TERMS OF REFERENCE

Canadian ADS-B Out Performance Requirement Mandate

NAV CANADA
Navigation and airspace
Level of Service
77 Metcalfe Street, 7th Floor
Ottawa, Ontario
K1P 5L6

August 2017

The information and diagrams contained in this Terms of Reference are for illustrative purposes only and are not to be used for navigation.

TABLE OF CONTENTS

1.0 Purpose

The purpose of this Terms of Reference (TOR) document is to initiate an aeronautical study to deliberate a requirement for a Canadian Automatic Dependent Surveillance – Broadcast (ADS-B) Out performance requirement mandate, to enhance surveillance services and provide air traffic control (ATC) with more accurate information to safely separate aircraft in the air in order to improve efficiency and aviation safety.

2.0 Scope of the study

The aeronautical study will determine the requirement for a Canadian ADS-B Out performance requirement mandate in the Canadian Domestic Airspace using a phased approach as follows:

1. Class A, B and FL600 and Above (Class E).
2. Class C Airspace, Class D Control Zones and Class E Control Zones.
3. All other controlled airspace.

The Aeronautical Study will determine the implementation plan. Consultations for each phase will be based on system impact and affected customers and stakeholders. This will include IFR and VFR operations.

3.0 Background

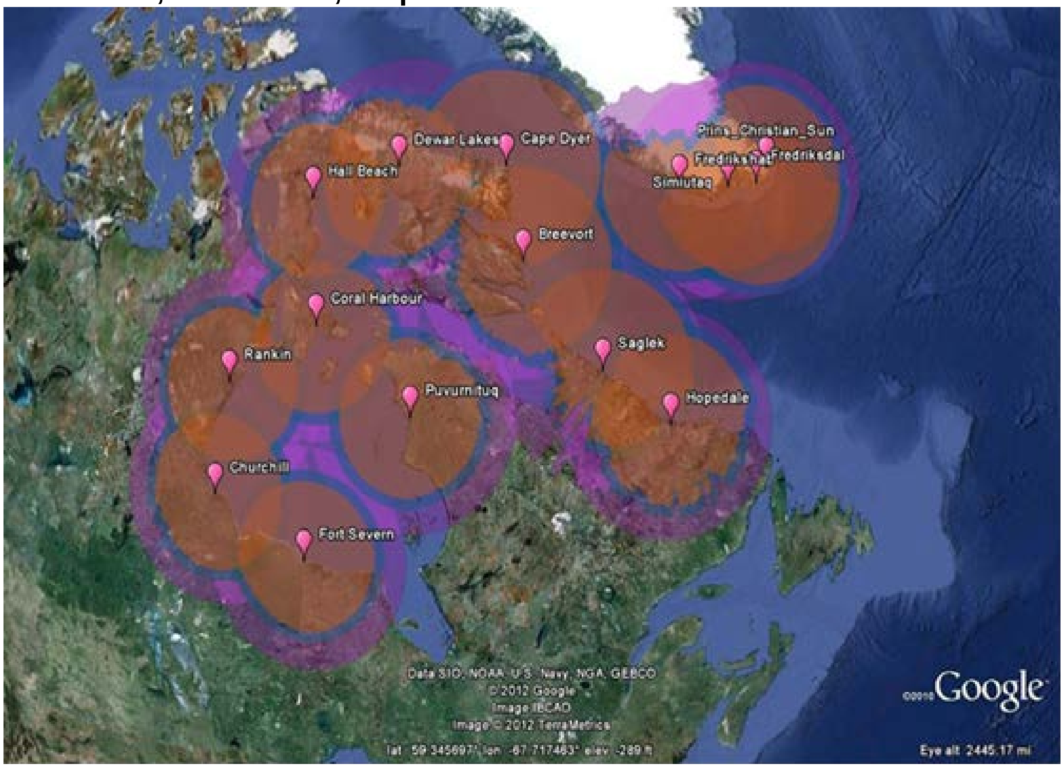
3.1 The ADS-B System

ADS-B Out is a technology that enhances safety and efficiency and benefits pilots, controllers, airports, aircraft operators and the public.

ADS-B Out is a system in which electronic equipment onboard an aircraft automatically broadcasts flight information from the aircraft via a digital data link. The data can be used by air traffic control to depict the aircraft’s position and altitude on display screens without the need for radar and at a much lower cost.

Using ADS-B, we have extended our air traffic surveillance to cover 4 million square kilometres of airspace (see figure 1). This expansion of surveillance coverage is estimated to save our customers an estimated $374 million in fuel costs by 2020 by enabling more fuel efficient routings, while reducing greenhouse gas emissions by an estimated 982,000 metric tons. (Collaborative Initiatives for Emissions Reductions- CIFER report 2016)

Figure1 Canadian ground based ADS-B Coverage Map:
Red 18000', Blue 24000', Purple 60000'



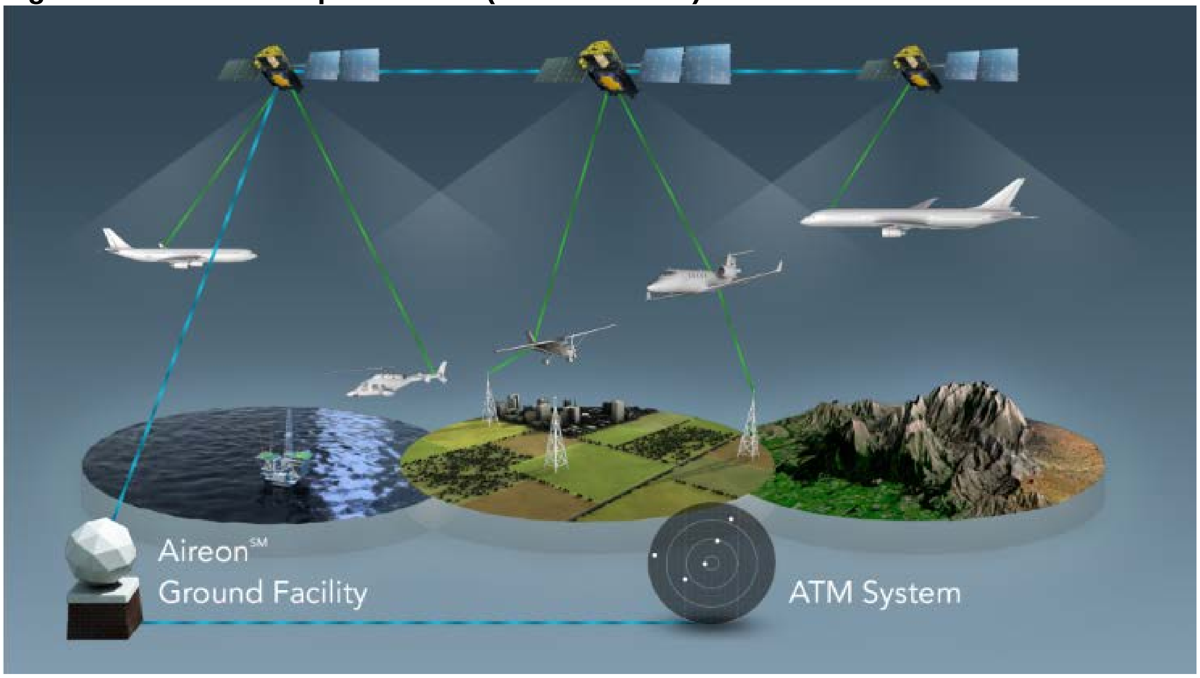
Automatic - Requires no pilot input or external interrogation.
Dependent – Depends on accurate position and velocity data supplied by the aircraft's navigation system.
Surveillance – Provides aircraft position, altitude, velocity, and other surveillance data to facilities that require the information.
Broadcast – Information is continually broadcast.

ADS-B data is broadcast every half-second on a 1090MHz digital data link. Broadcasts may include:

- Flight Identification (flight number or aircraft call sign)
- ICAO 24-bit Aircraft Address (globally unique airframe code)
- Position (latitude/longitude)
- Position integrity/accuracy (GPS horizontal protection limit)
- Barometric and Geometric Altitudes
- Vertical Rate (rate of climb/descent)
- Track Angle and Ground Speed (velocity)
- Emergency indication (when emergency code selected)
- Special position identification (when IDENT selected)

ADS-B ground stations are line-of-sight facilities. The ability for a ground station to receive ADS-B data from an aircraft depends on the aircraft's altitude, distance from the station and obstructing terrain (see figure 2). Coverage at high altitudes can exceed 250 nautical miles.

Figure 2 Ground and Space based (LEO Satellites) ADS-B



The International Civil Aviation Organization (ICAO), a United Nations specialized agency, specifies Automatic Dependent Surveillance – Broadcast (ADS-B) Out 1090 (digital data link frequency in MHz) ES (extended squitter) as the preferred surveillance system in the ICAO Global Air Navigation Plan as it is safer, provides richer and more accurate data to air traffic controllers, and enables more efficient use of airspace in combination with performance based navigation (PBN).

ADS-B OUT and PBN both rely on Global Navigation Satellite Systems (GNSS). It is therefore critical that the ADS-B Out work aligns with the Performance-based Navigation (PBN) implementation program.

In the Transport Canada PBN State Plan Block 1 2018-2022, Section 9.2.3. - Surveillance Key Goals

- Require ADS-B equipment for use in designated airspace.
- Regulatory changes to allow implementation of ADS-B mandatory airspace and to set ADS-B avionics equipment standards.

NAV CANADA ADS-B Timelines:

- Voluntary equipage – mixed mode operations
- 2009 - ADS-B surveillance separation in the Hudson and Minto Sectors
- 2010 - ADS-B surveillance separation in eastern Canada
- 2012 – ADS-B in southern Greenland serving a portion of the NAT
- 2014 - Ops Spec approval requirement removed
- 2017 – Develop a Preliminary Analysis and Terms of Reference for a proposed ADS-B Out mandate

Three Hazard Identification Risk Assessments (HIRA) for the use of Automatic Dependent Surveillance Broadcast (ADS-B) for surveillance in the Airspace surrounding Hudson Bay, Canada, were conducted prior to the implementation. The first was an initial investigation into the use of ADS-B technology (June 2006) for the purpose of aircraft surveillance; the second was dedicated to proceeding to operational ADS-B status in the area surrounding Hudson Bay (August 2007); and, the third was dedicated to proceeding to operational status on the East Coast of Canada, Baffin Island, and Southern Greenland (October 2009).

In addition, a HIRA for the use of Automatic Dependent Surveillance Broadcast (ADS-B) for surveillance in the Airspace surrounding Southern Greenland, the NAT, Eastern Shore of Labrador, and Baffin Island, Canada was conducted in 2010 prior to implementation.

3.2 Today's Surveillance Environment

Air Traffic Control (ATC) surveillance and aircraft separation services are provided by the use of primary and secondary surveillance radar systems. While radar technology has advanced, it is essentially a product of 1940s World War II technology. Both primary and secondary radars are very large structures that are expensive to deploy and maintain and also require leased land for site installation.

Primary radar is a passive detection method that requires no special equipment aboard the aircraft. It is a technology that transmits a beam that is reflected by a target. This reflection forms a return signal that is translated into an aircraft position by ATC automation systems. Primary radar, however, is not always able to distinguish aircraft from other objects that reflect radar beams, such as birds or severe weather, which can result in ''clutter'' on the ATC radar scope. In addition, with primary radar ATC is provided only with an aircraft's position relative to time. It does not provide any other information about the aircraft. Primary radar measures both the range and bearing of a particular aircraft. Bearing is measured by the position of the rotating radar antenna when it receives a response to its signal that is reflected from the aircraft. Range is measured by the time it takes for the radar to receive the reflected response. Detecting changes in an aircraft's velocity requires several radar sweeps that are spaced several seconds apart. Because the antenna beam becomes wider as the aircraft travels farther away from the radar, the accuracy of the radar is a function of range, and the accuracy decreases as the distance between the aircraft and the radar site increases. Consequently, aircraft on the outer fringes of radar coverage or in non-radar areas are separated by greater distances by ATC, directly affecting efficiency and ultimately capacity in the ANS.

A Secondary Surveillance Radar (SSR) system consists of antennas, transmitters, and processors installed in ATC facilities, and radio transponder devices that are installed in aircraft. This system enhances primary radar by improving the ability to detect and identify specific aircraft. An SSR transmits interrogation pulses that elicit responses from transponders on board the aircraft. A transponder installed on the aircraft ''listens'' for the interrogation signal and sends back a reply that provides aircraft information. The aircraft is then displayed as a tagged icon on the air traffic controller's radar screen.

Much of the SSR coverage comes from DND radars in the North Warning System (See Figure 3). NAV CANADA has an agreement with DND; however, the feeds are not always dependable. The DND Radars fail on a regular basis due to their age. Since they do not belong to NAV CANADA, maintenance of the facilities is beyond our control. The SSR sites are located in regions that are not easily and readily accessible.

Figure 3 DND North Warning System radar coverage - Yellow

Additionally, there are many areas in which radar coverage is not feasible, either geographically (e.g., mountainous areas) or in a cost-effective manner (e.g., remote areas). Furthermore, simply increasing the number of radars does not solve the inherent limitation of radar technology and would not allow the application of the most efficient surveillance separation standards.

Consequently, the future of air traffic surveillance cannot be based solely on the use of radar. To accommodate the projected level of traffic without increasing delay, more comprehensive surveillance in the ANS is necessary.

3.3 Non-Radar Airspace

There are pockets of airspace across the Canadian Domestic Airspace that are outside of radar coverage and are managed by ATC using non-radar procedural separation. Presently ATC controls IFR operations in non-radar airspace using restrictive separation procedures and is unable to provide many advisory services otherwise available in a surveillance environment.

3.4 The Future of Air Traffic Surveillance

A significant step forward for Air Traffic Services (ATS) surveillance will be the creation of global coverage via the reception of Automatic Dependent Surveillance – Broadcast (ADS-B) signals by Iridium's replacement constellation of Low Earth Orbit (LEO) satellites (See figure 2). NAV CANADA is the majority partner in the joint venture, Aireon LLC, that has built ADS-B receivers to be carried on the Iridium NEXT satellites along with the necessary infrastructure to provide this data to the aviation industry. The Iridium NEXT constellation will consist of 66 in-service satellites operating on 6 near-polar orbits, 9 in-orbit spares and 6 additional satellites on the ground. The first launch took place on January 14, 2017, with the Aireon service planned to be fully operational in mid-2018. The Aireon receivers are compatible with all current DO-260 (or equivalent) compliant transponders; software upgrades will enable compatibility with future DO-260 specifications when required.

NAV CANADA, as an Aireon customer, will use the Aireon service to expand and augment ATS surveillance coverage. NAV CANADA is currently assessing where and how the Aireon service could be used to enhance ATS surveillance coverage in the Canadian Domestic Airspace (CDA). ATS surveillance can be used for separation and flight information services. As with any other form of ATS surveillance, the actual separation and other services that can be provided will be dependent upon communications capability and aircraft equipage. Airspace classification and service changes, including upgrading uncontrolled airspace to controlled airspace, could be possible and would be subject to independent aeronautical studies.

Where VHF voice coverage exists, the expected performance of the ATS surveillance service provided by Aireon will support the application of 5 nautical mile target to target separation between aircraft. The International Civil Aviation Organization (ICAO) is developing Advanced Surveillance-Enabled Procedural Separations (ASEPS) for use with communications media other than VHF voice. ATS surveillance data is a high-quality input for ground-based safety nets that compare aircraft reported positions with the flight data in ATM systems. ADS-B data, in particular, allows for the Selected Flight Level set by the flight crew to be compared to the cleared flight level known to air traffic controllers to potentially prevent or minimize vertical errors.

Operators will benefit in other ways if they equip with ADS-B. This will ensure they are visible to ACAS/TCAS systems of other aircraft, providing a safety benefit to both. Aireon will provide, free of charge to registered users, the location and flight track to assist emergency tracking and location of any ADS-B equipped aircraft anywhere in the world.

An environment in which aircraft meet the proposed ADS–B Out performance requirements would result in greater capacity and efficiency in the ANSP, maintain safety, and provide a flexible, expandable platform to accommodate future traffic growth while avoiding possible system delays and limitations in service. Aircraft operating in areas with a high volume of traffic will benefit from fuel savings through reduced separation.

3.5 Previous Canadian performance requirements mandates

The North Atlantic Tracks (NAT) Data Link Mandate (DLM) was implemented in 2015 for use of CPDLC/ADS-C data link services to reduce the number and duration of operational errors and pilot deviations. The NAT Standards and Procedures Group (SPG) goal for the expansion of the NAT DLM was to increase the level of aircraft data link system equipage to be in concert with the ICAO Global Air Navigation Plan (GANP). The NAT SPG objectives are that by 2018, 90 per cent of aircraft operating in the NAT region airspace at FL 290 to FL410 inclusive will be equipped with FANS 1/A (or equivalent) ADS-C and CPDLC systems and that by 2020, 95 per cent of aircraft operating in that airspace will be so equipped.

Currently, Canadian domestic airspace is Reduced Vertical Separation Minimum (RVSM) airspace from FL 290 up to and including FL 410. All air operators intending to operate within RVSM airspace are required, since 2005, to be equipped with altimetry and height-keeping systems, which meet RVSM Minimum Aircraft System Performance Specifications (MASPS). Operators also require special authorization (Ops Spec) from the State of Registry of the aircraft, or the State of the Operator, prior to operating within this airspace. Operators without this authorization are excluded from flying within RVSM airspace (TC Advisory Circular No.0220).

3.6 Foreign ADS-B Mandates

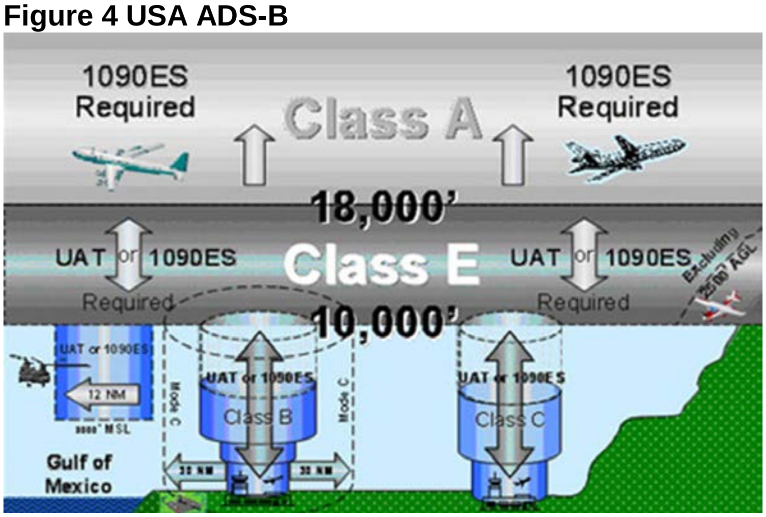
Australia:
Effective 2 February 2017, all aircraft operated under IFR must carry serviceable ADS-B transmitting equipment that complies with an approved equipment configuration by meeting the conditions for approval set out in Appendix XI to Australian Civil Aviation Order 20.18.

New Zealand:
The Civil Aviation Authority (CAA) is currently developing policy and rule changes to support the replacement of New Zealand's aviation surveillance radar infrastructure, which will reach the end of its operational life in 2021.

The proposal includes implementing Automatic Dependent Surveillance – Broadcast (ADS-B) Out as the principle surveillance system in New Zealand. The ADS-B Out implementation project is a foundation project under New Southern Sky (NSS), a ten year program to modernize New Zealand's aviation system. NSS proposes that ADS-B Out will be required on all aircraft operating in controlled airspace above Fight Level 245 (FL 245) after 31 December 2018 and all controlled airspace by 31 December 2021.

United States
In the U.S., aircraft that operate in airspace that currently requires a Mode C or Mode S transponder will need to be equipped with ADS-B Out by December 31, 2019. This includes Class A, B, or C airspaces, Class E airspace at and above 10,000 ft MSL over the 48 contiguous United States and the District of Columbia, and Class E airspace over the Gulf of Mexico from the coastline of the U.S. out to 12 nm and above 3,000 ft MSL. Outside of these categories an ADS-B Out solution will still be required for operations from the surface up to 10,000 ft MSL within 30 miles of most primary Class B airports. (see figure 4).

Figure 4 USA ADS-B



Mexico
Proposed requirement for 1090ES beginning January 1, 2020, in Class A, B, C, E above 10,000 feet, and other specified airspace; requirement could take effect earlier in some airspace over the Gulf of Mexico.

Europe
Currently, all aircraft weighing greater than 5,700 kg (12,500 lbs) or having a max cruise speed greater than 250 kts TAS in European airspace need ADS‑B 1090ES Out with diversity. The current requirement is for forward fit of aircraft and after 2020, the rule applies to retrofit aircraft. By June 2020, all existing aircraft weighing greater than 5,700 kg (12,500 lbs.) or having max cruise speed greater than 250 kts TAS in European airspace need ADS‑B Out 1090ES with diversity.

Hong Kong
All aircraft operating in Hong Kong airspace at and above FL290 need ADS‑B Out 1090ES.

Indonesia
ADS-B Out 1090ES required at FL290 and above.

Singapore
All aircraft that operate on select airways and within a select region of the Singapore FIR at FL290 or above need ADS‑B Out 1090ES.

Sri Lanka
1090ES required within the Colombo Terminal Control Area (TMA), FL290 and above.

Taiwan
All aircraft operating in Taiwan airspace at and above FL290 need ADS‑B Out 1090ES.

Vietnam
All aircraft that operate on airways L625, M771, N892, L642, M765, M768, N500 and L628 at FL290 or above need ADS‑B Out 1090ES.

4.0 Methodology

An aeronautical study assesses and analyzes information gathered through data collection and customer/stakeholder consultation.

The aeronautical study team will:

- Confirm stakeholder requirements related to the implementation of a Canadian ADS-B Out mandate;
- Analyze the concerns and issues raised by the stakeholders;
- Develop possible solutions and/or options;
- Conduct a HIRA as required;
- Present recommendations to senior management for approval;
- Coordinate with the appropriate managers who would be involved with the technical and operational implementation of the proposed service change; and
- Coordinate with Transport Canada.

The study team will ensure that consultation with customers and affected or interested stakeholders is sufficient prior to making any recommendations to senior management.
A business case will be prepared to describe and quantify the economic and other achievable benefits and costs of implementing the described mandate. Benefits will include more use of efficient operator-preferred flight trajectories in areas currently without surveillance, ground surveillance replacement capital cost avoidance and redundant surveillance in certain areas.

The Study team will conduct the HIRA and may call upon stakeholders to contribute to the assessment of some scenarios.

5.0 Safety Management Plan

The manager responsible for implementing any decisions resulting from this aeronautical study will prepare a project safety management plan. The plan will include mitigation and monitoring actions that are required to implement the change in service.

6.0 Human Resources

The team will be multi-disciplined with representation as required from key technical, operational and support areas. Where significant resources are required, this will be negotiated between the respective managers.

Team Leader: Manager, Level of Service and Aeronautical Studies

Other Team Members: Manager, Level of Service and Aeronautical Studies

Advisors:
Senior CNS Operations Technology Specialist
National Manager, Level of Service
Specialist, Level of Service
Director, Government and Public Relations
Managers/Staff ACC, all 7 ACCs will be consulted
Manager, NOCC
Manager, AIM
Manager, Commercial Services

7.0 Work Management Plan

TOR approval: Summer 2017

When conducting an Aeronautical Study, the following will be undertaken:

1. Develop Communication and Consultation Plan - Fall, 2017
2. Study commencement – Fall, 2017
3. Consultation – Fall, 2017 and Winter, 2017/18
4. Assess consultation input – Winter, 2018
5. Conduct HIRA – Winter/Spring, 2018
6. Finalize Aeronautical Study Report – Spring, 2018
7. Management Approvals – Summer 2018

8. Board of Director Approval (as Required) – Summer, 2018
9. Circulate to Transport Canada for safety oversight review – Fall 2018

Following Transport Canada review

10. Coordinate implemention plan and dates with appropriate departments –TBD
11. Prepare AIM Submission –TBD
12. Prepare and publish AIC –TBD
13. Prepare and publish Notice –TBD
14. Implement –TBD
15. Monitoring – Post implementation Reviews

8.0 Finance Resources

Each responsibility manager is accountable for any travel and related expenses of the study team including the management of overtime.

Service design changes may generate an engineering support requirement. These requirements will be identified as the study progresses and an Opportunity Proposal (OP) generated to initiate project planning for implementing the engineering related recommendations from the study.

9.0 Materiality of the changes

There is the potential that some of the service delivery options may represent a material change. If this is the case formal notifications as per the Civil Air Navigation Services Commercialization Act will apply.

10.0 Consultation

An appropriate communications plan incorporating a full consultation plan will be prepared.

Aviation organizations representing airport, general aviation, business aviation and others as appropriate will be consulted during the Aeronautical Study.

A complete list of customers and stakeholders consulted will be attached to the aeronautical study.

11.0 Authority

Vice President Operations or NAV CANADA Board of Directors.