

# ICE GENESIS Final Public Workshop

6-7 December 2023  
Toulouse, France



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# Conclusion to the Final Public Workshop

06/12/2023



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# Agenda

- Supercooled Liquid Water - Outcomes and Gaps
- Snow - Outcomes and Gaps
- Conclusion

# Supercooled Liquid Water - Outcomes

## • Icing Wind Tunnel Tests :

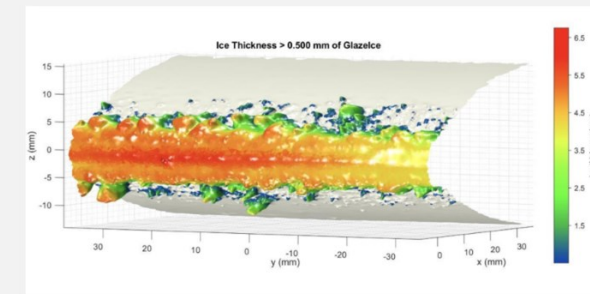
- **upgraded capabilities** in **FZDZ** (CIRA & RTA)
- **preliminary capability** for **FZRA** (RTA)
- preliminary droplet temperature characterization, 3D scanning of ice shapes

## • Methods & Tools :

- **some capabilities** demonstrated in **FZDZ** :
  - drop impact and mass deposit (splashing)
  - droplet re-emission
  - 3D capability: new methodologies for remeshing or multi-step processes
- **new experimental observations** to be implemented in future models
- validation in progress by industrials

- **Common experimental database** : <https://www.icing-database.eu/>

Supercooled Liquid Water TRL Status			
Icing Conditions		Appendix C	Appendix O (FZDZ)
Test Facilities	RTA	Already available	TRL5
	CIRA	Already available	TRL4
3D Numerical Tools		TRL4 target <b>TRL5</b> (11/2023)	TRL4 target <b>TRL5</b> (11/2023)

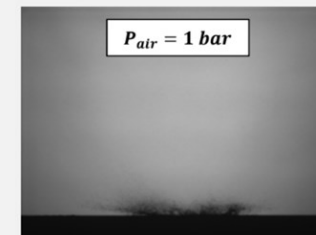


← 3D scan of an ice shape generated in icing wind tunnel (color is proportional to thickness)

$D_0 \approx 325 \mu m$  ;  $V_{air} = 140 m/s$  ;  $T_{air} = 15^\circ C$

Experimental observation of the altitude effect on droplet impact →

$P_{air} = 1 \text{ bar}$



$P_{air} = 0.6 \text{ bar}$



# Supercooled Liquid Water - Gaps

## • Icing Wind Tunnel Tests :

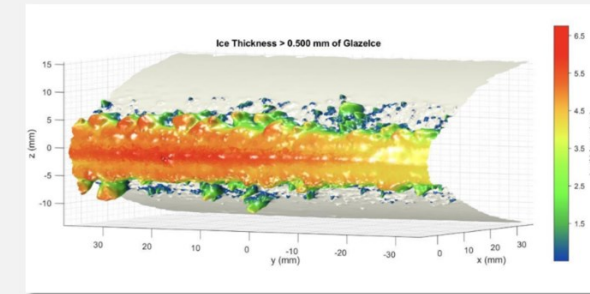
- missing **full FZDZ capability** : cloud uniformity, LWC too high, droplet temperature effect, instrumentation standardization for particle size distribution and LWC, **extend calibration** to the broad CIRA envelope (altitude, speed)
- improve **efficiency** of the SLD set-up and App.C/O switching for industrial applications

## • Methods & Tools :

- missing **full FZDZ capability** : high speed effect/erosion, altitude effect
- lack of reliable **experimental data** to properly assess the models
- industrialization** of the tools

- In general : some efforts are needed to provide applicants for future A/C configurations the same level of acceptance for the Means of Compliance in Appendix O as it is in Appendix C

Supercooled Liquid Water TRL Status			
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	CIRA	Already available	TRL4
3D Numerical Tools		TRL4 target TRL5 (11/2023)	TRL4 target TRL5 (11/2023)

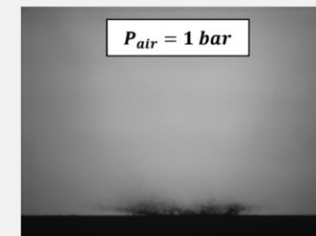


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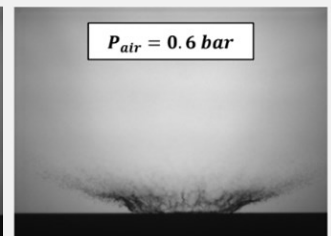
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Experimental observation of the altitude effect on droplet impact →

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$P_{air} = 0.6 bar$



# Snow - Outcomes

- **Characterization of falling snow conditions** (field campaigns)
- **Icing Wind Tunnel Tests :**
  - Development of **snow generation systems** in RTA & NRC with the capability to change the particle melt
  - **Calibration of snow wind tunnel** test facilities
- **Methods & Tools :**
  - **Modelling of the physical phenomena** related to snow : drag, melting; preliminary model for sticking efficiency, erosion, accretion
  - Validation in progress by industrials

Snow TRL Status		
Test Facilities	RTA	TRL4
	NRC RATFac	TRL4/5
Tools	Transport : <b>TRL4</b> , target <b>TRL5</b> (12/2023) Accretion : <b>TRL3</b> , Target <b>TRL4</b> (12/2023)	

ATR42 Snow Field Campaign at Les Eplatures (Swiss Jura) - 01/2021



IAG SnowFall snow generation system into RTA Climatic Wind Tunnel and calibration

# Snow - Gaps

- **Icing Wind Tunnel Tests :**

- **Upscaling** to regulatory Total Water Content (TWC)
- Validation database on **representative industrial configurations**
- **Efficiency and operability** of the snow generation systems

- **Methods & Tools :**

- Modelling: snowflake impact and accretion, heated surface, ice shedding, saltation
- **Validation on complex 3D cases** (engine air inlet)

Snow TRL Status		
Test Facilities	RTA	TRL4
	NRC RATFac	TRL4/5
Tools	Transport : <b>TRL4</b> , target <b>TRL5</b> (12/2023) Accretion : <b>TRL3</b> , Target <b>TRL4</b> (12/2023)	

ATR42 Snow Field Campaign at Les Eplatures (Swiss Jura) - 01/2021



IAG SnowFall snow generation system into RTA Climatic Wind Tunnel and calibration

# CONCLUSION & WAY FORWARD

## CONCLUSION

- **Clear progress on wind tunnel test facilities** for the simulation of SLD and Snow conditions (FZDZ: TRL4/5, FZRA: Preliminary Capability, Snow: TRL4)
- **Improved understanding and modelling** of SLD and Snow conditions, though **some progress remains necessary on the new models** in order to use them as certification means of compliance
- **Beneficial international cooperation, to be continued**: enhanced impact, harmonization, orientation of fundings towards common targets, scientific excellence

## CONTEXT

- **Climate evolution**: increasing weather hazards, need for disruptive aircraft and powerplant configurations to achieve CO<sub>2</sub> emissions reduction targets
- **Certification**: New stringent policies and certification requirements or increasing level of authorities expectations
- **No approved engineering tools** for use as workable direct means of compliance (free from excessive conservatism) → **the future clean and sustainable aviation products cannot be certified without further research.**

**NEXT TARGET:** Obtain workable means of compliance for Icing, Snow and Ice Crystals for application to future products design and certification at horizon 2030+

## WAY FORWARD

- Will be discussed on 07/12/2023



# AGENDA for 07/12/2023

Time			Item	Presenter
Start	End	Duration		
9:00	9:05	0:05	Introduction	AIRBUS
9:05	9:25	0:20	Feedback from the MICG	AIRBUS
9:25	9:45	0:20	FAA (TBC)	FAA
9:45	10:05	0:20	EASA	EASA
10:05	10:25	0:20	SENSE4ICE presentation (guest)	DLR
10:25	10:45	0:20	MUSIC-HAIC presentation (guest)	ONERA
10:45	11:00	0:15	<i>Coffee break</i>	
11:00	11:30	0:30	Conclusions from ICE GENESIS internal review	DASSAV, AIH
11:30	12:30	1:00	Discussion on the needs for the industry (part 1): aircraft, helicopters and Advisory Board feedback	All
12:30	14:00	1:30	<i>Lunch</i>	
14:00	15:00	1:00	Discussion on the needs for the industry (part 2): engine manufacturers, airworthiness authorities and Advisory Board feedback	All
15:00	15:30	0:30	Recommendations and way forward	AIRBUS
15:30	15:40	0:10	Conclusions	AIRBUS
15:40			<i>End of meeting</i>	

The purpose of the sessions will be to give context and share expectations on the way forward after ICE-GENESIS.

Thank you for your attention.



**ICE-GENESIS, SENS4ICE and MUSIC-HAIC teams at the SAE Icing Conference in Vienna, June 2023**



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