INTERNATIONAL CIVIL AVIATION ORGANIZATION

Second Meeting of the Africa - Indian Ocean Aviation System Planning and Implementation Group (AASPG/2)

Livingstone, Zambia, 2 - 6 November 2026

Agenda Item 4: Implementation of safety and air navigation goals, targets and indicators, including priorities set in the Regional Aviation Safety and Air Navigation Plans

GNSS Vulnerabilities from the Perspective of Air Traffic Controllers (ATCOs) and Operational Resilience

(Presented by IFATCA Africa and Middle East (AFM) Region)

SUMMARY
This paper examines the growing vulnerability of ATM operations to GNSS disruptions and their implications for the AFI Region. It highlights regional challenges that may amplify operational risks and affect service continuity. The paper proposes practical measures to strengthen resilience to GNSS degradation while supporting continued PBN implementation and ATM modernization. **Action by the meeting is in paragraph 3**

Strategic Objectives	*A. Every Flight is Safe and Secure;* *B. Aviation Delivers Seamless, Accessible, and Reliable Mobility for All.*

1. INTRODUCTION

1.1. The transformation of aviation navigation from ground-based systems toward satellite-enabled operations has generated substantial operational benefits, including improved route efficiency, reduced fuel consumption, increased airspace capacity, greater accessibility to remote aerodromes, and enhanced surveillance coverage.

1.2. Across Africa, GNSS-based navigation has become especially important due to the vast scale of many Flight Information Regions (FIRs), extensive oceanic and remote continental airspace, and the relatively limited availability of conventional navigation and surveillance infrastructure.

1.3. Many AFI States have embraced PBN implementation as a cost-effective means of enhancing air navigation services. However, increasing dependence on GNSS has introduced a strategic vulnerability. GNSS signals remain susceptible to:

- Intentional jamming;
- Spoofing and signal manipulation;
- Cyber-related threats;
- Interference from unauthorized transmitters;
- Equipment malfunction;
- Space weather and ionospheric disturbances;
- Cross-border radio frequency interference (RFI).

1.4. Recent operational experience worldwide has demonstrated that GNSS disruptions can affect multiple aircraft simultaneously, resulting in route deviations, loss of surveillance confidence, communications challenges, increased controller workload, and network-wide operational disruptions.

2. DISCUSSION

Increasing Dependence on GNSS within ATM Operations

2.1 Global Navigation Satellite Systems (GNSS) have evolved from being primarily navigation aids to becoming foundational components of modern Air Traffic Management (ATM) systems. Across the AFI Region, GNSS supports Performance-Based Navigation (PBN), Area Navigation (RNAV), Required Navigation Performance (RNP) operations, ADS-B surveillance, terrain awareness systems, and several timing-dependent communication applications.

2.2 The increasing adoption of PBN has been particularly beneficial for the Region by enabling more direct routing, improving access to remote airports, reducing fuel burn, and improving airspace capacity and supporting the optimization initiatives.

2.3 However, this transformation has also resulted in a growing dependency on space-based navigation services. In many parts of the AFI Region, GNSS has become the primary means of navigation, and in some cases the sole enabler of modern instrument procedures.

2.4 Consequently, any degradation or loss of GNSS services has the potential to affect multiple ATM functions simultaneously. A disruption may not only impact an aircraft's navigation capability but may also affect surveillance systems that depend on GNSS-derived position information and communications systems that rely on satellite-based timing references.

2.5 As ATM modernization continues across Africa, the resilience of GNSS-dependent operations has therefore become a strategic safety concern.

Evolving Threats to GNSS Reliability

2.6 The threat environment surrounding GNSS has changed significantly in recent years. Interference to satellite navigation signals is no longer considered a rare occurrence confined to isolated geographical areas. Incidents of jamming and spoofing have increased globally, with regulators and industry organizations reporting a growing number of events affecting civil aviation operations.

2.7 While many of these occurrences have been associated with conflict zones and areas of geopolitical tension, experience has shown that interference effects can extend far beyond the immediate source and can affect aircraft operating in adjacent regions and FIRs.

2.8 Jamming remains the most commonly encountered form of interference. It occurs when radio frequency transmissions prevent GNSS receivers from acquiring or tracking legitimate satellite signals. The result may be loss of navigation capability, degradation of surveillance performance, or failure of systems dependent on accurate timing data.

2.9 In contrast, spoofing introduces counterfeit signals that may lead aircraft systems to calculate an incorrect position, velocity, or time while continuing to indicate apparently normal operation. From an ATM perspective, spoofing presents a particularly complex challenge because both pilots and controllers may initially be unaware that displayed navigation information is unreliable.

2.10 Recent operational experience in the AFI Region demonstrates that GNSS interference is not only a theoretical or global concern. In the Democratic Republic of the Congo (DRC), GNSS spoofing affecting operations in and around the Goma TMA has been documented since May 2024 and reported to ICAO through APIRG. This experience highlights the potential for GNSS interference to directly affect aircraft navigation and ATM operations within the region.

2.11 The possibility that misleading information could be accepted as valid introduces significant safety concerns, especially in high-density traffic environments or during critical phases of flight.

2.12 In addition to deliberate interference, natural phenomena continue to present operational challenges. The AFI Region is particularly susceptible to ionospheric disturbances associated with equatorial and low-latitude regions. Solar activity and space weather events can degrade GNSS performance and accuracy, emphasizing the need for resilience planning that considers both intentional and unintentional sources of disruption.

Consequences for Air Traffic Management

2.13 For air traffic controllers, GNSS disruption is not simply a navigation problem; it is a complex operational challenge that can affect surveillance, communications, workload management, and safety assurance. The first challenge is often recognizing that an interference event is occurring.

2.14 Air Traffic Controllers (ATCOs) may receive reports of navigation anomalies from pilots, observe unexplained deviations from assigned routes, detect inconsistencies in ADS-B tracks, or encounter failures in Controller-Pilot Data Link Communication (CPDLC). In cases involving spoofing, there may be no immediate indication that the underlying position information is incorrect, making detection particularly difficult.

2.15 The degradation of surveillance capability is another significant concern. Many AFI ANSPs have implemented ADS-B as a cost-effective means of providing surveillance in areas where radar coverage is unavailable or financially impractical. Because ADS-B positions are frequently derived from GNSS, interference may undermine confidence in surveillance information and force controllers to apply larger separation minima or revert to procedural control. Such transitions inevitably reduce airspace capacity and increase controller workload.

2.16 Communications systems may also be affected where GNSS timing information supports CPDLC and other digital communication applications. Aircraft may experience delayed or undelivered messages, requiring a reversion to voice communications. In sectors operating near capacity, a sudden increase in voice communications can create frequency congestion and significantly increase the risk of misunderstandings or coordination errors.

2.17 The cumulative effect of these operational consequences is a substantial increase in workload for controllers. Managing multiple affected aircraft simultaneously may require tactical vectoring, increased coordination with adjacent sectors, verification of aircraft positions through alternative means, management of diversions and missed approaches, and implementation of contingency procedures.

2.18 Under such circumstances, the safety implications extend beyond the navigation anomaly itself and include the human performance effects associated with increased workload and reduced situational awareness.

Specific Challenges for the AFI Region

2.19 While GNSS vulnerabilities represent a global aviation concern, their operational consequences are likely to be more pronounced within the Africa-Indian Ocean Region due to a combination of technical, operational, and economic factors.

Resource Constraints and Infrastructure Limitations

2.20 Many AFI States continue to face significant financial and technical challenges in developing and maintaining air navigation infrastructure. Although satellite-based navigation has enabled substantial modernization at comparatively lower costs than extensive ground-based networks, resource limitations have in some cases accelerated the withdrawal of conventional navigation aids without a corresponding investment in resilient alternatives. Consequently, several States may have limited capability to sustain operations during extended GNSS disruptions.

2.21 Budgetary constraints also affect the availability of spectrum monitoring equipment, interference detection systems, technical specialists, and contingency infrastructure. In an environment where ANSPs must balance modernization with numerous competing priorities, investment in resilience measures can be difficult to justify until a significant disruption occurs. Nevertheless, the increasing frequency of GNSS interference worldwide suggests that resilience should be regarded as an essential component of modernization rather than an optional enhancement.

Dependence on ADS-B Surveillance

2.22 Many areas of the AFI Region lack comprehensive radar coverage due to the vast geographic size of FIRs, challenging terrain, and the high cost of infrastructure deployment. Space-based ADS-B has therefore emerged as a primary surveillance solution, particularly in remote and oceanic areas. While this approach has delivered significant operational benefits, it creates an additional dependency on GNSS-derived positioning.

2.23 In the event of widespread GNSS interference, ANSPs that rely heavily on ADS-B are very likely to experience a reduction in surveillance confidence across large areas of airspace. The resulting need to revert to procedural separation can significantly reduce capacity and place additional workload on ATCOs and flight crews.

Remote and Oceanic Operations

2.24 The AFI Region contains some of the world's largest remote and oceanic airspace environments, including extensive portions of the South Atlantic and Indian Ocean route networks. Aircraft operating in these areas often relies on a combination of GNSS navigation, ADS-B surveillance, and CPDLC communications. The loss of one or more of these capabilities may have operational consequences that are more severe than those experienced in densely surveilled continental airspace.

2.25 ATCOs managing remote operations may have limited alternative means of verifying aircraft position or providing navigation assistance. Consequently, GNSS disruptions in such environments have the potential to affect not only safety but also search and rescue preparedness, contingency planning and regional traffic flow management.

Uneven Levels of ATM Modernization

2.26 The pace of ATM modernization varies considerably across the AFI Region. While some States have implemented advanced surveillance, communications and PBN capabilities, others continue to depend on legacy systems and procedural control. These disparities can make

regional harmonization of contingency measures difficult and may complicate cross-border management of GNSS interference events.

2.27 A disruption affecting multiple FIRs may therefore produce different operational responses depending on the capabilities and procedures available in each State. This underscores the importance of regional coordination through ICAO mechanisms such as AASPG to ensure common understanding and harmonized responses.

Civil-Military Coordination

2.28 Civil-military coordination remains a critical element of GNSS resilience. International experience has demonstrated that some interference events originate from military exercises, testing activities, or broader security-related operations. Effective communication and advance notification can significantly reduce the operational impact of such activities on civil aviation.

2.29 Within the AFI Region, there remains considerable variation in the maturity of civil-military coordination arrangements. Strengthening these mechanisms would improve situational awareness, allow timely dissemination of information to airspace users, and support more effective risk mitigation measures before disruptions affect operations.

Sustaining PBN While Enhancing Resilience

2.30 The AFI Region has made significant progress in implementing PBN as part of ICAO's aviation modernization objectives. These achievements should not be compromised by concerns regarding GNSS vulnerability. Rather, the challenge for States and ANSPs is to ensure that modernization is accompanied by adequate resilience measures.

2.31 A balanced approach is therefore required. The objective should be to preserve the efficiency, capacity and environmental benefits of PBN while ensuring that aircraft and ATM systems retain sufficient capability to continue safe operations when GNSS services are degraded or unavailable.

2.32 This approach aligns with ICAO's evolving emphasis on Alternative Positioning, Navigation and Timing (APNT) capabilities and Navigation Minimum Operating Networks (NAV MON) as essential elements of future CNS resilience.

IFATCA's Position

2.33 IFATCA AFM Region recognizes GNSS interference as an operational ATM safety issue rather than solely a technical avionics concern. Effective mitigation must address:

- Human factors;
- Operational procedures;
- Surveillance resilience;
- Communication continuity;
- Controller workload;
- Cross-border coordination.

2.34 ATCOs must be actively involved in the design of contingency procedures, training programmes, reporting frameworks, and future resilience initiatives. Operational expertise from ATCOs is essential to ensure that proposed solutions remain practical and effective under real-world operating conditions.

CONCLUSION

2.35 GNSS has become indispensable to the modernization of aviation across the AFI Region. Nevertheless, growing dependence on satellite navigation has introduced vulnerabilities that could significantly affect safety, capacity, and continuity of ATM services.

2.36 For the AFI Region, where resource limitations and infrastructure disparities remain realities, resilience must be considered an essential component of modernization rather than an optional enhancement.

2.37 A balanced strategy that combines PBN advancement with appropriate backup navigation capability, operational preparedness, regional cooperation, and ATCO involvement will enable States from the AFI Region and ANSPs to sustain safe and efficient air navigation services in an increasingly contested GNSS environment.

3. Action by Meeting:

3.1 The Meeting is invited to:

a) Recognize GNSS jamming, spoofing, and other forms of interference as an emerging operational risk to ATM within the AFI Region;
b) Encourage States and ANSPs to conduct comprehensive assessments of their dependence on GNSS and identify vulnerabilities affecting navigation, surveillance, communications, and timing systems;
c) Support the establishment of regional GNSS interference reporting and information-sharing mechanisms within the AFI Region;
d) Encourage implementation of Navigation Minimum Operating Networks (NAV MON) and other Alternative Position, Navigation and Timing (APNT) solutions appropriate to regional circumstances;
e) Promote development of harmonized contingency procedures and phraseology for GNSS-related operational events;
f) Encourage recurrent training for ATCOs and technical personnel on GNSS interference detection, mitigation, and operational management;
g) Request ICAO, AASPG, AFCAC, States, ANSPs and industry stakeholders to develop an AFI Regional GNSS Resilience Strategy addressing operational, technical, regulatory, and human-factor considerations; and
h) Urge States to strengthen civil-military coordination arrangements and establish formal notification procedures for activities with the potential to affect GNSS availability.

==END==