SENS4ICE

SENSORS AND CERTIFIABLE HYBRID ARCHITECTURES
FOR SAFER AVIATION IN ICING ENVIRONMENT

Collins Ice Differentiator System

FINAL DISSEMINATION EVENT OF SENS4ICE PROJECT

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Directorate General for Research and Innovation, Brussels, Belgium – 29 November 2023

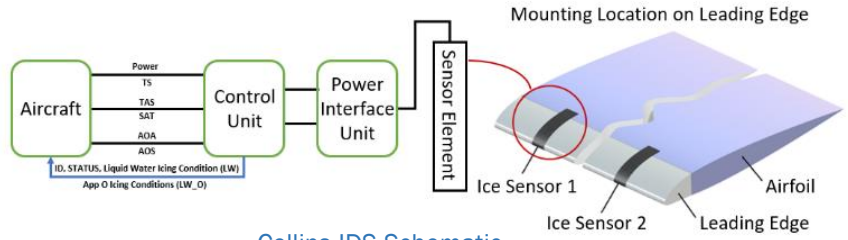
This project has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement n° 824253

Collins Ice Differentiator System – Collins-IDS

Collins-IDS measures heat flux variations in different icing conditions using a metallic heater

- IDS completed 180h IWT testing, 40h system integration IWT testing, 25.7h flight testing

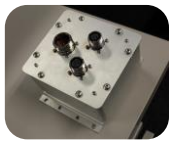
SYSTEM DESIGN



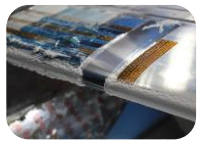
Collins-IDS Schematic

Embraer Phenom 300

Control unit



Power unit

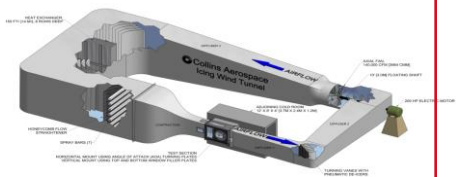


Sensing element

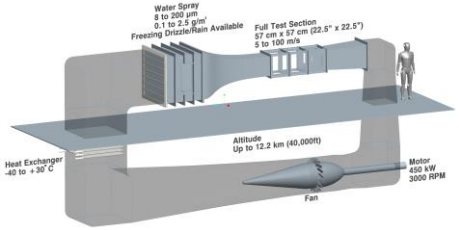
Collins-IDS components

IWT TESTING

Completed 4 round of IWT testing at Collins, Ohio



Completed 1 round of IWT testing at NRC, Canada



FLIGHT TEST

- IDS mounted on vertical fin and operated during 13 flights
- IDS was successful at detecting and differentiating App C and App O icing conditions and had 40 icing encounters

Results – Development IWT Testing

IWT Results Summary – Detection

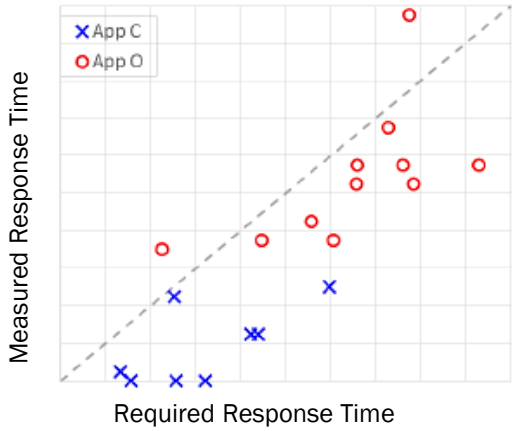
IWT	Test	Percentage of Test Points Detected	Percentage of Test Points Within Required Response Time	Percentage of Test Points Within 1.5x Required Response Time
NRC	Appendix C Test Points	100.00%	100.00%	100.00%
	Appendix C Repeat Points	100.00%	100.00%	100.00%
	Appendix O Test Points	100.00%	88.24%	94.12%
	Appendix O Repeat Points	100.00%	100.00%	100.00%

IWT Results Summary – Differentiation

IWT	Test	Percentage of Test Points Detected	Percentage of Test Points Within Required Response Time	Percentage of Test Points Within 1.5x Required Response Time
NRC	Appendix O Test Points	100.00%	88.24%	94.12%
	Appendix O Repeat Points	100.00%	100.00%	100.00%

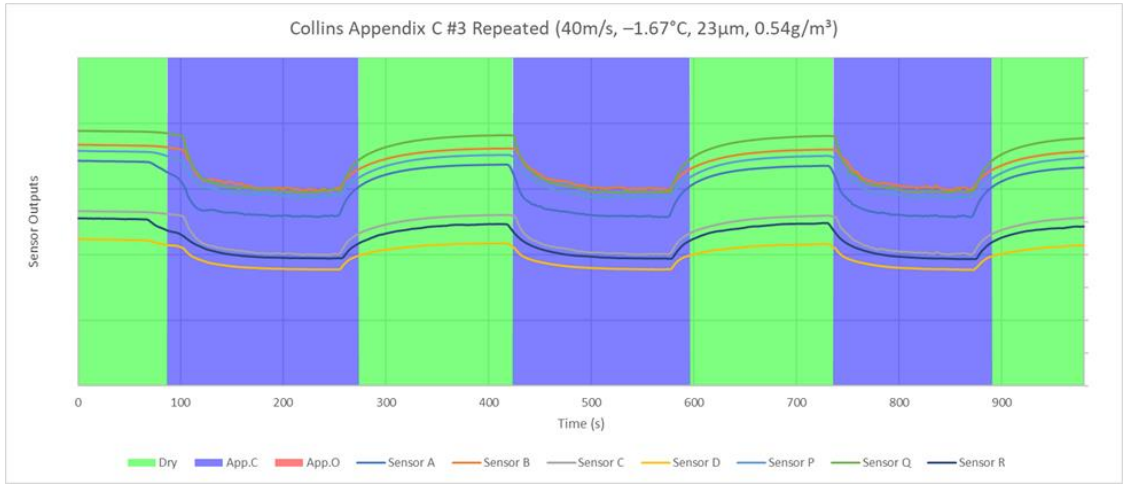
Detection Time, All Conditions

NRC Measured v. Required Response Time



Discrimination Time, App O Conditions

NRC Measured v. Required App O. Differentiation Time

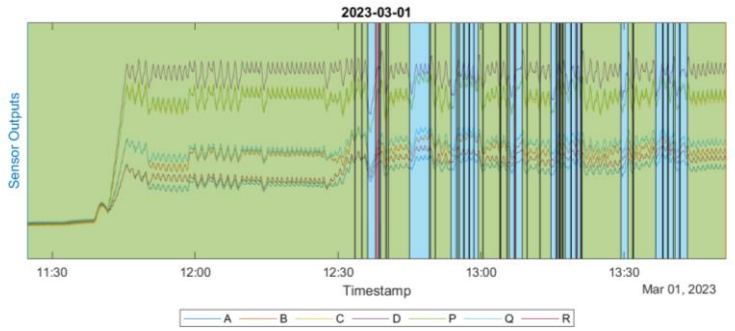


Results – Natural Icing Flight Test

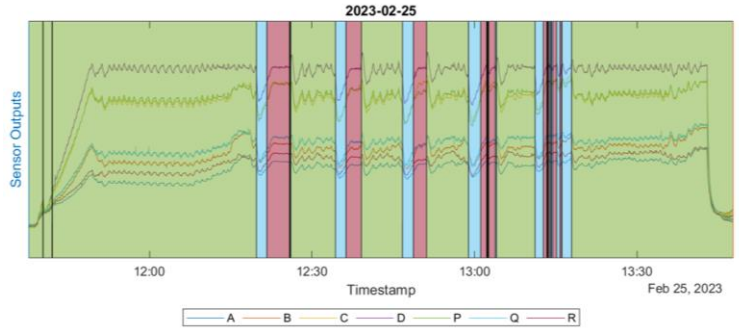
- The sensor operated during 12 flights, totaling 25 flight hours.
  - 4.3 hours was in icing conditions, of which 1.2 hours was inside SLD conditions.
- The Collins-IDS correctly detected/differentiated as follows:
  - Dry → 97.17%
  - Appendix C → 91.53%
  - Appendix O → 79.27%
- This equates to a total loss of ~6%.

		Predicted Class		
		Dry	**App.C**	**App.O**
True Class	**Dry**	97.17%	2.83%	0%
	App.C	1.69%	91.53%	6.78%
	App.O	2.44%	18.29%	79.27%

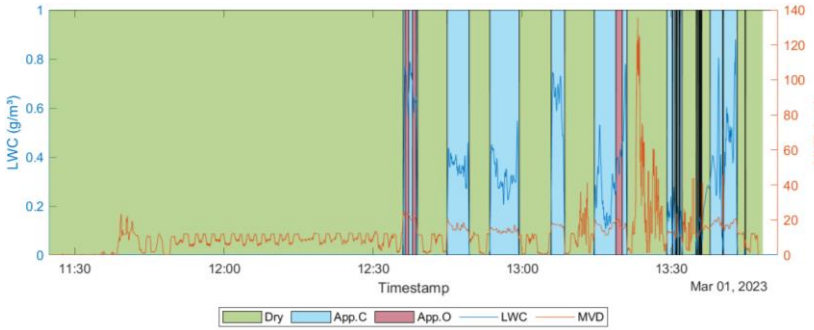
- Collins-IDS Output



- Collins-IDS Output



- Reference Measurements



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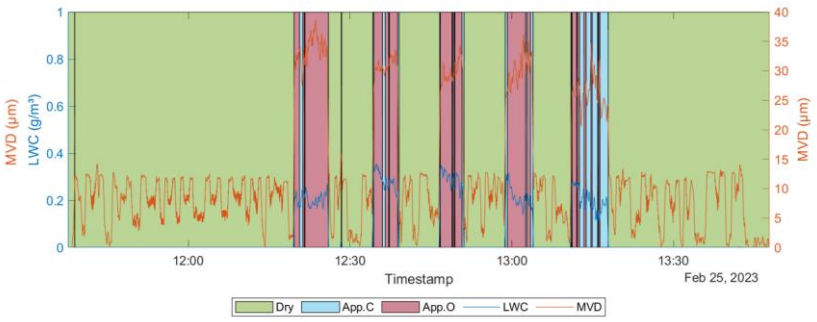
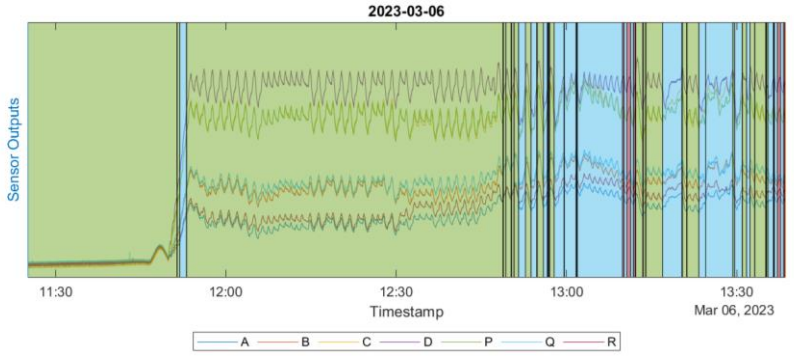


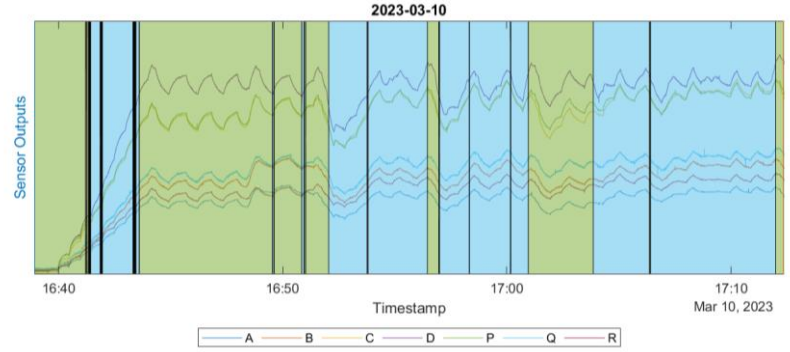
Results – Natural Icing Flight Test

- Upper graph is Collins-IDS performance
- Lower graph is reference sensor measurements combined with micro-physics analysis
- A, B, C, D, P, Q, R are RTD temperature signals
- Green = Dry, Blue = App C icing, Red = App O (SLD icing
- Flight dominated by App C icing conditions
- Sensor successfully detected and differentiated SLD conditions over multiple icing cycles

Collins-IDS Output



Collins-IDS Output



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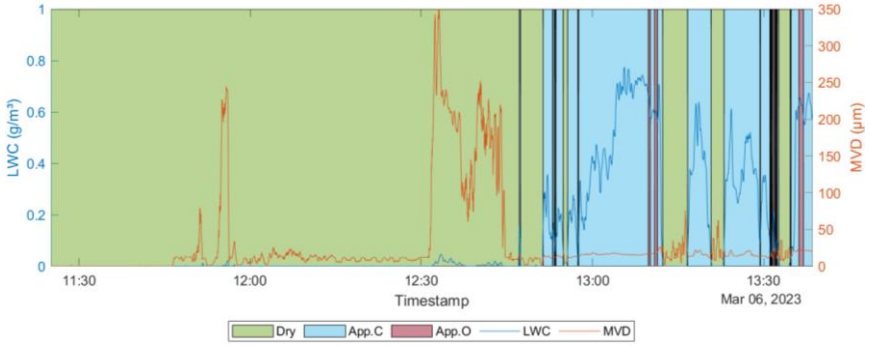
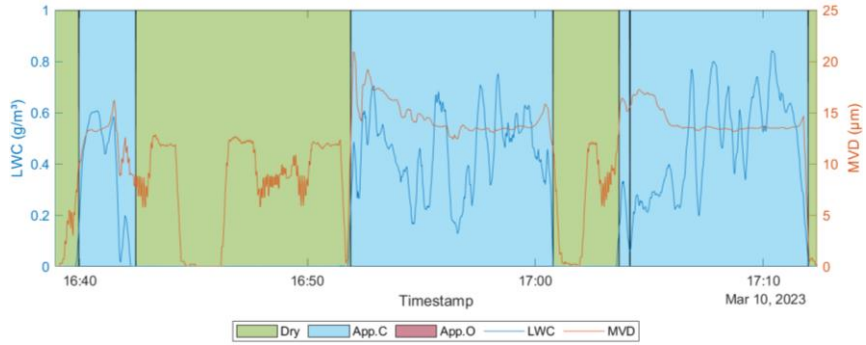


Reference Measurements



Conclusions and Future Work

- The Collins Ice Differentiator System has successfully completed the following:
  - 180 hours of development IWT testing in the system's various iterations
  - 40 hours of system integration IWT testing
  - 25 hours of flight testing
- In the IWT, the Collins-IDS proved to be a viable ice detector and ice differentiator.
- The Collins-IDS demonstrated its capabilities as an effective ice detector, detecting icing conditions from dry and differentiating between Appendix C and Appendix O ice conditions, with high accuracy, during flight.

Future Work:

- Develop a dedicated Power Interface Controller Unit for the SENS4ICE Application.
- Additional flight test data needed covering wide range of App O conditions. IWT enhancements to cover App o envelope needed, which:
  - Will allow for the ice detection/differentiation algorithm to be refined further.
  - Develop and test the Collins-IDS for different aircraft applications.

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If not acknowledged, images courtesy of the consortium partners.

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