



**Manual on the Assessment of Large
Height Deviations (LHDs) based on an
ATS Safety Management System (SMS)
for the AFI Regions**

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1. INTRODUCTION

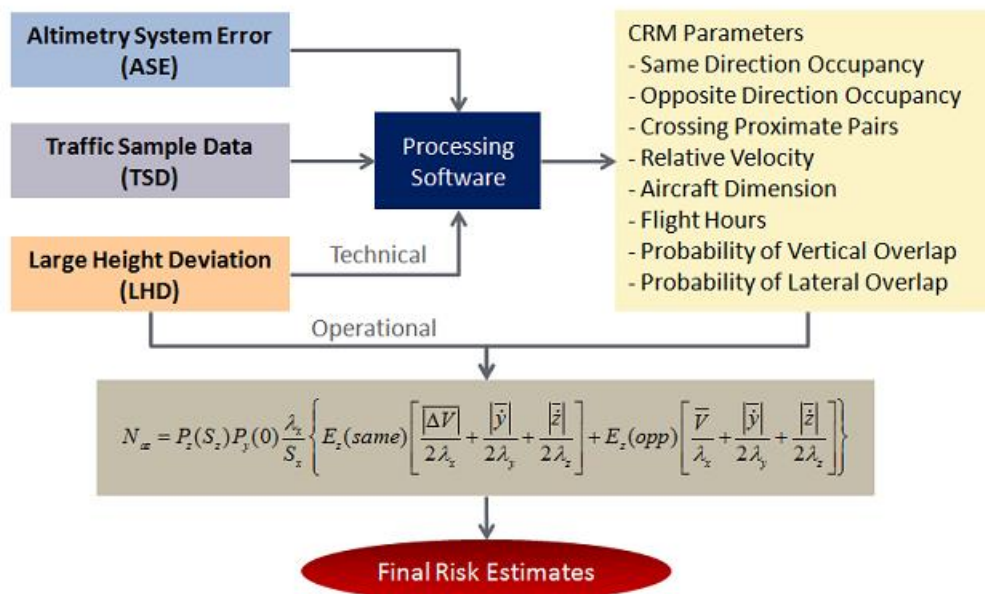
The AFI Monitoring Agency (ARMA) have developed a methodology for the analysis and assessment of Large Height Deviations (LHDs), based on a Safety Management System (SMS), with the purpose of increasing the level of safety in AFI (Africa Indian Ocean Region)RVSM airspace.

This methodology is used for assessing the level of risk of each occurrence individually, and helps to identify trends and critical points of occurrence.

ARMA will continue calculating the Risk Value using the Collision Risk Assessment (CRA) established in ICAO Doc 9574 (Manual on implementation of a 300m vertical separation minimum between FL290 and FL410 inclusive), using a TLS of 5×10^{-9} fatal accidents per hour of flight as reference parameter. The objective is to conduct a quantitative (CRA) and qualitative (SMS) assessment of operations in RVSM airspace and increase the level of safety in the AFI Regions.

2. Background

The Scrutiny Group recognised the need to analyse LHDs applying a safety management system (SMS) approach, since the Collision Risk Model uses a mathematical formula to calculate the level of risk of the Regions without giving details of the occurrences analysed.



3. LHD Analysis and Assessment

During the analysis, the cause of the occurrence is identified using the LHD code table, which is contained in appendix B to this manual.

Following the identification of the causes (LHD code) by ARMA, the Scrutiny Group must analyse the risks associated to each LHD code that has been identified, assessing their severity and likelihood of occurrence.

For the **Severity Analysis**, the Scrutiny team, based on its experience, applies the Severity Table as follows:

Effects	Severity of Hazard (LHD)
---------	--------------------------

ATC	Catastrophic 5	Hazardous 4	Major 3	Minor 2	Insignificant 1
	Collision with aircraft, ground or obstacle. TCAS (RA) warning	Significant reduction of separation or total loss of capacity (ATC zero)	Significant reduction of separation or ATC capacity	Slight reduction of ATC capacity or significant increase of ATC workload	Slight increase of ATC workload

Table 1

Each code is associated to an LHD severity based on the impact on safety:

5	4	3	2	1
J, K	B, D, F, G, H, I	A, C, E, L	E	M

Table 2

After determining the severity, the **Likelihood** is established based on statistical data showing the points with higher rates of occurrence in the CAR/SAM Regions, bearing in mind the worst-case scenario. To this end, the following table is used:

Likelihood	Level of ATC service/system	Operational
Frequent 5	Continuously occurring in the system	Expected to occur every 1-2 days
Occasional 4	Expected to occur frequently in the system	Expected to occur several times a month
Remote 3	Expected to occur several times during the lifetime of the system	Occur approximately once every few months
Unlikely 2	Unlikely, but may be reasonably expected to occur during the lifetime of the system	Expected to occur approximately once very three years
Extremely unlikely 1	One of them is unlikely but possible in the lifetime of the system	Expected to occur approximately every 30 years

Table 3

After determining the likelihood, the duration of the occurrence is established based on the following table:

1 Short	$d \leq 1$ minutes
2 Medium	$1 < d \leq 2$ minutes
3 Long	$d > 3$ minutes

Table 4

Thus, the following expression may be used:

Likelihood (P)	Duration (D)	Severity (G)
5 Frequent		5 Catastrophic
4 Occasional		4 Hazardous
3 Remote	3 Long	3 Major
2 Unlikely	2 Medium	2 Minor
1 Extremely unlikely	1 Short	1 Insignificant

Table 5

Once the aforementioned values have been obtained, it is determined whether the FIR that is subject to the risk has an ATS surveillance system, if meteorological conditions were VMC or IMC, and whether there was other conflicting traffic, based on which the following values are assigned:

Surveillance system	Meteorological conditions	Other traffic
YES = 5	VMC = 0	With surveillance = 10
NO = 10	IMC = 5	Without surveillance = 10

Table 6

4. Risk Value Calculation

Once the aforementioned data is obtained, the following formula is applied for calculating the risk value:

$$VR = (P \times D \times G) + R + W + T, \text{ where:}$$

Parameter	Description	Value
VR	Risk value	To be calculated
P	Probability of the position	Varies from 1 to 5
D	Duration of the occurrence	Varies from 1 to 3
G	Severity of the occurrence	Varies from 1 to 5
R	With or without ATS surveillance	With=5 or Without=10
W	Meteorological conditions	VMC=0 or IMC=5
T	Other traffic (if any)	10
	TOTAL	Maximum 100 points

Table 7

5. Target level of safety (TLS)

Once the LHD analysis and assessment process has been completed, the resulting Risk Value for each LHD is inserted in the risk matrix, which is designed to show if the level of risk of each occurrence is above or below the TLS that has been defined as the acceptable level for the AFI Regions, i.e., 20 points.

RV	Risk Level	Control
76-100	HIGH	Unacceptable risk, RVSM airspace must be cancelled until the hazard is mitigated and the risk is reduced to the medium or low level
21-75	MEDIUM	Acceptable risk, but monitoring and management are mandatory.
01-20	LOW	Acceptable without restriction or limitation, hazards do not require active management, but must be documented.

Table 8

After defining the level of risk for each LHD, the States and international organisations shall develop and implement mitigation plans, as needed, which shall be presented at face-to-face Scrutiny Group meetings. The analyses conducted by ARMA and the Scrutiny Group at the virtual and face-to-face meetings will be presented in a final report to the ICAO W A C A F and E S A F Regional Offices and at APIRG meetings.

6. Terms of Reference (TOR) of the AFI Regional RVSM Scrutiny Group

The Terms of Reference (TOR) of the AFI Regional RVSM Scrutiny Group (RVSM/SG), known as the TAG(Tactical Action Group), were established with a view to analysing issues affecting the TLS, based on LHD information provided by the States and international organisations.

Terms of reference

- a) To assemble safety management subject matter experts in air traffic control, aircraft flight operations, regulation and certification, data analysis, and risk modelling;
- b) To analyse and evaluate large height deviations of 300 ft or greater as defined in ICAO Doc 9574, Manual on the implementation of a 300 m (1 000 ft) vertical separation minimum between FL 290 and FL 410 inclusive;
- c) To coordinate the collection and review of large height deviation data with the ARMA;
- d) To determine and validate an estimate of the flight time away from the cleared flight level to be used to estimate the Collision Risk Assessment (CRA) made by ARMA;
- e) To identify safety trends based on the analysis of large height deviations (LHD) reports, recommend mitigation actions in accordance with ICAO SMS provisions, and submit annual reports on safety assessment results to APIRG so as to improve safety in the RVSM airspace of the AFI Regions; and
- f) To accomplish other tasks as directed by APIRG.

Composition:

AFI States, ARMA, ICAO, IATA, IFALPA, IFATCA.

7. Terms of Reference (TOR) of ARMA

Duties of ARMA:

- a) Maintain a central registry of RVSM-approved operators and aircraft of each State/Territory that use AFI RVSM airspace;
- b) Facilitate the transfer of approved data to and from other RVSM Regional Monitoring Agencies (RMAs);
- c) Establish and maintain a database containing the height-keeping errors and height deviations of 300 ft or more within AFI RVSM airspace;
- d) Submit timely information for State civil aviation authorities (CAAs) on changes or monitoring status of aircraft type classifications;
- e) Submit the results of the monitoring flight using the Enhanced GPS global monitoring system (E2GMU);
- f) Provide the means for identifying aircraft non-RVSM approved operating in the AFI RVSM airspace, and notify the appropriate State civil aviation authority (CAA) accordingly;
- g) Develop the means for summarising and communicating the content of relevant databases to the RVSM Scrutiny Group (TAG) for the corresponding safety assessment; and
- h) Conduct the assessment of the collision risk level (CRA) in the RVSM airspace of the AFI Regions, in accordance with ICAO Doc 9574 and Doc 9937.

APPENDIX A

Acronyms:

TAG:	Scrutiny Group/ Tactical Action Group
LHD:	Large Height Deviation
AFI:	Africa Indian Ocean
RVSM:	Reduced Vertical Separation Minimum
ARMA:	Africa Indian Ocean Regional Monitoring Agency
SMS:	Safety Management System
CRA:	Collision Risk Assessment
FIR:	Flight Information Region
VMC:	Visual Meteorological Conditions
IMC:	Instrument Meteorological Conditions
TLS:	Target Level of Safety
ICAO :	International Civil Aviation Organization
APIRG:	AFI Planning and Implementation Regional Group
TOR:	Terms of Reference
WACAF:	Western and Central African Office
ESAF:	Eastern and Southern African Office

APPENDIX B

LHD Code Table

LHD CODE	LHD Code Description
OPERATIONAL EVENTS	
A	Fail to climb/descend the aircraft as cleared.
B	Climb/descent without ATC clearance.
C	Incorrect operation or interpretation of airborne equipment (<i>e.g.</i> , 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.)
D	ATC system loop error (<i>e.g.</i> , ATC issues incorrect clearance or flight crew misunderstands clearance messages)
E	Coordination errors in the ATC to ATC transfer or control responsibility as a result of human factors issues (<i>e.g.</i> , late or non-existent coordination, incorrect time estimate/actual, flight level, ATS route, etc., not in accordance with agreed parameters)
F	Coordination errors in the ATC to ATC transfer or control responsibility as a result of equipment outage or technical issues.
DEVIATION DUE TO CONTINGENCY EVENTS	
G	Deviation due to aircraft contingency event leading to sudden inability to maintain assigned flight level (<i>e.g.</i> , pressurisation failure, engine failure)
H	Deviation due to airborne equipment failure leading to unintentional or undetected change of flight level
DEVIATION DUE TO METEOROLOGICAL CONDITIONS	
I	Deviation due to turbulence or other weather related cause
DEVIATION DUE TO TCAS ADVISORIES	

J	Deviation due to TCAS resolution advisory, flight crew correctly following the resolution advisory
K	Deviation due to TCAS resolution advisory, flight crew incorrectly following the resolution advisory.
OTHERS	
L	An aircraft being provided with RVSM separation is not RVSM approved (<i>e.g.</i> , flight plan indicating RVSM approval but aircraft not approved, ATC misinterpretation of flight plan)
M	Other – this includes situations of flights operating (including climbing/descending) in airspace where flight crews are unable to establish normal air-ground communications with the responsible ATS unit.

These codes are mainly for the use of RMAs. However, reporters may use this taxonomy in order to understand what types of events are considered LHDs. Detailed description of large height deviation occurrences is crucial for the RMA to assess the risk of the LHD and its duration

Responsibility	Issuance	Assessment	Analysis	Mitigation	Analysis
	phase	phase	phase I	phase	phase II
States/ANSP					
ARMA					
TAG Telecon					
States and International Organisations					
RASG/Scrutiny Group					

Each ANSP should have an internal safety management system that defines an internal reporting process and the treatment of each report. The system should take into account the LHD reporting requirement.

APPENDIX C

LHD FAQs (Large Height Deviation Frequently-Asked-Questions)

General

Q: What is an LHD?

A: An RVSM Large Height Deviation (LHD) is defined as any vertical deviation of 300 feet (90 m.) or more from the flight level expected to be occupied by the flight. The deviation may be the result of any operational error or technical condition affecting the flight and includes any operational error that causes the aircraft to be at a location (position and/or time) that is unexpected by the controller.

In other words, an LHD occurs when a controller expects an aircraft to be at one location, but the aircraft is actually at another location.

Q: Why States are required to submit LHD report?

A: ICAO Doc9574 RVSM Implementation Manual section 6.4 specifies that ATC authorities are responsible to report LHD for any reason to their responsible RMA for collision risk assessment.

Q: How does an LHD contribute to mid-air collision risk?

A: An aircraft occupies space unexpected by a controller. Not knowing that the space is occupied, the controller may clear another aircraft to that location, which may cause a mid-air collision.

Q: What is the benefit of LHD reporting while it may be perceived as additional workload by some units?

A: Reporting safety significant occurrences is a key process of a good safety managementsystem since it enables an organization to have the necessary information to be able to manage the associated risk. LHDs are considered 'hazards' in the RVSM airspace as they could potentially lead to a catastrophic outcome - a mid-air collision. Do not fall into a trap where we get too comfortable with the risk just because nothing has not happened yet

To report to the RMA or not

Q: Some states impose flow restrictions by issuing NOTAMs or AFTN service message. If the incoming

traffic violates the flow restriction but complies with separation agreed in the LOA, should this incident be reported as an LHD?

A: No. This operational error may be reported internally, but does not need to be reported as an LHD to the RMA.

Q: A controller does not receive a transfer or the appropriate revision of the transfer of an aircraft from the transferring unit, but surveillance system enables the accepting controller to determine the location of the incoming aircraft well before the Transfer-of-Control (TOC) point, allowing the accepting controller to call the transferring controller back to confirm the aircraft's intent. Should this incident be reported?

A: Yes. Although such occurrences typically do not contribute to the quantitative estimate of risk, these occurrences should still be reported as LHDs to the responsible RMA. Even though the individual event has been mitigated, those errors were still made by the transferring ACC unit. With our online LHD reporting system, such an occurrence will be notified to the transferring ACC unit's POC. If such occurrences are not reported, then the transferring ACC unit would not have known about these transfer errors. States are strongly encouraged to collaborate with their neighboring ACC to prevent such occurrences in the future.

Q: The transferred SSR code does not match the incoming traffic. The controller sees the incoming traffic, but cannot identify it. Should this be reported?

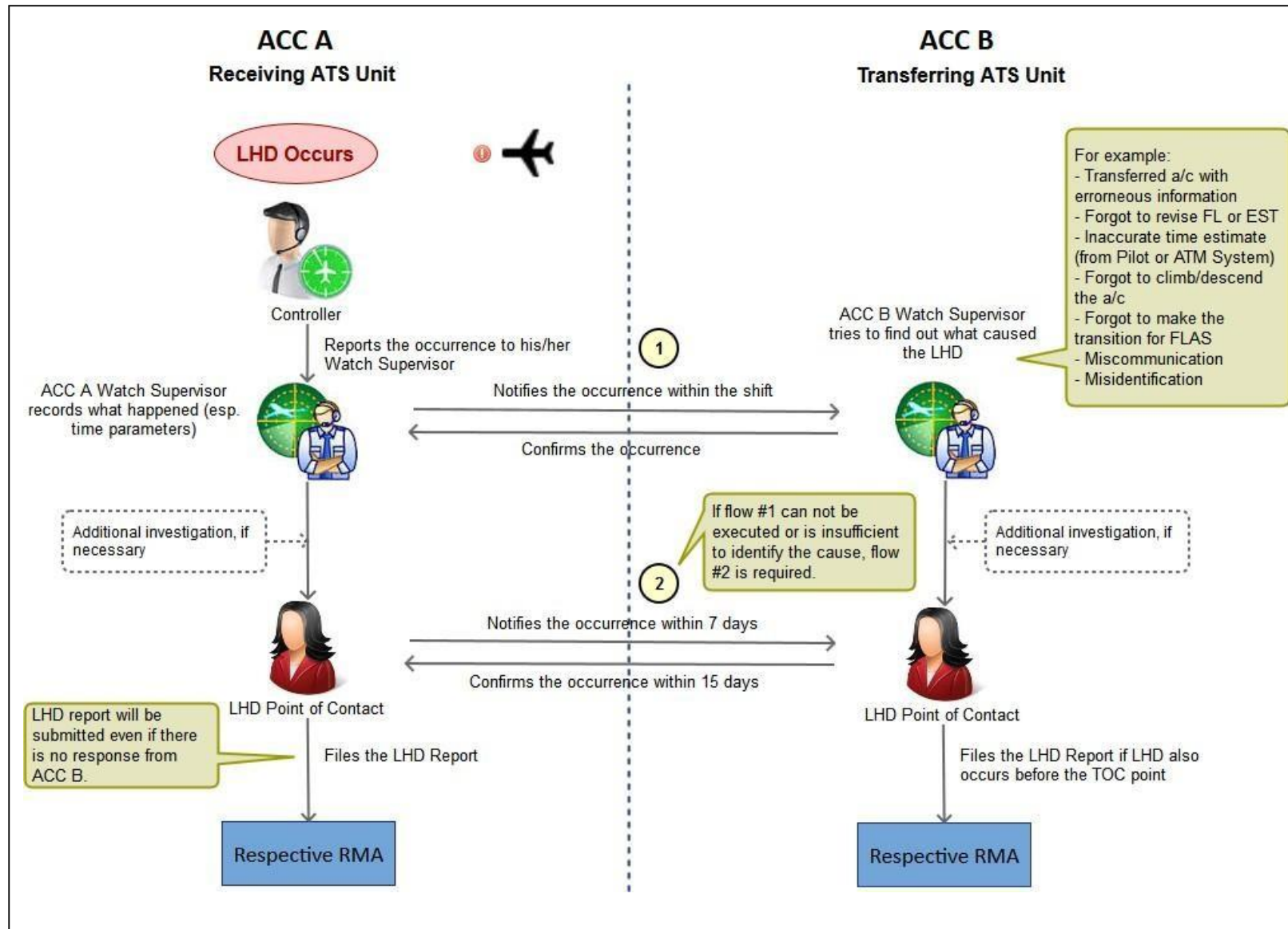
A: Yes. The RMA will analyze this type of occurrence case by case.

Q: The traffic doesn't arrive at the transferred time. The controller calls the transferring unit to get an updated transferred time. Should this occurrence be reported?

A: Yes, but it should be reported to your designated Regional Monitoring Agency (RMA). If the time difference is big, such an occurrence would be an LHD;

CROSS-BOUNDARY LHDS

Cross-boundary LHDS are mostly, but not limited to, Category E "coordination errors in the ATC-to-ATC transfer of control responsibility as a result of human factors issues". Category E LHDS constitute about 90% of all LHD occurrences and usually most of the risk in RVSM. To ensure that there is coordination between the two involving ATS units to uncover the cause and prevent future occurrences, the following additional coordination procedure is recommended for every LHD occurrence that involves another ATS unit.



FORM A - LHD Analysis

Due to the continuing prevalence of LHDs, States are encouraged to conduct further investigation and provide in-depth analyses of LHDs, especially those induced by their responsible ATS units. The purpose is not to apportion blame on any organizations but to understand the underlying root causes in order to develop safety mitigations to prevent reoccurrence. In case of significant occurrences (such as long duration LHDs), States are encouraged to provide an analysis for each occurrence. For other occurrences, States can provide analysis of a group of similar occurrences. ***Please, return the filled form to afirma@atns.co.za***

1. Organization:
2. Date of Analysis:
3. If it is a single occurrence - Please provide occurrence date, call sign*, and location:
4. If it is a group of occurrences – Please describe the nature of occurrences:
5. Details of the analysis: Please provide detailed description of the followings

Description of Occurrence(s)	
Contributing Factors and Mitigations	
-Contributing factors/causes: Please describe <u>all</u> factors leading to such occurrence(s) -Mitigations/controls/barriers: Please describe any measure which could be used to <u>prevent/detect</u> LHD occurrence(s), or <u>reduce</u> their duration. Also, please describe existing barriers which could be improved. Procedures/LOAs –which could be non-existent, inappropriate, not strictly adhered to, or needed review	
Procedures/LOAs –which could be non-existent, inappropriate, not strictly adhered to, or needed review	
Contributing factors/causes	Mitigations/controls/barriers
Human Factor Issues –ex. fatigue, workload, competency, English proficiency, teamwork, situational awareness	
Contributing factors/causes	Mitigations/controls/barriers
Systems/Equipment –ex. equipment failures, unserviceability, usability, reliability, poor design	
Contributing factors/causes	Mitigations/controls/barriers
Other Factors – ex. training, staffing, clearly defined roles and responsibilities, workplace condition, weather	
Contributing factors/causes	Mitigations/controls/barriers

*This information is used for reference by the ARMA only. Sensitive information will later be de-identified. If you plan to present this form directly in a meeting, you can omit call sign.

FORM B - LHD

Preventive/Mitigation Measures

Due to the continuing prevalence of LHDs, States are urged to provide a list of measures planned or taken to minimize LHDs (including detection of LHD occurrences and actions taken to reduce LHD duration). Please list all actions planned or taken by your organization, including comments on their effectiveness and **return the completed form to afirma@atns.co.za**

1. Organization:

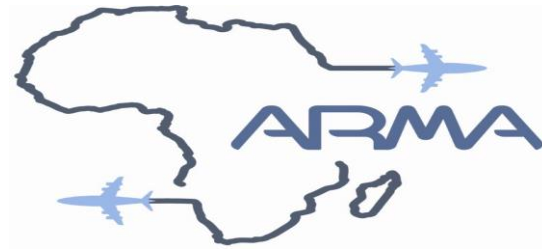
2. Date of analysis:

3. Hotspot/Area (example: eastern boundary of FIR A):

4. Please provide detailed description of the followings:

No.	Preventive/mitigation measures planned/taken	Target/actual effective date	Progresses/difficulties	Comments on effectiveness of mitigations
1				
2				
3				
4				
5				
6				

5. Is there anything the RMA/RASG-AFI/ICAO can assist with related to LHDs? :



LARGE HEIGHT DEVIATION REPORTING FORM

The information contained in this form is confidential and will be used for statistical safety

Report altitude deviations of 300 ft or more, including those due to TCAS, turbulence and contingency events.

1. Today's date:	2. Reporting unit:		
DEVIATION DETAILS			
3. Operator name:	4. Call sign: Aircraft registration number:	5. Aircraft type:	6. Altitude displayed:
7. Date of occurrence:	8. Time UTC:	9. Occurrence position (latitude/longitude or fix):	
10. Cleared route of flight:			
11. Cleared flight level:	12. Estimated duration at incorrect flight level (seconds):	13. Observed deviation (± ft):	
14. Other traffic involved:			
15. Cause of deviation (<i>brief description</i>): (Examples: turbulence, equipment failure)			
AFTER DEVIATION IS RESTORED			
16. Observed/reported final flight level*: *Please indicate the source of information: <input type="checkbox"/> Surveillance system <input type="checkbox"/> Pilot	Mark the appropriate box: 17. The FL is above the cleared level: <input type="checkbox"/> 18. The FL is below the cleared level: <input type="checkbox"/>		19. Does this FL comply with the ICAO Annex 2 tables of cruising levels? <input type="checkbox"/> Yes <input type="checkbox"/> No

Operating Procedures and Practices for Regional Monitoring Agencies in Relation to the Use of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive

NARRATIVE
<p>20. Detailed description of the deviation: <i>(Please give your assessment of the actual track flown by the aircraft and the cause of the deviation.)</i></p>
CREW
<p>21. Please provide crew comments (if any):</p>

When completed, please forward the report(s) to:

ARMA

Email : Afirma@atns.co.za /

armad@atns.co.za _____

Phone : 011 928 6546 / 0636912295