Unmanned aerial vehicles (UAVs) in cold climate and wind energy applications

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Richard Hann

- Aerospace engineer
- PhD at NTNU in Norway
- Cold climate aerodynamics
- Unmanned aerial vehicles
- Wind turbine IPS
- Icing noise
- Simulation expert

Rotary-Wing UAV

- Easy to operate
- Vertical take-off & landing
- Relatively inexpensive
- Limited range
- Limited payload
- Weather sensitive

Fixed-Wing UAV

- Requires intensive training to operate
- Requires take-off & landing area
- Weather robust
- Large range
- Large payload

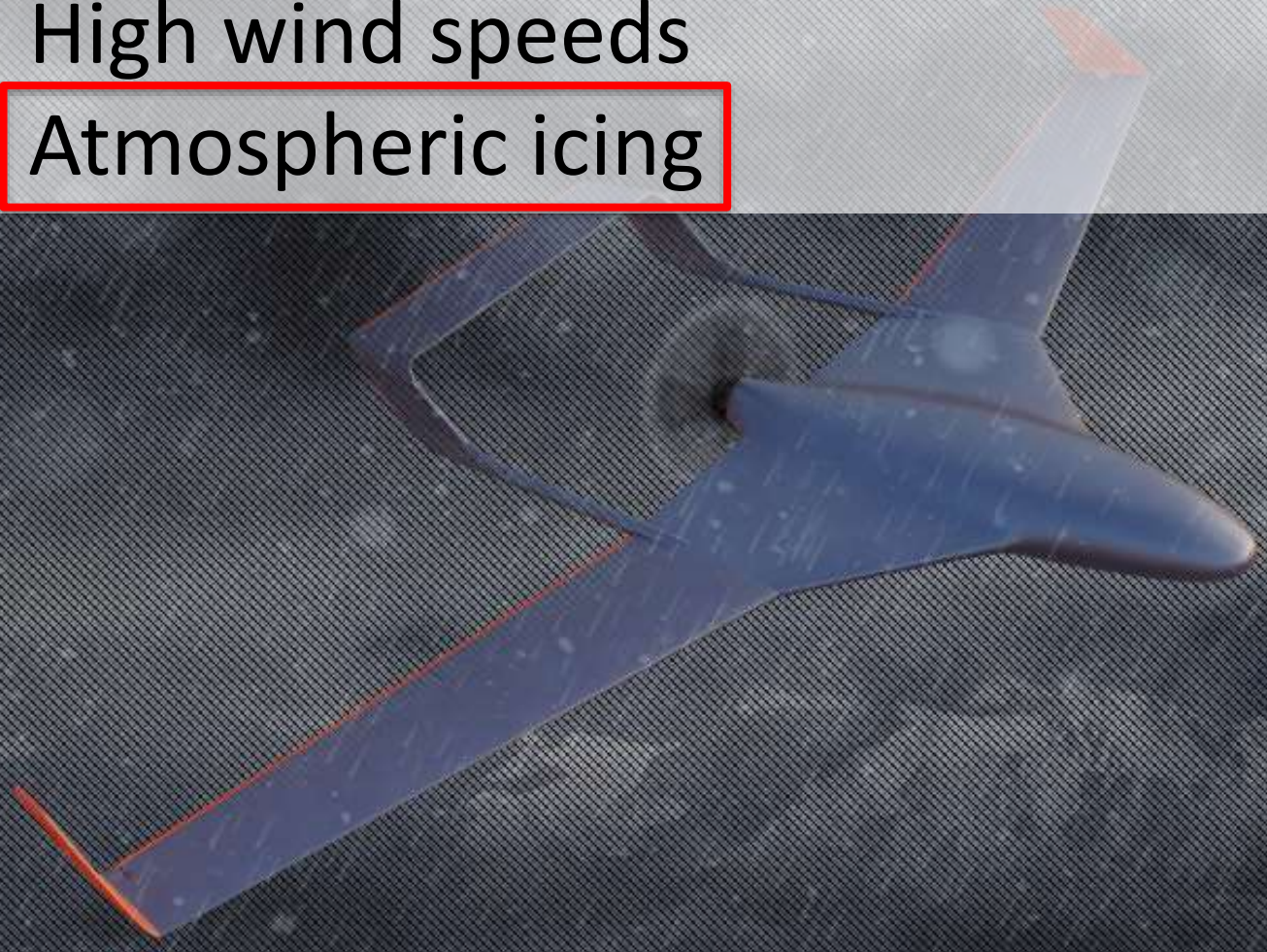
➢ **Well suited for the Arctic**

Opportunities for UAVs in the Arctic

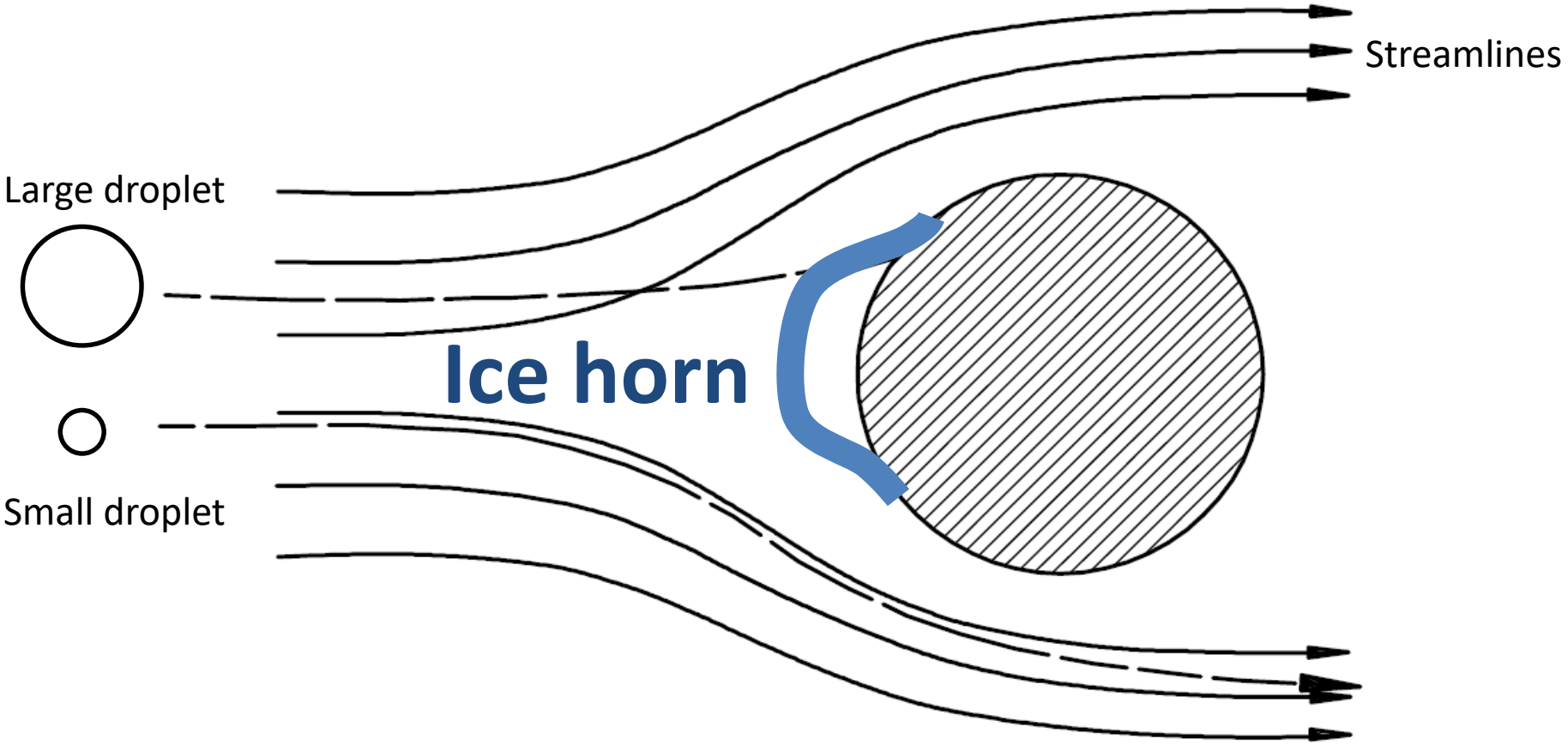
- Sea ice monitoring
- Ship-based iceberg detection
- Oil spill detection
- Search and rescue
- Remote sensing
- **Icing detection on wind turbines & power lines**
- **In-situ icing forecasting**
- **Maintenance on wind turbines**

Challenges for UAVs in the Arctic

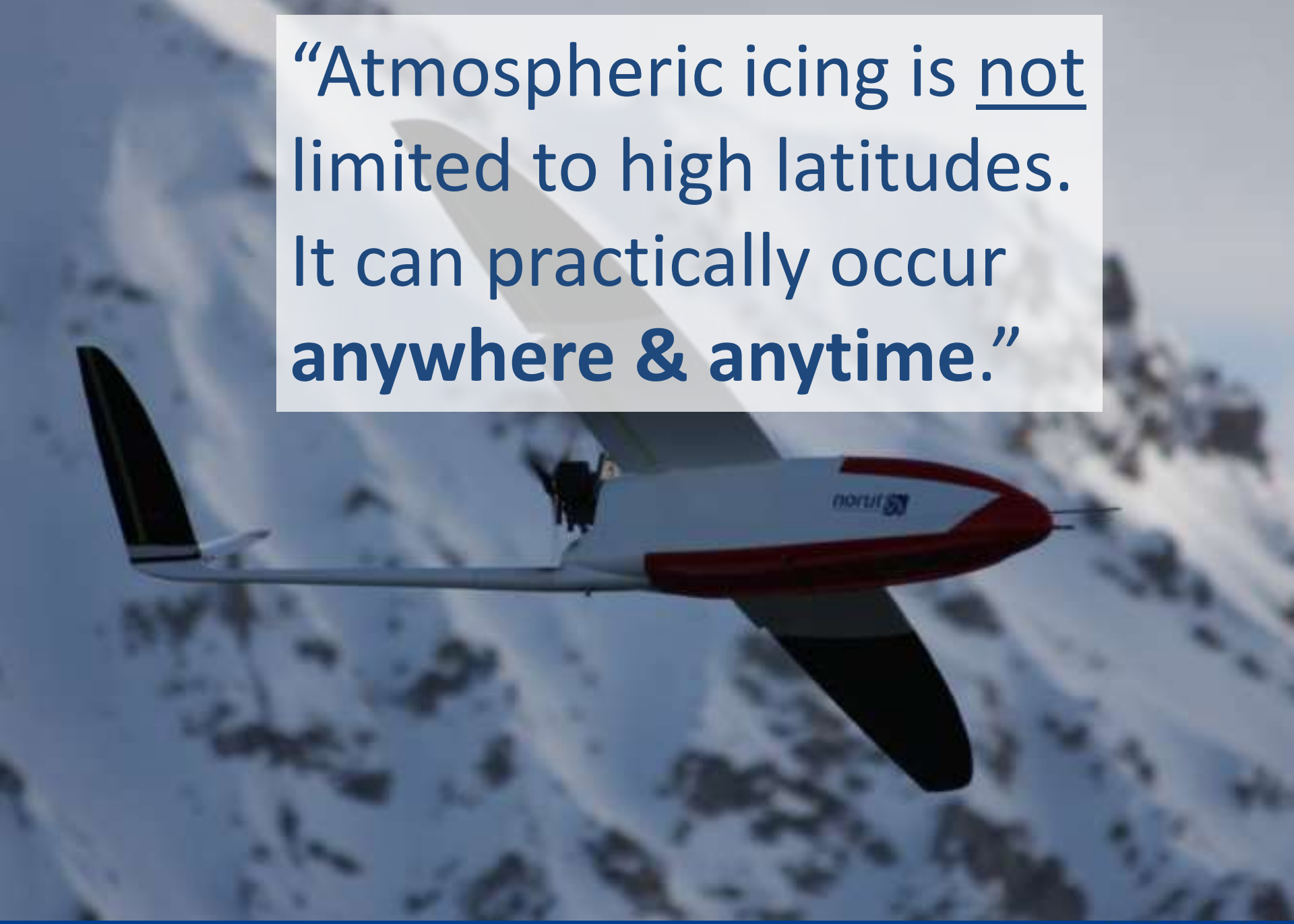
- Low temperatures
- High wind speeds
- Atmospheric icing



Atmospheric Icing



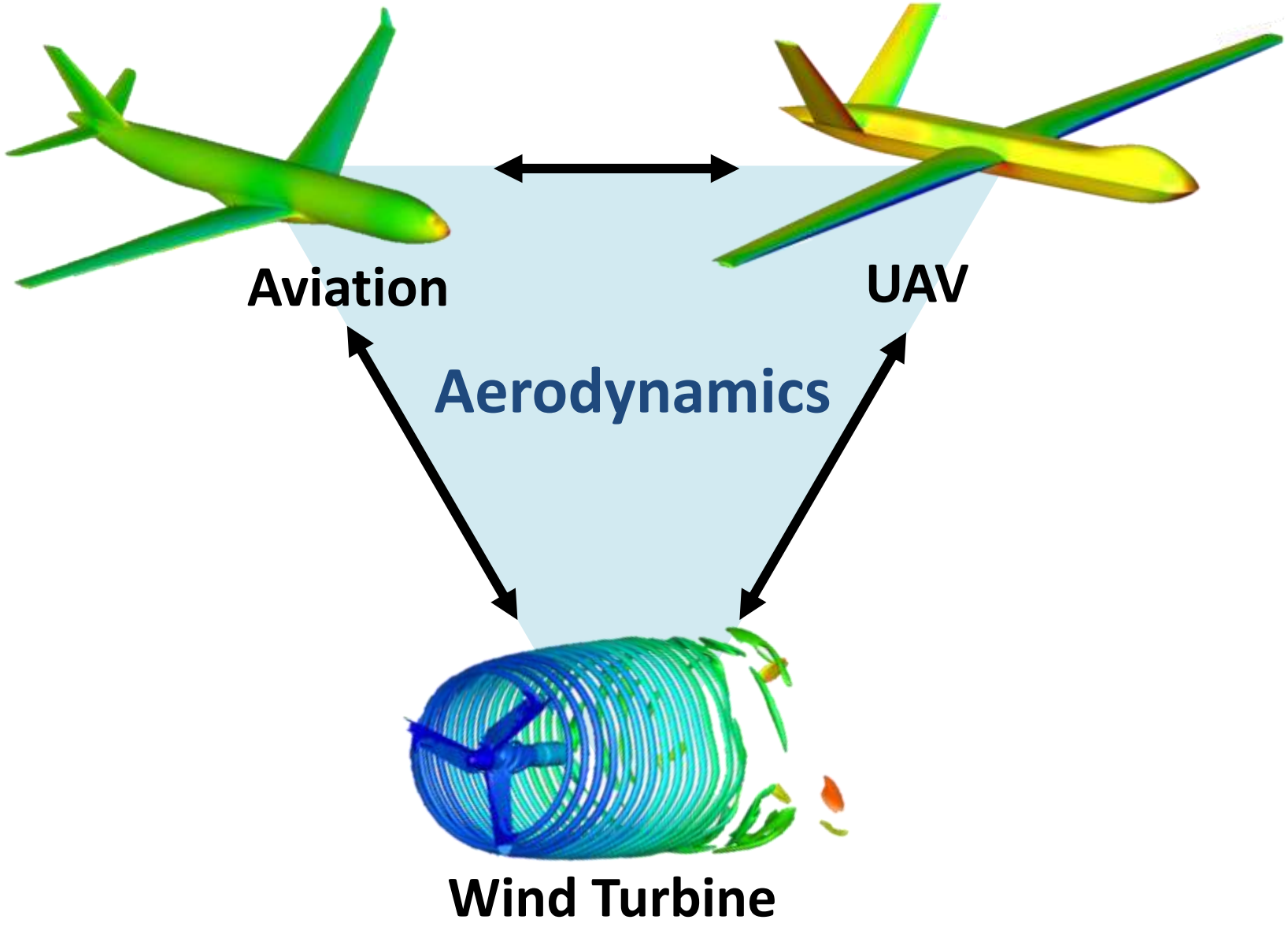

REDUCED LIFT
DECREASED THRUST
INCREASED DRAG
INCREASED WEIGHT



"Atmospheric icing is not limited to high latitudes. It can practically occur **anywhere & anytime**."

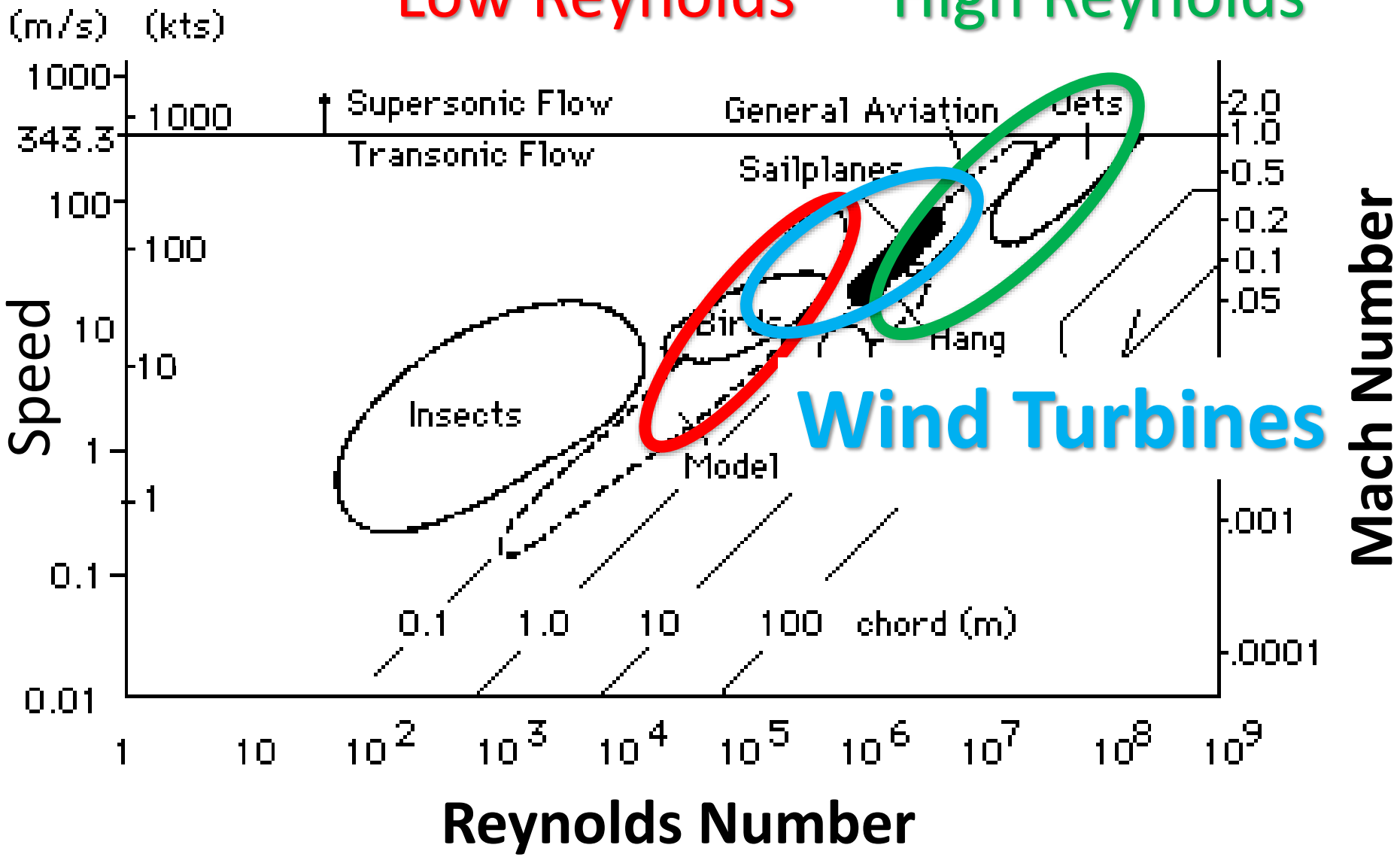

“Atmospheric icing is not limited to high latitudes. It can practically occur **anywhere & anytime**.”
“UAVs today are **not** all-weather capable.”

Icing affects planes, rotorcraft, power lines, wind turbines, …


Aviation
UAV
Aerodynamics
Wind Turbine

UAVs vs Aviation

Low Reynolds High Reynolds



Wind Turbines

NTNU

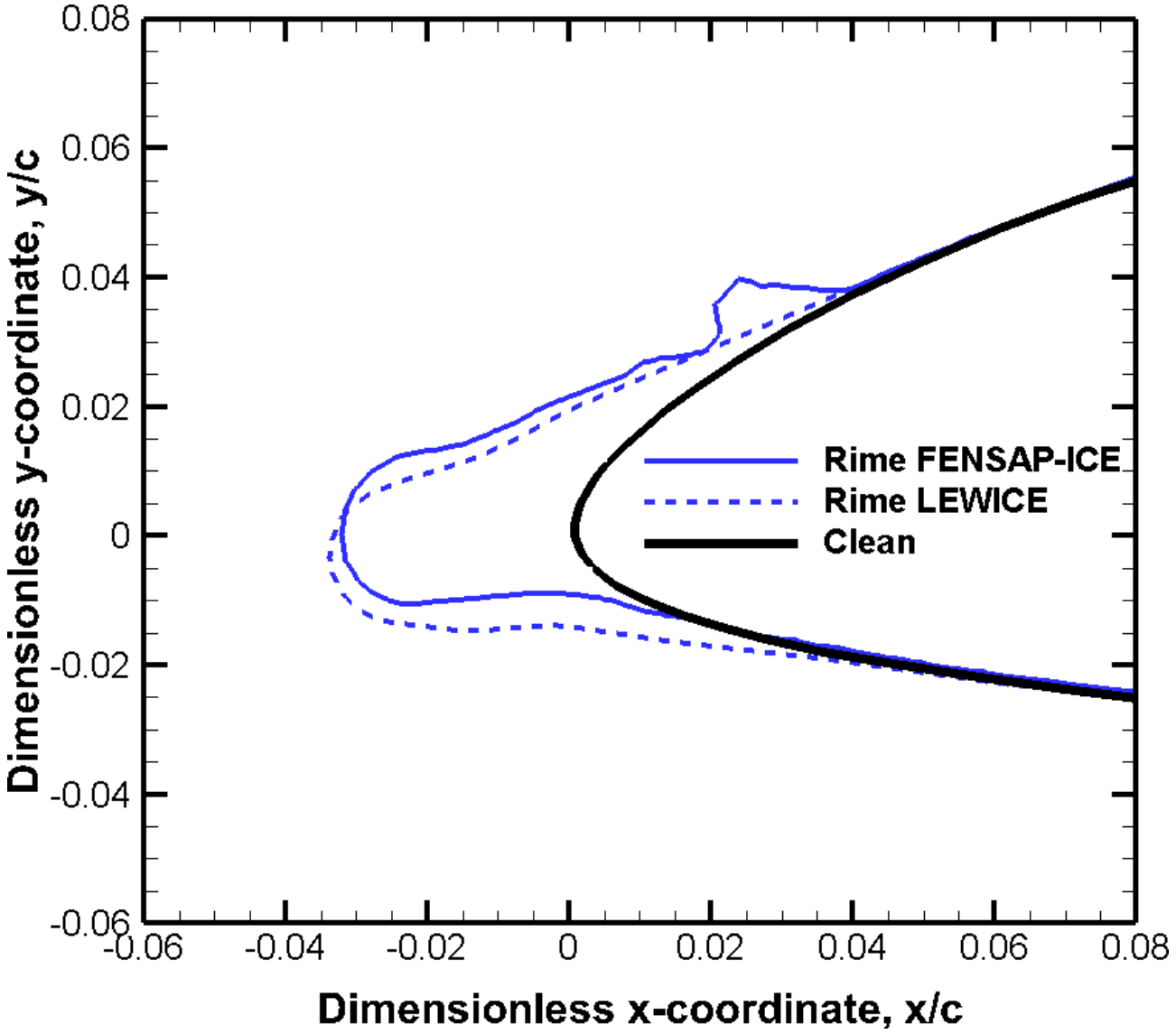
„A toolbox alone, does not make a handyman!“

- German proverb


ANSYS
FENSAP-ICE
NASA
LEWICE

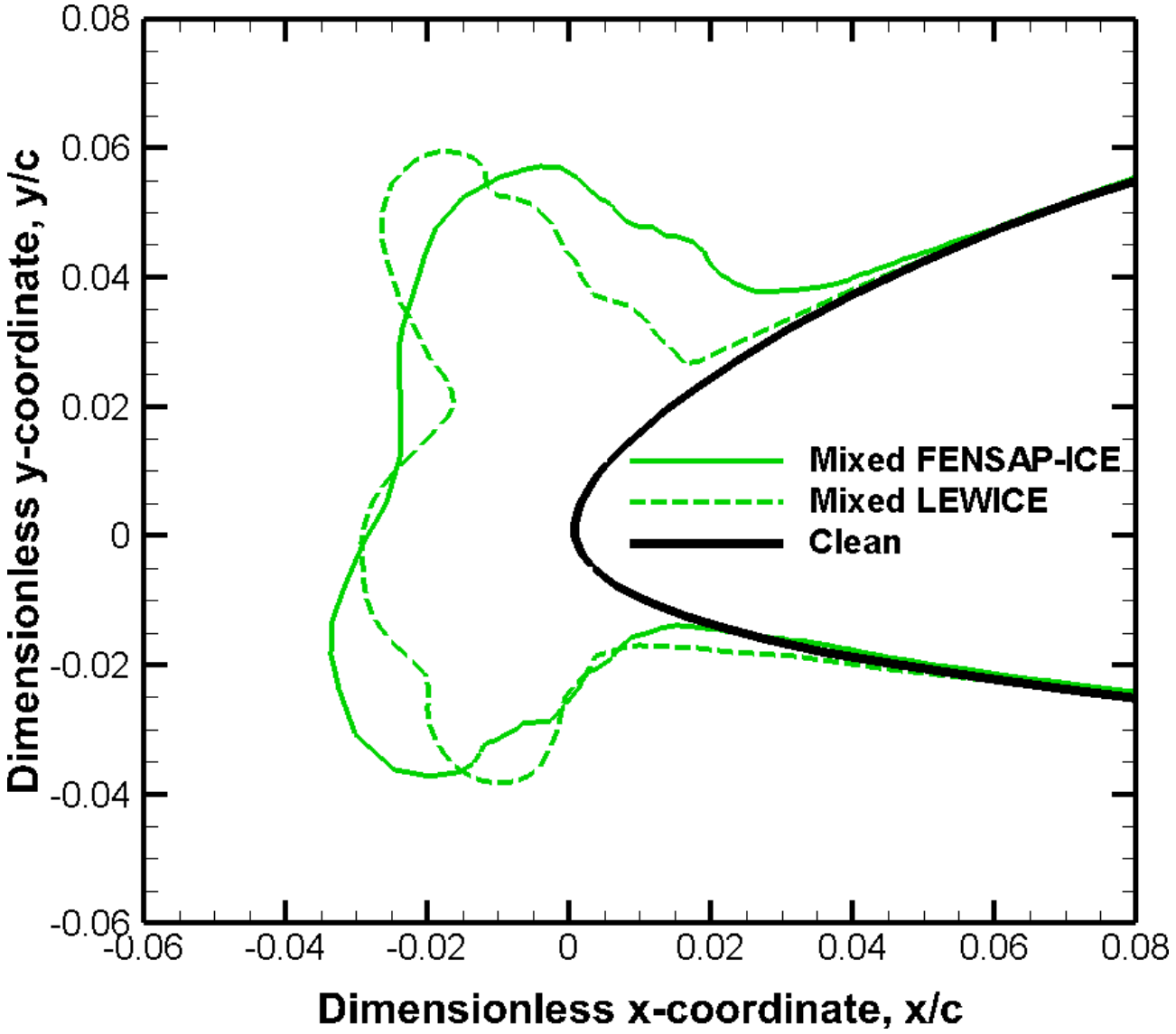
Rime Ice

NREL S826, c=0.45, v=25m/s, α=0°, t=40min, T=-2°C, MVD=30µm, LWC=0.34



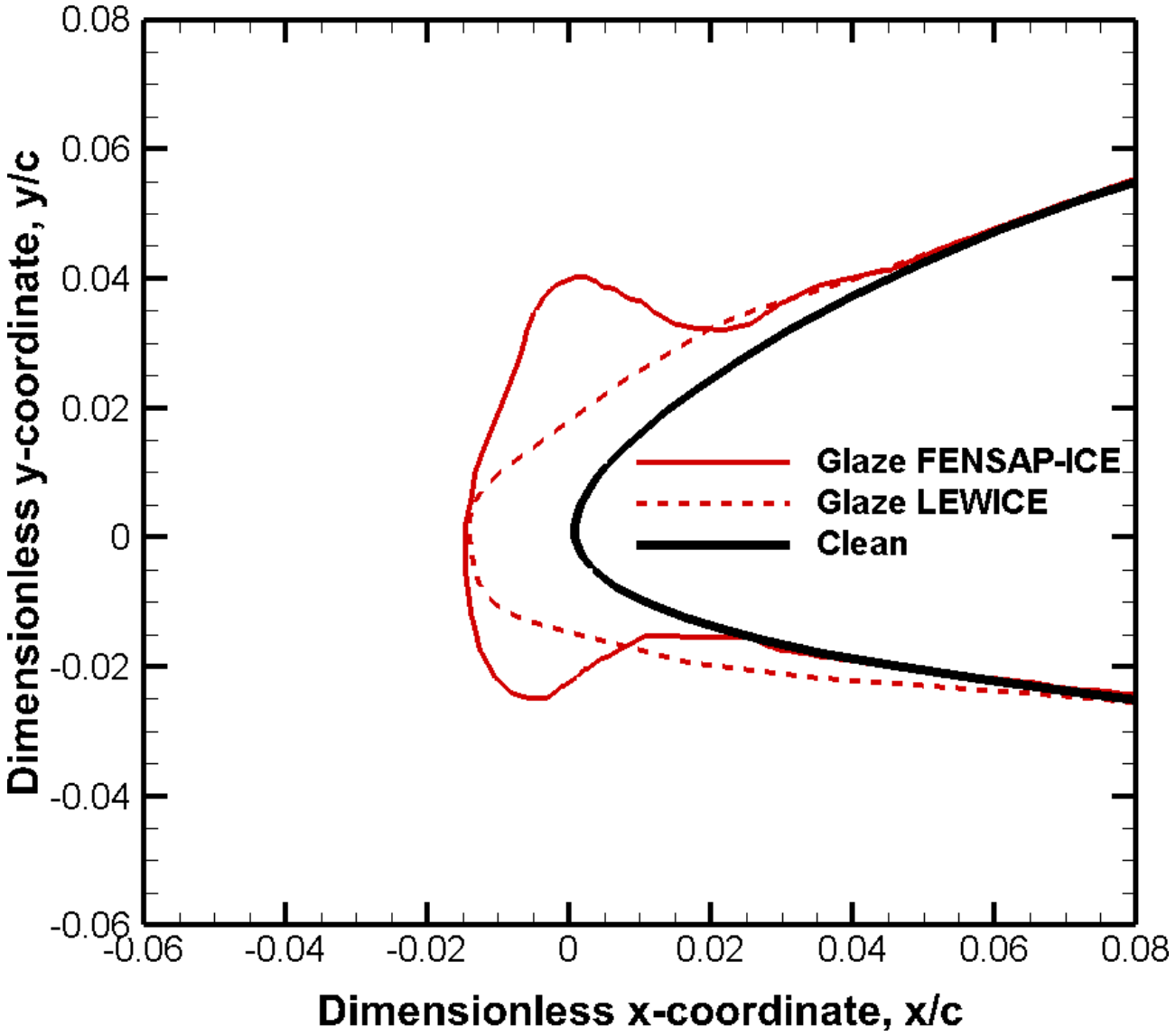
Mixed Ice

NREL S826, c=0.45, v=40m/s, α=0°, t=40min, T=-5°C, MVD=30µm, LWC=0.55

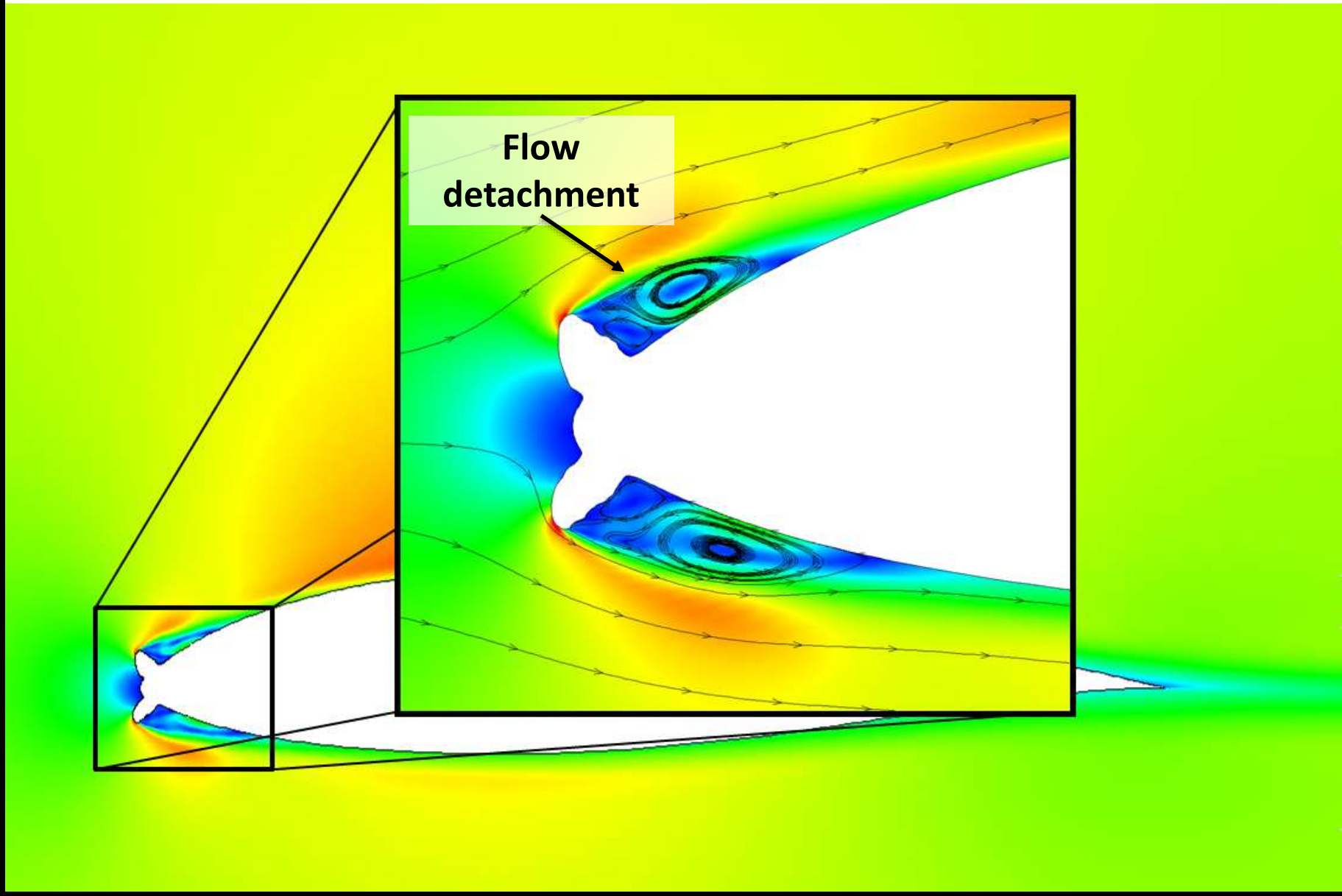


Glaze Ice

NREL S826, c=0.45, v=40m/s, α=0°, t=40min, T=-5°C, MVD=30µm, LWC=0.55



Computational Fluid Dynamics (CFD)



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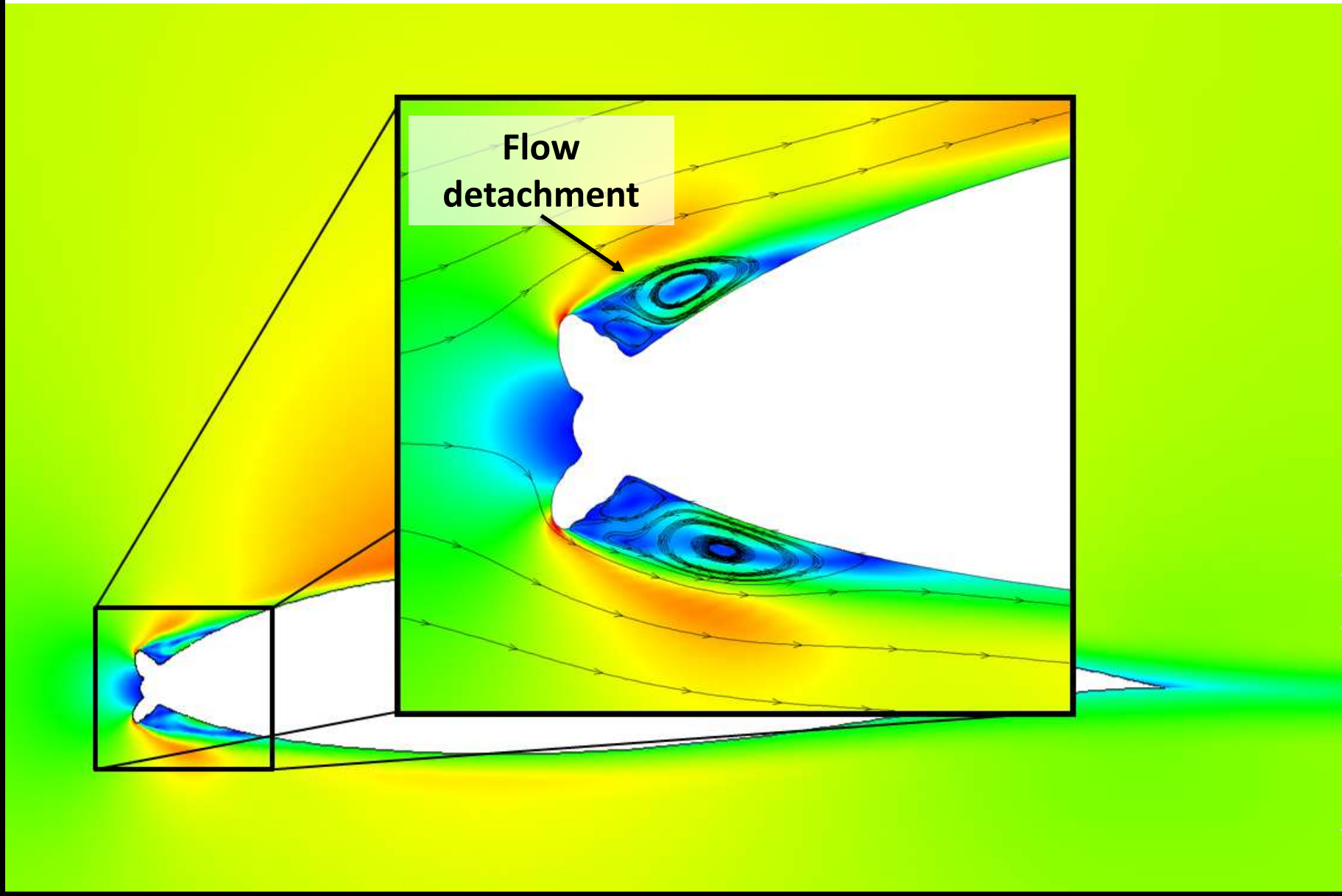

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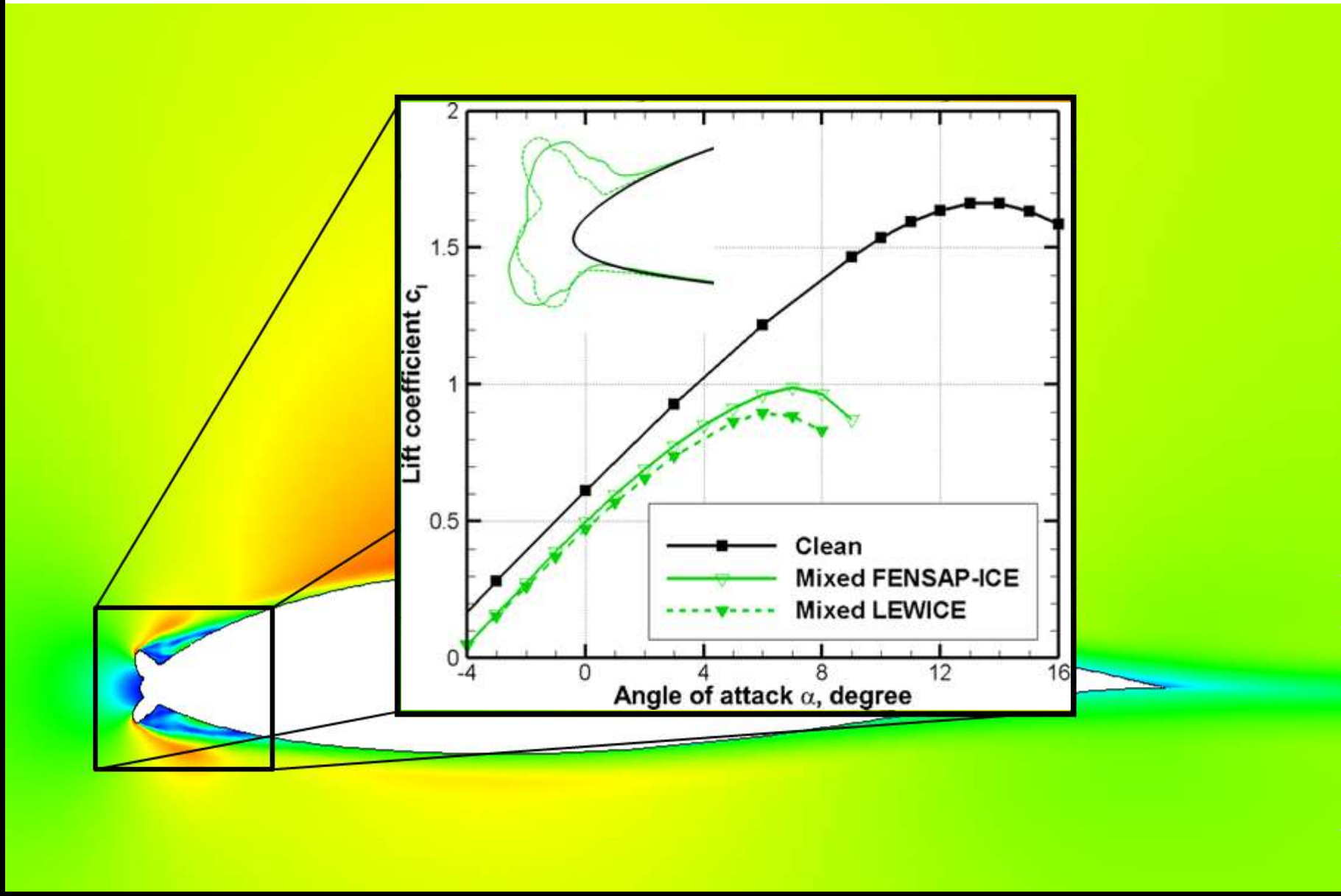
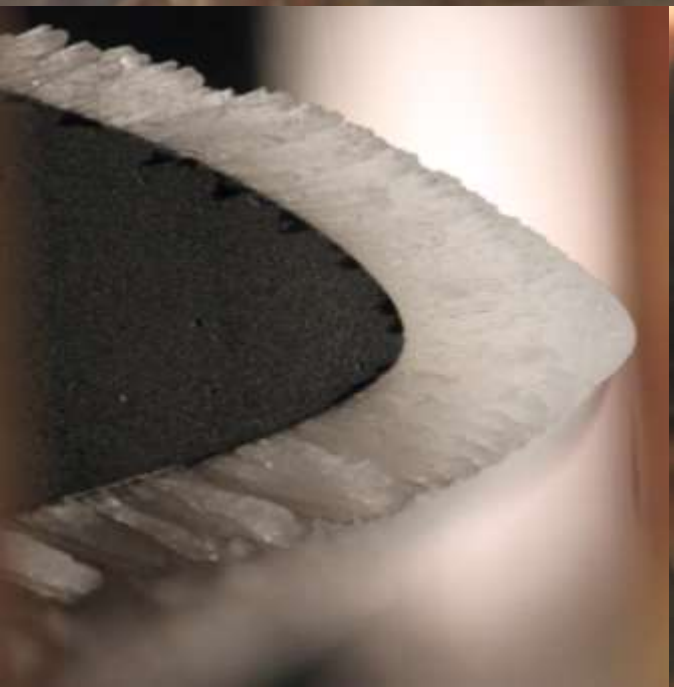
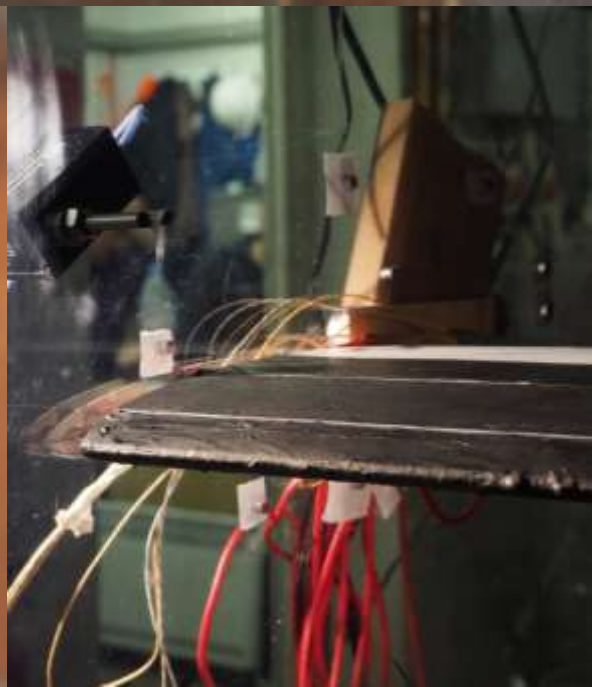
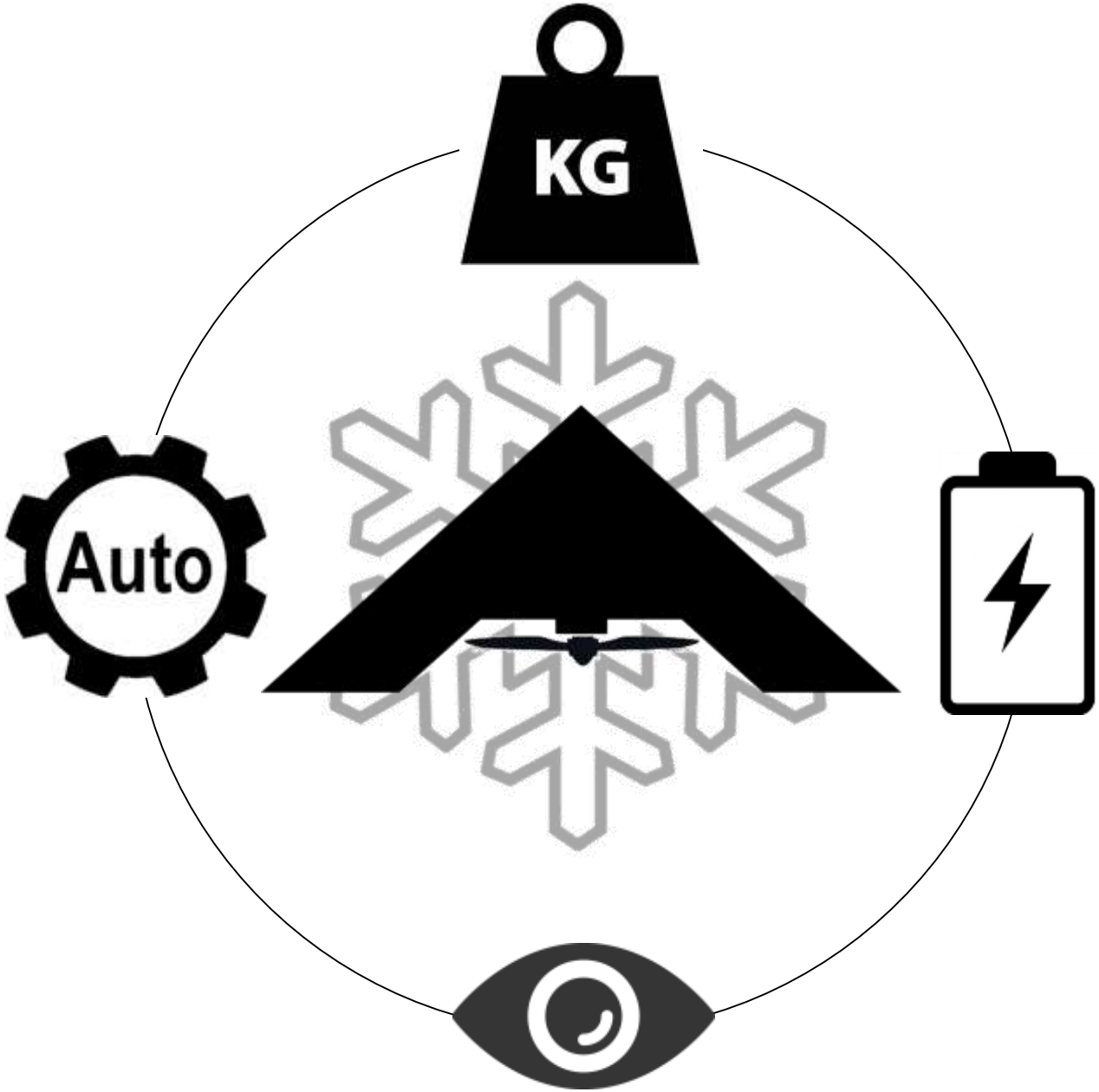
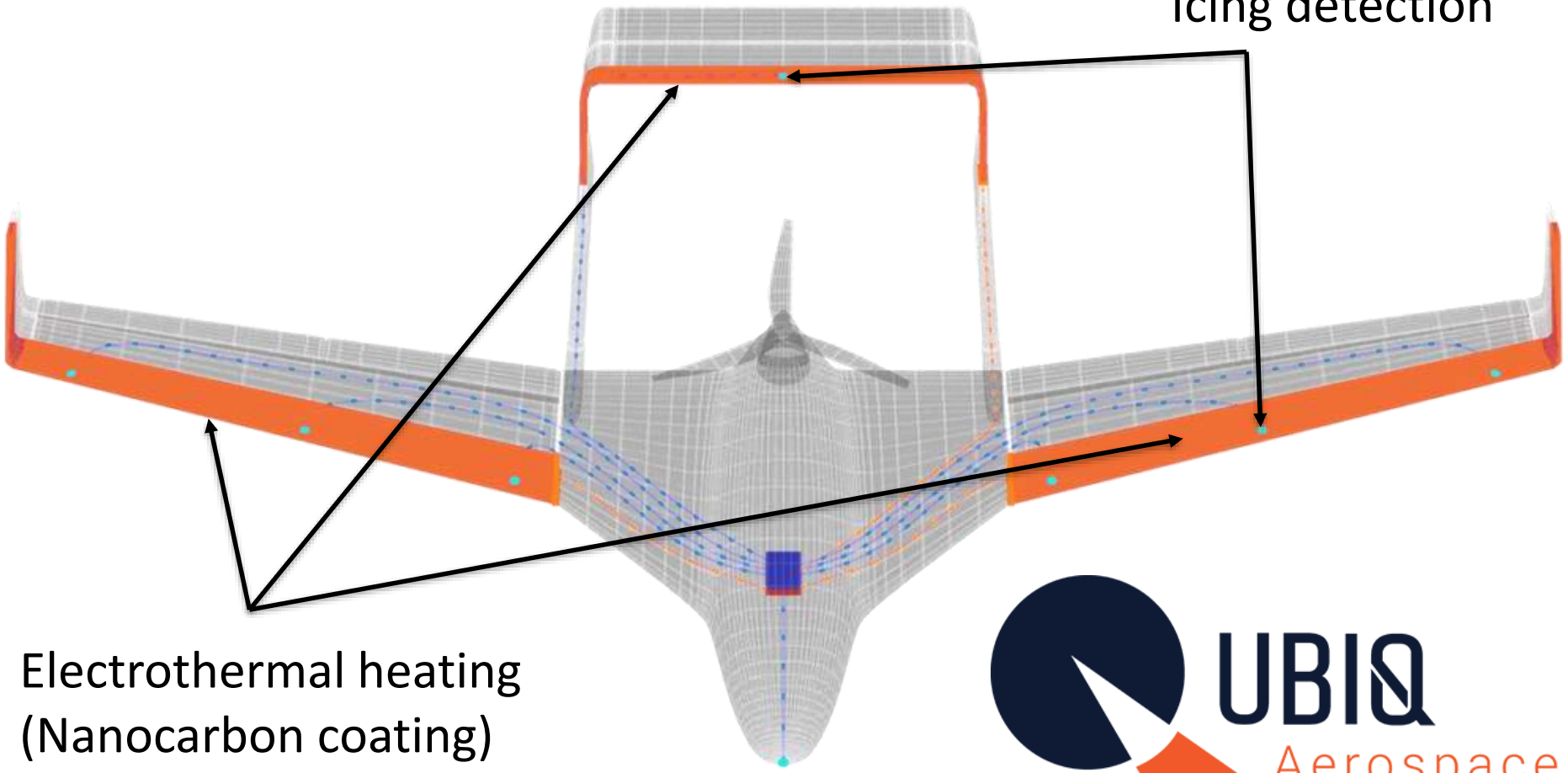







KG
Auto

Icing Protection System



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Conclusions

- UAVs have many opportunities in cold climate conditions.
- UAV icing is an emerging topic.
- Synergies between UAVs and wind energy:
  - Drone support for wind turbines
  - Icing modeling
  - Detection & mitigation technologies