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Aeronautical Communication System (LDACS)  
Based Communication Navigation and  
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# Simulated implementation of L-Band Digital Aeronautical Communication System (LDACS) based Communication Navigation and Surveillance Network for Pakistani Airspace

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**Abstract.** The L Band Digital Aeronautical Communication System (LDACS) is a new generation of air-ground communication systems designed to meet the increasing demand for air traffic data transmission. It is based on a cellular concept. The system has been under trial in Europe. This paper presents a detailed architecture and simulated performance validation of LDACS in Northern Airspace of Pakistan. The main focus is on the system's ability to provide high-speed data transmission, improved coverage, and increased spectrum efficiency while ensuring compatibility with existing communication systems. The LDACS system is intended to provide a reliable, secure, and cost-effective solution for air-ground communication in the L band frequency range. The paper primarily verifies performance verification of Communication and Navigation features. The verification of communication comprises coverage, reliability in terms of BER, and Cell sizes for frequency reuse. The modulation scheme is Orthogonal Frequency Division Multiplexing (OFDM) where sub-carriers are to be adjusted in available pockets "L" band. The Navigation feature is tested in terms of flight path accuracy and the Required Navigation Performance (RNP) category is determined.

**Keywords:** Avionics, Communication, Navigation, LDACS, Air Traffic Control

## 1 Introduction

Air traffic is said to be increasing at a rate of 6% per annum and the L band digital aeronautical communication system (LDACS) is a broadband system developed to meet the rising demand for reliable and efficient communication in the aviation industry. It is a multi-application cellular broadband system that provides digital data links between aircraft and ground stations. It accounts for communication, navigation, and surveillance functions. The LDACS was developed by the European Organization for the Safety of Air Navigation, EUROCONTROL, and the Single European Sky ATM Research (SESAR) and is considered to be the next step of communication systems that will replace the current systems used in aviation. There have been multiple limitations of the existing communication systems, VHF and HF, such as bandwidth ca-

capacity, reliability, and data digitization. LDACS has several advantages over the other communication systems used in aviation and one of the key advantages is a high data transfer rate, reliability, and security with built-in error correction and encryption features, and reduced interference. It is a Frequency Division Duplex (FDD) configuration that utilizes Orthogonal Division Multiplexing (OFDM) which allows for higher data rates and spectral efficiency [1]. Consider it as 4G mobile communication but for aircraft. It operates in the L band frequency range between 960-1164 MHz and this band overlaps with DME (see Fig 1).

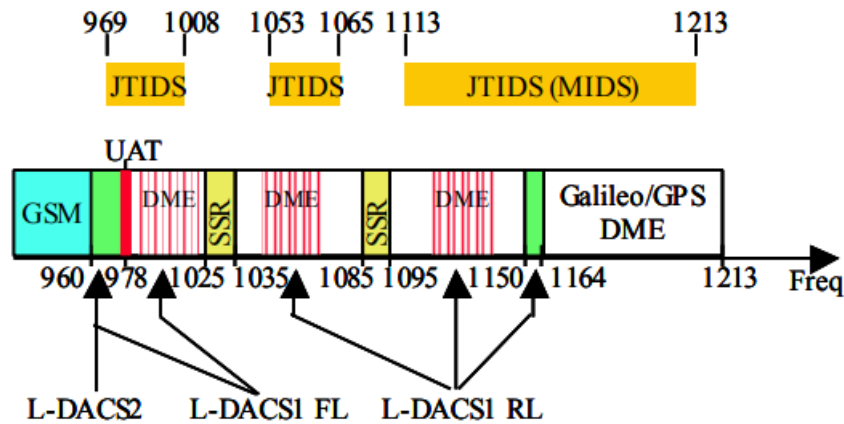


Fig. 1. L-Band Spectrum [2]

The larger bandwidth enables high-speed transmission of data which is up to 20mbps and provides high security via methods of encryption and authentication so that only authorized personnel can receive data. The objective of this paper is to implement LDACS for the Pakistan airspace, particularly in the northern area in collaboration with the Civil Aviation Authority of Pakistan. Ultimately, the goal is to digitalize voice communication and this system will be deployed sometime in the near future. The communication function depends on cell entry, cell exit, and the seamless transition between ground stations. Furthermore, the navigation function is an alternative to the ILS with an expected navigation performance RP of 0.3 nautical miles or higher.

## 2 Implementation Methodology

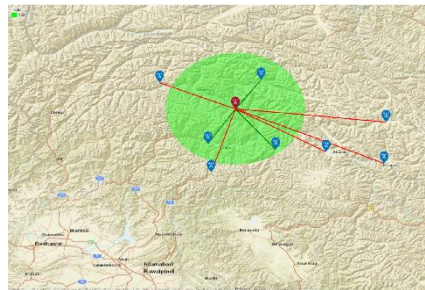
The communication functionality of LDACS has been assessed through both qualitative and quantitative validation methods. The qualitative validation aims to ensure the proper functioning of the main control plane and user plane communication functions. This includes verifying features such as cell entry, cell exit, handover between ground stations, and the transmission of user data [3]. On the other hand, quantitative validation focuses on evaluating the performance of LDACS communication. This involves

assessing the control plane and user plane based on specific performance indicators. Key metrics such as the SNR and BER are measured and compared with the specifications provided by EUROCONTROL/SESAR.

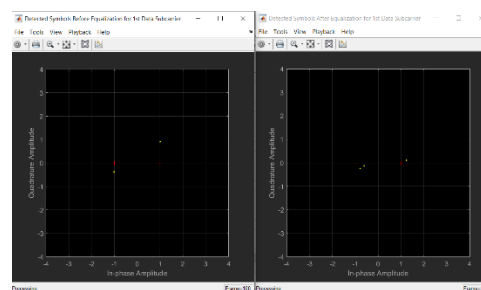
Parameter	Value
Effective bandwidth (FL or RL)	498.05 kHz
Subcarrier spacing	9.765625 kHz
Used subcarriers	50
FFT length	64
OFDM symbol duration	102.4 $\mu$ s
Cyclic prefix	17.6 $\mu$ s
Guard time	4.8 $\mu$ s
Windowing time	12.8 $\mu$ s
Total OFDM symbol duration	120 $\mu$ s

**Fig. 2.** LDACS OFDM parameters [1]

Detailed receiver and transmitter specifications are available in Ref [4]. The specific bit error rate for LDACS can vary depending on factors such as signal quality, interference, and modulation scheme. To achieve a certain BER target, LDACS utilizes various techniques such as error detection codes, error correction codes, and modulation schemes optimized for robustness and efficient data transmission. These techniques help minimize the probability of bit errors during communication. The cell placement in LDACS involves determining the optimal locations for deploying communication cells to provide effective coverage and ensure efficient communication within the system.



**Fig. 3a.** Coverage Plot



**Fig. 3b.** OFDM Synchronization plot

Typical BER for LDACS at the transition edge of the cell is shown in Fig 3a. With these values, it has been computed that generally cell placement at a distance should work in ground regions. OFDM modulation is used its synchronization was also verified through simulations as shown in Fig 3b. The LOS coverage in various regions is computed using the Matlab utility, Antenna Coverage Map.

In navigation, trilateration typically involves using three or more fixed reference points with known positions, such as landmarks, buoys, or GPS satellites, GPS information in this case. By measuring the distance between the aircraft and each of these base stations, it is possible to calculate the position. The placement of LDACS cells depends on several factors, including Coverage requirements, Interference management, Traffic in the area, Terrain, and obstacles. They are placed to ensure that the frequencies can be reused after a certain number of cells.

### 3 Results

The evaluation of the LDACS prototype during laboratory tests focuses on assessing its fundamental functionality. These tests involve analyzing the spectrum and the signal-to-noise ratio (SNR) dependence to evaluate both communication and navigation performance. Furthermore, the bit error rate of different ground stations is also examined.



**Fig. 4.** 7 Cells placed in different northern Areas of Pakistan namely, Islamabad, Thowar, Sargodha, Mastuj, Dera Ismail, Saidu, and Multan.

This particular cell placement is to ensure seamless handover between cells with frequency reuse.



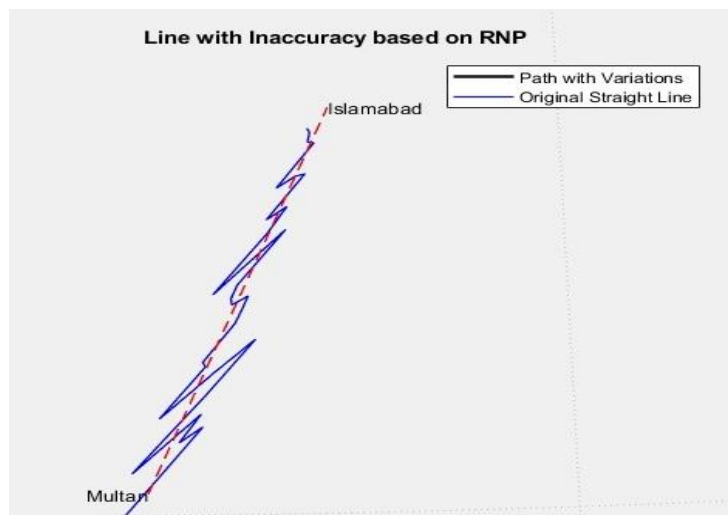
**Fig. 5.** Cell handover during flight path from Rahim Yar Khan to Chitral

OFDM simulation with the specified receiver and transmitter characteristics resulted in values of  $E_b/N_0$  and BER as 12.00dB and 0.000079 respectively and comparing these with our given values (see Ref 4) of  $E_b/N_0$  and BER as 11.33dB and  $9 \times 10^{-6}$  verify similar results. Variation in BER may vary depending on factors such as signal quality, interference, modulation scheme, coding techniques, and other environmental conditions.

At  $E_b/N_0 = 12.00\text{dB}$ , 100 frames detected among the 100 transmitted frames with FER = 0.010000 and BER = 0.000079

**Fig. 6.** Values of  $E_b/N_0$  and BER obtained for OFDM simulation with LDACS parameters.

The navigation function, by the process of trilateration on MATLAB, uses 3 latitudes and longitudes to verify the current position. The RNP value was verified and values around 0.3nm were observed and plots of a straight path and a varied path from Multan to Islamabad were plotted on the map. Which means that the system can qualify as RNP 0.3nm. It has to be improved further for landing approach use.



**Fig. 7.** Variated path vs original straight-line path, with a maximum deviation of 0.3nm

## 4 Conclusion

The objective of this work was to verify and implement LDACS for Pakistan. LDACS has great potential and represent a significant advancement in the field of aviation, with higher data rates, more reliability, and more secure communication. After comprehensive literature analysis and studies, the communication function was successfully implemented through simulations, using 7 base stations spread around different areas of Northern Pakistan, the functionality and the performance parameters were verified according to the given EUROCONTROL specifications, specifically, Eb/No and BER values. The navigation function was verified by extracting the current position using three latitudes and longitudes and the Required navigation performance was confirmed to be around 0.3nmi and a plot of a straight as well as varied path were plotted on the map. The future holds great potential for this system and with flight trials and working with the Pakistan Civil Aviation Authority (CAA), LDACS can be seen as replacing the current communication system in Pakistan.

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