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AGENDA ITEM 4: AIR NAVIGATION

MALAYSIA'S EXPERIENCE IN EVALUATING SOFTWARE-DEFINED WIDE AREA NETWORK (SD-WAN) AS AN ALTERNATIVE COMMUNICATION NETWORK FOR AIR TRAFFIC MANAGEMENT (ATM)

(Presented by Malaysia)

INFORMATION PAPER

SUMMARY

This paper presents Malaysia's experience in conducting a proof of concept (PoC) between September 2025 and April 2026 to evaluate Software-Defined Wide Area Network (SD-WAN) technology as a supplementary and alternative communication network for Air Traffic Management (ATM) operations within the Kota Kinabalu Flight Information Region (KK FIR).

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1. INTRODUCTION

1.1 Reliable inter-site communication networks are essential to support safe, orderly and efficient ATM operations. In Malaysia's Kota Kinabalu Flight Information Region (KK FIR), connectivity between operational ATM facilities has traditionally been supported by a dual MPLS VPN architecture intended to provide redundancy. However, past experience has shown that common backbone-level failures can affect both MPLS VPN paths simultaneously, resulting in a complete loss of network connectivity and a direct operational impact on ATM services.

1.2 The ICAO Global Air Navigation Plan (GANP) and Aviation System Block Upgrades (ASBUs) support the progressive modernisation of CNS infrastructure to improve resilience and availability. In this context, SD-WAN was identified as a potential technology to provide additional path diversity by enabling dynamic routing across multiple diversified transport links without replacing the existing primary communication networks.

1.3 Malaysia conducted a structured five-phase PoC to assess whether SD-WAN could be safely integrated as a supplementary CNS/ATM data connectivity layer alongside an existing MPLS VPN network. The PoC was conducted at the Kota Kinabalu Air Traffic Control Centre (ATCC) , the Kuching ATCC, and the Tawau Air Traffic Control (ATC) Tower using a secure SD-WAN platform.

2. DISCUSSION

2.1 Objective and Implementation Approach

2.1.1 The objective of the PoC was to evaluate SD-WAN as an alternative and supplementary communication path for ATM operations, particularly in situations where the existing MPLS VPN network may experience service degradation or simultaneous link failure. The evaluation focused on network resilience, performance, security, failover capability, and suitability for ATM-related data, voice, and surveillance services.

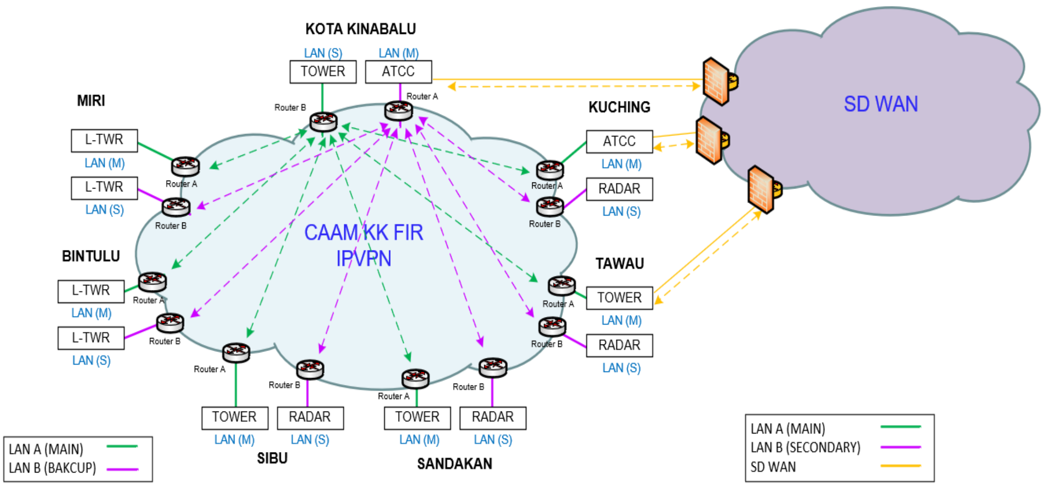


Figure 1: Existing and PoC of SD-WAN Network Architecture in KK FIR

2.1.2 The PoC was implemented across three operational sites using route-based IPsec tunnels over two underlay connections: Fibre-To-The-Home (FTTH) Fibre broadband as the primary SD-WAN and 5G wireless as the secondary underlay. The existing IPVPN remained as the primary operational network throughout the PoC period.

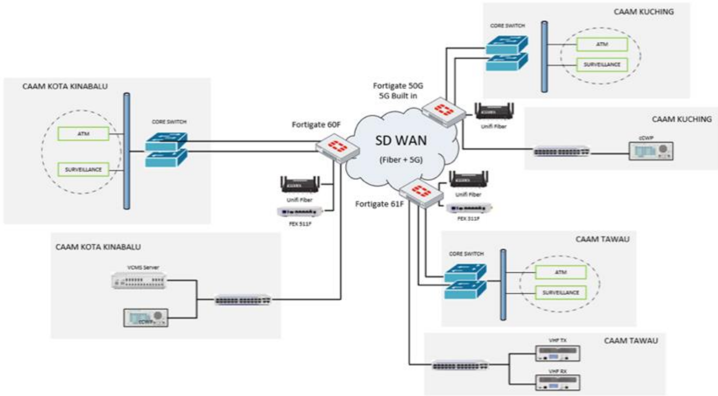


Figure 2: SD-WAN PoC Network Architecture across KK FIR

2.1.3 Operational safety was maintained by limiting SD-WAN activation to a daily maintenance window and only selected VLANs through the SD-WAN environment, with fallback capability to the existing IPVPN. Continuous monitoring was carried out through the SD-WAN management platform.

2.2 The PoC phases:

Phase	Activity	Period
1	Planning, risk assessment, Work Method Statement (WMS) preparation	September – November 2025
2	FortiGate deployment, underlay provisioning, VXLAN configuration	December 2025
3	Performance monitoring, security validation, failover testing	January – February 2026
4	Controlled integration with operational ATM systems	February – March 2026
5	Post-PoC signoff	April 2026

Table 1: Phases and Timeline of the SD-WAN PoC

2.3 Key Technical Findings

2.3.1 The PoC demonstrated that FTTH fibre broadband provided stable inter-site performance with latency of approximately 10-30 ms, packet loss of 0%, and jitter below 5ms. These results were considered high-performance for the PoC environment and were comparable to the existing MPLS VPN performance.

Parameter	Fibre FTTH	5G Wireless (Secondary)	Recommended Threshold (ICAO CRV)	Recommended Threshold EUROCAE ED138	Conclusion
Latency	<30ms	>100ms	< 100ms	< 100ms	Fibre FTTH: Acceptable 5G: Site improvement needed
Jitter	<5ms	>25ms	< 100ms for Data < 15ms for Voice	< 50ms for Data < 15ms for Voice	Fibre FTTH: Acceptable 5G: Site improvement needed
Packet Loss	0%	>0.10%	0.10%	0.5%	Fibre FTTH: Acceptable 5G: Site improvement needed

Table 2: Performance Matrix Comparison Between the FTTH and 5G Wireless

2.3.2 The 5G wireless underlay was successfully implemented and tested in failover scenarios. The SD-WAN automatic path-switching mechanism functioned correctly by redirecting traffic to the 5G path when fibre service degradation was simulated and encountered. However, 5G performance was inconsistent across the three PoC sites due to site-specific signal coverage, environmental attenuation, and network congestion.

2.3.3 The findings indicate that FTTH fibre broadband may provide a viable supplementary path for ATM communication resilience, while 5G wireless requires further site optimisation before it could be considered reliable for operational ATM-grade connectivity.

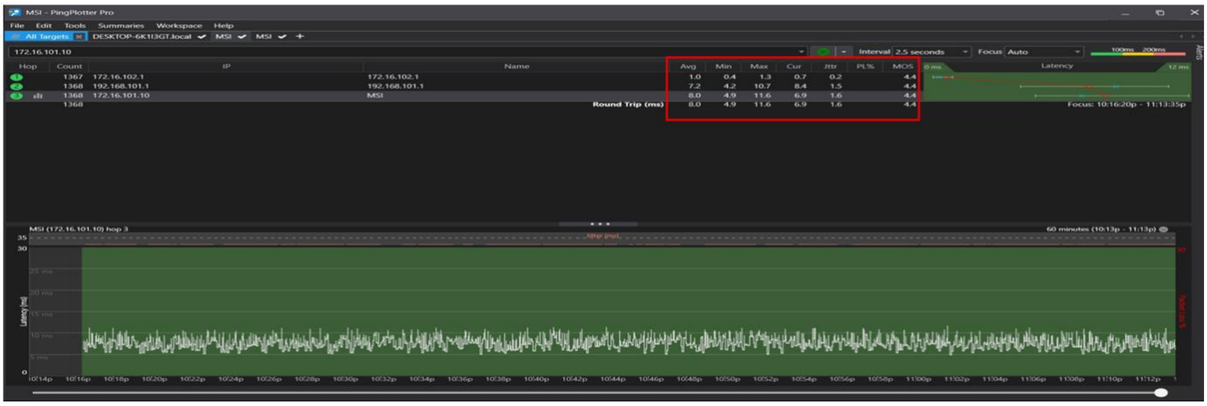


Figure 3: SD-WAN Latency Performance during the PoC

2.1 Live Operational Validation

2.1.1 A significant outcome of the PoC was an unexpected simultaneous failure affecting both the primary and secondary MPLS VPN connections serving one of the ATCC under PoC. This incident reflected the vulnerability that motivated the SD-WAN PoC, namely the risk that redundant MPLS links may still fail simultaneously if affected by common backbone-level infrastructure issues.

2.1.2 Following approval by the operational officer-in-charge and the Watch Manager on duty, the SD-WAN solution was activated as an immediate remedial measure. The SD-WAN successfully restored WAN connectivity between both ATCC, returning ATM automation and surveillance systems to operational status.

2.1.3 The SD-WAN link remained in service for more than 24 hours before the MPLS VPN was restored and resumed service. During this period, no abnormal behaviour was observed in the system’s technical monitoring systems, nor any abnormal behaviour was reported by the air traffic controllers.

2.1.4 This incident provided practical validation of SD-WAN under real operational conditions; it demonstrated that SD-WAN can provide an alternative communication path during major network disruptions and highlighted the operational value of communication path diversity in ATM environments.

2.2 Lessons Identified

2.2.1 The PoC highlighted that conventional dual MPLS VPN arrangements may not fully eliminate the risk of service disruption if both links remain dependent on shared underlying backbone infrastructure. Additional diversity at the transport layer may therefore be necessary to improve ATM communication resilience.

2.2.2 The PoC also demonstrated that the SD-WAN may be used to complement existing communication networks rather than replace them immediately. A progressive implementation approach allows States and ANSPs to evaluate performance, security, failover behaviour and operational suitability before considering wider deployment.

2.2.3 FTTH fibre broadband showed promising performance as a supplementary underlay, while 5G wireless requires careful site assessment, signal optimisation and sustained monitoring before operational use can be considered. The PoC therefore reinforces the importance of site-specific validation when using commercial communication services for ATM support purposes.

2.2.4 Cybersecurity remains a key consideration when introducing SD-WAN and internet-based underlay services into ATM-related communication environments. Encryption, segmentation, firewall controls, centralised logging and continuous monitoring are essential components of a controlled implementation approach.

2.3 Future Recommendation

2.3.1 Based on the initial PoC findings, Malaysia is undertaking a second phase of SD-WAN evaluation. The second phase will further assess Quality of Service implementation, traffic classification principles, Differentiated Services Code Point Markings, sustained long-term jitter monitoring and benchmarking against relevant international network performance requirements/standards.

2.3.2 Long-period monitoring is considered important because SD-WANs that use commercial underlay services operate on a best-effort basis rather than a guaranteed service model. Extended monitoring will help Malaysia assess whether the performance stability observed during the PoC can be sustained over a longer operational period.

2.3.3 Any future operational application of SD-WAN for ATM communication will remain subject to further technical assessment, operational validation, cybersecurity assurance and compliance with applicable performance and safety requirements. Malaysia intends to use the findings from the second phase to determine the appropriate role of SD-WAN as a supplementary or alternative ATM communication network solution.

3. ACTION BY THE CONFERENCE

3.1 The Conference is invited to note the information contained in this Paper.

— END —

ATTACHMENT A

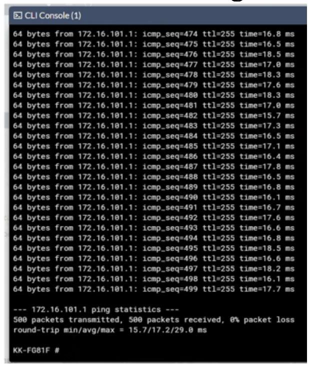
Technical Observation: Ping Test

Bil	Site	Site to Site Tunnel	Number of Packet	Average Latency (ms)	Packet Loss (%)
1	Kota Kinabalu SD WAN	KK to Tawau	500	10.3	0
2		KK to Kuching	500	17.2	0
3	Tawau SD WAN	Tawau to KK	500	10.3	0
4		Tawau to Kuching	500	24.9	0
5	Kuching SD WAN	Kuching to KK	500	17.5	0
6		Kuching to Tawau	500	24.5	0

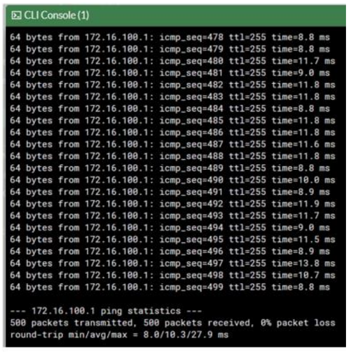
Table A-1: Inter-site Ping Test Results during SD-WAN PoC

KK to Tawau

KK to Kuching

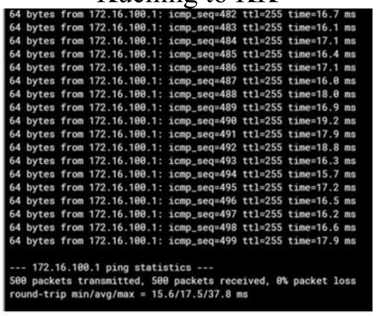


Tawau to KK



Tawau to Kuching

Kuching to KK



Kuching to Tawau

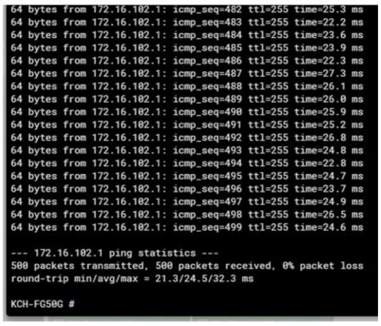


Figure A-1: Inter-site Ping Test Results during SD-WAN PoC