International Civil Aviation Organization

MIDANPIRG Communication, Navigation and Surveillance Sub-Group

Eleventh Meeting (CNS SG/11)
(Muscat, Oman, 16-19 May 2022)

Agenda Item 4: CNS planning and implementation in the MID Region

USE OF MICROWAVE LINKS FOR NAVIGATIONAL AIDS MONITORING AND TRANSFER OF SURVEILLANCE DATA

(Presented by Saudi Arabia)

SUMMARY

This paper provides an overview on Microwave Line of Sight (LoS) Links and its use by Saudi Air Navigation Services (SANS) to monitor navigational aids at certain aerodromes and to transfer surveillance data for the provision of approach service within Jazan TMA. The paper also describes the methodology used by SANS to validate the solutions proposed by the operators of Microwave LOS links.

Action by the meeting is in paragraph 4.

REFERENCE(S)

ICAO Annex 10 Volume I, II, III & IV.

Doc 9750, Global Air navigation Plan

Doc 9718, ICAO Handbook on Radio Frequency spectrum for Civil Aviation.

ICAO MID eANP. https://www.icao.int/MID/MIDANPIRG/Pages/MID-eANP.aspx

MIDANPIRG/19 Final Report, Section §5.8.38

1. INTRODUCTION

1.1 The monitoring of radio navigation aids is conducted by Saudi Air navigation Services (SANS), the ANSP in the kingdom of Saudi Arabia, at operational and technical levels as required by General Authority of Civil Aviation (GACA) Regulation Parts 171 and 173. In general, SANS is using available ground network and wired connections, between the navigation aid site and ATS TWR and technical rooms, to automatically monitor the status of each navigation facility.

1.2 However, at some domestic and regional aerodromes and at certain remote sites, SANS has faced challenges for the deployment of wired connections for navigational aids monitoring due mainly to aging ground wired network infrastructure which requires substantial investment for the renewal and replacement of existing cables. To overcome these limitations, SANS initiated an engineering program to explore the best sustainable and cost-effective solution. The focus was on the use of available technologies to build wireless access.

1.3 The worldwide Interoperability for Microwave Access (WiMAX) technology was elected as the best candidate option to provide connectivity between facility sites and local network **to support the monitoring of certain navigational aids at aerodromes with low to medium traffic levels and for the transfer of surveillance data for the provision of Jazan approach** service effective since 24 February 2022.

1.4 The deployment of this solution is based on point-to-point microwave Line of Sight (LoS) links (A link that connects two terminal stations that conveys either unidirectional or bidirectional traffic) setting using two main nodal stations, each one at the edge of the link path, without obstacles in the propagation path that could cause blocking or diffraction, and using antennas with high directivity, also named narrow-beam antennas. An illustration of the Microwave LoS link network topology deployed by SANS is shown in **Appendix B**.

1.5 Moreover, SANS identified the microwave LoS links as a quick and low-cost solution for access and transit network as its rollout is fast and offers deployment of flexible connectivity for the deployment for CNS/ATM facilities. One of the key characteristics of microwave LoS link is the mobility with the possibility of moving physically the equipment used for microwave LoS link which provides further benefits for its use in the case of disaster recovery, emergency situations, or as temporary backup system where the wired networks (e.g fiber-optic cables) have broken down requiring the application of contingency arrangements.

2. OVERVIEW ON THE DESIGN OF MICROWAVE LOS LINK SYSTEMS

2.1 Saudi Air Navigation Services has defined a structured- methodology and design procedures for the implementation of microwave LoS links. The providers of Microwave links are selected based on their experience and infrastructure within the target areas. For each critical Microwave link, two providers are selected with an adequate level of redundancy, different frequency band, and frequency plans for the repeaters. The main phases and activities for setting a new microwave LoS link can be summarized as follows:

- **Phase 1 Preliminary Studies.** This phase includes the following activities:

  a) Analysis of the specifications and study of the application for which the link will be designed (Navigational aids monitoring and transfer of surveillance data). This activity involves an evaluation of the technologies upon which the link will be designed (TDM, IP, Ethernet) in relation to the capacity requirements of the application and the possible restrictions arriving from the network that the link is going to belong.
  b) Coordination with the third-party providers (Telecom operators) to assess their capabilities and solutions
  c) Study of the frequency band (in many cases, this is a specification that cannot be modified as it is proposed by the third-party providers (COM operators)). The frequency band must be approved and assigned by Saudi Communications and Information Technology Commission (CITC) based on Wireless Access Systems, including Radio Local Area Networks (WAS/RLAN).
  d) Equipment selection and specification studies. Analysis of the capacities provided by different manufacturers and models, base band and multiplexing options, system upgrade and extension possibilities, diversity and redundancy schemes allowed, etc.
  e) Study of the availability and error performance objectives and the allocation of a portion to the Microwave link in relation to the network where the system will be installed and used. This task is based on reference values found in ITU-T and ITU-R Recommendations for availability and error performance objectives (Cross check with the values proposed by the operator of the radio link considering the experience in previous designs on the specific geographic area).
  f) First analysis of the link radio route and terrain profile. This first path analysis identifies the number of hops (link section between two radio Stations either between a nodal and a repeater station or between repeater stations) and the candidate sites for intermediate repeater stations if those are required.

- **Phase 2 Detailed Link Design submitted by the operator of the link**

  a) Design of an initial frequency plan. This activity will propose the radio channel arrangements in each one of the hops of the link.
  b) Detailed study of the radio network route. Intermediate repeater station choice and calculations associated with terrain profiles (antenna heights, clearance criteria, etc.).
  c) Assignment of error performance objectives to the different sections (hops) of the radio link and analysis of the system threshold values.
  d) Link budget design in each one of the link hops. Evaluation of system margins and preliminary decision about the use of diversity and redundancy techniques.
  e) Interference analysis. Study of intersystem interferences and optimization of the radio channel plan. Discussion and Decision about the need for special antennas that might mitigate interference problems in complex frequency reuse scenarios.

- **Phase 3 Installation and Testing**

  a) Inspection of path obstacles and relevant spots in the field/locations. Site redesign and antenna height recalculation if necessary.
  b) Equipment setup and installation. System tests to evaluate Background Bit Error Rates (BBERs), system threshold checks, identification of unexpected interference problems, etc.

3. CONCLUSION

3.1 The implementation of Microwave LoS links can support various CNS/ATM applications associated with the transfer of information and data. It allows the ATS providers to overcome limitations in the ground wired network infrastructure and introduce cost-effective solutions that deliver high speed data communication, and maintain dedicated links at a reliable and high quality speed.

3.2 For the use of Microwave LoS links for navigation aids monitoring and Surveillance data transfer, special considerations should be given to the integration requirements. The **Appendices A & B** are describing the main special considerations for setting Microwave LoS links.

3.3 The Microwave LoS links can also support the setting of sustainable solutions as backup links where wired network infrastructure breaks and allow identification of contingency arrangements that may include moving of equipment associated with the Microwave LoS links when an evacuation of an ATS facility is needed.

4. ACTION BY THE MEETING

4.1 The meeting is invited to:

a) note the information provided in this paper; and

b) consider Saudi Arabia’s experience in the development of Guidance on the usage of wireless Links for the connectivity and monitoring of CNS facilities.

APPENDIX A

WIRELESS LINK USE CASE IN NAVIGATION AIDS MONITORING

SPECIAL CONSIDERATIONS FOR INTEGRATION WITH NAVIGATION AID SYSTEM

1) The wireless link is the media of communication used when conventional physical means of communication is either not feasible or not cost effective. In the context of Navigational Aids (NAVAIDs) systems, the wireless link is used to exchange status, control, and ident synchronization data between the respective systems, at aerodromes, and for sites serving en-route navigation including remote sites.

2) The wireless link employed by SANS for use in NAVAIDs systems is a mixture of Point to Point (PTP) Local Area Networks (LAN) and Wide Area Network (WAN) IP/VPN. The two means are used depending on the circumstance and use case as explained below.

3) Dedicated wireless PTP Links used when latency and continuity are crucial. This solution is often owned by SANS and used for the following cases:

   - Connecting NAVAID ground systems to remote control and status indication panel installed at an ATS tower.
   - Ident Synchronization between Localizer and DME.

4) WAN IP/VPN is used in cases where latency fluctuation (within a reasonable limit) and minor connection downtime is acceptable. This is often deployed and maintained by a third party (Telecom provider)and used for the following cases:

   - Connecting NAVAID ground systems to remote control and status indication panel installed at an ATS tower.
   - Connecting systems to remote monitoring and control system or center.
   - Connecting shelter/site to monitor environment and ancillary parameters and conditions.

5) After selecting the best solution (PTP LAN, WAN IP/VPN, etc.) installation and testing are the next steps. The installation process will entail fulfillment of predefined criteria of Line of Sight, link budget, and frequency spectrum analysis survey, etc.

6) Upon satisfactory completion of the above criteria and conditions thorough extensive testing of the link using various Network testing tools, the NAVAIDs systems are integrated. Careful consideration and attention are needed when an integration with NAVAIDs legacy equipment as this integration should not affect the performance of the systems.

7) The New navigation aid systems usually incorporate some form of network connection in the design, but in the case of legacy equipment using specific connectivity ports (serial, I/O, etc.), a protocol or media converter will be required if the wireless links don’t have built-in support.

8) When using protocol converters special and careful consideration should be paid to the encoding, decoding, and relay of messages. Depending on the complexity and characteristics of the message format and the error handling mechanism, thorough testing must be conducted to ensure that the wireless link will not cause abnormal behave of the system.

9) Some forms of erroneous and abnormal behavior have been recorded while testing the systems such as:

- False indication.
- NAVAIDs equipment shutting down.
- Intermittent connection loss causes many aural alarms and may be stressful for ATCOs at an ATC TWR.
- Ident synchronization causing false DME warning or change over.

10) The use of a comprehensive Network Management system is recommended for all wireless links. A careful monitoring of the system should be organized at operational and technical levels.

11) The wireless links employed by SANS are monitored, maintained, and managed by maintenance personnel to ensure timely identification of failures and continuity of the service.

In conclusion the use of a wireless link for NAVAIDs has proven to be a flexible, cost-effective solution, especially in challenging areas with rough terrain. The quick and rapid deployment and relocation of wireless links make it the best option for providing connectivity between access points or backbone and local network. The benefits of wireless access infrastructure also come with challenges that can be summarized as follows:

- The complexity of integration with NAVAIDS legacy equipment and systems.
  - Thorough and extensive testing of the integration of the link with the NAVAIDs systems in a laboratory/simulation environment and in the field. The sharing of information and experience with other Member States and ANSPs on the use of wireless links can support proven solutions.
- The occasional sporadic and inconsistent nature of wireless connectivity.
  - The use of redundant links is recommended in either mesh or ring topology, and the use of network monitoring and management systems should be a requirement.
- The susceptibility to interference, jamming, and solar events.
  - Collection of information from the manufacturer on weaknesses of links and factors that may impact the connectivity and the overall performance (e.g. weather phenomena).
  - For jamming and interference, the use of automated dynamic spectrum optimization techniques or frequency hopping should be a requirement to reduce their impact on the performance of the links.
- Reliance on shelter AC main-power.
  - The use of independent standby power for the wireless link is recommended to ensure continuity of the service.
- Wireless ident synchronization.
  - Coordination and consultation with the manufacturer of the NAVAIDs system is mandatory to collect information on best practice and expected outcome.
  - Testing the NAVAIDs systems behavior and performance in a laboratory/simulation environment.

APPENDIX B

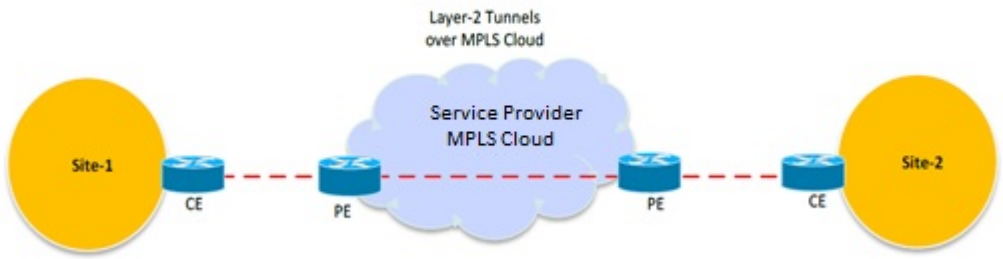
WIRELESS LINK USE CASE FOR ATS SURVEILLANCE

SPECIAL CONSIDERATIONS FOR INTEGRATION WITH SURVEILLANCE SYSTEM SERVING JAZAN APP

1) **Telecom Operators Agreements:**

a) An enterprise Layer-2 VPN switched solution implemented over a high-performance Multi-Protocol Label Switching (MPLS) backbone that transports Layer-2 traffic over an MPLS network, offering reliable and secure access to the customer network and providing a communication platform for their mission critical business needs. In the proposed Ethernet-VPN solution both sites will be connected to MPLS cloud. Theses links will be connecting both locations to nearest Point of Presence "PoP" on MPLS network cloud.

Point-to-Point Topology connecting two sites:



b) SANS is maintaining the control of its own network as there is no need to share any routing information with the Operator and support IP and non-IP traffic as well.

c) A Service Level Agreement (SLA) is signed with the Telecom Operator with definition of various metrics used to measure the operational SLA (Handling Time: defined as the time during which customer can call for support, Response Time: defined as the time starting from the creation of the trouble/failure ticket upon any complaint, until the Operator engineer calls back to handle the ticket, Resolution Time: defined as the time starting from the reporting of the trouble/failure ticket upon complaint until the problem has been resolved and/or service restored. It includes providing a workaround solution for the connection to be up and running). Response and resolution times are tracked per incident (Critical: Indicates that branch is completely down, Major: Indicates service impairment/degradation e.g. signal fade, excessive drops, Minor: Indicates no loss of functionality. Minimal service impact e.g. cannot reach desired bandwidth, slowness, etc.) , and thus the operational SLA violation is calculated per incident. SLA measurement applies from Point-of-Presence (PoP) to the Customer-Provided Equipment (CPE) of connectivity service. This is monitored and managed by the Operator all the time to ensure Quality of Service and available network. Any Planned outages and maintenance activity is systematically notified to SANS three (3) days earlier.

d) Operators Network Operations Centre (NOC) operates 24x7x365 (account Management team in Business Care) is available for receiving any reported incidents and resolving interruptions in service or service problems. All calls to Business Care are logged in a Ticketing System using the Service Desk Process confirming the receipt stating the trouble/failure ticket number.

e) The escalation for Connectivity Service faults is using a hierarchy model to handle technical helpdesk operational activities at all levels. This includes performing tasks such as following up problems, returning phone calls, reporting of incidents, notification, incident report, monitoring, and escalation. Operator Business Care will record event in an incident tracking system that allows a logging process to take place at the onset of a call also notifying all concerned staff as well as those responsible for managing the tickets.

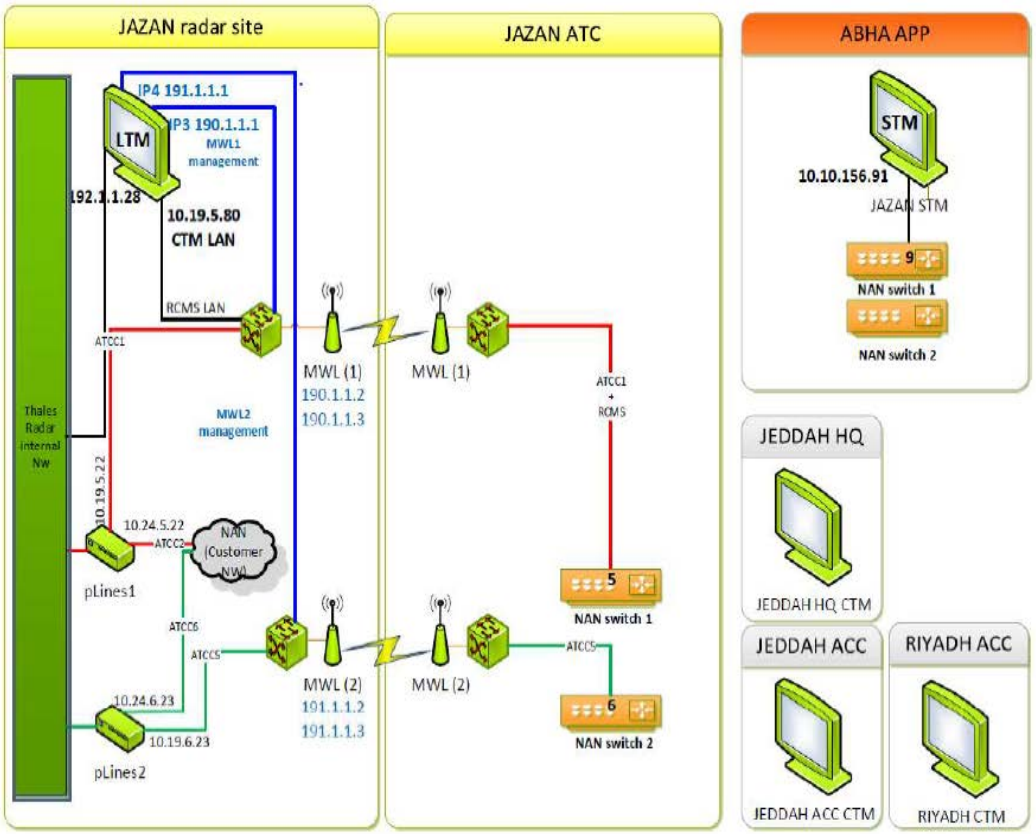
2) Integration with ATM system:

a) Deep checking and analysis of the Data availability at Local Control and Monitoring System (LCMS) & Remote Control and Monitoring System (RCMS) Technical Positions after Microwave link ancillaries connection and Data reliability on Trackers Positions at the Maintenance Management System (MMS) in the HQ Maintenance Control building. A demonstration on MMS capabilities can be offered on request.

b) Connection of the surveillance data serving Jazan approach to the ATM system Simulator

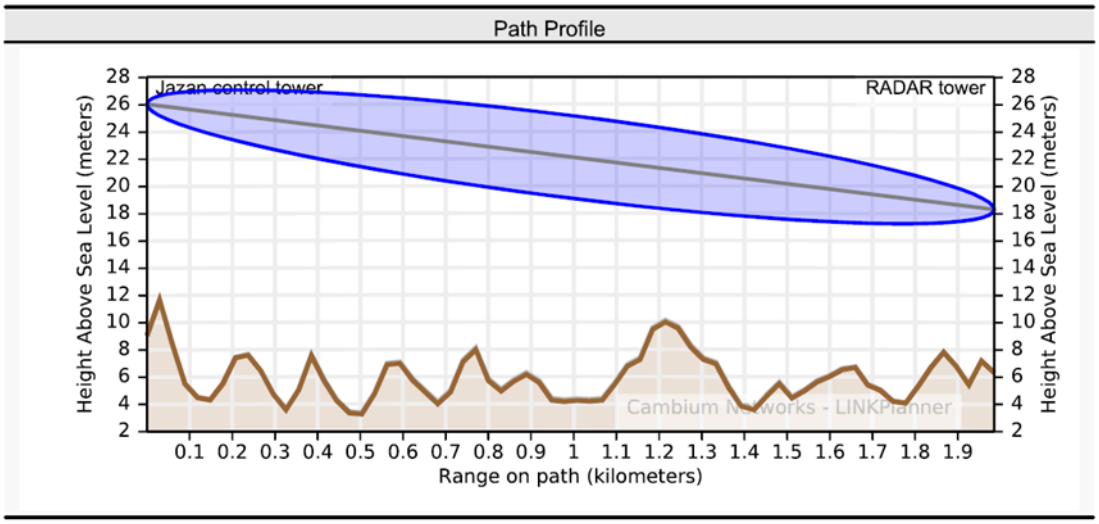
c) Evaluation of the Surveillance Data integrity, reliability, and availability by APP ATCOs on the Simulator and Automation/Surveillance Technical Team on the Control and Monitoring Display (CMD) Positions

d) Analysis of the evaluation and report submission with safety assessment and safety requirements implementation to General Authority of Civil Aviation (GACA) for regulatory approval



3) Operations and Maintenance

a) Successful migration and integration of systems to network considering selected sites as illustrated hereafter.
b) Continuous monitoring of the Microwave Links (MWLs).
c) Development of Safeguarding criteria and measures with the Airport Authority in order to protect the MWLs Line of Sight.


Path Profile
Jazan control tower
RADAR tower
Height Above Sea Level (meters)
Range on path (kilometers)
Cambium Networks - LINKPlanner

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