



ICAO

International Civil Aviation Organization  
North American, Central American and Caribbean Office

WORKING PAPER

NACC/WG/4 — WP/35  
17/03/14

**Fourth North American, Central American and Caribbean Working Group Meeting  
(NACC/WG/4)**

Ottawa, Canada, 24 to 28 March 2014

**Agenda Item 3 Follow-up on the NAM/CAR Regional Performance-Based Air Navigation  
Implementation Plan (NAM/CAR RPBANIP) Progress  
3.3 ANI/WG and other regional group progress reports**

**CANADIAN AUTOMATIC DEPENDENT SURVEILLANCE — BROADCAST (ADS-B)  
IMPLEMENTATION AND PLANNING**

(Presented by Canada)

**EXECUTIVE SUMMARY**

This paper provides an overview of the implementation of Automatic Dependent Surveillance - Broadcast (ADS-B) in airspace where Canada is responsible for the provision of air navigation services and outlines the planned implementation of a global Air Traffic Service (ATS) surveillance system using space-based reception of ADS-B signals.

<b>Action:</b>	The NACC WG is invited to take the necessary steps within their States to ensure support for the further development and implementation of ATS surveillance based on ADS-B, as detailed at section 4.
<i>Strategic Objectives:</i>	<ul style="list-style-type: none"><li>• Safety</li><li>• Air Navigation Capacity and Efficiency</li><li>• Economic Development of Air Transport</li><li>• Environmental Protection</li></ul>

**1. Introduction**

1.1 Prior to 2009, Canada relied upon primary and secondary radar systems to provide Air Traffic Services (ATS) surveillance services. Due mainly to the high costs of installing and maintaining equipment in harsher and more remote environments, this resulted in ATS surveillance coverage being mainly provided in the southernmost and east and west coast areas, usually associated with the busier airports.

1.2 Traffic growth and complexity, due in part to interactions between growing numbers of cross-polar flights and other en route international traffic flows, led to studies of how best to address the necessary efficiency improvements. As a result, NAV CANADA, the main Canadian Air Navigation Services Provider (ANSP) commissioned a network of 5 ADS-B ground stations in the Hudson Bay area of northern Canada. This expanded ATS surveillance coverage to include an additional 850,000 square kilometres of airspace, used by approximately 35,000 flights per year.

1.3 In November 2010, ADS-B installations along the north-eastern Coast of Labrador and Baffin Island added another 1,920,000 square kilometres of airspace under ATS surveillance. Most recently, in March 2012, ground stations in Greenland added an additional 1,320,000 square kilometres of airspace, including a portion of the North Atlantic Region where Canada provides air navigation services.

1.4 The foregoing ADS-B implementations allow air traffic controllers to apply surveillance-based separation minima rather than procedural separation minima, which were on the order of 60 nautical miles (NM) laterally and 80 NM longitudinally. The fuel savings from the Hudson Bay implementation are estimated at 21 million litres annually, and those from the Labrador, Baffin Island and Greenland implementations are estimated at 9 million litres annually. These estimated fuel savings equate to avoided CO<sub>2</sub> emissions of 77,000 tonnes annually.

## 2. Future ADS-B Planning

2.1 As reported to the 12<sup>th</sup> Air Navigation Conference and the 38<sup>th</sup> ICAO Assembly, there is an initiative underway to provide global ATS surveillance based on the space-based reception of ADS-B signals. The concept was positively received and it was agreed that the ICAO Council should consider the development of ICAO provisions and guidance material. It was further agreed that such work should be, to the extent possible, performance-based.

2.2 If ATS surveillance were available, the estimated emissions savings for operations over the Pacific and North Atlantic is on the order of 35 million tonnes annually. An International partnership between NAV CANADA, ENAV (the ANSP for Italy), Irish Aviation Authority (IAA), NAVIAIR (the ANSP for Denmark) and Iridium will provide space-based ADS-B surveillance as early as 2018. A Concept of Operations to support stakeholder coordination in relation to this project has been developed and is provided at **Attachment A**.

2.3 Space-based reception of ADS-B signals avoids the necessity for ground-based infrastructure which can be costly to install and maintain and which is subject to reception limitations. In oceanic and some remote areas, geographic and cost considerations render ground-based infrastructure unfeasible. For these reasons, among others, it is estimated that only 10% of airspace is currently under ATS surveillance coverage. Using space-based ADS-B, it will be possible for air traffic controllers to provide ATS services to ADS-B equipped aircraft anywhere in the world, augmenting the current ground-based ADS-B and radar infrastructure. This will reduce the necessity to make potentially very costly investments to extend ATS surveillance coverage to oceanic, polar and other remote areas.

2.4 The necessary aircraft equipage to be detected using space-based ADS-B reception is 1090 megahertz (MHz) Mode S extended squitter transponders, the same aircraft equipage as is required for ground-based ADS-B reception. This is the same equipage required to comply with current ADS-B mandates in Australia and Europe and with upcoming United States ADS-B regulations; a significant portion of the current population of aircraft operating in high level airspace is already equipped. This percentage is expected to rise as a result of the aforementioned mandates and regulations.

2.5 The frequency 1090 MHz operates in a protected aeronautical band. Currently, this protection pertains to terrestrial uses; i.e. aircraft to aircraft and aircraft to ground transmissions. Coordination is underway to extend this regulatory protection to include the aircraft to satellite transmissions. Coordination to amend the current 1090 MHz allocation is being carried out at the regional and global level within the International Telecommunication Union (ITU) and within ICAO's Aeronautical Communication Panel working structure. It is hoped the necessary agreement on amending the current 1090 MHz allocation to also include the aircraft to satellite signal can be concluded at the upcoming ITU World Radio Communication Conference (WRC) which will take place in Geneva, Switzerland, from 2 to 27 November, 2015.

2.6 The upcoming WRC-15 is the subject of Assembly Resolution A38-6: Support of the ICAO policy on frequency spectrum matters. *Inter alia*, this Resolution calls upon States to provide civil aviation experts to fully participate in the development of States' and regional positions and development of aviation interests at the ITU and to ensure, to the maximum extent possible, that their delegations to regional conferences, ITU study groups and WRCs include experts from their civil aviation authorities and other civil aviation stakeholders who are fully prepared to represent aviation interests.

### **3. Conclusion**

3.1 Expanding ATS surveillance coverage supports:

- a) enhanced safety in remote airspace;
- b) the reduction of carbon dioxide and other GHG emissions in support of ICAO, State and industry environmental objectives;
- c) the ability to apply reduced separation minima between aircraft;
- d) significantly increased availability of optimum speeds and altitudes and preferred routings;
- e) increased capacity and airspace efficiency; and
- f) overall significant operational benefits and reduced fuel costs to air carriers.

3.2 ADS-B offers a cost-effective means to provide ATS surveillance, when compared to radar. Space-based ADS-B offers a means of providing ATS surveillance in areas where it is currently not possible or feasible to provide ground-based surveillance.

4. **Suggested Actions**

4.1 The Meeting is invited to:

- a) note the content of this working paper and Attachment A;
- b) support actions to develop performance-based provisions and guidance material in relation to space-based ADS-B; and
- c) take the necessary actions to support Assembly Resolution A38-6 and the expansion of the current 1090 MHz allocation at the upcoming WRC-15.

— END —



# SPACE BASED ADS-B

CONCEPT OF OPERATIONS

VERSION 2 - JANUARY 2014

COORDINATION DRAFT

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**Purpose of this Document**

The purpose of this Concept of Operations is to facilitate coordination between stakeholders who will be involved in, or affected by, the implementation of services using space-based reception of Automatic Dependent Surveillance-Broadcast (ADS-B) data. In support of the overall concept presented in this document, stakeholders will develop more detailed plans and roadmaps to guide their preparations for, and contributions to, the implementation of space-based ADS-B services. As developments occur and procedures and schedules mature, this Concept of Operations will be updated accordingly.

This Concept of Operations has been developed in accordance with the guidance provided in ICAO's *Manual on Airspace Planning Methodology for the Determination of Separation Minima* (Doc 9689).

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For illustrative purposes, details are provided concerning the implementation plans for the Canadian Domestic and North Atlantic airspaces where NAV CANADA provides air traffic services. Planned implementations in other airspaces would need to account for the traffic and air navigation infrastructure therein.

### **Introduction**

Installing and maintaining ground-based aviation infrastructure in remote areas can be challenging and costly. In some cases, such as oceanic areas, there is no viable way it can be done.

Currently, Air Traffic Services (ATS) providers depend upon ground-based infrastructure to receive ADS-B data from aircraft. This concept of operations proposes the use of Low Earth Orbiting Satellites (LEOS) to receive ADS-B data from aircraft so as to expand the geographic area where ATS surveillance services can be provided.

Canada has completed the commissioning of ground-based ADS-B in its northern airspace over Hudson Bay and within the Gander Oceanic Control Area (OCA) over southern Greenland and the northwest portion of the Gander Oceanic Flight Information Region (FIR). The supporting safety analyses, testing and monitoring for these implementations provides the foundation for expansion of ATS surveillance services based on ADS-B.

COORDINATION DRAFT



### **Focus Areas**

Supporting plans and deliverables to achieve this Concept will be organized under Focus Areas as described below.

#### **Governance**

The objective of this Focus Area is the development and promulgation of policies and decisions regarding the overall scope and conduct of the project, including the development and on-going maintenance of a detailed Concept of Operations. The initial Concept was completed in 2013 to address the following points:

- involvement of stakeholders;
- description of service delivery changes attributable to ADS-B;
- devolving NAT and Canadian domestic airspace classifications which are not globally applicable (MNPS, CMNPS, RNPC) and replacing with Performance Based Navigation (PBN) designations and separation applications which are appropriate for the aircraft and ground system capabilities in the airspaces concerned;
- aligning NAT and Domestic airspace designations and services as appropriate; and
- using Canadian Domestic airspace for “proof of concept” and procedures validation.

This Concept is a living document and will continue to be updated and expanded to include subjects such as:

- timeframes including air traffic controller (ATCO) training, procedures, inter-unit agreements and Air Traffic Management (ATM) system changes; and
- communications and surveillance requirements envisioned for the proposed air traffic control services;

Progress towards reaching the goals and objectives of the project will be tracked under this Focus Area. To achieve this and to take account of any changes in direction, the Concept and supporting Action Plans will be updated as required. Under this Focus Area, deployment strategies will be reviewed to ensure alignment between Data Link, ADS-B and other related technical initiatives.

#### **IATA and other Stakeholder Coordination**

The objective of this Focus Area is to conduct consultation and coordination with stakeholders outside of NAV CANADA and Aireon to support and achieve the objectives of the project.

Information concerning Aireon and its objectives has been provided in numerous fora attended by operators, Air Navigation Services Providers (ANSP) and other aviation stakeholders. Briefing information includes this document and information concerning the benefits analysis which supported NAV CANADA’s decision to become part of the Aireon joint venture. With the assistance of the International Civil Aviation Organization (ICAO) European and North Atlantic (EUR/NAT) and North American, Central American and Caribbean (NACC) Regional Offices, coordination will include briefings at ICAO events in the other regions.

#### **Safety Management**

The objective of this Focus Area is to complete all Safety Management System (SMS) related activities, such as the Safety Management Plan (SMP), Hazard Identification and Risk Assessments (HIRA) and Safety Management Reports (SMR). The expected timeframe of activities is from 2013 to 2019.

The SMP will be completed in accordance with ICAO established guidelines and procedures and must support all areas of the initiative to provide ATS surveillance services using space-based ADS-B.

## **Communications**

The objective of this Focus Area is to assess communications performance and identify communication performance requirements to support the safe provision of ATS surveillance services using space-based ADS-B. This includes activities necessary to assess and improve communications procedures or infrastructure where needed. The communications types to be considered within this Focus Area include:

- Direct Controller Pilot Communications (DCPC) via Very High Frequency (VHF) voice;
- DCPC via Satellite Voice Communications (SATVOICE);
- DCPC via data link (i.e. Controller Pilot Data Link Communications (CPDLC));
- third party communications, where a Communication Service Provider (CSP), such as the Gander International Flight Service Station, relays communications between the flight crew and the ATCO, usually using High Frequency (HF) radio to communicate with the flight crew; and
- data link or automated position reporting, including for the purposes of flight profile conformance monitoring.

This Focus Area will also consider any new technologies which may become available to support DCPC during the planning phases of the project. This Focus Area will provide the information on communications performance necessary to support the development of appropriate Air Traffic Management (ATM) procedures for the use of space-based ADS-B data.

## **Surveillance**

The objective of this Focus Area is to assess surveillance performance and identify surveillance performance requirements to support the safe provision of services using space-based ADS-B data. This includes activities necessary to assess the surveillance infrastructure related to receiving, transmitting and processing space-based ADS-B data. This Focus Area will provide the information on surveillance performance necessary to support the development appropriate ATM procedures for the use of space-based ADS-B data.

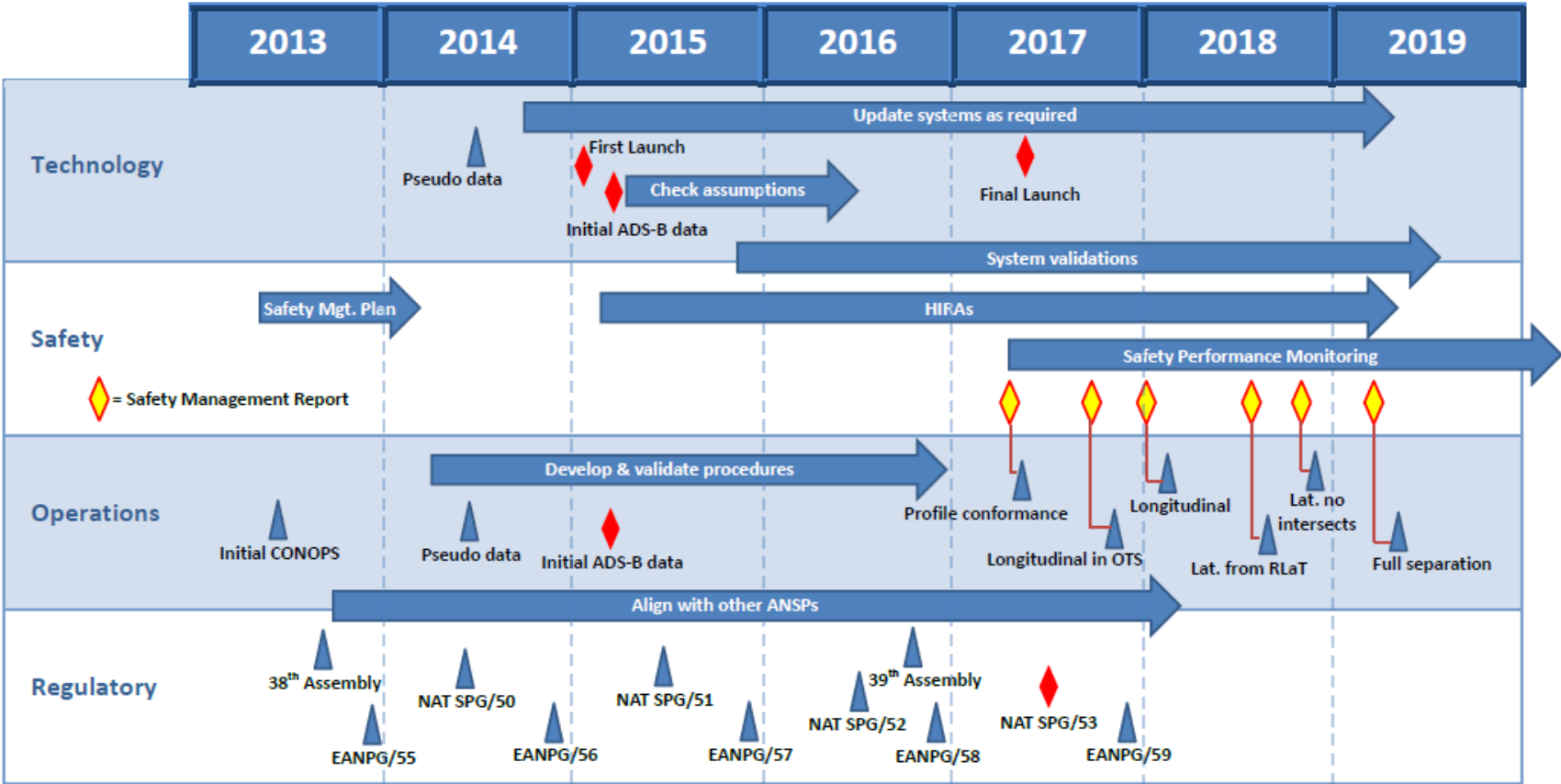
## **Air Traffic Management**

The objective of this Focus Area is to develop and validate air traffic management procedures, system requirements and updates, training material and documentation to support the provision of ATS surveillance services using space-based ADS-B. This will include the alignment of Data Link messages and procedures between NAT and Canadian Domestic airspace and also, to the extent possible, the alignment of procedures, including separation provision. The goal of this alignment is to ease the eventual transition from a procedural operational environment to an ATS surveillance environment. The goal of this project is to provide a seamless operating environment within the Canadian Domestic and NAT airspace through the provision of services using space-based ADS-B.

## **Regulatory**

The objective of this Focus Area is to carry out timely and on-going coordination with all regulatory bodies, standards organizations and ICAO groups so as to ensure that all required agreements, standards, guidelines and approvals are in place when space-based ADS-B data becomes available to ANSPs. This includes activities related to ensuring frequency protection and any other subject which is within the remit of global or regional coordination and regulatory bodies. Activities relating to the approval and conduct of operational trials in the ICAO NAT Region will be tracked under this Focus Area.

Overview of main project milestones



COOK

### **Identification of the Need for Change**

Where ATS surveillance services are not provided, maintaining a safe, orderly and expeditious flow of air traffic requires the use of the largest air traffic control separation standards. To ensure that the required spacing will be maintained between aircraft, flights must often operate at less than optimum flight levels,

Expanding the geographic area where ATS surveillance is available is expected to enhance safety, increase operational efficiency and predictability and reduce negative environmental impacts from aviation operations. The specific operational improvements to be supported through the use of expanded ATS surveillance coverage should be based on the user requirements in the airspace concerned, taking account of available communications capabilities.

Airspace users require more fuel-efficient flight profiles (route, altitude and speed) that will reduce operating costs and show a return on operator investment in aircraft avionics. Where fuel burn is reduced, there are commensurate environmental benefits from reduced aircraft emissions. ATS surveillance is expected to enhance the provision of fuel and cost-efficient profiles.

Minimum cost flight profiles need not be limited to fixed speeds or flight levels. Recent initiatives such as ENGAGE and Top Flight have demonstrated the economic and environmental benefits which can accrue if flights are able to vary their speed and altitude within a defined operating band. Such flexibility is more easily accommodated where ATS surveillance services are provided.

Recently, the aviation community has been discussing the possible benefits of “extended arrival metering”. Extending ATS surveillance coverage will support more fuel efficient management of arrivals into congested airports. It is believed that the earlier adjustments to flight profiles are made, the lower the resulting fuel penalties will be.

Ground based safety nets use ATS surveillance data to generate alerts for ATCOs of increased risks to flight safety. Predominantly, these alerts concern potential, impending or actual violations of required spacing between aircraft or proximity alerts regarding terrain. Expanding ATS surveillance coverage will expand the airspace for which such safety nets can be implemented.

Search and Rescue (SAR) operations are more efficient and effective when aircraft locations can be accurately determined. Expanding ATS surveillance coverage will expand the airspace within which aircraft positions can be accurately determined in support of SAR operations.

This Concept mainly details the potential benefits within Canadian Domestic and NAT airspace. Additional assessments will be required to identify specific benefits which could be realized in other airspaces.

## Description of the Current Airspace and the CNS/ATM Systems

### **Airspace Structure - North Atlantic**

The responsibility for air traffic control services within the ICAO NAT Region is shared among nine states: Canada, Denmark, France, Iceland, Ireland, Norway, Portugal, the United Kingdom and the United States.

The ICAO NAT Region mainly consists of Class A airspace; in which Instrument Flight Rules (IFR) apply at all times. Class A airspace has been established at and above FL55 except in the Bodø OCA and in the Søndrestrøm FIR where it has been established above FL195 and in the domestic portion of the Reykjavik FIR where it has been established at and above FL200.

The ICAO NAT Region airspace is divided into seven FIRs or Control Areas (CTA) for the implementation of Communications Navigation Surveillance/Air Traffic Management (CNS/ATM) systems. The ICAO NAT Region comprises the following FIRs/CTAs: Bodø Oceanic, Gander Oceanic, New York Oceanic, Reykjavik, Santa Maria, Shanwick. and Søndre Strømfjord.

Traffic is controlled by oceanic area control centres at Reykjavik, Bodø, Gander, New York, Santa Maria and Prestwick and by Shannon and Brest Area Control Centres (ACC).

The traffic operating in the ICAO NAT Region is predominantly commercial. International General Aviation (IGA) Business aircraft comprise a high proportion of the higher altitude airspace operations.

For most of the NAT airspace radar surveillance and VHF voice communications is unavailable. Therefore, procedural control is exercised. The exception is the south and east sector of the Reykjavik area, Bodø oceanic airspace with the exception of the north-west part, the NOTA, SOTA and BOTA<sup>1</sup> airspaces in the eastern portion of Shanwick FIR controlled by Shannon and Brest ACCs and in the central portion of the Santa Maria OCA where radar aided services are provided. Based on current progress and plans, ground-based ADS-B installations in southern Greenland and Iceland will expand ATS surveillance, creating a “Greenland surveillance corridor” in the 2014/2015 timeframe.

NAT Minimum Navigation Performance Specifications (MNPS) airspace has been established between FL285 and FL420 within the Oceanic Control Areas of Santa Maria, Shanwick, Reykjavik, Gander Oceanic and New York Oceanic, excluding the area west of 60° West longitude and south of 38°30’ North latitude. Only MNPS approved aircraft are permitted to operate within the NAT MNPS airspace. Monitoring is conducted to verify aircraft performance and scrutinize operational safety performance.

Reduced Vertical Separation Minima (RVSM) airspace has been established within the ICAO NAT Region from FL290 to FL410 inclusive. In RVSM airspace, 1,000 feet vertical separation is applied between approved aircraft. Only RVSM approved aircraft are allowed to operate within NAT RVSM airspace. Monitoring is conducted to verify aircraft performance and scrutinize operational safety performance.

Strategic lateral offsets of one or two miles right of a route or track centreline have been introduced as a means of reducing collision risk and is now standard operating procedure in the entire NAT Region.

In addition to the requirements of Annex 6, - *Operation of Aircraft*, Part I, paragraph 6.16 and Part II, paragraph 6.14, ACAS II shall be carried and operated in the ICAO NAT Region by all turbine-engine aeroplanes having a maximum certificated take-off mass exceeding 5,700 kg or authorized to carry more than 19 passengers.

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<sup>1</sup> The dimensions of the Brest Oceanic Transition Area (BOTA) and the Shannon Oceanic Transition Area are defined in the NAT SUPPs; the dimensions of the Northern Oceanic Transition Area (NOTA) are defined in the Irish Aeronautical Information Publication.

### **Airspace Structure - Canadian Domestic**

The Canadian Domestic Airspace is divided into Northern and Southern domestic airspace with further classification into Canadian Minimum Navigation Performance Specifications (CMNPS) and Required Navigation Performance Capability (RNP) airspaces. Currently, navigation performance requirements in Canada are classified as meeting either of these unique Canadian standards; however, these designations will be replaced by Performance Based Navigation (PBN) or other internationally recognized designations. Aircraft meeting the NAT MNPS requirements are permitted to operate within CMNPS airspace and the CMNPS requirements are the same as those specified for NAT MNPS in the *North Atlantic Regional Supplementary Procedures* (NAT SUPPs, Doc 7030). The RNP designation pertains to the ability to apply certain separation minima between appropriately equipped flights; this is a pre-PBN designation.

The Canadian Domestic Airspace consists of controlled and uncontrolled airspace. In the Southern domestic airspace, controlled airspace is designated to ensure, to the extent possible, that aircraft operating between, into and out of controlled airports will remain within controlled airspace. These structures include control zones, control area extensions and controlled airspace associated with the protected airspace of specified ATS routes. Outside of these airspace structures, the base of controlled airspace is 18,000 Above Sea Level (ASL) or 7,000 feet Above Ground Level (AGL), whichever is higher.

In the Northern Domestic Airspace, controlled airspace is designated at and above FL230.

The Canadian Domestic Airspace is divided into seven FIRs: Edmonton, Gander Domestic, Moncton, Montréal, Toronto, Vancouver and Winnipeg. Traffic is controlled by ACCs associated with each FIR.

Radar or ADS-B surveillance services are provided throughout most of the Southern Domestic Airspace and the southern portions of the Northern Domestic Airspace. Outside of surveillance coverage or where VHF DCPC is not available, procedural control is exercised.

Strategic lateral offsets are not approved within the Canadian Domestic Airspace.

RVSM airspace has been established within Canadian Domestic Airspace from FL290 to FL410 inclusive. In RVSM airspace, 1,000 feet vertical separation is applied between approved aircraft. Under specified conditions, and subject to additional procedures to ensure safety, non-RVSM certified aircraft may be permitted to operate in RVSM airspace; such aircraft are separated from all other aircraft in RVSM airspace by a minimum of 2,000 feet vertically. Monitoring is conducted to verify aircraft performance and scrutinize operational safety performance.

Transport Canada has not initiated rule-making to adopt the ICAO provisions related to the carriage and operation of ACAS II. The ICAO definition of fully compliant ACAS II (Annex 10, Volume 4, Chapter 4 refers) is equivalent to the North American Traffic Alert and Collision Avoidance System (TCAS) II software version 7.1. In Canadian domestic airspace, outside RVSM airspace, the minimum requirement is TCAS I which provides traffic alerts only. Within RVSM airspace, the minimum requirement is TCAS II software version 7.0, which provides traffic alerts and vertical resolution advisories; if the intruder aircraft is also TCAS II equipped, coordinated vertical resolution advisories will be provided. For a complete description of regulatory requirements airspace users should consult the Transport Canada Aeronautical Information Manual (TP 1437).

### **CNS/ATM Systems - North Atlantic**

Canadian ATCOs providing services in the ICAO NAT Region utilize the Gander Automated Air Traffic System (GAATS) suite of decision support tools. These tools have been tailored to the NAT operational environment and assist ATCO's in planning conflict-free flight profiles, formulating air traffic control clearances, exchanging data link messages from flights, monitoring flight progress, detecting potential conflicts and exchanging flight data with other air traffic control sectors and units.

ATCOs providing services in the Shanwick FIR use a nearly identical system, the Shanwick Automatic Air Traffic System (SAATS), which provides for a high degree of interoperability between the two busiest OCAs in the ICAO NAT Region. This interoperability supports, among other benefits, the provision of conflict free profiles for the entire oceanic transit throughout the adjoining Gander and Shanwick OCAs, including for flights which make requests for profile changes after oceanic entry. As a result, flights operating through the busiest oceanic airspace in the world are operating on a fully protected flight profile which assures safe spacing from all other aircraft operating in the airspace, even in the event of a communications disruption affecting numerous aircraft. This safety benefit is of particular importance because of the current dependence on HF communications, which can be subject to severe disruptions affecting a wide geographic area.

Aircraft operating within the NAT MNPS airspace must be equipped and certified in accordance with the requirements detailed in the NAT SUPPs. The NAT Systems Planning Group (NAT SPG), the Planning and Implementation Regional Group for the ICAO NAT Region, has embarked upon a plan to devolve the NAT MNPS and transition to a system of air traffic management and associated aircraft and flight crew requirements defined in accordance with the *Performance-based Navigation (PBN) Manual* (Doc 9613). In accordance with the plan, the current NAT MNPS requirements will no longer be applicable as of 2020.

ATCOs providing services in the other OCAs within the ICAO NAT Region also rely upon robust decision support systems which assist in planning and monitoring air traffic. Except for the Bodø Oceanic FIR and the BOTA, CPDLC and ADS-C services are available throughout the ICAO NAT Region. The NAT SPG has implemented a data link mandate for the ICAO NAT Region which will require aircraft operating in the busiest portions of the region to be equipped with and operate FANS 1/A or equivalent CPDLC and ADS-C as of February 2015. This mandate is not applicable within the New York Oceanic FIR.

Within the New York Oceanic FIR, eligible flights are provided with 50 NM lateral separation based on RNP 4 or RNP 10 certification. 50 NM longitudinal separation based on RNP 4 or RNP 10 certification and 30 NM lateral and 30 NM longitudinal separation based on RNP 4 certification will be introduced in 2014.

### **CNS/ATM Systems - Canadian Domestic**

In the southern portion of the Canadian Domestic Airspace, there is extensive secondary surveillance radar coverage, supplemented by primary radar in the busier terminal areas. Over the past number of years, ground-based ADS-B has extended ATS surveillance coverage further north and north-east. In general, VHF DCPC coverage coincides with ATS surveillance coverage.

Canadian ATCOs are provided with a full suite of decision support tools, integrated into the situation display. Where flights are not under surveillance coverage, the flight data processing system displays extrapolated targets which are clearly distinguishable from surveillance targets; both types are indicated on the same display.

Automated coordination is accomplished internally first by the FDPS providing up to date synchronised data that is available to all users within the ACC and secondly by providing all ATCOs with display tools that allow electronic coordination of some flight data. Any data which cannot be managed automatically is coordinated using interphone or hotline tools.

For external communications, each Canadian ACC's ATM system is connected to the other and messages are exchanged via dedicated interfaces. Outside of NAV CANADA, communication is accomplished through automated interfaces to Towers, Flight Service Stations, and to international agencies such as the FAA and ISAVIA.

Conflict prediction is provided in respect to non-surveillance flights and medium and short term conflict alerts are provided in respect to surveillance flights. In areas where RNPC and CMNPS separations are provided, the FDPS provides conflict detection and alerting appropriate for these minima, in addition to the other minima applicable to the airspace.

Except for the Toronto FIR, which is planned for late in 2014, CPDLC has been implemented throughout the Canadian Domestic Airspace. Commonly used messages, such as vertical clearances and contact and monitor instructions have been integrated into the existing situation display tools related to vertical profile monitoring and inter-sector and inter-unit coordination. Where conflict prediction is provided, CPDLC clearances are subject to conflict probing before they can be uplinked. All CPDLC messaging is done through on-screen menus on the situation display.



### **Customer Expectations and Benefits**

ATS surveillance services enable:

- ➔ enhanced safety monitoring
- ➔ increased operational predictability and efficiency
  - operations at, or closer to, the preferred flight level
  - more route options when flight planning
  - more route options to tactically respond to weather conditions, wake vortex avoidance, etc.
  - fewer speed restrictions
- ➔ longer timelines for arrival planning

ATS surveillance directly benefits operators by providing a safer operating environment which also allows them to more closely adhere to minimum cost flight profiles. Such profiles need not be limited to fixed speeds or flight levels; recent initiatives such as Top Flight and ENGAGE have demonstrated the economic and environmental benefits which can accrue if flights are able to vary their speed and altitude within a defined operating band. Such flexibility is more easily accommodated where ATS surveillance services are provided.

Flight profiles which result in reduced fuel burns directly decrease the environmental impact from that flight, along with reducing fuel costs.

Recently, the aviation community has been discussing the possible benefits of “extended arrival metering”. Extending ATS surveillance into the North Atlantic could support more fuel efficient management of arrivals into congested European airports.

The following benefits can be expected from the expansion of ATS surveillance:

- ➔ increased operational safety
- ➔ reduced fuel burns
- ➔ fewer greenhouse gas emissions
- ➔ lower operating costs
- ➔ increased ATM flexibility

### Guiding Principles and Assumptions

A number of principles will guide the activities, participants, responsibilities and deliverables, to achieve the goals and objectives of the Space-Based ADS-B project, including:

- adherence to a “Safety First” risk management approach;
- collaboration with airlines, industry groups such as IATA and ANSPs,
- coordination with, and involvement of, State regulators and ICAO throughout the planning and implementation;
- leveraging existing technology and aircraft separation standards to minimize regulatory and equipage changes;
- validation of capabilities through incremental changes to existing systems and procedures;
- developing and maintaining a Concept of Operations document;
- establishing incremental change aligned procedures;
- communicating the plan and process and providing updates on achievements;
- demonstrating readiness via operational trials;
- monitoring performance with empirical evidence, analysis and metrics; and
- reporting on risk management, efficiency and environmental enhancements.

A number of assumptions underlie the assessments being developed to quantify the potential benefits of space-based ADS-B and the operational scenarios being considered:

- traffic patterns (i.e. city pairings) will remain the same;
- increases in air traffic demand will be in accordance with current forecasts;
- the application of 5 minutes longitudinal separation between ADS-C equipped aircraft and, in the NAT airspace, ½ degree spacing between tracks, will have already been implemented;
- in the NAT airspace, aircraft equipage will be in accordance with the NAT Region Data Link Mandate;
  - 90% of aircraft will be equipped with FANS 1/A ADS-C and CPDLC by 2018;
- **[To be developed: relevant estimates for FANS 1/A equipage in Canadian Domestic airspace]**
- More than 85% of the aircraft operating in the Gander OCA are equipped with ADS-B;
- **[To be developed: estimate of when, in the NAT airspace, 85% of aircraft will be equipped with ADS-B]**
- **[To be developed: relevant estimates for ADS-B equipage in Canadian Domestic airspace]**
- controller decision support tools will include a Flight Data Processing System (FDPS) in which the current approved flight profiles are maintained up to date for all aircraft in the airspace;
  - the FDPS will provide automated conflict monitoring and alerting;
- continuous surveillance, based on a mixture of ADS-B and radar, will be possible throughout the Gander and Shanwick OCAs, the southern portion of the Reykjavik OCA and the northern portion of the Santa Maria OCA and all of Canadian Domestic airspace;

*Note: Only an aircraft equipped with ADS-B would be subject to continuous ATS surveillance through these airspaces.*

- CPDLC is available as a means of communication and related procedures will be in accordance with the *Global Operational Data Link Document (GOLD)*;
- controller initiated SATVOICE will only be via a system, such as the NAV CANADA National Voice Communication System (NCVS), which automates the dialling process;
- in the NAT airspace, all flights will operate on Oceanic Clearances; these clearances provide for conflict free profiles within certain parameters, which will not initially be changed;
- between FL285 and FL420, priority will be given to flights equipped with ADS-B; and
- the NAT Organized Track Structure will be maintained during the initial implementation.

*Note: In the future, the peak traffic pattern across the NAT airspace will likely continue to resemble a collection of laterally separated organized tracks. However, rather than being determined and published 8 hours ahead of time, this structure will be the natural result of de-conflicted clearances provided in response to requested routings and post-departure estimates for the oceanic entry points. The expected evolution will be to a more tactical OTS which permits operators to more dynamically amend their track choice, even after oceanic entry. Eventually, it can be foreseen that operators would no longer be expected to select from a pre-determined set of organized tracks based upon the minimum-time track for that flow; the requested trans-Atlantic route will be the operator preference for that particular flight.*

## Current System

### **Flight Information Regions**

See chart at Appendix B (page B-1)

### **Surveillance**

Radar and ground-based ADS-B coverage - see chart at Appendix B (page B-2)

### **Communications**

CPDLC service area - see chart at Appendix B (page B-3)

VHF coverage - see chart at Appendix B (page B-4)

### **Air Traffic Management - Gander OCA**

- North Atlantic Organized Track System used to manage heavy east/west flows, balancing operational efficiency against capacity and cost-effective ATM
- Conflict free profiles
- MNPS lateral separation
  - 60 NM track to track separation OR 1 degree gentle slope (as close as 50.5 NM)
- Longitudinal separation
  - 60, 30, 20 or 15 minutes
  - 10 minutes using MNT
  - 5 to 9 minutes using MNT with speed differential
- RLongSM
  - 5 minutes between appropriately equipped aircraft
- Non-MNPS lateral separation
  - 120 NM track to track within, above or below NAT MNPS airspace, or 2 degrees gentle slope
  - 90 NM track to track outside NAT MNPS or 1 ½ degrees gentle slope

### **Air Traffic Management - Canadian Domestic Airspace**

- Within ATS surveillance, VHF DCPC
  - Enroute: 5 NM
  - Terminal: 3 NM
- Within ATS surveillance, no DCPC
  - Non-surveillance minima
- Outside ATS surveillance, within CMNPS airspace
  - 60 NM track to track or 1 degree gentle slope

15 minutes meet time

10 minutes or 60 NM tail to tail

No overlap of airspace to be protected (ATP) for each flight, based on navigation method or signal coverage

15 minutes longitudinal

20 or 15 minutes crossing track

10 minutes longitudinal using MNT

5 to 9 minutes longitudinal using MNT and speed differential

50 NM longitudinal, RNP/10 or RNP/4 aircraft, if DCPC

RNP/10 and RNP/4, 50 NM laterally

- Outside ATS surveillance, within RNP/4 airspace

30 NM tail to tail

No overlap of ATP

RNP/4 ATP, off airways, 10 NM either side of track

Longitudinal, same or crossing track, 10 minutes with DCPC

Longitudinal, same or crossing track, 30 NM (RNAV or surveillance from a common point)

10 minutes longitudinal using MNT

5 to 9 minutes longitudinal using MNT and speed differential

- Outside ATS surveillance, CMNPS and RNP/4 airspace

Any non-surveillance minimum

## **Operational Concept for space-based ADS-B supported ATS surveillance services**

### **Communications**

Communications between flight crews and ATCOs will be achieved via VHF or CPDLC. Third party communications via SATVOICE and HF communications will be available. ATCOs will have the ability to contact flights directly using SATCOM voice.

Flights will contact ATCOs directly, via VHF, CPDLC. Flights may contact the ATSU using a third party communications service via SATVOICE or HF.

Outside of VHF coverage, it is expected that most profile change requests will be made via CPDLC, using the existing standard CPDLC message elements.

Where CPDLC services are available, including within areas of VHF coverage, flights will have the option to use either CPDLC or VHF to make requests and ATCOs will have the option of using either CPDLC or VHF to request information or issue instructions. Preferably, communications will be initiated and completed using CPDLC in such cases.

ATCOs will respond to CPDLC messages via CPDLC. Outside of VHF coverage, it is expected that most clearances or instructions will be issued via CPDLC, using the existing standard CPDLC message elements; ATCOs will have the option of directly contacting a flight using SATVOICE, using the existing capabilities of National Voice Communication System (NVCS). ATCOs will have the option of initiating contact with a flight using third party communications service.

### **Horizontal Separation Minimum**

The candidate separation minimum using space-based ADS-B is 15 NM. Appropriate ATM procedures will be developed, taking account of available communications capability, to ensure an acceptable level of safety is maintained during any application of this minimum.

Validation of operational applications using space-based ADS-B data will be carried out in Canadian Domestic airspace. This will leverage the ability to carry out trials which mimic different levels of communications and surveillance performance in an environment where VHF DCPC and ground-based surveillance is available.

Prior to the full constellation of LEOS being operational, space-based ADS-B data will be available. Following testing and validation of the accuracy of this data, it will be introduced into ATM systems which provide conformance monitoring of flight profiles. Along with providing early safety benefits, this will provide validation that affected ATM systems have been appropriately configured and updated to use this new source of surveillance data, prior to using that data to provide separation between aircraft. It is anticipated that separation services will not be implemented until the full LEOS constellation is operational, which is expected in 2018.

Consideration will be given to introducing the operational use of space-based ADS-B data in a phased approach, possibly on a timeline resembling:

- Mid 2017: implementation of flight profile conformance monitoring using available space-based ADS-B data
- Late 2017: application of 15 NM longitudinal separation between surveillance-identified aircraft operating on the NAT OTS;
- Early 2018: application of 15 NM longitudinal separation between surveillance-identified aircraft, whether or not operating on the NAT OTS;
- Mid 2018: allowing surveillance identified aircraft to operate on tracks which do not intersect with and are separated by ½ degree laterally from the outer-most RLatSM track or OTS track, as applicable;

- Late 2018: use of ATS surveillance to maintain 15 NM lateral separation between the tracks of surveillance-identified aircraft operating on non-intersecting tracks; and
- Early 2019: application of 15 NM separation between surveillance-identified aircraft.

The 15 NM minimum is to be applied centre to centre between surveillance targets or from the centre of a surveillance target to the edge of the airspace to be protected for a non-surveilled flight.

### **Air Traffic Management**

Segregation of airspace is not being considered at this time.

Surveillance separation will be applied between surveillance-identified aircraft in accordance with current procedures, irrespective of whether the aircraft concerned are being ATS surveillance services using radar, ground-based ADS-B, space-based ADS-B or a mixture.

Surveillance separation will be applied between surveillance-identified aircraft and the protected airspace for a flight which is not surveillance identified, in accordance with current procedures.

Automated conformance monitoring will be conducted for all flight profiles under ADS-B coverage in the vertical and horizontal planes. Inter-facility coordination will also be monitored and alerts provided when manual coordination is required or the observed flight profile differs from the coordinated flight profile.

Improvements to meteorological data, including frequency of updates, may be considered.

In the Canadian Domestic Airspace:

- operators will be encouraged to file minimum cost routes, not necessarily on airways or published tracks;
- existing non-surveillance minima will be reviewed to determine which, if any, should be discontinued; and
- outside of VHF coverage, consideration will be given to defining conflict free “look ahead” times.

In the NAT airspace:

- a transition strategy for the devolution of the current NAT OTS approach, taking account of customer efficiency and flow management requirements, will be developed;
- the conflict free window (currently from oceanic entry to oceanic exit) will be reduced, possibly in phases;
- Mach numbers will not be assigned except when required to maintain required longitudinal spacing; and
- safety-related monitoring using ADS-C event contracts will be retained and ADS-B enabled safety monitoring will be added as an additional safety net.

### Pre-Trial Activities

The current operating environment over the North Atlantic, utilizing ADS-C and CPDLC provides a suitable environment in which to gather data concerning existing communications and surveillance performance. Data collection has been implemented for the Gander OCA to validate the current system as being sufficiently robust and to identify potential improvements to existing communications capabilities in support of reducing separation standards.

NAV CANADA will create pseudo data by modifying existing ADS-B data to mimic the expected performance of the space-based data. This pseudo data will be used in simulation and modelling activities supporting the development of procedures for the operational use of space-based ADS-B data. Performance comparisons will be possible as soon as the first space-based ADS-B data becomes available in 2015. This will support validation of the assumptions used in the simulations. Thus, there will be technical and operational validation of space-based ADS-B applications prior to any trial application in the NAT environment.

The addition of same altitude ADS-B surveillance over southern Greenland provides another opportunity to gather data in support of applying a surveillance minimum over the North Atlantic or other surveillance areas without the use of DCPC voice. Same altitude separation of 10 NM was introduced in the Greenland ADS-B environment in March 2013. This mode of operation resembles the expected space-based ADS-B environment with the exception that VHF communications is available. It is important to note however, that all clearances and controller/pilot exchanges (with the exception of the initial contact) are to be completed using CPDLC where possible. The methodology for data collection was being reviewed at the time of this update (January 2014).

#### Considerations for upcoming ADS-B Southern Greenland & Continuation of data gathering for ADS-C/CPDLC outside of surveillance areas

1. It is necessary to establish ADS-B data collection methodology for climbs and same altitude. Currently this information resides in different log files so may have to be identified manually during the early stages until a more suitable method can be achieved. This is currently being assessed by NAV CANADA.
2. NAV CANADA will continue the assessment of CPDLC communications performance for specified messages, identified as being critical for ATC intervention, to identify possible areas of concern and provide solutions where necessary to improve the measured performance as much as we possibly can.
3. It is necessary to establish test protocols for contacting aircraft through SATVOICE to verify/validate suitable alternatives for ATC intervention capabilities in support of a Safety Case for Separation Reductions.
4. Discussions on-going as to whether NAV CANADA will conduct a trial under which flights use SATVOICE as the primary data link communications media rather than selecting the lowest cost medium (VHF, HF, SATVOICE) as is done currently.



**Appendix A - Acronyms**

<b>ACAS</b>	(ICAO) Airborne Collision Avoidance System
<b>ACC</b>	Area Control Centre
<b>ADS-B</b>	Automatic Dependent Surveillance - Broadcast
<b>ADS-C</b>	Automatic Dependent Surveillance - Contract
<b>AGL</b>	Above Ground Level
<b>ANS</b>	Air Navigation Services
<b>ANSP</b>	Air Navigation Services Provider
<b>ASL</b>	Above Sea Level
<b>ATC</b>	Air Traffic Control
<b>ATCO</b>	Air Traffic Controller
<b>ATM</b>	Air Traffic Management
<b>ATS</b>	Air Traffic Services
<b>CMNPS</b>	Canadian Minimum Navigation Performance Specifications
<b>CAATS</b>	Canadian Automated Air Traffic System
<b>CPDLC</b>	Controller Pilot Data Link Communications
<b>CRM</b>	Collision Risk Model
<b>CSP</b>	Communication Service Provider
<b>CTA</b>	Control Area
<b>DCPC</b>	Direct Controller Pilot Communication
<b>Doc 4444</b>	(ICAO) Procedures for Air Navigation Services - Air Traffic Management (PANS-ATM)
<b>Doc 9613</b>	(ICAO) Performance-based Navigation (PBN) Manual
<b>EUR</b>	(ICAO) European (Region)
<b>FIR</b>	Flight Information Region
<b>FL (number)</b>	Flight Level
<b>GAATS</b>	Gander Automated Air Traffic System
<b>GNSS</b>	Global Navigation Satellite System
<b>HF</b>	High Frequency
<b>HIRA</b>	(NAV CANADA) Hazard Identification and Risk Assessment
<b>IATA</b>	International Air Transport Association
<b>ICAO</b>	International Civil Aviation Organization
<b>IGA</b>	International General Aviation
<b>LEOS</b>	Low Earth Orbiting Satellites
<b>MNPS</b>	Minimum Navigation Performance Specifications
<b>MTCD</b>	Medium Term Conflict Detection
<b>NACC</b>	(ICAO) North American, Central American and Caribbean (Region)

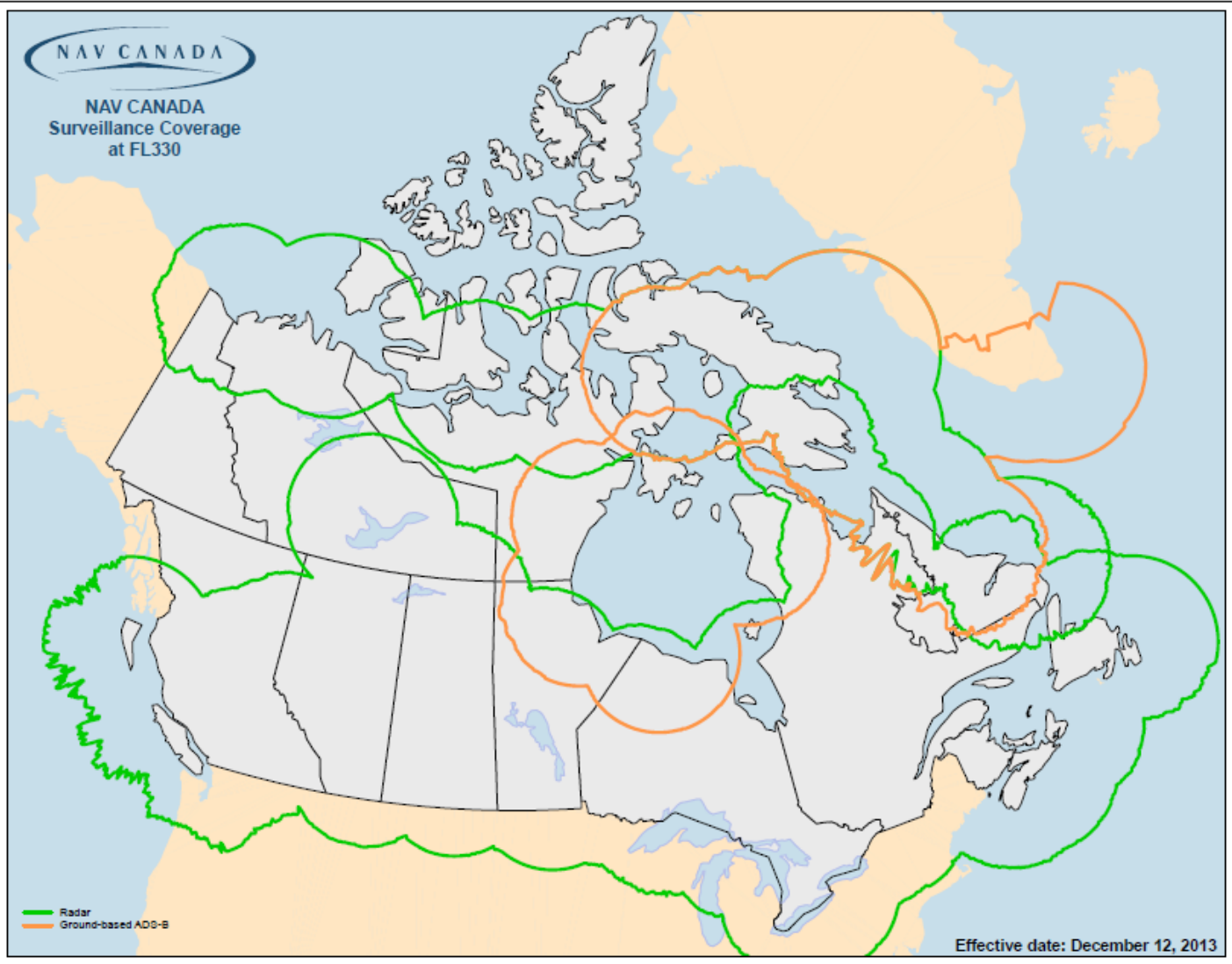
<b>NAT</b>	(ICAO) North Atlantic (Region)
<b>NAT SPG</b>	(ICAO) North Atlantic Systems Planning Group
<b>NM</b>	Nautical Miles
<b>NVCS</b>	(NAV CANADA) National Voice Communication System
<b>OCA</b>	Oceanic Control Area
<b>PBN</b>	Performance Based Navigation
<b>RCP</b>	Required Communication Performance
<b>RNPC</b>	Required Navigation Performance Capability
<b>RVSM</b>	Reduced Vertical Separation Minima
<b>SAATS</b>	Shanwick Automated Air Traffic System
<b>SAR</b>	Search And Rescue
<b>SATCOM</b>	Satellite Communications (for data link applications)
<b>SATVOICE</b>	Satellite Voice Communications
<b>SMP</b>	(NAV CANADA) Safety Management Plan
<b>SMR</b>	(NAV CANADA) Safety Management Report
<b>SMS</b>	Safety Management System
<b>TCAS</b>	Traffic Collision Avoidance System
<b>VHF</b>	Very High Frequency

**Appendix B - Charts**

**FIRs where NAV CANADA provides services**



Surveillance coverage at FL330



CPDLC Service Area



**Surveillance and VHF Coverage at FL330**



-- END --