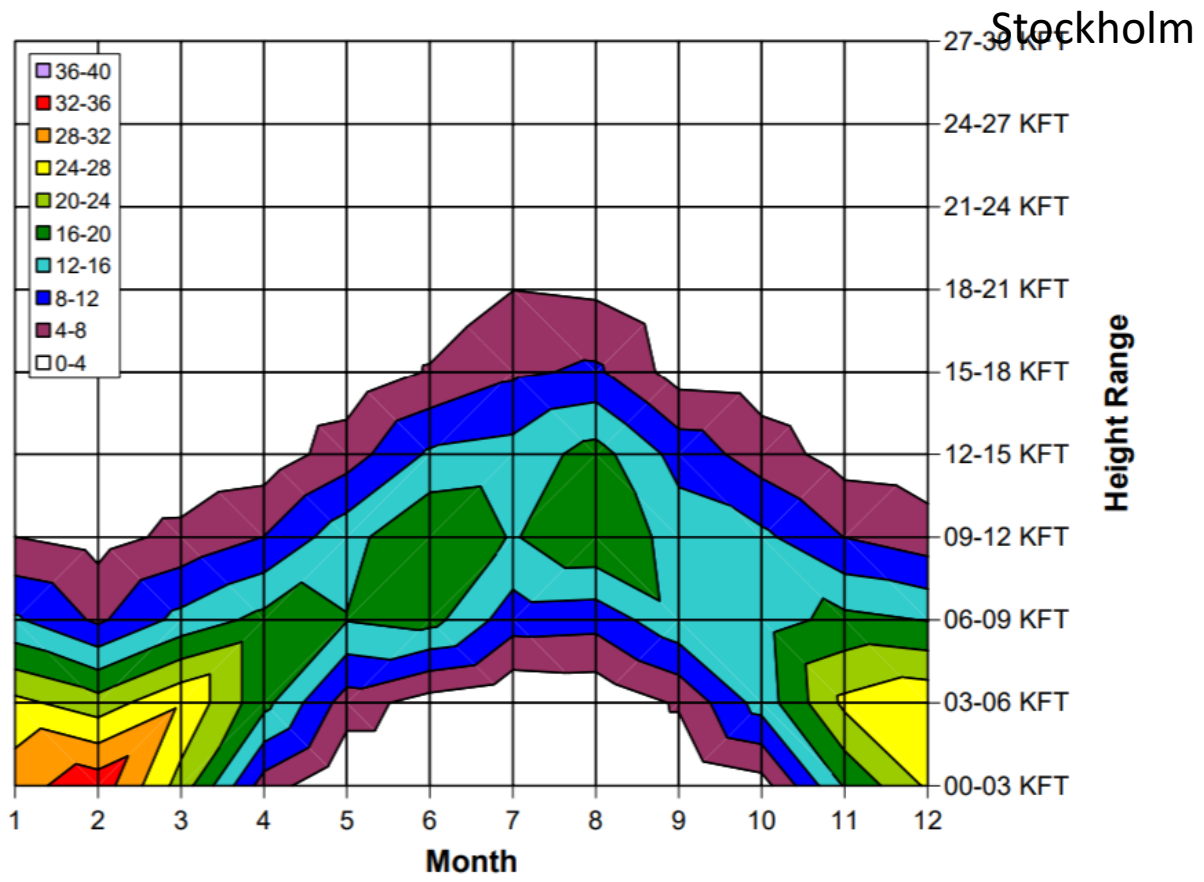
Nicolas Müller, Richard Hann, Thorsten Lutz

NTNU

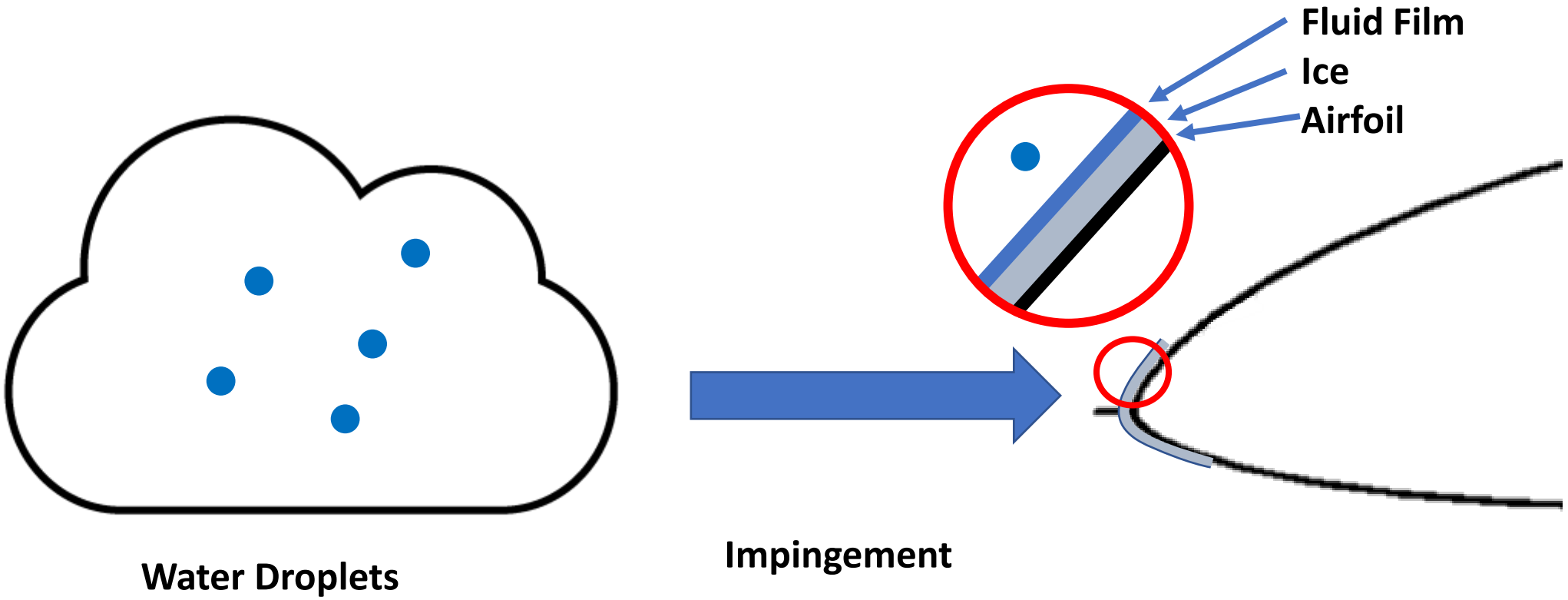
Why is icing on UAVs important?



Why is icing on UAVs important?



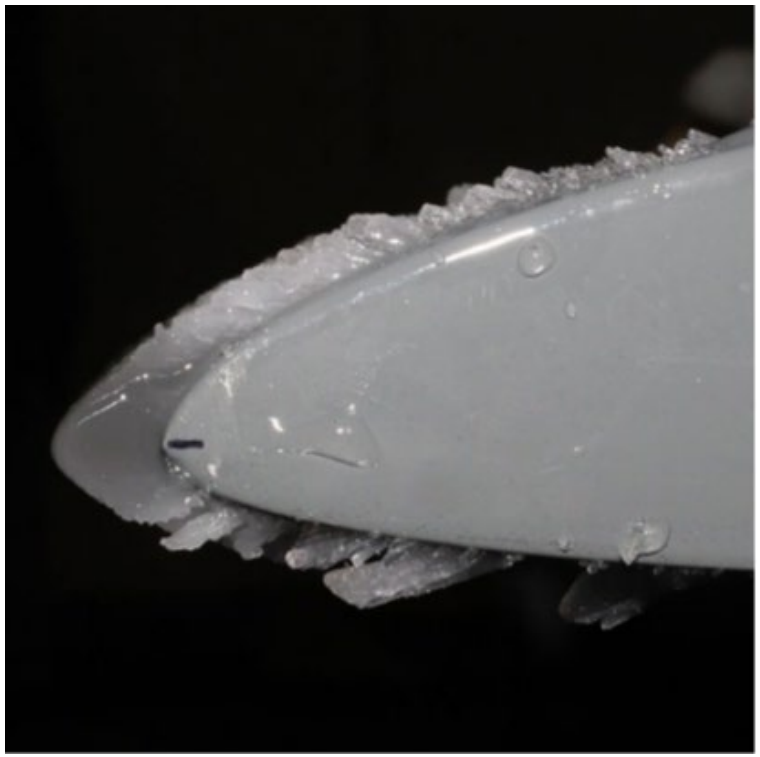
Inflight Icing



Ice shapes

Rime

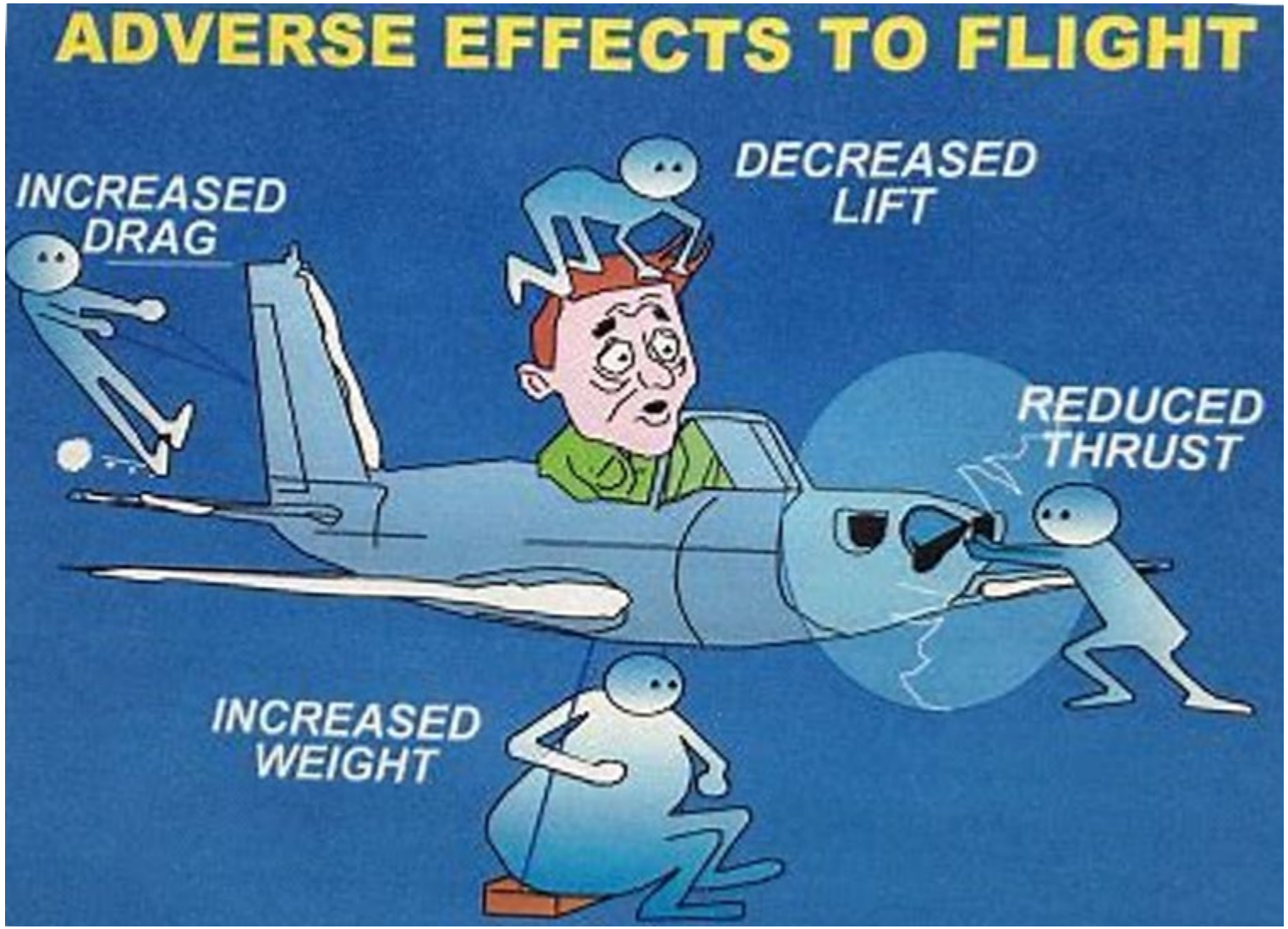
Glaze



Mixed

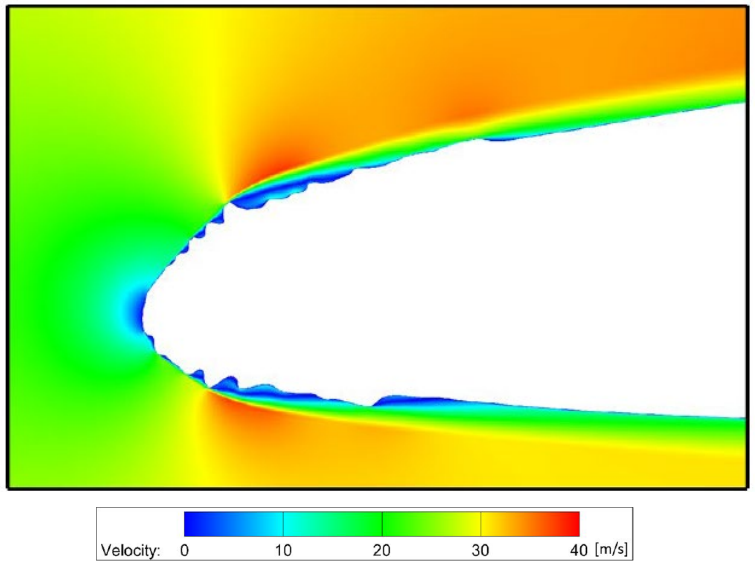
Hann, R. (2020). Atmospheric Ice Accretions, Aerodynamic Icing Penalties, and Ice Protection Systems on Unmanned Aerial Vehicles. PhD Thesis NTNU2020:200, Norwegian University of Science and Technology

Icing Hazards

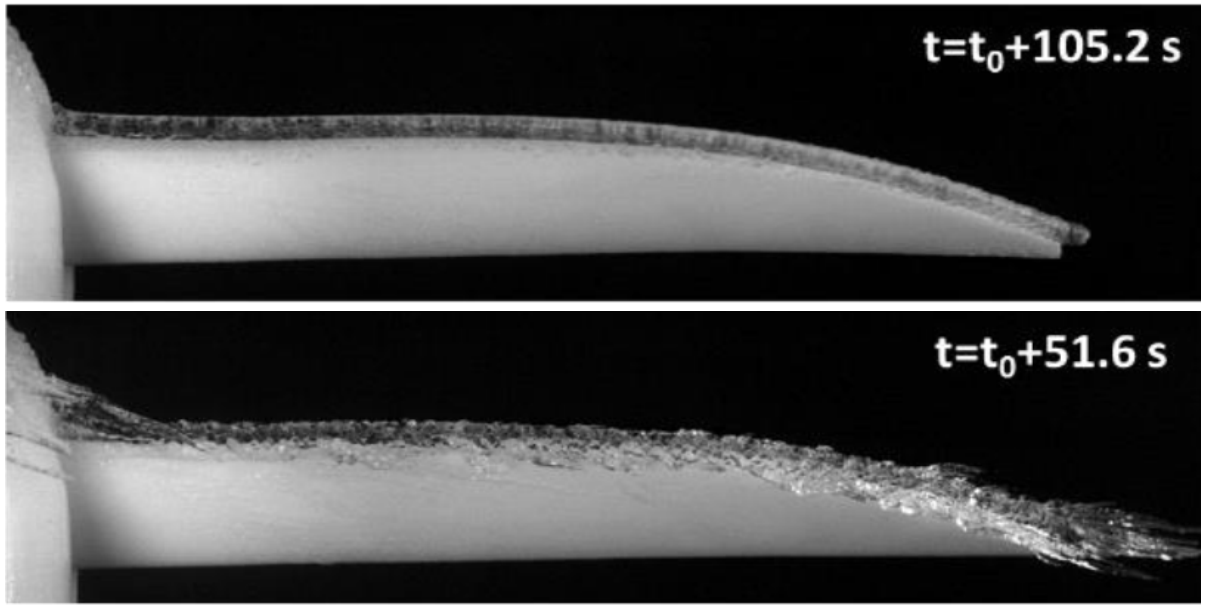


Previous Works

→ Focussed on manned aircraft



Hann, R. (2020). Atmospheric Ice Accretions, Aerodynamic Icing Penalties, and Ice Protection Systems on Unmanned Aerial Vehicles. PhD Thesis NTNU2020:200, Norwegian University of Science and Technology

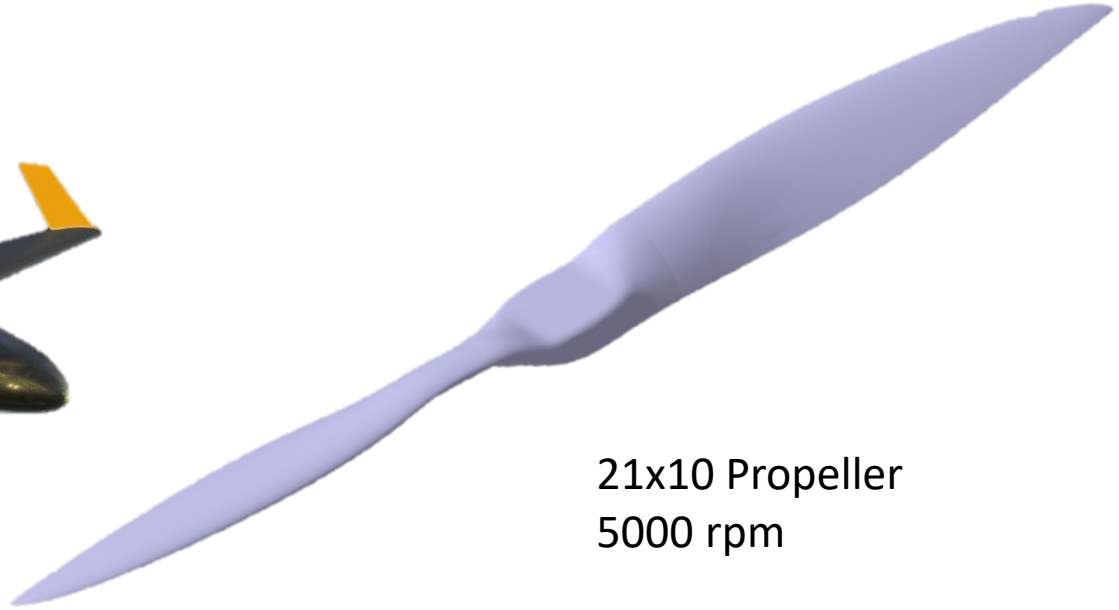


Yang Liu, Linkai Li, Zhe Ning, Wei Tian and Hui Hu;An Experimental Study on the Transient Ice Accretion Process
over the Blade Surfaces of a Rotating UAS Propeller; Department of Aerospace Engineering, Iowa State University; 2017

➔ No numerical analysis of icing on UAV propellers

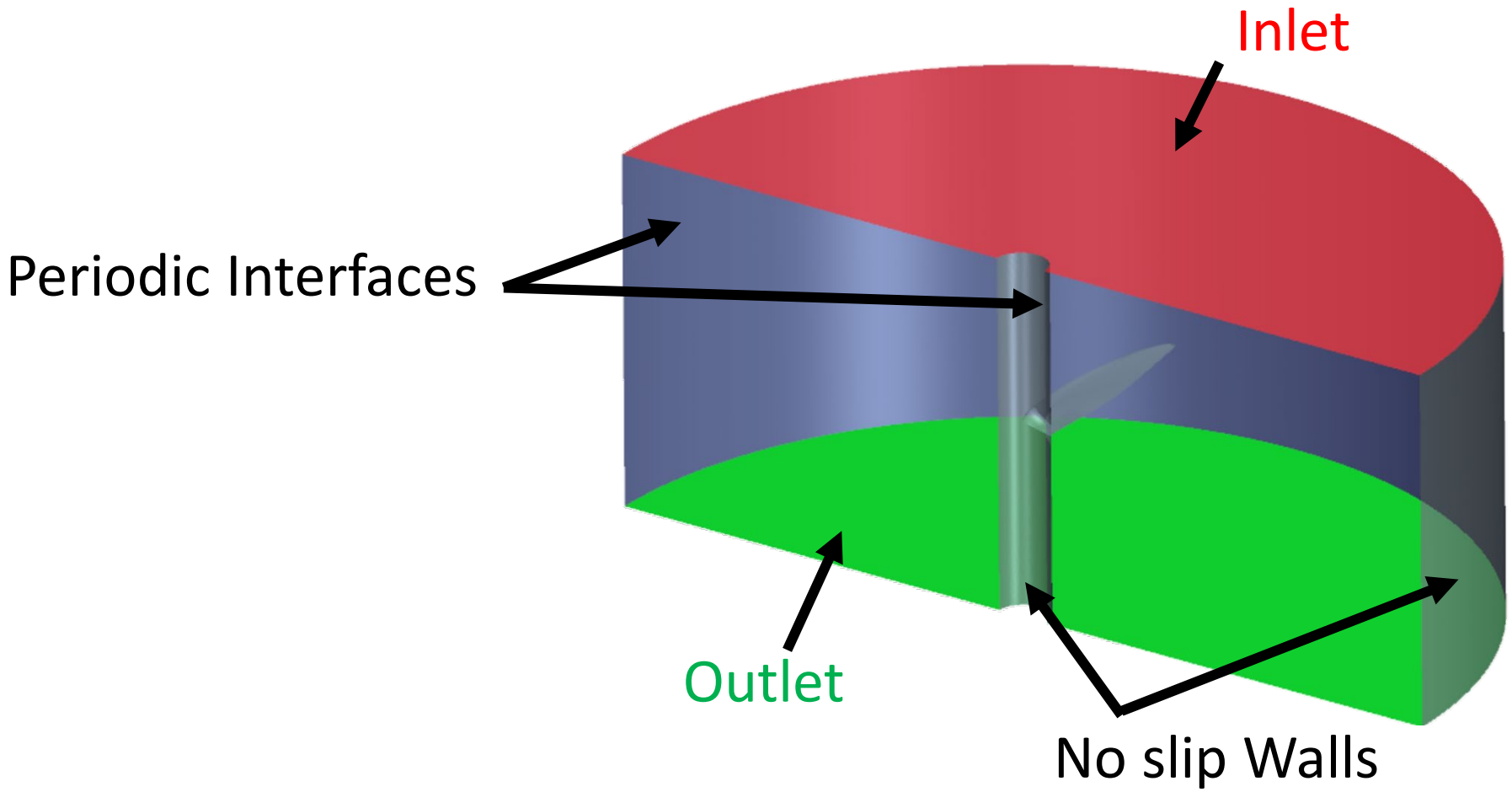
Testcase

Maritime Robotics PX 31
Wingspan: 3.2 m
Payload: 3 kg



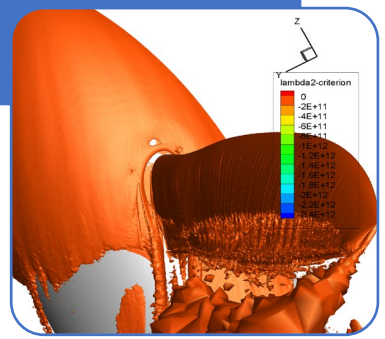
21x10 Propeller
5000 rpm

Computational Region



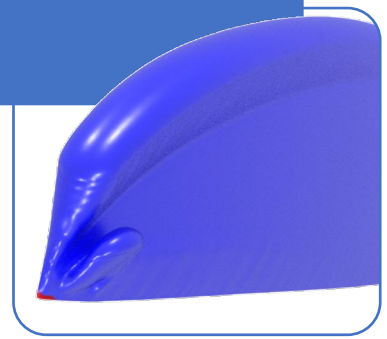
Icing Calculations

Flowfield

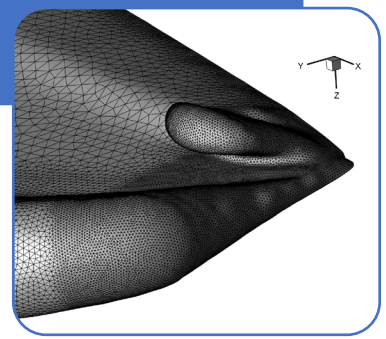


Droplets

Ice Shape

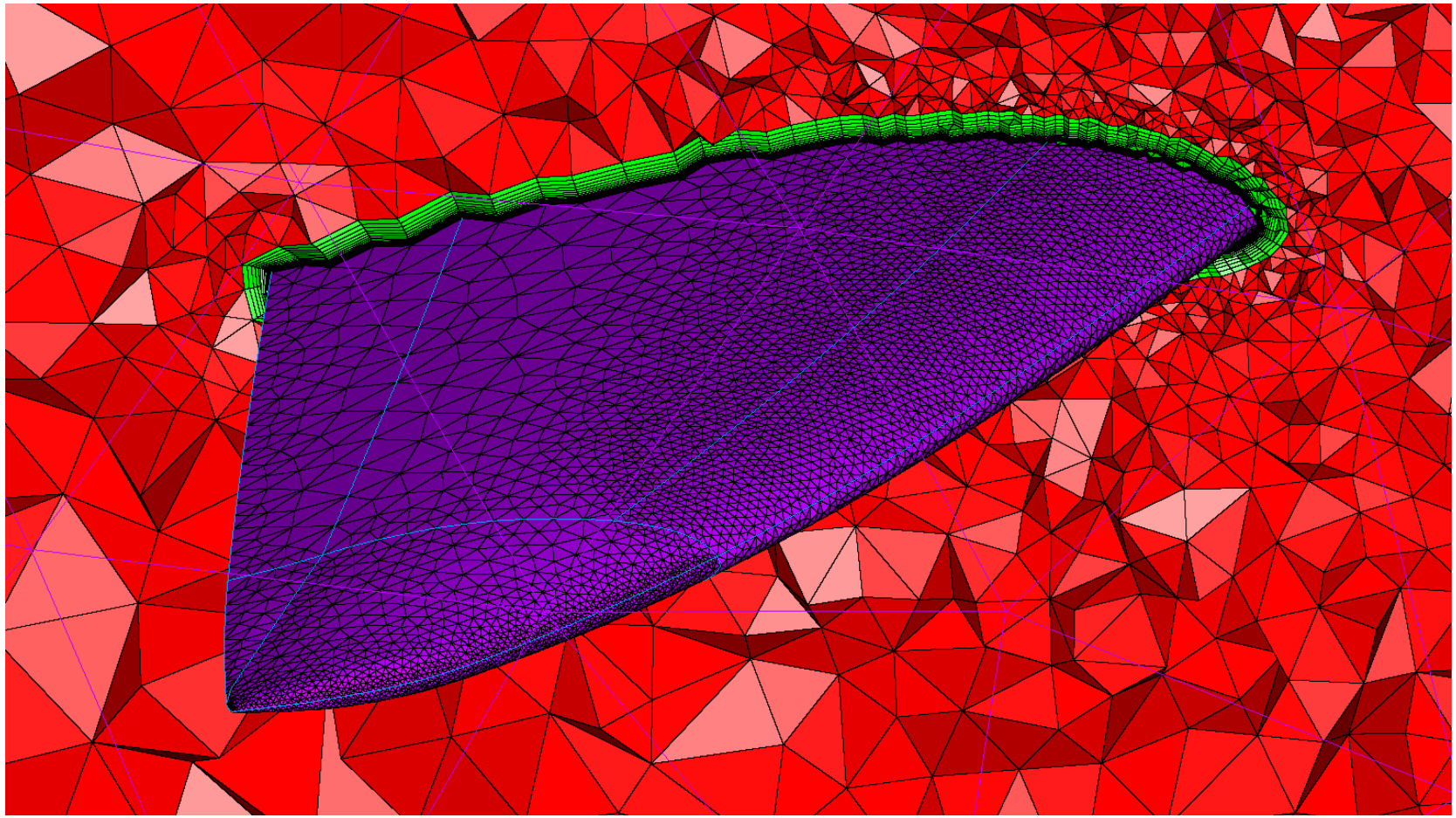


Remesh



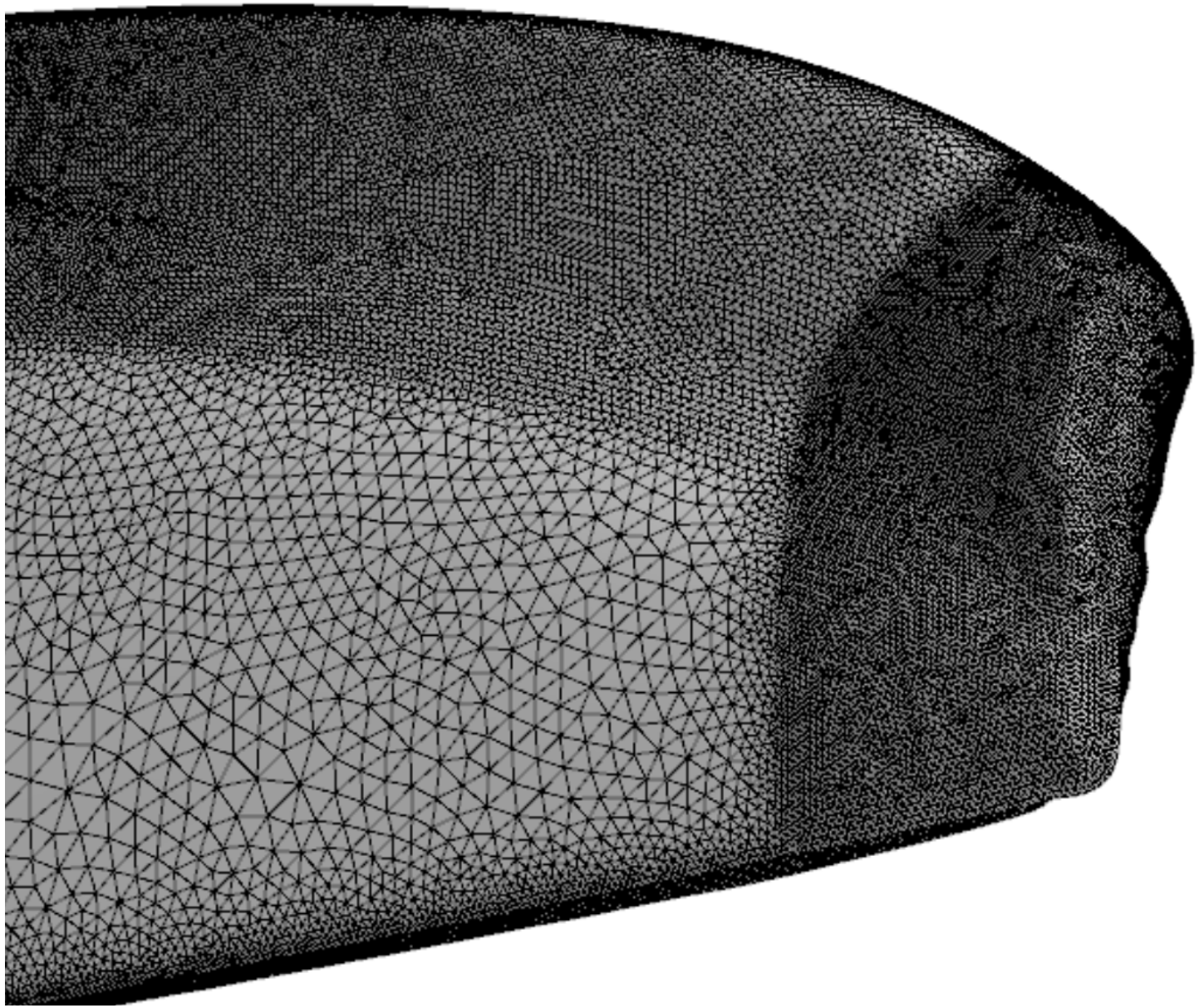
Initial Mesh

- Pointwise
- 9 mio. Cells
- Thethrahedal Cells
- 25 Prisim Layers
- y+ < 1



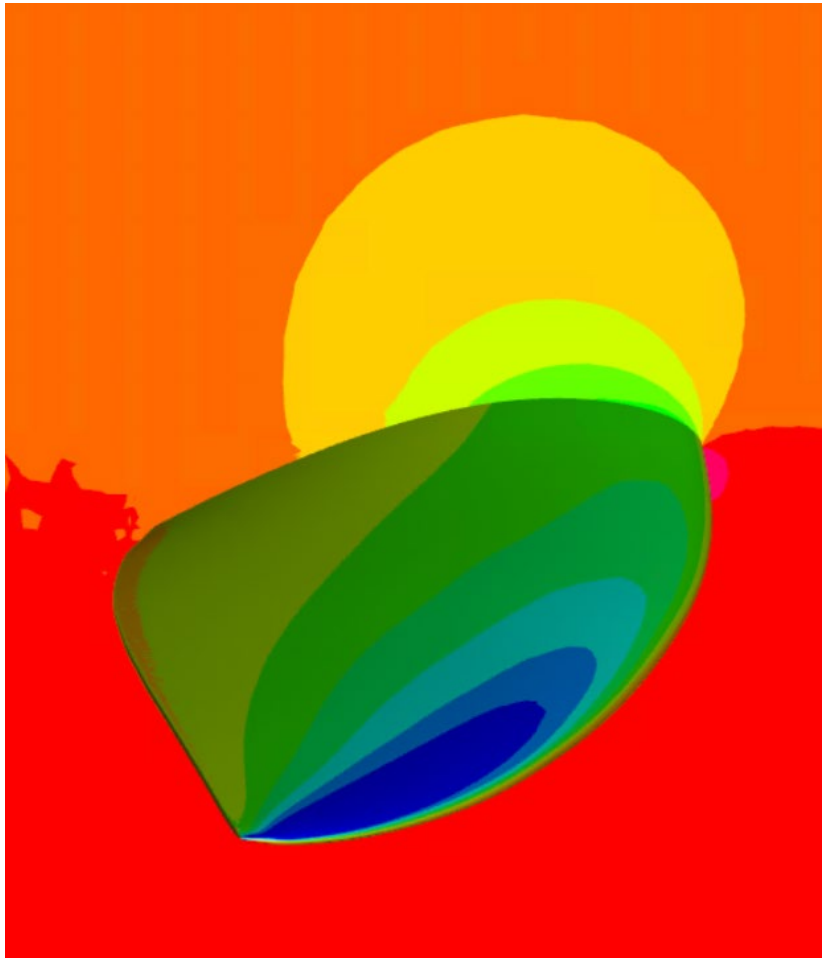
Remeshing

- Fluent Meshing
- 9-12 mio. Cells
- Thethrahedal Cells
- 25 Prisim Layers
- y+ < 1



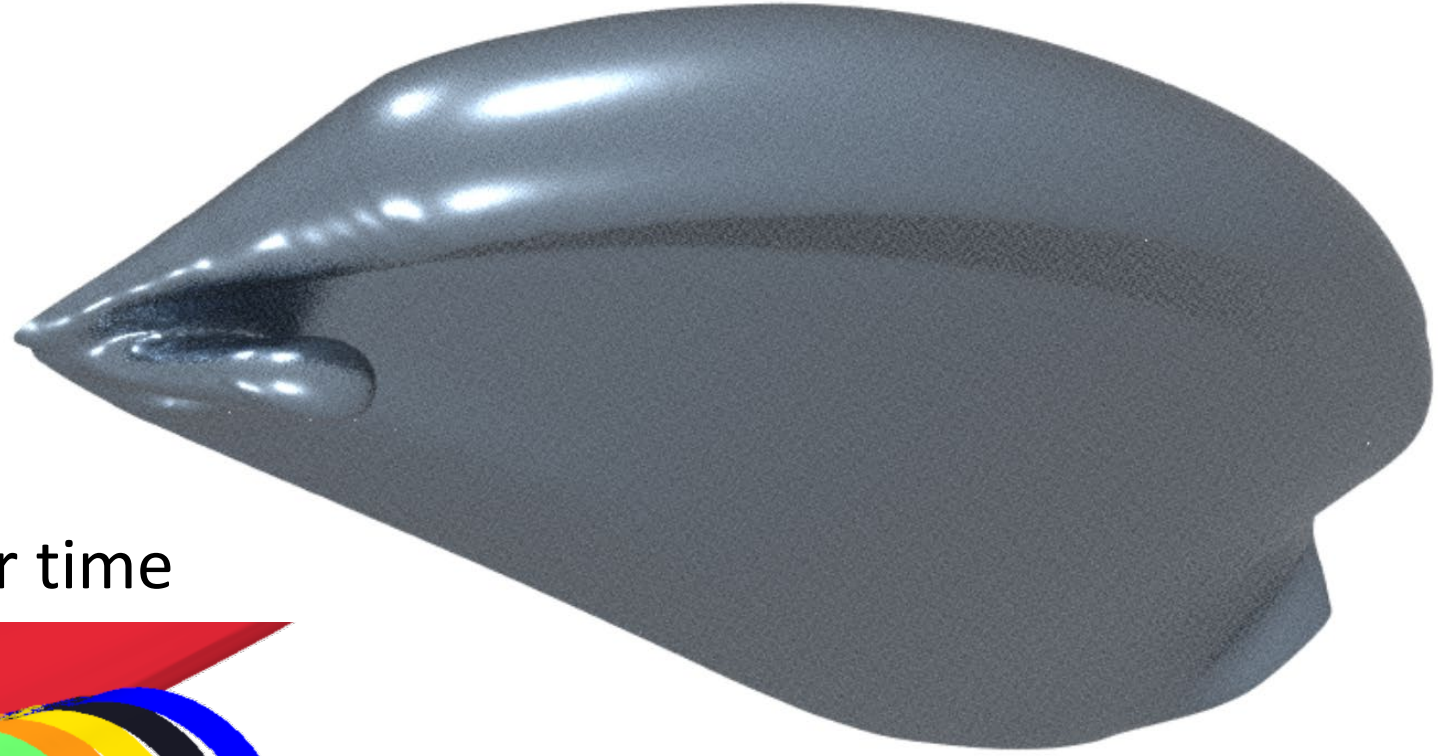
Numerical Setup

- CFD Solver: ANSYS Fensap
- Turbulence Model: Spalart Allmaras
- Droplet Solver: DROP3D
- Ice Accretion Solver: ICE3D



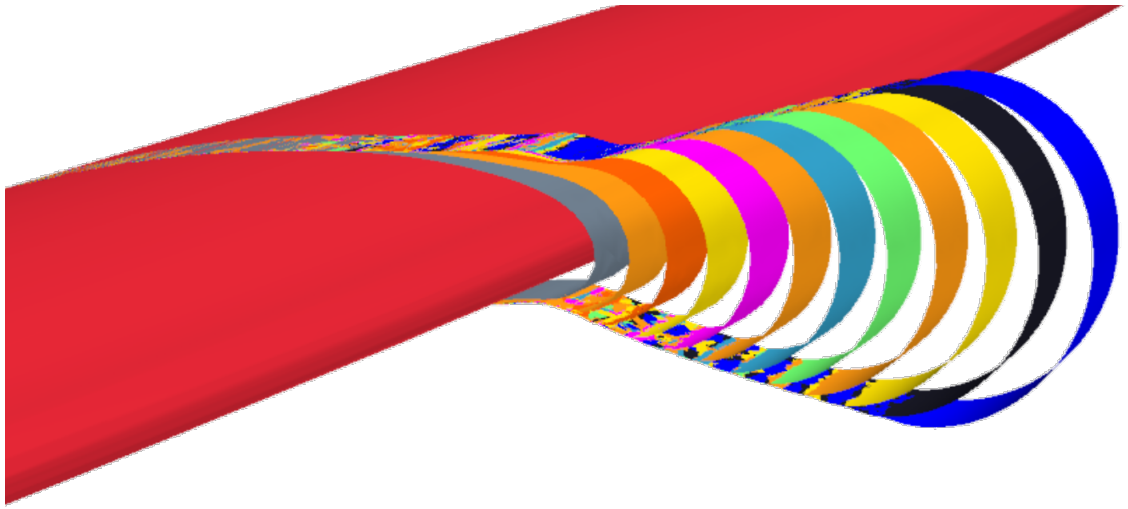
Ice Shape

- Icing duration 120s
- Remeshing every 10 s



➔Rime ice

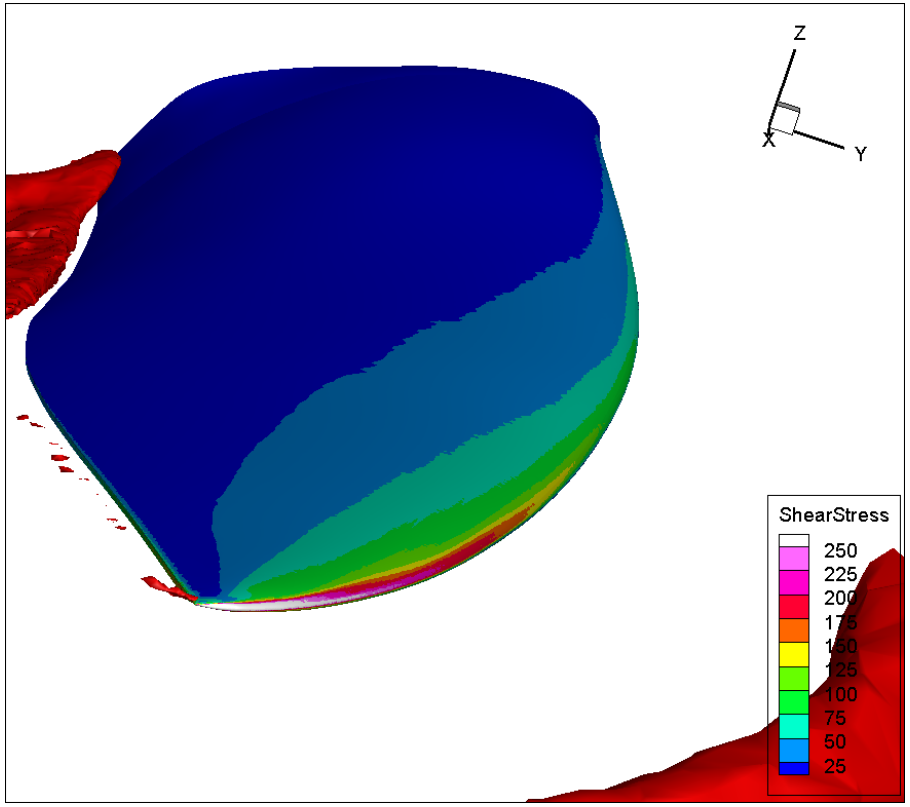
➔Linear ice growth over time



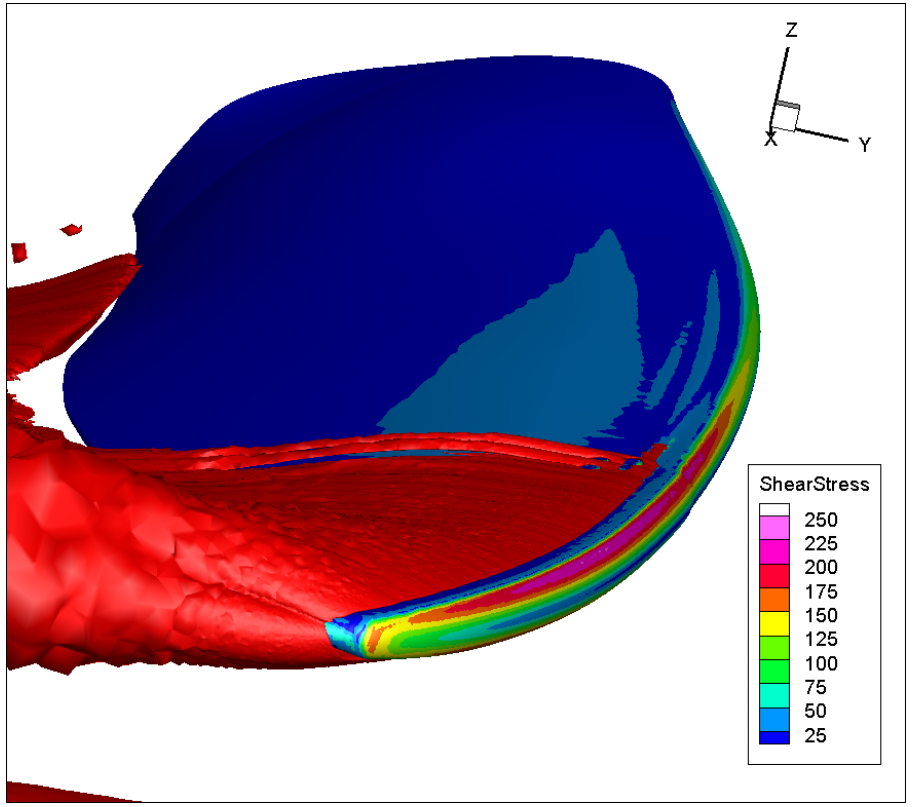
90% R
10s per cut

Performance Results

No Ice



120 s icing



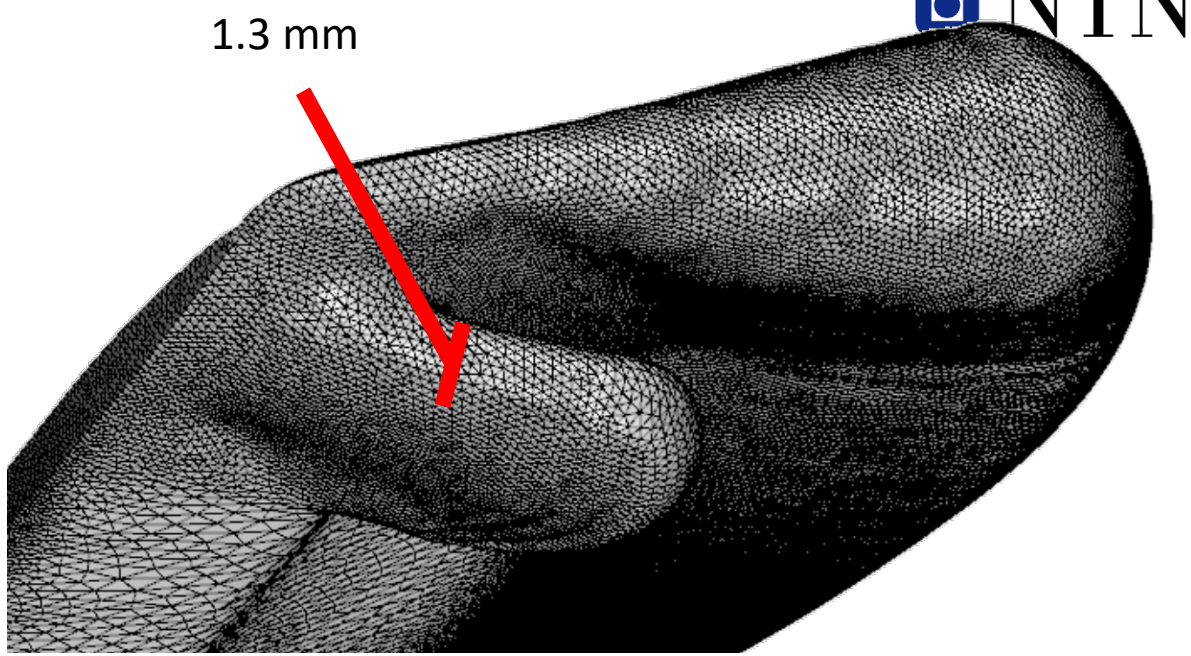
➔ **Reduction of the Thrust by 23.8%**

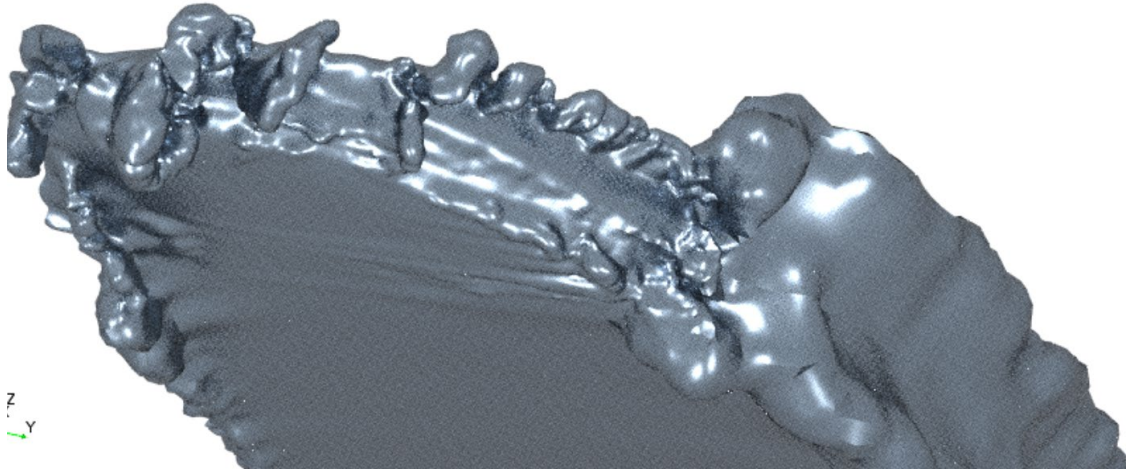
➔ **Reduction of the Efficiency by 24.6%**

Outlook

Future Investigations:

- Glaze Ice
- Ice shedding
- Wind tunnel testing





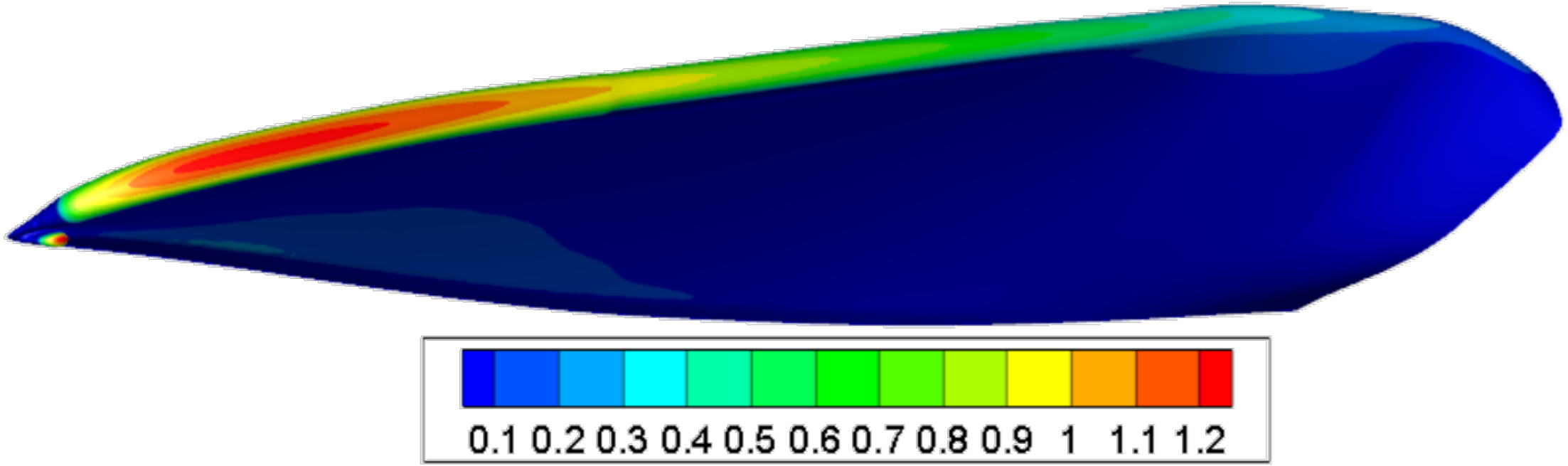
➔ **Anti icing systems**

Appendix

Impingement

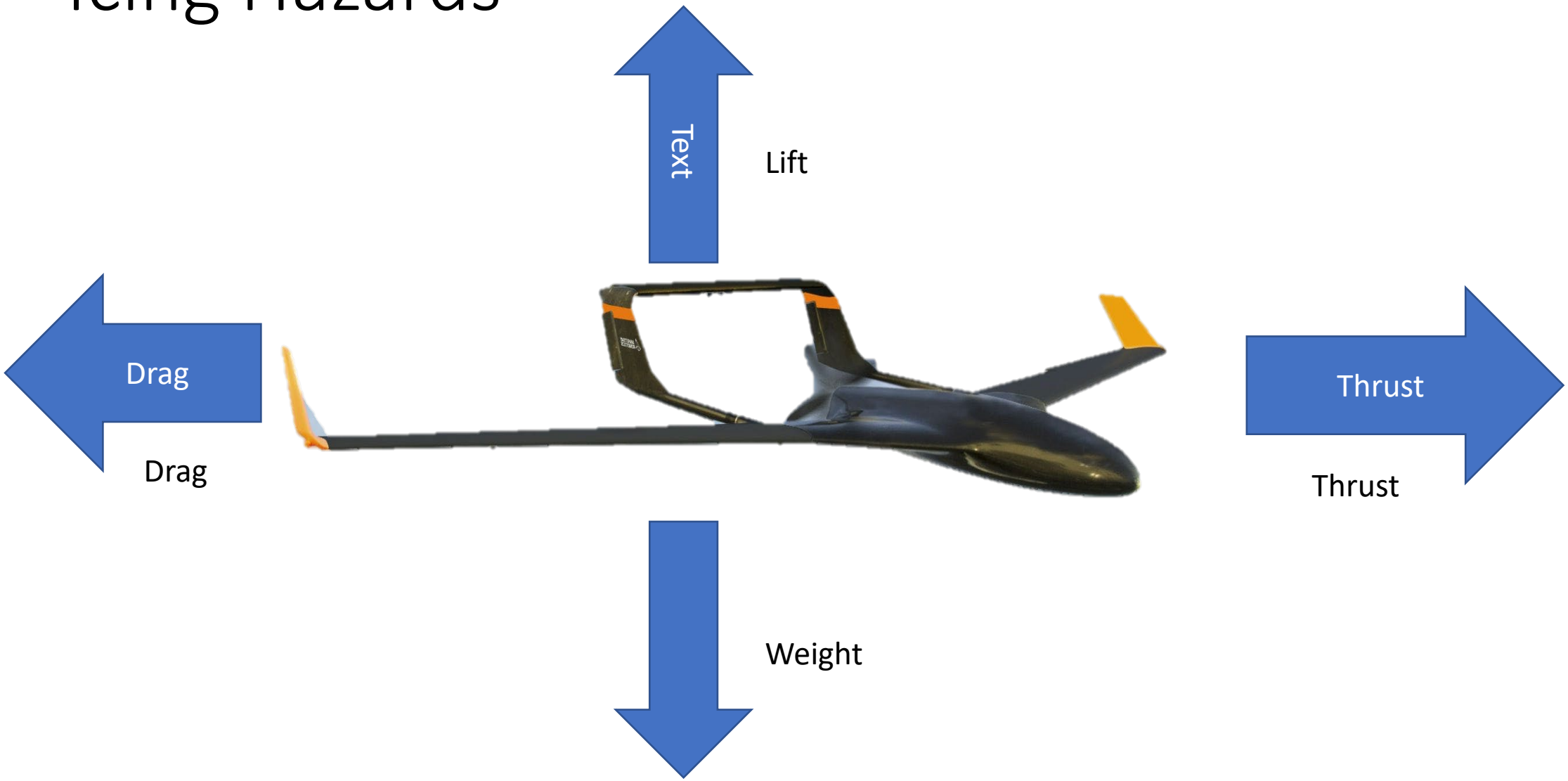
→Highest impingemnt on the Leading edge

→Increase from center to tip



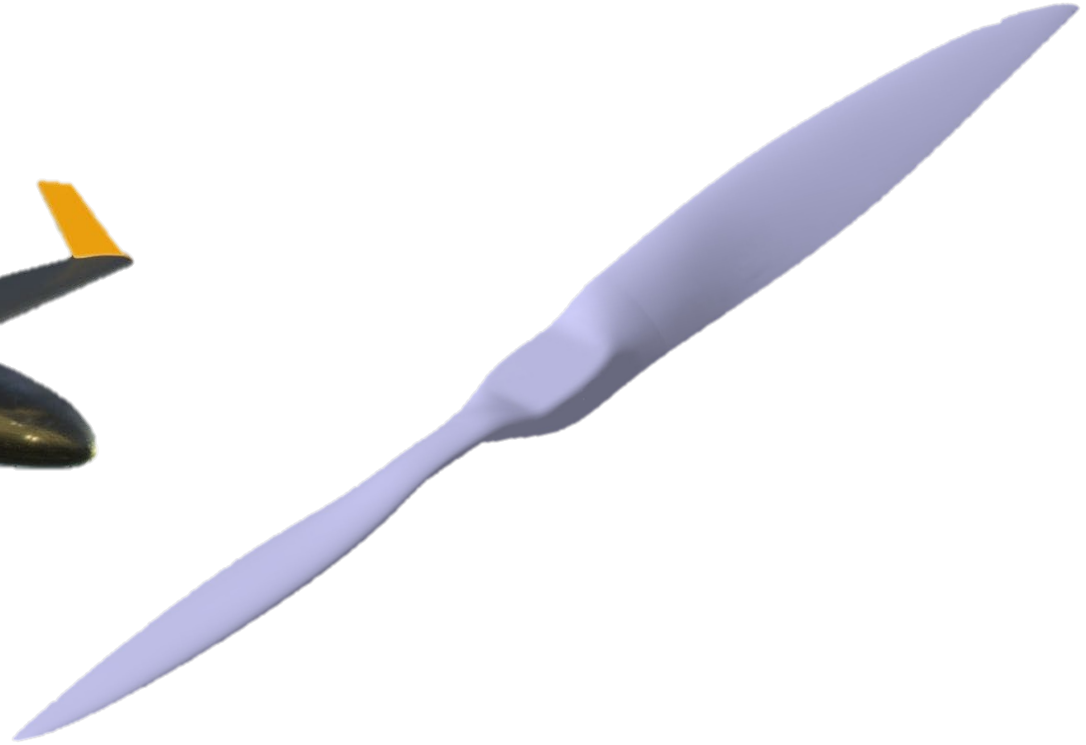
Collection efficiency

Icing Hazards



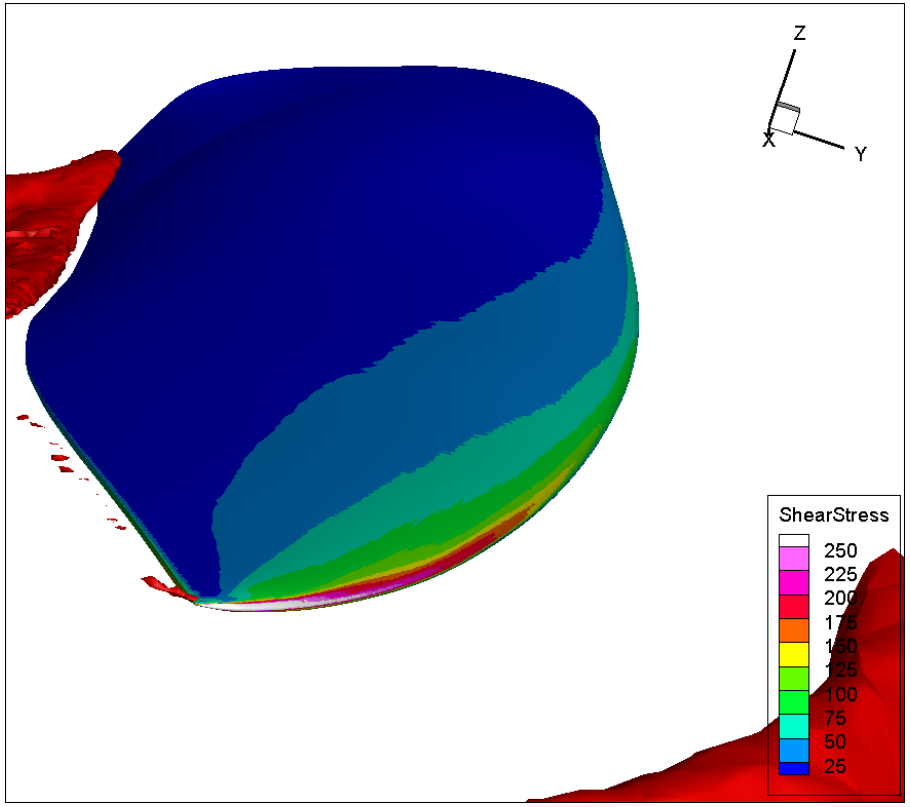
https://www.aeroexpo.online/prod/maritime-

Test Case

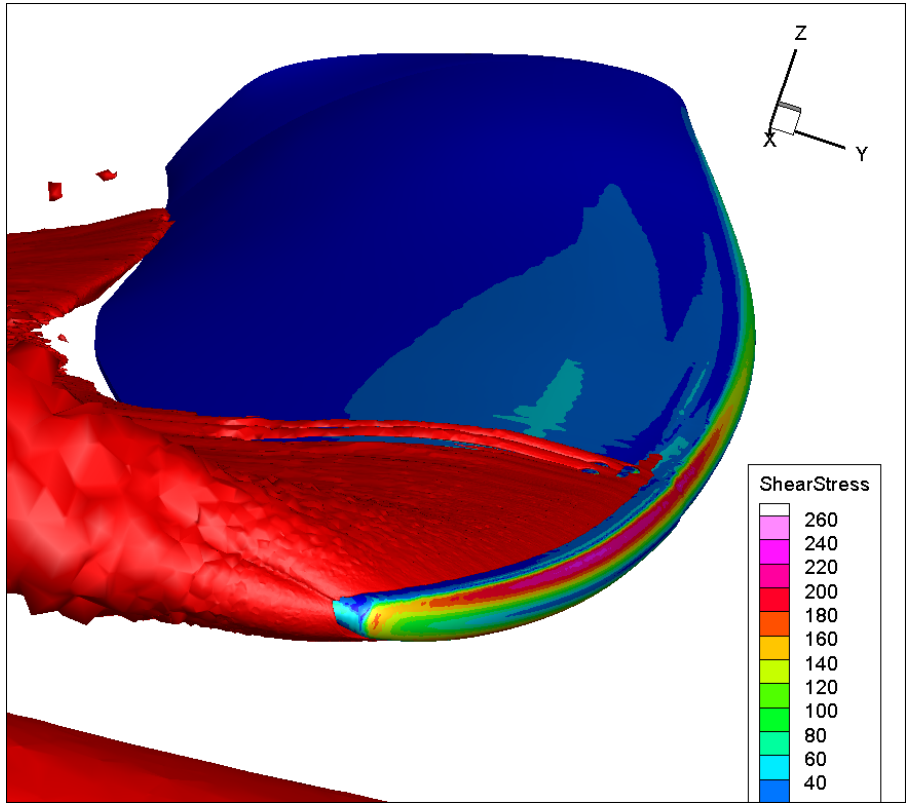


Performance Results

No Ice



120 s icing



➔ **Reduction of the Thrust by 23.8%**

➔ **Reduction of the Efficiency by 24.6%**

The Influence of Meteorological Conditions on the Icing Performance Penalties on a UAV Propeller

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SLD