Considerations on future EU icing research strategy

aligned with the European aviation industry,
certification authorities and research clusters

Brussels, Nov 29, 2023

Members of the working group

DASSAULT AVIATION

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DLR
Deutsches Zentrum
für Luft- und Raumfahrt

FEDERAL AVIATION ADMINISTRATION

National Research
Council Canada

Conseil national de
recherches Canada

Outline

- **Climate change** and relevance to aircraft icing
- The 4th revolution: **Sustainable aviation** that faces climate change

- **Disruptive technologies** challenged by aircraft icing
- How to **certify aircraft** of the future?

- **EU Icing research strategy**
  - Supercooled Large Droplets (SLD)
  - Ice crystals and snow
  - Novel aerial vehicles

Arctic sea ice coverage
1984

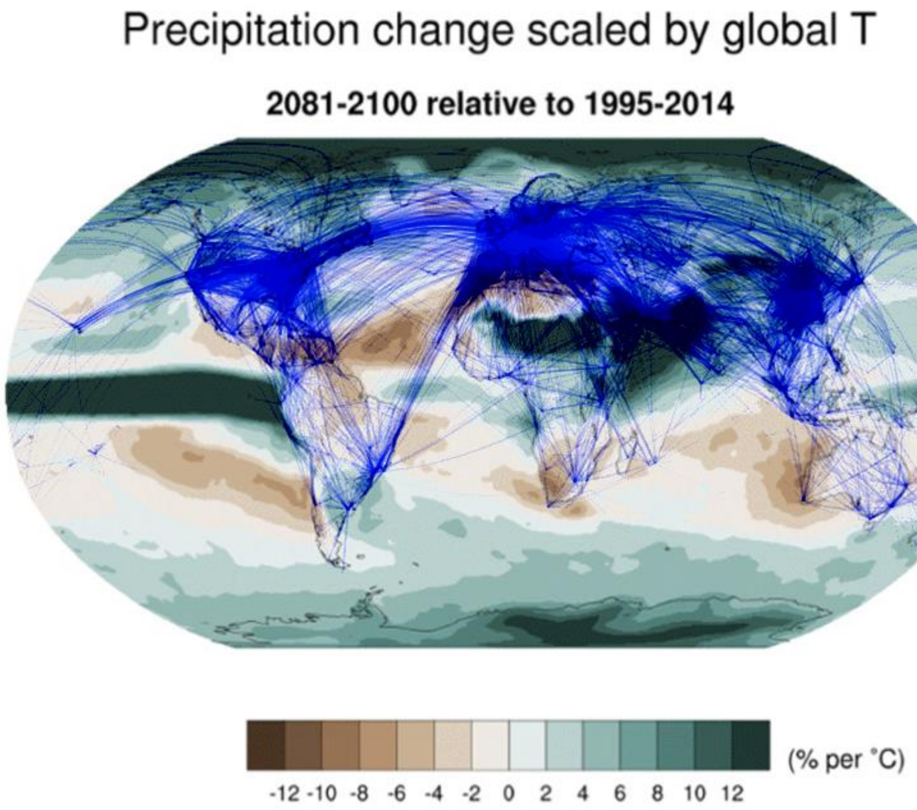
GLOBAL CLIMATE CHANGE
Vital Signs of the Planet

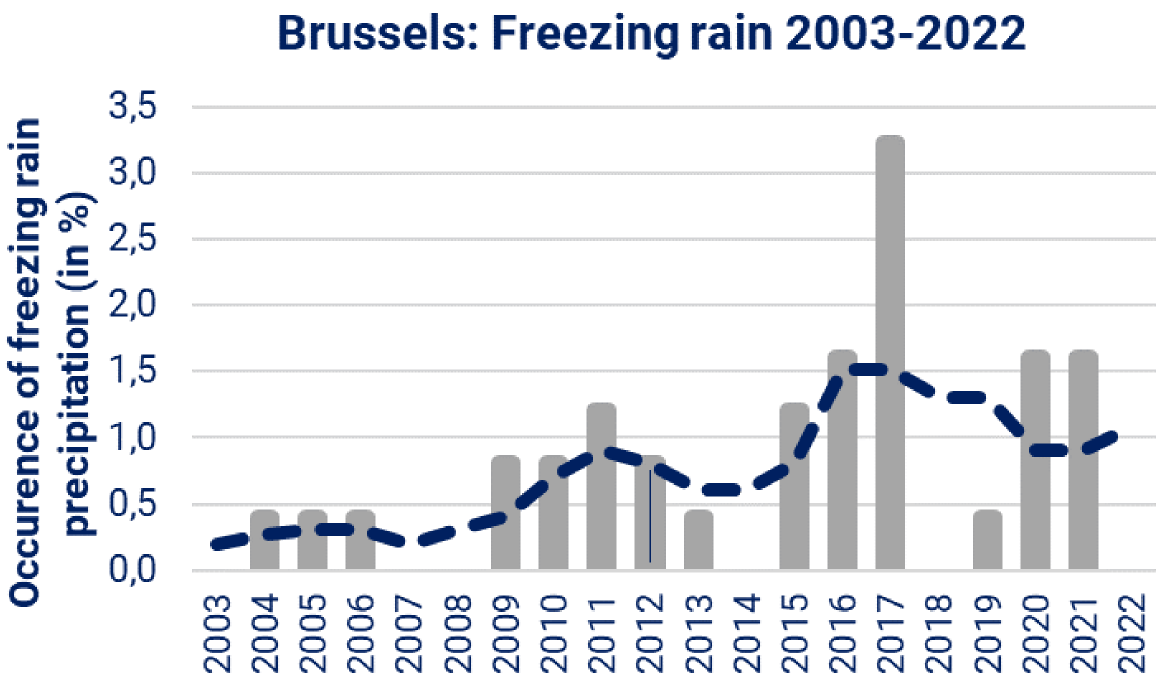
Arctic sea ice coverage
2012

GLOBAL CLIMATE CHANGE
Vital Signs of the Planet

12% sea-ice loss per decade since the late 1970s

Precipitation forecast and icing events





Increase in global temperature leads to increase in precipitation and changes on cloud properties. **Aircraft icing will be affected by a changing climate.**

DLR, Dave Orchard and Copernicus database

The 4th revolution in aviation

1st revolution
to make things fly

Otto Lilienthal (1895)

The 4th revolution in aviation

1st revolution
to make things fly

2nd revolution
to make flying the safest mode of transportation

Boeing database on engine and probe events due to **ice crystal icing** until 31 Jan 2019.

Red: Events from 2014-2019

Bravin, M. and Strapp, J.W., “A Continuing Investigation of Diurnal and Location Trends in an Ice Crystal Icing Engine Event Database,” *SAE Int. J. Advances & Curr. Prac. in Mobility* 2(1):90-105, 2020, doi:10.4271/2019-01-1964.

The 4th revolution in aviation

1st revolution
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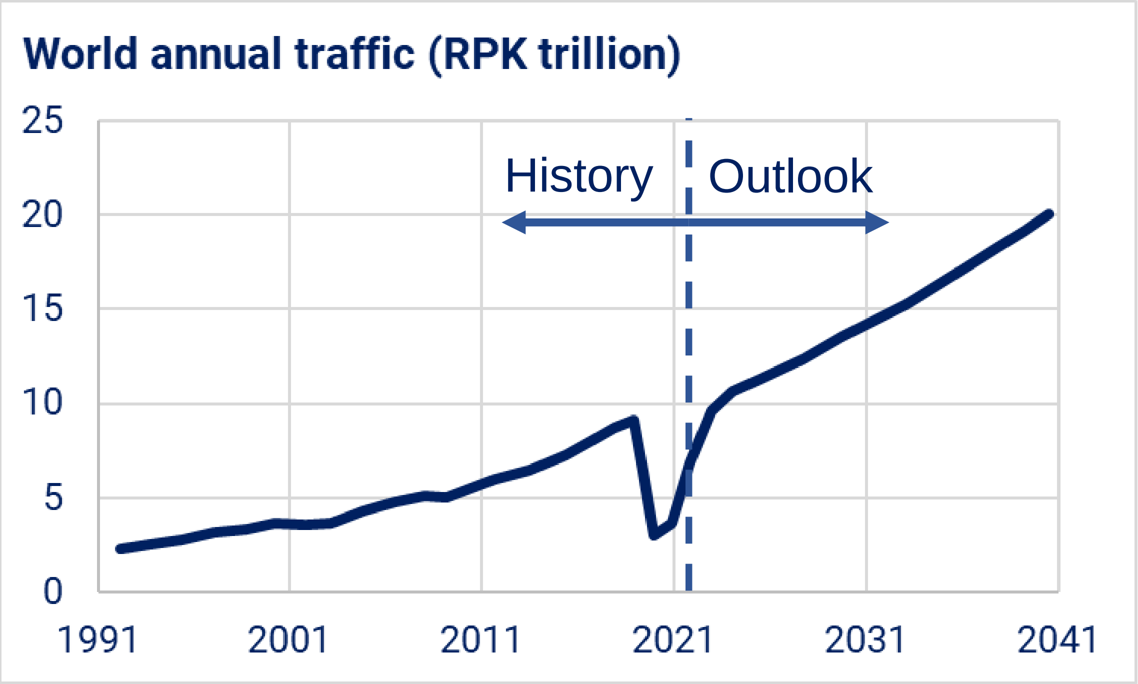
3rd revolution
to make flying affordable



Global market forecast 2022 by Airbus suggests a CAGR of 3.6%.

The 4th revolution in aviation

1st revolution
to make things fly

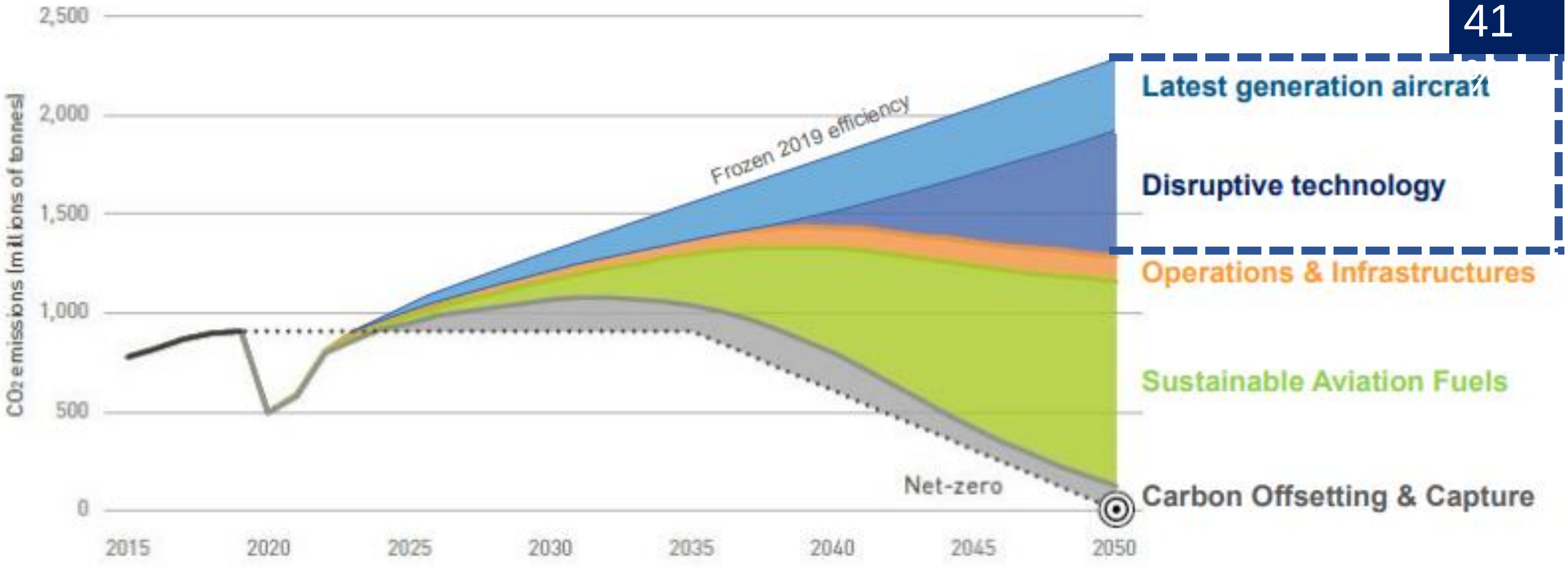
2nd revolution
to make flying the safest mode of transportation

3rd revolution
to make flying affordable

4th revolution
to make aviation sustainable

Levers for achieving Sustainability

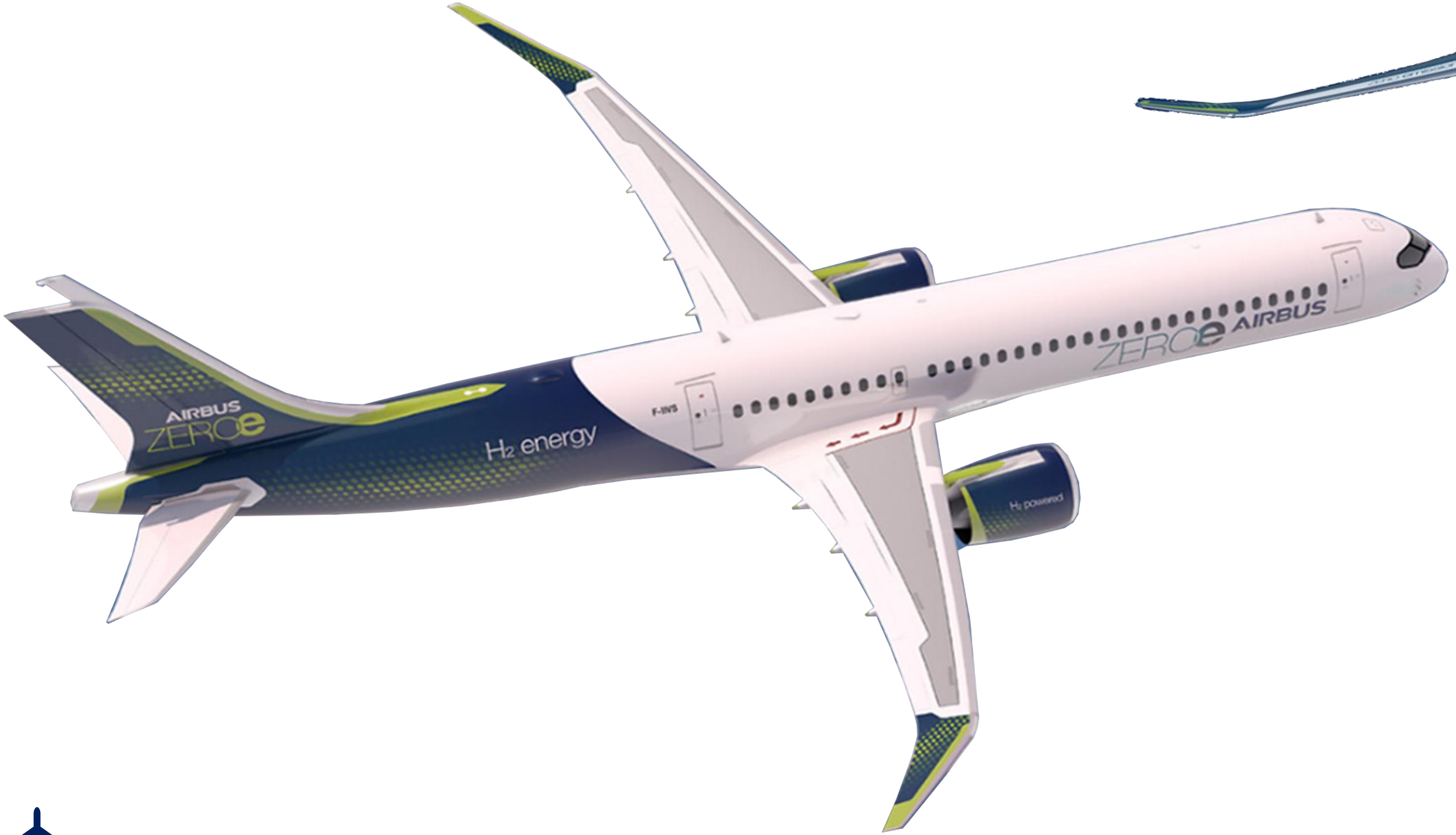
41



ATAG CO_2 Roadmap (most ambitious technology scenario & central traffic growth scenario: 3.1% CAGR 2019-2050)

Fleet replacement, Sustainable Aviation Fuels, **Disruptive Technologies**, and New Ways of Operation are key levers.

Disruptive technology
Large transport aircraft



- High Aspect Ratio Wing
- Natural Laminar Flow
- Hydrogen Propulsion
- Advanced Composites
- Wing Tip devices
- Hybrid electric propulsion

Disruptive technology
Business jet and regional aircraft

Hybrid electric propulsion

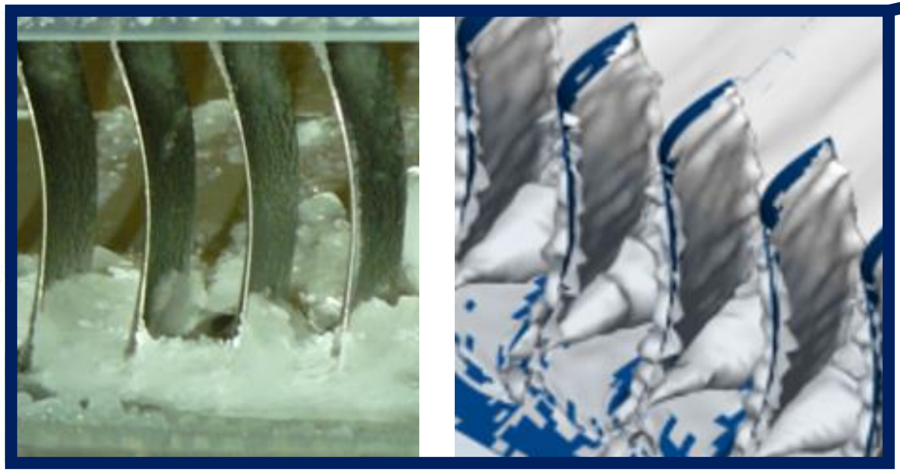
Versatile

Affordable

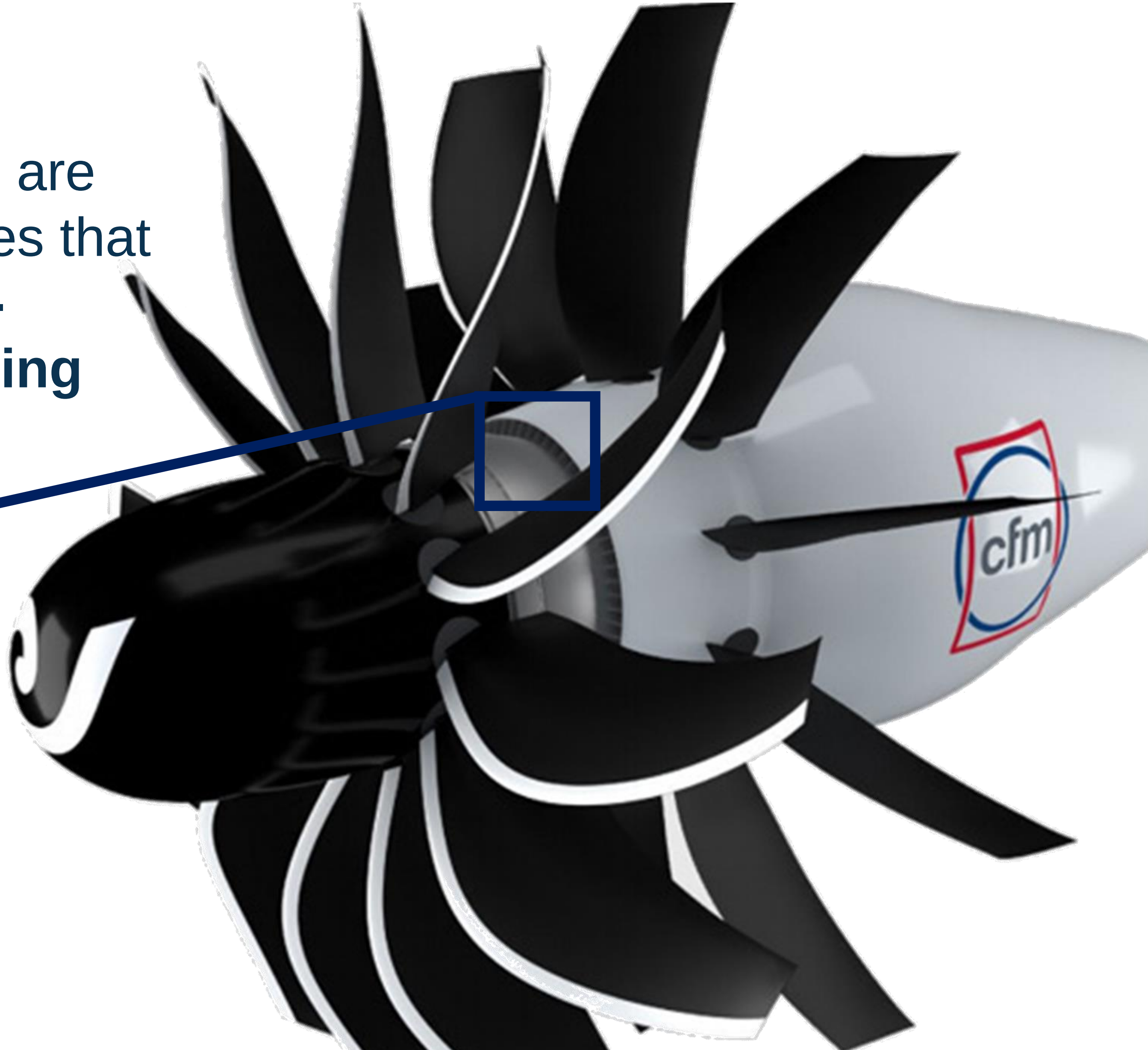
Efficient

Disruptive technology
RISE : Open fan engine

Future engines such as open fan RISE are based on disruptive engine architectures that require predictive and **validated multi-physics numerical capabilities for icing conditions.**



potential ice accretion scenarios depicted in the figures not specific for Open Rotor



Novel aerial vehicles
New market opportunities

The development of UAM has the potential to create major **economic**, **environmental** and **safety** benefits for EU citizens.

~4.2 billion € Market size in Europe in 2030 (31% of global)[1]

15-40 min Saved on travel time for city-airport transfers [3]

~90,000 jobs Directly and indirectly created in Europe in 2030 [2]

~73% faster Delivery of organs between city hospitals [3]

The certification of UAM solutions need ad-hoc considerations due their novel design and unmanned operability.

1. Based on McKinsey VTOL market model, 2. Based on projected expenditures of UAM industry, 3. Compared to a car drive on a Thursday at 5pm

How to certify aircraft of the future?

- Challenging compliance with the Comparative Analysis because of **no true reference fleet history** for such an airplane
- Need for **large icing wind tunnels** facilities
- Need for **reliable numerical tools** for ice shape computations

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The certification of future aircraft cannot only rely on comparison with existing fleets.

EU Icing research strategy
addressing three types of icing challenges

Supercooled Large Droplets (SLD) Icing

Ice crystal icing and snow

Novel aerial vehicles

SENS4ICE

ICE GENESIS

- **Provide Reliable Means of Compliance with respect of SLD regulations, especially for new aircraft architectures**
- Generate generic **SLD icing shapes in large facilities** (CIRA, RTA and collaboration with NASA, NRC)
- **Update numerical tools** with state-of-the-art physics to avoid over-dimensioning ice protections systems and quantify numerical simulations uncertainties taking into account experimental data spreading.

EU Icing research strategy
addressing three types of icing challenges

Supercooled Large Droplets (SLD) Icing

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- **Finding a unified approach to handle snow and ice crystals.**
- Implementing state-of-the-art physics for **improved numerical capabilities** including rotating systems, heated and unheated surfaces, altitude effects, ice shedding and wet operability
- **Complex validation case in collaboration with Europe, NRC and NASA**: Multi-stage Compressor water ingestion rig for steady state and transient wet operability – stage by stage heavily instrumented ; engine air inlet that incorporate design features prone to snow accumulation

EU Icing research strategy
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TRACES DOCTORAL NETWORK

National Research Council Canada

- **Development of evidence-based regulatory framework** through
  - UAS/UAM icing data including lower atmosphere characterization
  - Advanced knowledge of UAS/UAM icing through generic icing studies using typical configurations/geometries
- Coordinated development, assessment and qualification of innovative **highly automated, low power/ lightweight ice detection and protection technologies**, performance monitoring, envelope protection and loss-of-control prevention as particularly required for novel UAS/UAM configurations

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contact
Dr Stephan Bansmer
Coldsense Technologies GmbH
stephan.bansmer@cold-sense.com
+49 160 54 14 187