2.1.2 Standard and Reference

The manufacturing facility shall be certified to the following standards. Valid certificates from accredited bodies shall be submitted for evaluation.

- ISO 14001 Environmental Management
- ISO 9001 Quality Management
- ISO 27001 Information Security Management

2.2 RECORDING SYSTEM GENERAL REQUIREMENTS

2.2.1 The Tenderer shall provide detailed information about the proposed Recording System, including its components, functions, and other relevant details.

2.2.1.1 The recording system **must be ATC Recording System in Air Traffic Control Systems with a fully IP architecture,** including voice recording of radio communications, voice recording of telephone communications, Voice Recording Environments, and the signal used for all relevant proposed in Air Traffic Control should be recorded.

2.2.1.2 The recording system must continuously store all active audio channels and retain over 180 days. (Internal storage is not deleted)

2.2.1.3 The recorded data must be stored for at **least 180 days** with **CODEC standard G.711**

2.2.1.4 Ambience Channel uses **100% Utilization.** Ambience Data must be stored **at least 180 days**

2.2.1.5 All Channels (except Ambience) use 35% Utilization**.** All data/audio must be stored for at least 180 days.

2.2.1.6 The Tenderer must submit a detailed storage calculation for the Recorder Storage to Keep Data 180 Days and **NAS or SAN** Storage to Keep Data 360 Days.

2.2.1.7 The recording system must **support the Graphical User Interface (GUI)** for system setup and recorder configuration.

2.2.1.8 The Tenderer shall **provide the product description** of the proposed **recorder units detailing functionalities**, capabilities, and benefits.

2.2.1.9 The recording system architecture must have enough simultaneous voice paths to carry the maximum offered voice traffic to the recording system.

2.2.1.10 The Tenderer shall **provide details of the capacity** of **duplex Analogue Audio Channels, VoIP Channel** that can simultaneously be recorded in the recorder units.

2.2.1.11 The Tenderer shall **provide details of** the capability to duplicate recordings to the standard Analogue recording and VoIP ED-137 recording Architecture.

2.2.1.12 The recording system design **shall allow the expansion of the system capacity by the addition of VoIP and Analog Gateway units or modules.**

2.2.1.13 The Tenderer shall **provide channel's expansion to maximum capacity** for each recorder unit.

2.2.1.14 The Tenderer shall **provide details of the synchronization mechanism** between the Recording System's clock and GPS master clock.

2.2.1.15 The Tenderer shall **provide details of the synchronization mechanism** between the Recording System's **clock and multiple NTP master clocks.**

2.2.1.16 The Tenderer shall **provide details of** the **synchronization methodology between the corresponding output from the Replay feature** and other relevant recordings capability of the replay units.

2.2.1.17 The recorder unit shall be capable of time **synchronization with** an external **multiple NTP at least 2 Target IP Addresses**

2.2.1.18 The Tenderer shall **provide details of** the **recording capacity** (in **terms of hours of recording**) for the archival media of the recorder units without necessitating any operator involvement.

2.2.1.19 The Tenderer shall **provide details of** the **recorded content,** such as **time stamps, additional data of the recorder units.** In case VoIP shall **provide details of** the metadata of Recording Call Properties.

2.2.1.20 The Tenderer shall **provide details of** the capability, capacity and performance of **archival media types of the recorder units.**

2.2.1.21 The system must be able to **automatically back up data from internal Hard Disk to Archive** Media (NAS or SAN).

2.2.1.22 The Tenderer shall **provide details of** the capability and performance of the **short-term media type of the recorder units.** (The short-term media type is specified to store **the latest 180 days of data online.**)

2.2.1.23 The Tenderer shall **provide details of** the capability and performance of **simultaneous recording and replay of the recorder units.** (Such as maximum time used for **query data** records in **the short-term** media **and long-term** media.)

2.2.1.24 The Tenderer shall **provide details of the configuration**, type, and performance of the media used for **short-term media recording in the recorder units.**

2.2.1.25 The Tenderer shall **provide details of the simultaneous recording capability between short-term media and archival media** of the recorder units.

2.2.1.26 The Tenderer shall **provide details of the retrieval** from **both short-term media and archival media**

2.2.1.27 Recorded audio must be able to be copied or **exported** in the form of a data file to be replayed to an external file in a standard format, such as **WAV, etc.**

2.2.1.28 Recording Systems must be able to manage Incident cases for support, backup/export of data with security encryption, and must be able to playback in offline mode with security requirements.

2.2.1.29 The Tenderer shall provide details of the capability and configuration of the interconnection between the Workstation Unit and the Recording System.

2.2.1.30 The Tenderer shall **provide the product description of the Workstation units detailing functionalities, capabilities, and benefits.**

2.2.1.31 The Tenderer must specify the details of the proposed system's capabilities, such as the maximum number of analog voice records, VoIP records and screen that the system can operate and the ability to expand in the future.

2.2.1.32 The Tenderer shall provide several simultaneous duplex channels for live monitoring, with at least 32 channels of the Recording System at the same time.

2.2.1.33 The voice recording system shall ensure that the delay between the reception of the audio signal and live monitoring shall not exceed 5 seconds.

2.2.1.34 **Playback Query** must be able to determine the conditions for search by channel name, date, and time or by specifying the desired channel.

2.2.1.35 **Query or Playback** of recorder shall be possible **without interruption** to normal operation of recorder.

2.2.1.36 **Playback and live monitoring feature should be on the activity view,** Users can playback or live monitor in the same main window (activity view)

2.2.1.37 The **Channel Selection area is a tree view or list view for presentation of all the sources** (channels) recorded in the system. Channel name of source can be search or filter

2.2.1.38 **Each source can be selected for presentation in the activity view,** for viewing data activity. Also, each source can be enabled or disabled for playback.

2.2.1.39 **Activity View plots the graphics data recorded on selected channels** on a timeline to see where data has been recorded.

2.2.1.40 **The timeline of activity view can be varied** from quick selection

2.2.1.41 The Tenderer shall provide the details of **the variable playback speed, pitch interval and loop interval controller capability and all control functions to play** the replay units.

2.2.1.42 Replay Control must be able to replay by date and time selection and also control start, pause, stop, loop, speaker on/mute each channel and etc.

2.2.1.43 The Recording Systems must have a built-in Speech-to-text integration function for investigation. An accurate transcript should achieve a minimum accuracy rate of 90% and include timestamps to provide evidence of its accuracy.

2.2.1.44 The Recording Systems should restrict access to authorized users, with secure logins and role-based permissions.

2.2.1.45 The Recording Systems have Audit Trails. To maintain system integrity, recording systems must log access and configuration changes.

2.2.1.46 The recording system software must be able to access to real-time data being processed by the sampling and possible to adjust the analog input signal settings to suit the actual recorded audio signal by managing the tuning of the analog inputs from each channel, displaying the signal level graphically, and also being able to listen to the live signal while adjusting settings.

2.2.1.47 The Tenderer shall **provide details of** all **alert/alarm indication methods, audible, and message events.**

2.2.1.48 The Tenderer shall **provide details of** all **alert/alarm indication methods, audible, and message, when each channel is inactive or not recording.**

2.2.1.49 When the Recorder Unit crashes, the **alert/alarm status** must be **displayed as graphic and audio at the recorder and workstation**

2.2.1.50 The Recording Systems **must notify the user activity or export activity.**

2.2.1.51 The recording unit can be monitored using the Simple Network Management Protocol (SNMP). Which SNMP monitoring software included (Unlimited License) and **support SNMP V2C, V3**

2.2.1.52 The contractor **shall provide a full software license for** workstation units that detail the recorded content, such as time stamps, which will be displayed.

2.2.1.53 The Contractor shall provide a **list of all necessary standards documents** and Interface Control Document (**ICD**) with regards to the Recording System between **CCMS** (AEROTHAI's Communication Control Monitoring System) **information exchange**. That means included of all API manuals.

2.2.1.54 **A roll-back feature** to the previous version(s) of recorder software shall be possible.

2.2.1.55 Recorder Server can support RADIUS (Remote Authentication Dial-In User Service) or LDAP Authentication

2.2.1.56 The Recording & Replay System has been designed for synchronize recording analog, VoIP **and screen** recording solutions and synchronous playback of all recording sources

2.2.1.57 Replay System capable to Channel Selection area is a tree view presentation of all the sources (channels) recorded in the system, grouped by type of source, such as audio, screen etc. The tree is an integrated view of sources handled by all recorders in a distributed system.

2.2.1.58 The Replay System in activity view shall be able to adjust the timeline, which must vary from at least 10 minutes up to 12 hours

2.2.1.59 The Replay System shall allow users to view the screen recording as an add-on to the replay client.

2.2.1.60 The Recording system **shall export screen media files** in a standard format and shall synchronize with audio playback and shall be to export **selected audio and video channel into one file, e.g. mp4** or etc.

2.2.1.61 The tenderer shall submit, at a minimum, the following documentation of the system's capabilities: a user manual, a system operation manual, a technical manual, a hardware manual, and a manual demonstrating all functions that the system can perform with the submission for evaluation of the Recording software qualification.

2.2.1.62 Playback and live monitoring function shall not interruption to recording operation.

2.3 EQUIPMENT UNIT REQUIREMENT

2.3.1 Recorder Server

2.3.1.1 The size of the Recorder Unit must be 1U to 2U rack-mounted server

2.3.1.2 Recorder **Power Supply Units (PSUs)** shall be **Redundant hot-pluggable** power supplies, dual 750W or higher, supporting high-efficiency levels.

2.3.1.3 Recorder **Power Supply Units (PSUs)** type N+1 power redundancy can be set up if one power supply fails, the extra (redundant) power supply will automatically take over, allowing the server to continue running without interruption. If the server's **fault tolerance** and **uptime,** it can handle the failure of one power unit without affecting operations.

2.3.1.4 Recorder Unit Processor CPU Configuration: Dual-socket server configuration with **Installed 2 CPU 3rd Generation Intel Xeon**

processors, each with a minimum of 16 cores and a base frequency of 2.1 GHz or higher.

2.3.1.5 **Processor Core Count for Each processor must have a minimum of 16 physical** cores, for a total of 32 cores across the two CPUs. Higher core count processors are acceptable if they enhance performance for workload requirements

2.3.1.6 Recorder Unit **Memory Installed 256 GB** of DDR4 RDIMM or LRDIMM, and available for scalable based on the requirements, Memory Type Support for ECC (Error-Correcting Code) for data integrity.

2.3.1.7 Recorder Unit **Storage Type** is Hot-pluggable 2.5" or 3.5" drives with support for **SAS, SATA, and NVMe SSDs**. Configurable up to 24 NVMe drives or a mix of SAS/SATA drives to meet data storage requirements.

2.3.1.8 Recorder Unit **Storage** available for Data Security Optional self-encrypting drives (SED) for additional data security.

2.3.1.9 Recorder Unit Hardware RAID controller supporting RAID 0, 1, 5, 6, 10, 50, and 60 for data redundancy and performance optimization.

2.3.1.10 Recorder Server Hard Disk must install **2 Group with RAID** (Hot Swapped) first **Group RAID for OS, second Group RAID for Data Record Store**

2.3.1.11 Recorder Server **Network Ports** shall install Minimum of **2 x 10GbE (Gigabit Ethernet)** ports, with options for expansion to support additional network interfaces as required.

2.3.1.12 Recorder Server shall be Thermal Management for Advanced cooling technology with adaptive fan control to maintain optimal operating temperatures under heavy loads.

2.3.1.13 Recorder Server shall be available for PCIe Slots. Minimum of 6 PCIe Gen4 slots to allow for additional expansion cards, such as network or storage controllers.

2.3.1.14 Recorder Server shall have GPU support, capable of supporting one or more GPUs (if required for specific applications).

2.3.1.15 Recorder Server must have Management Port: Dedicated 1 x RJ45 management port for remote monitoring and server management as follows:

a) Recorder Server should be individual, and each server must be equipped with an RJ45 Ethernet port **dedicated for out-of-band management**. This port enables remote server monitoring, configuration, and maintenance independently of the server's operating system. Accepted management interfaces included

b) **Remote Management Capabilities.** The server's integrated remote management system should be supported.

c) **Remote System Reboots and Power Control** Allows administrators to restart or shut down the server remotely.

d) **Health Monitoring: Provides real-time** monitoring of system status, including temperature, power supply, and hardware health.

e) **Firmware and BIOS Updates** Capable of remotely updating firmware and BIOS to maintain security and performance standards.

f) **Secure Access** to remote management should be encrypted (e.g., via HTTPS) to ensure data security.

g) Network Requirements: The management port should be accessible over an internal, secure network to prevent unauthorized external access.

h) The server should support the gigabit Ethernet (1000BASE-T) for the RJ45 management port, ensuring high-speed communication between servers and management consoles.

2.3.1.16 **Compatible Operating Systems** with major operating systems including Windows Server, Red Hat Enterprise Linux, SUSE Linux Enterprise Server, VMware ESXi.

2.3.1.17 Recorder Server Fully **supports virtualization** technologies for consolidating workloads and efficient resource management.

2.3.1.18 Compliance and Standards Certifications: Meets Energy Star, CE, and RoHS standards for environmental and energy compliance.

2.3.1.19 Reliability Standards: Designed to meet 24x7 uptime requirements with enterprise-grade hardware reliability.

2.3.2 Analogue Voice Gateway Recording

2.3.2.1 **Analog audio lines convert to VoIP** also support via Ethernet connections (External Unit) from same of Manufacturer Brand. Analog Voice Gateway shall be Supports two power sources AC+AC or AC+DC or DC+DC

2.3.2.2 Analog Audio Converter must have **LEDs or LCD to indicating** power, and recording process status.

2.3.2.3 Analog Audio feature available in management is tuning of analogue inputs for each individual channel. The signal is displayed graphically, and it is also possible to listen to the signal. Parameters can be set using the graphical display

2.3.2.4 Analog Audio conversion **preferred codecs** are presently **G711 (A-law)**

2.3.2.5 Analog Audio recording at least **8** channels per unit or per card.

2.3.2.6 Analog Audio must meet the frequency response between **300 to 3,400 Hz (Hertz).**

2.3.2.7 Analog Audio **line input impedance** shall be selectable **600 ohms or Hi Impedance.**

2.3.2.8 Analog Audio Total Harmonic Distortion **(THD)**. Each channel must not exceed 5% per channel

2.3.2.9 Analog Audio **input sensitivity** range at **least -30dBm to +5dBm**

2.3.2.10 Analog Audio input for each channel must have an **independent AGC function,** which should be selectable from software setup.

2.3.2.11 Signal-to-Noise Ratio **(SNR)** shall be better than **60dB**

2.3.2.12 Crosstalk between **adjacent** channels shall be less than **-60 dB**

2.3.2.13 Analog input channel must be able to **record from threshold voice level, ambient mic and analog telephone line**

2.3.2.14 Each channel **recording mode** can be **adjusted independently.**

2.3.2.15 Each channel can be set up with an **individual gain** to match the amplitude of the signal to the range of the AD converter. This gives optimal dynamic range of the signal.

2.3.3 VoIP Recording License (VoIP ED-137)

2.3.3.1 Audio Encoding in ED-137 specifies using G.711 (64 kbps) CODECS for high-quality audio and efficient bandwidth use.

2.3.3.2 Signal-to-Noise Ratio (SNR) The standard requires a high SNR to ensure voice clarity, typically **at 50 dB or higher.**

2.3.3.3 Packet Loss and Latency acceptable limits for **packet loss below 1%** particularly critical for recording clarity and real-time playback.

2.3.3.4 Failover Mechanisms of VoIP Systems must incorporate automatic failovers to ensure continuous recording in case of hardware or network issues.

2.3.3.5 Dual Recording VoIP ED-137 design for dual or redundant recording paths to avoid data loss.

2.3.3.6 Time Synchronization Accurate timestamps for replaying and correlating recordings with other data sources. ED-137 requires synchronization with an accurate NTP time source shall **be better than 10 milliseconds**

2.3.3.7 Session Initiation Protocol (SIP) and RTP/RTCP in ED-137 uses SIP to establish and manage calls between ATC entities. The recording system must support SIP to handle call setup and teardown reliably. From all of the above in this topic if use RTSP must support and handle at least RTSP state such as GET, RECORD, PAUSE, TEARDOWN.

2.3.3.8 The recording system should fully support RTSP or RTP and RTCP for Media Transmission used for streaming audio, while Real-Time Control Protocol (RTCP) monitors and controls the quality of service, captures and monitor voice data accurately.

2.3.3.9 Interoperable with ED-137 Equipment, the recording system must be compatible with other ED-137-compliant equipment, including ATC radios, ATC VCCS and other VoIP ED-137 communication devices.

2.3.3.10 The recording system should be scalable to accommodate future expansions, such as additional VoIP channels and **screen record channel.**

2.3.3.11 The system **should provide instant playback functionality for quick access during real-time monitoring.**

2.3.3.12 VoIP ED-137 recorded data should be searchable by criteria like time start/stop, channel name, callerID, callingID, FrequencyID

2.3.3.13 The voice recording system software shall be capable of **displaying logs, events, or activity** indicators **when VoIP ED-137 signals are being received** by the recording system, in order to notify the user.

2.3.4 Ambient Audio Interface Unit

2.3.4.1 The Ambient Audio Interface Unit shall provide ambient and operational audio capture for Air Traffic Control (ATC) environments. It shall support connection to microphones installed at each ATC Controller Working Position (CWP) and shall transmit audio over the IP network (LAN) for recording and monitoring purposes, or operate in accordance with the architecture and design of the proposed VCCS system, provided that the functionality and recording performance are fully maintained.

2.3.4.2 Ambient microphones shall be installed for all Controller Working Positions (CWP) in accordance with the number and configuration of CWPs defined in the VCCS system design.

2.3.4.3 The Ambient Audio Interface Unit may be provided as An integrated unit within the VCCS system, or A dedicated unit within the Voice Recorder (DVR) system, provided that full functional compatibility with the overall recording system is ensured.

2.3.4.4 The Ambient Audio Interface Unit shall support analog-to-digital audio conversion and transmission over IP (VoIP), or operate according to the native architecture and technology of the proposed VCCS or Voice Recorder, while ensuring reliable audio recording quality.

2.3.5 Archive Media Unit (NAS or SAN)

2.3.5.1 Form Factor 1U-2U Rackmount

2.3.5.2 Processor (CPU) Intel Xeon Scalable Gen4 or higher

2.3.5.3 CPU Configuration 1 × Xeon Silver 4410Y (12C/24T, 2.0 GHz) or higher; Dual CPU capable

2.3.5.4 Chipset Intel C741 or higher

2.3.5.5 Memory Type DDR5 ECC RDIMM (4800 MT/s) or higher

2.3.5.6 Memory Slots / Max Capacity 32 DIMM slots / up to 8 TB or higher

2.3.5.7 Standard Memory Installed at least 64 GB

2.3.5.8 Drive Bays (Front) at least 8 × LFF (3.5") or 12 × SFF (2.5"), hot-swap

2.3.5.9 Supported Drive Types at least SATA/SAS/NVMe

2.3.5.10 RAID Controller shall support at least RAID 0/1/5/6/10

2.3.5.11 User Management shall support LDAP and AD integration

2.3.5.12 Archive Media shall connect to existing LAN infrastructure and Network Interface at least 4 × 1GbE + 2 × 10GbE SFP+

2.3.5.13 Power Supply Redundant

2.3.5.14 Install and configure the Archive Media operating system shall supports at least TrueNAS and OpenMediaVault

2.3.5.15 Supported Protocols at least SMB/NFS/FTP

2.3.5.16 File System support ZFS or equivalent

2.3.5.17 Management Interface Web GUI / CLI / SNMP

2.3.5.18 Archive Media shall have a built-in **redundancy power supply** and be able to store audio files at **least 360 days**

2.3.5.19 The Archive Media Unit must have two sets per system as Table 1.

2.3.5.20 Each Archive media shall be able to store audio files at least 360 days at 100% utilization with ambience and 50% with CWP, Radio, Telephone etc.

2.3.5.21 Each Archive Media **Hard Disk shall be qualified. Hot-Swappable Removable** hard disk can be replaced immediately without shutdown and continuous operation.

2.3.5.22 The system must be remote control accessible to stop or start, reboot, log off, Shut down and also monitor using SNMP such as recording status, CPU, memory and disk usage display.

2.3.6 Storage Data Center (SAN)

2.3.6.1 **Storage Data Center** media shall be **SAN Storage**

2.3.6.2 **Storage Data Center** shall have a built-in **redundancy power supply** and be able to store audio files at **least 360 days**

2.3.6.3 SAN Storage is capable of delivering over **70,000 IOPS** for affordable application acceleration

2.3.6.4 SAN Drive Available Up to 24 Slot SFF HDD and/or SSD

2.3.6.5 Capacity for total array are **installed for ready to use 128TB** capacity can upgrade with maximum expansion **at least 192TB**

2.3.6.6 Storage controller 2 per array, 2-ports each (4-ports total)

2.3.6.7 The Storage Data Center must have two sets as Table 1.

2.3.6.8 Each SAN media shall be able to store audio files at least 360 days at 100% utilization with ambience and 50% with CWP, Radio, Telephone etc.

2.3.6.9 Each SAN media shall support RAID 1, 5, 6, 10

2.3.6.10 Each SAN Media **Hard Disk shall be qualified. Hot-Swappable Removable** hard disk can be replaced immediately without shutdown and continuous operation.

2.3.6.11 The system must be remote control accessible to stop or start, reboot, log off, Shut down and also monitor using SNMP such as recording status, CPU, memory and disk usage display.

2.3.6.12 Each SAN media shall be able to operate on a Gigabit Ethernet LAN and have at least two interface port

2.3.6.13 SAN Unit Type 19-inch Rackmount

2.3.7 Management Server for SAN

2.3.7.1 The **size of the Management Server Unit** shall be **1U rack-mounted** server.

2.3.7.2 Management Server Power Supply Units **(PSUs)** shall be **redundant hot-pluggable power supplies**

2.3.7.3 The Management Server shall support **N+1 power redundancy**, such that failure of one PSU does not interrupt system operation.

2.3.7.4 Management Server Processor **CPU Configuration Dual-socket server** configuration supporting **2 x Intel Xeon Scalable 4th/5th Generation processors**, each with minimum **16 cores**, base frequency ≥ **2.1 GHz**.

2.3.7.5 Each processor shall have a minimum of **16 physical cores, total minimum 32 cores**. Higher core counts are acceptable.

2.3.7.6 Memory Installed minimum **256 GB DDR5 RDIMM**, scalable, with full **ECC support**.

2.3.7.7 Support **hot-pluggable 2.5" SFF drives** with support for **SAS, SATA, and NVMe SSDs**, configurable at least **8 SFF bays** depending on chassis.

2.3.7.8 Support for **Self-Encrypting Drives (SED)** for data security.

2.3.7.9 **Hardware RAID Controller** Shall support at least **RAID 0, 1, 5, 6, 10, 50 and 60**.

2.3.7.10 Server shall support installation of **two separate RAID groups.** RAID group for Operating System and Installed RAID group for Data / VM storage

2.3.7.11 Network Interfaces Minimum **2 x 10GbE ports**, with support for expansion via PCIe.

2.3.7.12 Thermal Management Advanced cooling with intelligent fan control to maintain stability under continuous load.

2.3.7.13 Expansion Slots shall support **Minimum 4 PCIe Gen4/Gen5 expansion slots** (including risers + OCP or mezzanine)

2.3.7.14 Management Server shall support **GPU installation** (if required for future workloads).

2.3.7.15 Management Port and Remote Management Server must include dedicated **1 x RJ45 out-of-band management port** supporting Dedicated management per server, Remote management via web interface, Remote power on/off/reset, Hardware health monitoring (temperature, PSU, fan, storage, CPU, memory), Remote firmware and BIOS updates, Secure encrypted access (HTTPS, TLS), Designed for secure internal management network, Supports **1GbE RJ45** management interface

2.3.7.16 Operating System Compatibility Shall support OS at least fallowing Microsoft Windows Server, Red Hat Enterprise Linux, SUSE Linux Enterprise, VMware ESXi.

2.3.7.17 Management Server shall be Virtualization Support and Pre-installed Management VM. The Management Server shall fully support virtualization technologies, including VMware, Microsoft Hyper-V, and KVM. The server shall be delivered with pre-installed and fully configured Virtual Machine(s) ready for use for the purpose of managing the SAN Unit. All required software licenses must be genuine, legally licensed, and included as part of the delivery.

2.3.7.18 Compliance and Certifications Shall comply with **Energy Star, CE, RoHS**.

2.3.7.19 Reliability Designed for **24x7 continuous operation**, enterprise-grade reliability.

2.3.8 Network Switch (Storage Data Center)

2.3.8.1 The switch shall be provided with not less than **16 ports** and mounting must be contained within 19" rack

2.3.8.2 The switch shall support **Fibre Channel** and **Fibre Channel over Ethernet (FCoE)** standards for SAN environments.

2.3.8.3 The switch shall provide **wire-speed forwarding** for **Fibre Channel frames** and **Ethernet frames** over a **dual-fabric architecture** for high availability.

2.3.8.4 The switch shall support a **maximum of 4,096 VLANs** for **FCoE** and **Fibre Channel** traffic isolation across the network.

2.3.8.5 The switch shall support **802.1d Spanning Tree Protocol (STP)** or 802.1W RSTP for standard Ethernet traffic, and **Fibre Channel** zoning for SAN fabric isolation.

2.3.8.6 The switch shall support **IEEE 802.3ad Link Aggregation Control Protocol (LACP)** for aggregating Ethernet links to enhance bandwidth.

2.3.8.7 The switch shall have advanced **Quality of Service (QoS)** capabilities, including support for **Ethernet QoS (802.1p)**, ensuring **time-sensitive traffic such as voice and video** is handled with appropriate levels of priority in both **Ethernet and Fibre Channel fabrics**.

2.3.8.8 The switch shall support **auto voice capabilities** for seamless deployment of **Voice over IP (VoIP)** services, ensuring optimal delivery in **converged environments**.

2.3.8.9 The switch shall provide **full Layer 3 IP routing** for **IPv4 and IPv6** networks, including support for protocols such as **OSPF**, **EIGRP**, and **BGP**, allowing for efficient routing across **SAN and Ethernet networks**.

2.3.8.10 The switch must support **SSH (v1 and v2)** for secure management and **SCP (Secure Copy Protocol)** for secure file transfers, replacing **Telnet**.

2.3.8.11 The switch shall support **802.1X for RADIUS authentication**, offering robust security features such as **Dynamic VLAN Assignment** and **guest VLAN support** for **network access control**.

2.3.8.12 The switch shall be able to **lock Source MAC addresses to ports** and limit the number of learned MAC addresses to enhance **network security**.

2.3.8.13 The switch must support **TCP congestion avoidance algorithms** such as **WRED (Weighted Random Early Detection)** to **minimize TCP packet loss** across the network.

2.3.8.14 The switch shall provide **built-in Denial-of-Service (DoS) protection**, including **IP filtering, rate-limiting**, and **anti-spoofing mechanisms** for secure operations.

2.3.8.15 The switch shall include an **integrated configuration utility** accessible via a web interface (**HTTP/HTTPS**) for device management, system monitoring, and maintenance.

2.3.8.16 The switch shall support **SNMP v1, v2c, and v3**, with **SNMP v3 user-based security model (USM)** for secure network management and **traps for event notification**.

2.3.8.17 The switch shall support **embedded RMON (Remote Monitoring) software agent**, providing at least **four RMON groups: history, statistics, alarms**, and **events**, to enhance **traffic management and monitoring**.

2.3.8.18 The switch shall support **port mirroring** capabilities for analyzing traffic, with the ability to mirror up to **8 source ports to a single destination port** for network troubleshooting and performance analysis.

2.3.8.19 The switch shall support **IEEE 802.3af PoE** and **IEEE 802.3at PoE+** standards, delivering **intelligent power management** for devices such as **IP phones** and **access points**, with the ability to allocate power efficiently across multiple devices.

2.3.8.20 The switch offer a **minimum throughput of 88 Gbps** (for 24-port model) or higher, ensuring **high bandwidth availability** for both **Ethernet and Fibre Channel traffic**.

2.3.8.21 The switch shall have a **switching capacity of at least 176 Gbps**, with the ability to scale efficiently and support **SAN traffic** along with **Ethernet-based workloads**.

2.3.8.22 **Dual redundant power supplies (RPS)** shall be supported for **uninterrupted operation** in mission-critical environments.

2.3.8.23 The switch shall include a **minimum of 4 GB of flash memory** to store configurations, logs, and operational data.

2.3.8.24 The switch shall support **real-time monitoring** via **Syslog**, **SPAN**, and **sFlow/NetFlow**, enabling comprehensive visibility into both **Ethernet and SAN traffic** for network optimization.

2.3.8.25 **Support Managed multiple switches** shall allow multiple switches to be **scalability**.

2.3.8.26 The Network Switch shall support **multi-protocol** operations, including **Fibre Channel, and FCoE** to ensure compatibility with a wide variety of storage environments, included Fiber and FCoE sufficient modules suitable for ready to use.

2.3.8.27 **Fibre Channel ports** supporting speeds of **16/32 Gbps**, which is essential for high-performance storage environments.

2.3.8.28 The switch provides advanced **SAN zoning** for secure and isolated traffic flows within the storage network, ensuring optimal performance and security.

2.3.8.29 **The switch** supported **Virtual Port Channels (vPC)** to provide a single logical link across multiple switches for better redundancy and load balancing.

2.3.9 Network Switch (Recording System and Analog Voice Gateway)

2.3.9.1 **The Ethernet switch shall be provided with not less than 24 ports and mounting must be contained within 19" rack**

2.3.9.2 Ethernet switch shall be standard 802.1d Spanning Tree support

2.3.9.3 Ethernet switch shall be support for IEEE 802.3ad Link Aggregation Control Protocol (LACP)

2.3.9.4 Ethernet switch shall be support at least 4096 VLANs simultaneously Port based and 802.1Q tag-based VLANs MACbased VLAN and Management VLAN

2.3.9.5 Ethernet switch's voice traffic shall be automatically assigned to a voice-specific VLAN and treated with appropriate levels of QoS.

2.3.9.6 The Ethernet switch shall support advanced Quality of Service (QoS) features, including traffic prioritization, congestion avoidance, traffic

shaping, and policing to ensure the optimal handling of time-sensitive traffic such as voice and video.

2.3.9.7 Ethernet switch's auto voice capabilities deliver network-wide zero touch.

2.3.9.8 deployment of voice endpoints and call control devices.

2.3.9.9 Ethernet switch shall be wire speed routing of IPv4 packets

2.3.9.10 The Ethernet switch shall support industry-standard Layer 3 routing protocols such as OSPF, EIGRP, and BGP to enable efficient routing across the network.

2.3.9.11 Ethernet switch must have SSH which is a secure replacement for Telnet traffic.

2.3.9.12 SCP also uses SSH. SSH v1 and v2 are supported

2.3.9.13 Ethernet switch shall be support for 802.1X: RADIUS authentication and accounting, MD5 hash; guest VLAN; unauthenticated VLAN, single/multiple host mode and single/multiple sessions Supports time-based 802.1X Dynamic VLAN assignment

2.3.9.14 Ethernet switch shall be able to lock Source MAC addresses to ports and limit the number of learned MAC addresses.

2.3.9.15 A TCP congestion avoidance algorithm is required to minimize and prevent global TCP loss synchronization.

2.3.9.16 Ethernet switch must have Denial-of-Service (DOS) attack prevention

2.3.9.17 Built-in Ethernet switch configuration utility for easy browser-based device configuration (HTTP/HTTPS). Supports configuration, system dashboard, system maintenance, and monitoring.

2.3.9.18 Ethernet switch shall be support SNMP versions 1, 2c, and 3 with support for traps, and SNMP version 3 user-based security model (USM)

2.3.9.19 Ethernet switch shall be support embedded RMON software agent supports 4 RMON groups (history, statistics, alarms, and events) for enhance traffic management, monitoring, and analysis

2.3.9.20 The traffic on a port can be mirrored to another port for analysis with a network analyzer or RMON probe. Up to 8 source ports can be mirrored to one destination port. A single session is supported.

2.3.9.21 The Ethernet switch shall support IEEE 802.3af PoE and IEEE 802.3at PoE+ standards, with intelligent power management that optimizes power distribution for efficient energy use while delivering adequate power to devices such as IP phones and access points.

2.3.9.22 Minimum throughput of 88 Gbps (for 24-port model) or higher.

2.3.9.23 Switching capacity: At least 176 Gbps.

2.3.9.24 Dual redundant power supply (RPS) support is preferred for uninterrupted operation.

2.3.9.25 Flash Memory: Minimum of 4 GB.

2.3.9.26 Telemetry and Monitoring for Real-time monitoring support with Syslog, SPAN, and sFlow/NetFlow.

2.3.9.27 Stacking Capability: The switch must support Stack technology, allowing multiple switches to be interconnected into a single logical unit.

2.3.9.28 Stacking Bandwidth: Minimum stacking bandwidth of 160 Gbps to enable high speed data transfers and seamless traffic distribution across the stack.

2.3.9.29 Scalability: Capable of stacking up to 8 switches to accommodate network growth without significant reconfiguration or additional hardware.

2.3.10 Recorder Loudspeaker

2.3.10.1 The Recorder Loudspeaker At least 2-Channel Input.

2.3.10.2 The Recorder Loudspeaker shall be Network-Based for Web Control, Configuration and allow rebooting from the remote.

2.3.10.3 The Recorder Loudspeaker must be an integrated power indicator when the system is powered and ready for use.

2.3.10.4 The Knob Volume can control speakers, headphones, and the analog outputs. When the Volume control is turned, a graphic will appear at the Front Meter Display screen

2.3.10.5 The unit has a built-in stereo amplifier and compact speakers for high audio quality.

2.3.10.6 A headset or Aux shall be connected at the front or back panel.

2.3.10.7 The Recorder Loudspeaker unit shall be Graphic screen for Audio Meter.

2.3.11 Workstation Unit

2.3.11.1 Tower workstation

2.3.11.2 CPU Type at least Intel Core i9 Gen14th or equivalent, supporting high-performance workloads

2.3.11.3 Core Count, **Minimum of 24 cores, 32 threads,** physical cores with multithreading support, scalable up to higher core counts if required for specific applications.

2.3.11.4 Base Frequency **Minimum base clock speed of 3.0 GHz** or higher, with Turbo Boost technology for increased performance under heavy workloads.

2.3.11.5 Memory Type ECC (Error-Correcting Code) **DDR4 or DDR5** memory for data reliability.

2.3.11.6 Memory Capacity Minimum **64 GB installed**, with expansion capability up to 128 GB or more to support memory-intensive applications.

2.3.11.7 **Memory Speed** 2933 MT/s or higher to ensure fast data access and system responsiveness.

2.3.11.8 **Primary Storage**: At least **1 TB NVMe SSD** for the operating system and primary applications, ensuring fast read/write performance.

2.3.11.9 **Secondary Storage** Additional **1 TB HDD or SSD** for data storage, with support for RAID 1 or RAID 5 for data redundancy.

2.3.11.10 **Storage Expandability** Capability to add additional drives, with support for at least **4 x 3.5" or 2.5" storage bays**.

2.3.11.11 **GPU** with at least 16 **GB of dedicated VRAM**

2.3.11.12 Multi-Monitor Support, Capable of supporting up to 4 monitors for multitasking and enhanced productivity.

2.3.11.13 **Ethernet** Integrated **1 x Gigabit Ethernet (GbE) RJ45** port, with optional installed **1 GbE (Summary Ready to Use 2 Port GbE)**

2.3.11.14 Wireless Connectivity Wi-Fi and Bluetooth module for wireless network access

2.3.11.15 **USB Ports**: Minimum of **4 x USB 3.1/3.2 ports** (including front and rear accesses) for high-speed connectivity with external devices.

2.3.11.16 **PCIe Expansion Slots,** Minimum of **2 PCIe slots** (Gen3 or higher) for additional cards such as GPU, RAID controller, or network cards.

2.3.11.17 Audio Ports Integrated audio with front and rear 3.5mm jacks for headphones and microphone support.

2.3.11.18 Power Supply, Minimum 80 PLUS Platinum power supply for reliable operation under heavy workloads and covers support for additional graphics cards and network cards.

2.3.11.19 Operating System **Windows 11 Pro 64-bit license or Linux**

2.3.11.20 **Software Antiviruses include license at least 5 Year**

2.3.11.21 The minimum size of the display screen must be 27 inches diagonal.

2.3.11.22 **Resolution**: at least 2560 x 1440 (QHD) for sharp, clear visuals

2.3.11.23 **Aspect Ratio**: at least 16:9 widescreen

2.3.11.24 **Contrast Ratio**: 1000:1 typical (static contrast) for deep blacks and bright whites.

2.3.11.25 **Video Ports**: Must include the following ports for versatile connectivity **1 x HDMI,** 1 x DisplayPort 1.2, 1 x Mini DisplayPort 1.

2.3.11.26 **Audio Out**: 3.5mm audio output port for connecting external audio devices.

2.3.11.27 **Response Time**: 6 ms (gray-to-gray) in Fast mode, suitable for smooth image transitions without blurring in typical usage.

2.3.11.28 **Warranty**: Minimum **5-year warranty** with advanced exchange service.

2.3.11.29 Wireless Premium Keyboard & Mouse Combo, **Full-size keyboard with dedicated numeric keypad,** Ergonomic wireless mouse with an ambidextrous design suitable for both right- and left-handed users, Connectivity Dual-mode wireless connectivity, supporting both **Bluetooth 4.0** and **2.4 GHz USB receiver,**

2.3.11.30 Soundbar speaker: 2 channels, 5 watts, built-in microphone, call pick-up button.

2.3.12 Power Distribution

2.3.12.1 Power distribution unit (PDU) Delivers AC power to servers, equipment, and connected devices via a power distribution unit.

2.3.12.2 Support Remote access and configuration are available through secure Web, SNMP, CLI or Telnet interfaces.

2.3.12.3 Local Display for local monitoring and alert indications: Voltage and Current.

2.3.12.4 Power distribution unit (PDU) dashboard web management

2.3.12.5 Power distribution unit (PDU) minimum 20A, at least 12 AC outlet(s)

2.3.12.6 Power distribution unit (PDU) can be turned on, turned off, or recycled on demand or at programmed times to address a number of needs including remote rebooting of locked equipment.

2.3.13 LCD and KVM Slideway

2.3.13.1 LCD+KVM Over IP Access Minimum 8 x RJ-45 Port

2.3.13.2 Integrated KVM console with 19" LED-backlit LCD monitor in a dual rail housing

2.3.13.3 Supports web-friendly KVM-over-IP access with Web Client viewer

2.3.13.4 Video at Remote Resolution: at least 1920 x 1200

2.3.13.5 KVM adapter 8 set cables with automatic conversion allow flexible interface combinations (PS/2, USB, Sun and serial) to control all computer types

2.3.13.6 Dual rail housing is slightly less than 1U with top and bottom clearance for smooth operation in 1U of rack space

2.3.13.7 At least 32 user management accounts, 32 concurrent logins

2.3.13.8 Event logging, Linux-based or Windows-based Log Server support

2.4 SYSTEM INTERCONNECTION

The Tenderer shall be responsible for the complete installation and interconnection of the system in a fully integrated and operational condition. All necessary equipment, materials, cables, and accessories shall be provided in sufficient quantities to support the system operation.

The Tenderer shall supply all cables, equipment, tools, and accessories required for connecting external audio signals to be imported into the Recorder system, including installation, termination, configuration, and testing, to ensure full functionality upon delivery.

2.4.1 **Indoor Cable,** Type 24AWG 50pairs or 100pairs TPEV at least 100 meters for 4 Systems

2.4.2 The Tenderer shall prepare and install all equipment related to the installation in a complete manner. This includes all cables used for installation such as **power cables, grounding cables, network cables, and cables between the input signal and the analog audio gateway**, which shall be fully installed and ready for

operation prior to delivery. All materials shall be provided in sufficient quantities for the entire installation.

2.4.3 The Tenderer shall supply and deliver additional spare LAN cables, CAT6A, with a minimum length of 300 meters x 4 systems, together with the system delivery.

2.4.4 The Tenderer shall supply and deliver additional spare **LAN connectors RJ-45 and RJ-45 boots**, minimum **100 pieces** x **4 systems**.

2.4.5 The Tenderer shall supply and deliver **Cable Management** shall be installed for LAN and Network connections to the network switch for All System. The quantity shall be sufficient and appropriate for the complete installation.

2.4.6 The Tenderer shall supply and deliver additional spare AC Cable, VCT 450/750V 70c PVC 3x4 sq.mm. at least 100 meters x **4 systems**

2.4.7 Rack and Wiring All cables must be tagged and labeled properly.

2.4.8 The Tenderer shall supply and deliver additional spare LAN Cat6 Crimp Tools for **4 sets.**

2.4.9 The Tenderer shall supply and deliver additional spare Insertion Cutting Tools (Puch Krone) for **4 sets.**

2.4.10 The Tenderer shall supply and deliver additional spare Fiber Module and Patch Cord Cable Multi-Mode for connectivity between Storage Data Center (SAN) to Network Switch **(SAN Switch) at least 4 sets**

2.4.11 The Tenderer shall supply and deliver additional spare FCoE Gigabit Module and Cable **at least 4 sets**

2.5 ENVIRONMENTAL CONDITION

2.5.1 The recorder equipment shall be able to operate in a controlled environment of approximately 15-35°C and relative humidity of up to 70% or better.

2.5.2 The vendor shall install the rack and all voice recording system equipment at the locations specified in the TOR. This shall include signal cabling, interconnections, electrical, network connection and complete configuration, ensuring that the system is fully installed, integrated, and ready for operation upon delivery.

2.6 TECHNICAL MANUAL

2.6.1 The tenderer shall provide all technical manuals of the Recording system. (4 sets of hard copy and 30 sets of USB soft copy)

2.6.2 The technical manuals shall contain comprehensive instructions covering the installation, operation, maintenance, and troubleshooting of the system.

2.6.3 The technical manuals shall include

a) list of user and password of all systems and included user pass for database management, hardware documentation includes hardware and schematic diagram of Analog voice gateway unit, system configuration, complete installation, user manual, administration manual, operation instructions, preventive maintenance instruction and corrective maintenance instruction.

2.6.4 The Tenderer shall deliver all documentations for all equipment installed to AEROTHAI Office at Suvarnabhumi Air Traffic Control Tower.

2.7 INITIAL SPARE PART

2.7.1 Voice Recording System Table 2

2.8 ACCESSORIES AND OTHER EQUIPMENT

2.8.1 Rack Cabinet

2.8.1.1 Rack shall be a standard 19-inch 42U with wheels, slide cover, front and back doors equipped with electronic or biometric locks. The server shall be installed properly in the rack and the rack shall be able to close the front and back door properly.

2.8.1.2 An adequate cooling system shall be installed without affecting the operation of the recording system.

2.8.2 Analog Signal Connection

The signal connection points before entering the recording systems shall consist of

2.8.2.1 Module mounting panel (Back Mount Frame) size 19" Rack 15-way Recessed, sufficient quantity for signal connection.

2.8.2.2 Disconnected Module for installation in LSA Module Back Mount Frame must be able to use Disconnected Contact throughout its life and support ISO/IEC 11801 and TIA/EIA-568-A standards to have sufficient number for the signal entering the recording system.

2.8.2.3 Gas tube Arrester 3-electrode arrester type with Socket with DC Spark-Over Voltage = 230 V ± 20%, not less than 700 channels.

2.8.3 Electrical Design (AC Power Distribution)

2.8.3.1 AC Power Distribution must be installed inside a 19" Rack Cabinet, with a Main Breaker installed for the first power supply and a Main Breaker for the second power supply.

2.8.3.2 The Power Supply Modules inside both Recorder Units must have separate Circuit Breakers as follows: Power Supply Module 1 must be connected to the first power supply and Power Supply Module 2 must be connected to the second power supply.

2.8.4 Ground Cable and Ground Bus Bar

2.8.4.1 Ground Cable must be installed connecting from the device to the Ground Bus Bar inside the cabinet.

2.8.4.2 Ground Bus Bar for Device shall be installed inside a rack.

2.8.5 Label Printer

2.8.5.1 Tube & Label Printer shall be equipped with an automatic cutter with half-cut function. The printer shall provide a minimum print resolution of 180 dpi and a minimum print speed of 30 mm/sec.The printer shall support **label printing using laminated TZe tape** and **printing on PVC tubes (heat shrink tubes)**.Connectivity shall support **wireless connectivity**.The supplier shall **deliver the printer complete with accessories**, including: **Heat Shrink Tube minimum 20 packages**. **Laminated TZe Tape minimum 20 packages.**

2.8.6 Cable and Network Tester

2.8.6.1 Cable + Network Tester Color Touchscreen Interface, supports both IPv4 and IPv6 with Multi-Connector Adapter Fully Set and integrated Wi-Fi Tester, Modular platform design supporting copper cable certification certifying twisted-pair copper cabling up to Category 8 (Class I / Class II). with **frequency testing up to 2000 MHz**, supporting **10GBASE-T, 25GBASE-T, and 40GBASE-T** applications. The tester shall include main and remote units, rechargeable batteries, adapters, and a protective carrying case.

2.8.6.2 Cable + Network Tester shall perform **full ANSI/TIA and ISO/IEC compliant certification tests**, including **wire map, length, insertion loss, NEXT, PS NEXT, return loss, ACR-N, ACR-F, TCL, and delay skew**, with **fast test time** suitable for field installation and acceptance testing.

2.8.6.3 Cable + Network Tester shall support **automatic test result storage**, allowing **at least 1000 certification results** to be saved internally with **descriptive names**, reviewed on the device, and transferred to a PC via