TECHNICAL DESCRIPTION OF WEATHER RADAR FOR LUNGI INTERNATIONAL AIRPORT AND INLAND AREAS IN SIERRA LEONE

Introduction

Radar used to find precipitation, determine its motion, and determine its type is called weather radar. An essential component of every Automated Weather Observation System (AWOS) in the network of airport weather observatories is radar (Figure 1). Radars are the only meteorological monitoring device that can provide localized, incredibly detailed, timely, and three-dimensional sensing and observing capabilities. They can detect changes in precipitation rates at time intervals of the order of a few minutes, with resolutions of a few square kilometers or better. This is in addition to the ability to track quickly changing weather phenomena, which is essential for the delivery of severe and hazardous weather early warnings. This covers torrential downpours, hail, powerful winds (such tornadoes and tropical cyclones), and wind shear. Of all the meteorological factors, radar has the greatest effect on society. Information obtained by radar is particularly helpful for agricultural, aviation, and other weather-related operations.

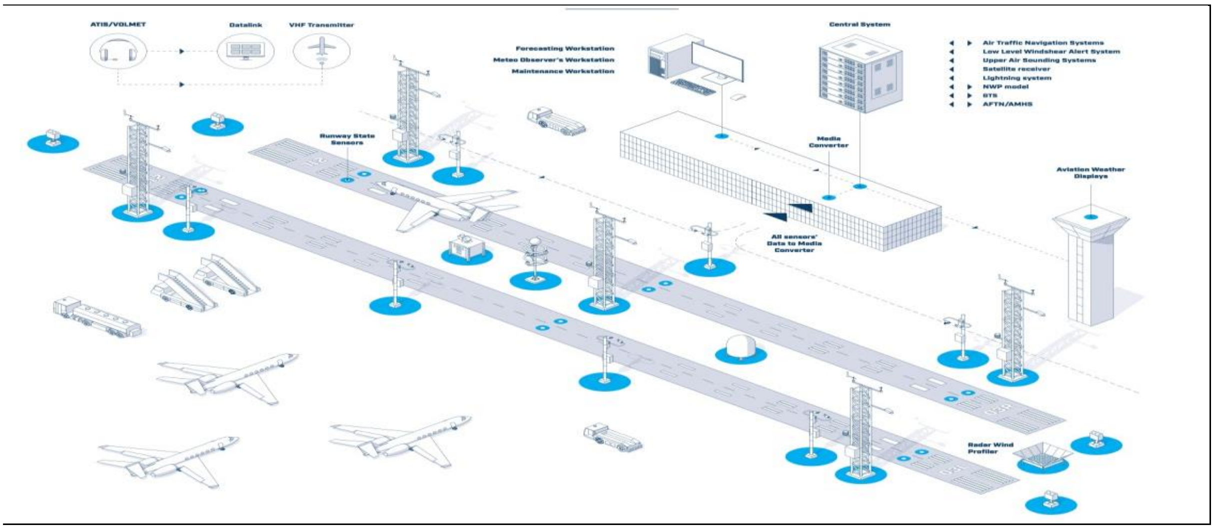

Figure 1: Setup for Automatic Weather Observation System of airport weather observing network

Lungi International Airport (LIA), often known as Freetown International Airport, is a major airport serving the coastal community of Lungi in Sierra Leone. In Sierra Leone, there is only one international airport. The capital city of Sierra Leone, Freetown, is separated from Lungi International Airport by the Sierra Leone River. The Sierra Leone Airports Authority runs the airport. It was a British Royal Air Force base before it was used as a civilian airport. A bridge to improve access between the airport and Freetown is currently being planned. The president announced the Lungi Bridge project in 2019. Parliamentary approval to allot the sum of USD $270 million for the airport development came after this announcement in December 2020. A new passenger terminal, a VIP terminal, new taxiways, and a wider runway are all included in the project. Three million passengers per year will be the capacity. On the northern side of the runway, near the eastern end, is where you'll find the new terminal.

The Sierra Leone Meteorological Agency (SLMet) at the LIA, which is directly in charge of producing and transmitting consistent, timely, and reliable weather information for the SL and international airspace, is still in need of the contemporary tools and systems necessary to provide its services. Therefore, the LIA's meteorological services must be improved. By using the information provided by SLMet to reduce climate-related risks and take advantage of opportunities brought on by extreme weather events, the improved meteorological services will benefit economic activities and increase the capacities of citizens and institutions to adapt to climate change. Improved meteorological services are among those that benefit the airlines that fly into and out of airports in Sierra Leone as well as those that fly in Sierra Leonean airspace to increase their operations' safety and profitability. This is one of the reasons why support is highly needed from the Green Climate Fund to improve the service delivery of the SLMet at the LIA. This will go a long way to improve its operations in terms of generating and delivering consistent, timely and accurate weather information for Sierra Leone and the international airspace.

Automated Weather Observation System (AWOS)

For regional, national, and international airports, the Automated Weather Observation System (AWOS) is a crucial part of the airport weather observation system. As seen in Figure 2, the AWOS collects, analyzes, records, communicates, and displays all meteorological data at the airport.

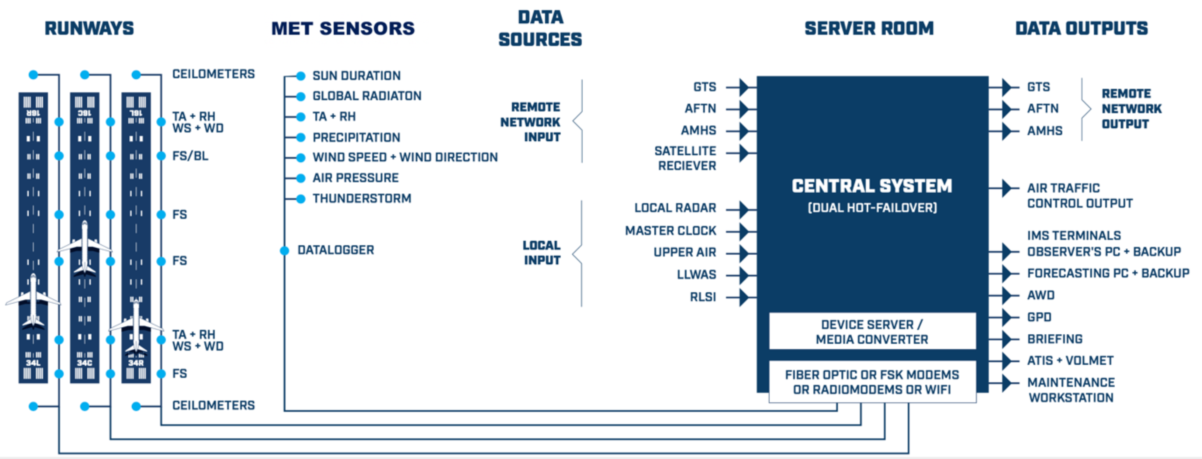

Figure 2: An ideal Automated Weather Observation System of airport weather observation

For observers, air traffic controllers, pilots, and other users, the system integrates and offers weather data in the form of real-time screens, graphs, WMO codes, alarms, and audio reports. It connects radars, low level wind shear alert systems, and upper air systems. Regardless of measurements and reporting, the AWOS is set up to follow all ICAO and WMO recommendations. It creates alerts, METAR, SPECI, SYNOP reports, national codes, and different derived meteorological data such as QNH, QFE, and Runway Visual Range. Numerous different data logger and sensor kinds can be interfaced by the system. It is built to measure, compute, and process a variety of meteorological quantities, including temperature (dry, surface, soil, soil under vegetation), wind speed and direction, pressure (station, QNH, QFE, QFF), relative humidity, precipitation (indicator and amount), runway surface temperature, freezing temperature for various deicing materials, runway condition (dry, damp, wet, etc.), visibility and RVR, cloud height, sunshine duration, solar and gamma radiation, cloud height, and runway condition. In order to back up these networks, the AWOS features a Central System that acts as the hub for all communication networks and connects field sensors, displays, and individual stations deployed on the airport. All preprocessed data is made accessible to distant workstations and displays, thick or thin clients, by the Central System.

Radar System

Radar is highly advanced technology with a variety of uses, including navigation, military operations, and weather monitoring. It is an essential component of the AWOS being offered at Roberts International Airport's weather observation system with GCF support. Platform, application, frequency spectrum, component, dimension, and regional variations in radar use are possible. It can cover the VHF, UHF, and L bands in terms of frequency. Antenna, Transmitter, Duplexer, Receiver, Display, Digital Signal Processor, and Stabilization System are some of its possible components. Additionally, its dimensions might be 2D, 3D, or 4D radars. In order to support national weather monitoring and forecasting in Sierra Leone, GCF revenues will be utilized to purchase a distinctive and cutting-edge X-band weather radar with a wide range of functions.

Figure 3: Phototype and functions of the modern X-Band Radar for LIA

Some key features of the X-Band Radar to be procured for the LIA are listed below while the minimum specification needed is provided in Table 1.

- Radar Studio Software for displaying meteorological spatial data in user-friendly graphic form;
- Programmable scan of echoes from the radar range (including but not limited to full 3D volume scan, PPI scan, RHI scan);
- Data transformation into spatial matrix;
- Input data processing;
- Data distribution to customer graphic workstation;

Table 1:Technical Specification of the modern X-Band Radar to be procured

Height	1630 mm
Width	1310 x 1310 mm
Weight	125kg
Antenna	Parabolic, diameter 1160mm
Antenna elevation	-1 to +90°, angle span
Antenna scanning speed	0 to 15 rpm
Transmitter tube	Magnetron
Receiver sensitivity	-111 dBm 10dBz at 200km
Modulator type	Solid-state
Dynamic range	90 dB
Operating frequency range	9410 MHz (X-band)
Half power beam width	1.8°
Polarization	Horizontal
Antenna gain	40 dBi typical
Transmitter power peak	40 kW
Raw data resolution	32 bit
RF pulse width	2 μs
Pulse repetition frequency	250 Hz
Maximum range	200 km
Radial resolution	600 m
Consumption	250 W
Data update rate	3D full scan 1 min (depending on configuration)
Data transfer	TCP/IP (LAN, private networks, internet, etc)
Operating temperature range	-40 to +60°C without AC

Radar Studio Software

The data processing is built on a web server architecture, allowing all goods to be freely accessible to anyone using a web browser and available over an HTTP interface. The web interface's password-restricted access is safeguarded via the encrypted (https) protocol. The earth's curvature and air refraction are taken into consideration by the data processing software. Non-meteorological data, such as ground clutters, are filtered out (removed) in the final display outputs during data processing. Different file formats, including BUFR, GRIB, HDF5, OPERA ODIM, and UF data formats, can be used to store the result. The radar can output images in GIF, GeoTiff, PNG, and JPG formats.

Radar products

The product of the radar includes:

1) Standard meteorological products such as;
   - Plan Position Indicator (PPI) one radar elevation
   - Constant Altitude PPI (CAPPI) horizontal cross section
   - Range Height Indicator (RHI) vertical cross section
   - Echo Tops heights of cloud tops
   - Composite Reflectivity (Column max) maximas in columns
   - Vertically Integrated Liquid Water (VIL) column sums

2) Hydrological products of which;
   - Quantitative Precipitation Estimate (QPE)
   - Rainfall Accumulation
   - River basin statistics

3) Composite products from multiple radars such as;
   - Generation of the composite products from the heterogenous radar networks

4) Nowcasting
   - Storm cell identification and nowcasting
   - Tracking radar echoes by correlation (TREC) nowcasting up to 2 h including QPE

Radar map server

This includes, but not limited to;

- Zoomable maps with layers,
- Integration of Openly Licensed Maps for Offline use,
- Radar product layers,
- OGC Web Map Service

In addition, low emitted power will enable the device to comply with standards for operation in settled areas (towns, airports, highways, ports, etc.). Despite the low emitted power, the radar is able to monitor small precipitation up to distance of 200 km.

Proposed Budget (GCF Financed)

Component Description	Unit	Cost (USD)
X-band Weather Radar System including a map server, radar studio software, workstations, technical training and maintenance fee, an AWOS and other auxiliary accessories.	4	1,273,462.90
TOTAL COST		1,273,462.90

**The radar system will be procured through International Competitive Bidding (ICB) method*