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APPLICATION OF THE POINT MERGE SYSTEM TO IMPROVE AIR TRAFFIC CONTROL EFFICIENCY UNDER INCREASING FLIGHT INTENSITY

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Abstract

With the steady growth in global air traffic, air navigation systems face increasing pressure to ensure safe, efficient, and timely aircraft sequencing and separation. This article explores the application of the Point Merge System (PMS) as a modern air traffic control technique designed to enhance operational efficiency under conditions of high flight intensity. PMS provides a structured and predictable approach to aircraft sequencing through predefined navigation points and systematic merge techniques, thereby reducing controller workload and minimizing delays. The paper analyzes the benefits of PMS in terms of fuel efficiency, airspace capacity, and environmental sustainability. Furthermore, it discusses the integration of PMS with performance-based navigation (PBN) and automation technologies as a scalable solution for future air traffic management.

Keywords: Point Merge System (PMS), Air Traffic Control (ATC), Flight Intensity, Performance-Based Navigation (PBN), Sequencing Efficiency, Terminal Maneuvering Area (TMA), Controller Workload, Flight Path Optimization, Arrival Management.

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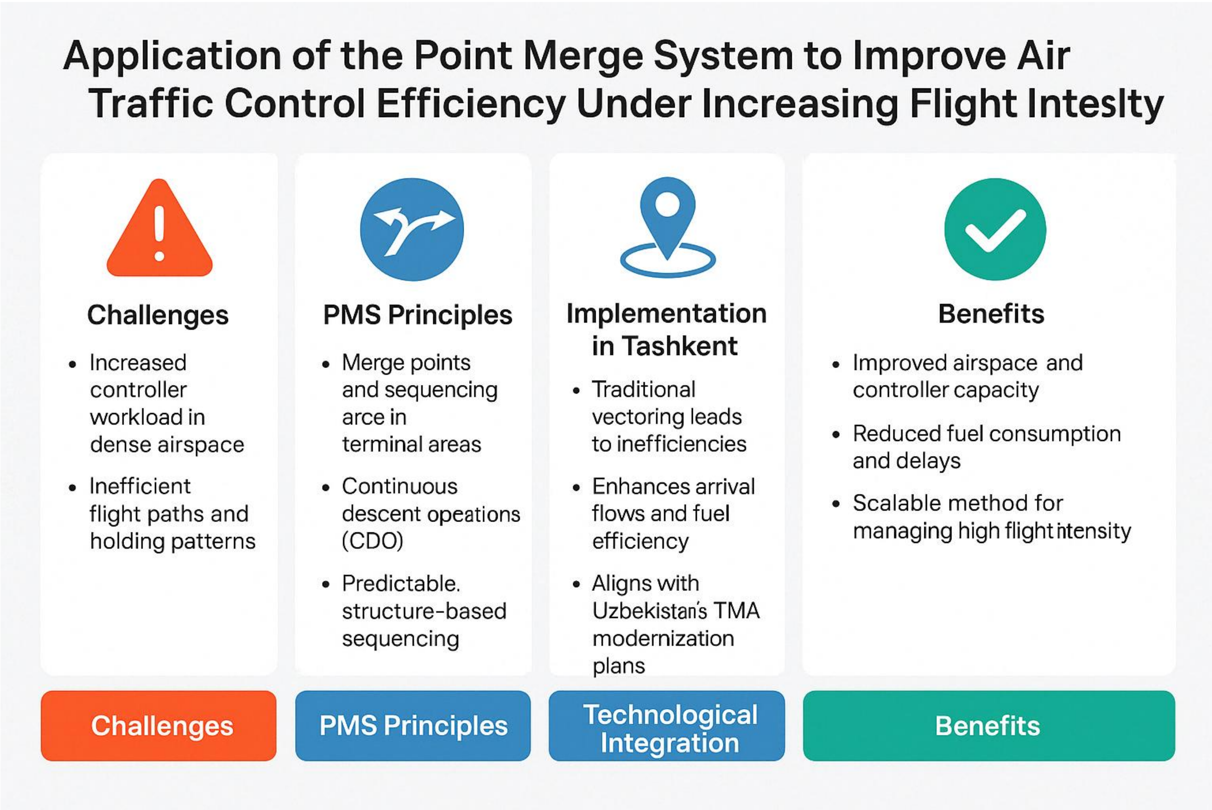
Introduction

The rapid expansion of global air traffic in recent decades has significantly increased the operational demands on air traffic control (ATC) systems, particularly within Terminal Maneuvering Areas (TMAs), where aircraft density and precision requirements are highest. As flight intensity continues to rise, conventional sequencing techniques—primarily reliant on tactical radar vectoring—struggle to maintain optimal performance. This often results in controller overload, extended holding patterns, and diminished safety margins.To address these growing challenges, air navigation service providers (ANSPs) are exploring innovative solutions aimed at enhancing the efficiency, predictability, and safety of arrival management processes. One such approach is the Point Merge System (PMS), a structured method that facilitates systematic sequencing of inbound aircraft using predefined arcs and merge points. By enabling Continuous Descent Operations (CDO) and minimizing reliance on tactical instructions, PMS not only improves airspace utilization but also reduces fuel consumption, environmental impact, and controller workload.This paper investigates the application of the Point Merge System as a means of improving ATC efficiency under high flight intensity conditions. The study reviews the system's operational principles, assesses its potential for implementation in Tashkent, and compares it with established PMS use cases in international settings. Furthermore, the paper discusses how PMS, when combined with Performance-Based Navigation (PBN) and decision-support technologies, offers a scalable solution to the evolving demands of modern air traffic management.

Challenges of Traditional Air Traffic Control in High-Intensity Environments

Air traffic control systems are designed to ensure the safe, orderly, and efficient flow of aircraft, particularly in terminal maneuvering areas (TMAs), where traffic density is highest. However, as global air traffic volumes continue to rise, traditional ATC methods—primarily based on tactical radar vectoring and manual sequencing—struggle to keep pace with operational demands(image -1). This leads to several critical inefficiencies and safety risks. Increased Controller Workload. In high-density airspace, controllers must issue frequent instructions for heading, speed, and altitude adjustments. This reactive control model imposes significant cognitive stress, increasing the likelihood of human error and fatigue. Inefficient Flight Paths. Tactical vectoring often results in non-optimal trajectories and level-off segments during descent, contributing to unnecessary fuel consumption, extended flight times, and higher CO_2 emissions. Reduced Operational Predictability. Lack of standardized sequencing reduces arrival time predictability, complicating both en-route coordination and airport resource planning.



Application of the Point Merge System (image-1).

Holding Patterns and Delay Accumulation. Under peak loads or unexpected disruptions, aircraft are placed in holding stacks, leading to delays, congestion, and reduced situational awareness for both pilots and controllers. Underutilization of Performance-Based Navigation (PBN). Legacy vectoring procedures limit the full application of modern navigation capabilities, such as Required Navigation Performance (RNP), which could otherwise improve trajectory accuracy and airspace efficiency. These challenges underscore the urgent need for a modern, structured, and automation-compatible approach to aircraft sequencing. The Point Merge System directly addresses these shortcomings by offering a predictable, fuel-efficient, and controller-friendly solution for managing high-intensity air traffic environments.

Operational Principles of the Point Merge System

The Point Merge System (PMS) is an innovative and structured arrival management concept developed to optimize aircraft sequencing in terminal maneuvering areas (TMAs). Unlike traditional radar vectoring, PMS enables a standardized, automation-compatible process that enhances both predictability and efficiency in high-density airspace. PMS is based on the use of fixed navigation points and predefined flight paths, allowing aircraft to be sequenced more effectively with minimal ATC intervention. Merge Point. A fixed point in the TMA where aircraft from multiple directions converge. It serves as the common destination for all arriving aircraft following designated sequencing legs. Sequencing Legs (Arcs). These are curved or straight trajectory segments located equidistantly from the merge point. Aircraft follow these legs at level flight while waiting to be directed toward the merge point. Continuous Descent

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Operations (CDO). PMS enables smoother descent profiles by reducing the need for level-offs, contributing to reduced fuel consumption, noise, and engine wear. Operational Workflow. Aircraft are assigned to a specific sequencing leg upon entering the TMA. Air traffic controllers delay or space aircraft by directing them to fly longer or shorter portions of the sequencing arc, instead of issuing frequent heading changes. Once the appropriate in-trail spacing is achieved, aircraft receive a clearance to proceed directly to the merge point for final approach. This structure allows controllers to maintain high levels of situational awareness while decreasing radio communication frequency. It also improves arrival flow stability and paves the way for integration with automated arrival management tools such as AMAN (Arrival Manager).

Implementation of the Point Merge System in Tashkent: Current Status and Opportunities
Tashkent International Airport (UTTT), as Uzbekistan's primary aviation hub, currently employs traditional vectoring methods for arrival sequencing and spacing. While these techniques have proven adequate under moderate traffic conditions, recent trends show increasing pressure on the system due to both rising flight intensity and operational complexity. Current Operational Challenges. Airspace Limitations. The airport is surrounded by terrain constraints and nearby international borders, limiting flexible vectoring options and increasing complexity in terminal airspace design. Seasonal Traffic Surges: Periodic increases in flights—particularly during summer and holiday seasons—create congestion in the Terminal Maneuvering Area (TMA). Heterogeneous Aircraft Mix: Varying performance characteristics between domestic, regional, and international carriers complicate sequencing under conventional radar-based procedures. Heavy Reliance on Manual Control. Tashkent ATC operations are still largely dependent on controller experience and tactical instructions, which reduces consistency and increases workload under pressure. Limited Utilization of PBN. Although Uzbekistan is part of the ICAO PBN roadmap, full implementation of advanced RNP procedures has yet to be completed in the Tashkent TMA. Benefits and Opportunities for PMS Implementation. The introduction of PMS offers a promising opportunity for transforming Tashkent's arrival management process. Increased Airspace Capacity without the need for extensive infrastructure changes. Smoother and More Predictable Arrival Flows, reducing the occurrence of holding stacks and vectoring loops. Reduced ATC Workload, especially during peak periods, allowing controllers to focus on safety-critical decisions. Improved Fuel Efficiency and Environmental Impact, due to smoother continuous descent profiles. PBN Compatibility, making PMS a future-ready solution aligned with Uzbekistan's aviation modernization initiatives. Potential as a Regional Model, establishing Tashkent as a reference site for Point Merge adoption in Central Asia. By implementing PMS, Tashkent International Airport can significantly enhance both efficiency and safety, making it more resilient to future traffic growth and aligned with global air navigation modernization standards.

International Comparison: Lessons from Other Airports
Oslo Gardermoen (ENGM). First operational PMS, shown to reduce controller workload and fuel use by up to 15%. Highly structured TMA supported seamless sequencing. Paris Charles de Gaulle (LFPG). Implemented PMS in congested European airspace with complex arrival flows.

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Resulted in improved predictability and time-based spacing. London Heathrow (EGLL). Although Heathrow uses a hybrid model, PMS principles have influenced arrival management to reduce holding times. Compared to these hubs, Tashkent presents fewer airspace constraints and lower traffic density, making it an ideal candidate for early-stage PMS adoption and as a model for other airports in the Central Asian region.

Integration of the Point Merge System with Technological Solutions

While the structural design of the Point Merge System provides the foundation for efficient sequencing, its full potential is realized when integrated with advanced air traffic management technologies. In the context of increasing traffic volumes at Tashkent International Airport, the combination of PMS with modern systems will enable smarter, safer, and more responsive airspace operations.

Performance-Based Navigation (PBN)

The success of PMS relies heavily on the implementation of PBN procedures, particularly Required Navigation Performance (RNP), which allows aircraft to fly precise 3D trajectories. Benefit. Reduces dependence on tactical vectoring by enabling predefined routing. Application. Aircraft follow standardized arcs and merge points with minimal ATC input. Tashkent's gradual adoption of RNP approaches creates a strong platform for PMS-based arrivals to be introduced in phases.

Automation and Arrival Management Systems (AMAN)

Automation tools such as Arrival Management (AMAN) systems are essential for optimizing aircraft spacing in real time. In European ATC centers, AMAN systems are integrated with PMS to generate time-based sequencing advisories. For Tashkent, where resources may be more limited, AMAN integration can reduce controller workload and enhance coordination across en-route and terminal sectors.

Real-Time Surveillance with ADS-B

Automatic Dependent Surveillance–Broadcast (ADS-B) enables continuous tracking of aircraft in all phases of flight, including in airspace with limited radar coverage. Relevance to Tashkent: Enhances visibility of inbound aircraft from multiple FIRs and supports more dynamic sequencing. Benefit: Enables improved safety margins and reduces reliance on voice communication in coordination with PMS.

Artificial Intelligence (AI) and Machine Learning

AI and machine learning offer powerful tools to optimize PMS operations and forecast traffic trends. At airports such as Paris and Tokyo, AI is used to predict arrival saturation, optimize merge timing, and generate sequencing recommendations. In Tashkent, AI-based simulations could help design custom PMS configurations, improve training programs, and identify system bottlenecks before implementation. The integration of these technologies will not only

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strengthen the operational benefits of PMS but also position Tashkent as a forward-looking ATC system aligned with global digital transformation initiatives.

Recommendations for PMS Implementation in Tashkent

To ensure a smooth and effective transition to the Point Merge System at Tashkent International Airport, a phased implementation strategy is recommended. This approach allows for gradual integration, system testing, and operational fine-tuning while minimizing disruptions to existing procedures. Airspace Redesign

Develop a revised terminal airspace structure that incorporates sequencing legs and merge points, tailored to Tashkent's geographic constraints and traffic flows. This phase should involve simulation-based layout testing and ICAO PBN design standards. Targeted Training Programs. Conduct comprehensive training sessions for air traffic controllers, flight procedure designers, and airline pilots. Training should focus on PMS procedures, phraseology, system logic, and real-time response scenarios. Simulation and Validation. Utilize fast-time and real-time simulations to assess system performance under various traffic intensities. This phase should help validate separation standards, capacity improvements, and system resilience under abnormal conditions.Technological Integration. Gradually integrate Performance-Based Navigation (PBN) procedures, Arrival Management (AMAN) systems, and ADS-B surveillance into Tashkent's operational environment. Ensure compatibility with existing infrastructure and upgrade where necessary. Collaborative Planning. Involve key stakeholders—including the Civil Aviation Authority, Uzbekistan Airways, international carriers, and regional ATC centers—from the outset. Early collaboration ensures shared objectives, reduces resistance to change, and promotes alignment with regional initiatives.Performance Monitoring and Feedback. After implementation, establish a framework for ongoing performance monitoring, using metrics such as average delay, fuel savings, and voice communication load. Integrate feedback loops from operational staff and airline partners to refine procedures over time.

Conclusion

As global air traffic continues to grow, enhancing the efficiency of air traffic control systems has become a strategic priority for aviation authorities worldwide. In increasingly saturated airspace environments, traditional radar-based vectoring methods are no longer sufficient to manage arrivals effectively, particularly in terminal areas where demand, complexity, and environmental concerns intersect.

The Point Merge System (PMS) presents a structured, scalable, and technology-friendly solution that directly addresses these challenges. By replacing reactive, voice-intensive control with predefined merge structures and optimized descent paths, PMS improves airspace utilization, reduces controller workload, and supports environmentally sustainable operations. For Tashkent International Airport, PMS offers a transformative opportunity. The city's growing flight intensity, paired with existing modernization efforts, makes it an ideal candidate for early PMS adoption in Central Asia. By combining PMS with Performance-Based Navigation (PBN), surveillance technologies like ADS-B, and automation tools such as AMAN, Uzbekistan's airspace system can take a major step toward global best practices in air traffic management.

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Furthermore, with proper planning, training, and stakeholder collaboration, the implementation of PMS at Tashkent can serve as a regional model—demonstrating how smart procedures, supported by modern technologies, can future-proof ATC operations for a new era of aviation growth.

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