



Agenda Item 4: Assessment of operational requirements to determine the implementation of improvements in communication, navigation and surveillance (CNS) capabilities for operations in en-route and terminal areas

ESTIMATED IMPACT OF SPACE-BASED ADS-B SURVEILLANCE ON VERTICAL COLLISION RISK IN THE NORTH ATLANTIC REGION

(Presented by Aireon)

SUMMARY	
This Information Paper presents a summary of the information contained in Information Note 05 (NAT SOG/15 - IP/05) of the Fifteenth Meeting of the North Atlantic Safety Group, which shows the potential to reduce the risk of vertical collision with the use of spaced - based ADS-B, in the oceanic areas of the NAT Region.	
Reference:	
- Information Paper AT SOG/15 – IP/05	
ICAO strategic goals:	<i>A – safety</i> <i>B – Air Navigation Capacity and efficiency</i>

1. Introduction

1.1 Aireon is developing the spaced-based ADS-B system that will provide, as of 2018, global surveillance coverage, which will change the current context from less than 35% to 100% areas with complete surveillance coverage.

1.2. To date, three launches have been made with 30 satellites in orbit and six new launches will complete the constellation of 66 active satellites, nine orbiting backup satellites and six spare satellites on ground.

1.3. Flight tests were conducted with the participation of FAA, NAV Canada and Polaris as part of the rigorous process of payload validation of each satellite, with a vision of maximizing operational effectiveness. These tests have had successful results and have verified compliance with performance parameters of the spaced- based ADS-B system in its role as a surveillance system. Within this approach, the system will be fully implemented and operational in second half of 2018.

1.4. With a full-time real-time surveillance system on the globe, a significant increase in flight safety is expected in all air operations. One of these benefits is the possible risk reduction of mid-air collision.

1.5 ATM systems having the functions of processing and displaying Selected Flight Level (SFL), including cross-checking with Cleared Flight Level (CFL), will benefit from more accurate and frequent information (every 1.5 seconds) of ADS-B, providing early indications of any aircraft with intentions of not flying its cleared trajectory.

1.6 The ability to detect any vertical deviations before they occur provides a significant benefit to operational safety and is being successfully implemented by UK Air Navigation Service Providers (ANSPs).

2. Study/ Assessment

2.1 The Mathematic Working Group (MWG) of the North Atlantic Region (NAT) analyzed data provided by the NAT Scrutiny Group for a period of 12 months, beginning on July 1, 2015. The vertical collision risk model developed by the MWG was applied, assuming the current values of vertical occupation, proportions of the Strategic Lateral Offset Procedures (SLOP), traffic, aircraft dimensions and the probability of lateral overlap.

3. Results of the study/ assessment

3.1 The increase in the capacity and frequency to check and update vertical compliance and position through the spaced-based ADS-B surveillance system may, when operational, potentially reduce the risk of vertical collision in the NAT Region by approximately 80%, based on reported vertical deviations in a recent period of 12 months.

3.2 When considering the Strategic Lateral Offset Procedures (SLOP), the estimated vertical collision risk falls to $4.6 \times 10E-9$ fatal accidents per hour of flight, below the Target Level of Safety (TLS) of $5 \times 10E-9$ fatal accidents per flight hour.

3.3 Within the adopted Operational Concept to be implemented with spaced-based ADS-B in the NAT Region, in airspaces served by Canada and the United Kingdom, functionality will be introduced in the GAATS systems used in the Gander and Shanwick Ocean Airspaces.

4. Suggested action

4.1 The Meeting is invited to take note of the information presented in this information paper and its **Appendix** (Information Paper NAT SOG/15 – IP/05 Estimated Impact of Space-Based ADS-B Surveillance on Vertical Collision Risk in the ICAO North Atlantic Region) and make comments that deem appropriate.



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 Risk In 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 5×10^{-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**).

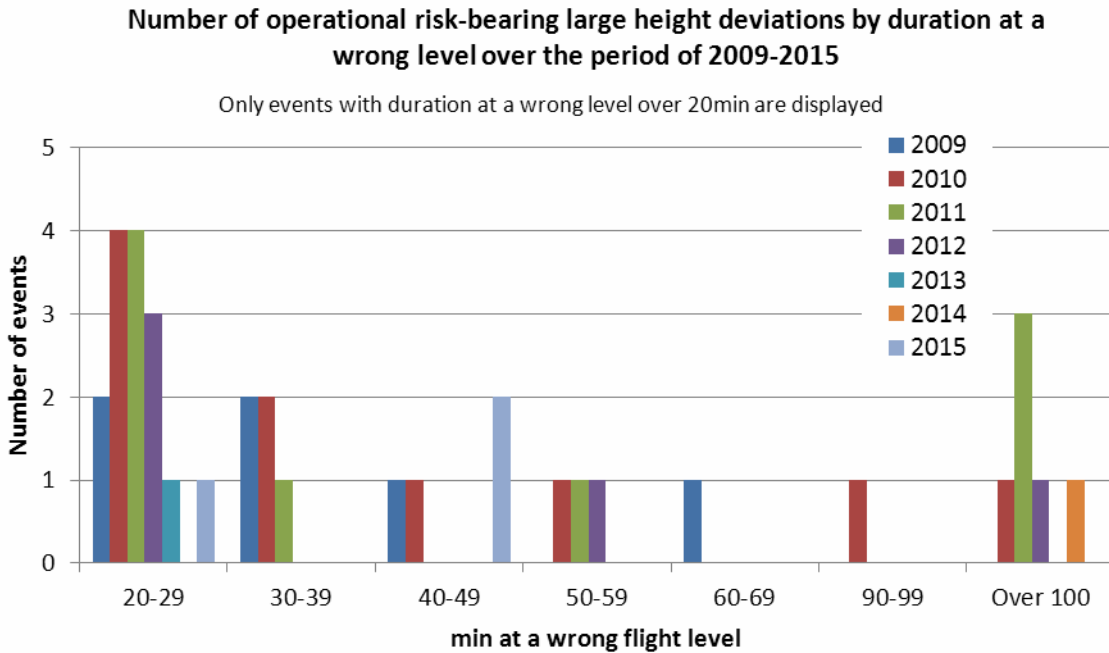
2.3 The NAT SG reviewed the vertical deviation events reported during the 12 month period. The deviation data includes the number of un-cleared flight levels crossed (and their corresponding speed of climb/descent) and the duration at an un-cleared flight level. The Group also identified 18 of the 52 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 4.6×10^{-9} fatal accidents per flight hour, below the Target Level of Service (TLS) of 5×10^{-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.

APPENDIX

SAM/IG/20-IP/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 5×10^{-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)		
		# 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%