SENS4ICE

SENSORS AND CERTIFIABLE HYBRID ARCHITECTURES FOR SAFER AVIATION IN ICING ENVIRONMENT

Indirect ice detection for the hybrid ice detection system

SAE symposium

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In Aviation

- Icing is a relevant issue for aviation
  - Safety of flight
  - Turnaround time
  - Costs and resources

- Factors increasing likelyhood to encounter icing:
  - High speed relative to ice or fluid particles
  - Wide range of temperatures during one single flight
  - All kinds of atmospheric disturbances and weather phenomena
  - Long ranges passing different climate zones

German Federal Bureau of Aircraft Accident Investigation
Interim Report: BFU CX001-13

Dangers of Icing in Flight

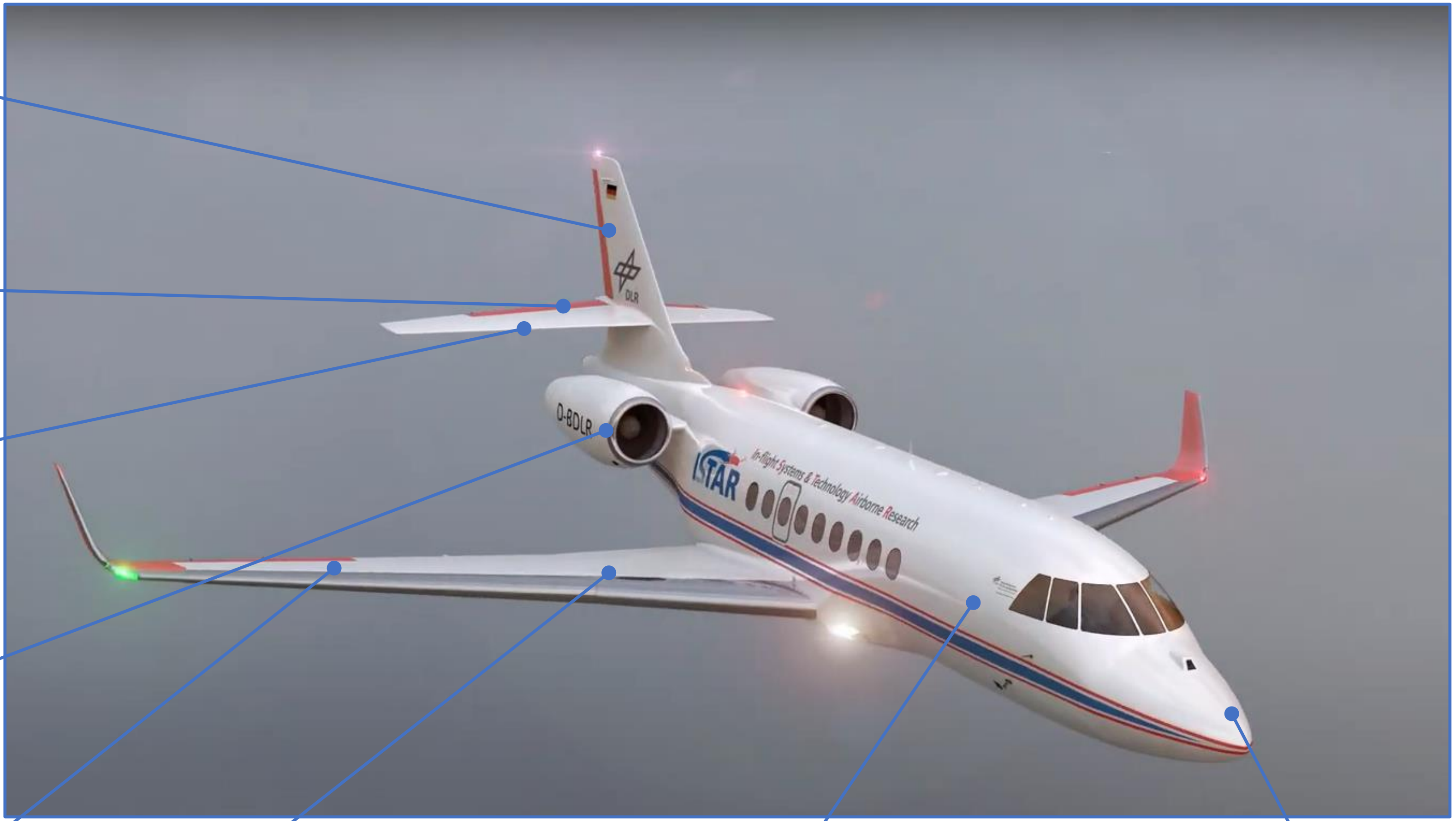
Vertical Tail Plane
- Control degradation
- Drag increase

Elevator Gap
- Control degradation

Stabilizer
- Control degradation
- Drag increase

Engines
- Danger of flameout or damage due to contaminants

Aileron Gap
- Control degradation



Wing
- Performance loss
- Control degradation

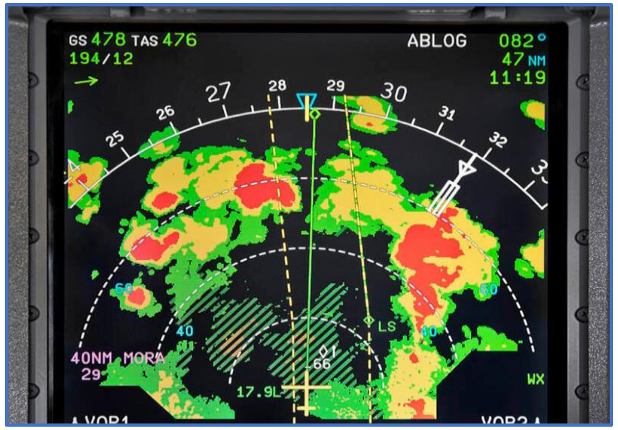
Fuselage
- Drag increase
- Collected contaminant ice layer

Sensors
- Malfunction
- Blockage

Means to Identify Icing

https://www.flightglobal.com/safety/swiftair-atr-icing-stall-inquiry-catalogues-series-of-crew-failures/136543.article

http://www.b737.org.uk/iceandrain.htm



https://www.ctsys.com/blog/entry/aviation-weather-radar-part-i-attenuation.html

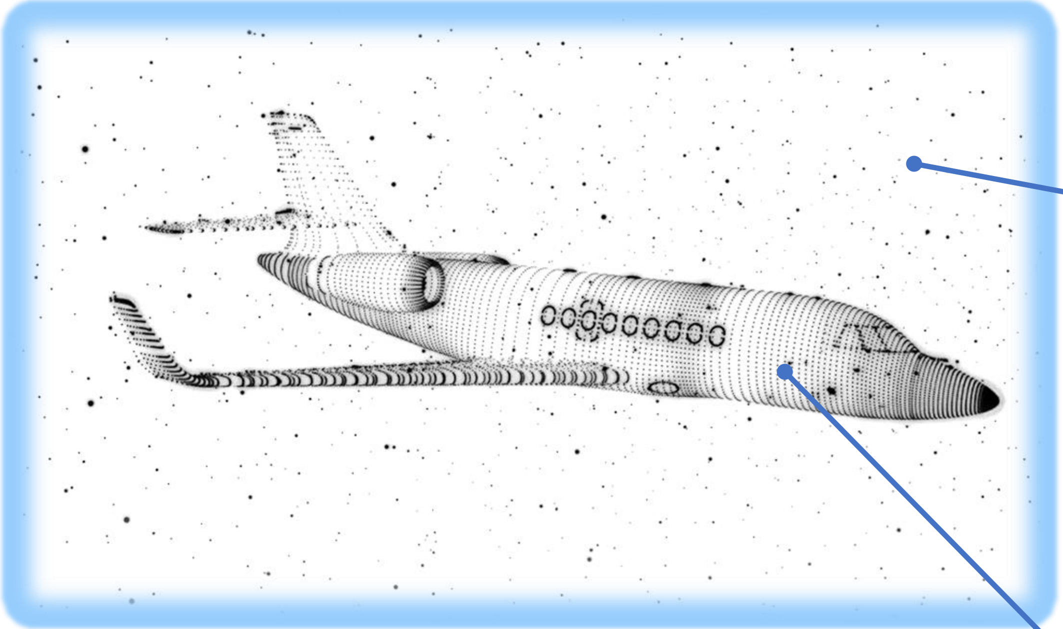
- Visual cues
- Change in powersetting
- Weather forecast / radar
- Pilot experience

Situational Awareness

- Cues for the flight crew are given but not 100% reliable.

- Today‘s situation:
  - Ice detection by performance monitoring is commonly established in commercial aviation
  - Pilot experience and procedures play a significant role in counteracting icing
  - Room for interpretation – room for false or missed decisions

Indirect Ice Detection within the Hybrid Ice Detection System

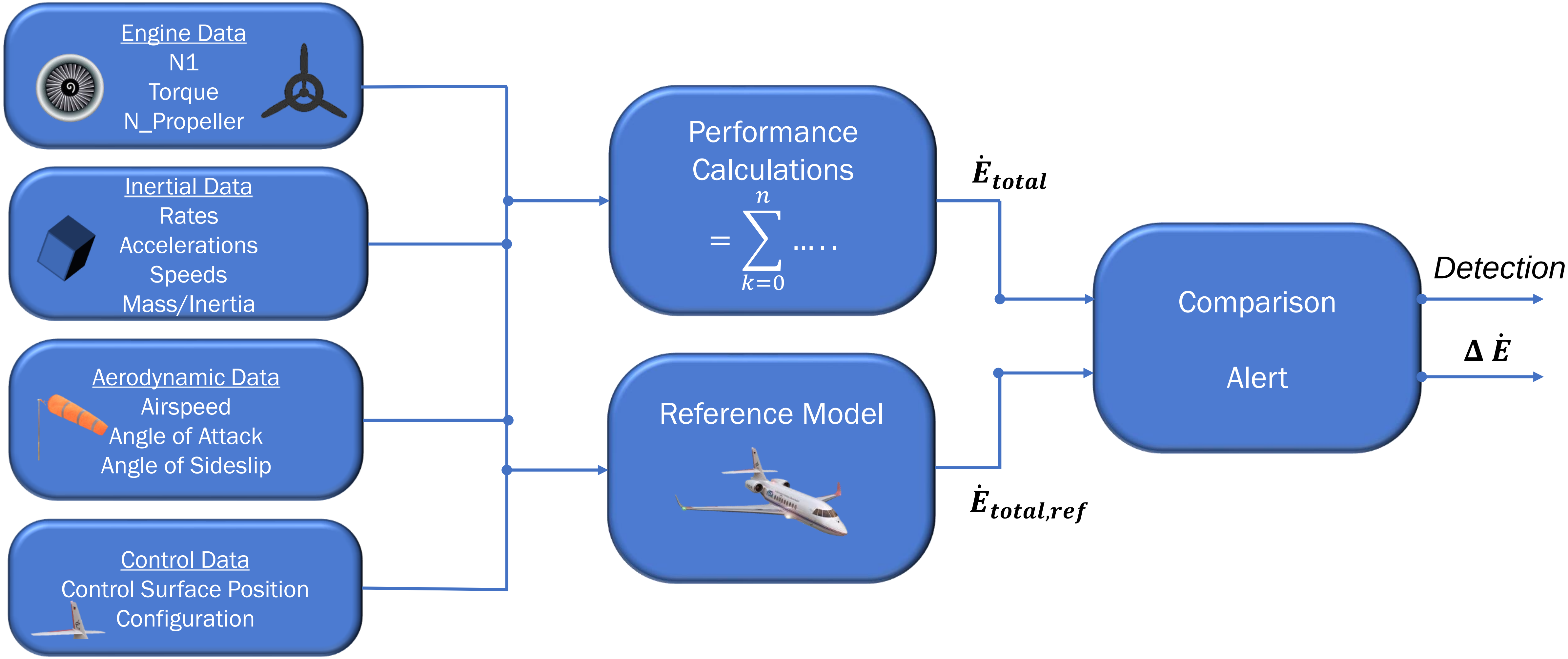


- Direct Sensors focus on the surrounding environment
  - Atmospheric icing conditions detectors
  - Median volume diameter (MVD)
  - Liquid water content (LWC)
  - Air temperature
  - Ice accretion rate (IAR)
  - ....

- Indirect System regards the aircraft itself
  - Engine parameters
  - Aero parameters
  - Inertial data
  - Aircraft configuration
  - ...

- The mix of internal and external information creates additional value
  - Reliability
  - Accuracy

Indirect System Design



System Performance

Conflicting demands

Detection time ⟷ Trade-Off ⟷ **Detection accuracy/reliability**

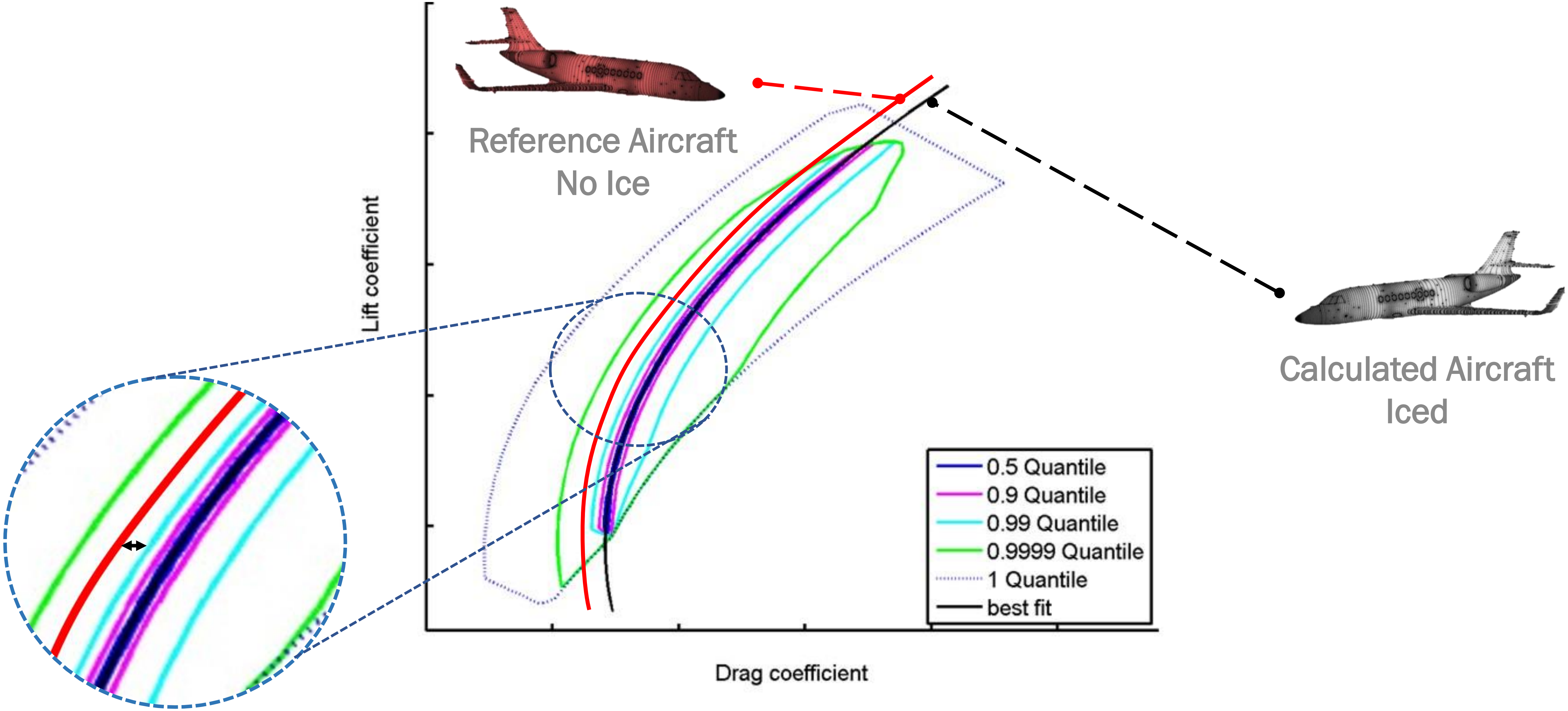
- Early detection information
- Enable early countermeasures
- Faster than any hazardous effects could occur

- Prevent false alarms
- Increase reliability of detection information
- Increase situational awareness
- Basis for automatic system response

System is based on ice accretion effects on performance (continous change, no significant step)

→ Determine a threshold that represents the necessary compromise

Detection Performance I



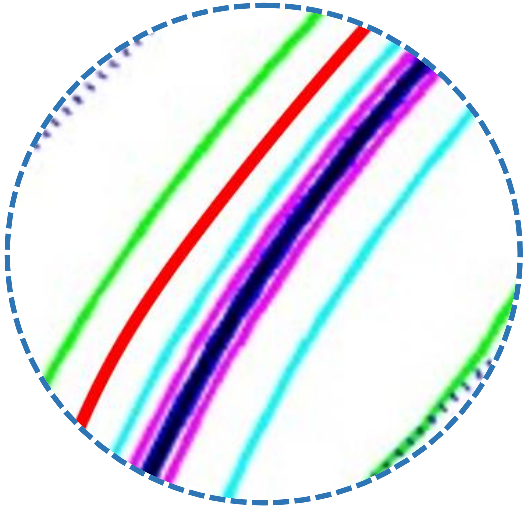
Detection Performance II

Necessary:

- Good aerodynamic database / model
- Good engine database / model
- Sufficient sensor quality and quantity
- Sufficient computing power

	EMB Phenom 300	ATR 42
Data available	2.3 million flight data samples	80000 flight data samples
Parameter of S4I flight test configuration	Flight tests with clean aircraft before icing flight‘s for parameter adjustment	

Detection Threshold



- Threshold determination depends on several factors
  - Aircraft type
    - Features of the specific A/C type
    - Critical ice accretion
    - Corresponding change of flight characteristics
  - Expectable ice accretion rate
    - Flight speed and trimming
    - Collection efficiency
  - Accuracy of calculations depend on quality of
    - Used reference (thrust models, aerodynamic database, flight test database)
    - Flight data (sample times, delays, synchronization, sensor quality)

- Poor data quality causes miscalculations

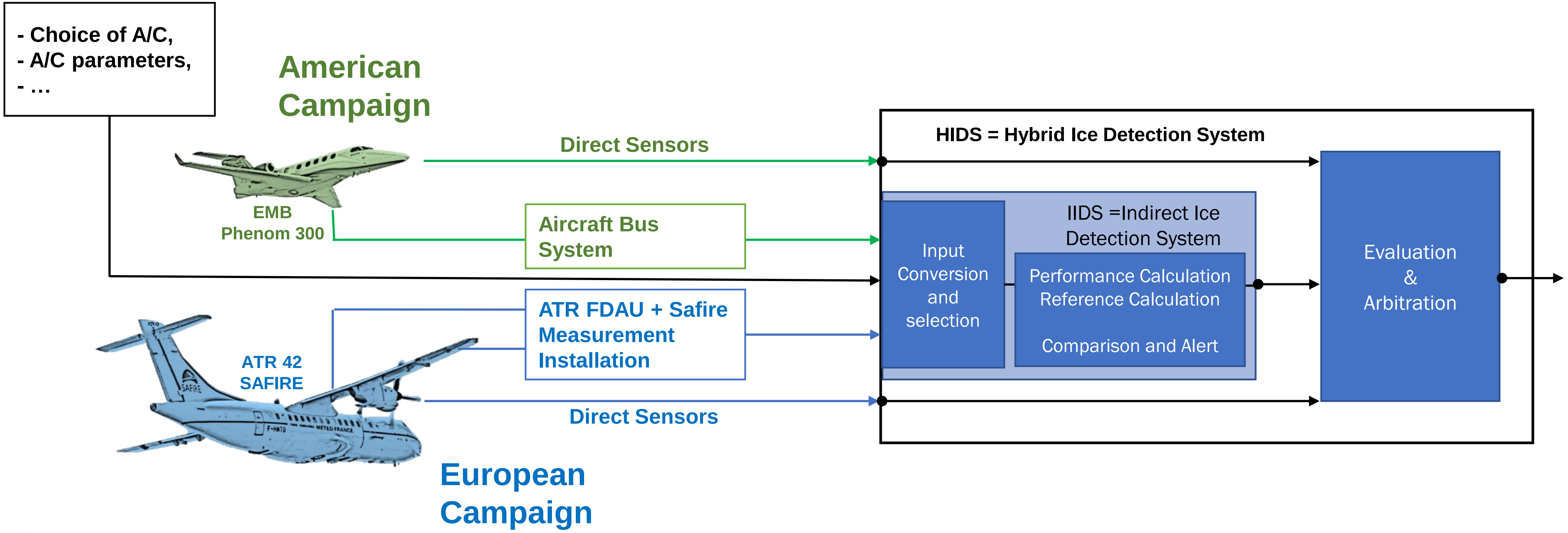
  → Filtering necesssary to prevent multiple false alarms

  → Time delay before reliable detection alert

  → Higher threshold value to prevent false alarms

Indirect System in S4I Flight Test

- Basic Indirect Ice Detection System design is generic
- Switches and different datasets (configuration and reference) forseen for two flight test campaigns



Outlook

- SENS4ICE aims for flight tests of the indirect ice detection system in the frame of the hybrid ice detection system

- It will be tested on a jet as well as a turboprop aircraft

- All flight data gathered will be used for tuning of the current system and for future system design changes (offline and post flight)

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