International Civil Aviation Organization

AIR NAVIGATION SYSTEMS IMPLEMENTATION GROUP

Second Meeting (ANSIG/2)
(Cairo, Egypt, 06 – 08 December 2016)

Agenda Item 4.2.2: Specific air navigation issues

DRAFT MID RVSM SMR 2015

(Presented by MIDRMA)

SUMMARY

This working paper details the results for the second draft version of the MID RVSM Safety Monitoring Report 2015 (Version 0.2) and tries to demonstrate according to the data received that the key safety objectives of the SMR in accordance with ICAO Doc 9574 were met in operational services in all the Middle East RVSM airspace except for Tripoli and Sana'a FIRs.

Action by the meeting is at paragraph 3.

REFERENCES

- MIDANPIRG/15 Report
- MIDRMA Board/14 Report.
- MID RVSM SMR 2014

1. INTRODUCTION

1.1 The Middle East Regional Monitoring Agency produces a periodic MID RVSM Safety Monitoring Report which is distributed once every 18 months and required to be reviewed by a technical body to raise their comments and their recommendations concerning the report to MIDANPIRG for their final endorsement.

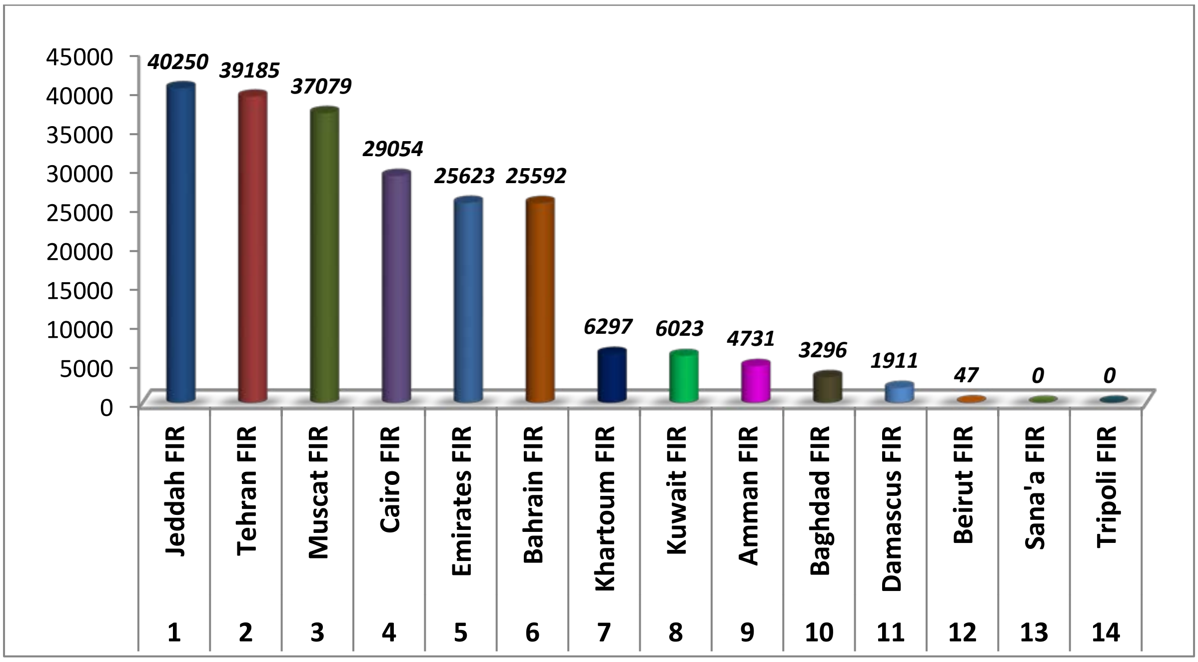
1.2 The second draft version for the MID SMR 2015 (Ver 0.2), at **Appendix A**, was calculated for 12 FIRs in the ICAO Middle East Region. Tripoli and Sanaa FIRs were excluded from the RVSM safety analysis due to the non-submission of the required traffic data and LHD reports for more than two years.

1.3 The results present evidence that the key safety objectives, as set out in the MID RVSM safety policy in accordance with ICAO Doc 9574 (2nd Edition), continue to be met in the Middle East RVSM airspace except for the FIRs mentioned in 1.2.

2. DISCUSSION

2.1 Further to the outcome of MIDANPIRG/15 meeting Conclusion 15/8 concerning the development of the MID RVSM SMR 2015, the Traffic Data Sample (TDS) required for the safety analysis must be collected from 01 September 2015 until 30 September 2015 for all traffic operating within the ICAO Middle East RVSM airspace and must be submitted to the MIDRMA not later than 31 October 2015.

2.2 The description of the traffic data processed for each MIDRMA Member State by the MID Risk Analysis Software (MIDRAS) is depicted in the graph below, a total of **219,088** flights were processed for the 12 FIRs, these flights were evaluated and processed very carefully to ensure accurate results according to the data submitted.



MID States RVSM Traffic Data for SMR 2015 (September 2015)

2.3 The MIDRMA decided to go ahead with the calculations of the SMR safety parameters without the Member States mentioned in 1.2 and estimated the risk of collision associated with RVSM and compare this risk to the agreed RVSM safety goals, the Target Level Safety (TLS) taking into consideration that the key issue for the assessment of RVSM safety is the satisfaction of the three Safety Objectives defined for the MIDRMA.

2.4 The MID RVSM safety assessment work is accomplished through the collection of the TDS related to the operations in the RVSM airspace and with the help of the MID RVSM Scrutiny Group which evaluated and validated all LHD reports received for the SMR 2015 reporting period until February 2016, while the MIDRMA followed the same steps to evaluate all the remaining LHD reports until October 2016 , the components for the safety analysis were completed and the final results calculated for the three safety objectives.

2.5 **Outcome of the MID RVSM Scrutiny Group Meeting**

2.5.1 The MID RVSM Scrutiny Group convened on 01st February 2016 during the MIDRMA Board 14 Meeting (Khartoum – Sudan 01-03 February 2016) and chaired by the MIDRMA and attended by representatives from 8 Member States (Bahrain, Egypt, Iran, Iraq, Saudi Arabia, Sudan, Oman and UAE) .

2.5.2 The MIDRMA presented to the Scrutiny Group all Large Height Deviation Reports (LHDs) received from the attended MIDRMA Member States during the period from 01 May 2015 to 31st December 2015.

2.5.2 Most of the LHD reports were related to coordination failures between adjacent ACCs. Accordingly, States were encouraged to implement AIDC/OLDI, which can improve the coordination process and would reduce the amount of coordination failures and improve safety.

2.5.3 A total of 47 LHD reports contributed in the risk analysis (the MIDRMA validated and endorsed the rest of the reports received from 01 January 2016 until 31st October 2016) the meeting noticed the same main reasons for filing LHD reports still exist from the last SMRs as the extreme majority of the reports were because of the transferring units failed to coordinate their traffic to the accepting units, the participants scrutinized the LHD reports filed during that period and discussed their impact on the implementation of RVSM in the Middle East RVSM airspace and determined parameter values necessary for the collision risk estimation.

2.6 The table below presents the fidelity with which the MIDRMA Member States provided Large Height Deviation Reports for the SMR 2015 reporting period. Since May 2015, the MIDRMA has received LHD reports for each month from all Member States except for Libya and Yemen. The MIDRMA continues to request that ATS providers forward reports of large height deviations as soon as they occur by using the LHD online reporting tool.

MID STATES	LHD Reports Submitted for SMR 2015 Reporting Period
Bahrain	363
Egypt	48
Iran	27
Iraq	175
Jordan	33
Kuwait	350
Lebanon	NIL Report
Libya	**No Reports Received**
Oman	85
Qatar	N/A
Saudi	62
Sudan	19
Syria	2
UAE	85
Yemen	**No Reports Received**

2.7 The LHD reports are separated by categories based on the details provided for each deviation. There are two such categories: large height deviations contributing to technical risk and large height deviations contributing to operational risk. The above table reflects the LHD reports received which contributed for operational risk but the vast majority of these reports have no direct or serious risk to the RVSM airspace.

2.8 A sharp decrease in the total LHD duration was observed from the last SMR reporting period, so far only **47** events contributed to operational risk and none contributed to technical risk, the total LHD duration is **25.12** minutes.

The total Altitude Deviation period gathered from the validated LHD occurrences in the MID Region airspace was = **25** minutes and **07** seconds.

2.9 Safety Monitoring Report 2015 (Second Draft Version)

2.9.1 **RVSM Safety Objective 1:**

The risk of collision in MID RVSM airspace due solely to technical height-keeping performance meets the ICAO target level of safety (TLS) of 2.5×10^{-9} fatal accidents per flight hour.

The 2015 value computed for technical height risk is $\mathbf{3.056 \times 10^{-10}}$. This meets RVSM Safety Objective 1.

2.9.1.1 According to the technical risk values as shown in the table below from the previous SMRs, the TLS value increased from the last SMR but safe comparing to the ICAO TLS **2.5 x 10^{-9}**.

Technical Risk Values						
Year 2006	Year 2008	Year 2010	Year 2012	Year 2013	Year 2014	**Year 2015***
2.17x10^{-14}	1.93x10^{-13}	3.96x10^{-15}	5.08 x 10^{-14}	6.37x10^{-12}	3.18x10^{-12}	**3.056 x 10^{-10}**

*****Note: The calculated result measured without Sana'a and Tripoli FIRs.

2.9.1.2 **Pz(1000) Compliance:**

The Pz(1000) is the probability that two aircraft at adjacent RVSM flight levels will lose vertical separation due to technical height keeping errors. The value of the probability of vertical overlap Pz(1000), based on the actual observed Altimetry System Error (ASE) and typical Assigned Altitude Deviation (AAD) data is estimated to be of **2.493 x 10^{-9}**. This value meets the Global System Performance Specification that the probability of two aircraft will lose procedural vertical separation of 1000ft should be no greater than **1.7x10^{-8}**.

2.9.1.3 **Middle East RVSM Airspace Horizontal Overlap Frequency (HOF):**

The estimate of the frequency of horizontal overlap is based on the number of proximate events, which is defined as the occurrence of two aircraft passing within a horizontal distance R whilst separated by the vertical separation minimum, and based on the range of different geometries and relative velocities seen across the set of proximate events, the probability that the proximity is less than a distance equal to the size of the average aircraft, given that it is within the distance R, is calculated. This probability, combined with the proximity frequency, gives the horizontal overlap frequency.

a. The calculated horizontal overlap frequency for all the MID RVSM airspace was estimated to be **3.405 x 10^{-9}** per flight hour.

Horizontal Overlap Frequency (HOF)						
Year 2006	Year 2008	Year 2010	Year 2012	Year 2013	Year 2014	**Year 2015**
6.99x10^{-3}	5.1x10^{-11}	2.88x10^{-6}	6.49x10^{-5}	4.34x 10^{-8}	5.04x 10^{-9}	**3.405 x 10^{-9}**

b. With the new feature added in the MIDRAS (MID Risk Analysis Software), the MIDRMA is able to measure the HOF for all the Middle East RVSM airspace which gave the MIDRMA the ability to continuously monitor each individual FIR.

2.9.2 **RVSM Safety Objective 2**

The overall risk of collision due to all causes which includes the technical risk and all risk due to operational errors and in-flight contingencies in the MID RVSM airspace meets the ICAO overall TLS of 5 x 10^{-9} fatal accidents per flight hour.

The computed overall risk of collision due to all causes which includes the technical risk and all risk due to operational errors and in-flight contingencies in the MID RVSM airspace is **7.351×10^{-10}** which meets the ICAO overall TLS of **5×10^{-9}** fatal accidents per flight hour, the table below reflects a comparison with the overall risk values calculated for the previous SMRs.

Overall Risk Values						
Year 2006	Year 2008	Year 2010	Year 2012	Year 2013	Year 2014	**Year 2015**
N/A	$4.19x10^{-13}$	$6.92x10^{-12}$	$1.04x10^{-11}$	3.63×10^{-11}	4.91×10^{-11}	**7.351×10^{-10}**

*Note: The calculated result measured without Sana'a and Tripoli FIRs.

2.9.3 **RVSM Safety Objective 3**

Address any safety-related issues raised in the SMR by recommending improved procedures and practices; and propose safety level improvements to ensure that any identified serious or risk-bearing situations do not increase and, where possible, that they decrease. This should set the basis for a continuous assurance that the operation of RVSM will not adversely affect the risk of en-route mid-air collision over the years.

2.9.3.1 Conclusions for RVSM Safety Objective 3:

a. The MIDRMA improved its monitoring capabilities with the new Enhanced GMUs which gave the ability to respond for more height monitoring requests even from outside the Middle East Region.

b. The MIDRMA will continue to include in its work program briefings to the focal points appointed for airworthiness issues to ensure their follow up with their monitoring targets and to resolve any non-compliant RVSM approved aircraft. At the same time the MIDRMA will coordinate with the focal points appointed for ATC issues to deliver RVSM safety assessment briefing as necessary or when requested.

c. The MIDRMA shall continue to carry out continuous survey and investigation on the number and causes of non-approved aircraft operating in the MID RVSM airspace.

d. The MIDRMA will continue to encourage States to submit their Large Height Deviation Reports using the MIDRMA online reporting tool which has been continuously upgraded to improve the level of reporting.

e. The MIDRMA completed the Hot Spot feature in the (MIDRAS) Software and started to address the results in the SMR.

f. The MIDRMA will continue to enhance the (MIDRAS) Software and started phase 3 of the upgrade project to add visualization features in 4D.

g. Current risk-bearing situations have been identified by using the MIDRAS and actions will be taken to ensure resolving all violations and information which will be collected during the MID RVSM Scrutiny Group meeting in order to identify operational issues and potential mitigations.

Therefore, it is concluded that this Safety Objective is currently met.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a. review and discuss the second draft version of MID RVSM SMR 2015, and

b. discuss any relevant matters as appropriate.

THE MID RVEM SAFETY

MONITORING REPORT 2015

Draft Version 0.2

ANSIG/2

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Document Characteristic

Report Title: The MID RVSM SAFTY MONITORING REPORT

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Abstract
This document constitutes the RVSM Safety Monitoring Report for the MID RVSM Airspace for the reporting period (01st May 2015 until 31st October 2016) The aim of this document is to highlight by means of argument and supporting evidence that the implementation of RVSM in the Middle East is acceptably safe.

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ACKNOWLEDGMENTS

Table of Contents

DOCUMENT CHANGE RECORD

VERSION NUMBER	EDITION DATE	REASON FOR CHANGE
0.1	26/01/2016	Draft version presented to the MIDRMA Board/14 Meeting.
0.2	01/12/2016	Draft version presented to the ANSIG / 2 Meeting.

EXECUTIVE SUMMARY

The MID RVSM Safety Monitoring Report is issued by the Middle East Regional Monitoring Agency (MIDRMA) for endorsement by the Middle East Air Navigation Planning and Implementation Regional Group (MIDANPIRG).

The report presents evidence that according to the data and methods used, the key safety objectives set out in the MID RVSM Safety Policy in accordance with ICAO Doc 9574 (2nd Edition) continue to be met in operational service in the Middle East RVSM airspace .

To conclude on the current safety of RVSM operations, the three key safety objectives endorsed by MIDANPIRG have to be met:

Objective 1 The risk of collision in MID RVSM airspace due solely to technical height-keeping performance meets the ICAO target level of safety (TLS) of $\mathbf{2.5 \times 10^{-9}}$ fatal accidents per flight hour. The value computed for technical height risk is $\mathbf{3.056 \times 10^{-10}}$ This meets RVSM Safety Objective 1.

Objective 2 The overall risk of collision due to all causes which includes the technical risk and all risk due to operational errors and in-flight contingencies in the MID RVSM airspace meets the ICAO overall TLS of $\mathbf{5 \times 10^{-9}}$ fatal accidents per flight hour.

The value computed for overall risk is $\mathbf{7.351 \times 10^{-10}}$ This meets RVSM Safety Objective 2.

Objective 3 Address any safety-related issues raised in the SMR by recommending improved procedures and practices; and propose safety level improvements to ensure that any identified serious or risk-bearing situations do not increase and, where possible, that they decrease. This should set the basis for a continuous assurance that the operation of RVSM will not adversely affect the risk of en-route mid-air collision over the years.

Conclusions

(i) The estimated risk of collision associated with aircraft height- keeping performance is **3.056×10^{-10}** and meets the ICAO TLS of **2.5×10^{-9}** fatal accidents per flight hour (RVSM Safety Objective1).

(ii) The estimated overall risk of collision due to all causes which includes the technical risk and all risk due to operational errors and in-flight contingencies is **7.351×10^{-10}** and meets the ICAO overall TLS of **5×10^{-9}** fatal accidents per flight hour (RVSM Safety Objective 2).

(iii) Based on currently-available information (Except for Tripoli and Sana'a FIRs), there is no evidence available to the RMA that the continued operations of RVSM adversely affects the overall vertical risk of collision.

1 INTRODUCTION

1.1 Background

Reduced Vertical Separation Minima (RVSM) was introduced in the Middle East RVSM airspace on 27th November 2003. In compliance with Annex 11 and ICAO Doc. 9574 provisions, a monitoring programme was established by the MIDRMA and a safety monitoring report is presented to each MIDANPIRG meeting. The present document represents the second draft version of the Safety Monitoring Report which covers the period from 01st May 2015 until 31st October 2016.

1.2 Aim

This Report responds to the official ICAO request to MIDRMA to show by means of argument and supporting evidence that the implementation of RVSM in the ICAO Middle East Region satisfies the safety objectives defined in Section 2 of this Report.

This draft version of the report is issued for the ANSIG/2 Meeting.

1.3 Scope

The geographic scope of the MID RVSM Safety Monitoring Report covers the MID RVSM Airspace which comprises the following FIRs/UIRs:

Amman	Bahrain	Baghdad	Beirut	Cairo	Damascus	Emirates
Jeddah	Kuwait	Khartoum	Muscat	Sana'a*	Tehran	Tripoli *

T-1: FIRs/UIRs of the Middle East RVSM Airspace

Notes:

1). *Sana'a and Tripoli FIRs were excluded from the safety analysis due to lack of data.*

The Data Sampling periods covered by the SMR 2015 are as displayed in the below table

Report Element	Time Period
Traffic Data Sample	01/09/2015 - 30/09/2015
Operational & Technical Errors	01/05/2015 - 31/10/2016

T-2: Time Period for the Reported Elements

1.4 Structure of the Document

The Report is constructed using an approach that claims that the Middle East RVSM operations are acceptably safe. This claim is broken down into three main safety objectives, which represent necessary and sufficient conditions to be met for the above claim to be true. These principal safety objectives are listed in Section 2 and are discussed and assessed in Section 3,4,5 and 6 of this report.

- **Section 2** of this document describes the three RVSM safety objectives and the individual components that relate directly to the on-going safety of MID RVSM.
- **Sections 3, 4, 5** details the assessment made against the safety objectives. Each Section contains Conclusion(s) and Recommendation(s) pertinent to the associated safety objective.
- **Section 6** summarises all the Conclusions and Recommendations raised in the previous sections together with additional Recommendations arising from on-going RMA operations.
- **Appendices**

  - **Appendix A:** Member States Traffic Data Analysis.
  - **Appendix B:** Provides Information on the MID MMR.
  - **Appendix C:** Provides Information on RVSM Minimum Monitoring Requirements (*Updated as of November 2016*).
  - **Appendix D:** Includes the MIDRMA duties and responsibilities.
  - **Appendix E:** Provides definitions and explanations of RVSM terms.
  - **Appendix F:** MID Region RVSM Hot Spots.
  - **Appendix G:** Provides Abbreviations.

2 MID RVSM SAFETY OBJECTIVES

A key issue for the assessment of RVSM safety is the satisfaction of a number of safety objectives defined in the Safety Policy for RVSM. The following three safety objectives endorsed by MIDANPIRG are directly relevant to the on-going safety of RVSM:

Objective 1 The risk of collision in MID RVSM airspace due solely to technical height-keeping performance meets the **ICAO target level of safety** (TLS) of **2.5×10^{-9}** fatal accidents per flight hour.

Objective 2 The overall risk of collision due to all causes which includes the technical risk and all risk due to operational errors and in-flight contingencies in the MID RVSM airspace meets the **ICAO** overall TLS of **5×10^{-9}** fatal accidents per flight hour.

Objective 3 Address any safety-related issues raised in the SMR by recommending improved procedures and practices; and propose safety level improvements to ensure that any identified serious or risk-bearing situations do not increase and, where possible, that they decrease. This should set the basis for a continuous assurance that the operation of RVSM will not adversely affect the risk of en-route mid-air collision over the years.

2.1 Considerations on the RVSM Safety Objectives

When considering the three safety objectives for RVSM, the following considerations should be borne in mind:

1. The assessment of risk against the TLS, both for technical and overall risk estimates, relies on height keeping performance data to assess the risk in the vertical plane and studies of traffic density to calculate the risk in the horizontal plane. There are a number of assumptions that must be verified to satisfy the reliability of the risk assessment. The verification of these assumptions is contained in Section 3 which deals primarily with monitoring aircraft performance issues.
2. The Aircraft performance is assessed by individual airframe and by monitoring group. A monitoring group consists of aircraft that are nominally of the same type with identical performance characteristics that are made technically RVSM compliant using a common compliance method. Monitoring group analysis is necessary to verify that the Minimum Aviation System Performance Standards (MASPS) for that group is valid. Aircraft that are made RVSM compliant on an individual basis are termed non-group.

3. The RVSM Safety Objective 2, dealing with overall risk, takes into account the technical risk presented in Section 3 together with the risk from all other causes. In practice this relates to the human influence and assessment of this parameter relies on adequate reporting of Large Height Deviation (LHD) Reports, and the correct interpretation of events for input to the CRM.
4. RVSM Safety Objective 3 requires the RMA to monitor long term trends and to identify potential future safety issues. This Section compares the level of risk bearing incidents for the current reporting period. It also highlights issues that should be carried forward as recommendations to be adopted for future reports.

2.2 The Collision Risk Model (CRM)

2.2.1 The risk of collision to be modelled is that due to the loss of procedural vertical separation between aircraft flying above FL 290 in a given portion of an airspace. One collision between two aircraft is counted as the occurrence of two accidents. The risk of collision depends both on the total number and types of aircraft flying in the system and the system characteristics.

2.2.2 The CRM provides an estimate of the number of accidents within an airspace system that might occur per aircraft flight hour due to aircraft collisions resulting from the loss of procedural vertical separation in an RVSM environment analysis, is expressed in terms of quantifiable parameters. In the vertical dimension the CRM can be broken down in order to separately model a single route on which aircraft are flying in the same or opposite directions at adjacent flight levels, pairs of crossing routes and combinations of individual and intersecting routes, this model is applied equivalently to vertical, lateral and longitudinal separation.

2.2.3 Three parameters used within the CRM :

a. The Vertical Overlap Probability, denoted as Pz(1 000).
b. The Lateral Overlap Probability, denoted as Py(0).
c. The aircraft Passing Frequency are the most important quantities in determining the vertical collision risk. Of these, the vertical overlap probability is the most important parameter to calculate.

3 TECHNICAL HEIGHT KEEPING PERFORMANCE RISK ASSESSMENT

RVSM Safety Objective 1

The risk of collision in MID RVSM airspace due solely to technical height-keeping performance meets the ICAO target level of safety (TLS) of **2.5 x 10^{-9}** fatal accidents per flight hour.

3.1 Direct evidence of compliance with TLS for technical height-keeping error

The result shows that the risk of collision due to technical height-keeping performance is estimated to be **3.056 x 10^{-10}** fatal accidents per flight hour, which meets the ICAO TLS of **2.5 x 10^{-9}**.

3.2 Supporting evidence of compliance with TLS for technical height-keeping performance

To demonstrate that the result is reliable, it is necessary to demonstrate that the following assumptions are true:

a. The estimated value of the frequency of horizontal overlap, used in the computations of vertical-collision risk, is valid;

b. Pz(1000) – the probability of vertical overlap due to technical height-keeping performance, between aircraft flying 1000 ft. separation in MID RVSM airspace is **2.493 x 10^{-9}** valid and is less than the ICAO requirement of **1.7 x 10^{-8}**.

c. All aircraft flying 1000ft separation in MID RVSM airspace meet the ICAO Global Height Keeping Performance specification for RVSM;

d. All aircraft flying 1000ft separation in MID RVSM airspace meet the individual ICAO performance specification for the components of total vertical error (TVE).

e. The monitoring target for the MID RVSM height-monitoring programme is an on-going process.

f. The input data used by the CRM is valid.

g. An adequate process is in place to investigate and correct problems in aircraft technical height-keeping performance.

3.2.1 Calculating the Probability of Lateral Overlap ($P_y(0)$)

The probability of lateral overlap $P_y(0)$ is the probability of two aircraft being in lateral overlap which are nominally flying on (adjacent flight levels of) the same route. The calculation of the Py (0) for the SMR 2015 has the following to consider:

a. Due to lack of radar data available for most of the congested airspace in the Middle East Region to calculate the probability of lateral overlap $\boldsymbol{P_y(0)}$ which is fundamental for the SMR, the MIDRMA decided to calculate the probability of lateral overlap $\boldsymbol{P_y(0)}$ for all the MID RVSM airspace and not only the congested airspace by adopting the ICAO methodology developed for this purpose and by adding this feature in the MID Risk Analysis Software (MIDRAS).

b. The MIDRMA calculated the average of the probability of lateral overlap $\boldsymbol{P_y(0)}$ for the whole MID RVSM airspace **3.405 x 10^{-9}**.

c. Overall, the results are considered to be valid.

3.2.1.2 Method Used For Calculating the Probability of Lateral Overlap ($\mathrm{P_y(0)}$)

To compute the probability of lateral overlap $\mathrm{P_y(0)}$, the probability density of the lateral distance $\mathrm{Y_{12}}$ between the two aircrafts flying with lateral deviations $\mathrm{Y_1}$ and $\mathrm{Y_2}$ from the nominal route i.e. $\mathrm{Y_{12} = Y_1 - Y_2}$ is computed.

This probability density denoted by $\mathrm{f_y(y)}$ is dependent on the type of navigation equipment being used in the airspace under consideration. The ground-based navigation infrastructure in the MIDRMA Region consists of NDBs and VOR/DMEs. However, more and more aircraft have started to use satellite-based navigation (GNSS).

This is calculated by taking the proportion of time that an airplane is flying using satellite navigation (GNSS) versus radio navigation (VOR/DME). By representing the probability of an aircraft being in a specific lateral position by a normal distribution, the following equation is found:

$$f_y(y) = (1-\alpha)\frac{1}{\sigma_{\mathrm{VOR/DME}} \times \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{y}{\sigma_{\mathrm{VOR/DME}}}\right)^2} + \alpha \frac{1}{\sigma_{\mathrm{GNSS}} \times \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{y}{\sigma_{\mathrm{GNSS}}}\right)^2}$$

Where, α is the proportion of flights flying with satellite navigation (GNSS) and $\sigma_{\mathrm{VOR/DME}}$ and σ_{GNSS} are the standard deviations for radio and satellite navigation, respectively. For MIDRAM region it is assumed that 75% of flights (α =0.75) are using GNSS and 23% of flights are using VOR/DME for navigation.

Following the RVSM global system performance specification, the standard deviation for VOR/DME navigation is taken as 0.3 NM and a standard deviation of 0.06123 NM will be used for the GNSS. i.e. $\sigma_{\mathrm{VOR/DME}} = 0.3$ NM and $\sigma_{\mathrm{GNSS}} = 0.06123$ NM.

With this probability distribution function for one aircraft, the function for two aircraft can be found by convoluting the two together;

$$f_{y_{1,2}}(y) = (1-\alpha)^2 \frac{1}{\sigma_{\mathrm{VOR/DME}} \times 2\sqrt{\pi}} e^{-\frac{1}{4}\left(\frac{y}{\sigma_{\mathrm{VOR/DME}}}\right)^2} + 2\alpha(1-\alpha)\frac{1}{\sqrt{\sigma_{\mathrm{VOR/DME}}^2 + \sigma_{\mathrm{GNSS}}^2} \times \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{y}{\sqrt{\sigma_{\mathrm{VOR/DME}}^2+\sigma_{\mathrm{GNSS}}^2}}\right)^2} + \alpha^2 \frac{1}{\sigma_{\mathrm{GNSS}} \times \sqrt{\pi}} e^{-\frac{1}{4}\left(\frac{y}{\sigma_{\mathrm{GNSS}}}\right)^2}$$

This function then allows the probability of lateral overlap to be calculated as:

$$P_y(0) \approx 2\lambda_y f_{y_{1,2}}(0)$$

Where λ_y is the average wingspan of the aircraft within the region.

Horizontal Overlap Frequency (HOF)						
Year 2006	Year 2008	Year 2010	Year 2011	Year 2012/13	Year 2014	Year 2015
6.99×10^{-3}	5.1×10^{-11}	2.88×10^{-6}	6.49×10^{-5}	6.49×10^{-5}	5.04×10^{-9}	3.405×10^{-9}

The Frequency of HOF Values

3.2.2 Pz(1000) Compliance

The Pz(1000) is the probability that two aircraft at adjacent RVSM flight levels will lose vertical separation due to technical height keeping errors. The value of the probability of vertical overlap Pz(1000), based on the actual observed ASE and typical AAD data is estimated to be of **2.493×10^{-09}** . This value meets the Global System Performance Specification that the probability that two aircraft will lose procedural vertical separation of 1000ft should be no greater than **1.7×10^{-8}**.

3.3 Evolution of Technical Risk Estimate

Technical Risk Values						
Year 2006	Year 2008	Year 2010	Year 2011	Year 2012/13	Year 2014	Year 2015
2.17×10^{-14}	1.93×10^{-13}	3.96×10^{-15}	5.08×10^{-14}	6.37×10^{-12}	3.18×10^{-12}	3.056×10^{-10}

The Technical Risk Values

According to the technical risk values as shown in the above table the TLS values increased, the MIDRMA issued an updated minimum monitoring requirements (MMR) for each MIDRMA member states according to the latest RVSM approvals received from all members as of November 2016, these tables are available in **Appendix B**.

Note: The MIDRMA is continuously updating the MMR for all Member States; all members are required to check their MMR through the MIDRMA website (www.midrma.com).

3.4 Conclusions on Technical Height-Keeping:

a. The current computed vertical-collision risk due to technical height-keeping performance meets the ICAO TLS.

b. The probability of vertical-overlap estimation satisfies the ICAO global system performance specification.

c. The probability of vertical-overlap estimate, Pz (1000), satisfies the global system performance specification.

d. Most monitoring groups are complying with technical height-keeping requirements, there are, however, a few groups that do not meet all the requirements. The MIDRMA will continue to coordinate with EUR RMA, NATS and the FAA when problems are identified as they arise and associated corrective actions will be taken.

3.5 Recommendations for Safety Objective 1:

a. The MIDRMA shall continue to review the contents and structure of its aircraft monitoring groups.

b. The MIDRMA shall continue to use its own software (MIDRAS) to calculate the technical collision risk parameters.

4 ASSESSMENT OF OVERALL RISK DUE TO ALL CAUSES AGAINST THE TLS OF 5 X 10^{-9} FATAL ACCIDENTS PER FLIGHT HOUR

RVSM Safety Objective 2

The overall risk of collision due to all causes which includes the technical risk and all risk due to operational errors and in-flight contingencies in the MID RVSM airspace meets the ICAO overall TLS of **5 x 10^{-9}** fatal accidents per flight hour.

The objective of this Section is to set out the arguments and evidence that the overall risk of collision due to all causes which includes the technical risk and all risk due to operational errors and in-flight contingencies in the MID RVSM airspace.

The computed value is **7.351 x 10^{-10}** which meets the ICAO overall TLS of **5 x 10^{-9}** fatal accidents per flight hour.

4.1 Evolution of the overall Risk Estimate

The vertical risk estimation due to atypical errors has been demonstrated to be the major contributor in the overall vertical-risk estimation for the MID RVSM airspace, The final conclusions of the data processed have been severely limited by the continued NIL reporting of Large Height Deviations (LHDs) from some members which does not support a high confidence in the result, the MIDRMA is reiterating the importance of submitting such reports especially from FIRs with high volume of traffic.

Overall Risk Values						
Year 2006	Year 2008	Year 2010	Year 2011	Year 2012/13	Year 2014	Year 2015
Not calculated	4.19x10^{-13}	6.92x10^{-12}	1.04x10^{-11}	3.63 x 10^{-11}	4.91 x 10^{-11}	7.351 x 10^{-10}

The following Tables present the status of provision of LHDs received from MID States for the period 01st May 2015 – 31st December 2015.

MID STATES	LHD Reports Submitted for SMR 2015 Reporting Period
Bahrain	363
Egypt	48
Iran	27
Iraq	175
Jordan	33
Kuwait	350
Lebanon	NIL Report
Libya	**No Reports Received**
Oman	85
Qatar	N/A
Saudi Arabia	62
Sudan	19
Syria	2
UAE	85
Yemen	**No Reports Received**

MID States LHD Reports Received for the SMR 2015 Reporting Period

4.1 MID RVSM Scrutiny Group Meeting:

4.1.1 The MID RVSM Scrutiny Group convened on 01st February 2016 during the MIDRMA Board 14 Meeting (Khartoum – Sudan 01-03 February 2016) and chaired by the MIDRMA and attended by representatives from 8 Member States (Bahrain, Egypt, Iran, Iraq, Saudi Arabia, Sudan, Oman and UAE) .

4.1.2 The MIDRMA presented to the Scrutiny Group all Large Height Deviation Reports (LHDs) received from all MIDRMA Member States during the period from 01 May 2015 to 31st December 2015.

4.1.3 Most of the LHD reports were related to coordination failures between adjacent ACCs. Accordingly, States were encouraged to implement AIDC/OLDI, which can improve the coordination process and would reduce the amount of coordination failures and improve safety.

4.1.4 A total of 49 LHD reports contributed in the risk analysis (the MIDRMA validated and endorsed the rest of the reports received from 01st May 2015 until 31st October 2016, the meeting noticed the same main reasons for filing LHD reports still exist from the last SMRs as the extreme majority of the reports were because of the transferring units failed to coordinate their traffic to the accepting units, the participants scrutinized the LHD reports filed during that period and discussed their impact on the implementation of RVSM in the Middle East RVSM airspace and determined parameter values necessary for the collision risk estimation.

4.2 Effects of Future Traffic Growth

The effect of future traffic growth on the vertical collision risk can be evaluated on the assumption of a linear relationship between traffic growth and frequency of horizontal overlap, which will directly affect the two components of the risk: the risk due to technical height-keeping performance and due to atypical operational errors.

It is clear that even for the most optimistic forecast range of 13%, the overall risk of collision will continue to meet the TLS at least until 2018. With the current uncertainty over traffic growth this issue will be revisited when the Middle East economic conditions return to more normal growth.

4.3 Conclusions on the overall vertical risk:

a. The overall risk of collision due to all causes which includes the technical risk and all risk due to operational errors and in-flight contingencies in the MIDRVSM airspace, estimated from the operational and technical vertical risk meets the ICAO overall TLS of 5×10^{-09} fatal accidents per flight hour.

b. Current risk-bearing situations have been identified and actions will be taken to ensure resolving all violations, information collected during the MID RVSM Scrutiny Group meeting on 1st February 2016 in order to identify operational issues and potential mitigations.

c. The effect of future traffic growth has also been assessed. The overall risk of collision will continue to meet the TLS at least until 2018.

4.3 Recommendations Applicable to Safety Objective 2 :

a. Since the operational risk is the most important factor to the overall risk, the MIDRMA launched a new Large Height Deviation (LHD) reporting campaign by using the LHD online reporting tool which was developed by the MIDRMA in order to collect as much data as possible, also assess the increasing trend of the operational risk value and further investigate safety improvements to offset the effects.

b. The MIDRMA will continue to improve the LHD online reporting tool and add more features to exchange data between the MIDRMA Member States, this will allow the LHD reporting rates to be updated regularly after investigated by the concerned States.

5 ASSESSMENT OF SAFETY-RELATED ISSUES RAISED IN THIS REPORT

RVSM Safety Objective 3

Address any safety-related issues raised in the SMR by recommending improved procedures and practices; and propose safety level improvements to ensure that any identified serious or risk-bearing situations do not increase and, where possible, that they decrease. This should set the basis for a continuous assurance that the operation of RVSM will not adversely affect the risk of en-route mid-air collision over the years.

5.1 Methodology

The identified safety-related issues are:

a. Confirmation of the approval status of aircraft filling RVSM flight plan (W in field 10).

b. Accuracy contents and quantity of supplied data is detaining the accurate determination of operational risk assessment.

c. Identification of operators requiring monitoring and address the minimum monitoring requirements to all MIDRMA member states.

Reference c. the recommended practice in this case is addressing all operators in the Middle East region which required conducting height monitoring**;** the MIDRMA published a new MMR for all member states. **Appendix-B** shows all operators requiring height monitoring in the MID Region.

5.2 Conclusions and Recommendations Applicable for Safety Objective 3

a. The MIDRMA improved its monitoring capabilities with the new Enhanced GMUs which gave the ability to respond for more height monitoring requests even from outside the Middle East Region.

b. The MIDRMA will continue to include in its work program briefings to the focal points appointed for airworthiness issues to ensure their follow up with their monitoring targets and to resolve any non-compliant RVSM approved aircraft. At the same time the MIDRMA will coordinate with the focal points appointed for ATC issues to deliver RVSM safety assessment briefing as necessary or when requested.

c. The MIDRMA shall continue to carry out continuous survey and investigation on the number and causes of non-approved aircraft operating in the MID RVSM airspace.

d. The MIDRMA will continue to encourage States to submit their Large Height Deviation Reports using the MIDRMA online reporting tool which has been continuously upgraded to improve the level of reporting.

e. The MIDRMA completed the hotspot feature in the (MIDRAS) Software and started to address the results in the SMR.

f. The MIDRMA will continue to enhance the (MIDRAS) Software and started phase 3 of the upgrade project to add visualization features in 4D.

g. Current risk-bearing situations have been identified by using the MIDRAS and actions will be taken to ensure resolving all violations and information which will be collected during the MID RVSM Scrutiny Group meeting in order to identify operational issues and potential mitigations.

Therefore, it is concluded that this Safety Objective is currently met.

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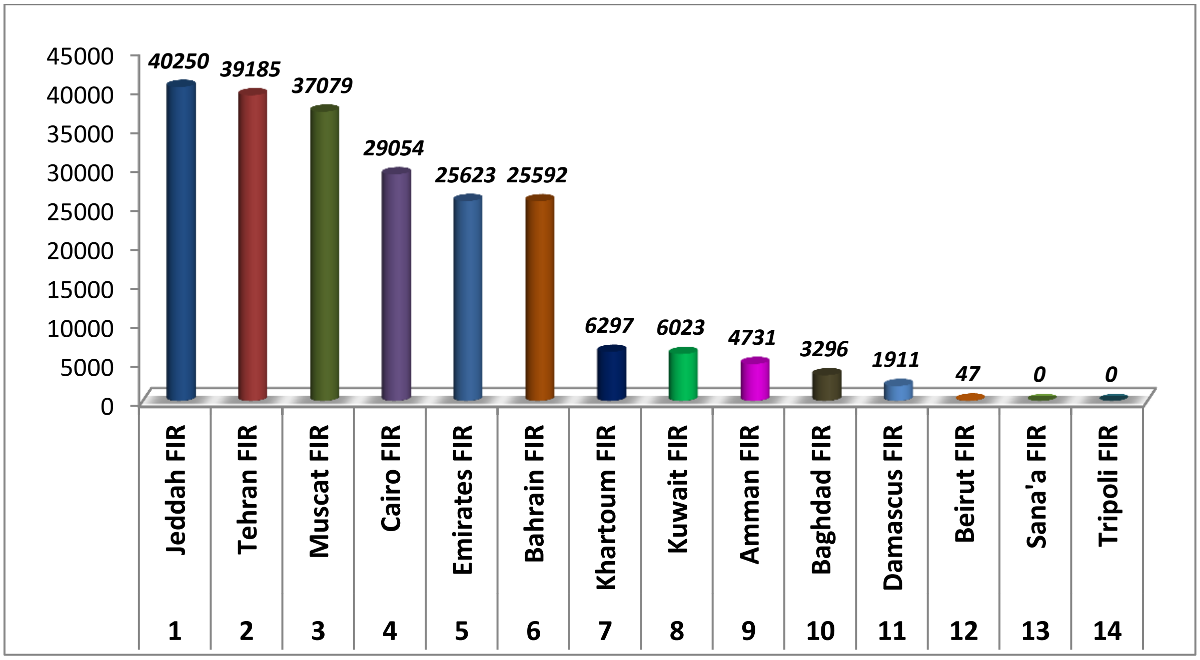
5.3 Appendix A – Member States Traffic Data Analysis:

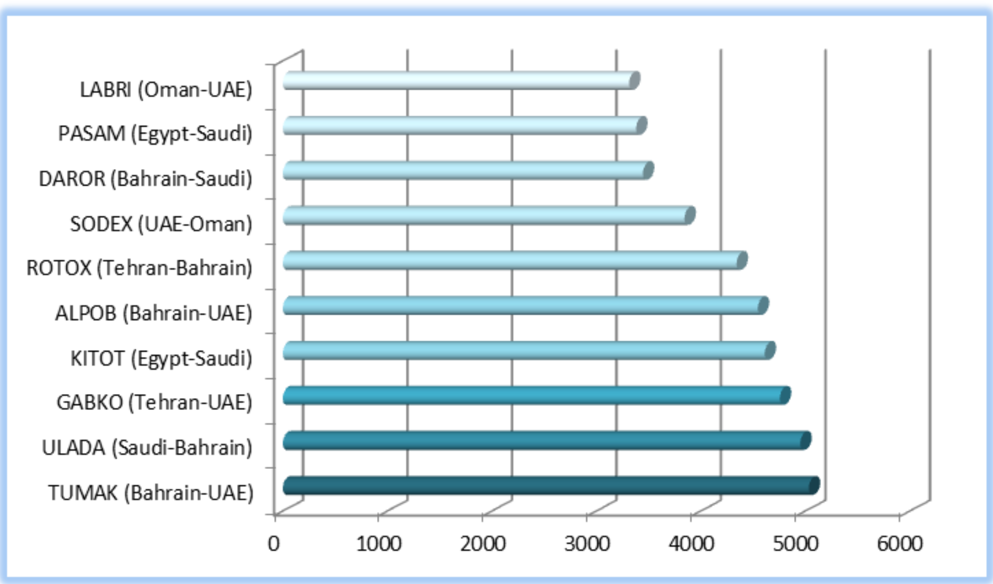
The quality of the SMR traffic data received from all State members varies from one State to another. The MIDRMA monitoring team spent a considerable time to correct the contents and fill all missing fields, the TDS which were not processed will be reviewed with the concerned focal points to update the TDS.

MIDRMA SMRs - RVSM TRAFFIC DATA

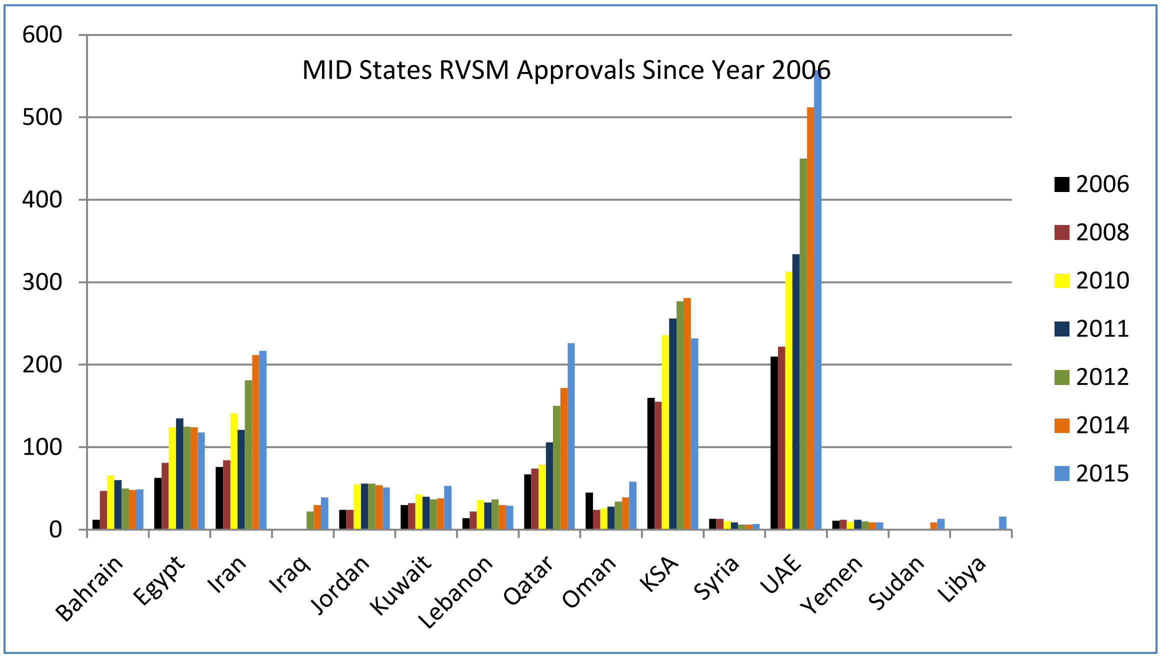
SN	MID States	Jun. 2009	Jan. 2011	Oct. 2012	Jan - Feb 2014	Sep. 2015
1	Jeddah/Riyadh	22422	25499	30944	32351	40250
2	Muscat FIR	22520	28224	30357	31735	37079
3	Cairo FIR	19228	14270	26332	27271	29054
4	Bahrain FIR	24285	30099	39345	25442	25592
5	Tehran FIR	10479	10638	17523	24727	39185
6	Emirates FIR	15868	21076	24676	24369	25623
7	Baghdad FIR	0	0	10496	12694	3296
8	Kuwait FIR	3570	10364	13596	10666	6023
9	Sana'a FIR	3490	4305	5170	5620	0
10	Khartoum FIR	0	0	0	4776	6297
11	Amman FIR	8554	10689	6857	4546	4731
12	Damascus FIR	9774	11719	8027	4095	1911
13	Beirut FIR	2949	3845	1286	105	47
14	Tripoli FIR	0	0	0	0	0
	Total	**143,139**	**170,728**	**214,609**	**208,397**	**219,088**



MID States RVSM Traffic Data for SMR 2015 *(September 2015)*



The Busiest 10 Reporting Points in the MID Region FIRs (*September 2015)*



MID States RVSM Approvals Since Year 2006 ***(Increased by 131% since year 2006)***

5.4 Appendix B – MID States Registered ACFT Required Monitoring

The tables below reflect the Minimum Monitoring Requirements (MMR) for each MIDRMA member State.

Seq.#	BAHRAIN Operator	ACFT Type	Required Monitoring
1	Royal Bahraini Air Force	RJ85	1
	TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED		1

Seq.#	EGYPT Operator	ACFT Type	Required Monitoring
1	Cairo Aviation	T204	2
2	Egyptian Air Force	FA20	1
3	Egyptian Air Force	GLF3	1
4	Egypt air Airlines	A342	1
5	Egypt air Airlines	B772	1
6	Smart Aviation	BE30	1
	TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED		7

Seq.#	IRAN Operator	ACFT Type	Required Monitoring
1	C.A.O.	F2TH	1
2	Caspian Airlines	B737	2
3	Iran Air	A30B	2
4	Iran Air	A320	1
5	Iran Air	B737	1
6	Iran Air	B742	2
7	Iran Air	B74S	1
8	Iran Aseman Airlines	B722	1
9	Iran Aseman Airlines	F100	1
10	Iranian Air Transport Company	F100	1
11	Kish Air	F100	1
12	Mahan Air	B743	2
13	Taban Air	B734	1
14	Taban Air	B752	1

15	Taban Air	RJ85	1
16	Taftan Airlines	MD82	1
17	ATA Air	A320	1
	TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED		21

Seq.#	IRAQ	ACFT	Required
	Operator	Type	Monitoring
1	Iraqi Airways	B744	1
2	Iraqi Airways	B763	1
3	Al Nasser Airlines	B732	1
4	Zagros Jet	A321	1
	TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED		4

Seq.#	JORDAN	ACFT	Required
	Operator	Type	Monitoring
1	Arab Wings	CL60	1
2	Royal Falcon Air Services	A320	1
3	Royal Falcon Air Services	B734	1
4	Royal Jordanian	E170	2
	TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED		5

Seq.#	KUWAIT	ACFT	Required
	Operator	Type	Monitoring
1	Kuwait Airways	GLF6	1
	TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED		1

Seq.#	LEBANON	ACFT	Required
	Operator	Type	Monitoring
1	IBEX Air Charter	H25B	2
2	Sky Lounge Services	GLF4	1
	TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED		3

Seq.#	LIBYA	ACFT	Required
	Operator	Type	Monitoring
1	Unknown	-	-

Seq.#	OMAN Operator	ACFT Type	Required Monitoring
1	Royal Air Force of OMAN	A320	1
2	Royal Air Force of OMAN	GLF4	2
	TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED		3

Seq.#	QATAR Operator	ACFT Type	Required Monitoring
1	Qatar Executive	GLF6	1
	TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED		1

Seq.#	SAUDI ARABIA Operator	ACFT Type	Required Monitoring
1	Arabasco	F900	1
2	Alwalaan	C650	1
3	Aviation Knights	B735	1
4	Aviation Knights	GLF2	1
5	Aero Medical Evacuation	GLF5	1
6	Kingdom Holdings	H25B	1
7	Private Air Saudi Arabia	CL60	1
8	Salem Aviation	H25B	1
9	Salem Aviation	C525	1
10	Saudi Gulf Airlines	A320	1
11	Sky Prime	E550	1
12	Sky Prime	E50P	1
13	Alpha Star	E50P	1
14	Alpha Star	H25B	2
15	Royal Fleet	B74S	1
16	Royal Fleet	B752	1
17	Royal Fleet	A340	1
18	NAS 91	H25B	1
19	Saudi Airlines	B744	1
20	Saudi Airlines	B789	1
	TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED		23

Seq.#	SUDAN	ACFT	Required
	Operator	Type	Monitoring
1	Badr Airlines	IL76	2
3	Green Flag	IL76	1
4	Kata Air Transport	IL76	1
5	Nova Airlines	B737	1
6	Nova Airlines	CRJ1	1
7	Nova Airlines	CRJ2	1
8	Sudan Airways	A306	2
9	Sudan Airways	A320	1
TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED			10

Seq.#	SYRIA	ACFT	Required
	Operator	Type	Monitoring
1	Syrian Air	T134	1
TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED			1

Seq.#	UNITED ARAB EMIRATES	ACFT	Required
	Operator	Type	Monitoring
1	Etihad	B788 or 789	1
2	Etihad Flying School	E50P	2
3	Gama Aviation	E135	1
4	Global Jet	B733	1
5	Midex Airlines	B742	2
6	Empire Aviation	H25B	1
7	Empire Aviation	FA7X	1
8	Empire Aviation	CL60	1
9	Rulers Flight Sharjah	A320	1
10	Emirates	A343	2
11	Emirates	A332	2
12	UAE Air Force	B743	2
13	UAE Air Force	B734	2
14	UAE Air Force	B752	2
TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED			21

Seq.#	YEMEN	ACFT	Required
	Operator	Type	Monitoring
1	Yemen Airways	A310	2
2	Yemen Airways	B74S	1
3	Felix Airways	CRJ7	2
TOTAL NUMBER OF ACFT REQUIRED TO BE MONITORED			5

Note: The MIDRMA raised their serious concern to the MIDRMA Board and to the ICAO MID office about the Libyan aircraft which are operating within the RVSM airspace in MID, Europe and the AFI regions and requested a decision to be taken concerning these non RVSM approved aircraft.

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5.5 Appendix C - RVSM MINIMUM MONITORING REQUIREMENTS (Updated on May 2015)

1. UPDATE OF MONITORING REQUIREMENTS TABLE AND WEBSITE. As significant data is obtained, monitoring requirements for specific aircraft types may change. When Table 1 below, is updated, The MIDRMA will advise all State members. The updated table will be posted on the MIDRMA website.

2. MONITORING PROGRAM. All operators that operate or intend to operate in the Middle East Region airspace where RVSM is applied are required to participate in the regional RVSM monitoring programme. Table 1 addresses requirements for monitoring the height-keeping performance of aircraft in order to meet regional safety objectives. In their application to the appropriate State authority for RVSM approval, operators must show a plan for meeting the applicable monitoring requirements. Initial monitoring should be completed as soon as possible but not later than 6 months after the issue of RVSM approval, the State of Registry that had issued an RVSM approval to an operator would be required to establish a requirement which ensures that a minimum of two aeroplanes of each aircraft type grouping of the operator have their height-keeping performance monitored, at least once every two years or within intervals of 1000 flight hours per aeroplane, whichever period is longer.

3. AIRCRAFT STATUS FOR MONITORING. Aircraft engineering work that is required for the aircraft to receive RVSM airworthiness approval must be completed prior to the aircraft being monitored. Any exception to this rule will be coordinated with the State authority.

4. APPLICABILITY OF MONITORING FROM OTHER REGIONS. Monitoring data obtained in conjunction with RVSM monitoring programmes from other Regions can be used to meet regional monitoring requirements. The RMAs, which are responsible for administering the monitoring programme, have access to monitoring data from other Regions and will coordinate with States and operators to inform them on the status of individual operator monitoring requirements.

5. MONITORING PRIOR TO THE ISSUE OF RVSM OPERATIONAL APPROVAL IS NOT A REQUIREMENT. Operators should submit monitoring plans to the responsible civil aviation authority and to the MIDRMA that show how they intend to meet the requirements specified in Table1. Monitoring will be carried out in accordance with this table.

6. AIRCRAFT GROUPS NOT LISTED IN TABLE 1. Contact the MIDRMA for clarification if an aircraft group is not listed in Table 1 or for clarification of other monitoring related issues. An aircraft group not listed in Table 1 will probably be subject to Category 2 or Category 3 monitoring requirements.

7. TABLE OF MONITORING GROUPS. Table 2 shows the aircraft types and series that are grouped together for operator monitoring purposes.

8. TRAILING CONE DATA. Altimetry System Error estimations developed using Trailing Cone data collected during RVSM certification flights can be used to fulfill monitoring requirements. It must be documented, however, that aircraft RVSM systems were in the approved RVSM configuration for the flight.

9. MONITORING OF AIRFRAMES THAT ARE RVSM COMPLIANT ON DELIVERY. If an operator adds new RVSM compliant airframes of a type for which it already has RVSM operational approval and has completed monitoring requirements for the type in accordance with the attached table, the new airframes are not required to be monitored. If an operator adds new RVSM compliant airframes of an aircraft type for which it has NOT previously received RVSM operational approval, then the operator should complete monitoring in accordance with the attached table.

MMR tables as of 22 May 2015
Version 2015.0
Table 1: MONITORING REQUIREMENTS TABLE (Civilian)

MONITORING IS REQUIRED IN ACCORDANCE WITH THIS TABLE

MONITORING PRIOR TO THE ISSUE OF RVSM APPROVAL IS **NOT** A REQUIREMENT

CATEGORY		DESCRIPTOR	MINIMUM MONITORING REQUIREMENTS
1	GROUP APPROVED: DATA INDICATES COMPLIANCE WITH THE RVSM MASPS	A124, A300, A306, A310-GE, A310-PW, A318, A320, A330, A340, A345, A346, A380, A3ST, AVRO, B712, B727, B737C, B737CL, B737NX, B747CL, B74S, B744-5, B744-10, B752, B753, B764, B767, B772, B773, BD100, BE40, C25A, C25B, C510, C525, C560, C56X, C650, C680, C750, CARJ, CL600, CL604, CL605, CRJ7, CRJ9, DC10, E135-145, E170-190, E50P, E55P, F100, F900, FA7X, GALX, GLEX, GLF4, GLF5, H25B-800, J328, LJ40, LJ45, LJ60, MD10, MD11, MD80, MD90, PRM1, T154	Operators of aircraft types contained in this category shall have a minimum of 2 airframes monitored every 2 years or 1,000 flight hours, whichever is longer. Operators with fleets consisting of aircraft from more than one group shall meet this requirement for each group in the fleet. In the event that an operator has a single airframe from a group, that aircraft shall be monitored every 2 years or 1,000 flight hours, whichever is longer.
2	GROUP APPROVED: INSUFFICIENT DATA ON APPROVED AIRCRAFT	Other group aircraft other than those listed above including: A148, A158, A350, AC90, AC95, AJ27, AN72, ASTR, ASTR-SPX, B701, B703, B731, B732, B744-LCF, B748, B787, BCS1, BD700, BE20, BE30, C25C, C441, C500, C550-B, C550-II, C550-SII, CRJ10, D328, DC85, DC86-87, DC91, DC93, DC94 DC95, E120, E45X, EA50, F2TH, F70, FA10, FA20, FA50, G150, G280, GLF2, GLF2B, GLF3, GLF6, H25B-700, H25B-750, H25C, HA4T, HDJT, IL62, IL76, IL86, IL96, L101, L29B-2, L29B-731, LJ23, LJ24, LJ25, LJ28, LJ31, LJ35-36, LJ55, MU30, P180, PAY4, PC12, SB20, SBR1, SBR2, SU95, T134, T204, T334, TBM, WW24, YK42	Operators of aircraft types contained in this category shall have a minimum of 60% of airframes monitored every 2 years or 1,000 flight hours, whichever is longer, (the number of airframes to be monitored shall be rounded up to the nearest whole integer). Operators with fleets consisting of aircraft from more than one group shall meet this requirement for each group in the fleet.
3	NON-GROUP	Aircraft types for which no generic compliance method exists: A225, AN12, AN26, B190, B462, B463, B720, B74S-SOFIA, BA11, BE9L, GSPN, H25A, L29A, PAY3, R721, R722, SJ30, STAR	Operators of aircraft types contained in this category shall have 100% of airframes monitored every 2 years or 1,000 flight hours, whichever is longer

Table 2: MONITORING GROUPS FOR AIRCRAFT CERTIFIED UNDER GROUP APPROVAL REQUIREMENTS

Monitoring Group	A/C ICAO	Manufacturer Type	Additional Defining Criteria
A124	A124	AN-124 RUSLAN	
A148	A148	AN-148	
A158	A158	AN-158	
A30B	A30B	A300	
A306	A306	A300	
A310-GE	A310	A310	Series: 200, 200F, 300, 300F
A310-PW	A310	A310	Series: 220, 220F, 320, 320F
A318	A318	A318	
A320	A319 A320 A321	A319 A320 A321	
A330	A332 A333	A330 A330	
A340	A342 A343	A340 A340	
A345	A345	A340	
A346	A346	A340	
A350	A359	AIRBUS 350-900	
A380	A388	A380	
A3ST	A3ST	A300	
AC90	AC90	COMMANDER 690 COMMANDER 840 COMMANDER 900	
AC95	AC95	AERO COMMANDER 695	
AJ27	AJ27	COMAC ARJ-21-700	
AN72	AN72	ANTONOV AN-72 ANTONOV AN-74	
ASTR	ASTR	1125 ASTRA	S/n 1-78, except 73
ASTR-SPX	ASTR	1125 ASTR SPX, G100	S/n 73, 79-145 S/n > 146
AVRO	RJ1H RJ70 RJ85	RJ100 Avroliner RJ70 Avroliner RJ85 Avroliner	
B701	B701	B707	
B703	B703	B707	Series 320, 320B, 320C
B712	B712	B717	
B727	B721 B722	B727 B727	
B731	B731	B737	
B732	B732	B737	
B737CL	B733 B734 B735	B737-300 B737-400 B737-500	

Monitoring Group	A/C ICAO	Manufacturer Type	Additional Defining Criteria
B737NX	B736	B737-600	
	B737	B737-700	Series: 700, BBJ only
	B738 B739	B737-800 B737-900	
B737C	B737	B737-700	Series: 700C
B747CL	B741 B742 B743	B747-100 B747-200 B747-300	
B74S	B74S B74R	B747SP B747SR	
B744-5	B744 B74D	B747-400	5 inch Probes up to SN 25350
B744-10	B744 B74D	B747-400	10 inch Probes from SN 25351
B744-LCF	BLCF	B747-400	
B748	B748	B747-800	
B752	B752	B757-200	
B753	B753	B757-300	
B767	B762 B763	B767-200 B767-300	
B764	B764	B767-400	
B772	B772 B77L B77L	B777-200 B777-F B777-200LR	
B773	B773 B77W	B777-300 B777-300ER	
B787	B788 B789	B787-8 B787-9	
BCS1	BCS1	BOMBARDIER 500 C SERIES CS100	
BD100	CL30	CHALLENGER 300	
BD700	GL5T	GLOBAL 5000	
BE20	BE20	200 KINGAIR	
BE30	BE30 B350	B300 SUPER KINGAIR B300 SUPER KINGAIR 350	
BE40	BE40	BEECHJET 400 BEECHJET 400A BEECHJET 400XP HAWKER 400XP	
C441	C441	CONQUEST II	
C500	C500 C500 C501	500 CITATION 500 CITATION I 501 CITATION I SINGLE PILOT	
C510	C510	MUSTANG	
C525	C525	525 CITATIONJET 525 CITATIONJET 1 525 CITATIONJET PLUS	
C25A	C25A	525A CITATIONJET II	
C25B	C25B	CITATIONJET III	

Monitoring Group	A/C ICAO	Manufacturer Type	Additional Defining Criteria
		525B CITATIONJET III	
C25C	C25C	525C CITATIONJET IV	
C550-B	C550	550 CITATION BRAVO	
C550-II	C550 C551	550 CITATION II 551 CITATION II SINGLE PILOT	
C550-SII	C550	S550 CITATION SUPER II	
C560	C560	560 CITATION V 560 CITATION V ULTRA 560 CITATION V ENCORE	
C56X	C56X	560 CITATION EXCEL 560 CITATION XLS	
C650	C650	650 CITATION III 650 CITATION VI 650 CITATION VII	
C680	C680	680 CITATION SOVEREIGN	
C750	C750	750 CITATION X	
CARJ	CRJ1 CRJ2 CRJ2 CRJ2	CRJ-100 CRJ-200 CHALLENGER 800 CHALLENGER 850	
CRJ7	CRJ7	CRJ-700	
CRJ9	CRJ9	CRJ-900	
CRJ10	CRJX	CRJ-1000	
CL600	CL60	CL-600 CL-601	S/n < 5000
CL604	CL60	CL-604	5000 < S/n < 5700
CL605	CL60	CL-605	S/n > 5700
DC10	DC10	DC-10	
D328	D328	328 TURBOPROP	
DC85	DC85	DC-8	
DC86-87	DC86 DC87	DC-8 DC-8	
DC91	DC91	DC-9	
DC93	DC93	DC-9	
DC94	DC94	DC-9	
DC95	DC95	DC-9	
E120	E120	EMB-120 Brasilia	
E135-145	E135 E145	EMB-135 EMB-145	
E45X	E45X	EMB-145 XR	
E170-190	E170 E170 E190 E190	EMB-170 EMB-175 EMB-190 EMB-195	
E50P	E50P	PHENOM 100	
E55P	E55P	PHENOM 300	
EA50	EA50	ECLIPSE	

Monitoring Group	A/C ICAO	Manufacturer Type	Additional Defining Criteria
F100	F100	FOKKER 100	
F2TH	F2TH	FALCON 2000 FALCON 2000-EX FALSON 2000LX	
F70	F70	FOKKER 70	
F900	F900	FALCON 900 FALCON 900DX FALCON 900EX FALCON 900LX	
FA10	FA10	FALCON 10	
FA20	FA20	FALCON 20 FALCON 200	
FA50	FA50	FALCON 50 FALCON 50EX	
FA7X	FA7X	FALCON 7X	
G150	G150	G150	
G280	G250 G280	G250 G280	
GALX	GALX	1126 GALAXY G200	
GLEX	GLEX	BD-700 GLOBAL EXPRESS	
GLF2	GLF2	GULFSTREAM II (G-1159)	
GLF2B	GLF2	GULFSTREAM IIB (G-1159B)	
GLF3	GLF3	GULFSTREAM III (G-1159A)	
GLF4	GLF4	GULFSTREAM IV (G-1159C) G300 G350 G400 G450	
GLF5	GLF5	GULFSTREAM V (G-1159D) G500 G550	
GLF6	GLF6	G650	
H25B-700	H25B	BAE 125 / HS125	Series: 700A, 700B
H25B-750	H25B	HAWKER 750	
H25B-800	H25B	BAE 125 / HS125	Series: 800A, 800B
		HAWKER 800XP HAWKER 800XPI HAWKER 800 HAWKER 850XP HAWKER 900XP HAWKER 950XP	
H25C	H25C	HAWKER 1000	
HA4T	HA4T	HAWKER 4000	
HDJT	HDJT	HONDAJET HA-420	
IL62	IL62	ILYUSHIN-62	
IL76	IL76	ILYUSHIN-76	
IL86	IL86	ILYUSHIN-86	

Monitoring Group	A/C ICAO	Manufacturer Type	Additional Defining Criteria
IL96	IL96	ILYUSHIN-96	
J328	J328	328JET	
L101	L101	L-1011 TRISTAR	
L29B-2	L29B	L-1329 JETSTAR II	
L29B-731	L29B	L-1329 JETSTAR 731	
LJ23	LJ23	LEARJET 23	
LJ24	LJ24	LEARJET 24	
LJ25	LJ25	LEARJET 25	
LJ28	LJ28	LEARJET 28 LEARJET 29	
LJ31	LJ31	LEARJET 31	
LJ35-36	LJ35	LEARJET 35 LEARJET 36	
LJ40	LJ40	LEARJET 40	
LJ45	LJ45	LEARJET 45	
LJ55	LJ55	LEARJET 55	
LJ60	LJ60	LEARJET 60	
MD10	MD10	MD-10	
MD11	MD11	MD-11	
MD80	MD81 MD82 MD83 MD87 MD88	MD-80 MD-80 MD-80 MD-80 MD-80	
MD90	MD90	MD-90	
MU30	MU30	MU-300 DIAMOND	
P180	P180	P-180 AVANTI P-180 AVANTI II	
PAY4	PAY4	PA-42 Cheyenne 400	Series: 1000 CHEYENNE
PC12	PC12	PC-12	
PRM1	PRM1	PREMIER 1	
SB20	SB20	SAAB 2000	
SBR1	SBR1	SABRELINER 40 SABRELINER 60 SABRELINER 65	
SBR2	SBR2	SABRELINER 80	
SU95	SU95	SUKHOI SUPERJET 100-95	
T134	T134	TU-134	
T154	T154	TU-154	
T204	T204	TU-204 TU-214 TU-224 TU-234	
T334	T334	TU-334	
TBM	TBM7 TBM8	TBM-700 TBM-850	
WW24	WW24	1124 WESTWIND	

Monitoring Group	A/C ICAO	Manufacturer Type	Additional Defining Criteria
YK42	YK42	Yakovlev YAK-42 Yakovlev YAK-40	

Table 3: Non-GROUP AIRCRAFT (i.e, Not certified under group approval requirements) (Civilian)

Descriptor	A/C ICAO	Manufacturer Type	Additional Defining Criteria
A225	A225	ANTONOV AN-225	Non-Group
AN12	AN12	ANTONOV AN-12	Non-Group
AN26	AN26	ANTONOV AN-26	Non-Group
B190	B190	BEECH 1900	Non-Group
B462	B462	BAe-146-200	Non-Group
B463	B463	BAe-146-300	Non-Group
B720	B720	B720	Non-Group
B74S-SOFIA	B74S	NASA B74SP with Sofia telescope	Non-Group: N747NA (s/n 21441)
BA11	BA11	BAC-111	Non-Group
BE9L			Non-Group
GSPN	GSPN	GROB G-180 SPn Utility Jet	Non-Group
H25A	H25A	HS125-400, -600	Non-Group
L29A	L29A	L-1329 JETSTAR 6/8	Non-Group
PAY3	PAY3	PIPER Cheyenne 3	Non-Group
R721	R721	B-727-100: Re-engined	Non-Group
R722	R722	B-727-200: Re-engined	Non-Group
SJ30	SJ30	SWEARINGEN SJ-30	Non-Group
STAR	STAR	BEECH 2000 STARSHIP	Non-Group

Version 2015.0

Table 1: MONITORING REQUIREMENTS TABLE (Military)

MONITORING IS REQUIRED IN ACCORDANCE WITH THIS TABLE

MONITORING PRIOR TO THE ISSUE OF RVSM APPROVAL IS **NOT** A REQUIREMENT

CATEGORY		DESCRIPTOR	MINIMUM MONITORING REQUIREMENTS
1	GROUP APPROVED: DATA INDICATES COMPLIANCE WITH THE RVSM MASPS	C17, C130, KC135	Operators of aircraft types contained in this category shall have a minimum of 2 airframes monitored every 2 years or 1,000 flight hours, whichever is longer. Operators with fleets consisting of aircraft from more than one group shall meet this requirement for each group in the fleet. In the event that an operator has a single airframe from a group, that aircraft shall be monitored every 2 years or 1,000 flight hours, whichever is longer.
2	GROUP APPROVED: INSUFFICIENT DATA ON APPROVED AIRCRAFT	Other group aircraft other than those listed above including: A400, E3, C5, C550-552	Operators of aircraft types contained in this category shall have a minimum of 60% of airframes monitored every 2 years or 1,000 flight hours, whichever is longer, (the number of airframes to be monitored shall be rounded up to the nearest whole integer). Operators with fleets consisting of aircraft from more than one group shall meet this requirement for each group in the fleet.
3	NON-GROUP	**Aircraft types for which no generic compliance method exists:** GLF5-AEW, GLEX-ASTOR	Operators of aircraft types contained in this category shall have 100% of airframes monitored every 2 years or 1,000 flight hours, whichever is longer

Table 2: MONITORING GROUPS FOR AIRCRAFT CERTIFIED UNDER GROUP APPROVAL REQUIREMENTS (Military)

Monitoring Group	A/C ICAO	Manufacturer Type	Additional Defining Criteria
A30B-M	A30B	A300	B2-100 (Zero-G)
A310-M	A310	A310	MRT, MRTT
KC30	A332	KC30-A	MRTT
A400	A400	A400M	
ASTR-M	ASTR	1125 ASTRA	NAV&COM
B737-AWACS	E737	B737	Series: 700W (AWACS)
E3	E3TF E3CF	E-3 Sentry	
E4	B742	E-4	
E6	E6	E-6 Mercury	
E8	B703	E-8 J-Stars	
C12	BE20	C-12	
C130	C130	C-130 Hercules	Series: H only
	C30J	C-130J Hercules	
C17	C17	C-17 Globemaster III	
C21	LJ35	C-21	
C32	B752	C-32	Series: A, B
C40	B737	C-40 Clipper	
C5	C5	C5 Galaxy	
C550-552	C550	552 CITATION II (USN)	
C550-B-M	C550	550 CITATION BRAVO	
C550-M	C550	550 CITATION II	
C35	C560	560 CITATION V UC-35	
C9	DC93	C-9 VC-9	Series: A, B Series: C
CL60-M	CL60	CL604	MPA
E135-M	E135	EMB-135	MRT
FA10-M	FA10	FALCON 10	MRT
FA20-M	FA20	FALCON 20	EW/ELINT, MRT, EXP
FA50-M	FA50	FALCON 50	MPA/SAR
GLF3-M	GLF3	C-20	Series: A, B, C, D, E
GLF4-M	GLF4	C-20 S102B TP102	Series: F, G, H
C37	GLF5	C-37 TP102D	
IL76-M	IL76	IL-76	MRT, T
KC10	DC10	KC-10 Extender KDC-10 DC-10	

Monitoring Group	A/C ICAO	Manufacturer Type	Additional Defining Criteria
KC135	B703 K35E K35R	KC-135 Stratotanker KC-135 Stratotanker C-135 Stratotanker	
P180-M	P180	P-180 AVANTI	
	P8		
R135	R135	RC-135	
VC25	B742	VC-25	

Abbreviations:

EW/ELINT	Electronic Warfare / Electronic Intelligence
EXP	Experimental
MPA	Maritime Patrol Aircraft
MRT	Multi Role Transporter
MRTT	Multi Role Transporter and Tanker
SAR	Search And Rescue
T	Transporter

Table 3: Non-GROUP AIRCRAFT (i.e, Not certified under group approval requirements) (Military)

Descriptor	A/C ICAO	Manufacturer Type	Additional Defining Criteria
GLEX-ASTOR	GLEX	Raytheon Sentinel aka RAF's ASTOR (Airborne STand-Off Radar)	Non-Group
GLF5-AEW	GLF5	GULFSTREAM G550	Non-Group : AEW

Abbreviations:

AEW	Airborne Early Warning

5.6 Appendix D – MIDRMA Duties and Responsibilities

The Middle East Regional Monitoring Agency (MIDRMA) has the following duties and responsibilities:

1- To establish and maintain a central registry of State RVSM approvals of operators and aircraft using the Middle East Region airspace where RVSM is applied.

2- To initiate checks of the “approval status” of aircraft operating in the relevant RVSM airspace, identify non-approved operators and aircraft using RVSM airspace and notify the appropriate State of Registry/State of the Operator and other RMAs, accordingly.

3- To establish and maintain a database containing the results of height keeping performance monitoring and all altitude deviations of 300 ft or more within Middle East Region airspace, and to include in the database the results of MID RMA requests to operators and States for information explaining the causes of observed large height deviations.

4- Provide timely information on changes of monitoring status of aircraft type classifications to State Authorities and operators.

5- To assume overall responsibility for assessing compliance of operators and aircraft with RVSM height keeping performance requirements in conjunction with RVSM introduction in the Middle East Region.

6- To facilitate the transfer of approval data to and from other RVSM Regional Monitoring Agencies.

7- To establish and maintain a database containing the results of navigation error monitoring.

8- To conduct safety analysis for RVSM operations in the MID Region and prepare RVSM Safety Monitoring Reports (SMR) as instructed by MIDANPIRG and the MID RMA Board.

9- To conduct readiness and safety assessments to aid decision-making in preparation for RVSM implementation in those FIRs where RVSM is not yet implemented.

10- To carry out post-implementation safety assessments, as appropriate.

11- Based on information provided by States related to planned changes to the ATS routes structure, advise States and MIDANPIRG on the effects of such changes on the safe RVSM operations in the MID Region.

12- To liaise with other Regional Monitoring Agencies and organizations to harmonise implementation strategies.

5.7 Appendix E – Definitions and Explanations of RVSM Terms

Note: The following definitions are taken from ICAO Document 9574 (2nd Edition) **[1]** - Manual on Implementation of a 300m (1000ft) vertical separation minimum between FL290 and FL410 inclusive.

Collision Risk

The expected number of mid-air aircraft accidents in a prescribed volume of airspace for a specific number of flight hours due to loss of planned separation.

Flight technical error (FTE)

The difference between the altitude indicated by the altimeter display being used to control the aircraft and the assigned altitude/flight level.

Height-keeping Performance

The observed performance of an aircraft with respect to adherence to cleared flight level.

Probability of vertical overlap (Pz(1000))

The probability that two aircraft nominally separated by the vertical separation minimum are in fact within a distance of λz of each other, i.e. in vertical overlap. This probability can be calculated from the distribution of total vertical error.

Target level of safety

A generic term representing the level of risk which is considered acceptable in particular circumstances.

Technical height-keeping performance (or error)

That part of the height-keeping performance (or error) which is attributable to the combination of ASE and autopilot performance in the vertical dimension.

Total vertical error (TVE)

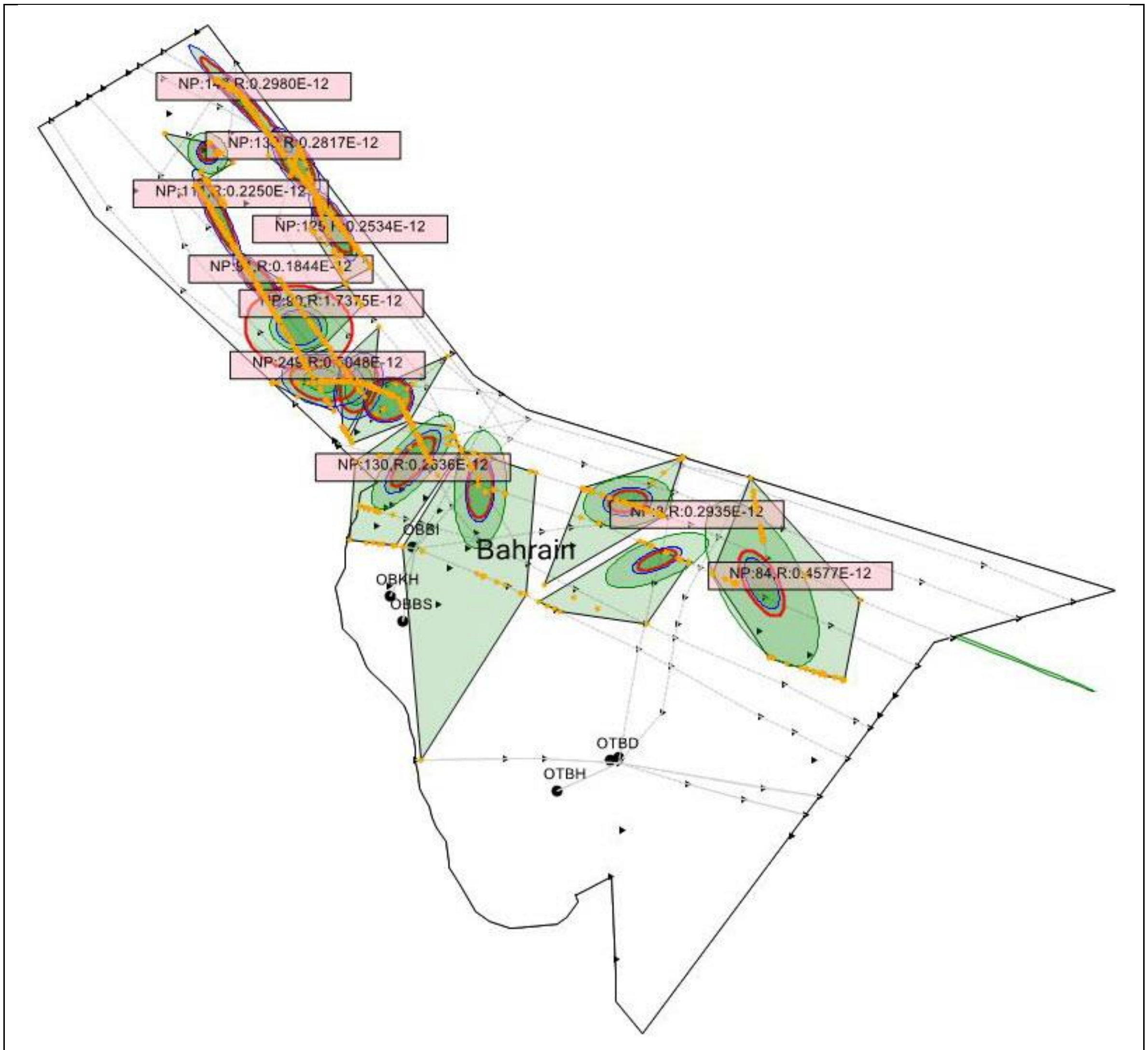
The vertical geometric difference between the actual pressure altitude flown by an aircraft and its assigned pressure altitude (flight level). TVE can be split into two components, altimetry system error (ASE) and flight technical error (FTE). TVE=ASE + FTE.

Vertical-collision risk

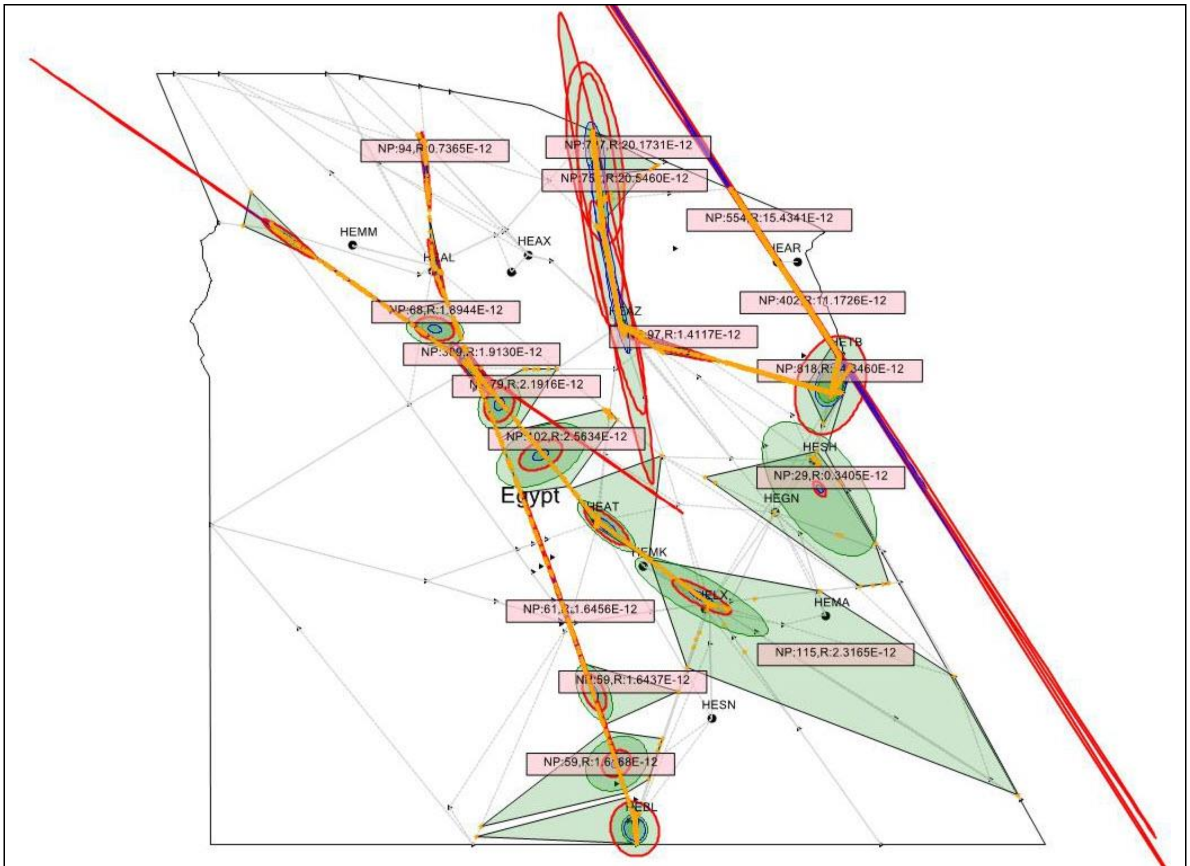
That expected number of mid-air aircraft accidents in a prescribed volume of airspace for a specific number of flight hours due to loss of planned vertical separation. Note: one collision is considered to produce two accidents.

5.8 Appendix F – MID REGION RVSM HOT SPOTS

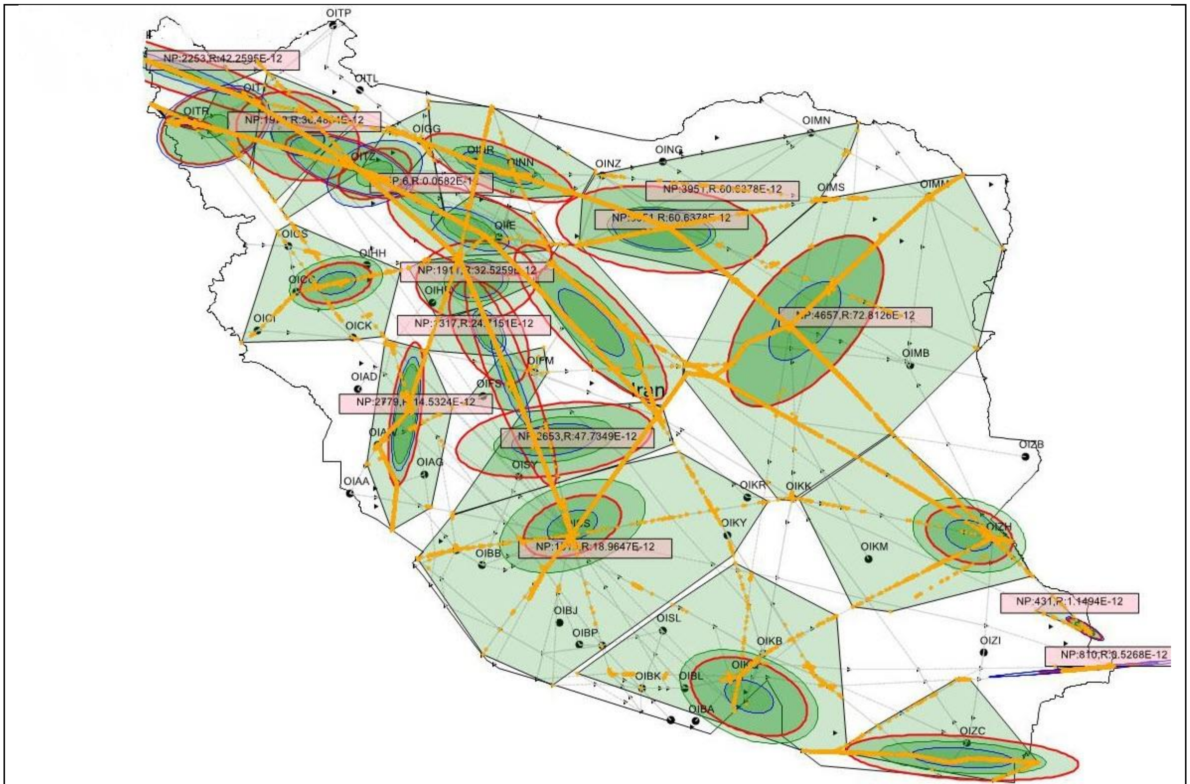
<u>FOR INFORMATION ONLY</u>: This appendix contained the hot spots for each MIDRMA Member State as generated by the MID Risk Analysis Software (MIDRAS).



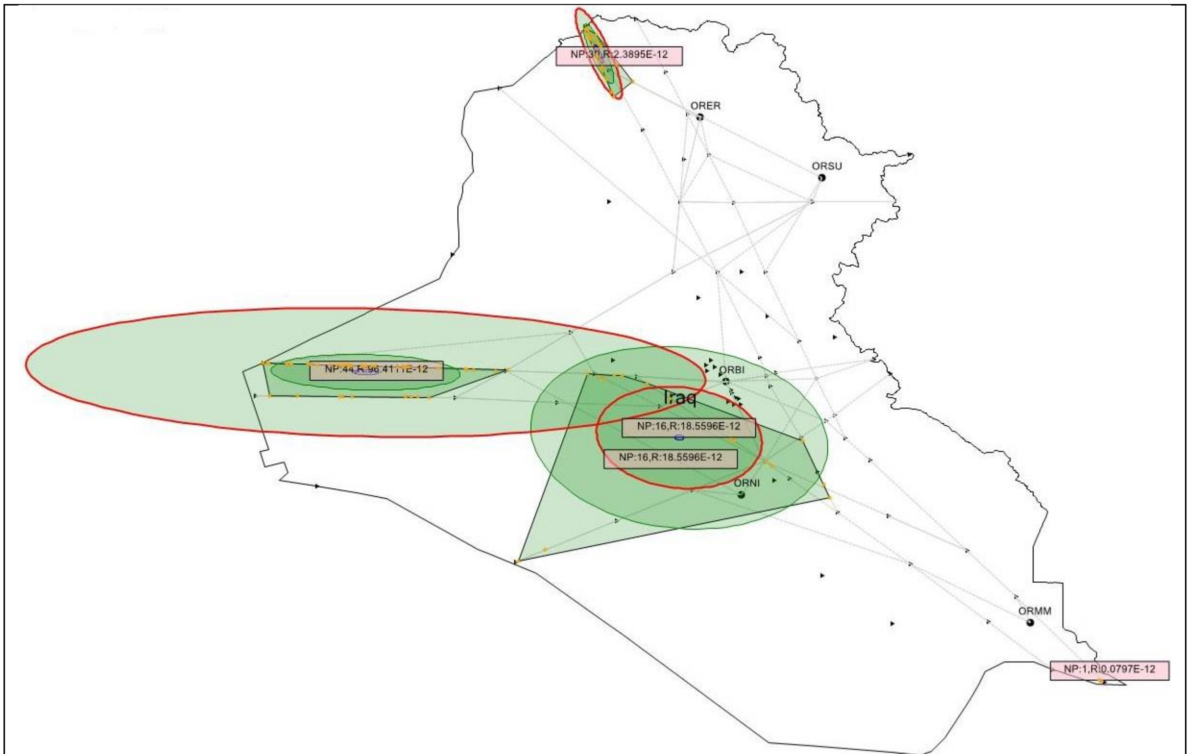
Bahrain RVSM Hot Spots



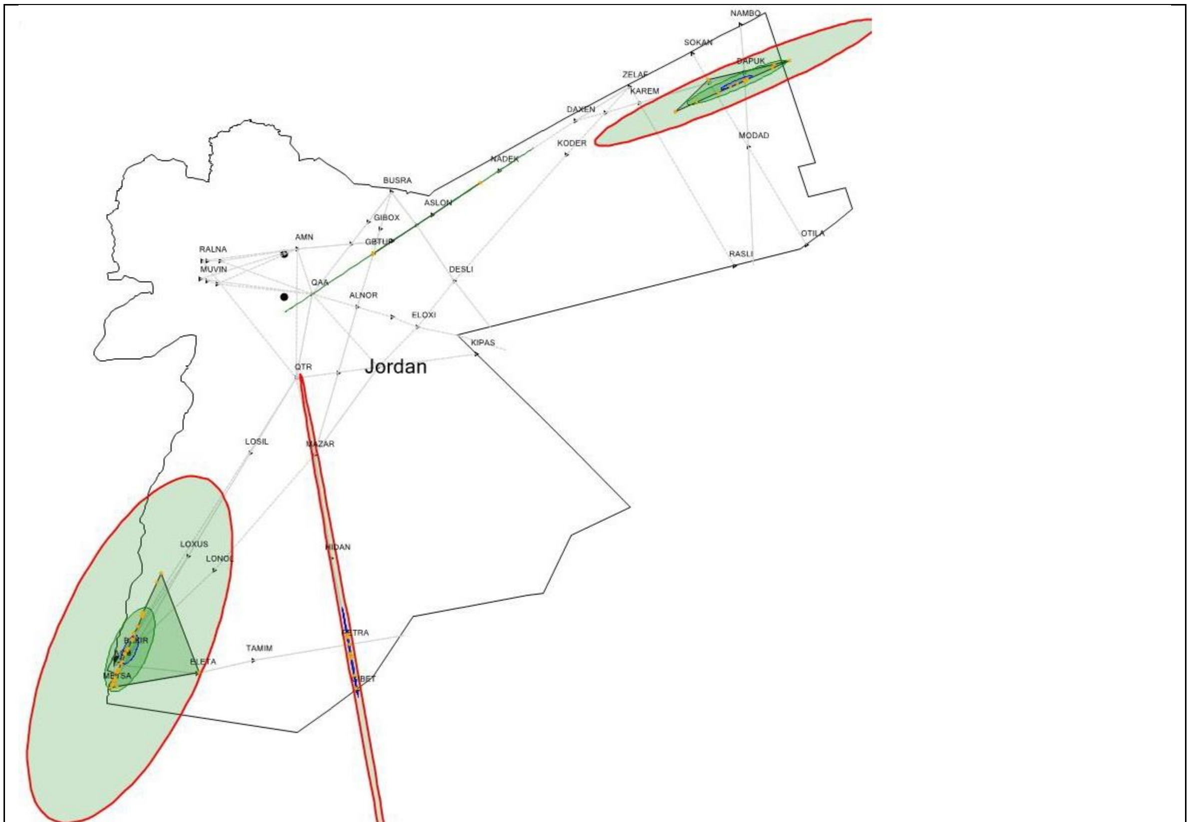
Egypt RVSM Hot Spots



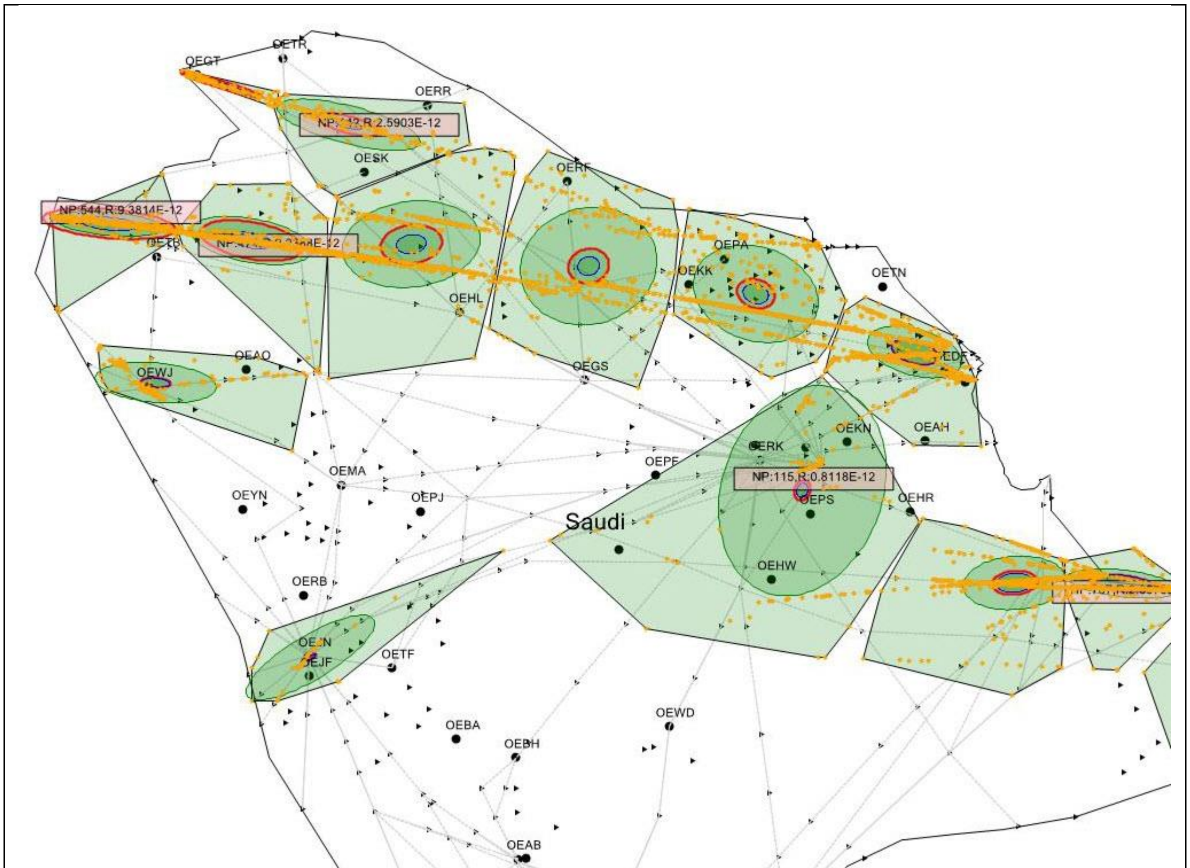
Iran RVSM Hot Spots



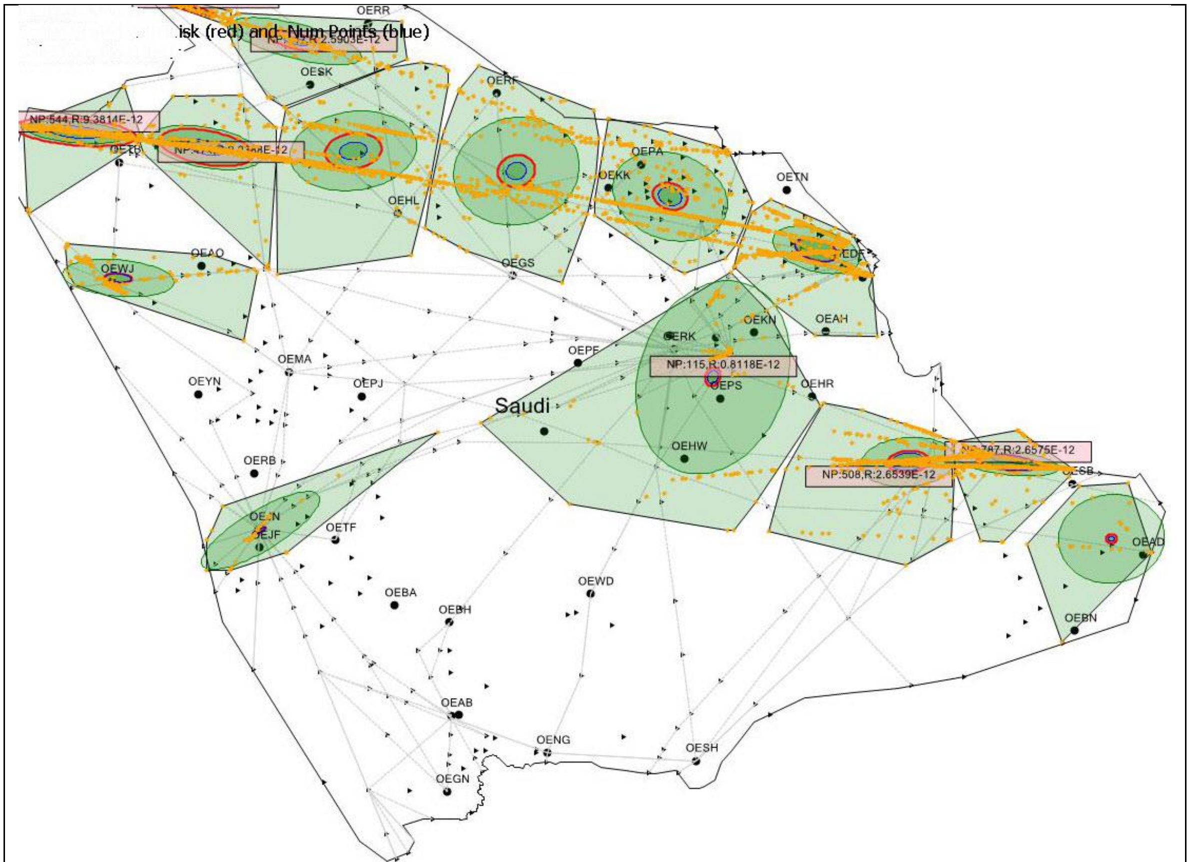
Iraq RVSM Hot Spots



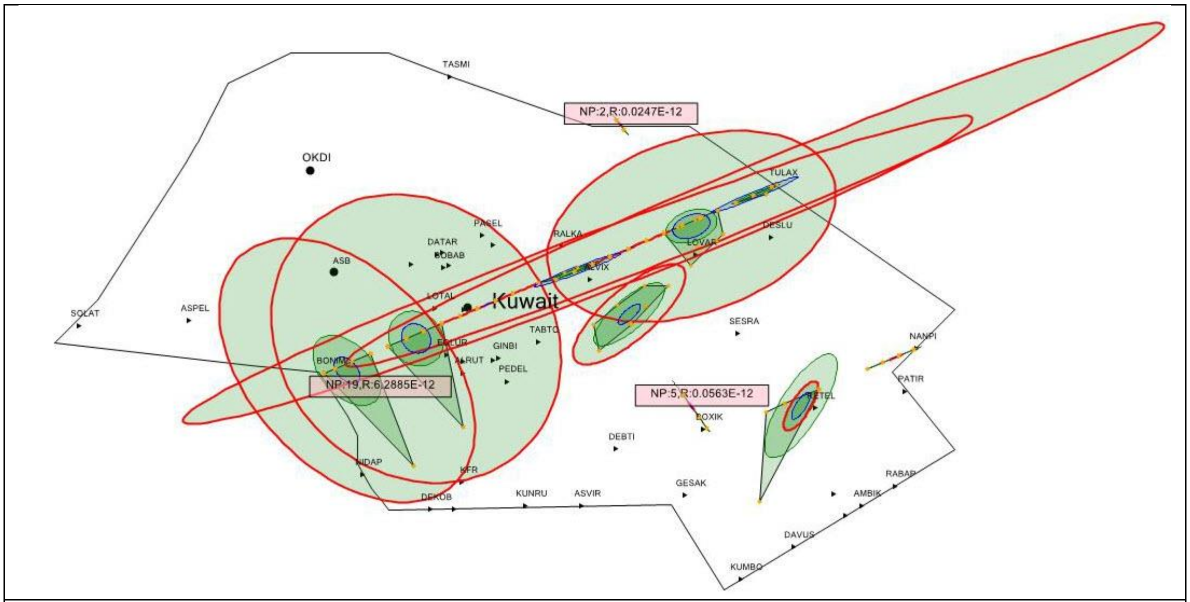
Jordan RVSM Hot Spots



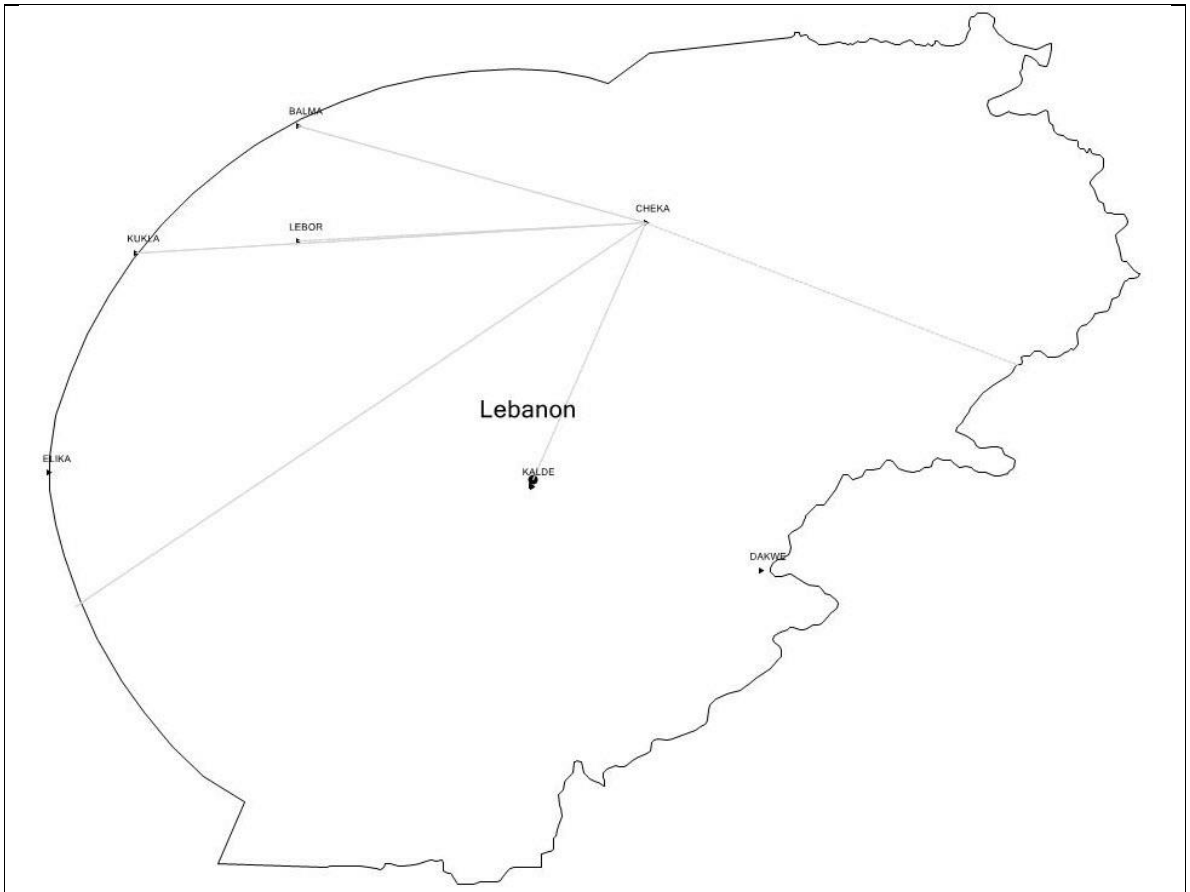
Saudi RVSM Hot Spots 1/2



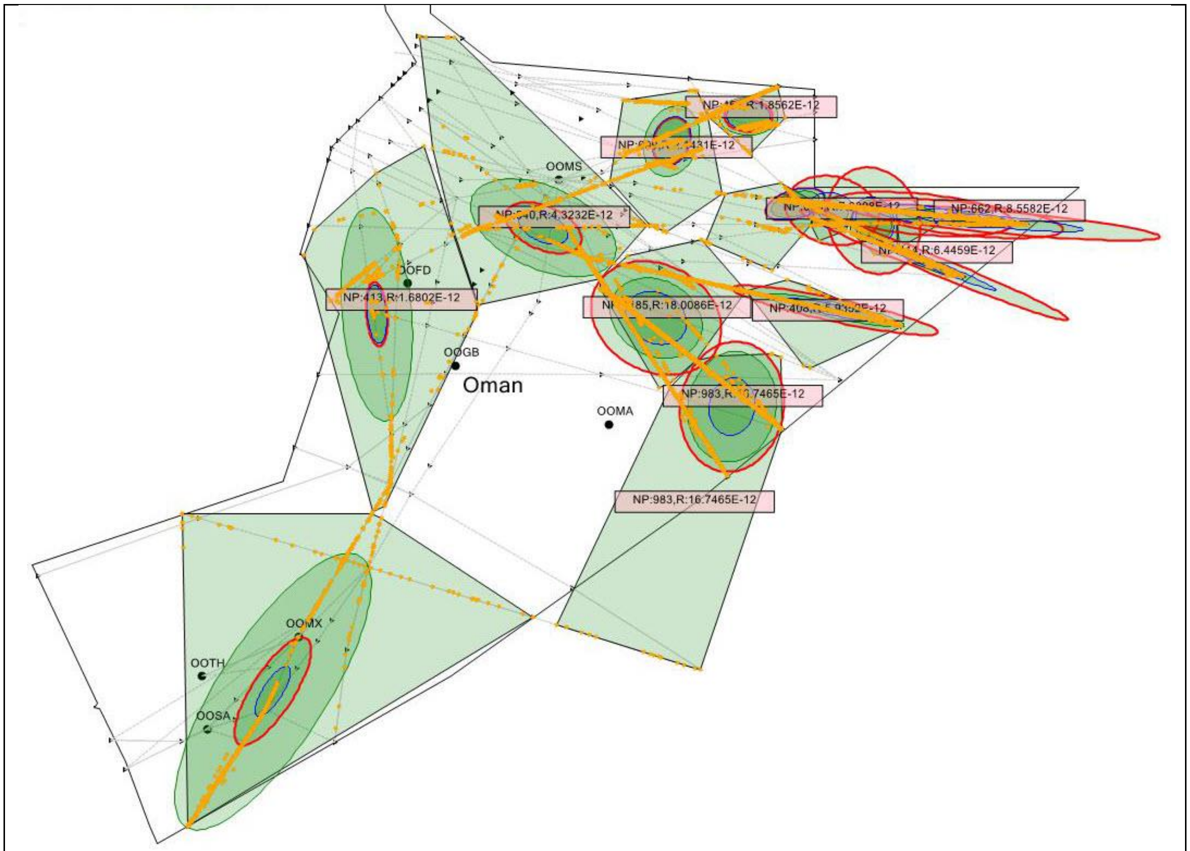
Saudi RVSM Hot Spots



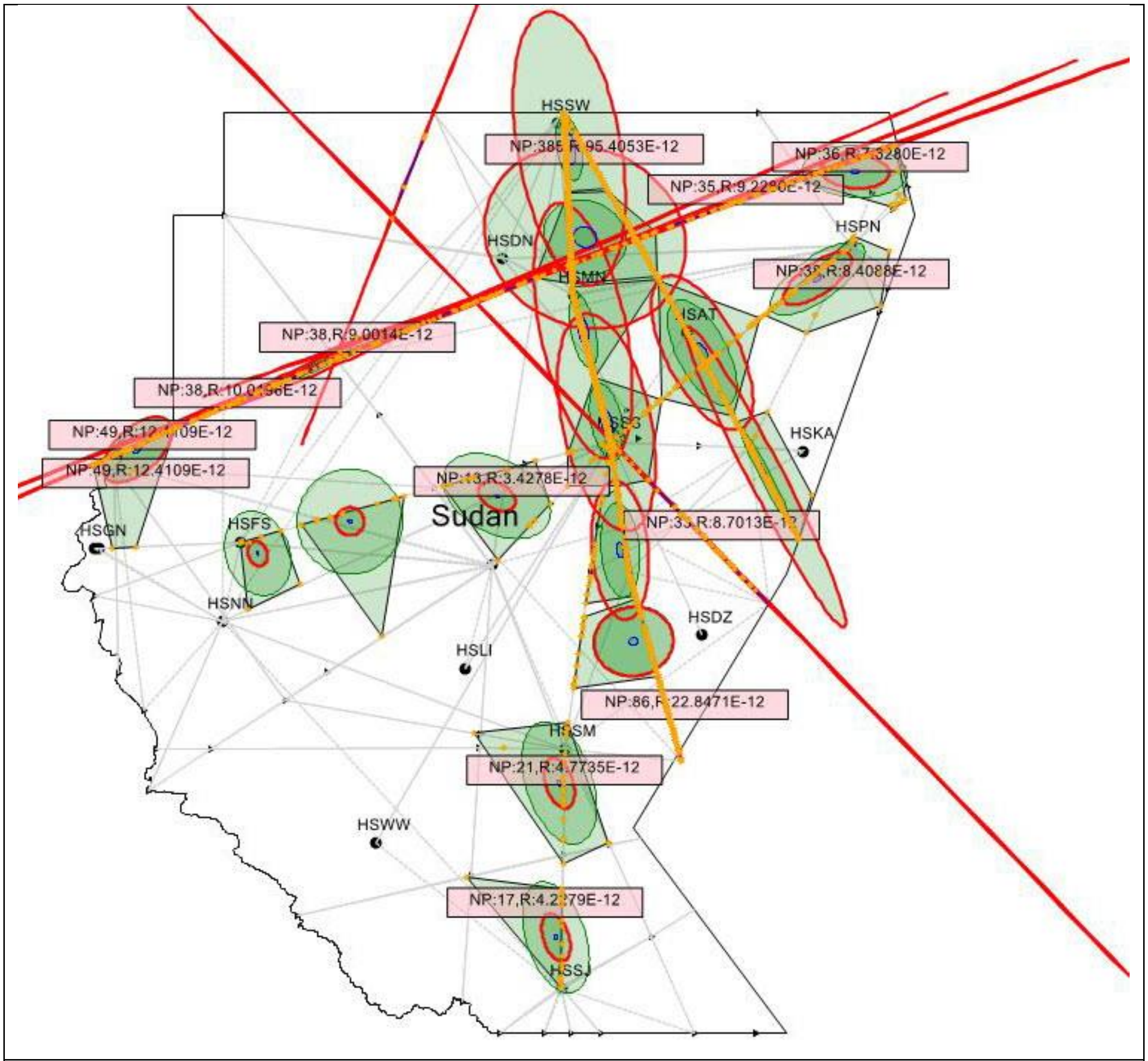
Kuwait RVSM Hot Spots



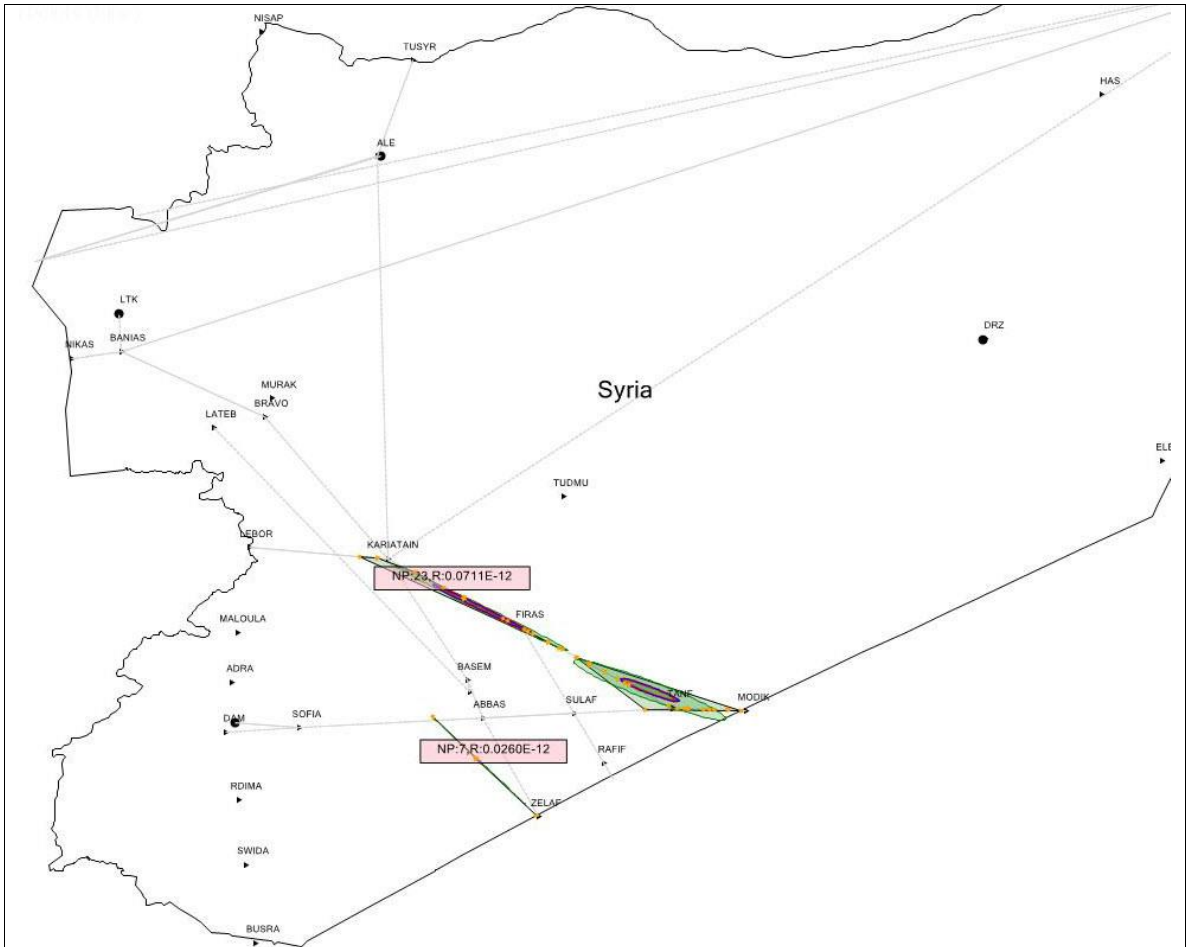
Lebanon – No RVSM Hot Spots



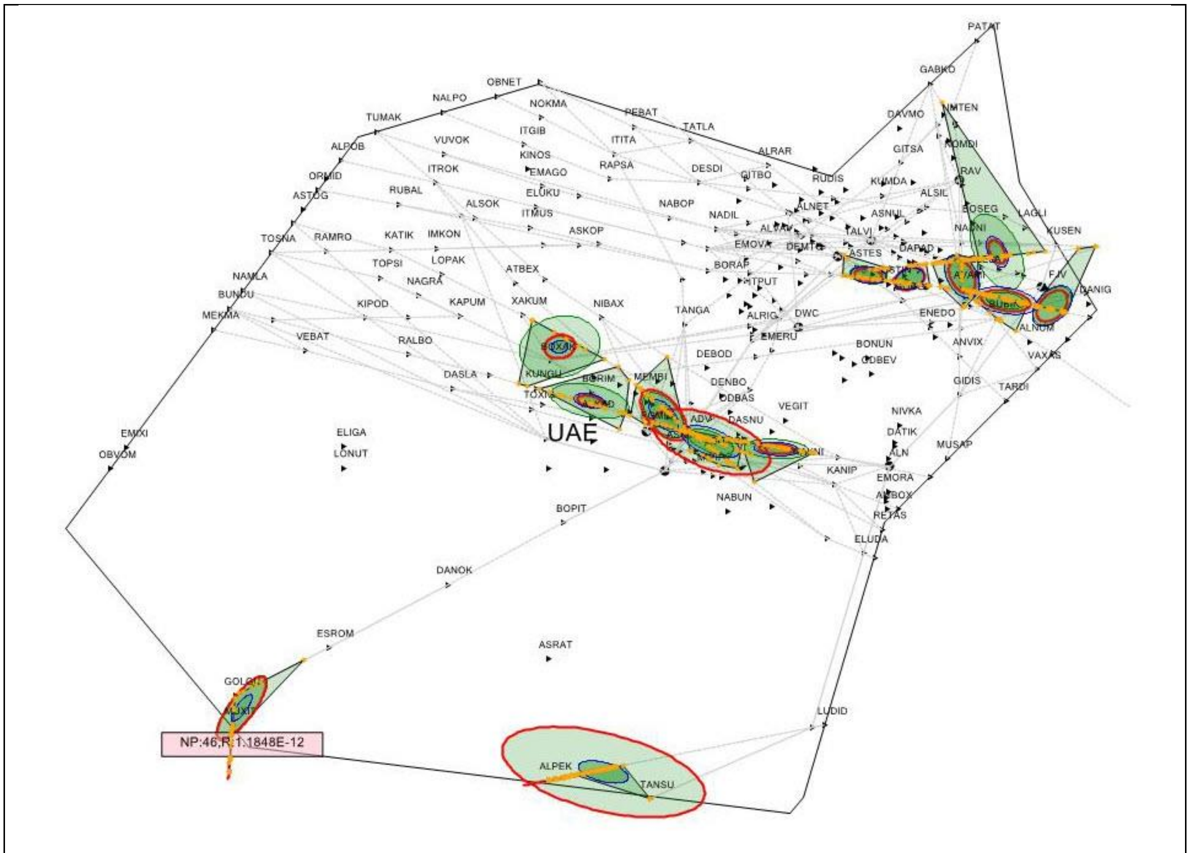
Oman RVSM Hot Spots



Sudan RVSM Hot Spots



Syria RVSM Hot Spots



UAE RVSM Hot Spots

5.9 Appendix G – Abbreviations

AAD	Assigned altitude deviation
ACAS	Airborne collision avoidance system
ACC	Area control center
AD	Altitude deviation
ADR	Altitude deviation report
ASE	Altimetry system error
ATC	Air traffic control
ATM	Air traffic management
ATS	Air traffic services
CAA	Civil aviation authority
CFL	Cleared flight level
CFR	Coordination failure report
CRA	Collision risk assessment
CRM	Collision risk model
DE	Double exponential density
FIR	Flight information region
FL	Flight level
FPL	Flight plan
FTE	Flight technical error
GAT	General air traffic
GDE	Gaussian double exponential density
EGMU	Enhanced GPS height-monitoring unit
GPS	Global positioning system
HMU	Height-monitoring unit
HOF	Horizontal overlap frequency
ICAO	International Civil Aviation Organization
JAA	Joint Aviation Authorities
LHD	Large height deviations
MASPS	Minimum aircraft system performance specification
MIDRAS	MID Risk Analysis Software
MMR	Minimum Monitoring Requirement
MTCD	Medium term conflict detection
OAT	Operational air traffic
OLDI	On-line data interchange
OVR	Overall vertical risk
PISC	Pre-implementation safety case
PSSA	Preliminary system safety assessment
RMA	Regional Monitoring Agency
RVSM	Reduced vertical separation minimum

SMR	Safety Monitoring Report
TCAS	Traffic Alert and Collision Avoidance System
TLS	Target level of safety
TVE	Total vertical error
TVR	Technical vertical risk
UAC	Upper Area Control Center
UIR	Upper Flight Information Region
VSM	Vertical Separation Minimum