

Atmospheric Icing Patch

A low power ice detection system

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UAV Icing Workshop

November 29-30, 2022

Trondheim, Norway

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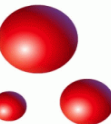


SENS4ICE

SENSORS AND CERTIFIABLE HYBRID ARCHITECTURES
FOR SAFER AVIATION IN ICING ENVIRONMENT

SENS4ICE

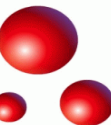
Sensors and certifiable hybrid architectures for safer aviation in icing environment
This project has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement n° 824253.



AEROTEX BACKGROUND

AeroTex Background

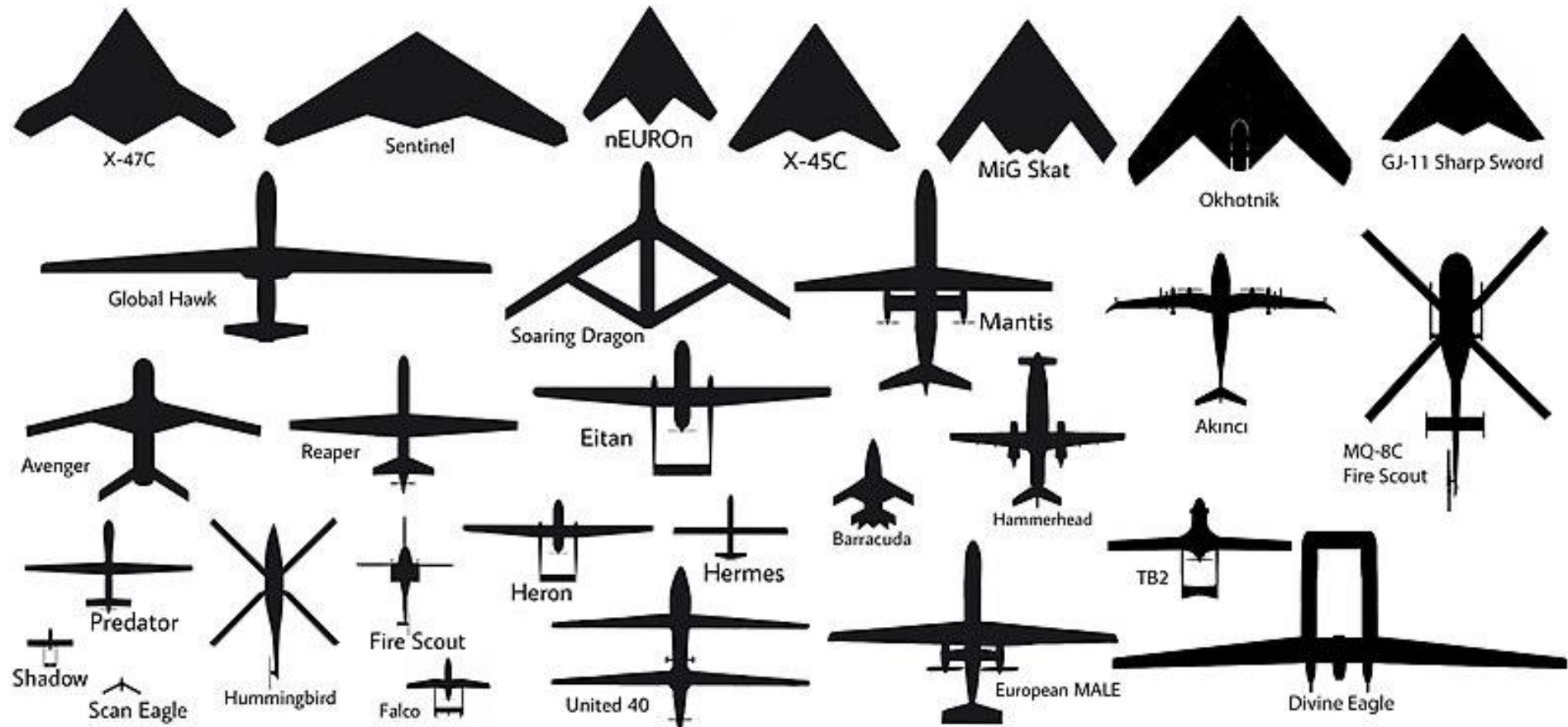
- AeroTex (ATX) background
 - ATX staff have long-term experience of in-flight icing and have experience in the design, development and certification of ice detection and protection systems
 - ATX staff experience covers:
 - Hot air ice protection systems – inlets
 - Electromechanical ice protection systems – UAV
 - Electrothermal ice protection systems – commercial WIPS, helicopter rotors, engine/air inlets
 - Icephobic materials – NRC test rig development, back-to-back coating comparisons
 - Sensor certification – pitot, ice detector, military sensors
 - ATX design and certification work is supported by our validated in-house icing analysis codes and tunnel testing at facilities around the world
 - ATX customers/partners span the whole globe; from academia to aircraft OEMs



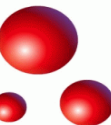
UAV ICING REQUIREMENTS

UAV Icing Requirements

- What is a UAV?



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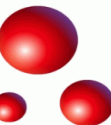
UAV Icing Requirements

<https://www.pexels.com/photo/quadcopter-flying-on-the-sky-1034812/> - Josh Sorenson

- What do we mean by a UAV and why is icing different?
 - *Generally* we are considering aircraft that can vary between a small quad-copter to Medium Altitude Long Endurance (MALE) aircraft
 - The common challenge is that they have a low power available for ice detection and protection
 - Power budget can vary from < 10 watts to < 5kW
 - Similar challenges are now arising in the air-taxi community which may require similar solutions

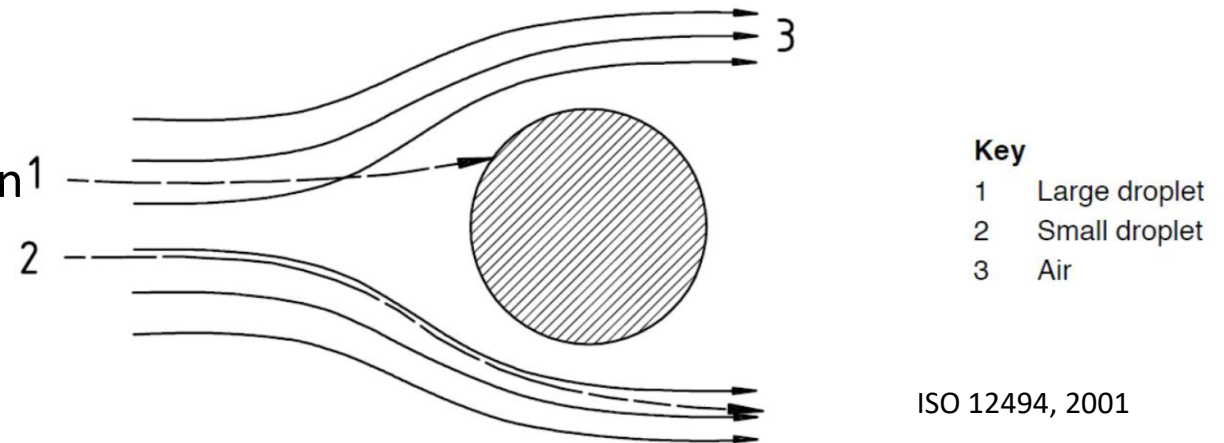


<https://nara.getarchive.net/media/a-hunter-joint-tactical-unmanned-aerial-vehicle-uav-in-flight-during-a-combat-f1f7a8> - SSGT Reynaldo Ramon, USAF



UAV Icing Requirements

- Specific UAV challenges
 - Smaller bodies accrete ice at a much faster rate relative to their size than a larger body
 - Smaller UAVs particularly could be assumed to have a collection efficiency of 1
 - Quadcopters and their like are particularly vulnerable
- What is the solution
 - Protect
 - Power/weight challenges
 - Balance depends on the size and duration
 - Detect and exit
 - Potentially very quickly!





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SENSORS AND CERTIFIABLE HYBRID ARCHITECTURES
FOR SAFER AVIATION IN ICING ENVIRONMENT

ATMOSPHERIC ICING PATCH – DEVELOPMENT UNDER SENS4ICE

EU Project SENS4ICE

SENSors and certifiable hybrid architectures for safer aviation in ICing Environment

💧 Problem

- 💧 Detect icing conditions (including App. O/ SLD icing) – detection very challenging

💧 Solution

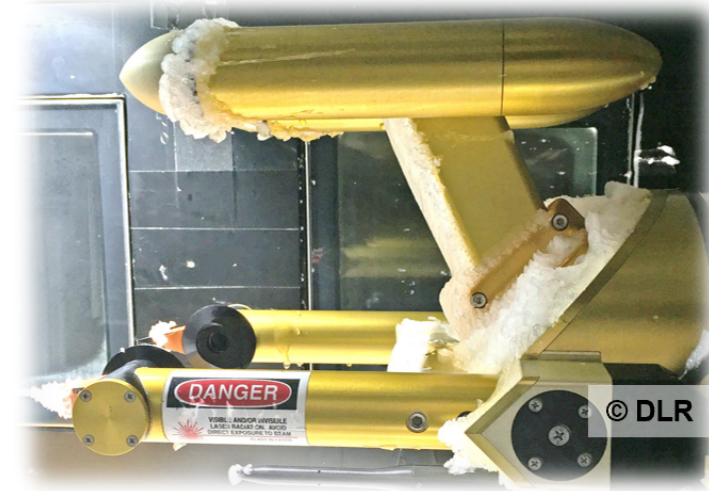
- 💧 Hybrid approach – fusion of input data: sensor(s) and indirect detection

💧 Benefits

- 💧 Operational: activate anti-/de-icing, avoid/ leave icing conditions
- 💧 Certification process – flights in App. O/ SLD icing: safety & efficiency

💧 Technology demonstration in relevant icing conditions

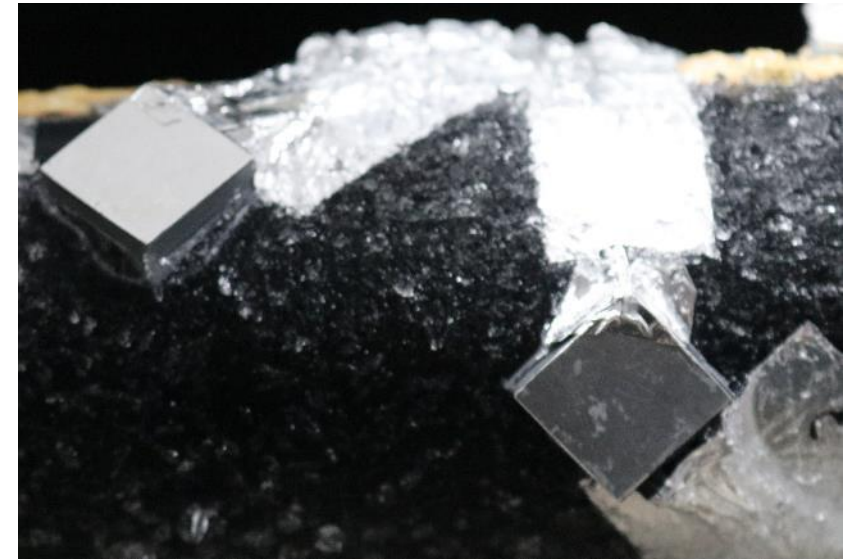
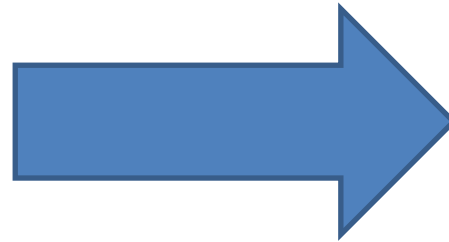
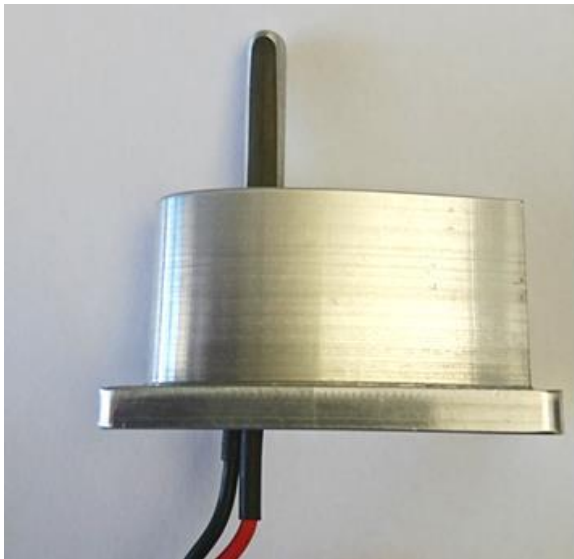
- 💧 3 icing wind tunnel testing facilities
- 💧 2 flight test platforms



- 💧 JAN 2019 – DEC 2023 (originally DEC 2022) 💧 <https://www.sens4ice-project.eu>
- 💧 Coordinator DLR + 16 project partners 💧 [#sens4iceproject](#) on LinkedIn
- 💧 8.7 M EUR including 6.6 M EUR EU contribution 💧 SENS4ICE community on [Zenodo](#)

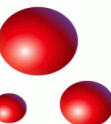
AIP – Development Under SENS4ICE

- In the early 2010's ATX first tested a probe based thermal ice detector
- In 2018, we were given the opportunity to further develop the technology under the SENS4ICE programme
 - **Atmospheric Icing Patch (AIP)**



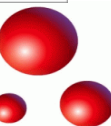
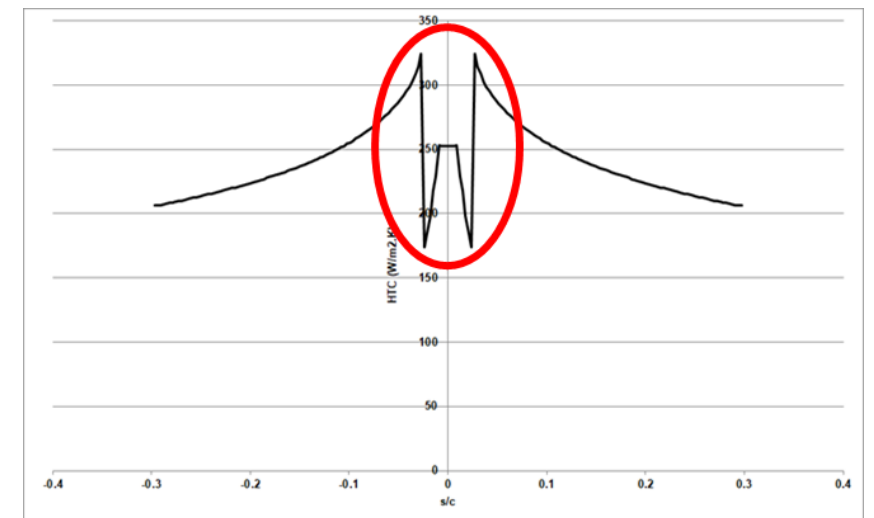
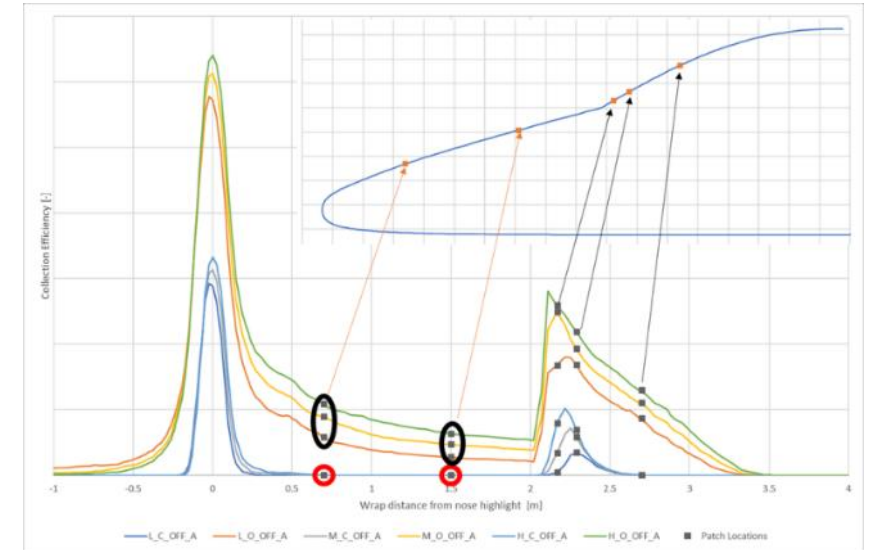
AIP – Development Under SENS4ICE

- The fundamental AIP technology is based on monitoring the power required to maintain the patch at a constant temperature
- The concept is simple, but the power will change with atmospheric and operating conditions anyway:
 - Operating temperature, speed, angle-of-attack etc.
- SENS4ICE had an additional challenge of detecting and differentiating SLD conditions from Appendix C icing conditions



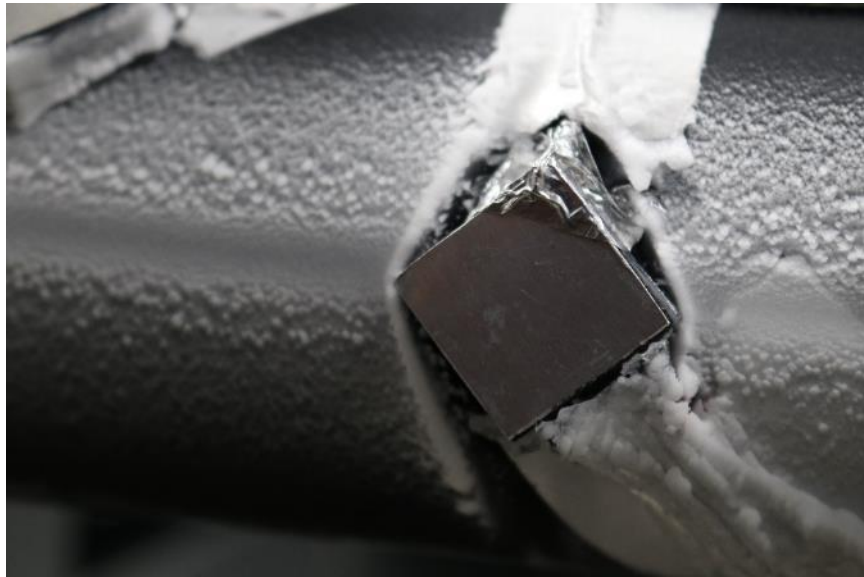
AIP – Development Under SENS4ICE

- To address the variation with flight parameters dry air calibration flights are required
- The AIP concept includes the aircraft itself as part of the detection system
 - Inertially separating the droplets an array of sensors can be used to detect icing and differentiate the icing conditions
 - Virtual visual-cue
 - More invariant HTC with angle changes as the aircraft has a large straightening effect
 - Simplifies sensor correlation



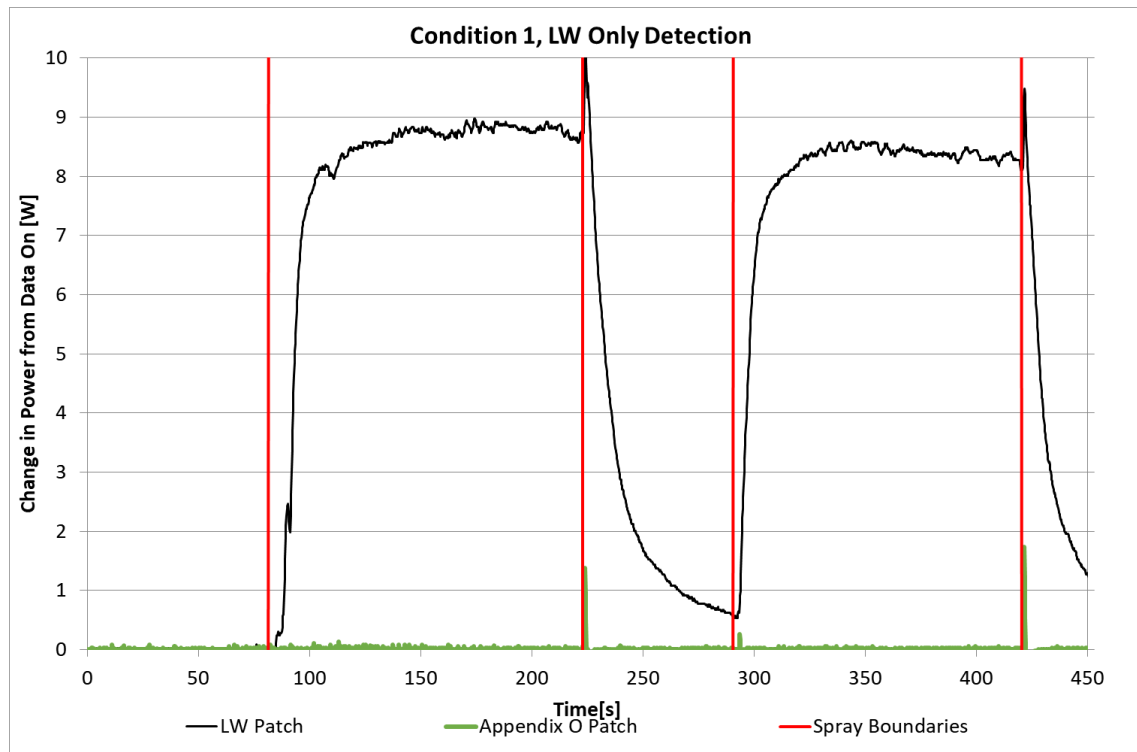
AIP – Development Under SENS4ICE

- Under the S4I programme we performed testing of the sensor technology at both the NRC icing wind tunnel for initial proof of concept and TU Braunschweig to demonstrate the final technology to be taken to flight.

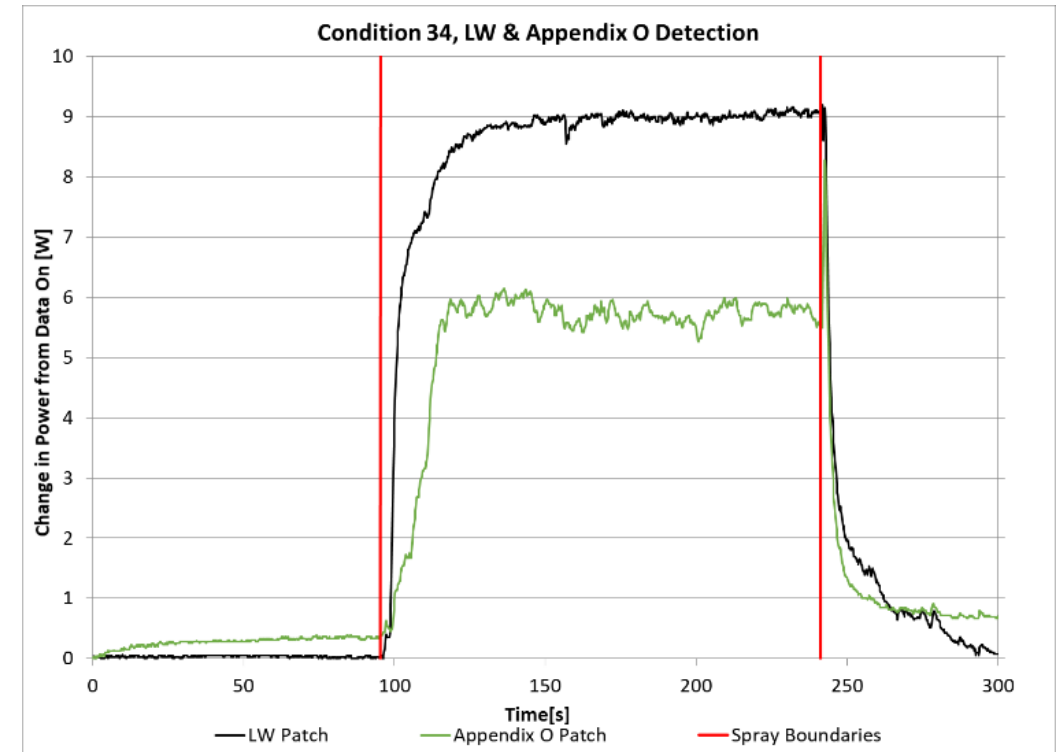


AIP – Development Under SENS4ICE

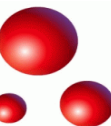
- Results from NRC modified wing shape showed the ability to detect and differentiate between Appendix C and Appendix O conditions



15micron MVD

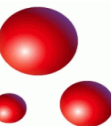
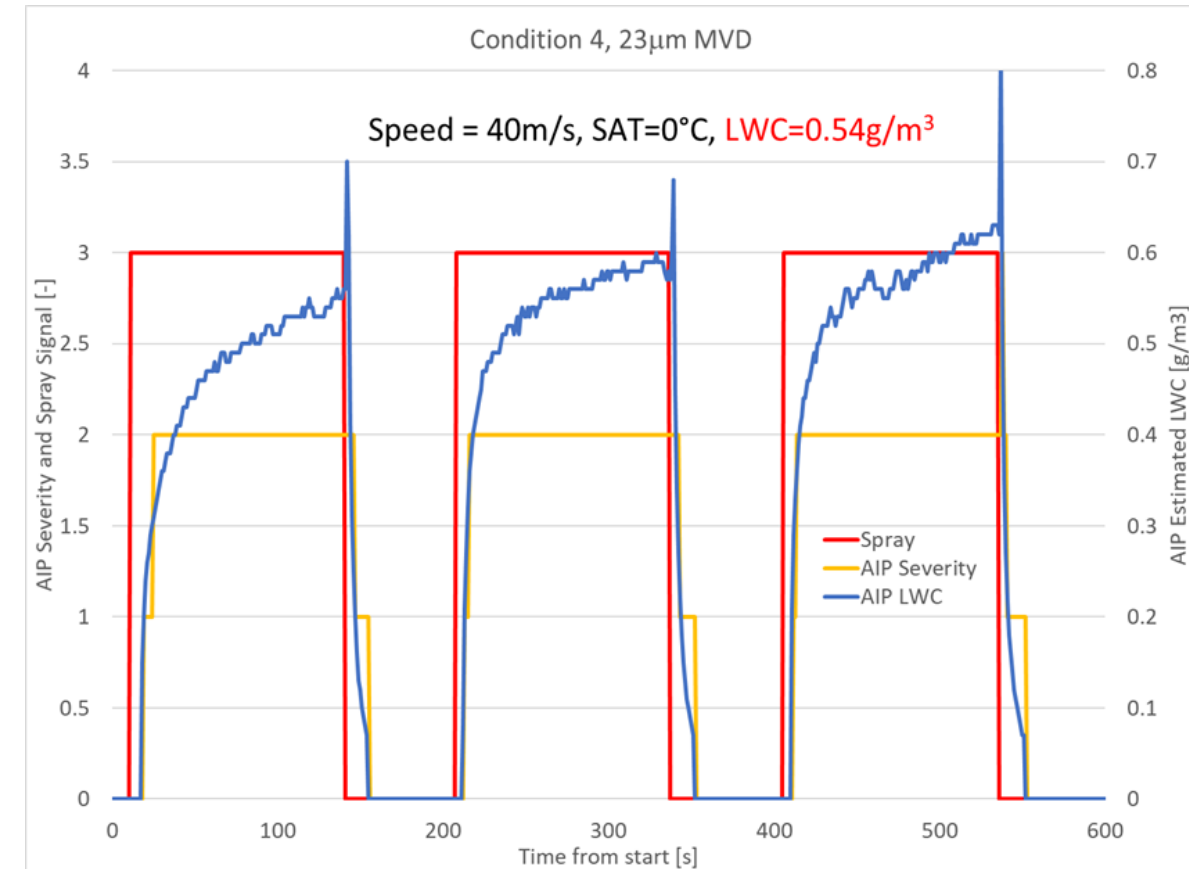


110micron MVD



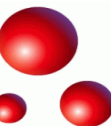
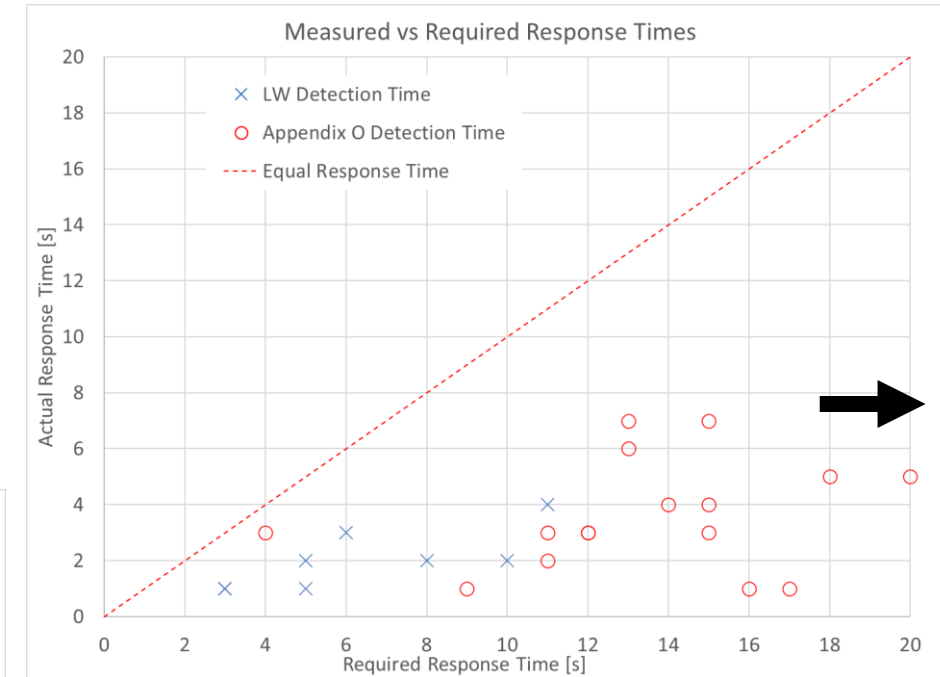
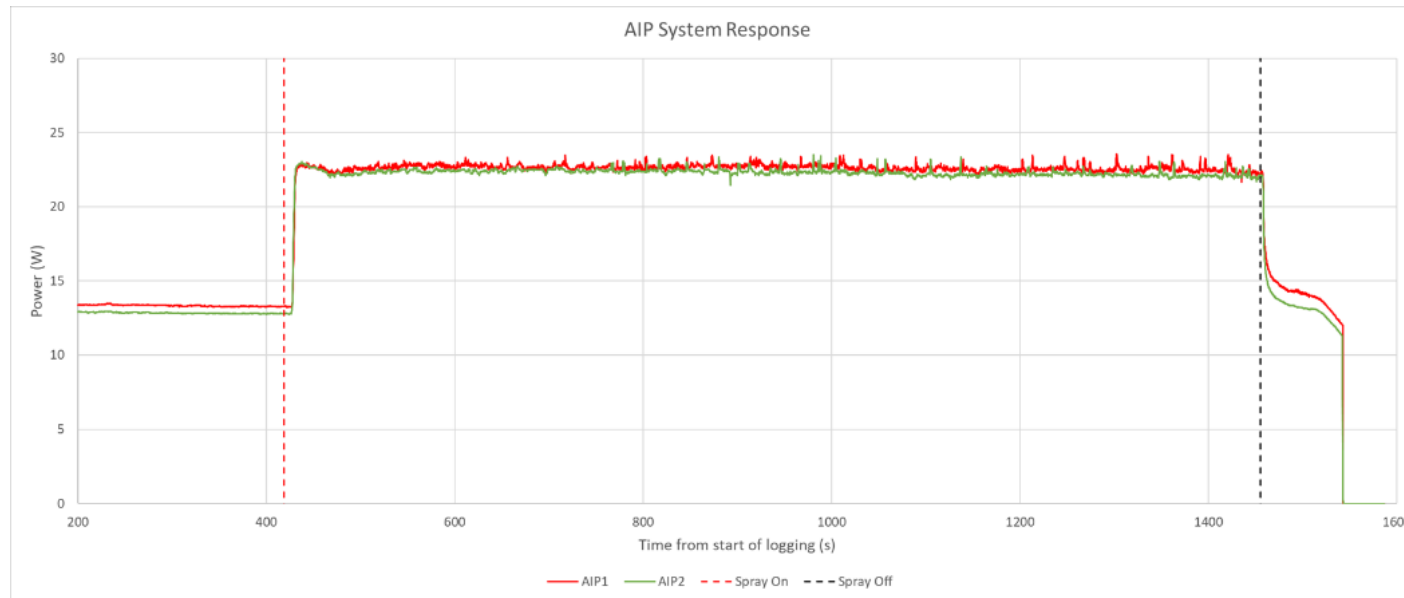
AIP – Development Under SENS4ICE

- By pushing the AIP to a high temperature and ensuring the water is fully evaporative on the sensor it is also possible to calculate the severity of the icing conditions as well as their presence



AIP – Development Under SENS4ICE

- Quick detection always better than the ED-103 requirements
- Detection down to trace icing conditions

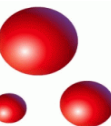


AIP – Development Under SENS4ICE

- Next Steps
 - Flight test on Embraer Phenom in North America during February 2022



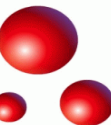
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ATMOSPHERIC ICING PATCH FOR UAVS

AIP for UAVs

- The AIP offers significant benefits for UAVs
 - The current AIP concept is a patch that is 22x22mm and draws less than 30W at fast jet operating conditions
 - Does not require a deicing cycle
 - This concept can be used as is, on larger MALE type drones, or could be minaturised for smaller drones such as quadcopters
 - The sensor response is very quick and requires only a small amount of processing
 - Options for application:
 - Detect severity to optimise the IPS; or
 - Operate at a lower temperature to further reduce power
 - For smaller drones there is a potential multi-functional use – for both detection and protection



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