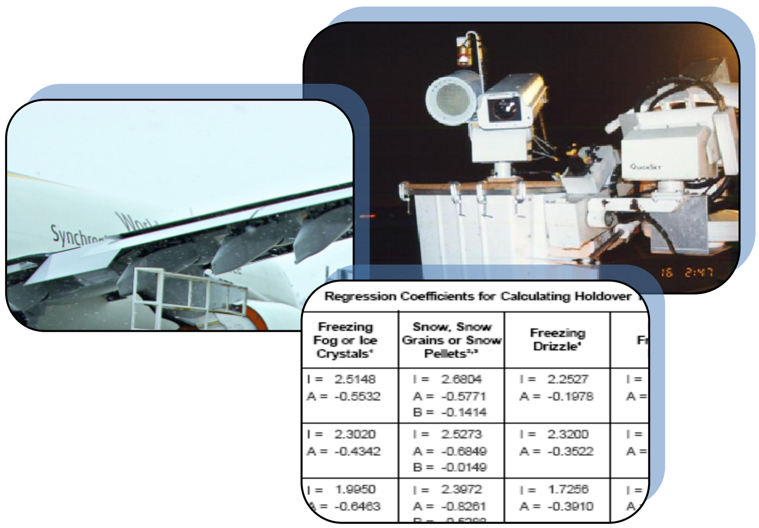
TP 15231E

Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing

(Year 2 of 3)



Prepared for

Transportation Development Centre

In cooperation with

Civil Aviation
Transport Canada

and

The Federal Aviation Administration
William J. Hughes Technical Center

Prepared by

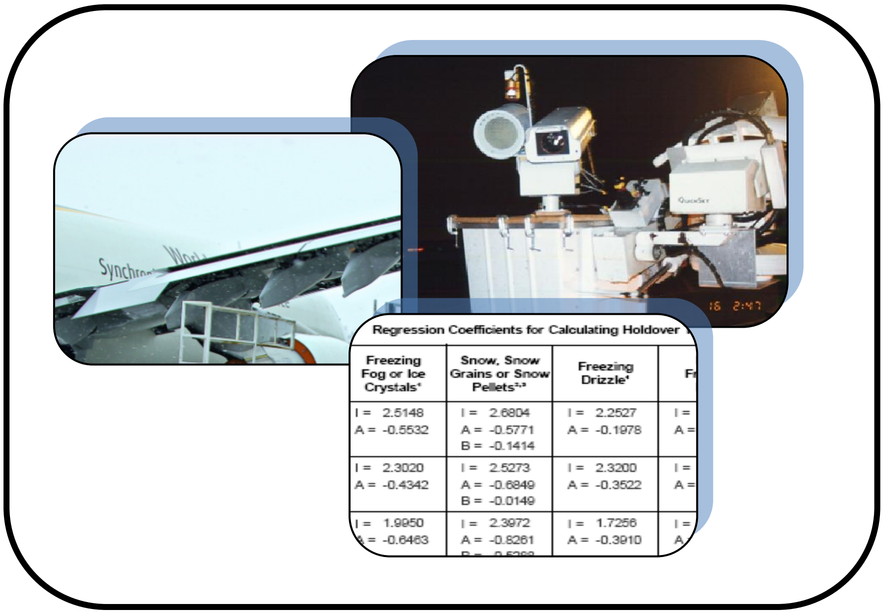
APS Aviation Inc.

October 2013
Final Version 1.0

TP 15231E

Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing

(Year 2 of 3)



by

John D'Avirro

APS Aviation Inc.

October 2013
Final Version 1.0

The contents of this report reflect the views of APS Aviation Inc. and not necessarily the official view or opinions of the Transportation Development Centre of Transport Canada.

The Transportation Development Centre does not endorse products or manufacturers. Trade or manufacturers' names appear in this report only because they are essential to its objectives.

DOCUMENT ORIGIN AND APPROVAL RECORD

Prepared by:

Jun. 27, 2019

John D'Avirro, Eng., PBDM — Date
Director, Aviation Services

Approved by: **

John Detombe — Date
Chief Engineer
ADGA Group Consultant Inc.

Un sommaire français se trouve avant la table des matières.

This report was first provided to Transport Canada as Final Draft 1.0 in October 2013.
It has been published as Final Version 1.0 in June 2019.

***Final Draft 1.0 of this report was signed and provided to Transport Canada in October 2013. A Transport Canada technical and editorial review was subsequently completed and the report was finalized in June 2019; John Detombe was not available to participate in the final review or to sign the current version of the report.*

PREFACE

Under contract to the Transportation Development Centre of Transport Canada with support from the Federal Aviation Administration, APS Aviation Inc. has undertaken a research program to advance aircraft ground de/anti-icing technology. The specific objectives of the APS Aviation Inc. test program are the following:

- To develop holdover time data for all newly-qualified de/anti-icing fluids and update and maintain the website for the holdover time guidelines;
- To evaluate weather data from previous winters that can have an impact on the format of the holdover time guidelines;
- To conduct general and exploratory de/anti-icing research;
- To conduct tests to evaluate the effect of deployed flaps and slats prior to anti-icing;
- To conduct tests and research on surfaces treated with ice phobic products;
- To conduct tests to evaluate holdover times in heavy snow conditions;
- To develop an SAE AIR for the evaluation of aircraft coatings;
- To support the evaluation of the NRC propulsion icing wind tunnel to determine its flow characteristics;
- To develop holdover time guidance for operation in ice crystal conditions;
- To continue research for development of ice detection capabilities for pre-deicing, engine deicing and departing aircraft at the runway threshold;
- To develop a performance specification for electronic holdover time applications;
- To investigate pre-take-off contamination check 5-minute allowance;
- To conduct full-scale general aviation aircraft windshield washer fluid deicing testing to substantiate and support flat plate testing results;
- To update the regression coefficient report with the newly-qualified de/anti-icing fluids; and
- To develop Type II/IV holdover times in light and very light snow conditions.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2012-13 are documented in seven reports. The titles of the reports are as follows:

- TP 15227E Winter Weather Impact on Holdover Time Table Format (1995-2013);
- TP 15228E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2012-13 Winter;
- TP 15229E Regression Coefficients and Equations Used to Develop the Winter 2013-14 Aircraft Ground Deicing Holdover Time Tables;
- TP 15230E Aircraft Ground Icing General Research Activities During the 2012-13 Winter;

- TP 15231E Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 2 of 3);
- TP 15232E Wind Tunnel Trials to Examine Anti-Icing Fluid Flow-Off Characteristics and to Support the Development of Ice Pellet Allowance Times, Winters 2009-10 to 2012-13; and
- TP 15233E Exploratory Wind Tunnel Aerodynamic Research, Winter 2012-13.

In addition, the following two interim reports are being prepared:

- *Evaluation of Endurance Times on Extended Flaps and Slats; and*
- *Investigation of Ice Phobic Technologies to Reduce Aircraft Icing in Northern and Cold Climates (Year 2 of 3).*

This report, TP 15231E has the following objective:

- To investigate sensor technologies as an alternative means of detecting aircraft icing in northern and cold climates.

This objective was met by conducting three individual research projects, each focusing on a different research initiative which included the use and development of sensor systems for ground de/anti-icing applications.

PROGRAM ACKNOWLEDGEMENTS

This multi-year research program has been funded by Transport Canada with support from the Federal Aviation Administration, William J. Hughes Technical Center, Atlantic City, NJ. This program could not have been accomplished without the participation of many organizations. APS Aviation Inc. would therefore like to thank the Transportation Development Centre of Transport Canada, the Federal Aviation Administration, National Research Council Canada, the Meteorological Service of Canada, and several fluid manufacturers.

APS Aviation Inc. would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data. This includes the following people: Yelyzaveta Asnytska; Brandon Auclair; Steven Baker, Stephanie Bendickson, Kirby Bennett; Patrick Caines; John D'Avirro, Jesse Dybka, Derek Foebel; Benjamin Guthrie, Dany Posteraro, Marco Ruggi, James Smyth, Fillipo Suriano; David Youssef and Victoria Zoitakis.

Special thanks are extended to Howard Posluns, Yvan Chabot, Doug Ingold and Warren Underwood, who on behalf of the Transportation Development Centre and the Federal Aviation Administration, have participated, contributed and provided guidance in the preparation of these documents.

Transport Canada / Transports Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No. TP 15231E	2. Project No. B14W	3. Recipient's Catalogue No.
4. Title and Subtitle Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 2 of 3)		5. Publication Date October 2013 6. Performing Organization Document No. CM2265.002
7. Author(s) John D'Avirro		8. Transport Canada File No. 2450-BP-14
9. Performing Organization Name and Address APS Aviation Inc. 6700 Chemin de la Cote-de-Liesse, Suite 105 Montreal, Quebec, H4T 2B5		10. PWGSC File No. TOR-4-37170 11. PWGSC or Transport Canada Contract No. T8156-140243/001/TOR
12. Sponsoring Agency Name and Address Transportation Development Centre Transport Canada 330 Sparks St., 26th Floor Ottawa, Ontario, K1A 0N5		13. Type of Publication and Period Covered Final 14. Project Officer Antoine Lacroix for Yvan Chabot

15. Supplementary Notes (Funding programs, titles of related publications, etc.)

Several research reports for testing of de/anti-icing technologies were produced for previous winters on behalf of Transport Canada. These are available from the Transportation Development Centre. Several reports were produced as part of this winter's research program. Their subject matter is outlined in the preface. This project was co-sponsored by the Federal Aviation Administration.

16. Abstract

This research program aims to respond to the emerging challenges and opportunities for Canada and its northern communities and address Transport Canada's adaptation to cold and changing climates and sustainable transportation research and development strategic priorities.

This report provides a summary of the projects completed as part of the sensors technology research program for year 2. The objective of the project (year 2) is to investigate sensor technologies as an alternative means of detecting aircraft icing in northern and cold climates. Specific research projects, each with a different research initiative, were planned in the winter of 2012-13 to meet the program objective. The research projects are listed below.

1. Support for the Use of Ice Detection Cameras at End-of-Runway.
2. Regression Coefficients and Equations Used to Develop the Winter 2013-14 Aircraft Ground Deicing Holdover Time Tables.
3. Development of Light and Very Light Snow Holdover Times for Type II and Type IV Fluids (Final Phases).

17. Key Words ROGIDS, Ice Detection, HOTDS, LWE, Active frost, Very light snow, Deicing, Holdover time, Sensor, Camera	18. Distribution Statement Limited number of copies available from the Transportation Development Centre

19. Security Classification (of this publication)	20. Security Classification (of this page)	21. Declassification (date)	22. No. of Pages	23. Price
Unclassified	Unclassified	—	xvi, 14 app.	—

CDT/TDC 79-005
Rev. 96

Canada

Transports Canada Transport Canada

FORMULE DE DONNÉES POUR PUBLICATION

1. Nº de la publication de Transports Canada: TP 15231E

2. Nº de l'étude: B14W

3. Nº de catalogue du destinataire:

4. Titre et sous-titre: Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 2 of 3)

5. Date de la publication: Octobre 2013

6. Nº de document de l'organisme exécutant: CM2265.002

7. Auteur(s): John D'Avirro

8. Nº de dossier - Transports Canada: 2450-BP-14

9. Nom et adresse de l'organisme exécutant:
APS Aviation Inc.
6700 Chemin de la Côte-de-Liesse, Bureau 105
Montréal (Québec) H4T 2B5

10. Nº de dossier - TPSGC: TOR-4-37170

11. Nº de contrat - TPSGC ou Transports Canada: T8156-140243/001/TOR

12. Nom et adresse de l'organisme parrain:
Centre de développement des transports
Transports Canada
330 rue Sparks, 26ième étage
Ottawa (Ontario) K1A 0N5

13. Genre de publication et période visée: Final

14. Agent de projet: Antoine Lacroix pour Yvan Chabot

15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.)

Plusieurs rapports de recherche sur des essais de technologies de dégivrage et d'antigivrage ont été produits au cours des hivers précédents pour le compte de Transports Canada. Ils sont disponibles au Centre de développement des transports. De nombreux rapports ont été rédigés dans le cadre du programme de recherche de cet hiver. Leur objet apparaît à l'avant-propos. Ce projet était coparrainé par la Federal Aviation Administration.

16. Résumé

Ce programme de recherche vise à répondre aux possibilités et aux défis émergents qui se présentent au Canada et à ses communautés nordiques, ainsi qu'à se pencher sur les priorités stratégiques en matière de recherche et développement que sont pour Transports Canada l'adaptation au froid et aux changements climatiques et le transport durable.

Ce rapport présente un sommaire des projets achevés au cours de la 2e année du programme de recherche sur les technologies de détection. L'objectif de ce programme (année 2) est d'examiner l'utilisation des technologies de détection comme un autre moyen de déceler le givrage des aéronefs dans les climats nordiques et froids. Des projets de recherche spécifiques, chacun proposant une initiative de recherche différente, ont été planifiés au cours de l'hiver 2012-2013 afin d'atteindre l'objectif du programme. Ces projets de recherche sont énumérés ci-dessous.

1. Soutien à l'utilisation de caméras de détection de givre en bout de piste.
2. Coefficients et équations de régression utilisés pour produire les tableaux des durées d'efficacité relatives au dégivrage d'aéronefs au sol pour l'hiver 2013-2014.
3. Établissement des durées d'efficacité des liquides de type II et de type IV dans des conditions de neige faible et très faible (phases finales).

17. Mots clés: ROGIDS, détection de givre, HOTDS, LWE, givre actif, neige très faible, dégivrage, durée d'efficacité, détecteur, caméra

18. Diffusion: Le Centre de développement des transports dispose d'un nombre limité d'exemplaires

19. Classification de sécurité (de cette publication)	20. Classification de sécurité (de cette page)	21. Déclassification (date)	22. Nombre de pages	23. Prix
Non classifiée	Non classifiée	—	xvi, 14 ann.	—

CDT/TDC 79-005
Rev. 96

Canada

EXECUTIVE SUMMARY

Under contract to the Transportation Development Centre (TDC), APS Aviation Inc. (APS) undertook a research program to investigate sensor technologies as an alternative means of detecting aircraft icing in northern and cold climates. The research program was completed in response to the Government of Canada's Northern Strategy, which seeks to meet emerging challenges and opportunities for Canada's northern communities, and to Transport Canada's (TC) adaptation to cold and changing climates initiative and sustainable transportation research and development strategic priorities. This report contains the sensor technology research for the second year of a three-year program.

The research program involved three types of sensor technologies: ice detection on aircraft wings, sensor technology to measure precipitation intensity and type, and sensors to detect active frost. TC report, TP 15200E, *Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 1 of 3)* (1), contains the research from year one of the three-year program.

For year two, the following research projects, each with a different research initiative, were completed in the winter of 2012-13 as part of the sensor technologies research program. The following provides a summary of the conclusions and recommendations.

Support for the Use of Ice Detection Cameras at End-of-Runway

It was concluded that locating a Remote On-Ground Ice Detection Systems (ROGIDS) at the departure end of the runway could have a significant positive impact on safety. As a result, it was recommended that resources be allocated to advance the use of ROGIDS technology for the end-of-runway application and that this work should be conducted with the guidance and support of the ROGIDS working group.

Regression Coefficients and Equations Used to Develop the Winter 2013-14 Aircraft Ground Deicing Holdover Time Tables

The 2013-14 regression information was published online on the TC Holdover Time (HOT) Guidelines website on August 1, 2013. The information can be used by Holdover Time Determination Systems (HOTDS) manufactures to calculate holdover times during the winter of 2013-14. It was recommended that both regression publications – the online document and the technical report – be updated in one year to reflect any changes made to the HOT Guidelines for the winter of 2014-15.

Development of Light and Very Light Snow Holdover Times for Type II and Type IV Fluids (Final Phases)

The new light and very light snow holdover times were integrated into the Federal Aviation Administration (FAA) and TC HOT Guidelines for winter 2013-14. These changes were made only to the holdover time tables for the ten fluids included in the project and the new Type IV fluid. The holdover time tables for those Type II/IV fluids which were not part of the project retained the standard Type II/IV holdover time table format, which has a single snow column based on moderate snow precipitation rates.

SOMMAIRE

En vertu d'un contrat conclu avec le Centre de développement des transports, APS Aviation Inc. (APS) a entrepris de mener un programme de recherche afin d'examiner l'utilisation des technologies de détection comme un autre moyen de déceler le givrage des aéronefs dans les climats nordiques et froids. Ce programme de recherche a été mis en œuvre en réponse à la Stratégie pour le Nord du gouvernement du Canada, qui vise à relever les possibilités et les défis émergents qui se présentent au Canada et à ses communautés nordiques, ainsi qu'aux priorités stratégiques en matière de recherche et développement que sont pour Transports Canada (TC) l'adaptation au froid et aux changements climatiques et le transport durable. Ce rapport traite des études menées sur les technologies de détection au cours de la deuxième année de ce programme de trois ans.

Le programme de recherche s'attardait à trois types de technologies de détection : la détection de givre sur les ailes des aéronefs, la technologie de détection permettant de mesurer l'intensité et le type de précipitations et les détecteurs de givre actif. Le rapport de TC, TP 15200E, *Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 1 of 3)* (1), contient la recherche de la première année de ce programme de trois ans.

Pour la deuxième année, les projets de recherche suivants, chacun proposant une initiative de recherche différente, ont été menés au cours de l'hiver 2012-2013 dans le cadre de ce programme sur les technologies de détection. Les pages qui suivent présentent un résumé des conclusions et recommandations mises de l'avant.

Soutien à l'utilisation de caméras de détection de givre en bout de piste

Il a été conclu que l'installation des systèmes de détection à distance du givrage au sol (ROGIDS) à l'extrémité de départ d'une piste pouvait avoir d'importantes répercussions positives sur la sécurité. Par conséquent, il a été recommandé que des ressources soient allouées afin de promouvoir le recours à la technologie des ROGIDS en bout de piste, et que ce travail soit mené avec l'aide et le soutien du groupe de travail sur les ROGIDS.

Coefficients et équations de régression utilisés pour produire les tableaux des durées d'efficacité relatives au dégivrage d'aéronefs au sol pour l'hiver 2013-2014

L'information de régression pour 2013-2014 a été publiée en ligne le 1er août 2013, par l'entremise du site Web sur les lignes directrices relatives aux durées

d'efficacité de Transports Canada. Elle peut servir aux fabricants de systèmes de détermination des durées d'efficacité (HOTDS) pour calculer les durées d'efficacité pour l'hiver 2013-2014. Il a été recommandé que les deux publications sur la régression – le document en ligne et le rapport technique – soient actualisées dans un an, afin de refléter tout changement apporté aux lignes directrices relatives aux durées d'efficacité pour l'hiver 2014-2015.

Établissement des durées d'efficacité des liquides de type II et de type IV dans des conditions de neige faible et très faible (phases finales)

Les nouvelles durées d'efficacité dans des conditions de neige faible et très faible ont été incluses dans les lignes directrices relatives aux durées d'efficacité de la Federal Aviation Administration (FAA) et de TC pour l'hiver 2013-2014. Ces changements ont uniquement été apportés aux tableaux des durées d'efficacité des dix liquides inclus dans le projet et du nouveau liquide de type IV. Les tableaux des durées d'efficacité des liquides de type II/IV ne faisant pas partie du projet ont repris le format standard du tableau des durées d'efficacité des liquides de type II/IV, qui ne comprend qu'une seule colonne relative à la neige, basée sur des taux de précipitations neigeuses modérées.

CONTENTS Page

LIST OF APPENDICES

This page intentionally left blank.

LIST OF PHOTOS Page

This page intentionally left blank.

GLOSSARY

AIRA	Aircraft Icing Research Alliance
ALB	Albany International Airport
APS	APS Aviation Inc.
FAA	Federal Aviation Administration
HOT	Holdover Time
HOTDS	Holdover Time Determination System
LWE	Liquid Water Equivalent
MSC	Meteorological Service of Canada
NRC	National Research Council Canada
ROGIDS	Remote On-Ground Ice Detection Systems
SAE	SAE International
TC	Transport Canada
TDC	Transportation Development Centre
YMX	Montréal-Mirabel International Airport

This page intentionally left blank.

1. INTRODUCTION

Under winter precipitation conditions, aircraft are cleaned with a freezing point depressant fluid and protected against further accumulation by an additional application of such a fluid, possibly thickened to extend the protection time. Aircraft ground deicing had, until recently, never been researched and there is still an incomplete understanding of the hazard and of what can be done to reduce the risks posed by the operation of aircraft in winter precipitation conditions. This "winter operations contaminated aircraft – ground" program of research is aimed at overcoming this lack of knowledge.

Since the early 1990s, the Transportation Development Centre (TDC) of Transport Canada (TC) has managed and conducted de/anti-icing related tests at various sites in Canada; it has also coordinated worldwide testing and evaluation of evolving technologies related to de/anti-icing operations with the co-operation of the United States Federal Aviation Administration (FAA), the National Research Council Canada (NRC), the Meteorological Service of Canada (MSC), several major airlines, and deicing fluid manufacturers. The TDC is continuing its research, development, testing and evaluation program.

Under contract to the TDC, with financial support from the FAA, APS Aviation Inc. (APS) has undertaken research activities to further advance aircraft ground de/anti-icing technology.

The research program aims to respond to the Government of Canada's Northern Strategy, which seeks to meet emerging challenges and opportunities for Canada's northern communities, and address TC's adaptation to cold and changing climates initiative and sustainable transportation research and development strategic priorities. Additionally, Canada is an active member of the Aircraft Icing Research Alliance (AIRA), a strategic partnership that collaborates on aircraft icing research activities that improve the safety of aircraft operations in icing conditions.

1.1 Background

Cold temperature precipitation on various sections of aircraft, including wings and engines, poses a great risk for their safe functioning. These conditions tend to occur at greater length and increased intensity in Canada's cold climate regions. Additionally, airports with de/anti-icing capabilities can run the risk of departing aircraft with heavily contaminated anti-icing fluid if misleading information is used to determine the appropriate fluid holdover time.

To operate using ground de/anti-icing methods and fluids, both ground crews and flight crews must assess whether take-off is safe based on weather information, visual assessments, and the use of standardized guidelines. Changing climatic conditions over recent years have made this practice more challenging. Another area of concern is the overuse of deicing and anti-icing fluids. Many of Canada's more remote airports are not fully equipped to manage run-off fluids in an environmentally sound manner and, as a consequence, there can be contamination of the surrounding sensitive ecological areas.

In response to these concerns, a research program was undertaken to examine and support the development of sensor devices that can detect ice and/or anti-icing fluid contamination conditions and the means for utilizing and integrating into operations such devices for these purposes. These sensor technologies may be utilised to assist ground crews in cold climate deicing and anti-icing practices, assist airport operators in determining precise amounts of deicing and anti-icing fluids required, and assist flight crews in the assessment of aircraft overall airworthiness and safe takeoff conditions.

1.2 Objective

The objective of this project was to investigate sensor technologies as an alternative means of detecting aircraft icing in northern and cold climates. This report contains the sensor technology research for the second year of a three-year program. The research involved three types of sensor technologies: ice detection on aircraft wings, sensor technology to measure precipitation intensity and type, and sensors to detect active frost. TC Report, TP 15200E, *Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 1 of 3)* (1), contains the research from year one of the three-year program.

For year two, the work required for this research program was divided into three projects, each focusing on a different research initiative. These projects, listed below, were conducted during the winter of 2012-13:

1. Support for the use of Ice Detection Cameras at End-of-Runway;
2. Regression Coefficients and Equations Used to Develop the Winter 2013-14 Aircraft Ground Deicing Holdover Time Tables; and
3. Development of Light and Very Light Snow Holdover Times for Type II and Type IV Fluids (Final Phases).

1.3 Report Format

This report provides a summary of each of the three projects completed as part of the sensors technology research program. The individual projects are documented in detail in three separate reports (referenced in the respective sections of this report). The goal of this report is to provide an overview of all research completed for the sensor technology project.

Each of the following chapters summarizes one of the three research projects completed as part of the sensor technologies research program. The content of the chapters is as follows:

- Section 2: Support for the use of Ice Detection Cameras at End-of-Runway;
- Section 3: Regression Coefficients and Equations Used to Develop the Winter 2013-14 Aircraft Ground Deicing Holdover Time Tables; and
- Section 4: Development of Light and Very Light Snow Holdover Times for Type II and Type IV Fluid (Final Phases).

The sections of the TDC work statement pertaining to the work described in this report are provided in the separate detailed reports, and a copy has been included in Appendix A for reference.

1.4 Purpose of Consolidated Report

The TC – FAA joint aircraft ground icing research program is funded from several sources. Two components of the program are funded by TC: research on sensor technologies and research on ice phobic technologies. This report has been developed to document the work completed for the sensor technologies funding.

The report provides summaries of the three projects completed as part of the sensor technologies research program, with the goal of providing an overview of all work completed as part of the program for year two of three. Three separate reports document the three projects in more detail. References to these reports are made in each project summary that follows.

This page intentionally left blank.

2. SUPPORT FOR THE USE OF ICE DETECTION CAMERAS AT END-OF-RUNWAY

2.1 Background

Remote on-ground ice detection systems (ROGIDS) have been in development for the aircraft ground icing industry for many years (see Photo 2.1). A significant amount of research has been conducted with these systems to assess their performance, with varying results over the years.

A turning point was reached in the winter of 2004-05, when research demonstrated that in certain scenarios, ROGIDS are more reliable than human visual and/or tactile checks in detecting clear ice on aircraft critical surfaces. An SAE International (SAE) work group was subsequently formed to develop an aerospace standard defining the minimum operational performance requirements for ROGIDS in this application. The standard was published by the SAE in September 2007 and was followed by TC and FAA Advisory Circulars in the years following.

Discussions in the working group about other potential applications for ROGIDS (end-of-runway, engine icing, and pre-deicing) determined the next application that should be focused on was the use of ROGIDS at the departure end of the runway. The working group determined that before operational research and new regulatory documents were considered, the need for ROGIDS at end-of-runway should be researched and documented.

In addition to participation in the work group, APS completed research to evaluate the need for ROGIDS at end-of-runway, which included a survey of flight crews and an analysis of accident reporting databases.

It was concluded that locating a ROGIDS at the departure end of the runway could have a significant positive impact on safety. As a result, it was recommended that resources be allocated to advance the use of ROGIDS technology for the end-of-runway application and that this work should be conducted with the guidance and support of the ROGIDS working group. For a detailed account of this research, refer to TC report, TP 15199E, *Research to Assess the Need for Remote On-Ground Ice Detection Systems (ROGIDS) at End-of-Runway* (2).

2.2 Work Group Activities

The work group has not been very active in the last year, primarily because the sensor manufacture has been delayed with the production of ice detection cameras. For an account on the workgroup activities, refer to TC report, TP15230E, *Aircraft Ground Icing General Research Activities During the 2012-13 Winter* (3).

2.2.1 Use of ROGIDS for Full-Scale Flaps/Slats Research

The SAE G-12 Ice Detection ROGIDS working group has been evaluating and supporting the development and use of ROGIDS since 2003. The working group began assessing applications for the technology, including end-of-runway, engine icing, and pre-deicing. PV Labs is developing an ice detection system (see camera in Photo 2.1) to address the post-deicing application. In the winter of 2012-13, plans were put in place to examine the outputs of this system as part a full-scale flaps/slats research project conducted on an Airbus A300 at Montréal-Mirabel International Airport (YMX) and a Boeing 737 at Albany International Airport (ALB). PV Labs was unable to participate in this research.

Photo 2.1: Ice Detection Camera

3. REGRESSION COEFFICIENTS AND EQUATIONS USED TO DEVELOP THE WINTER 2013-14 AIRCRAFT GROUND DEICING HOLDOVER TIME TABLES

In recent years, several companies have developed systems that measure temperature, precipitation type, and precipitation rate in real-time. These systems, referred to as Holdover Time Determination Systems (HOTDS), use the weather data they collect and holdover time regression information to calculate more specific holdover times than the ranges that are currently provided in the Holdover Time (HOT) Guidelines.

In order for HOTDS to be used by operators, the regulatory authorities must make the regression information underlying the HOT Guidelines available to users. TC publishes two documents on holdover time regression information annually:

- An online document, which provides users with the regression information for the current winter's HOT Guidelines in a timely manner and user-friendly format; and
- A technical report, which documents how and from where the regression information provided in the online document was obtained.

The 2013-14 regression information was published online on the TC HOT Guidelines website on August 1, 2013. The information can be used by HOTDS manufactures to calculate holdover times during the winter of 2013-14.

It was recommended that both regression publications – the online document and the technical report – be updated in one year to reflect any changes made to the HOT Guidelines for the winter of 2014-15.

The TC report, TP 15229E, *Regression Coefficients and Equations Used to Develop the Winter 2013-14 Aircraft Ground Deicing Holdover Time Tables* (4), provides a detailed description of the work completed for this project.

Similar documentation was prepared for the FAA for the first time.

This page intentionally left blank.

4. DEVELOPMENT OF LIGHT AND VERY LIGHT SNOW HOLDOVER TIMES FOR TYPE II AND TYPE IV FLUIDS (FINAL PHASES)

Through the forum of the SAE G-12 Holdover Time Committee, the aircraft ground deicing industry expressed the need for increased operational flexibility in lighter snow conditions. Specifically, a motion was passed at the May 2011 SAE G-12 Holdover Time Committee meeting in San Francisco requesting that TC and the FAA add light and very light snow columns to the Type II and Type IV holdover time tables to provide longer holdover times in lighter snow conditions.

An evaluation was conducted following the May 2011 meeting to evaluate the feasibility of developing light and very light snow holdover times for Type II and Type IV fluids using the existing endurance time data and standard regression analysis methodology. It was concluded that sufficient data exists to develop light and very light snow holdover times using the standard regression analysis methodology for many, but not all, Type II and Type IV fluids.

Subsequently, a four-phase project plan was developed:

- Phase 1: Determine a minimum acceptable precipitation rate input for HOTDS and Liquid Water Equivalent (LWE) Systems;
- Phase 2: Evaluate the robustness of Type II, III and IV snow data sets at light and very light precipitation rates and identify non-robust data sets;
- Phase 3: Collect and evaluate new data for non-robust data sets and use this data to validate existing regression coefficients or determine appropriate new regression coefficients for these data sets; and
- Phase 4: Incorporate light and very light snow holdover times for Type II and Type IV fluids into the HOT guidelines.

The new light and very light snow holdover times were integrated into the FAA and TC HOT Guidelines for winter 2013-14. These changes were made only to the holdover time tables for the ten fluids included in the project and the new Type IV fluid. The holdover time tables for those Type II/IV fluids which were not part of the project retained the standard Type II/IV holdover time table format, which has a single snow column based on moderate snow precipitation rates.

A complete account of the activities can be found in TC report, TP 15228E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2012-13 Winter* (5).

This page intentionally left blank.

5. CONCLUSIONS AND RECOMMENDATIONS

For year two, the following research projects, each with a different research initiative, were completed in the winter of 2012-13 as part of the sensor technologies research program. The following provides a summary of the conclusions and recommendations.

5.1 Support for the Use of Ice Detection Cameras at End-of-Runway

It was concluded that locating a ROGIDS at the departure end of the runway could have a significant positive impact on safety. As a result, it was recommended that resources be allocated to advance the use of ROGIDS technology for the end-of-runway application and that this work should be conducted with the guidance and support of the ROGIDS working group.

5.2 Regression Coefficients and Equations Used to Develop the Winter 2013-14 Aircraft Ground Deicing Holdover Time Tables

The 2013-14 regression information was published online on the TC HOT Guidelines website on August 1, 2013. The information can be used by HOTDS manufactures to calculate holdover times during the winter of 2013-14. It was recommended that both regression publications – the online document and the technical report – be updated in one year to reflect any changes made to the HOT Guidelines for the winter of 2014-15.

5.3 Development of Light and Very Light Snow Holdover Times for Type II and Type IV Fluids (Final Phases)

The new light and very light snow holdover times were integrated into the FAA and TC HOT Guidelines for winter 2013-14. These changes were made only to the holdover time tables for the ten fluids included in the project and the new Type IV fluid. The holdover time tables for those Type II/IV fluids which were not part of the project retained the standard Type II/IV holdover time table format, which has a single snow column based on moderate snow precipitation rates.

This page intentionally left blank.

REFERENCES

1) D'Avirro, J., Ruggi, M., *Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 1 of 3),* APS Aviation Inc., Transportation Development Centre, Montreal, December 2012, TP 15200E, XX (to be published).

2) Bendickson, S., *Research to Assess the Need for Remote On-Ground Ice Detection Systems (ROGIDS) at End-of-Runway,* APS Aviation Inc., Transportation Development Centre, Montreal, November 2012, TP 15199E, XX (to be published).

3) Bendickson, S., D'Avirro, J., Ruggi, M., Youssef, D., Zoitakis, V., *Aircraft Ground Icing General Research Activities During the 2012-13 Winter,* APS Aviation Inc., Transportation Development Centre, Montreal, November 2013, TP 15230E, XX (to be published).

4) Bendickson, S., *Regression Coefficients and Equations Used to Develop the Winter 2013-14 Aircraft Ground Deicing Holdover Time Tables,* APS Aviation Inc., Transportation Development Centre, Montreal, December 2013, TP 15229E, 46.

5) Bendickson, S., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2012-13 Winter,* APS Aviation Inc., Transportation Development Centre, Montreal, March 2014, TP 15228E, XX (to be published).

This page intentionally left blank.

APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE WORK STATEMENT EXCERPT – AIRCRAFT & ANTI-ICING FLUID – WINTER TESTING 2012-13

TRANSPORTATION DEVELOPMENT CENTRE WORK STATEMENT EXCERPT – AIRCRAFT & ANTI-ICING FLUID – WINTER TESTING 2012-13

4.32 Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing

The focus of this project will be to examine and support the development of sensor devices that can detect ice, or can detect anti-icing fluid contamination conditions and the means for integrating such devices for these purposes:

The overall goal of this project will be to analyze sensor technologies that may be utilized to assist ground crew in typical cold climate deicing and anti-icing practices, assist airport operators in determining precise amounts of deicing and anti-icing fluids required and assist cockpit crew in the assessment of the aircraft's overall air worthiness and safe take-off conditions.

The specific research and work required for these activities include:

- A review of previous work completed on detection of ice on aircraft stabilizer, wing and engine surfaces at various locations throughout Canada to obtain a representative sample of current activities.
- Conduct stakeholder consultations and participate with industry members (airport authorities, aircraft operators, fluid manufacturers) to identify priorities and discuss issues with respect to innovative sensor technologies and the need to further investigate this area in the context flight safety, environmental sustainability and cost savings.
- In addition to potential current sensor technologies uses, investigate the feasibility of applicability to other aircraft parts or mechanisms (e.g. engine fan blades and cowlings).
- Identify the limitations of various northern and cold climate airport activity infrastructures (e.g. airstrips, deicing fluid mixing facilities) to manage excess and run-off fluids, determine exact requirements and potentially evaluate environmental compliance with various environmental standards.
- Identify the limitations and technological of current technologies for various climatic scenarios.
- Evaluate options of utilizing modern sensor technologies considering safety and efficiency of current de/anti-icing procedures and financial constraints of airport authorities and aircraft authorities.
- Carry out testing and simulations of sensor technologies and provide informed reports to Transport Canada and various stakeholders.

As part of this project, work will be conducted according to the following tasks:

4.33 Support: Pre-Deicing, Engine, and Runway Threshold Ice Detection

a) Review previous work completed on detection of ice on aircraft surfaces at a location close to the runway threshold. In addition, investigate feasibility of using this technology for pre-deicing applications and engine applications (fan blades and cowlings);

b) Identify the limitations of current technologies for the specific applications. Evaluate option of using low-tech alternative to sensor (i.e. binoculars) to allow for initial procedural implementation in operations while technology is being further developed;

c) Participate with industry members to discuss the need to further investigate this area of study; It is anticipated that four meetings of two days will be needed with the work group to develop a test implementation plan;

d) Determine testing requirements for preliminary full-scale or flat plate testing based on the recommendations from industry meetings. These tests will be defined during the meetings. While it would be desirable to do testing outdoors in natural snow, testing in simulated indoor conditions may be less costly and more realistic due to time constraints on the equipment;

e) Develop methodology and procedure for indoor NRC testing;

f) Conduct testing at the NRC CEF. Eight days of testing are anticipated at the NRC facility. This will require one person for all conditions;

g) Analyze data and results; and

h) Report the findings and prepare presentation material for the SAE G-12 meetings.

4.34 Use of Ice Detection in Conjunction with Full-Scale Flap/Slat Testing

a) Contact camera manufacturers to ensure availability of equipment;

b) Develop procedure for testing and arrange for necessary non-intrusive camera installation;

c) Support full-scale testing at Albany airport;

d) Support full-scale testing at Mirabel airport;

e) Organize possible participation of manufacturer wind tunnel tests; for this activity, no additional personnel will be needed for support; and

f) Analyze results; prepare report on the findings and present, as required, the results at the industry meetings.