**Cuestión 4 del Orden del Día:** **Evaluación de los requisitos operacionales para determinar la implantación de mejoras de las capacidades de comunicaciones, navegación y vigilancia (CNS) para operaciones en ruta y área terminal**

# IMPACTO ESTIMADO EN EL RIESGO DE COLISIÓN VERTICAL CON EL USO DE LA VIGILANCIA ADS-B SATELITAL EN LA REGIÓN NAT

(Presentada por Aireon)

**RESUMEN**

Esta Nota Informativa presenta un resumen de las informaciones contenidas en la Nota Informativa 05 (NAT SOG/15 – IP/05) de la décima quinta Reunión del Grupo de Seguridad Operacional del Atlántico Norte, que muestra el potencial para reducir el riesgo de colisión vertical con la utilización del ADS-B satelital, en las áreas oceánicas de la Región NAT.

**REFERENCIA**

- Nota Informativa NAT SOG/15 – IP/05

| | |
|---|---|
| ***Objetivos estratégicos de la OACI:*** | A – *Seguridad operacional; y*<br>B – *Capacidad y eficiencia de la navegación aérea.* |

## 1. Introducción

1.1 Aireon está desarrollando el sistema ADS-B satelital (Spaced-based ADS-B) que proveerá, a partir de 2018, cobertura global de vigilancia, que cambiará el contexto actual de menos de 35% para 100% de áreas con cobertura de vigilancia.

1.2. Hasta el momento se han realizado dos lanzamientos con 20 satélites en órbita y seis nuevos lanzamientos completarán la constelación de 66 satélites activos, nueve satélites de respaldo en órbita y seis satélites de respaldo en tierra.

1.3. Pruebas en vuelo fueron realizadas con la participación de FAA, NAV Canada y Polaris como parte del rigoroso proceso de validación de las cargas (payload) de cada satélite, con miras a maximizar la efectividad operacional. Dichas pruebas han tenido resultados exitosos y han comprobado el cumplimiento de los parámetros de rendimiento del sistema ADS-B satelital, como un sistema de vigilancia. Dentro del planeamiento, el sistema estará completamente implantado y operacional en el segundo semestre del 2018.

1.4. Al contar con un sistema de vigilancia en tiempo real de cobertura completa en el globo terráqueo, se espera un incremento significativo en la seguridad de vuelo de las operaciones aéreas. Uno de estos beneficios es la posible reducción en el riesgo de colisión en aire.

1.5 Los sistemas ATM que disponen del procesamiento y visualización del Nivel de Vuelo Seleccionado (SFL), incluyendo el chequeo cruzado con el Nivel de Vuelo Autorizado (CFL), serán beneficiados con informaciones más precisas y frecuentes (cada 1,5 segundos) del ADS-B satelital, proporcionando una indicación anticipada de las aeronaves con intenciones de no volar la trayectoria aprobada.

1.6 La habilidad de detectar desvíos verticales antes que ocurran provee un beneficio significativo de seguridad operacional y está siendo empleada con éxito por los Proveedores de Servicio de Navegación Aérea (ANSP) de Reino Unido.

## 2. Estudio realizado

2.1 El Grupo de Trabajo de Matemáticos (MWG) de la Región del Atlántico Norte (NAT) analizó los datos proporcionados por el Grupo de Escrutinio NAT de un periodo de 12 meses, empezando en 1 julio 2015. El modelo de riesgo de colisión vertical desarrollado por el MWG fue aplicado, asumiéndose los valores actuales de ocupación vertical, proporciones del Procedimiento Estratégico de Desvío Lateral (SLOP), tráfico, dimensiones de las aeronaves y la probabilidad de superposición lateral.

## 3. Resultado del estudio

3.1 Las capacidades de chequeo de conformidad vertical y actualización de posición más frecuente de la vigilancia a través del ADS-B satelital podrá, cuando operacional, reducir potencialmente el riesgo de colisión vertical en la Región NAT en aproximadamente 80%, con base nos desvíos verticales reportados en un periodo reciente de 12 meses.

3.2 Cuando el Procedimiento Estratégico de Desvío Lateral (SLOP) es considerado, el riesgo de colisión vertical estimado cae para 4,6 x 10E-9 accidentes fatales por hora de vuelo, abajo de la Meta de Nivel de Servicio (TLS) de 5 x 10E-9 accidentes fatales por hora de vuelo.

3.3 Dentro del Concepto Operacional adoptado que implantará ADS-B satelital en la Región NAT de OACI, en los espacios aéreos servidos por Canadá y Reino Unido, la funcionalidad será introducida en los sistemas GAATS usados en los Espacios Aéreos Oceánicos de Gander y Shanwick.

## 4. Acción sugerida

4.1 Se invita a la Reunión a tomar nota de la información proporcionada en esta nota informativa y su **Apéndice** (Nota Informativa NAT SOG/15 – IP/05 *Estimated Impact of Space-Based ADS-B Surveillance on Vertical Collision Risk in the ICAO North Atlantic Region*) y hacer los comentarios que estime pertinentes.

European and North Atlantic Office

**NORTH ATLANTIC SAFETY OVERSIGHT GROUP**

**FIFTEENTH MEETING**

*(Paris, France, 7 to 9 December 2016)*

**Agenda Item 4:** NAT SOG work programme

# Estimated Impact of Space-Based ADS-B Surveillance on Vertical Collision RiskIn the ICAO North Atlantic Region

*(Presented by CANADA)*

**SUMMARY**

*Vertical conformance checking and more frequent position update capabilities of space-based ADS-B surveillance has the potential to reduce the vertical collision risk in the ICAO North Atlantic Region (NAT) by almost 80%, based on the vertical deviations reported over a recent 12 month period. With the application of Strategic Lateral Offset Procedure, the vertical collision risk would decrease to below the Target Level of Safety of 5 x 10-9 fatal accidents per flight hour. The analysis utilized the deviations from the ICAO NAT Scrutiny Group, and the vertical collision risk model and parameter values currently applied by the ICAO NAT Mathematicians Working Group.*

## 1. Introduction

1.1 Mode-S employs aircraft transponders that provide altitude and identification data, and with ADS-B, can also include navigation and position information obtained from onboard GPS receivers. This data, broadcast from aircraft with the enhanced functionality, is available to pilots and air traffic controllers. The data can contain a large number of down-link airborne parameters (DAPs), including ground speed, indicated airspeed, heading and selected altitude (flight level).

1.2 The Mode S/ADS-B data updates are frequent (every 1.5 seconds), very accurate and can provide pilots and air traffic controllers with a common situational awareness. Allowing the processing and display of the Selected Flight Level (SFL) in the ATM System, including cross-checking with the Cleared Flight Level (CFL), gives an early indication of an aircraft not intending to fly the approved flight trajectory. The ability to detect vertical deviations before they occur provides a significant safety benefit, and has been employed successfully by Air Navigation Service Providers within the United Kingdom.

1.3 Space-Based ADS-B (SB ADS-B) has the ability to provide this information and, within the agreed Concept of Operations to deploy this technology within the ICAO North Atlantic (NAT) Region airspace served by Canada and the United Kingdom, this functionality is planned to be introduced for the GAATS system used for the Gander and Shanwick Oceanic Control Airspaces (OCAs).

1.4 For vertical deviations not detected by the SFL-CFL conformance checking, the more frequent and reliable position reports provided by SB ADS-B can limit the duration of an aircraft on an un-cleared flight level. This would effectively reduce the duration of vertical events that would otherwise exceed this limit.

1.5 This paper presents the estimated impact on the vertical collision risk in the ICAO NAT Region resulting from both the SFL-CFL conformance checking functionality and the reduction in the vertical event duration as described within the Concept of Operations and supported by SB ADS-B.

**2. Discussion**

2.1 The analysis is based on data for the 12 month period beginning 1 July 2015 available from the NAT Scrutiny Group (SG) and the NAT Mathematicians Working Group (MWG).

2.2 The NAT MWG vertical collision risk model was used and the current MWG values for vertical occupancy, Strategic Lateral Offset Procedure (SLOP) proportions, traffic, aircraft dimensions and probability of lateral overlap (Py(0)) were assumed (**Reference 1**).

2.3 The NAT SG reviewed the vertical deviation events reported during the 12 month period. The deviation data includes the number of un-cleared flight levels crossed (and their corresponding speed of climb/descent) and the duration at an un-cleared flight level. The Group also identified 18 of the 52 risk bearing vertical deviations that could have been prevented had SFL-CFL conformance checking functionality been in place **(Reference 2)**. They are identified in Attachment A. Eleven of these were in the Gander and Shanwick OCAs.

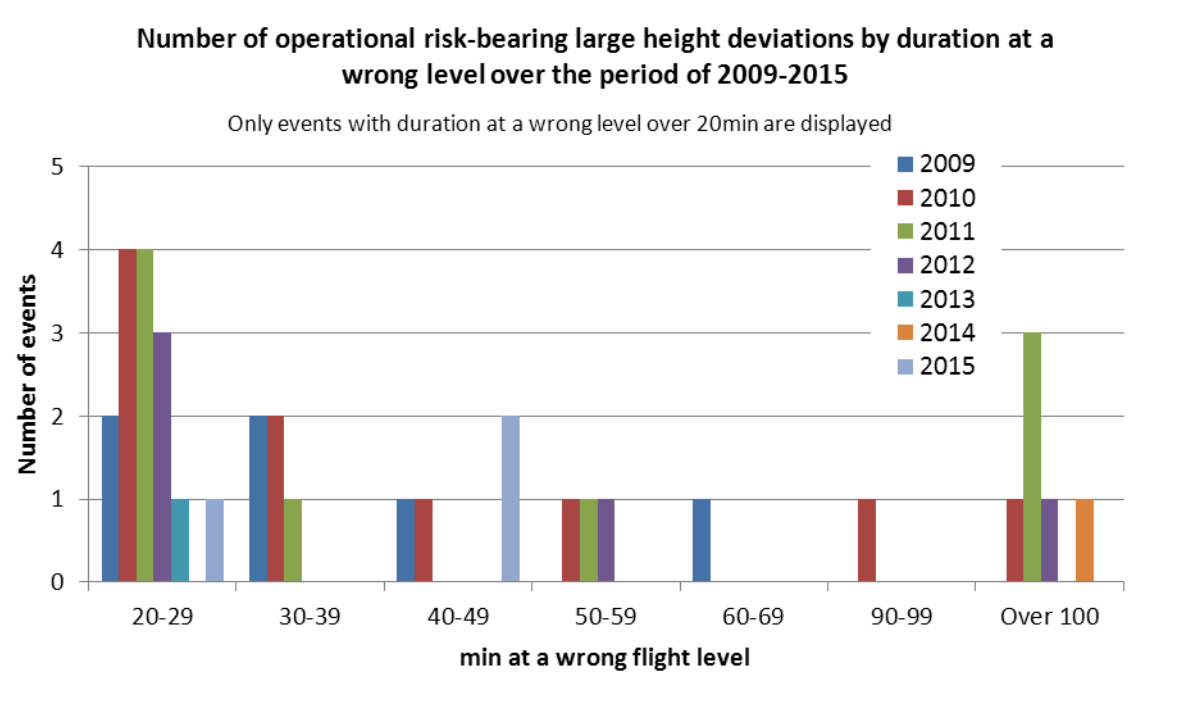
2.4 The remaining vertical deviations were assessed to determine the potential impact of limiting their duration at an un-cleared flight level as a result of the more frequent position updates from SB ADS- B. Westbound deviations in the Shanwick OCA reported prior to December 2015 were excluded from consideration since they could have been prevented, or their impact reduced, had the pre-boundary conformance checks introduced at the start of the RLatSM Phase 1 trial been available. These checks have been in place for the eastbound flights entering the Gander OCA for approximately four years.

2.5 The duration limit of vertical deviations was derived by applying the weighted average of the intervention times of the various communications scenarios developed by the SASP in the generation of proposed SB ADS-B separation standards **(Reference 3)**. For FANS aircraft the weighted average intervention time is 4.3 minutes. Including an update rate of SB ADS-B of 15 seconds (0.25 minutes), and accounting for the time to detect the vertical deviation, a duration limit of 5 minutes was assumed in this analysis.

2.6 The computed duration limit at an un-cleared flight level also considered the time required for the deviating flight to reach the un-cleared flight level using the rate of climb/descent data contained in the vertical deviation reports.

2.7 The present analysis assessed the impact of limiting the duration of all the vertical deviations. However, as would be expected, limiting the long duration events would result in the highest reduction in risk. Vertical height deviations of more than 20 minutes have consistently been observed over the years as displayed in Figure 1. Although these events represent a small proportion of the total number of vertical deviations, they have a major impact on the vertical risk. For example, in 2009 six long duration vertical deviations represented 44% of the total risk even though they represented only 6% of the risk- bearing vertical events in the year (**Reference 4**). In 2014, one long duration event accounted for a majority of the total time spent at wrong flight level, 127 minutes. Removal of this one vertical event would have reduced the overall operational risk by 41% (**Reference 5**).

**Figure 1: Long Duration Height Deviations Observed in the NAT: 2009 – 2015**




***RESULTS***

2.8 The analysis results for the NAT are summarized in Table 1, both with and without the application of SLOP. Attachment B contains the results specifically for the Gander-Shanwick OCAs.

2.9 With SLOP, SFL-CFL conformance checking would potentially prevent 18 vertical deviations from occurring in the 12 month period, reducing the collision risk estimate by 35%. The safety benefit increases to a 77% reduction in the collision risk when the remaining vertical deviation times are limited to 5 minutes.

2.10 When SLOP is considered, the vertical collision risk estimate falls to 4.6 x $10^{-9}$ fatal accidents per flight hour, below the Target Level of Service (TLS) of 5 x $10^{-9}$ fatal accidents per flight hour.

2.11 The NAT SG plans to continue to identify the vertical events that could benefit from this capability during its review process and the NAT MWG has agreed to assess this impact annually and report the results to the NAT Safety Oversight Group.

**Table 1: Summary of the Potential Impact of SB ADS-B on Vertical Collision Risk in the NAT (July 1, 2015-June 30, 2016)**

| SCENARIO | | # Vertical Deviations | Un-cleared | | Vertical Collision Risk (x $10^{-9}$ fapfh) | |
|---|---|---|---|---|---|---|
| | | | Duration (mins) | Flight Levels Crossed | Without SLOP | With SLOP |
| No Surveillance | | 52 | 273 | 38 | 94.4 | 19.8 |
| SB ADS-B | SFL-CFL only | 34 | 176 | 31 | 61.7 | 12.9 |
| | % Reduction from No Surveillance | -35% | -36% | -18% | -35% | -35% |
| | SFL-CFL & Limited Duration | 34 | 54 | 31 | 20.8 | 4.6 |
| | % Reduction from No Surveillance | -35% | -80% | -18% | -78% | -77% |

## 3. Action by the Meeting

3.1 The NAT SOG is invited to note the information provided.

REFERENCES

1. *NAT MWG/52, Report to the SOG, June 2016.*
2. *NAT SG/15, Summary of discussions. Appendix C Selected Flight Level-Cleared Flight Level (SFL-CFL) Conformance Checking via Space-Based ADS-B, September 2016.*
3. *SASP/29, Circular v4 draft, September 2016.*
4. *NAT MWG/47 WP05, Estimates of NAT MNPS vertical collision risk due to large height deviations during 2009, April 2010.*
5. *NAT MWG/51 WP12rev2, Estimates of NAT MNPS vertical collision risk due to large height deviations during 2014, May 2015.*

APÉNDICE SAM/IG/20-NI/07

**ATTACHMENT A –Vertical Deviations in the ICAO NAT Regional Preventable with SFL-CFL Conformance Checking Functionality with SB ADS-B (July 1, 2015 to June 30, 2016)**

| Date | Un-cleared Flight Levels Crossed | Duration on an Un-cleared Flight Level (mins) |
|---|---|---|
| 25/06/2016 | 0 | 3 |
| 22/05/2016 | 0 | 1 |
| 24/04/2016 | 0 | 0 |
| 26/02/2016 | 1 | 0 |
| 07/01/2016 | 0 | 0 |
| 26/11/2015 | 0 | 6 |
| 13/11/2015 | 1 | 0 |
| 09/11/2015 | 0 | 2 |
| 27/10/2015 | 1 | 3 |
| 10/10/2015 | 0 | 0 |
| 01/10/2015 | 0 | 24 |
| 21/09/2015 | 1 | 2 |
| 20/09/2015 | 1 | 1 |
| 06/09/2015 | 1 | 3 |
| 01/08/2015 | 1 | 2 |
| 30/07/2015 | 0 | 44 |
| 22/07/2015 | 0 | 0 |
| 15/07/2015 | 0 | 6 |
| **TOTAL** | **7** | **97** |

**ATTACHMENT B –Impact of SFL-CFL Conformance Checking Functionality and Limited Vertical Deviation Time with SB ADS-B in the Gander-Shanwick OCAs (July 1, 2015 to June 30, 2016)**

B1. The vertical collision risk results for the Gander-Shanwick are summarized in Table B1, both with and without the application of SLOP. With SLOP, SFL-CFL conformance checking would have potentially prevented 11 vertical deviations from occurring in the 12 month period, reducing the collision risk estimate by about 30%. The safety benefit increases slightly with the remaining vertical deviation times limited to 5 minutes before being intervened.

B2. When SLOP is considered, the vertical collision risk estimate falls below the Target Level of Service (TLS) of 5 x $10^{-9}$ fatal accidents per flight hour.

B3. The impact is lower for the Gander-Shanwick OCAs than the NAT lower number of long duration events reported in this airspace over the 12 month period. This can and does fluctuate from year-to-year.

**Table B1: Summary of the Potential Impact of SB ADS-B on Vertical Collision Risk in the Gander-Shanwick OCAs (July 2015-June 2016)**

| GANDER-SHANWICK (July 1, 2015 to June 30, 2016) | | | Un-cleared | | Vertical Collision Risk (x $10^{-9}$ fapfh) | |
|---|---|---|---|---|---|---|
| SCENARIO | | # Vertical Deviations | Duration (mins) | Flight Levels Crossed | Without SLOP | With SLOP |
| No Surveillance | | 30 | 43 | 26 | 20.9 | 5.0 |
| SB ADS-B | SFL-CFL only | 19 | 29 | 21 | 15.0 | 3.4 |
| | % Reduction from No Surveillance | -37% | -33% | -19% | -28% | -32% |
| | SFL-CFL & Limited Duration | 19 | 26 | 21 | 14.1 | 3.2 |
| | % Reduction from No Surveillance | -37% | -40% | -19% | -33% | -36% |