Agenda Item 4: Large Height Deviation (LHD) Analysis

LARGE HEIGHT DEVIATION ANALYSIS FOR THE WESTERN ATLANTIC ROUTE SYSTEM (WATRS) AIRSPACE CALENDAR YEAR 2016

(Presented by North American Approvals and Registry Monitoring Organization (NAARMO) / United States)

SUMMARY

The NAARMO, is an ICAO endorsed Regional Monitoring Agency (RMA) administered by the U.S. Federal Aviation Administration at the William J. Hughes Technical Center (WJHTC). In 2013, the New York Oceanic FIR was partitioned into two FIRs: New York Oceanic East and New York Oceanic West. The New York Oceanic East FIR is part of the ICAO NAT Region, and the New York Oceanic West FIR is part of the ICAO CAR/SAM Region. This working paper contains the LHD analysis for the Western Atlantic Route System (WATRS) airspace for calendar year 2016.

REFERENCES:

- ICAO State Letter, NACC13/01 - ATM - EMX694, Proposal for Amendment of the Caribbean and South American Regions (CAR/SAM-ANP - Doc 8733) and North Atlantic Region (NAT ANP - Doc 9634) Basic Air Navigation Plans, 15 August 2013;
- NAARMO, "Discussions on Safety Monitoring Activities for New York Oceanic West Flight Information Region (FIR)", GTE/16, IP/09, September 2016.

ICAO Strategic Objectives:	*A - Safety* *B - Air navigation capacity and efficiency* *D - Economic Development of Air Transport* *E - Environmental protection*

1. Introduction

1.1 The North American Approvals Registry and Monitoring Organization (NAARMO), is an ICAO endorsed Regional Monitoring Agency (RMA) administered by the FAA at the WJHTC. The New York Oceanic Flight Information Region (FIR) is shown in **Figure 1**. The fixed route system residing in the western portion of the FIR is referred to as the Western Atlantic Route System (WATRS) airspace. The WATRS airspace primarily contains operations travelling between North America and the Caribbean. The eastern portion of the New York Oceanic FIR consists of operations travelling between North America and Europe. The U.S. FAA is the ATS provider for the New York Oceanic FIR. The northern oceanic boundary of New York oceanic airspace borders the Gander FIR which is controlled by Transport Canada/NavCanada. The eastern boundary of the New York FIR borders the Santa Maria FIR which is controlled by Navagaçao Aerea de Portugal.

1.2 The RVSM was introduced in November 2001 into WATRS airspace. The NAARMO completed the RVSM safety assessment for this implementation and conducts the on-going airspace safety monitoring activities to ensure the continued safe-use of the RVSM.

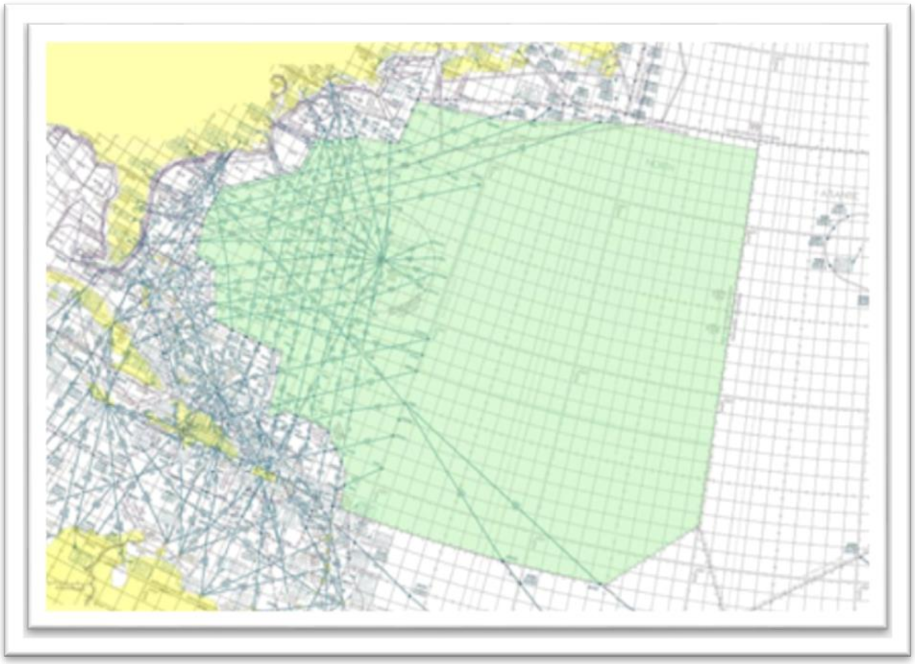

Figure 1 - New York Oceanic FIR

1.3 In August 2013, a change was made to partition the New York Oceanic Flight Information Region (FIR) into two FIRs: New York Oceanic East and New York Oceanic West. Prior to this change the entire New York Oceanic FIR was part of the ICAO North Atlantic (NAT) Region. After the change, the New York Oceanic East FIR is part of the ICAO NAT Region, and the New York Oceanic West FIR is part of the ICAO CAR/SAM Region (reference 1).

1.4 The flight operations within New York Oceanic West are comprised of two distinct traffic flows. The two main traffic flows are East-West (NAT routes) and North-South (NAM-CAR routes). **Figure 2** shows reported positions within the New York Oceanic FIR during December 2016.

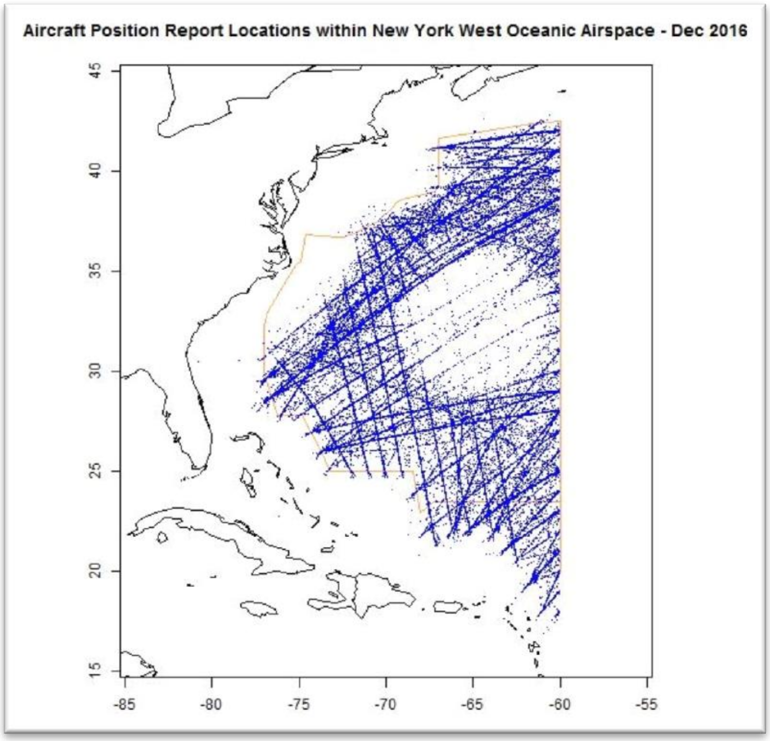

Figure 2 - Reported Positions within New York West Oceanic FIR - December 2016

1.5 The separation minima in the New York West Oceanic FIR are 1 000-ft vertical, 15 minute longitudinal (or 10 minute longitudinal with Mach Number Technique in place), and 50 NM lateral. The application of the 30-NM and 50-NM longitudinal separation standards and the 30-NM lateral separation standard is accomplished *ad hoc* between pairs of suitably equipped aircraft; this means that the application of the reduced horizontal separation minima is not planned prior to oceanic entry.

2. **Discussion**

2.1 Reports of Large Height Deviations (LHDs), Large Lateral Deviation (LLDs) and Large Longitudinal Errors (LLEs) are forwarded to the NAARMO from the Miami, New York and San Juan Oceanic Centers. In addition, the FAA's Comprehensive Electronic Data Analysis and Reporting (CEDAR) database provides access to several principal aviation safety data and information sources. The NAARMO scans this database periodically in search of incidents occurring in WATRS airspace. These data supplement the LHD, LLD, and LLE reports received from the ATS providers.

2.2 **Reports of LHDs**

2.2.1 There were a total of 40 LHD events reported for WATRS airspace in calendar year 2016. The LHD events can be attributed towards operational or technical causes. Of the 40 reported LHD events, 7 were considered to be attributed to technical risk and 33 events were attributed towards operational risk.

2.2.2 The 7 LHD events attributed towards technical risk consisted of 6 reports of turbulence and 1 report of an aircraft which lost RVSM capability and was subsequently provided with 2 000-ft separation. **Table 1** provides a summary of all the reported LHDs by category code.

Table 1 - WATRS Airspace LHD Summary for Calendar Year 2016

LHD Category Code	LHD Category Description	No. of LHD Occurrences	LHD Duration (Min)	No of FL Transitioned without Clearance
A	Flight crew failing to climb/descend the aircraft as cleared;	5	6	6
B	Flight crew climbing /descending without ATC clearance;	5	6	4
C	Incorrect operation or interpretation of airborne equipment (e.g. incorrect operation of fully functional FMS, incorrect transcription of ATC clearance or re-clearance, flight plan followed rather than ATC clearance, original clearance followed instead of re-clearance etc.)	0	0	0
D	ATC system loop error; (e.g. ATC issues incorrect clearance or flight crew misunderstands clearance message);	10	36	19
E	Coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility as a result of human factors issues (e.g. late or non-existent coordination, incorrect time estimate/actual, flight level, ATS route etc not in accordance with agreed parameters);	11	83	0
F	Coordination errors in the ATC-to-ATC transfer of control responsibility as a result of equipment outage or technical issues;	1	8	0
G	Aircraft contingency event leading to sudden inability to maintain assigned flight level (e.g. pressurization failure, engine failure);	1	0	6
H	Airborne equipment failure leading to unintentional or undetected change of flight level (e.g. altimetry errors)	1	0	0
I	Turbulence or other weather related causes	6	0	1
J	TCAS resolution advisory; flight crew correctly following the resolution advisory	0	0	0
K	TCAS resolution advisory; flight crew incorrectly following the resolution advisory	0	0	0
L	An aircraft being provided with RVSM separation is not RVSM approved (e.g. flight plan indicating RVSM approval but aircraft not approved, ATC misinterpretation of flight plan);	0	0	0
M	Other	0	0	0
Totals		**40**	**139**	**36**

2.2.3 The reported LHDs contained in Table 1 can be subdivided into one of three categories: air crew errors, ATC errors, or technical/avionic errors. The first three rows in Table 1, LHD Category Codes A, B, and C can be attributed to air crew errors. The next three rows, LHD Category Codes D, E, and F are associated with ATC errors. Technical or avionic errors would be categorized with LHD Category Codes G, H, I, J or K. **Table 2** provides a high level summary of the data contained in Table 1. Table 2 shows that LHD events attributed to ATC errors contribute more operational risk in the WATRS airspace compared to other causes.

Table 2 - High Level Summary of LHDs for Calendar Year 2016

	No. of LHD Occurrences	**LHD Duration (Min)**	**No of FL Transitioned without Clearance**
Air Crew Errors	10	12	10
ATC Errors	22	127	19
Technical/Avionic Errors	8	0	7
Totals	**40**	**139**	**36**

2.2.4 Table 1 shows that LHD events associated with errors in ATC coordination are the leading cause of operational risk in the WATRS airspace. The LHD category with the largest number of minutes spent at incorrect flight level was 'E', coordination errors in the ATC-unit-to-ATC-unit transfer of control responsibility as a result of human factors issues. The largest contributing LHD event in this category was caused by an error in read-back/hear-back coordination between adjacent ATC units, this event accounted for 45 minutes of the 83 total minutes associated with this category ('E').

2.2.5 Reported LHD events attributed to ATC system loop errors, LHD category 'D', account for a total of 36 minutes spent at incorrect flight level during calendar year 2016. There were two LHD category 'D' events that together contributed a total of 27 minutes of time at incorrect flight level. Both of these events were complicated by contributing errors involving the ATC automation system. There have since been several updates to the automation system that will prevent similar events in the future. **Figure 3** provides the approximate locations of the operational LHD reports in WATRS airspace for calendar year 2016.

2.2.6 The locations of the Technical LHD events within WATRS airspace during calendar year 2016 are shown in **Figure 4**. There were six reports of turbulence that caused vertical deviations from cleared flight level. There was one LHD report involving an aircraft with degraded RVSM capability that required ATC to establish 2 000-ft separation with two other aircraft.

2.2.7 It is noted that many of the events associated with LHD category codes are not directly attributable to the RVSM. However, the RVSM and increases the risk of collision due to the potential proximity of other traffic when there a blunder or human error occurs.

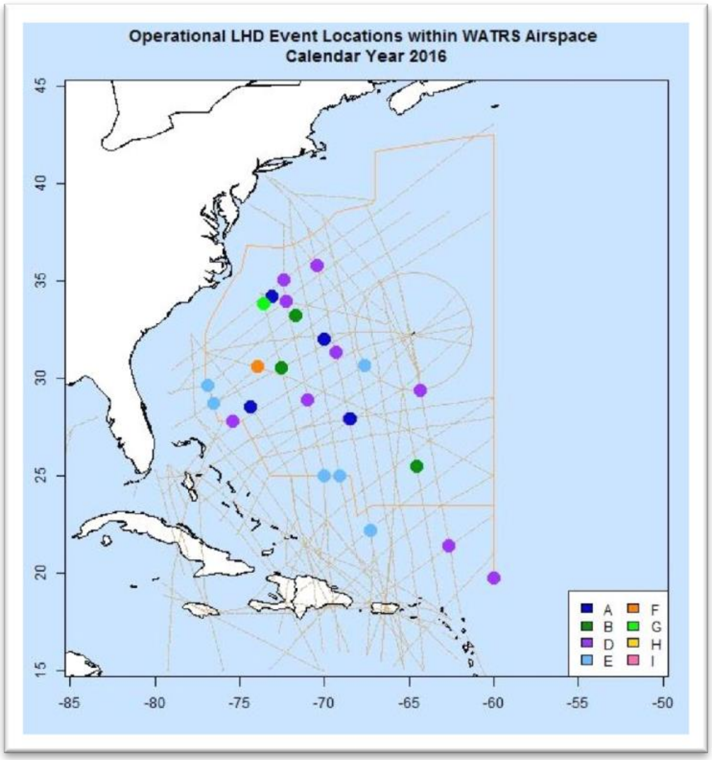

Figure 3 - Operational LHD Event Locations - Calendar Year 2016

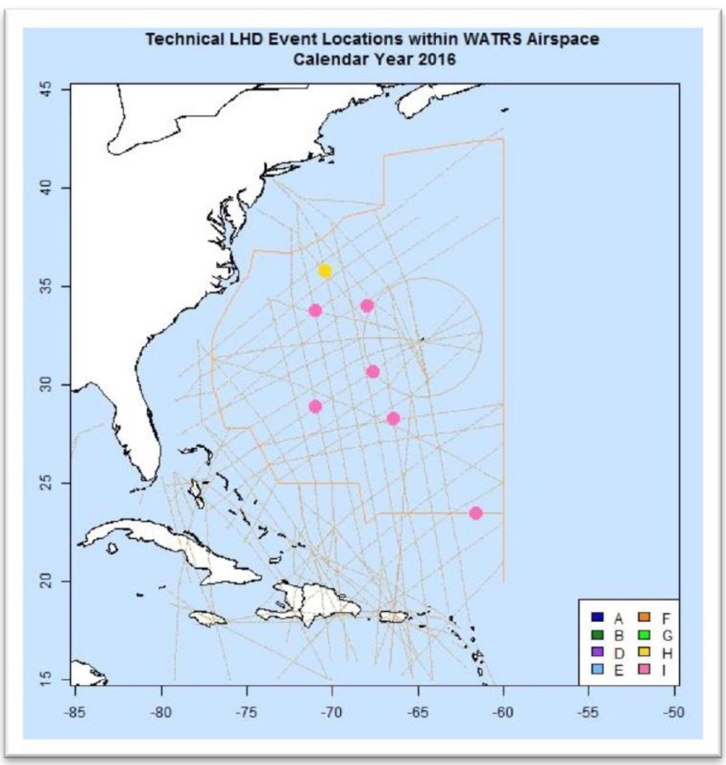

Figure 4 - Technical LHD Event Locations - Calendar Year 2016

2.3 LHD Trends

2.3.1 The NAARMO has provided RMA services for the WATRS airspace since the RVSM was introduced in 2001. In June 2008, a restructure of the airways within WATRS airspace was implemented in an effort to increase capacity and efficiency. With the reorganization of the WATRS route system, the 50-NM lateral separation standard was introduced. The NAARMO also conducted the safety assessment for the implementation of the 50-NM lateral separation standard.

2.3.2 In December 2013, the 50-NM longitudinal, 30-NM lateral, and 30-NM longitudinal separation minima were introduced in the New York Oceanic FIR, including the WATRS airspace. The reduced horizontal separation minima are available for suitably equipped aircraft pairs. The application of the reduced horizontal separation standards is accomplished ad hoc between pairs of eligible aircraft; this means that the application of the separation minima is not planned prior to oceanic entry. The NAARMO conducted the pre-implementation safety assessment and the post-implementation monitoring activities for these reduced horizontal separation standards in New York Oceanic FIR.

2.3.3 The source of the event data for the WATRS airspace has improved since the initial implementation of the RVSM in calendar year 2001. The FAA has made significant changes to the safety reporting system in use at all domestic, oceanic, and offshore facilities. The data from the Comprehensive Electronic Data Analysis and Reporting (CEDAR) system provides NAARMO with event reports and quality assurance (QA) summaries. **Figure 5** contains trend information for the number of LHD reports and associated duration at incorrect flight level. The values shown for calendar year 2010 and 2011 represent the qualified LHD reports using previous versions of the FAA event data base. The CEDAR event data became available to the NAARMO in calendar year 2013. There is a two-year gap in the data provided in Figure 5, the LHD event data for calendar years 2014 and 2015 are missing due to insufficient resources to complete the analysis. The NAARMO is working to fill this gap to assist in recognizing adverse trends in the airspace.

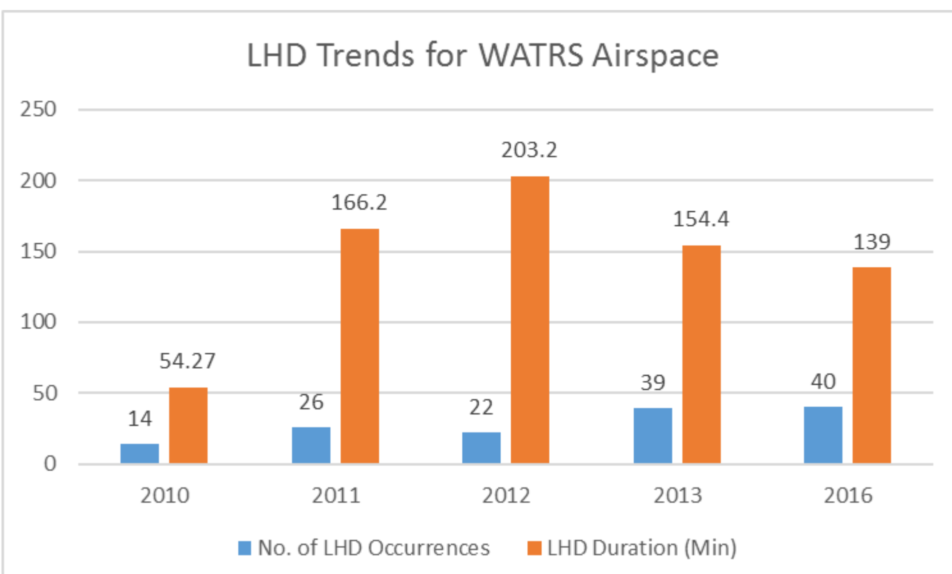

Figure 5 - LHD Trends for WATRS Airspace

2.4 **Measurement of Traffic Density in WATRS Airspace**

2.4.1 The traffic density within WATRS airspace has a seasonal variation. **Table 3** provides observed counts of flight operations and flying hours for March, June, September and December 2016. The highest traffic volumes are observed between the months of November and April, and lower traffic volumes are realized between the months of June and October each year.

Table 3 - Observed Flying Hours and Traffic Counts by Month

	No. of Flight Operations	Average No. of Flight Operations Per Day	Total Flying Hours	Average No. Flying Hours per Day
Mar-16	19,093	615.9	19,534.5	630.1
Jun-16	16,376	545.9	14,874.8	495.8
Sep-16	13,911	463.7	13,419.5	447.3
Dec-16	19,015	613.4	18,801.4	606.5

2.4.2 A majority of the flight operations utilize the fixed airway structure in WATRS Airspace (see Figure 1). The traffic levels during the month of December are examined as these represent a peak time period for WATRS traffic volume. The traffic counts observed on the north-south airways during the month of December 2016 are shown in **Figure 6**. The three airways, L453, L454, and L455 also account for the highest number of vertical passings in both the same and opposite direction. A vertical passing is counted when a pair of aircraft, nominally assigned to adjacent flight levels and operating on the same route, report over the same airway fix within 15 minutes of one another. The number of vertical passings is needed to assess the traffic density in the airspace. **Figure 7** provides the history of vertical occupancy estimates for WATRS airspace.

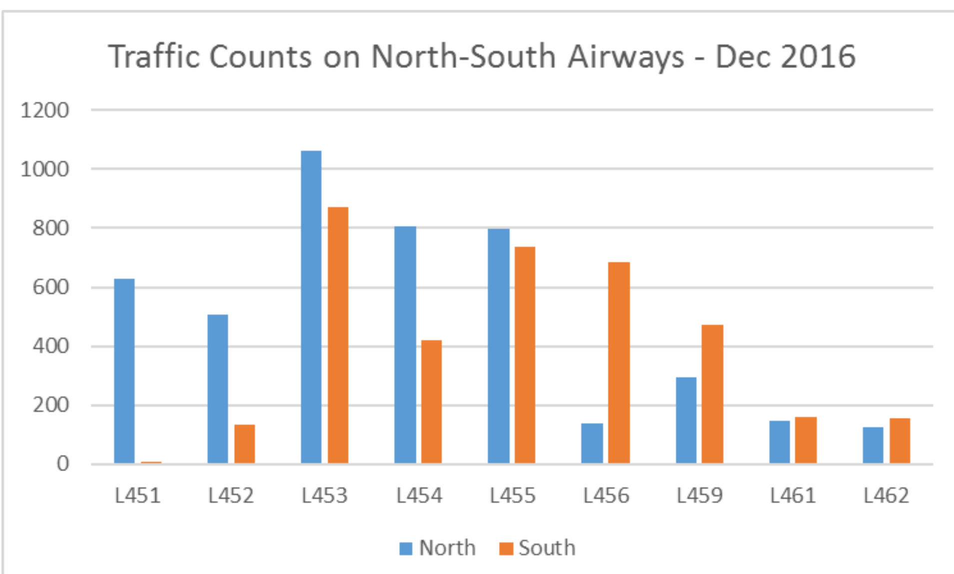

Figure 6 - Traffic Counts on North-South Airways - December 2016

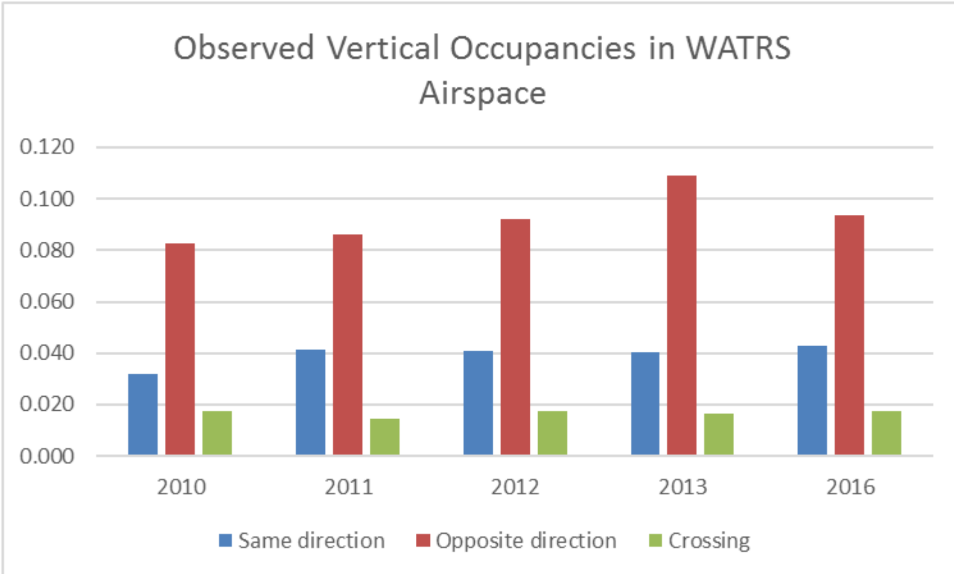

Figure 7 - Vertical Occupancy Trends for WATRS Airspace

2.4.3 Figure 7 shows the opposite direction vertical occupancy values are much larger than the same direction and crossing vertical occupancy values. This result is directly attributed to the flight level allocation scheme in place on the WATRS airways.

2.5 Comparison of Estimated Vertical Risk to the TLS

2.5.1 The vertical collision risk model is highly sensitive to the number of opposite direction vertical passings. The risk estimates provided in **Table 4** reflect the sensitivity of the opposite direction vertical occupancy values. The estimated number of flying hours in WATRS airspace during calendar year 2016 is 225,617.21 hours. The estimates of vertical risk provided in Table 4 are consistent with previous estimates, for example the 2013 estimate of overall vertical risk was 286.1 x 10^{-9} fapfh.

Table 4 - Vertical Risk Estimates Calendar Year 2016

	Vertical Risk Estimate (fapfh)
Technical Risk	0.84 x 10^{-9}
Operational Risk	218.4 x 10^{-9}
- Same Direction	2.22 x 10^{-9}
- Opposite Direction	216.1 x 10^{-9}
- Crossing	0.007 x 10^{-9}
Total Risk	219.2 x 10^{-9}

2.5.2 The use of automatic position reporting and ATC-pilot communications accomplished through data link, automatic dependent surveillance – contract (ADS-C_ and controller pilot data link communication (CPDLC), is on the rise in WATRS airspace. The ATC automation in the New York West FIR has supported the use of ADS-C and CPDLC for several years, but the operator use of data link in WATRS airspace has been relatively low when compared to other oceanic areas. The delivery of accurate and frequent position reports along with faster communications can help in reducing risk by decreasing the time spent at incorrect or unprotected flight levels.

2.5.3 Improvements in the ATC automation software are being developed and implemented to mitigate and prevent LHD causes that were determined to be related to the automation systems. The timeline for these improvements varies based on funding and task complexity.

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