Widebody Airliner: Ice Protection System Comparison

A comparison of CAV's Freezing Point Depressant IPS to legacy Bleed Air and emerging Electro-Thermal Systems.

AUGUST 2020

Airliner Ice Protection – the future:

The desire to increase turbine efficiency via higher by-pass ratio engines, coupled with the increased electrification of aircraft power plants and systems; leading to increased efficiency and reduced environmental impacts, requires aircraft manufacturers to consider alternative systems, including ice protection.

Airliner Ice Protection – the future:

Bleed air ice protection optimization is becoming more difficult

- *decreased supply of bleed air results in less areas that can be protected*
- *more surfaces are running wet, more surface roughness*
- *more ice shapes to test*

Electro thermal de-ice protection is of current interest for large aircraft ice protection

Why would an airframe manufacturer want to make a major change to the type of ice protection that has the following issues?

- *de-ice performance compared to anti-ice*
- *much more surface roughness*
- *many more ice shapes to test*

Airliner Ice Protection – the future:

A Freezing Point Depressant (FPD), Ice Protection System (IPS), is an anti-ice system much like Bleed Air. It is more robust, and more effective compared to an Electro Thermal de-ice system.

The following information is based on a study specific to Wing Slats....

Basis of calculations and comparison:

Significant data was acquired to determine:

- *High icing probability flights;*
- *High utilization.*
- *Simulate flights over one year of flight operations.*
- *Conservative frequency of icing conditions;*
- *Conservative weather conditions.*

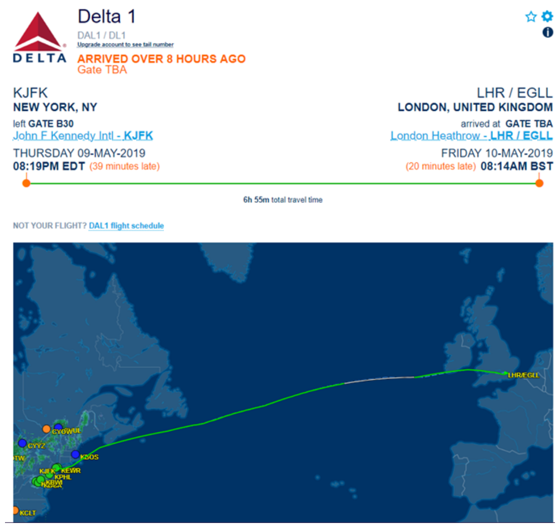
The data was used to model:

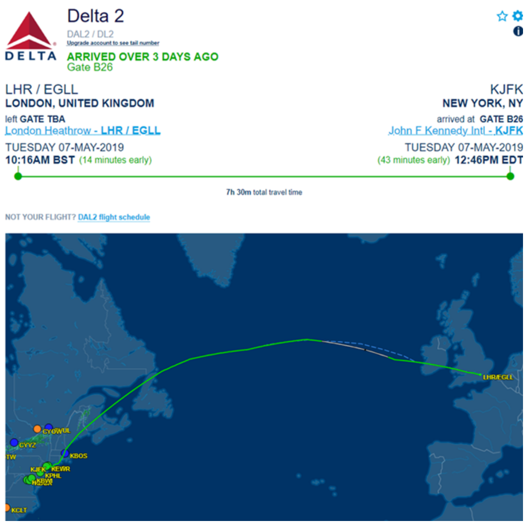
- *Airspace utilization and practises.*
- *FPD IPS usage;*
- *Bleed IPS usage;*
- *Electro Thermal IPS usage.*

Where does the data come from?

Flightaware and other online programs provide access to all civil flights

- Latitude, Longitude Course, Knots True Airspeed, Altitude, Rate of Climb/Descent are provide every 30s
- Click [here](#) for an example of DAL 1





- *Delta Flight 1 and Delta Flight 2 operate daily to from JFK and LHR*
- *3 trips (one way), per 24 hours, 90 trips per month, year round (1080/year)*
- *10% of flights will be considered for icing conditions; 9 per month*
- *Two icing encounters will be considered on climb*
- *Two icing encounters will be considered on descent*
- *All encounters will be considered a 50% probability icing encounter*
- *Flight airspeeds were derived from actual flight data*
- *Icing encounter flight times will be derived from actual flight data*

Basic & Common Approach

Based on available data and sound engineering judgement a typical widebody airline slat IPS was modelled to gather bleed air or electro thermal fuel burn data.

Using that same data and engineering judgement a comparable FPD IPS was designed

Bleed Air IPS

Assumed to operate as:

An evaporative anti ice system over all of the FAR Part 25 Appendix C Maximum Continuous Envelope

An evaporative/running wet ice protection system over the demanding portions of FAR Part 25 Appendix C Maximum Intermittent Envelope

Electro-thermal

Assumed to operate as:

A de-ice system over all of the FAR Part 25 Appendix C Maximum Continuous Envelope

A de-ice protection system over the demanding portions of FAR Part 25 Appendix C Maximum Intermittent Envelope

FPD IPS

Designed to operate as:

An anti ice system over all of the FAR Part 25 Appendix C Maximum Continuous Envelope

A de-ice protection system over the demanding portions of FAR Part 25 Appendix C Maximum Intermittent Envelope, with a very rapid ability to provide a completely clean airfoil upon exiting the Maximum Intermittent encounter

Determining the effect of FPD fluid usage

- FPD fluid usage was based on a “SMART SYSTEM” usage
- The SMART SYSTEM algorithm has been produced by CAV Design
- This algorithm utilizes current aircraft data bus parameters plus Liquid Water Content (LWC)
- Cloud LWC probes are commercially available
- The Fluid reservoir was sized for 15 to 45 days usage plus 45 minutes hold or 180 minute ETOPS event
- Fuel consumed to provide bleed air ice protection was calculated for comparison
- Fuel consumed to provide electro thermal de-ice protection was calculated for comparison
- This method is scalable for all aircraft produced by the Airframe manufacturer

Summary of One Year FPD Fluid usage:

- One year of service required 516 US Gallons of Freezing Point Depressant Fluid (4272 lbs)
- Usage per month varied from 21 US Gallons to 68 US Gallons required for icing events
- Therefore, going forward: Fluid reservoir size used for this exercise was 63 US Gallons

- The fluid reservoir required service no more than once per month for April, May, June, July August, and September, the reservoir was serviced when the quantity reached 29 US Gallons (Note: The aircraft is legal to dispatch with 29 US Gallons)

- The fluid reservoir required service twice per month for October, November, December, January, February, and March , the reservoir was serviced when the quantity reached 29 US Gallons (Note: The aircraft is legal to dispatch with 29 US Gallons)

- The 45 minute hold is far more critical than the 180 minute ETOPS event
- Extended hold events and ETOPS events required tank servicing before the next flight

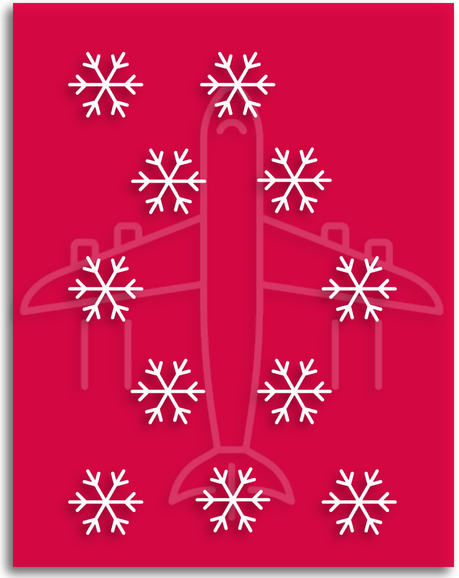
(CAV can provide an explanation of the relevant information relating to the analysis used to provide this information and that on the subsequent slides, upon request)

Ice Protection Performance

BLEED AIR
Evaporative Anti-Ice

Baseline for comparison

ELECTRO-THERMAL
De-Ice



Intercycle ice shapes

FREEZING POINT DEPRESSANT
Anti-Ice + SLD protection

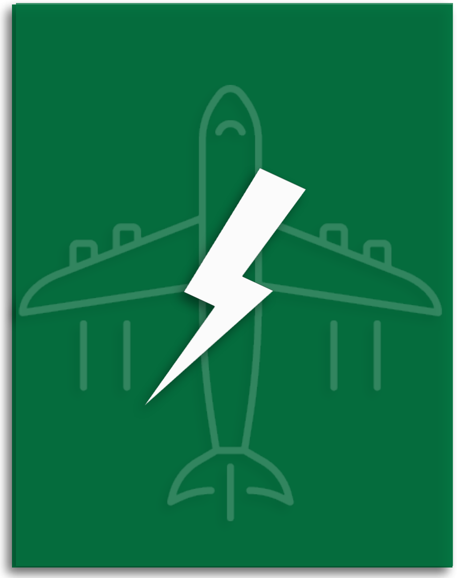
No ice shapes and no runback icing on airfoil

Power Usage

BLEED AIR
Evaporative Anti-Ice

Baseline for comparison

ELECTRO-THERMAL
De-Ice



-90KW

FREEZING POINT DEPRESSANT
Anti-Ice + SLD protection

-190KW

Annual Fuel Usage

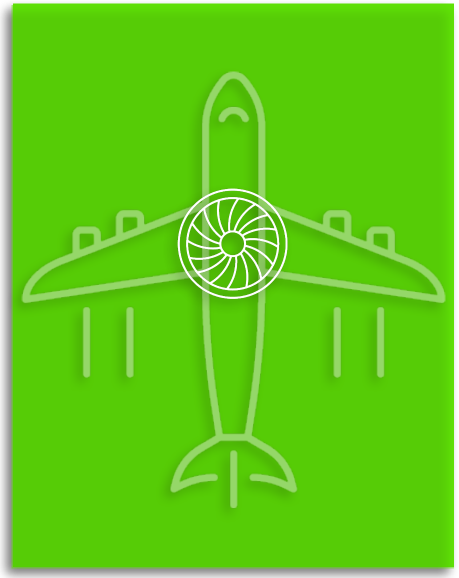
BLEED AIR
Evaporative Anti-Ice

Baseline for comparison

ELECTRO-THERMAL
De-Ice

957 US GAL JET A
Saving

FREEZING POINT DEPRESSANT
Anti-Ice + SLD protection



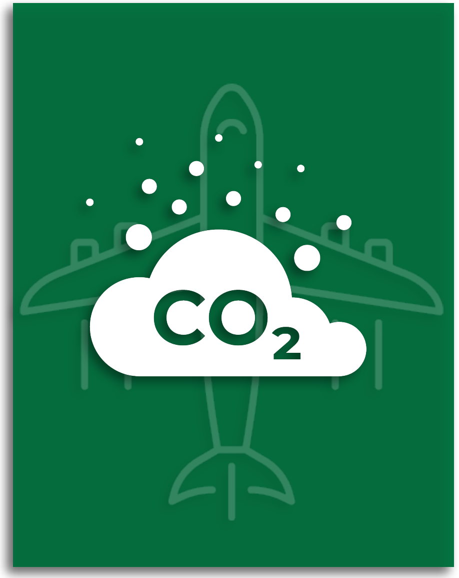
2552 US GAL JET A
Saving

Annual Carbon Emissions

BLEED AIR
Evaporative Anti-Ice

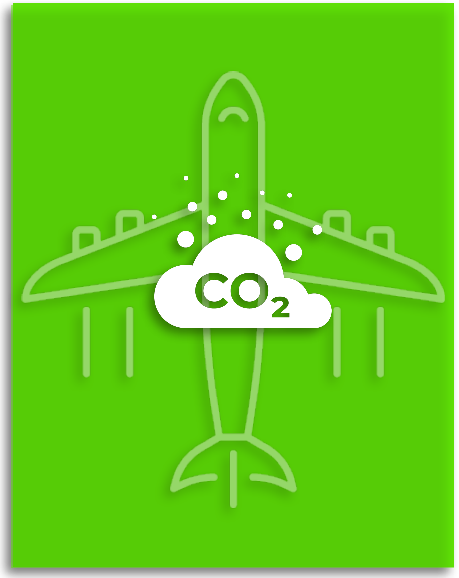
Baseline for comparison

ELECTRO-THERMAL
De-Ice



-20,000 lbs

FREEZING POINT DEPRESSANT
Anti-Ice + SLD protection



-55,000 lbs

Weight Comparison

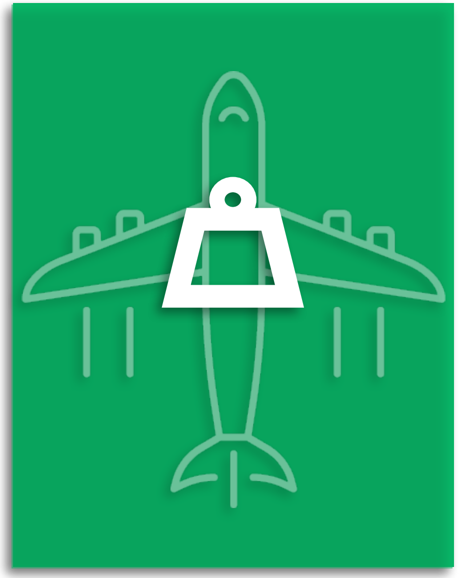
BLEED AIR
Evaporative Anti-Ice

Baseline for comparison

ELECTRO-THERMAL
De-Ice

460 lbs lighter
(system & fuel)

FREEZING POINT DEPRESSANT
Anti-Ice + SLD protection



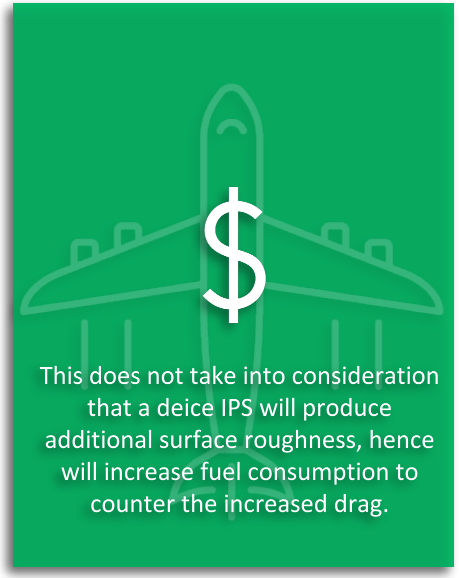
500 lbs lighter
(system & fuel, including FPD fluid)

Annual Running Cost Comparison

BLEED AIR
Evaporative Anti-Ice

Baseline for comparison

ELECTRO-THERMAL
De-Ice



-$1,913

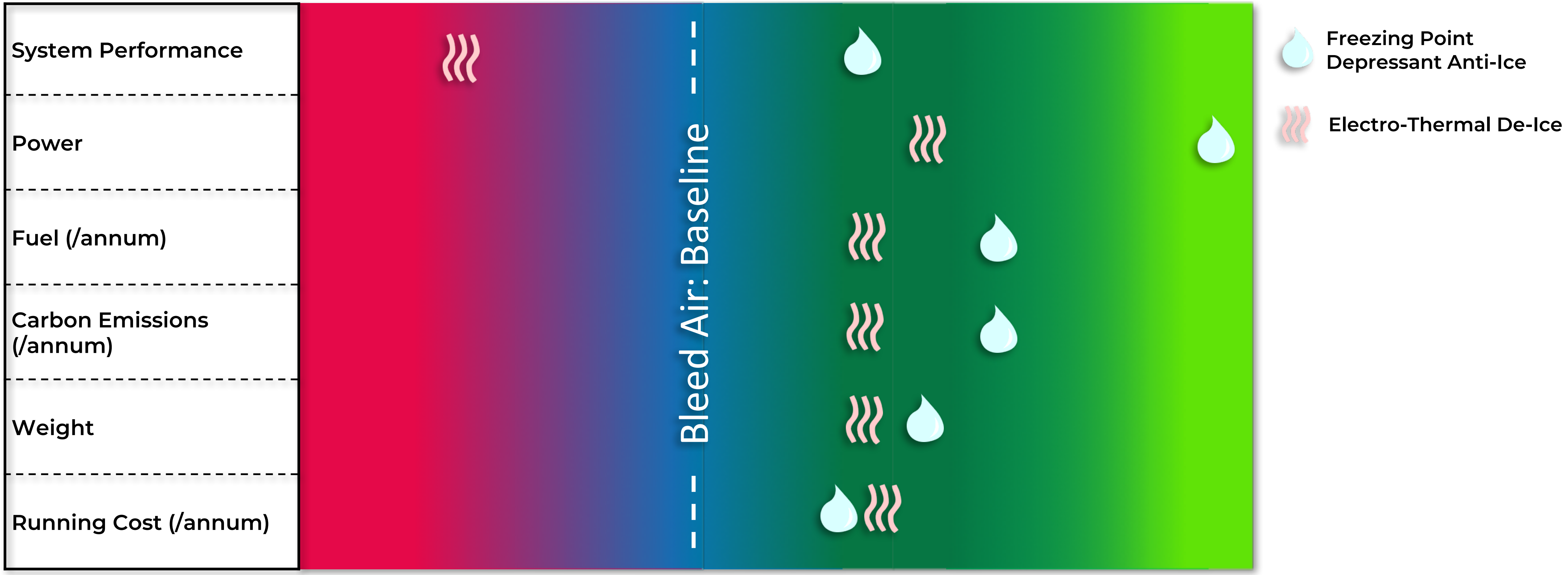
Assumes Jet A saving @ $2/US Gal

FREEZING POINT DEPRESSANT
Anti-Ice + SLD protection

-$1,103

Assumes Jet A saving @ $2/US Gal,
FPD Fluid cost @ $8/US Gal, bulk purchase

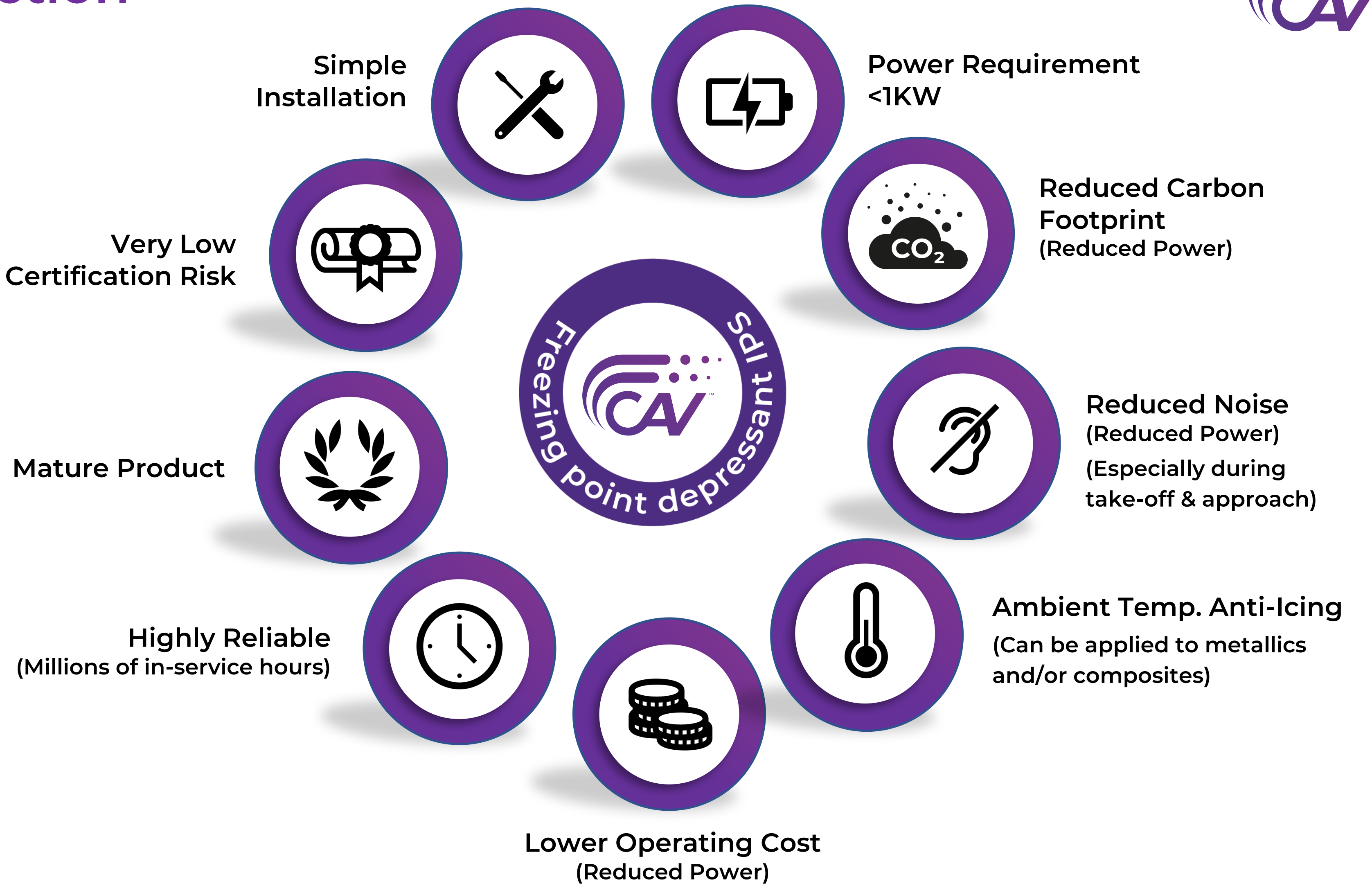
Summary comparison of alternate IPS technologies



CAV's Freezing Point Depressant outperforms vs the alternative systems.

FPD Anti-Ice Protection

Provides excellent anti-ice protection at a fraction of the power of either bleed air anti-ice protection or electro thermal de-ice



What’s stopping you?

Thank You

To find out more about partnering with CAV™ for your new aircraft's TKS® ice protection system, please get in touch at the details below:

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