International Civil Aviation Organization

MIDANPIRG/22 & RASG-MID/12 Meetings

(Doha, Qatar, 4 – 8 May 2025)

Agenda Item 4.2: Outcomes of the RASG-MID Groups (SEIG/6 Meeting)

AI-ENHANCED FLIGHT DATA MONITORING (FDM) FOR PROACTIVE RISK MANAGEMENT

(Presented by the Islamic Republic of Iran)

SUMMARY

Flight Data Monitoring (FDM) plays a crucial role in aviation safety by enabling proactive risk management. It allows airlines and aviation authorities to analyze operational performance, detect unsafe trends, and mitigate risks before they lead to incidents. However, traditional FDM methods rely heavily on manual analysis and threshold-based systems, which are often reactive rather than predictive.

Recent advancements in Artificial Intelligence (AI) and Machine Learning (ML) provide an opportunity to revolutionize FDM by introducing real-time, automated, and predictive safety monitoring. AI-driven FDM enhances flight safety by continuously processing vast datasets, identifying complex patterns, and predicting risks based on historical and real-time flight data.

This working paper discusses the benefits, challenges, and roadmap for integrating AI-based FDM in the ICAO MID Region, with a focus on improving flight operations safety.

Action by the meeting is at paragraph 4.

REFERENCE

- ICAO ANNEX 19 – SAFETY MANAGEMENT SYSTEMS (SMS).
- ICAO DOC 10000 – MANUAL ON FLIGHT DATA ANALYSIS PROGRAMMES (FDAP)
- BOEING SAFETY REPORT 2024.
- AIRBUS FLIGHT SAFETY INSIGHTS 2024.
- EUROCONTROL AI IN AVIATION SAFETY REPORT 2023.
- FAA ADVISORY CIRCULAR 120-82 – FLIGHT OPERATIONAL QUALITY ASSURANCE (FOQA).

1. INTRODUCTION

1.1 Flight Data Monitoring (FDM) is a fundamental component of modern aviation safety management. It involves the systematic collection and analysis of flight data to identify operational deviations, detect emerging risks, and enhance flight safety compliance.

1.2 Traditional FDM relies on predefined parameters and manual review, which limits the

ability to detect complex safety issues. AI-powered FDM, on the other hand, leverages machine-learning algorithms to analyze large volumes of flight data in real-time, automatically identifying safety risks before they escalate.

1.3 Given the increasing air traffic and operational complexities in the ICAO MID Region, adopting AI-driven FDM presents a significant opportunity to enhance aviation safety outcomes. This paper explores how AI can be effectively integrated into FDM programs and provides a structured roadmap for implementation.

2. DISCUSSION

2.1 The Role of AI in Flight Data Monitoring

AI-based FDM enhances traditional safety monitoring processes by automating data analysis and improving predictive capabilities.

Key functions of AI in FDM include:

- Real-time anomaly detection: AI can instantly flag deviations in flight parameters, including excessive descent rates, unstable approaches, and abnormal control inputs.
- Predictive risk assessment: Machine-learning models analyze past flight data to forecast potential risks and prevent safety incidents.

Automated trend analysis: AI detects long-term safety trends across multiple flights, identifying systemic risks that may otherwise go unnoticed.

2.2 Key Benefits of AI-Based FDM

The integration of AI into FDM provides several advantages over conventional methods, including:

2.2.1 Predictive Safety Analysis:

- AI models predict potential safety hazards by identifying patterns linked to previous incidents.
- Early detection enables airlines to take preventive measures before a risk escalates into an accident.

2.2.2 Automated Anomaly Detection:

- AI continuously monitors flight data and alerts safety teams about potential safety violations.
- This reduces reliance on manual data review and improves efficiency in safety decision-making.

2.2.3 Reduction in Human Workload & Bias:

- Traditional FDM requires human analysts to interpret vast amounts of flight data, leading to potential biases.

- AI eliminates subjective interpretation and provides data-driven insights, improving accuracy and consistency.

2.2.4 Regulatory Compliance & Safety Improvements:

- AI-driven FDM supports compliance with ICAO Annex 19 Safety Management System (SMS) requirements.

It enables data-driven decision-making, helping airlines and regulators maintain high safety standards.

2.3 Challenges in Implementing AI-Based FDM

Despite its benefits, integrating AI into FDM presents several challenges that must be addressed:

2.3.1 Data Privacy & Security Concerns:

- AI requires access to large datasets, raising concerns about data protection and confidentiality.
- Airlines and regulators must implement secure data-sharing frameworks to ensure compliance with privacy regulations.

2.3.2 Integration with Existing Systems:

- Many airlines use legacy FDM systems that may not be compatible with AI-based solutions.
- A phased integration approach is required to ensure smooth adoption without disrupting ongoing operations.

2.3.3 AI Transparency & Interpretability:

- The aviation industry must ensure that AI-generated risk assessments are interpretable by human analysts.
- Explainable AI (XAI) techniques should be used to provide clear justifications for AI-driven safety alerts.

2.4 AI-FDM Implementation Strategy for the MID Region

A structured approach is needed to implement AI-based FDM effectively across the MID Region. The following phased strategy is proposed:

- Short-Term (2025-2026):

- Conduct pilot projects to evaluate AI-driven FDM effectiveness in selected airlines.
- Develop regional AI guidelines for predictive safety analytics.

- Medium-Term (2027-2029):

- Expand AI adoption across major airlines in the ICAO MID Region.
- Establish a regional AI-powered safety data-sharing platform to facilitate cross-border collaboration.

- Long-Term (2030+):

- Standardize AI-FDM across ICAO MID States to ensure harmonized safety practices.
- Implement fully automated flight safety monitoring systems with real-time predictive capabilities.

3. CONCLUSION

3.1 The integration of Artificial Intelligence (AI) into Flight Data Monitoring (FDM) represents a transformative shift in aviation safety management. Traditional FDM methods rely on predefined thresholds and human analysis, which, while effective, are inherently limited in their ability to detect complex patterns and emerging risks. AI-powered FDM overcomes these limitations by leveraging machine learning algorithms to process vast amounts of flight data, identify anomalies, and predict potential safety hazards before they result in incidents.

3.2 The adoption of AI-driven FDM aligns with ICAO's Safety Management System (SMS) framework, particularly in supporting proactive risk identification and mitigation. By transitioning from a reactive to a predictive approach, AI can significantly reduce the occurrence of operational deviations, enhancing overall flight safety. Airlines, regulators, and aviation stakeholders in the MID Region stand to benefit from more efficient safety oversight, improved compliance with international safety standards, and enhanced decision-making capabilities.

3.3 Despite the clear advantages, challenges remain, including concerns related to data

privacy, AI interpretability, and integration with legacy systems. To ensure successful implementation, a structured approach is required, including pilot programs, regulatory development, and cross-industry collaboration. Stakeholders must work together to establish data governance policies, develop AI explain ability frameworks, and ensure that AI-driven safety recommendations remain transparent and actionable.

3.4 Furthermore, the transition to AI-powered FDM should be viewed as an evolution rather than an immediate replacement of existing systems. Hybrid models, combining traditional FDM methods with AI-driven insights, can serve as an effective bridge toward full AI integration. Airlines should also invest in workforce training to equip safety analysts with the necessary skills to interpret AI-generated data and integrate it into their operational risk management processes.

3.5 Looking ahead, the MID Region has a unique opportunity to become a global leader in AI-enhanced aviation safety by implementing a regional AI-FDM framework. Establishing a centralized AI-based safety data-sharing platform can further strengthen regional safety collaboration and allow for the early identification of industry-wide safety risks. Standardization efforts, led by ICAO MIDANPIRG, will be crucial in ensuring harmonized adoption across the region.

3.6 As AI technology continues to evolve, its role in aviation safety will only expand. Future advancements, such as deep learning models capable of real-time flight risk assessment and AI-driven pilot advisory systems, will further enhance safety operations. It is, therefore, essential for ICAO MID States to take proactive steps in embracing AI-driven FDM, ensuring that safety innovations are aligned with both regulatory requirements and industry best practices.

3.7 In conclusion, AI-powered FDM is not just a technological upgrade but also a fundamental shift toward a data-driven and predictive safety culture. By embracing this innovation, the MID Region can significantly enhance aviation safety, reduce risks, and build a more resilient air transport system. The adoption of AI in FDM is a necessary step toward meeting future aviation safety challenges and ensuring continued improvements in operational efficiency and accident prevention.

4. ACTION BY THE MEETING

4.1 The meeting is invited to:

a) Recognize the benefits of AI-driven FDM in enhancing aviation safety.

b) Encourage ICAO MID States and airlines to integrate AI-based solutions into FDM programs.

c) Support the development of a regional AI-powered predictive safety analytics framework.

d) Consider forming a regulatory working group to create implementation guidelines for AI-FDM adoption.

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