



RASG-PA SAFETY ADVISORY

RSA-13

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Regional Aviation Safety Group – Pan America (RASG-PA)

Large Height Deviations in Reduced Vertical Separation Minima (RVSM) Airspace – Coordination Errors

Document Abstract	This advisory adapts the Asia Pacific RSA 25-001 for the Pan America region on Elevated Mid-Air Collision (MAC) risk in Reduced Vertical Separation Minima (RVSM) Airspace with a focus on coordination errors , offering region-specific insights and recommendations to reduce MAC risk. The RSA promotes proactive reporting, shifting the focus from attribution to systemic improvement, inviting collaborative recalibration across the NAM, CAR, and SAM regions.
Target Audience	CAAs, ANSPs, Air Carrier Operators
Occurrence Category	MAC
Issue Summary	Rising Mid-Air Collision (MAC) risk due to increased Large Height Deviations (LHDs) in RVSM airspace. The analyses presented by CAR/SAM Planning and Implementation Regional Group (GREPECAS) Scrutiny Working Group (GTE) during their 2025 meeting (GTE/25) show an increase in FIRs nearing or exceeding ICAO’s Target level of safety (TLS) compared to previous year. ATC Coordination errors persistently account for more than 75% of LHDs at FIR boundaries. These trends reveal systemic vulnerabilities in inter-FIR coordination and human factors.
Key Recommendations	<p>For Operators: Strengthen SOPs for FIR boundary transitions Notify ATC immediately of any deviations and maintain readback discipline</p> <p>For FIRs: Expand AIDC implementation across all FIR boundaries Standardize coordination protocols</p>

	For Oversight Bodies: Review and align reporting formats Monitor effectiveness of corrective actions
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1. Purpose

This RASG-PA Safety Advisory (RSA) provides initial recommendations for operators, ANSPs and CAAs to address LHDs in RVSM Airspace.

2. Background

The risk of mid-air collision (MAC) is among the Global Aviation Safety Plan (GASP) High Risk Categories (HRC) of occurrences and is the focus of ongoing monitoring and mitigation efforts in the Pan America Region. The Caribbean/South American (CAR/SAM) Planning and Implementation Regional Group (GREPECAS), responsible for the development and maintenance of air navigation plans and provision of planning and implementation of air navigation systems in accordance with the planning frameworks agreed at the global and regional levels. GREPECAS facilitates the conduct of any necessary system performance monitoring, identifies specific air navigation deficiencies, especially in the context of safety, and proposes corrective measures. This includes monitor the risk of collision in Reduced Vertical Separation Minima (RVSM) airspace using a Collision Risk Model (CRM) to measure how Flight Information Regions (FIRs) meet ICAO’s set Target Level of Safety (TLS). As part of this work, the GREPECAS Scrutiny Working Group (GTE) during their 2025 meeting (GTE/25) showed an increase in FIRs nearing or exceeding ICAO’s Target level of safety (TLS) compared to the previous year. ATC Coordination errors persistently account for more than 75% of Large Height Deviations (LHDs) at FIR boundaries. These trends reveal systemic vulnerabilities in inter-FIR coordination and human factors

3. Hazard Statement

Reduced Vertical Separation Minima (RVSM) reduces vertical separation from 2,000 feet to 1,000 feet between flight levels 290 and 410, requiring robust safety monitoring to maintain collision risk within ICAO’s Target Level of Safety (TLS). States implement annual MAC risk assessments using airspace occurrence reports as a key measure of RVSM integrity Because the spacing is reduced, strong safety monitoring is essential to keep collision risk within ICAO’s safety limits.

A critical contributor to vertical MAC risk is the Large Height Deviation (LHD)—a deviation of 300 ft or more from an ATC-assigned altitude. LHDs occur when an aircraft occupies a flight level unexpected by ATC, disrupting anticipated trajectories and increasing collision risk. In simple terms, LHDs happen when an aircraft is not where ATC expects it to be, which can lead to loss of separation and collision risk. These deviations often stem from human coordination errors, equipment malfunctions, or flight plan inaccuracies.

Figure 1 outlines ICAO-defined LHD categories (A–I), with Category E split into two subgroups due to its frequency and involvement of multiple AC units.

Regional Monitoring Agencies (RMAs), established by each ICAO region’s Planning and Implementation Group, use LHDs to calculate airspace collision risk and identify airspace *hot spots*. States involved in the identified hot spots are expected to coordinate measures for minimizing the causal factors of the LHDs.

Figure 1 – Large Height Deviation (LHD) Categories and Descriptions

LHD Category	Description	Examples
A	Flight crew fails to climb/descend as cleared	Cleared to FL350, remains at FL330
B	Flight crew climbs/descends without clearance	Initiates descent without ATC instruction
C	Incorrect operation of airborne equipment	Altimetry error during climb
D	ATC system loop error or misunderstood clearance	ATC says “descend FL410,” crew hears “FL310”
E1	Human coordination error between ATC units	Wrong FL passed during coordination between FIRs
E2	Lack of coordination between ATC units	No estimate passed at TCP, aircraft enters unannounced
F	Coordination error due to equipment outage	AIDC link failure causes missed coordination
G	Aircraft contingency event	Sudden depressurization forces emergency descent
H	Equipment failure causes altitude deviation	Autopilot malfunction leads to drift from assigned FL
I	Weather-related deviation	Severe turbulence causes altitude loss
J	TCAS RA followed correctly	TCAS instructs climb, crew complies

LHD Category	Description	Examples
K	TCAS RA followed incorrectly	TCAS says descend, crew climbs instead
L	Aircraft not RVSM approved but receives RVSM separation	Aircraft not RVSM approved but receives RVSM separation

This table shows the different ways altitude deviations can happen in RVSM airspace. Each category explains the cause and gives an example in plain terms. These scenarios place an aircraft where ATC does not expect it, increasing collision risk

Figure 2 summarizes in an infographic the key coordination vulnerabilities and role-based actions. Each icon and phrase reflect a procedural ripple, a calibration cue, not a fault. It illustrates the nature, location, and contributors to LHDs, emphasizing their occurrence near FIR boundaries and the importance of coordinated action among aviation stakeholders. The infographic highlights that LHDs most commonly occur close to or, at the Transfer of Control Points (TCPs) between FIRs, particularly within 15–22 minutes of crossing, when coordination delays or errors are most likely. Contributors to LHDs include: missed estimates, misread clearances, training deficiencies, and systems malfunctions. Preventing LHDs requires actions:

- Ensuring timely and accurate coordination between FIRs by adjacent ANSPs
- Strict compliance with ATC clearances and communication procedures by air carrier operators
- Maintaining assigned altitude with validated equipment and procedures by air carrier operators
- States follow RMA procedures to keep the RVSM-approved aircraft database updated.



Figure 2 – Understanding Large Height Deviations (LHDs) in RVSM Airspace. See Appendix for details

4. Safety Analysis Summary

In 2024, the Pan American region recorded over 477 LHDs within RVSM airspace and continue to pose a measurable threat to vertical separation integrity. ATC Category E errors, which are errors in coordination between adjacent FIRs, emerged as the most frequent and risk-elevating type (86%). An analysis of Category E LHDs identified that they primarily stemmed from human coordination errors at FIR boundaries. These coordination errors refer to mistakes or delays in the exchange of information between air traffic controllers in neighbouring ATC sectors or units, such as incorrect or incomplete transfer of flight level assignments, missed handoff messages, or delayed communication during sector transitions. Though often brief in duration, their ripple effect on vertical separation and situational awareness can be profound.

ATC Category E LHDs stem from procedural gaps that can be mitigated by recalibrating ATC coordination routines, reinforcing fatigue-aware protocols, and validating mitigation strategies through living documentation. Operators, FIRs and oversight bodies can all contribute to address these gaps and strengthen safety reporting (see Section 5 for recommendations).

Every submitted LHD report helps build a clearer picture of procedural vulnerabilities and coordination gaps. This understanding can be further strengthened by encouraging operators, controllers, and agencies to share information on vertical loss of separation occurrences. This information ensures that safety analysis reflects both systemic and operational realities. While the concept of LHD may be unfamiliar to some organizations, ANSPs submit these reports to RMAs as part of ICAO monitoring. Although operators do not submit LHDs directly, they play a vital role by promptly reporting TCAS RA events to ATC and ensuring accurate flight plan data. These actions help maintain RVSM integrity and support regional safety analysis.

5. Recommendations

- a. **Recommendations for air carrier operators:** The following actions at the crew level help stabilize the coordination chain, especially during transitions at Transfer of Control Points:
 - **Strengthen SOPs for FIR boundary transitions**
 - Ensure flight crews are briefed on critical handoff points, especially Transfer of Control Points (TCPs).
 - Require timely check-ins with the next FIR's ATC during handoffs to avoid delays and maintain safe separation. Early and accurate check-ins reduce the risk of loss of separation and improve situational awareness for both pilots and controllers.
 - **Integrate LHD awareness in training programs**
 - Include LHD Category E error scenarios in simulator sessions and Crew Resource Management training modules. Examples may include missed verbal handoff at TCP, incorrect FL assignment, or failure to revise estimates. These exercises help crews recognize risks early and work together to prevent mistakes.
 - Include real-world examples of Level Change Errors in simulator sessions and Crew Resource Management training.
 - **Report anomalies quickly**
 - Flight crews should notify ATC right away if they need to change their route or flight level because of weather or other unexpected events.
 - Operators/flight crews should inform Aeronautical Information Manual (AIM) if incorrect altitudes or missing RVSM details are observed
 - **Validate flight level and time estimates**
 - Cross-check ATC instructions with flight plans and confirm climb/descent states proactively.
 - **Engage with monitoring agencies appropriately**
 - While ANSPs and ATCOs utilize the CARSAMMA and NAARMO portals for monitoring RVSM compliance and LHD trends, operators are also encouraged to access these resources to gain insight into regional performance and enhance internal safety reviews. These portals provide awareness to operators and may help in aligning flight planning and reporting practices with regional safety objectives.

- b. **Recommendations for ANSPs/FIRs:** ANSPs are key to safe handoffs and accurate level assignments. These recommendations focus on improving communication and monitoring during boundary transitions to reduce errors and maintain separation.
- **Expand Air Traffic Services Interfacility Data Communications (AIDC) implementation** across all FIR boundaries to reduce reliance on voice coordination, which is prone to human errors and delays. AIDC ensures timely and accurate transfer of flight level assignments and route information between ATC units, minimizing coordination gaps that contribute to LHDs and losses of separation
 - **Standardize and comply with coordination protocols**, especially around time estimates and flight levels to reduce ambiguity during handoffs and to minimize errors in altitude assignments.
 - **Integrate human factors awareness into controller training and procedural design** to mitigate cognitive workload, fatigue and communication challenges; fostering this awareness ensure sustained vigilance and accurate decision-making under pressure, resulting in a reduction of coordination of errors.
 - **Track recalibration efforts using printable ripple logs and FIR-level dashboards** Visual tracking tools provide transparency and accountability for procedural changes, enabling managers to monitor progress and identify gaps in implementation across FIR boundaries.
 - **Validate mitigation effectiveness through iterative feedback loops and MAC risk monitoring** Continuous evaluation ensures that implemented measures actually reduce mid-air collision risk, allowing timely adjustments based on real-world performance data.
- c. **Recommendations for oversight bodies:** Oversight agencies play a vital role in reducing Category E LHDs by setting clear expectations for ANSPs and operators, and ensuring accountability across States and operators.
- **Review and align LHD reporting formats** Require ANSPs to align the LHD reporting formats with RMA protocols (e.g., NAARMO, CARSAMMA) and enforce periodic review as required by ICAO provisions. Oversight bodies should monitor their ANSP timely and accurate submission the other ATC unit involved and the RMA, and implement compliance checks to address observed delays and inconsistencies
 - **Review and analyze their respective FIR LHD data** Identify LHD hotspots, recurring causal factors, and systemic weaknesses using aggregated FIR-level reports of LHDs.
 - **Develop and publish guidance** Develop and publish guidance that translates LHD findings into actionable circulars, training updates, and SOP enhancements. CAAs should review these findings and, where deficiencies are identified, issue or recommend corrective actions to address systemic or operational contributors to LHDs

- **Facilitate regional coordination**
Use ICAO platforms (e.g., GREPECAS, RASG-PA) to share lessons learned and harmonize mitigation strategies.
- **Monitor implementation and effectiveness**
Monitor the implementation and effectiveness of corrective actions that address LHDs by ANSPs and operators. Oversight bodies should track compliance, verify timely execution, and assess the impact of these actions on reducing MAC risk, using measurable indicators and periodic reviews.

6. References

The following resources offer guidance, best practices, and monitoring tools to support recalibration across all stakeholders.

- **RSA 25-001 – MAC Risk in RVSM Airspace (ICAO RASG-PA APAC)**. Strategic advisory for ANSPs, CAAs, and operators on mitigating coordination-related MAC risk.
- **SAFO 13004 – LHDs in Oceanic Airspace (FAA)**, Safety alert for operators with actionable recommendations for crew training and SOP refinement.
- **RASMAG/30 WP/21 – Human Factors Assessment Integration (ICAO)**, Guidance on incorporating human factors into LHD analysis and mitigation planning.

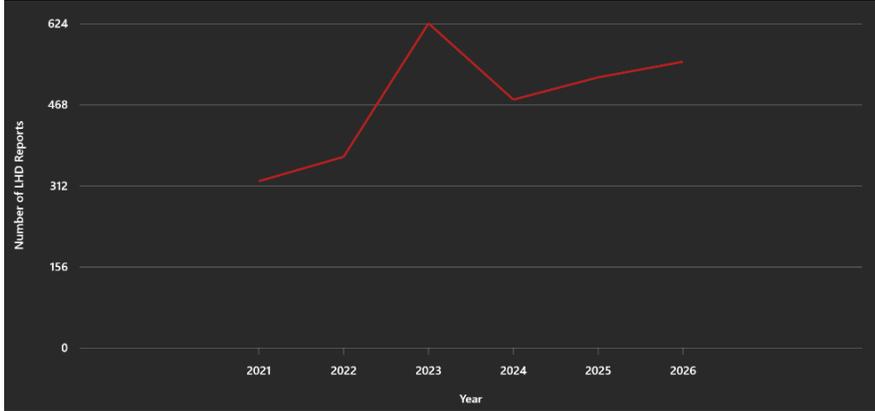
Monitoring Agency Portals

- **NAARMO RVSM Approvals and Monitoring Status (FAA)**, RVSM compliance data for U.S., Canada, and Mexico operators.
https://www.faa.gov/air_traffic/separation_standards/naarmo/rvsm_approvals
- **CARSAMMA Portal – RVSM Monitoring for CAR/SAM FIRs**, Access to LHD validation tools, ASE monitoring, and FIR-level risk assessments.
https://portal.cgna.decea.mil.br/carsamma/home/?l=en_uk

7. Appendix – Analysis and Projections

a. LHDs Expected to Increase in 2026

Figure 3: RVSM Large Height Deviations (LHD) Reports – Pan American Region (2021–2026)



Historical and projected LHD counts show a sharp increase in 2023, a slight dip in 2024, and a projected rise through 2026.

Insight:

Chart projections show **LHD reports are expected to continue increasing**, while the **TLS remains unchanged at 5×10^{-9} fatal accidents per flight hour**, serving as the benchmark for RVSM safety monitoring. This divergence signals rising risk due to persistent systemic vulnerabilities in inter-FIR coordination and human factors that are either overlooked or underreported. **Urgent recalibration of procedures and enhanced reporting is an important step to prevent MAC risk escalation.**

Disclaimer:

The LHD data presented in Figure A1 is derived primarily from CARSAMMA reports and ICAO GTE meeting summaries (GTE/21–GTE/25). Projections for 2025 and 2026 are estimates based on observed trends and should not be interpreted as official ICAO figures. For authoritative data, consult ICAO Regional Monitoring Agencies (CARSAMMA, NAARMO) and official ICAO documentation.

Figure 4 – Collision Risk Values (CRV) 2023

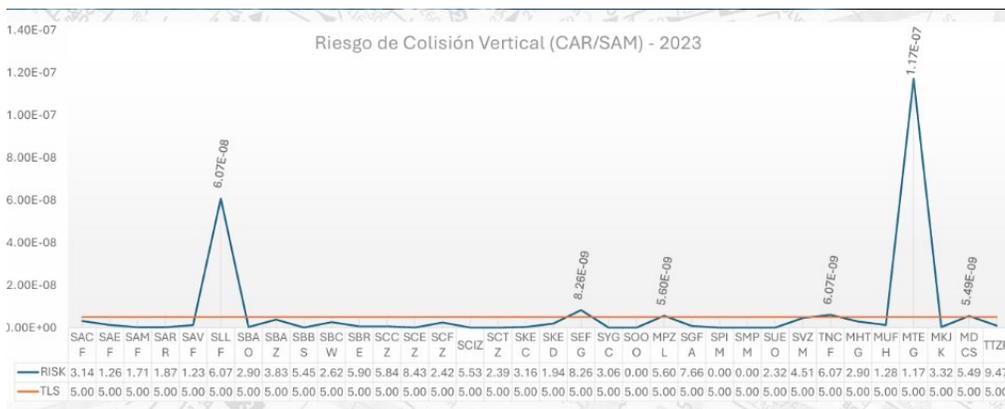


Chart taken from GTE 24 Meeting

Figure 5 – Collision Risk Values (CRV) 2024

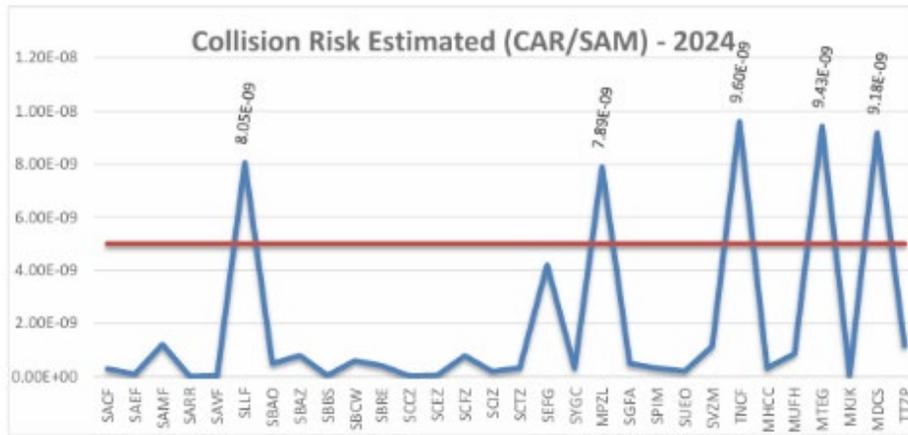
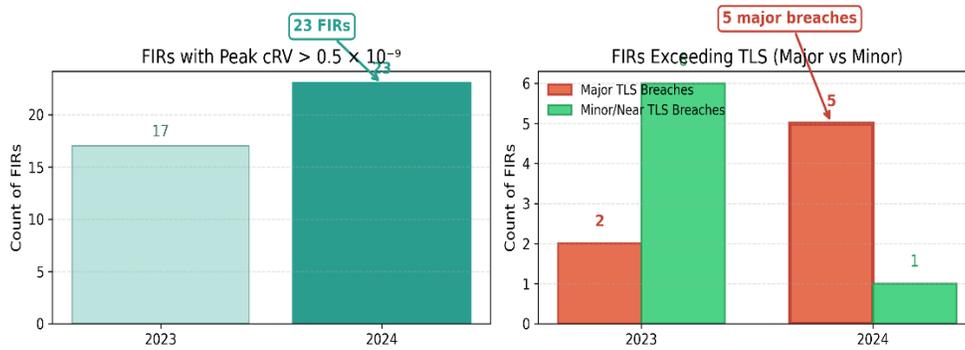


Chart taken from GTE 25 Meeting

Figure 6 – Aggregate CRV and TLS Insights



The first chart on the left shows the number of FIRs with higher CRVs while the second chart compares the number of FIRs that either exceeded or came close to exceeding the TLS. These aggregate patterns support trend-based monitoring without referencing individual FIRs.

- Peaks above 0.5×10^{-9} : 17 FIRs in 2023, increasing to 23 FIRs in 2024.
- Persistent peaks: 15 FIRs recorded peaks in both years, indicating sustained risk.
- TLS breaches: In 2024, five FIRs exceeded the TLS by significant margins (multiple standard deviations), compared to two FIRs in 2023. Additionally, four FIRs in 2023 were near or within the TLS range.

FIRs where the 2025 peak exceeded the 2024 peak were flagged as **rising risk**, and the proportion was calculated as:

$$\text{Rising Risk (\%)} = \frac{\text{\#FIRs where 2025 peak > 2024 peak}}{\text{Total FIRs with valid peaks}} \times 100\%$$

Remaining below the Target Level of Safety (TLS) is often perceived by States as sufficient, but this view ignores trend dynamics. An FIR that stays under the TLS yet shows a consistent upward trajectory in CRV may indicate emerging operational or systemic issues—such as delayed AIDC implementation, degraded safety culture, or reporting gaps. If these trends are dismissed, risk can escalate rapidly, leading to threshold breaches and reactive interventions. PA-RAST emphasizes rising risk because early detection enables proactive mitigation before safety performance deteriorates.

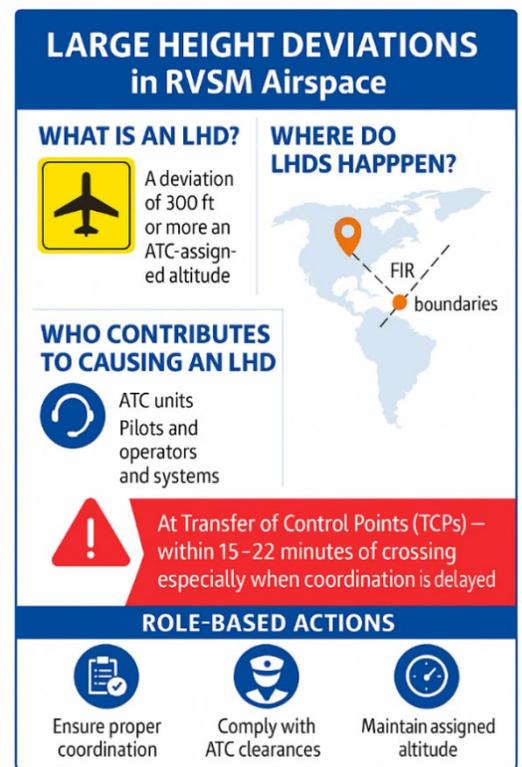
b. Infographic Summary

This infographic illustrates key insights from a random sample of validated Large Height Deviation (LHD) reports from CARSAMMA for 2024. The analysis addressed four core questions:

- 1. What is an LHD?**
A deviation of 300 ft or more from an ATC-assigned altitude.
- 2. Where do LHDs typically occur?**
At transfer control points (TCPs) between neighbouring ATC interfaces, within 15–22 minutes of crossing FIR boundaries.
- 3. Who contributes to causing an LHD?**
ATC units, pilots, and operational systems.
- 4. How do these deviations happen?**
Human factors dominate, but several reports cite flight plan errors as contributing factors.

Key Preventive Measures:

- Ensure proper coordination
- Comply with ATC clearances
- Maintain assigned altitude



The infographic closes with critical actions for the major roles, reminding us that *we all have a shared responsibility* in air navigation service provision.