

DESIGN AND IMPLEMENTATION OF DE/ANTI-ICING OPTIMIZATION STRATEGIES



ISO 9001:2000

**2007 SAE AIRCRAFT & ENGINE ICING
CONFERENCE AND EXHIBITION**

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PRESENTATION OUTLINE

- Background
- APS Research and Development – De/Anti-Icing Optimization
Optimization Technologies and Procedures
- ACRP Project 10-01: Optimizing the Use of Aircraft De/Anti-
De/Anti-Icing Fluids
- Compounding the Benefits of Optimization Strategies
- Airport De/Anti-Icing Strategy Development



BACKGROUND



APS AVIATION – COMPANY PROFILE

- ✈ Since 1990, APS has conducted extensive aircraft ground de/anti-icing de/anti-icing research and development on behalf of Transport Canada
Transport Canada / FAA



- ✈ APS has produced approximately 100 technical reports on aircraft aircraft ground de/anti-icing for Transport Canada / FAA



FLUID ENDURANCE TIME TESTING AND HOLDOVER TIME TABLE DEVELOPMENT



SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2004-2005¹

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type IV Fluid Concentration Neat Fluid/Water (Vol% / Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						Other ⁵
°C	°F		Frost ²	Freezing Fog	Snow ⁴	Freezing Drizzle ³	Light Freezing Rain	Rain on Cold Soaked Wing	
above 0	above 32	100/0	18:00	1:05 – 2:15	0:35 – 1:05	0:40 – 1:10	0:25 – 0:40	0:10 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	8:00	1:05 – 1:45	0:30 – 1:05	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	4:00	0:15 – 0:35	0:05 – 0:20	0:10 – 0:20	0:05 – 0:10		
0 to -3	32 to 27	100/0	12:00	1:05 – 2:15	0:30 – 0:55	0:40 – 1:10	0:25 – 0:40		
		75/25	5:00	1:05 – 1:45	0:25 – 0:50	0:35 – 0:50	0:15 – 0:30		
		50/50	3:00	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10		
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45 ³	0:10 – 0:25 ³		
		75/25	5:00	0:25 – 0:50	0:20 – 0:35	0:15 – 0:30 ³	0:10 – 0:20 ³		
below -14 to -25	below 7 to -13	100/0	12:00 ⁷	0:15 – 0:40 ⁷	0:15 – 0:30 ⁷				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.						

°C = Degrees Celsius °F = Degrees Fahrenheit OAT = Outside Air Temperature Vol = Volume

NOTES

- Based on tests of neat fluids with the lowest viscosity deliverable on the aircraft, yet meeting Type IV WSET and HHET.
- During conditions that apply to aircraft protection for ACTIVE FROST.
- The lowest use temperature is limited to -10°C (14°F) under freezing drizzle and light freezing rain.
- Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
- Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
- Snow includes snow grains.
- Ensure that the lowest operational use temperature (LOUT) is respected.

CAUTIONS

- The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when aircraft skin temperature is lower than OAT.
- The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.
- Fluids used during ground deicing do not provide ice protection during flight.

HOLDOVER TIME TABLE DEVELOPMENT



Transport
Canada



Transport Canada Holdover Time Guidelines

Winter 2005-2006

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2005-2006¹

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
Degrees Celsius	Degrees Fahrenheit		Active Frost	Freezing Fog	Snow or Snow Grains	Freezing Drizzle ⁴	Light Freezing Rain	Rain on Cold Soaked Wing	Other ²
-3 and above	27 and above	100/0	8:00	0:35 - 1:30	0:20 - 0:45	0:30 - 0:55	0:15 - 0:30	0:05 - 0:40	CAUTION: No holdover time guidelines exist
		75/25	5:00	0:25 - 1:00	0:15 - 0:30	0:20 - 0:45	0:10 - 0:25	0:05 - 0:25	
		50/50	3:00	0:15 - 0:30	0:05 - 0:15	0:05 - 0:15	0:05 - 0:10		
below -3 to -14	below 27 to 7	100/0	8:00	0:20 - 1:05	0:15 - 0:35	0:15 - 0:45 ³	0:10 - 0:25 ³		
		75/25	5:00	0:20 - 0:55	0:15 - 0:25	0:15 - 0:30 ³	0:10 - 0:20 ³		
below -14 to -25	below 7 to -13	100/0	8:00 ⁵	0:15 - 0:20 ⁵	0:15 - 0:30 ⁵				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the outside air temperature and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.						

→ Tables produced annually by TC and FAA using the data collected by APS
APS

→ Referenced by numerous other international organizations

A WEALTH OF EXPERIENCE

- Tests performed with 80+ de/anti-icing fluids
- Over 15,000 endurance time tests performed
- Generic holdover time tables developed for fluid fluid Types I, II, III and IV
- Brand-specific holdover time tables developed for for fluid Types II and IV



DE/ANTI-ICING FLUID HOLDOVER TIME TESTING ON OPERATIONAL AIRCRAFT



GLYCOL-BASED FLUIDS

- ➔ Most significant portion of all APS research and development focused on understanding and improvement improvement of glycol-based fluids



GLYCOL DEICING

- Glycol freeze point depressant fluids remain the most most prevalent technologies employed by the industry to de/anti-ice
- Although they have a proven track record, glycol-based fluids have several notable side-effects



NEGATIVE ASPECTS OF GLYCOL DEICING

- Elevated Costs
 - Fluid
 - Recovery
- Environmental Concerns
 - Toxicity
 - Biodegradability
- Occupational Hazards
- Aircraft Delays / Airport Throughput



INDUSTRY PRESSURES

- Industry pressures forced air carriers and airports to airports to examine the current way of doing business business
 - Economic
 - Environmental
- With these pressures came an interest in alternative alternative de/anti-icing technologies



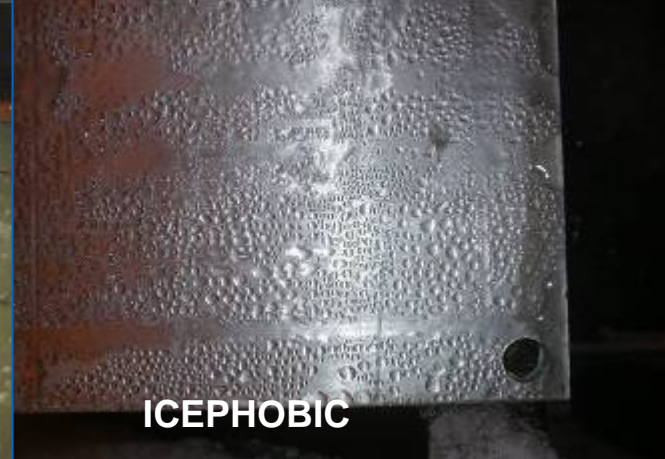
**APS RESEARCH AND
DE/ANTI-ICING OPTIMIZATION
TECHNOLOGIES
AND PROCEDURES**



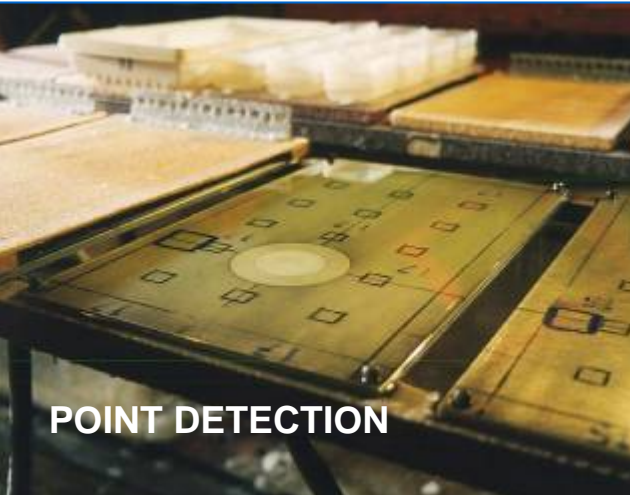




FAILURE MECHANISMS



ICEPHOBIC



POINT DETECTION



NCAR HOTPLATE



FLUID MANAGEMENT



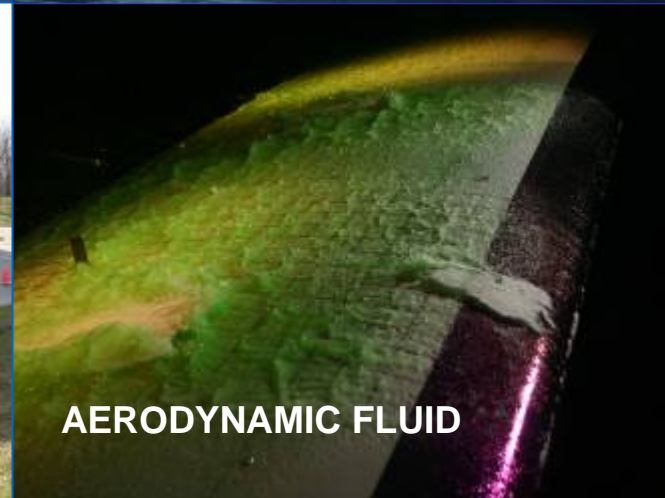
SPRAY



CONTAMINATION



WEATHER



ACRP PROJECT 10-01:

**OPTIMIZING THE USE OF
DE/ANTI-ICING FLUIDS**



ACRP PROJECT 10-01

- APS was contracted by the Transportation Research Board Board (TRB) in March 2007 to undertake a research project project under the Airport Cooperative Research Program Program (ACRP)
 - ACRP 10-01: *Optimizing the Use of Aircraft De/Anti-Icing Fluids Fluids*
- ACRP 10-01 Primary Objective:
 - Identify procedures and technologies to optimize the use of aircraft of aircraft de/anti-icing fluids



ACRP PROJECT 10-01

- The ACRP 10-01 Project will be performed in 2 phases:
 - **PHASE I:** review of currently available optimization strategies and promising technologies (**COMPLETED**)
 - **PHASE II:** design and conduct of an Experimental Plan



ACRP PROJECT 10-01

- Approach: Improve, not eliminate, current methodologies and methodologies and procedures
 - Examine “Quick-Hit” technologies and new developments

- Areas of examination:
 - 1) Non-glycol deicing technologies and procedures

 - 2) Remote detection of contaminants

 - 3) Optimization of flight crew de/anti-icing fluid selection

 - 4) Improved usage of current glycol aircraft de/anti-icing fluids at the point of fluid of fluid application



IDENTIFIED OPTIMIZATION TECHNOLOGIES AND PROCEDURES

#	Procedure/ Technology
1	Blowers and/or other mechanical means to remove dry contamination
2	Deicing-only fluid buffer reduction
3	First-step deicing fluid buffer reduction
4	Fluids applied before the start of precipitation to prevent bonding
5	Forced air used to remove contamination
6	Implementation of holdover time determination systems
7	Non-glycol freeze point depressant fluids
8	Point detection sensors to indicate fluid condition and contamination on aircraft surfaces
9	Remote ice detection sensors to scan aircraft critical surfaces before departure runway
10	Spot deicing for frost
11	Spray-and-go deicing
12	Tempered steam as a non-glycol gate deicing or pre-deicing tool
13	Threshold deicing
14	Type III fluids
15	Use of 10°C Type I buffer
16	Use of anti-icing fluid dilutions
17	Use of infrared deicing technology
18	Use of weather forecasting products for deicing process

ANALYTICAL CRITERIA

CAPITAL COST

OPERATING COST

ENVIRONMENTAL IMPACT

TRAINING

OPERATIONAL EFFICIENCY

MATURITY

SAFETY

RANKING

INTERNAL WEIGHING OF CRITERIA

FOCUS GROUP SURVEY

FOCUS GROUP WEIGHING OF CRITERIA

FINAL RANKING OF TECHNOLOGIES PROCEDURES

IDENTIFIED OPTIMIZATION TECHNOLOGIES AND PROCEDURES

RESEARCH

QUICK-HITS



#	Procedure/ Technology
1	Blowers and/or other mechanical means to remove dry contamination
2	Deicing-only fluid buffer reduction
3	First-step deicing fluid buffer reduction
4	Fluids applied before the start of precipitation to prevent bonding
5	Forced air used to remove contamination
6	Implementation of holdover time determination systems
7	Non-glycol freeze point depressant fluids
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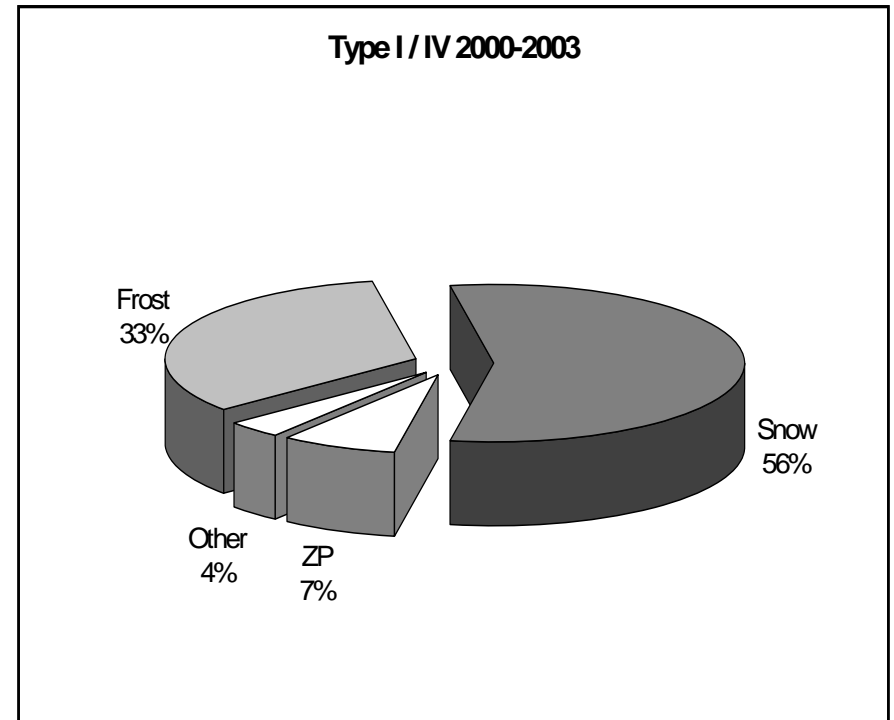
1. RESEARCH - TEMPERED STEAM

→ Gate deicing in periods without active precipitation (one-step deicing operations)

→ Frost

→ Snow, freezing precipitation that has ceased

→ Gate pre-deicing



DEFROSTING TEST – APRIL 11, 2007

FROST AMOUNT = 0.2 – 0.3 mm



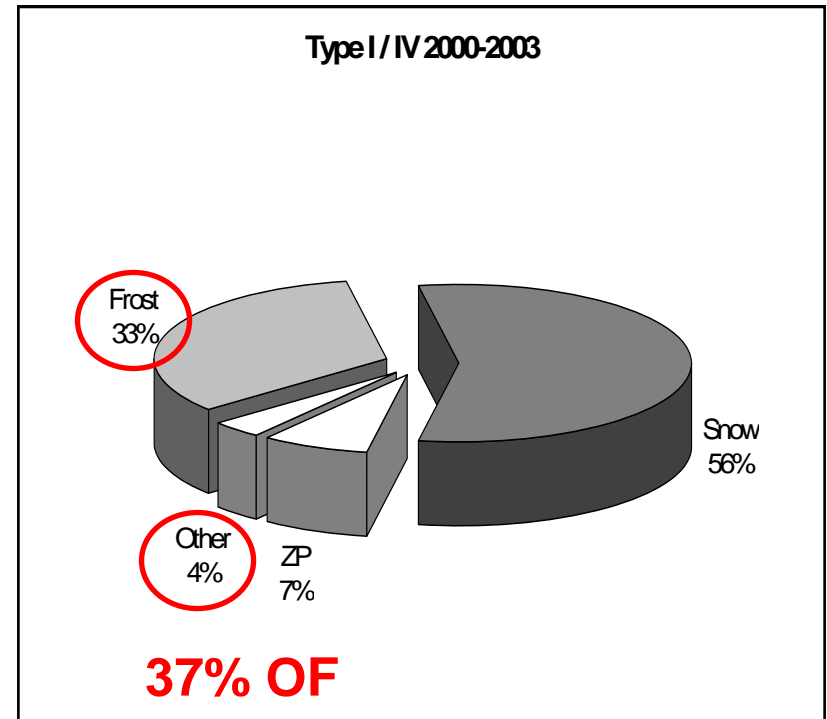
DEFROSTING TEST – APRIL 11, 2007

TIME TO DEFROST AND DRY = 2.5



POTENTIAL BENEFITS SUMMARY OF USING TEMPERED STEAM

- Economic Savings
 - Cost of fluids
 - Costs of glycol recovery and recycling recycling
- Source Reduction of Glycol
 - Reduction of environmental impacts and costs
- Operational Improvement
 - Airport throughput
 - Time management
- Reduction in Aircraft Fuel Burn



2. RESEARCH - HOLDOVER TIME DETERMINATION SYSTEMS

- Information system designed for airport use
- System consists of numerous sensors enabling the determination of:
of:
 - Rate of precipitation
 - Type of precipitation
 - Ambient temperature
- System outputs can generate a “single-value” holdover time for each each departing aircraft



BUSINESS CASE FOR USING LWE

FLIGHT CREW DE/ANTI-ICING DECISIONS AT YUL

OPERATIONAL DATA COLLECTION 2004-06

1459 Total Data Points (Departures)

Type IV fluid was unnecessary: **27%**



COST SAVINGS
ENVIRONMENTAL IMPACT
IMPROVED OPERATIONAL EFFICIENCY

Good fluid decision: **61%**

Aircraft did not deice: **8%**



SAFETY

Took off with Exceeded Holdover Times: **4%**

POTENTIAL BENEFITS SUMMARY OF USING HOTDS TO MEASURE LWE

→ Economic Savings

- Cost of fluids
- Costs of glycol recovery and recycling

→ Source Reduction of Glycol

- Reduction of environmental impacts and costs

→ Operational Improvement

- Airport throughput
- Time management

→ Safety Enhancements

- Reduction of departures with exceeded holdover time
holdover time



3. QUICK HIT – SPOT DEICING FOR FROST

- Air Carrier data has demonstrated that spot deicing for frost at the gate can be cost effective and efficient
- Frost Deicing at CDF (A320):
 - Average glycol consumed: 140 litres
 - Average time (pushback to wheels up): 31.5 minutes
- Spot Deicing at the Gate (A320):
 - Average glycol consumed: 12.2 litres
 - Average time (pushback to wheels up): 18.8 minutes



POTENTIAL BENEFITS SUMMARY OF USING SPOT DEICING FOR FROST

- Economic Savings
 - Cost of fluids
 - Costs of glycol recovery and recycling
- Source Reduction of Glycol
 - Reduction of environmental impacts and costs
- Operational Improvement
 - Operational Efficiency
 - Airport throughput
 - Time management
- Reduction in Fuel Burn



4. QUICK HIT – SPRAY-AND-GO DEICING

- Spray-and-Go deicing approaches have demonstrated numerous benefits
- Proximity to departure runways
 - More widespread use of Type I
 - Less reliance on anti-icing fluids with long long holdover times
 - Environmental impact reduction
 - Aircraft have less exposure to dramatic changes in operating conditions



POTENTIAL BENEFITS SUMMARY OF USING SPRAY-AND-GO DEICING

- Economic Savings
 - Cost of fluids
 - Costs of glycol recovery and recycling recycling
- Source Reduction of Glycol
 - Reduction of environmental impacts impacts and costs
- Operational Improvement
 - Airport throughput
 - Time management



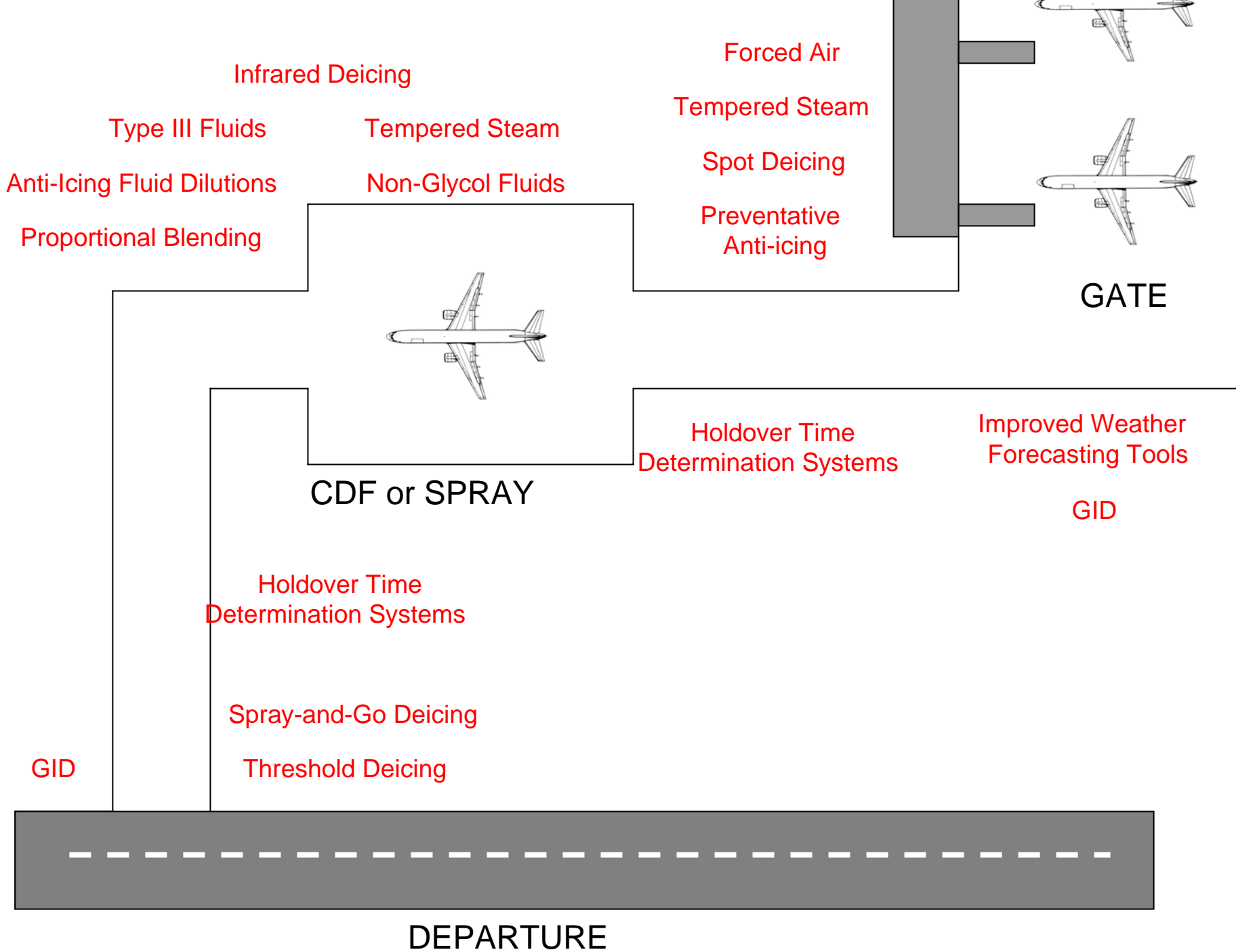
COMPOUNDING THE BENEFITS OF DE/ANTI-ICING OPTIMIZATION STRATEGIES



COMPOUNDING THE BENEFITS OF OPTIMIZATION STRATEGIES

- De/anti-icing optimization technologies and procedures have the ability to provide numerous benefits
 - Individual benefits vary greatly from approach to approach
- True enhancements to the industry can be achieved when the benefits of individual approaches are compounded





AIRPORT DEICING STRATEGY DEVELOPMENT



AIRPORT SITUATION

- Aircraft ground deicing varies from one operation to the next the next
- The appropriateness of any deicing strategy can be assessed assessed by the strength of:
 - Aircraft launch capability and airport throughput during during chaotic winter events;
 - The safety of the overall deicing operation;
 - The environmental compliance of the operation; and
 - The economic costs and viability of the operation



AIRPORT SITUATION

- Deicing strategy can be influenced by a myriad of different factors:
 - the nature and severity of airport winter weather;
 - the ambient temperature range experienced by the airport during winter during winter operations;
 - the air carrier make-up at the airport;
 - the air carrier fleet distribution;
 - airport infrastructure;
 - taxi and queue times;
 - deicing vehicle fleet;
 - environmental regulations and concerns;
 - glycol mitigation strategies; and
 - the economic stability of the major stakeholders.



DEICING STRATEGY DEVELOPMENT

- Custom-designed deicing strategies can be developed for any situation, based on careful consideration of the variables at play



EXAMPLE

DEICING STRATEGY DEVELOPMENT

AIRPORT A



AIRPORT A

CURRENT SITUATION

- Busy European airport with primary carrier
- Primary air carrier performs most of the deicing operations at the airport airport
- Relatively mild winter weather
- Approximately 8000 aircraft deiced annually
- Of the 8000 total deicings:
 - 5000 deicings are performed at remote locations near departure runways; runways;
 - 3000 deicings performed at gate locations (mostly frost)



AIRPORT A

CURRENT SITUATION

- Air carrier possesses older deicing vehicle equipment that contain only one fluid one fluid tank:
 - One fluid type (Type II) employed for de/anti-icing purposes
- Air carrier does not wish to make the capital investment at this time to purchase purchase new equipment
- The current deicing approach has also incurred high maintenance costs due to due to inspections for gel residue issues
- No gate collection of glycol; remote areas are equipped with collection drains in drains in the spray application areas



AIRPORT A

CURRENT SITUATION

- The glycol mitigation strategy consists of aerobic biodegradation of the collected waste
- There is currently no glycol recycling strategy
- Airport was fined on numerous occasions for BOD violations, and each violation entrained a sizeable fine
 - Fine was passed off to the air carriers



DEICING STRATEGY – AIRPORT A

SHORT TERM

- Move to Type I applications at gate positions for frost removal
 - Same vehicle equipment can be employed
 - Large percentage of all glycol falls to the ground immediately and can be collected
 - Spot deicing for frost removal
 - Immediate reduction in gel residue/BOD issues
- Employ Glycol Recovery Vehicle at gate locations to clean waste glycol and prevent tracking
- prevent tracking over airport locations by GSE and aircraft
- Employ Type I at remote locations in a spray-and-go procedure
 - Continue to employ Type II fluids at remote locations only on a per need basis
- Implement process to install Holdover Time Determination System at airport near the remote the remote areas
- Undertake activities to examine cost benefits of purchasing new de/anti-icing equipment



DEICING STRATEGY – AIRPORT A

MID TERM

- Supplement Type I at gate locations with non-glycol deicing methodologies
 - Cost reductions due to reduced glycol employment
 - Reduction of glycol recovery activities due to gate operations
 - Further reduction of BOD issues
- Initiate Holdover Time Determination System use at the airport
 - Move to use of expanded holdover times based on Holdover Time Determination System Determination System outputs
 - Move to expanded use of Type I fluids at remote locations
 - Continue use of Type II/IV on a per need basis
- Begin process of rejuvenating de/anti-icing vehicle fleet
 - Implement freeze point blending of Type I fluids (10C buffer) to further reduce costs
 - Forced air component
- Examine use of de/anti-icing fluid management models to further enable airport infrastructure enhancements



DEICING STRATEGY – AIRPORT A LONG TERM

- Eliminate the use of glycol-based fluids at gate locations in favor of non-glycol non-glycol methodologies
- Complete de/anti-icing fleet rejuvenation
 - Full employment of 10C buffer fluid
 - Increased operational efficiency
- Examine possible implementation of glycol recycling capabilities



