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South American Regional Office
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Agenda Item 3: Report on activities, deliverables and progress made by the GT – Interop and Subgroups

RESILIENT OPERATIONAL NETWORK

(Prepared by IATA)

SUMMARY

Recognizing the strategic importance of the **Resilient Operational Network (RON)** concept promoted by ICAO and other international organizations, this Working Paper aims to highlight the importance of strengthening the resilience of air navigation infrastructure and operational procedures, with particular emphasis on the preparedness and implementation of contingency measures for GNSS interference events. In addition, it seeks to promote the exchange of experiences and best practices among States and stakeholders, with a view to supporting a harmonized implementation that ensures the continuity, safety, and efficiency of air operations throughout the Region.

References:

- Report of the SAM/IG/33 Meeting
- Report of the GREPECAS/23 Meeting
- Global Air Navigation Plan

1. Background

1.1 The growing reliance of global aviation on GNSS-based systems has delivered significant benefits in terms of operational efficiency, route optimization, airspace capacity, and environmental sustainability. However, the substantial increase in GNSS interference, degradation, or signal-loss events across various regions of the world has highlighted the need to strengthen the resilience of the air navigation operational network—the Resilient Operational Network (RON)—by ensuring the safe and efficient continuity of air operations during contingencies affecting satellite-based navigation services.

1.2 For airlines, the availability of a resilient operational network is essential to maintaining operational predictability, minimizing safety impacts, and reducing the economic consequences of diversions, delays, cancellations, or capacity restrictions. The absence of clearly defined procedures for managing GNSS contingencies may create operational uncertainty for both aircraft operators and air navigation service providers (ANSPs), particularly in environments where PBN procedures constitute the primary means of navigation.

1.3 In this context, it is essential that States, ANSPs, and airspace users develop and implement harmonized operational procedures to enable a safe and orderly transition during GNSS interference events. Such procedures should address the timely detection and reporting of interference, the availability of alternative means of navigation, tactical air traffic management, the application of ATFM measures when appropriate, and effective coordination among all stakeholders involved.

2. Impacts of GNSS Interference on the Daily Operations of Airlines and ANSPs

2.1 GNSS interference can have a significant impact on the daily operations of airlines and air navigation service providers, particularly in environments where operations rely primarily on Performance-based Navigation (PBN).

2.2 Loss of PBN Navigation Capability

2.2.1 Aircraft may temporarily lose the capability to execute RNAV and RNP procedures, including GNSS-based SIDs, STARs, and instrument approaches. As a result:

- Conventional procedures must be used when available.
- Increases the workload of flight crews and air traffic controllers.
- Cancellations or operational restrictions may occur at PBN-dependent airports.

2.3 Reduction in Airspace Capacity

2.3.1 The loss of navigation accuracy requires ANSPs to apply more conservative measures, such as:

- Increased separation between aircraft.
- ATFM measures.
- Restrictions on direct routings and Free Route Airspace (FRA) operations.
- Reduced arrival and departure rates at congested airports.

2.3.2 Increased Delays and Fuel Consumption

- Longer routes.
- Additional holding patterns.
- Tactical diversions.
- Longer flight times.
- Higher operating costs and CO_2 emissions.

2.4 Impact on Approaches and Landings

2.4.1 Many airports rely exclusively on GNSS-based approaches and departures. In the event of interference:

- PBN approaches may become unavailable.
- Aircraft may need to proceed to alternate airports.
- The risk of delays, diversions, and cancellations increases.

2.5 Increased Operational Workload

2.5.1 Managing GNSS events requires:

- Continuous monitoring by flight crews.
- Additional coordination among pilots, ATC, and ATFM units.
- Continency procedures.
- Flight rescheduling and resource allocation.

2.6 Importance of a Resilient Operational Network (RON)

2.6.1 In response to these challenges, a Resilient Operational Network enables acceptable levels of safety and efficiency to be maintained through:

- Availability of conventional backup navigation aids (DME, VOR, and ILS).
- Pre-established contingency procedures.
- Publication of alternative routes and procedures.
- Coordination among States, ANSPs, and users.
- Timely notification of GNSS interference events.
- Harmonized application of operational and ATFM measures.

3. Key Contingency Measures to Be Considered by the SAM Region

3.1 Maintenance of a Minimum Operational Network (MON)

3.1.1 The most widely promoted measure consists of maintaining a Resilient Operational Network based on conventional navigation aids such as VOR, DME, and ILS, enabling navigation in the event of GNSS degradation or loss. This network should provide sufficient coverage to support en-route navigation, arrivals and, whenever possible, approaches to alternate aerodromes. It is important to emphasize that, in a contingency environment, the same air navigation performance levels are not expected to be maintained, particularly in airspace with low traffic volume and complexity.

3.2 Use of Conventional DME/DME and VOR/DME Navigation

3.2.1.1 In certain airspace, RNAV procedures may continue to be operated using DME/DME- or VOR/DME-based position updating, without relying exclusively on GNSS. This capability is considered one of the pillars of operational resilience in the most congested environments, such as Bogotá and São Paulo.

3.3 ATS Procedures for GNSS Loss

3.3.1 ANSPs should develop specific procedures for:

- **NOTAM** issuance following immediate notification of GNSS interference by flight crews.
- Application of increased separation minima.
- Temporary restrictions on PBN procedures.
- Reversion to conventional routes.
- Tactical ATFM management.

3.4 ATFM Management in Degraded Environments

3.4.1 When a GNSS event affects large geographical areas, ATFM measures may be applied to:

- Reduce demand.
- Limit sector capacity.
- Reconfigure routes.
- Prioritize certain flights.
- Minimize congestion resulting from the loss of PBN capacity.

3.5 Training and Procedures for Flight Crews

3.5.1 Airlines have increased training on:

- Recognition of spoofing and jamming events.
- Use of alternative means of navigation.
- System degradation procedures.
- Management of approaches and departures when PBN procedures are no longer available.

3.6 Urgent Need for Predefined, Harmonized Operational Procedures Known to All Stakeholders to Address GNSS Interference

3.6.1 From the airlines' perspective, the most critical aspect lies not only in the availability of alternative infrastructure, but also in having predefined, harmonized operational procedures that are widely known by all stakeholders involved. Recent experience shows that the Region is not yet sufficiently prepared to manage GNSS interference events, which has resulted in delayed responses and difficulties in preserving operational continuity during such contingencies. Significant differences also remain among SAM States in terms of operational procedures, criteria for NOTAM issuance, cross-border coordination, information exchange, and air traffic services preparedness. This lack of harmonization may lead to inconsistent responses to the same contingency and increase operational uncertainty for airspace users.

3.6.2 Accordingly, it is essential that States and ANSPs develop, publish, and exercise GNSS contingency procedures within the framework of the Resilient Operational Network, including clear criteria for transitioning to alternative means of navigation, ATFM management, communication with flight crews (including the issuance of **NOTAMs** as soon as possible), and regional coordination. This would help maintain acceptable levels of safety, capacity, and efficiency during GNSS interference events.

4. Implementation of Ground Infrastructure to Support the Resilient Operational Network

4.1 South America has unique geographical and operational characteristics, including extensive remote areas, mountain ranges, Amazonian regions, oceanic routes, and limited or unevenly distributed ground-based navigation aid infrastructure. In this context, Performance-based Navigation (PBN) and GNSS are fundamental to regional connectivity; therefore, any resilience strategy should preserve these benefits and avoid solutions based exclusively on the large-scale expansion of ground infrastructure.

4.2 IATA strongly supports the development of a Resilient Operational Network that enables adequate levels of safety, capacity, and efficiency to be maintained during GNSS interference events. The industry considers it essential to complement satellite-based navigation with a minimum, rational network of conventional infrastructure. Operational predictability for airlines is a key element of resilience and should be regarded as a priority objective in the development of future GNSS interference mitigation strategies.

4.3 In environments characterized by low traffic levels and limited operational complexity—which account for most of the South American airspace, TMAs, and airports—the implementation of a DME/DME network supported by inertial navigation to preserve RNAV 5 and/or RNAV 1 performance during GNSS contingencies may not represent the most cost-effective solution. In such scenarios, a strategy based on radar surveillance, ATS contingency procedures, maintained ILS capabilities, and a minimum network of strategically located conventional navigation aids may provide adequate levels of safety and operational continuity, consistent with the principles of a Resilient Operational Network.

4.4 From an operational and economic perspective, in low-volume, low-complexity air traffic environments, the most efficient solution is generally a combination of GNSS as the primary means of navigation, radar surveillance, ATS contingency procedures, and minimum conventional infrastructure (MON), including ILS and, where appropriate, selected VOR/DME facilities strategically located for GNSS interference contingencies.

4.5 It is important to emphasize that, in low-density, low-complexity airspace, separation minima are generally determined by ATS procedures rather than by navigation performance. Furthermore, radar vectoring may be used extensively, and the impact on capacity is limited.

5. Conclusion

5.1 GNSS interference has become one of the principal threats to the continuity and predictability of modern air operations, owing to the growing reliance on Performance-based Navigation (PBN) and multiple ATM systems that use satellite-based positioning information. Its effects extend beyond the mere degradation of navigation and may result in significant capacity reductions, increased delays, higher fuel consumption, operational limitations at airports dependent on PBN procedures, and increased workload for flight crews and air traffic controllers. Furthermore, the impairment of GNSS-dependent functions, including certain surveillance and trajectory-management applications, may compromise the efficiency of the ATM system. In this context, it is essential that States and ANSPs in the SAM Region recognize GNSS interference as a growing operational risk and adopt coordinated measures to preserve acceptable levels of safety, capacity, and operational predictability.

5.2 International experience demonstrates that operational resilience to GNSS interference events should be based on a combination of alternative infrastructure, harmonized operational procedures, and effective coordination among all stakeholders. In this regard, the SAM Region could benefit from the development and implementation of previously agreed and tested regional GNSS contingency procedures, including standardized notification mechanisms, timely NOTAM issuance, ATFM management in degraded environments, the application of temporary ATS measures, and the use of alternative means of navigation when available. Advance preparation and a common understanding of these procedures by States, ANSPs, airlines, and other airspace users are key factors in reducing operational uncertainty and improving response capability during future interference events.

5.3 The implementation of a Resilient Operational Network in the SAM Region should be based on a flexible approach proportionate to the operational complexity of each airspace. Although a minimum network of conventional navigation aids is an important element of resilience, the most efficient strategy does not necessarily require maintaining extensive ground-based navigation aid networks in all environments. In areas with low traffic volume and complexity, a combination of radar surveillance, ATS contingency procedures, conventional approach capabilities, and strategically located minimum infrastructure may provide adequate levels of safety and operational continuity with a more favorable cost-benefit ratio. Therefore, RON planning should prioritize solutions tailored to the operational needs of each State, ensuring an appropriate balance among resilience, efficiency, and economic sustainability.

6. Suggested Actions

6.1 The Meeting is invited to:

6.1.1 Take note of the information provided in this Working Paper.

6.1.2 Request the GT Interop and GESEA to establish an ATM/CNS working group to develop guidance material for the Resilient Operational Network, ensuring an appropriate balance among resilience, efficiency, and economic sustainability.

6.1.3 Urge SAM States to implement, as soon as possible, predefined and harmonized operational procedures, known to all stakeholders, to address GNSS interference, using the existing air navigation infrastructure to ensure continuity of operations at the principal airports in the SAM Region.

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