TP 13487E

Development of a Plan to Implement a Full-Scale Test Site

Prepared for

Transportation Development Centre
On behalf of
Civil Aviation

Transport Canada

APS AVIATION INC.

October 1999

Final – Version 4.1

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by

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Un sommaire français se trouve avant la table des matières.

PREFACE

At the request of the Transportation Development Centre of Transport Canada, APS Aviation Inc. has undertaken a research program to advance aircraft ground deicing/anti-icing technology. The specific objectives of the APS test program are the following:

- To develop holdover time tables for new anti-icing fluids, and to validate fluid-specific and SAE holdover time tables;
- To gather enough supplemental experimental data to support the development of a deicing-only table as an industry guideline;
- To examine conditions for which contamination due to anti-icing fluid failure in freezing precipitation fails to flow from the wing of a jet transport aircraft when subjected to speeds up to and including rotation;
- To measure the jet-blast wind speeds developed by commercial airliners in order to generate air-velocity distribution profiles (to predict the forces that could be experienced by deicing vehicles), and to develop a method of evaluating the stability of deicing vehicles during live deicing operations;
- To determine the feasibility of examining the surface conditions on wings before takeoff through the use of ice-contamination sensor systems, and to evaluate the sensitivity of one ice-detection sensor system;
- To evaluate the use of warm fuel as an alternative approach to ground deicing of aircraft;
- To evaluate hot water deicing to determine safe and practicable limits for wind and outside ambient temperature;
- To document the appearance of fluid failure, to measure its characteristics at the point of failure, and to compare the failures of various fluids in freezing precipitation;
- To determine the influence of fluid type, precipitation (type and rate), and wind (speed and relative direction) on both the locations and times to fluid failure initiation, with special attention to failure progression on the Canadair Regional Jet and on high-wing turboprop commuter aircraft;
- To evaluate snow-weather data from previous winters to identify a range of snow-precipitation suitable for the evaluation of holdover time limits;
- To compare the holdover times from natural and artificial snow trials and to evaluate the functionality of the NCAR simulated snowmaking system; and
- To develop a plan for implementing a full-scale wing test facility that would enable the current testing of deicing and anti-icing fluids in natural and artificial freezing precipitation on a real aircraft wing.

The research activities of the program conducted on behalf of Transport Canada during the 1998-99 winter season are documented in twelve reports. The titles of these reports are as follows:

- TP 13477E Aircraft Ground De/Anti-icing Fluid Holdover Time Field Testing Program for the 1998-99 Winter;

- TP 13478E Aircraft Deicing Fluid Freeze Point Buffer Requirements for Deicing Only Conditions;
- TP 13479E Contaminated Aircraft Takeoff Test for the 1998-99 Winter;
- TP 13480E Air Velocity Distribution Behind Wing-Mounted Aircraft Engines;
- TP 13481E Evaluation of Ice Detection Sensor Capabilities for End-of-Runway Application;
- TP 13482E Evaluation of Warm Fuel as an Alternative Approach to Deicing;
- TP 13483E Hot Water Deicing of Aircraft;
- TP 13484E Characteristics of Failure of Aircraft Anti-Icing Fluids Subjected to Precipitation;
- TP 13485E Aircraft Full-Scale Test Program for the 1998-99 Winter;
- TP 13486E Evaluation of Snow Weather Data;
- TP 13487E Development of a Plan to Implement a Full-Scale Test Site; and
- TP 13488E Evaluation of NCAR's Snow Generation System.

This report, TP 13487E, has the following objective:

- To develop a plan for implementing a full-scale wing test facility that would enable the current testing of deicing and anti-icing fluids in natural and artificial freezing precipitation on a real aircraft wing.

This objective was met by obtaining several quotations for the purchase and delivery of a surplus wing. Quotations were also obtained for the design and fabrication of a wing mount assembly. Finally, deicing test sites were examined based on certain requirements, such as ease of access and ability to contain sprayed fluids.

ACKNOWLEDGEMENTS

This research has been funded by the Civil Aviation Group, Transport Canada, and with support from the Federal Aviation Administration. This program could not have been accomplished without the participation of many organizations. APS would like to thank, therefore, the Transportation Development Centre of Transport Canada, the Federal Aviation Administration, the National Research Council Canada, Atmospheric Environment Services Canada, Transport Canada, and several fluid manufacturers. Special thanks are extended to USAirways Inc., Delta Airlines, Royal Airlines, Air Canada, the National Research Council Canada, Canadian Airlines International, AéroMag 2000, Aéroport de Montreal, the Greater Toronto Airport Authority, Hudson General Aviation Services Inc., Union Carbide, RVSI, Cox and Company Inc., the Department of National Defence, and Shell Aviation, for provision of personnel and facilities and for their co-operation on the test program. APS would like also to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data.

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Research reports produced on behalf of Transport Canada for testing during previous winters are available from the Transportation Development Centre (TDC). Twelve reports (including this one) were produced as part of this winter's research program (1998-99). Their subject matter is outlined in the preface.

16. Abstract

The objective of this study was to develop a plan to implement a full-scale test site, centred around a wing test bed.

Several aircraft salvage companies were contacted to locate and purchase a wing. Price quotations for 14 aircraft wings were evaluated and a Lockheed Jetstar wing was purchased.

The design and fabrication of a wing mounting system were also explored. Quotations for four wing dolly assemblies, which would hold the wing at an ideal working height and facilitate movement and use of the wing, were evaluated.

The final phase of the study involved the examination and selection of a suitable full-scale test site. The central deicing facility at Dorval Airport was selected for outdoor testing because it addressed several concerns, including accessibility, security, and proximity to current APS test installations. Furthermore, the facility is equipped with a glycol recovery system. For indoor testing, the wing can be suitably tested at the National Research Council's Climatic Engineering Facility.

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Les rapports de recherche produits au nom de Transports Canada sur les essais réalisés au cours des hivers antérieurs peuvent être obtenus auprès du Centre de développement des transports (CDT). Le programme de la saison hivernale 1998-1999 a donné lieu à douze rapports (dont celui-ci). On trouvera dans la préface l'objet de ces rapports.

16. Résumé

Cette étude visait la mise au point d'un plan d'implantation d'une installation d'essai en vraie grandeur, articulée autour d'une aile d'avion.

Les chercheurs ont contacté plusieurs entreprises d'enlèvement d'aéronefs accidentés, en quête d'une aile d'avion. Ils ont obtenu et étudié des propositions de prix pour 14 ailes. Leur choix a finalement porté sur une aile de Lockheed Jetstar.

Les travaux ont ensuite consisté à étudier et fabriquer un montage d'essai. Quatre propositions de chariots-supports pouvant soutenir l'aile à une hauteur optimale et en faciliter le mouvement et la manipulation lors des essais, ont été évaluées.

La dernière phase de l'étude a consisté à choisir un site adéquat pour la mise à l'essai de l'aile. Le poste de dégivrage central de l'Aéroport de Dorval a été retenu pour les essais extérieurs, se révélant commode à plusieurs égards (accessibilité, sécurité et proximité des installations d'essai existantes d'APS). Ce poste a aussi l'avantage d'être équipé d'un système de récupération du glycol. Pour les essais intérieurs, l'installation de génie climatique du Conseil national de recherches du Canada serait l'endroit tout désigné.

17. Mots clés Aile d'aéronef, Jetstar, montage d'aile, site d'essai en vraie grandeur	18. Diffusion Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

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EXECUTIVE SUMMARY

The full-scale test site implementation study involved three phases: purchase of a wing, mounting of the wing on a suitable platform, and selection of an ideal test location.

Following a long and sometimes difficult search, a Lockheed Jetstar wing was purchased during the 1998-99 test season. The wing's control surfaces were not attached upon delivery and remain in wooden storage crates, all stored at the National Research Council Canada (NRC). The exterior fuel tanks have been removed and fairings need to be added to maintain the original wing profile.

Quotations for the design and fabrication of the wing dolly assembly were received from several companies, including NRC. The assembly's design would hold the wing at the normal aircraft height and facilitate movement and use of the wing during tests. The assembly would allow for low-speed towing over short distances. The wing dolly assembly would be lifted onto a flatbed truck for any long-distance transportation. Because the aircraft wing is already located on the NRC premises, fabrication of the dolly assembly could be performed by NRC personnel. The estimated total cost of re-attaching the control surfaces and mounting the wing on the dolly assembly would be less than $18 000 (CDN).

Dorval Airport's deicing facility, operated by Aeromag 2000, was selected as the outdoor test site because it addressed several APS concerns, including ease of access, security, and proximity to current APS test installations. The facility is also equipped with a glycol recovery system. Furthermore, Aeromag deicing vehicles and personnel could be used in the spraying of fluids during wing tests. NRC's Climatic Engineering Facility in Ottawa would be a suitable location for wing tests conducted in simulated conditions.

SOMMAIRE

L'étude d'implantation d'un site d'essai en vraie grandeur comportait trois phases : achat d'une aile, montage de l'aile sur un support approprié, et choix d'un endroit optimal pour réaliser les essais.

Après une recherche longue et parfois ardue, une aile de Lockheed Jetstar a finalement été achetée, au cours de la saison d'essai 1998-1999. L'aile a été livrée avec ses gouvernes détachées. Le tout est présentement gardé dans des caisses d'entreposage en bois, au Conseil national de recherches du Canada (CNRC). Les réservoirs de carburant extérieurs ont été enlevés et il reste à ajouter des éléments de carénage pour redonner à l'aile son profil d'origine.

Quelques propositions pour l'étude et la fabrication d'un chariot-support pour l'aile ont été reçues, dont une du CNRC. Ce dispositif doit pouvoir soutenir l'aile à sa hauteur fonctionnelle normale, et en faciliter le mouvement et la manipulation lors des essais. L'ensemble doit également permettre de déplacer l'aile à faible vitesse sur de courtes distances. Pour le transport sur de longues distances, le chariot-support sera placé sur un fardier. Comme l'aile se trouve déjà au CNRC, il serait commode de confier la fabrication du chariot-support au personnel du CNRC. Les dépenses nécessaires pour l'assemblage des gouvernes et le montage de l'aile sur le chariot-support sont évaluées à moins de 18 000 $CAN au total.

Le poste de dégivrage de l'Aéroport de Dorval, exploité par Aeromag 2000, a été retenu pour les essais extérieurs, car il se révèle commode à plusieurs égards (facilité d'accès, sécurité et proximité des installations d'essai existantes d'APS). Ce poste a aussi l'avantage d'être équipé d'un système de récupération du glycol. De plus, on pourrait recourir aux véhicules et au personnel d'Aeromag pour la pulvérisation des liquides aux fins des essais. Pour les essais sous précipitations simulées, l'installation de génie climatique du Conseil national de recherches du Canada à Ottawa serait l'endroit tout désigné.

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1. INTRODUCTION

At the request of the Transportation Development Centre, APS has undertaken a research program to further advance aircraft ground deicing/anti-icing technology.

Aircraft ground deicing/anti-icing has been the subject of concentrated industry attention over the past decade due to a number of fatal aircraft accidents. Recent attention has been placed upon the enhancement of anti-icing fluids to provide an extended duration of protection against further contamination following initial deicing. This has led to the development of fluid holdover time tables (HOT tables), used by aircraft operators, and accepted by regulatory authorities. New fluids continue to be developed specifically to prolong fluid holdover times without compromising airfoil aerodynamics.

APS has conducted over 250 full-scale aircraft tests since 1993. Over the past few years, securing aircraft for full-scale testing has become increasingly difficult, due to the complexities of these trials.

This document reports the results of an APS study carried out over the 1998/99 test season on several subjects related to full-scale aircraft testing. This study considers the major aspects of the development of a plan to implement a full-scale test site, including a wing test bed.

Objectives

Due to the difficulties encountered in securing aircraft for full-scale testing in recent years, APS was asked to examine the feasilbility of implementing a full-scale test site. The work statement, not included in this report, states the following:

Develop a plan for implementing a deicing test site, centred on an aircraft wing and supported by current fluid and rainmaking sprayers.

The plan shall include the acquisition of a surplus complete wing, from either a scrapped or an accidented moderate sized aircraft or an outboard section of a larger aircraft. The wing section should, if possible, include ailerons and leading edge slats. The design of the test site shall include a test area that could contain and recover sprayed fluids. Installation of the wing should entail a mounting designed to allow the wing to be rotated relative to current winds. The site must be secure yet allow ease of access and ability to install inexpensive solutions to control sprayed fluid. Costs shall be estimated for the main elements of the development of a wing test *bed site including wing purchase and delivery, site lease and development, and wing mount design and fabrication.*

The initial work statement did not include the purchase of the selected wing; however, APS was instructed to proceed with the procurement of the wing during the 1998/99 test season.

2. TEST PLAN CONSIDERATIONS

2.1 Wing Acquisition

The implementation of a full-scale test site was explored by APS during the 1998/99 test season, prompted by recent problems obtaining operational aircraft for full-scale testing. The acquisition of a surplus wing, complete with all flight control surfaces, was central to the development of a test plan. The wing was to be obtained from either a scrapped or accidented moderate sized aircraft or an outboard wing section of a larger aircraft.

For manoeuvrability and to minimize costs, the wings of small executive jets (including all flight controls), such as the Falcon 20, were considered the best option. The possibility of purchasing a small section of a larger aircraft wing, such as a DC-9, was also considered. Salvage and retrieval companies, government agencies and insurance companies, were contacted in an effort to obtain quotations for various aircraft wings. The complete list of quotations obtained is shown in Table 2.1.

Initial efforts focused on the purchase of an accidented Canadair Regional Jet wing, considered available following the crash of an RJ in Fredericton in 1997. Despite considerable effort, all attempts in obtaining this wing from the insurance company failed.

Inquiries were also made to the Crown Assets Distribution Centre of Public Works and Government Services Canada to potentially locate a suitable wing. These attempts were unsuccessful.

Following lengthy discussions with over twenty salvage and retrieval companies in the Unites States, quotations for 14 different aircraft wings were obtained from four different companies. Using the information obtained, APS compiled a list of five suitable wings, with consideration given to cost and size. A document was compiled for the five wings and appears in Figures 2.1 to 2.3.

2.2 Test Bed Design Considerations

The design and fabrication of a wing mounting system were also explored. For practical purposes, designs examined allowed the wing to be rotated relative to winds as well as being easily transportable from one test location to another.

Table 2.1

Quotations Obtained for Various Aircraft Wings

Aircraft	Source	Location	Quotation ($US)
Canadair RJ	Airclaims International	Montreal, Quebec	N/A
Dassault Falcon 20	White Industries	Bates City, Missouri	$225,000
Dassault Falcon 20	White Industries	Bates City, Missouri	$150,000
Dassault Falcon 10	White Industries	Bates City, Missouri	$250,000
Dassault Falcon 10	White Industries	Bates City, Missouri	$140,000
Beechcraft Diamond Jet	White Industries	Bates City, Missouri	$140,000
Hawker Siddeley HS-125	White Industries	Bates City, Missouri	$55,000
Fokker F-27	White Industries	Bates City, Missouri	$50,000
Mitsubishi MU-2	White Industries	Bates City, Missouri	$50,000
Cessna Citation 500	Duncan Aviation	Battle Creek, Michigan	$25,000
Fokker F-28	Memphis Group	Memphis, Tennessee	$50,000
McDonnell Douglas DC-9	Memphis Group	Memphis, Tennessee	$50,000
Lear 24	Dodson International	Rantoul, Kansas	$50,000
Lockheed Jetstar	Dodson International	Rantoul, Kansas	$22,500
Beechcraft Diamond Jet	Dodson International	Rantoul, Kansas	$90,000

Figure 2.1
Aircraft Wing Options – Lockheed Jetstar

In no particular order:

1. Aircraft: **Lockheed Jetstar** quoted price: $22,500 US
   Supplier: Dodson International
   Ottawa, Kansas

   Wing length: 23 ft Wing chord (root): 13.5 ft
   Wing chord (tip): 5 ft

   Design Features: All aluminum construction, external wing tanks, no spoilers or slats.

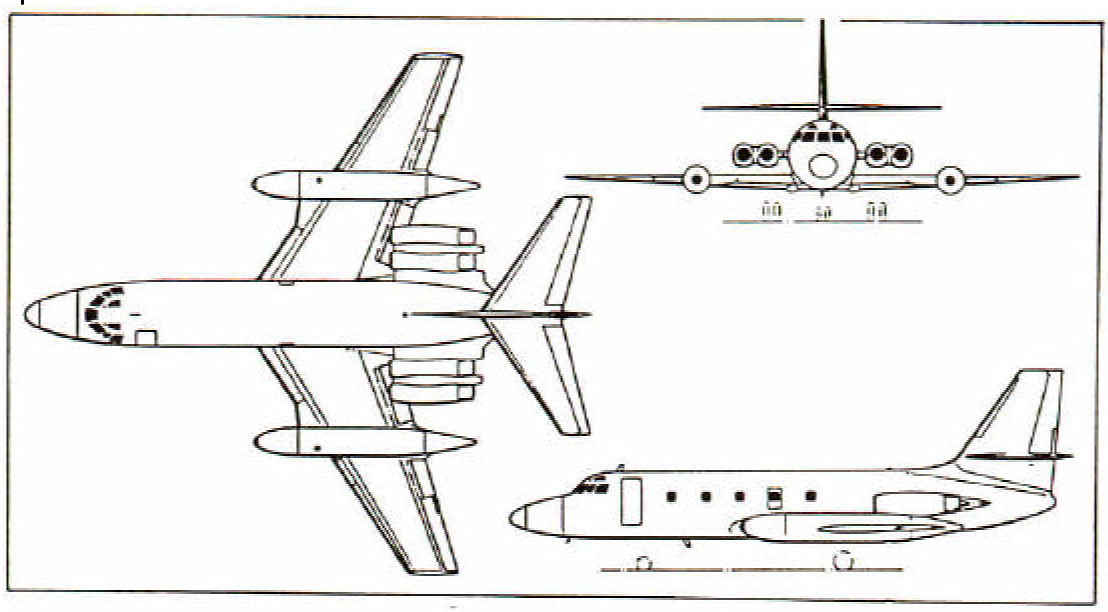


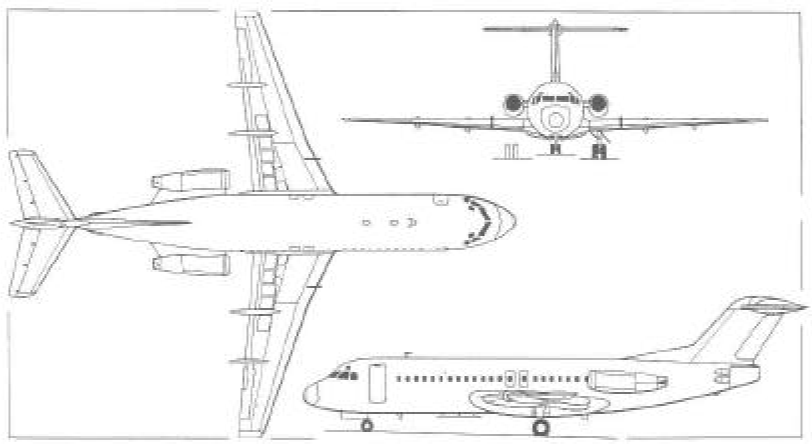
Figure 2.2

Aircraft Wing Options – F-28 and DC-9

2. Aircraft: **Fokker F-28** quoted price: $50,000 US
   Supplier: The Memphis Group
   Memphis, Tennessee

   Wing length: 33 ft   Wing chord (root): 16 ft
   Wing chord (tip): 6 ft

   Design Features: All aluminum construction, hard wing, five-section spoilers.



3. Aircraft: **McDonnell Douglas DC-9-30** quoted price: $50,000 US
   Supplier: The Memphis Group
   Memphis, Tennessee

   Wing length: 43 ft

   Design Features: All metal construction, aileron with tab, three spoilers, full-length leading edge slats (former Air Canada aircraft).

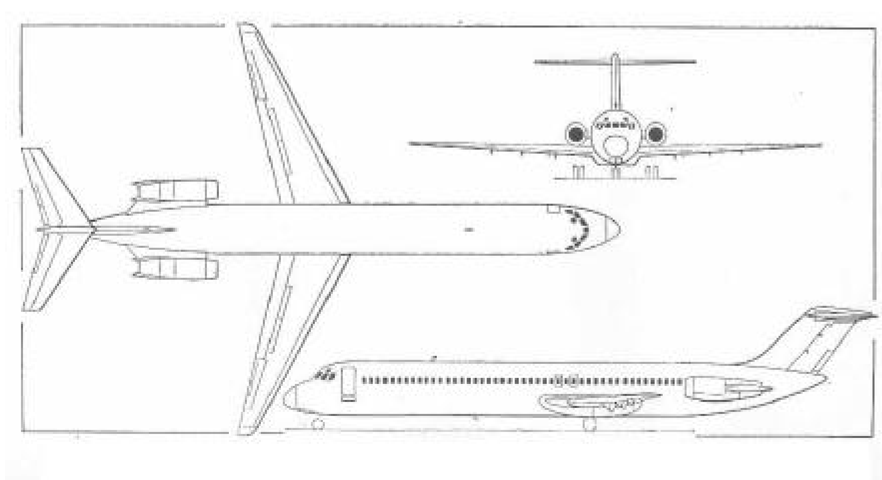


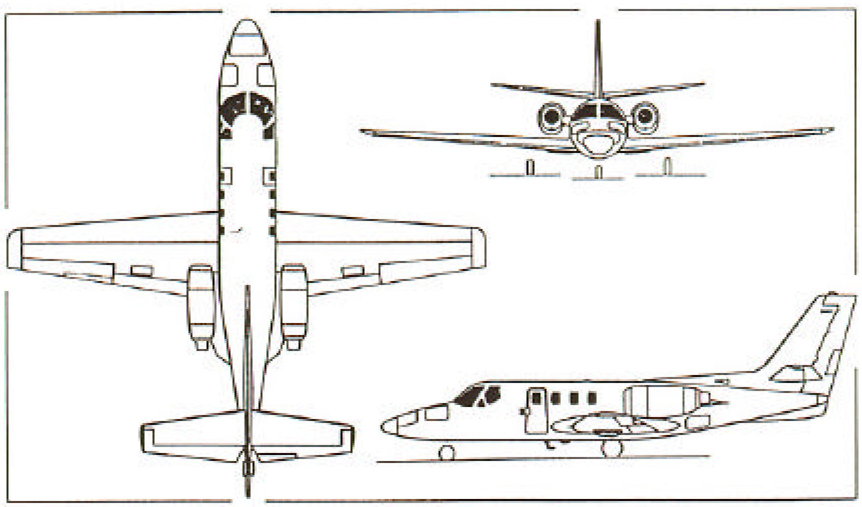
Figure 2.3

Aircraft Wing Options – Citation 500 and HS-125

4. Aircraft: **Cessna Citation 500** quoted price: $25,000 US
   Supplier: Duncan Aviation
   Battle Creek, Michigan

   Wing length: 22 ft

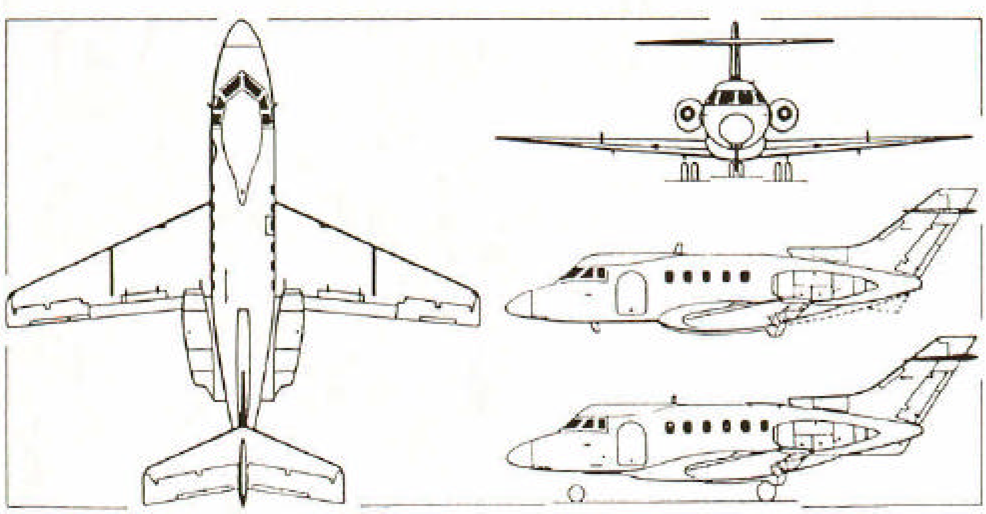
   Design Features: Hard wing, spoiler, aileron with tab, flap.



5. Aircraft : **Hawker Siddeley HS-125** quoted price: $55,000 US
   Supplier: White Industries
   Bates City, Missouri

   Wing length: 21 ft

   Design Features: Hard wing, spoilers, aileron with tab, flap.



2.3 Test Site Selection Considerations

Finally, test sites were examined based on certain requirements including ease of access, security, proximity, and the containment and recovery of sprayed fluids.

3. ACQUISITION DETAILS AND COST ESTIMATES

3.1 Wing Acquisition

Quotations for the purchase of fourteen aircraft wings were obtained by APS personnel. Due to aircraft wing size considerations and to minimize costs, this number was later narrowed down. The five proposed aircraft wing options were compiled in the document presented in Figures 2.1 to 2.3.

The Fokker F-28 aircraft wing, available from the Memphis Group, was selected. The F-28 wing was reasonably small, inexpensive, and was the same type of aircraft involved in the Dryden and LaGuardia accidents, both caused by ground deicing deficiencies. Following lengthy discussions, a purchase price for the entire wing was agreed on, and delivery of the wing was anticipated. Prior to completion of the deal, APS requested photographs of the wing to ensure its integrity. Upon inspection of the photographs, it was apparent that the wing was not intact. All control surfaces and several wing panels were missing (see Photos 3.1 and 3.2).

It was then decided to attempt to purchase one of the available executive jet wings. Inquiries into the conditions of the various wings available were then made. Duncan Aviation informed APS that the Citation 500 wing that they had offered was incomplete. The same situation occurred in the case of the Hawker Siddeley HS-125, offered by White Industries. Dodson International, owners of the Lockheed Jetstar wing, assured APS that the wing offered was fully intact. Digital photos confirmed the adequate condition of the wing (see Photo 3.3). Although the control surfaces were not attached to the wing in the photos, Dodson assured APS that they were available, having merely been removed for proper storage, and would be delivered with the main wing section if an agreement was signed between the two parties. The external fuel tanks had been removed, requiring a fairing in order to maintain the original wing profile. After several offers and counter offers, a negotiated price for the wing was reached: $20 000 US, including delivery of the wing from Kansas to the National Research Council Canada in Ottawa.

The Lockheed Jetstar wing was delivered shortly thereafter to the NRC's Climatic Engineering Facility in Ottawa. The truck and trailer used to transport the wing from Kansas to Ottawa are shown in Photos 3.4 and 3.5. As promised, all aircraft control surfaces were packaged in wooden crates and delivered with the main wing section (see Photo 3.6). The wing was removed from the transportation vehicle using a forklift operated by NRC personnel (see Photo 3.7), and was placed on blocks outside the NRC facility. The overall condition of the wing and control surfaces was deemed to be highly satisfactory upon initial inspection by APS personnel.

It is anticipated that the costs to reassemble the wing and remove the rubber deicing boot will be less than $3 000 (CDN).

3.2 Mounting of the Wing

The second phase of the full-scale test site implementation study considers mounting the acquired wing onto a platform. The ideal design of the platform would: hold the wing at an ideal working height; facilitate movement (rotation); permit actuation of the wing panel during testing; and allow for low-speed towing for short distance transportation. Several companies, such as Lazer Inox, Max-Atlas, Chagnon Ltée, and NRC were approached to tender quotations for the design and fabrication of a wing dolly system. Quotations obtained are included in Figures 3.1 and 3.2.

Similar dolly designs were proposed by every company. In general, the dolly would consist of two separate components, one to support the wing at the wing root, and the second to support the wing at the wing tip. The dolly assembly would fasten to existing attachment points at the wing root, while requiring minor modifications to the wing tip in order to facilitate the attachment of the dolly assembly at that end. The portion of the assembly at the wing root would consist of two non-swivelling wheels. The portion of the assembly at the wing tip would consist of one retractable swivelling wheel, two retractable feet that could be extended for stability during testing, and a towing eye. The dolly assembly would be designed so that the working height of the top surface of the wing would be approximately five feet above the ground.

The quotations received for the design and fabrication of the wing dolly assembly varied in price from $13 600 to $20 000. The price quoted NRC was $14 000. Since the aircraft wing is at NRC, this would appear be the most cost-effective and convenient option.

Since the design of the proposed wing dolly assembly does not conform to the highway code, transportation companies were contacted in order to determine the costs related to the transportation of the wing dolly assembly from the NRC to the proposed outdoor test site in Montreal by means of a flat-bed truck. The average transportation costs for a one-way delivery between Montreal and Ottawa was $1 200 (CDN). Further costs would be incurred from the loading and unloading of the dolly assembly, which would require a forklift or a crane. In Ottawa, loading and unloading of the wing assembly would be performed by NRC personnel for a nominal charge. In Montreal, a suitable forklift could be rented for approximately $500/day.

FIGURE 3.1

Quotation Received for the Design and Fabrication of the Wing Dolly System

Les Soudures Chagnon Itee.

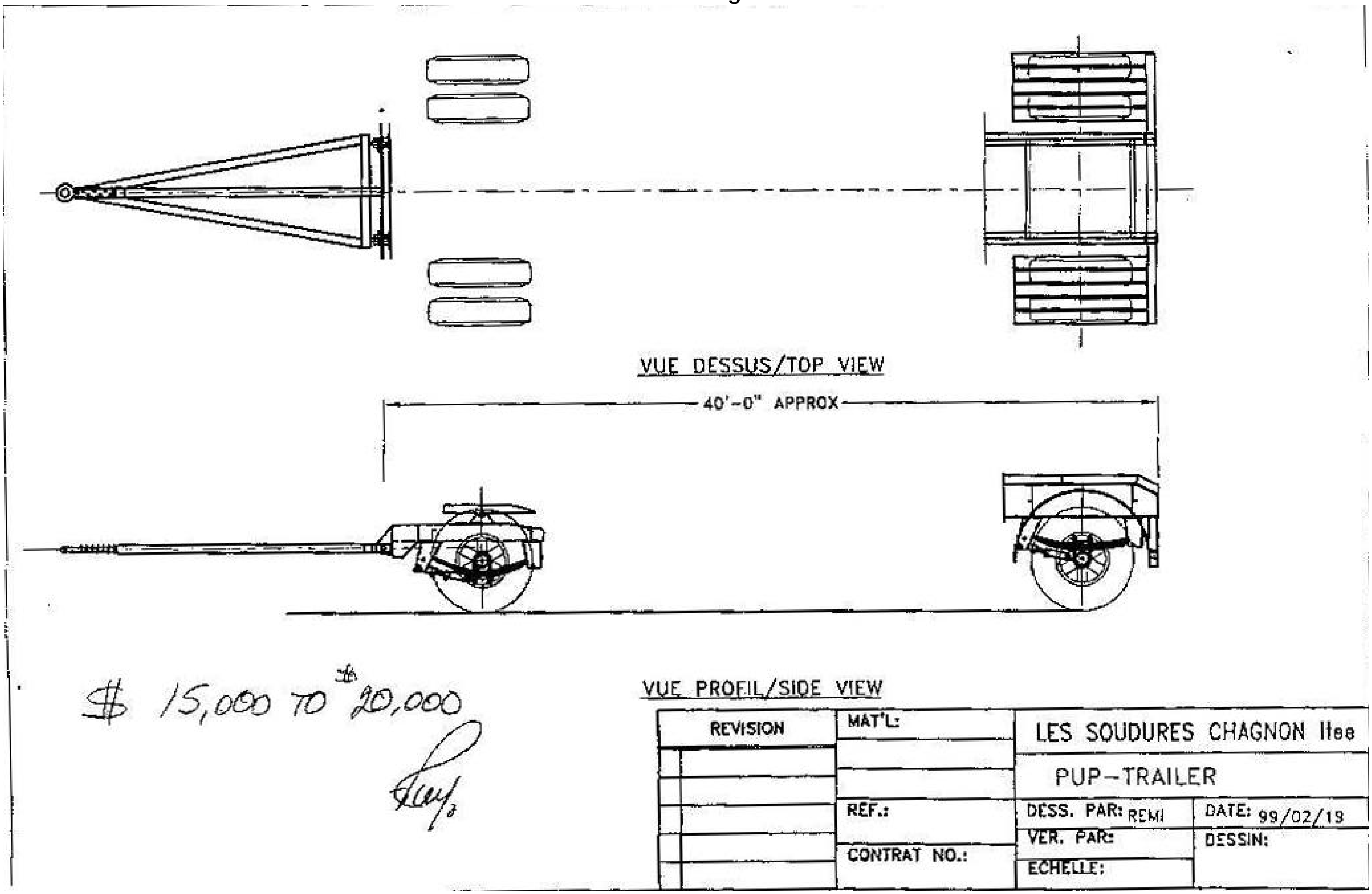
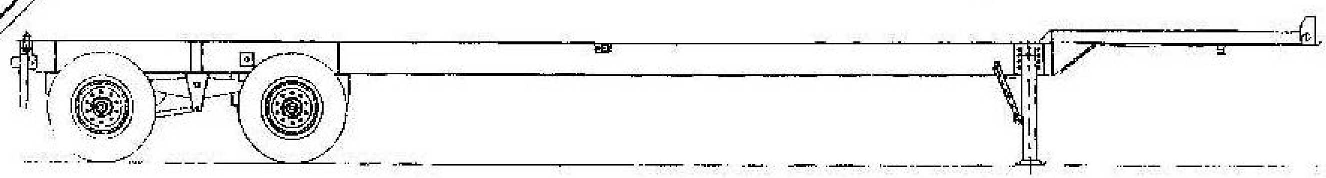


FIGURE 3.2

Quotation Received for the Design and Fabrication of the Wing Dolly System

Max-Atlas Equipment International Inc.



SPÉCIFICATIONS CONFORMES
PORTE-CONTENEUR 40' REMORQUE POIDS ALLÉGÉ
MODÈLE CCLW 40-2

DIMENSION :
Longueur : 40' 5"
Largeur : 96"
Hauteur en arrière : 48"

TIGES D'ACCOUPLEMENT :
Hauteur d'accouplement 48"
Tiges d'accouplement placées à 30" de l'avant. Plaque d'accouplement 3/8" (high tensile).

STRUCTURE :
Poutre à larges ailes : 12" x 19 lbs/pi
Tube carré 5" x 5" x 3/8"
Profil en U, 6" x 1.92" x 8.2 lbs/pi

SUPPORTS VERTICAUX :
Marque : Holland
Modèle : Mark V
Capacité : 200,000 lbs
Sabot : 12" x 12" avec essieux pleins

SUSPENSION :
Train : Fixe Marque : Reyco
Modèle : 91½
Espacement : 72" Tandem

RESSORTS :
3 lames, capacité de 11,000 livres de chaque côté.

ESSIEUX : (2)
Marque: Hayes Dana/Ingersoll
Modèle : D22 Voie : 71 ½
Diamètre : 5" standard tubulaire ½" mur

ROUES :
Unimount, disque acier 10 trous.

JANTES :
20" X 8.25"

FREINS :
16.5" x 7" x 0.75" conforme CMVSS

CHAMBRE À AIR :
Frein à ressort, système à l'air 30" diaphragme en double.

PNEUS :
Goodyear G 114, 11R 22.5, 14 plis

LUMIÈRES ET FILAGE :
Système étanche, 12 volts connecteurs 6 et 7 selon les normes canadiennes de la sécurité.

RUBAN RÉFLECTEUR :
Selon la norme DOT C2.

BARRURE DE CONTENEUR :
(4) Quatre verrous de coin.

PEINTURE :
Préparé au jet de sable sous pression,recouvert d'une couche de base(Primer)et de peinture commerciale couleur au choix du client.

MAX-ATLAS ÉQUIPEMENT INTERNATIONAL INC.

371 Grand Bernier Nord
Saint-Jean-sur-Richelieu (Québec) J3B 4S2

Tél :(514) 346-8848
Fax : (514) 358-5077

PRICE $ 13,586.00

3.3 Selection of a Test Site

The third and final phase of the full-scale test site implementation study involved the examination and selection of a suitable full-scale test site. In addressing this objective, certain requirements, such as accessibility, security, proximity to current APS installations, and containment and recovery of sprayed fluids were examined. The centralized deicing facility at Dorval Airport, operated by Aeromag 2000, was selected because it addressed every concern: the deicing facility is easily accessible, secure, located within one kilometre of the APS test site at Dorval Airport, and is equipped with a glycol recovery system. Furthermore, Aeromag deicing vehicles and personnel could be used in the spraying of fluids during wing tests. Outdoor tests using artificial precipitation sprayers could also be carried out at this facility. In return for the use of the facility, APS would make the wing section available to Aeromag personnel for training purposes.

Alternative locations for the conduct of outdoor testing include outside of NRC's Climatic Engineering Facility in Ottawa and outside of the ADGA hangar at Gatineau Airport.

NRC's Climatic Engineering Facility would be an ideal location for the conduct of any indoor tests in simulated precipitation. An alternative indoor site could be the Institut de Recherche d'Hydro-Québec (IREQ) climatic chamber in Varennes.

3.4 Lockheed JetStar Wing Geometry

The following information pertains to the design characteristics of the Lockheed Jetstar wing:

- Wing section NACA 63A112 at the wing root;
- Wing section NACA 63A309 (modified) at the wing tip;
- Wing chord of 4.16 m at the wing root (13 ft 7¾ in);
- Wing chord of 1.55 m at the wing tip (5 ft 1 in);
- Incidence 1° at the wing root, -1° at the wing tip;
- Sweepback 30° at quarter-chord;
- Conventional fail-safe stressed-skin structure of high-strength aluminum; and
- Aluminum alloy aileron, double-slotted all-metal trailing edge flap; hinged leading edge flap, no spoilers.

The following page shows a diagram of the Lockheed JetStar wing including dimensions (Figure 3.3), as well as a schematic of the wing in relation to the National Research Council CEF cold chamber (Figure 3.4).

Figure 3.3
Lockheed JetStar Wing Dimensions

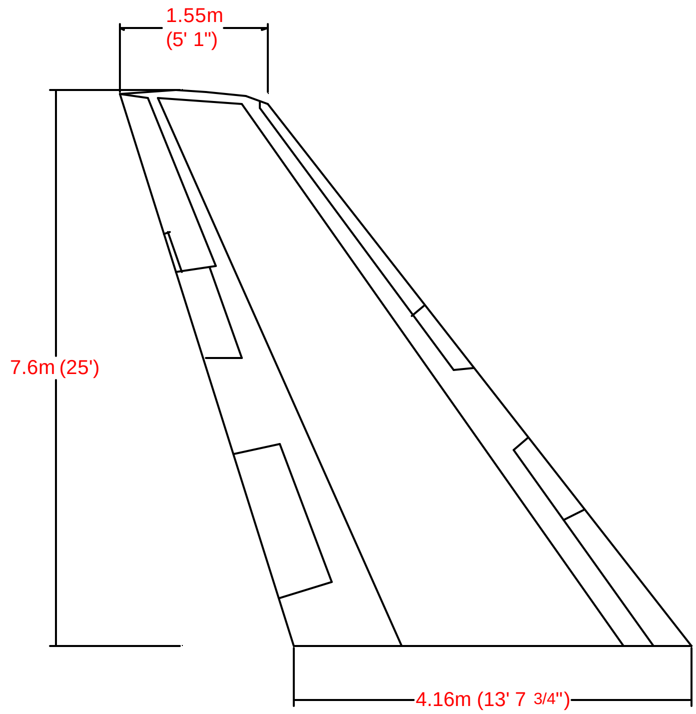


Figure 3.4
Lockheed JetStar Wing at National Research Council CEF

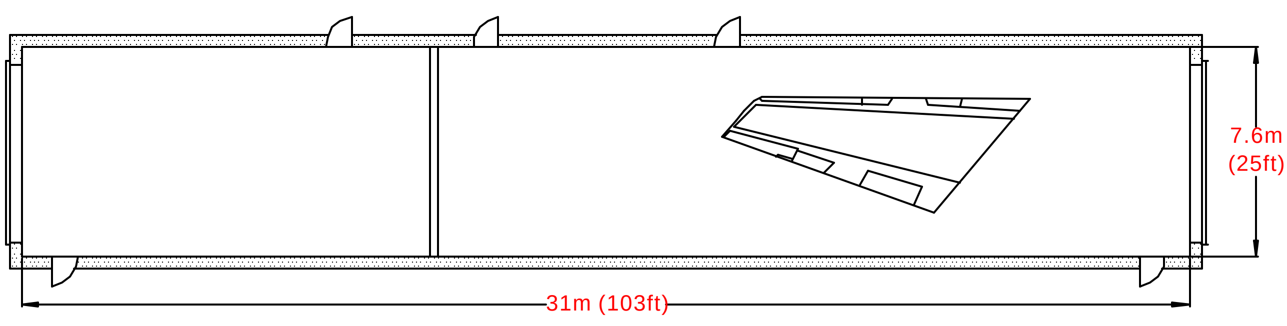


Photo 3.1
Fokker F-28 Starboard Wing Without Leading Edge and Control Surfaces

Photo 3.2
Fokker F-28 Port Wing Without Leading Edge and Control Surfaces

Photo 3.3
Wings of the Lockheed Jetstar at Dodson International in Kansas

Photo 3.4
Truck and Trailer Used to Transport Jetstar Wing

Photo 3.5
Jetstar Wing Upon Arrival in Ottawa

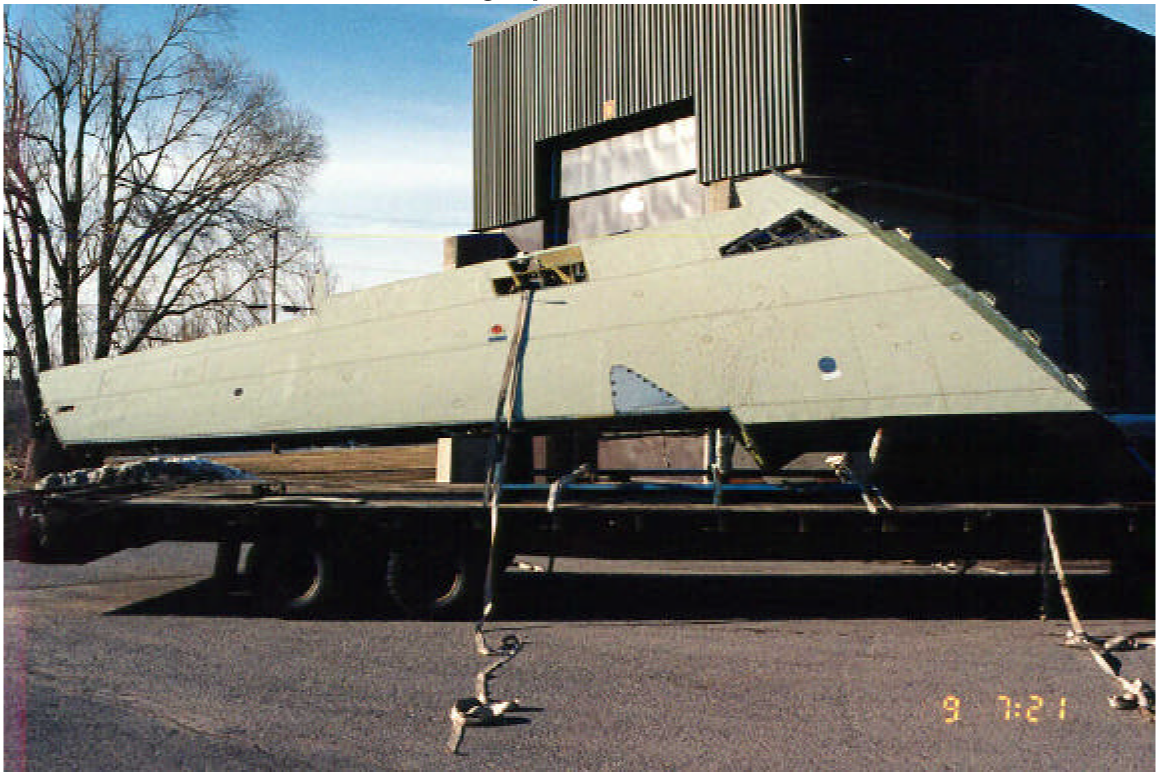


Photo 3.6
Jetstar Wing Control Surfaces

Photo 3.7
Removal of the Wing from the Transportation Vehicle

4. RECOMMENDATIONS

It is recommended that:

- The Lockheed Jetstar wing be reassembled;
- The fabrication of the wing dolly assembly be performed by the National Research Council in Ottawa;
- The Jetstar wing and wing dolly assembly be used in future full-scale aircraft trials in both natural and simulated precipitation conditions, including, but not limited to, forced air trials, ice detection sensor evaluation;
- Consideration should be given to exploring whether the fuel tanks could be filled with fluid for the conduct of cold-soaked wing trials; and
- Testing and comparison of failures on this wing in natural and artificial freezing precipitation be undertaken, to document similarities and differences between this wing and those of aircraft of primary interest.

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