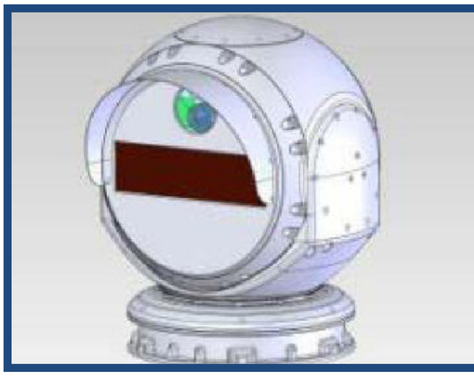
TP 15272E

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

(Year 3 of 3)

Regression Coefficients for Calculating Holdover Times Under Various W

Freezing Fog or Ice Crystals[1]	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[1]	Light Freezing Rain[1]	Rain Cold S Wi
I = 1.3735 A = -0.4751	I = 2.0072 A = -0.5752 B = -0.5585	I = 1.3829 A = -0.3848	I = 1.4688 A = -0.6200	I = 0. A = -0
I = 1.2734 A = -0.5299	I = 2.0072 A = -0.5752 B = -0.5585	I = 1.3842 A = -0.6152	I = 1.4688 A = -0.6200	
I = 1.1678 A = -0.5575	I = 2.0072 A = -0.5752 B = -0.5585	I = 1.2545 A = -0.5857	I = 2.2598 A = -1.4012	



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.

November 2014
Final Version 1.0

TP 15272E

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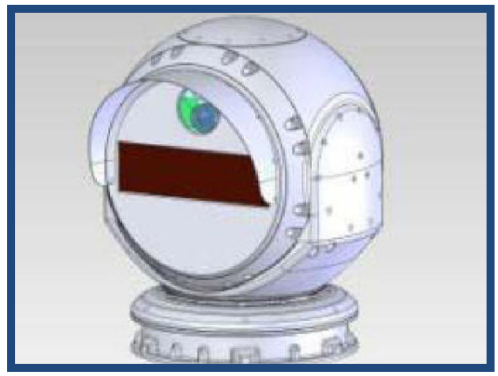

by

Chloë Bernier

APS Aviation Inc.

November 2014

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: June. 27, 2019

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Reviewed by: Jun. 27, 2019

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Director, Aviation Services

Approved by: **

John Detombe — Date
Principal Engineer, Defence and Security
ADGA Group Consultant Inc.

Un sommaire français se trouve avant la table des matières.

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***Final Draft 1.0 of this report was signed and provided to Transport Canada in November 2014. 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 with the snow machine to support ARP5485 changes;
- 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-takeoff 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 develop training and fluid failure photos/videos for global archive;
- To update the regression coefficient report with the newly-qualified de/anti-icing fluids; and
- To develop guidelines on radiation cooling during taxi.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2013-14 are documented in eight reports. The titles of the reports are as follows:

- TP 15268E Winter Weather Impact on Holdover Time Table Format (1995-2014);
- TP 15269E Aircraft Ground Icing General Research Activities During the 2013-14 Winter;
- TP 15270E Regression Coefficients and Equations Used to Develop the Winter 2014-15 Aircraft Ground Deicing Holdover Time Tables;

- TP 15271E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2013-14 Winter;
- TP 15272E Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 3 of 3);
- TP 15273E Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winter 2013-14;
- TP 15274E Exploratory Wind Tunnel Aerodynamic Research Winter 2013-14; and
- TP 15275E Investigation of Ice Phobic Technologies to Reduce Aircraft Icing in Northern and Cold Climates.

In addition, the following interim report is being prepared:

- *Evaluation of Endurance Times on Extended Flaps and Slats.*

This report, TP 15272E 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 two 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, 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, John D'Avirro, Jesse Dybka, Ben Falvo, Benjamin Guthrie, Michael Hawdur, Eric Perocchio, Dany Posteraro, Marco Ruggi, Gordon Smith, James Smyth, David Youssef, Nondas Zoitakis and Victoria Zoitakis.

Special thanks are extended to Howard Posluns, Yvan Chabot, Doug Ingold, Warren Underwood and Charles J. Enders, 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.

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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 3. The objective of the project (year 3) 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 2013-14 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 2014-15 Aircraft Ground Deicing Holdover Time Tables.

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14. Agent de projet
Antoine Lacroix pour Howard Polsuns

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 3e année du programme de recherche sur les technologies de détection. L'objectif de ce programme (année 3) 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 2013-2014 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 2014-2015.

17. Mots clés
ROGIDS, détection de givre, HOTDS, LWE, 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
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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 third 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.

TC report, TP 15231E, *Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 2 of 3)* (2), contains the research from year two of the three-year program.

For year three, the following research projects, each with a different research initiative, were completed in the winter of 2013-14 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 2014-15 Aircraft Ground Deicing Holdover Time Tables

The 2014-15 regression information was published online on the TC Holdover Time (HOT) Guidelines website in August 2014. The information can be used by Holdover Time Determination Systems (HOTDS) manufactures to calculate holdover times during the winter of 2014-15. 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 2015-16.

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 troisième 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.

Le rapport de TC, TP 15231E, *Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 2 of 3)* (2), contient la recherche de la deuxième année de ce programme de trois ans.

Pour la troisième année, les projets de recherche suivants, chacun proposant une initiative de recherche différente, ont été menés au cours de l'hiver 2013-2014 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 2014-2015

L'information de régression pour 2014-2015 a été publiée en ligne en août 2014, 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 2014-2015. 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 2015-2016.

CONTENTS Page

LIST OF APPENDICES

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LIST OF PHOTOS **Page**

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GLOSSARY

AIRA	Aircraft Icing Research Alliance
APS	APS Aviation Inc.
FAA	Federal Aviation Administration
HOT	Holdover Time
HOTDS	Holdover Time Determination System
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

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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 takeoff 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 third 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.

TC Report, TP 15231E, *Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 2 of 3)* (2), contains the research from year two of the three-year program.

For year three, the work required for this research program was divided into two projects, each focusing on a different research initiative. These projects, listed below, were conducted during the winter of 2013-14:

1. Support for the use of Ice Detection Cameras at End-of-Runway; and
2. Regression Coefficients and Equations Used to Develop the Winter 2014-15 Aircraft Ground Deicing Holdover Time Tables.

1.3 Report Format

This report provides a summary of each of the two projects completed as part of the sensors technology research program. The individual projects are documented in detail in two 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 two 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; and
- Section 3: Regression Coefficients and Equations Used to Develop the Winter 2014-15 Aircraft Ground Deicing Holdover Time Tables.

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 two 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 three of three. Two separate reports document the two projects in more detail. References to these reports are made in each project summary that follows.

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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* (3).

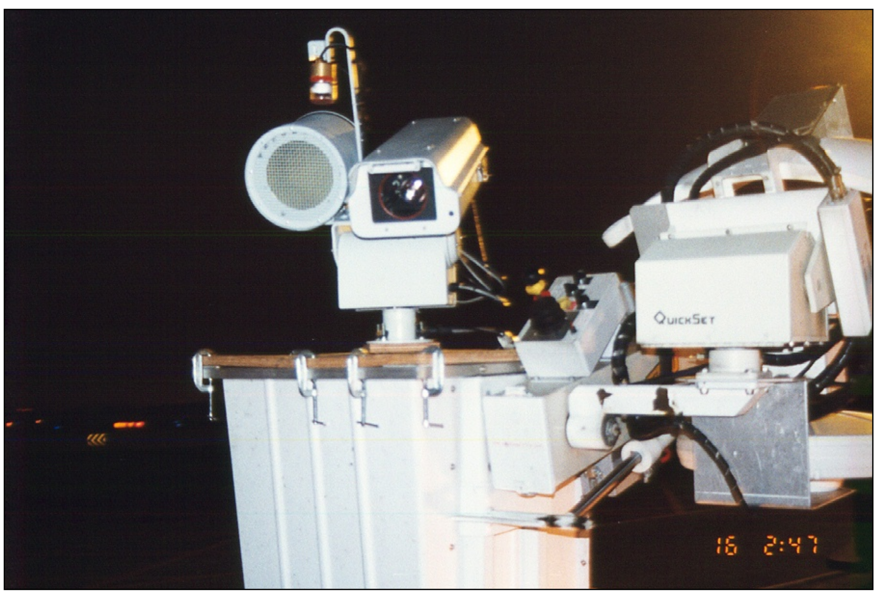
2.2 Work Group Activities

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, TP15269E, *Aircraft Ground Icing General Research Activities During the 2013-14 Winter* (4).

APS organized and led the changes to the ice detection document SAE AS5681. This included minor editorial changes, the addition of equipment required for thickness measurements, the relocation of radio frequency emission content, as well as a terminology change from “Recommended Tests” to “Optional Tests” and the removal of select optional tests.

In order to gain a larger audience, the SAE G-12 Committee passed a motion to disband the Ice Detection Committee and create a Workgroup that reports to the SAE G-12 Holdover Time Committee.

Photo 2.1: Ice Detection Camera



3. REGRESSION COEFFICIENTS AND EQUATIONS USED TO DEVELOP THE WINTER 2014-15 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 2014-15 regression information was published online on the TC HOT Guidelines website on August 1, 2014. The information can be used by HOTDS manufactures to calculate holdover times during the winter of 2014-15.

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 2015-16.

The TC report, TP 15270E, *Regression Coefficients and Equations Used to Develop the Winter 2014-15 Aircraft Ground Deicing Holdover Time Tables* (5), provides a detailed description of the work completed for this project.

Similar documentation was prepared for the FAA.

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4. CONCLUSIONS AND RECOMMENDATIONS

For year three, the following research projects, each with a different research initiative, were completed in the winter of 2013-14 as part of the sensor technologies research program. The following provides a summary of the conclusions and recommendations.

4.1 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.

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

The 2014-15 regression information was published online on the TC HOT Guidelines website in August 1, 2014. The information can be used by HOTDS manufactures to calculate holdover times during the winter of 2014-15. 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 2015-16.

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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) D'Avirro, J., *Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 2 of 3),* APS Aviation Inc., Transportation Development Centre, Montreal, October 2013, TP 15231E, XX (to be published).

3) 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).

4) Youssef, D., *Aircraft Ground Icing General Research Activities During the 2013-14 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, November 2014, TP 15269E, XX (to be published).

5) Bendickson, S., *Regression Coefficients and Equations Used to Develop the Winter 2014-15 Aircraft Ground Deicing Holdover Time Tables,* APS Aviation Inc., Transportation Development Centre, Montreal, January 2015, TP 15270E, 46.

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APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT –
AIRCRAFT & ANTI-ICING FLUID –
WINTER TESTING 2013-14

TRANSPORTATION DEVELOPMENT CENTRE WORK STATEMENT EXCERPT – AIRCRAFT & ANTI-ICING FLUID – WINTER TESTING 2013-14

5.50 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:

5.50.1 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) If necessary (not budgeted), 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 if necessary at the NRC CEF;

g) Analyze data and results; and

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

5.50.2 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 Ottawa 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.