VSAT SARTHI OPERATOR

A PROJECT REPORT

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CERTIFICATE

Certified that this project report **“VSAT SARTHI OPERATOR”** is the original work of **“EKTA MATHUR, BHAVNA GUPTA, JYOTI PANDEY, GAURAV SAVITA, GOPESH KIRAD”** student(s) of B. Tech. Final Year VIII Semester (Computer science & Engineering Branch) who carried out the project work under my supervision.

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ABSTRACT

Volatility and speed of communications is one of the challenges currently facing thousands of companies operating in remote or hard-to-reach places. Because of this, it is common today that many companies choose to implement in their process flow, satellite system that allow them to have an agile and independent communication network; for this reason, there are endless solution for this need in the market, such as: antennas, which offer a hole eco system of application and advantages to receive and send information regardless of geographic location. Therefore, this App will helpful for tracking the Geostationary Satellite & also calculate the Losses occurred in path during Satellite Communication through VSAT. By this Operator who is non technician can decide the level of Transmitted Power according to User input like location, data rate and symbol rate. VSAT Saarthi app operates in different frequencies, shapes and sizes. At present, this type of technologies offer companies a value proposal that comprises quality and comfort with a series of advantages that stand out in the market and compared to other antennas. VSAT technology represent a cost effective solution for companies that required to have an independent communication network and at the same time connect many geographically dispersed sites, each time there are more and more sectors and applications where this antenna is implemented, depending on its objective: to only receive and send data.

CHAPTER 1

INTRODUCTION

1.1 What Is Vsat?

With recent rapid development and widespread use of various wireless and satellite communication systems, over more stringent requirement are posed on RE-Microwave Filters such as smaller size, higher performance, and lower cost communication satellite systems like Very Small Aperture Terminal (VSAT) divide bandwidth between transponders. Usually a transponder is capable of sending and receiving signals about 45Mbis. Most of the GEO satellites employ microwave frequencies meanly between 35 and 650Hz and between 105 and 14.5GHz (Ka-band) Very Small Aperture Terminal was initially a trademark for a small earth station marketed in the 1980s by Tel-com General in the USA.

VSAT are one of the intermediary steps of the general trend in earth station size redaction that has been observed in satellite communications since the launch of the first communication satellites in the mid 1960s. VSAT with antenna diameters less than 2.4m, hence the name 'small aperture which refers to the area of the antenna. Such stations cannot support satellite links with large capacities, but they are cheap, with manufacturing costs in the range of $1000 to 50005 and easy sis metal anywhere, on the roof of a building or on a parking lot. Earth stations have evolved from the large INTELSAT Standard A earth stations equipped with antennas 30 m wide, to today's receive-only stations with antennas at 60 cm for direct reception of television transmitted by broadcasting satellites, or hand held terminals for radio location such as the Global Positioning System (CPS) receivers VSAT are at the lower end of product line which offers a large variety of communication services; at the upper end are large stations (often called trunking stations which support large capacity satellite links. They are mainly used within international switching networks to support tank telephony services between countries, possibly on different continents.

There were about 50000 VSATS in operation worldwide in 1990, and more than 600000 twelve years later. This trend is likely to continue. VSAT appear as natural means to bypass public network operators by directly accessing satellite capacity. They are flexible tools for establishing private networks, for instance between the different sites of a company. The bypass opportunity offered by VSAT network has not always been well accepted by national tele-com operators as it could mean loss of venireman, as a result of business traffic. Present VSAT networks use geostationary satellites, which are satellites orbiting in the equatorial plane of the earth at an altitude above the earth surface of 35786 km (Figure 1) The distance from an earth station to the geostationary satellite induces a radio frequency carrier power attenuation of typically 200 d on both uplink and downlink (Figure 2), and a propagation delay from earth station to earth station (hop delay) of 0.25s as a result of its apparent fixed.

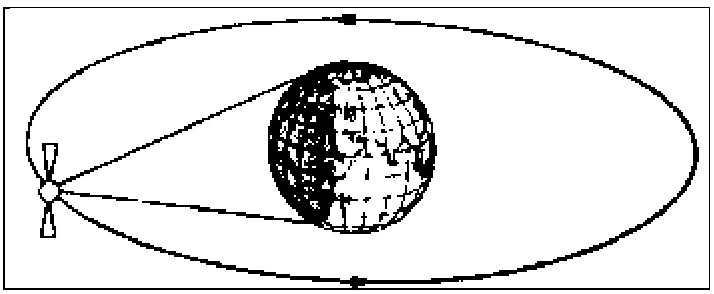

Figure 1: Geostationary satellite

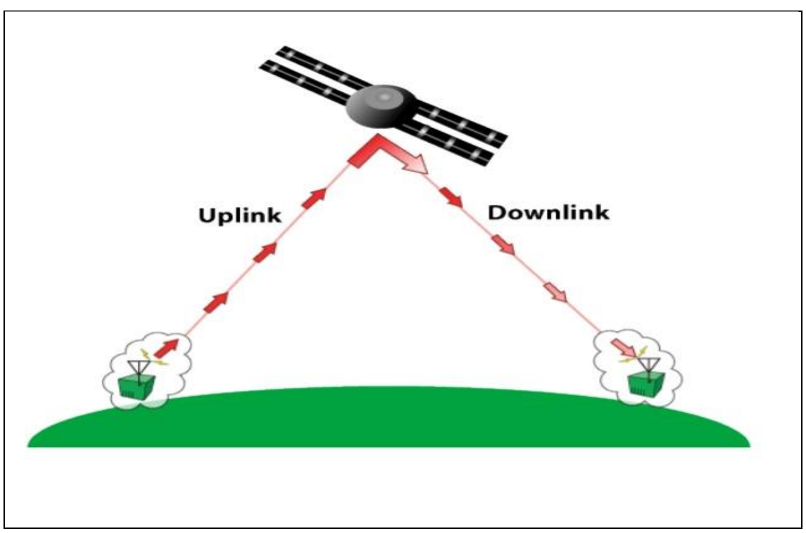

Figure 2:Representation of downlink and uplink

1.2 Problem Description

A very small aperture terminal (VSAT) is a small-sized earth station used in the transmit/receive of data, voice and video signals over a satellite communication network, excluding broadcast television.

At present, the set-up of VSAT is done with the help of lots of heavy devices and we need an engineer to set-up all this which is very costly sometimes.

With development of mobile satellite communication, trend of antennas in motion VSAT (very small aperture terminal) and USAT (ultra small aperture terminal) is high efficiency, low profile, light weight and miniaturization. This paper accords to ITU recommendation and INTELSAT IESS standard, side-lobe pattern envelope characteristic, cross polarization characteristic and off-axis EIRP for satellite communication VSAT and USAT earth station antenna are summarized systematically. Limitations of side-lobe characteristic standard application are pointed for low profile plane array antenna, active phased array antenna and low profile elliptical beam antenna etc. Recommendation of antenna pattern first side-lobe level requirement is put forward for VSAT and USAT earth station antennas. The paper has importance reference value to design and development of satellite communication VAST and USAT antennas.

CHAPTER 2

LITERATURE REVIEW

1. **El-Dosuky, M. F.**, & **Moustafa, H. A.** (2019). A comprehensive review on very small aperture terminal (VSAT) technology. Journal of King Saud University-Computer and Information Sciences, 31(1), 58-67. This literature review provides a comprehensive overview of VSAT technology, its components, applications, and performance analysis. The authors start by introducing VSAT technology and explaining its main components, including the outdoor unit (ODU), the indoor unit (IDU), and the satellite. They also describe the various frequency bands used in VSAT technology and their advantages and disadvantages. The authors then provide a detailed analysis of VSAT performance parameters, such as signal quality, noise, and interference. They also explain the factors that affect VSAT performance, such as the size and shape of the dish antenna, the location of the satellite, and the weather conditions.
2. **Bhat**, **M. A**., & **Khan, F. A**. (2018). A review on antenna for satellite communication. This literature review provides an overview of various types of antennas used in satellite communication, including dish antennas, patch antennas, helical antennas, and others. The authors discuss the characteristics and performance of each type of antenna, as well as their applications in satellite communication. They also provide information on the design and analysis of these antennas, highlighting the key parameters and considerations involved. Additionally, the review covers recent advancements in antenna technology and their potential impact on satellite communication. Overall, this literature review serves as a useful resource for researchers and engineers working in the field of satellite communication, providing an in-depth understanding of the various antenna types and their applications.
3. **Kuo, C. Y., Wu, H. W., & Chen, K. Y.** (2017). A review of dish antenna and VSAT system. This literature review provides a comprehensive overview of dish antennas and VSAT systems, focusing on their technical aspects. The authors cover topics such as antenna design, signal quality, noise, and interference, as well as applications such as remote site connectivity, maritime communications, and military communications. They also discuss the challenges associated with VSAT systems, such as rain fade, and

provide strategies for mitigating these issues. Additionally, the review explores recent advancements in dish antenna and VSAT technology, including the use of Ka-band frequencies and spot beam technology. Overall, this literature review serves as a valuable resource for researchers and engineers working in the field of VSAT systems, providing a detailed understanding of the technical considerations involved in their design and operation.

4. **Almasalma, A., & Ismail, M.** (2021). A review of dish antennas and their applications in satellite communications.This literature review provides a comprehensive overview of dish antennas and their applications in satellite communication. The authors discuss the design and analysis of dish antennas, as well as their performance characteristics such as gain, beamwidth, and sidelobe levels. They also explore the various applications of dish antennas in satellite communication, including remote sensing, broadcasting, and military communications. Additionally, the review covers recent advancements in dish antenna technology, such as the use of advanced materials and manufacturing techniques. Overall, this literature review serves as a valuable resource for researchers and engineers working in the field of satellite communication, providing a comprehensive understanding of dish antenna technology and its applications.
5. **Raj, J., & Singh, V.** (2018). Design and analysis of parabolic dish antenna for satellite communication – A review. This literature review focuses specifically on the design and analysis of parabolic dish antennas for satellite communication. The authors discuss the various parameters involved in the design process, such as focal length, aperture diameter, and feed position. They also explore the performance characteristics of parabolic dish antennas, such as gain, beamwidth, and sidelobe levels. Additionally, the review covers applications of parabolic dish antennas in satellite communication, including remote sensing and broadcasting. Overall, this literature review serves as a useful resource for researchers and engineers working on the design and analysis of parabolic dish antennas for satellite communication.
6. **Fadare, S. O., & Oke, O. M.** (2016). An overview of dish antenna design and analysis in satellite communication.This literature review provides an overview of dish antenna design and analysis in satellite communication, covering topics such as antenna parameters, radiation patterns, and gain. The authors discuss the various types of dish

antennas used in satellite communication, as well as their applications in remote sensing, broadcasting, and military communications. Additionally, the review explores recent advancements in dish antenna technology, such as the use of smart materials and active antennas. Overall, this literature review serves as a useful resource for researchers

CHAPTER 3

SOLUTION APPROACH

To reduce all the expenses to setup the VSAT connection, we are trying to implement an application named VSAT SARTHI OPERATOR for all the users out there which works only by giving some inputs and that will set-up your dish antenna.

We just need to input the values of latitude and distances, it will set-up your look angles and offset points. By selecting antenna, satellite or transponders we can easily use antennas or channels provided by the different service stations, In our application we are also providing voice or text inputs to satellite for ease. If user is facing any problem during set-up, then he can send his problem to that particular company to resolve this via text or voice signals.

A very small aperture terminal (VSAT) is a two-way ground station that transmits and receives data from satellites. A VSAT is less than three meters tall and is capable of both narrow and broadband data to satellites in orbit in real-time. The data can then be redirected to other remote terminals or hubs around the planet.

VSAT networks have a number of commercial applications, including, perhaps most notably, enterprise resource planning (ERP). The use of VSAT to track inventory was one of the many innovations Walmart pioneered in retail to effectively manage its vast inventory in real-time and reduce delivery costs between the warehouse and stores.

Combined with the hub system of inventory storage, VSAT allowed Walmart to stock its stores more precisely and reduce how many times a product had to move between locations before being sold. Other manufacturers use VSAT to relay orders, check production figures in real-time as well as other functions that are otherwise handled over a wired network.

The National Stock Exchange (NSE) of India has one of the largest VSAT networks in the world and offers it as one of its connectivity options. VSAT provided the NSE with a way to offer access in areas where wired options are limited.

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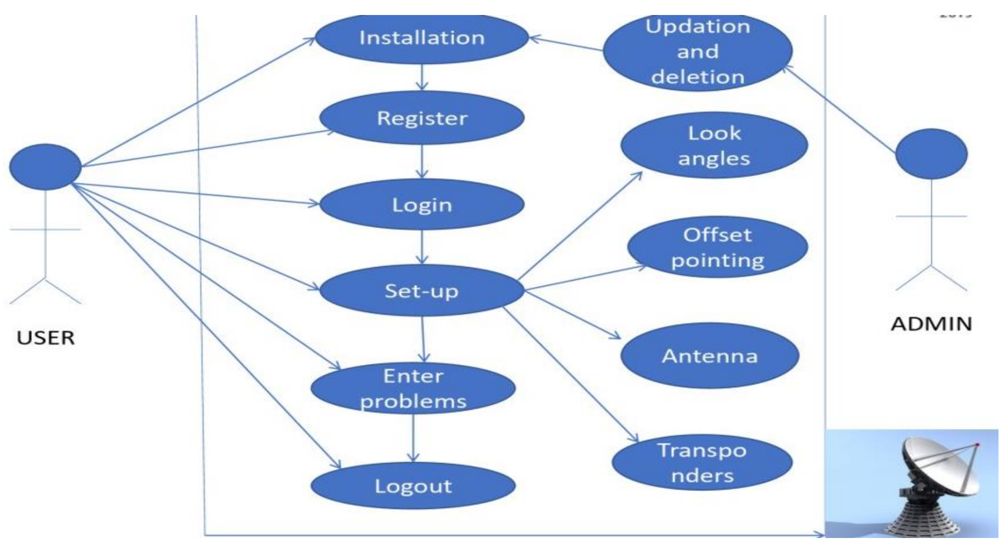

Figure 3:Use case diagram

3.1 Vsat Station

Figure4 illustrates the architecture of a VSAT station. As shown in the figure, a VSAT station is made of two separate sets of equipment the door unit (ODU) and the indoor unit (IDU). The outdoor unit is the VSAT interface to the satellite, while the IDU is the interface to the customer's terminals or local area network (LAN)

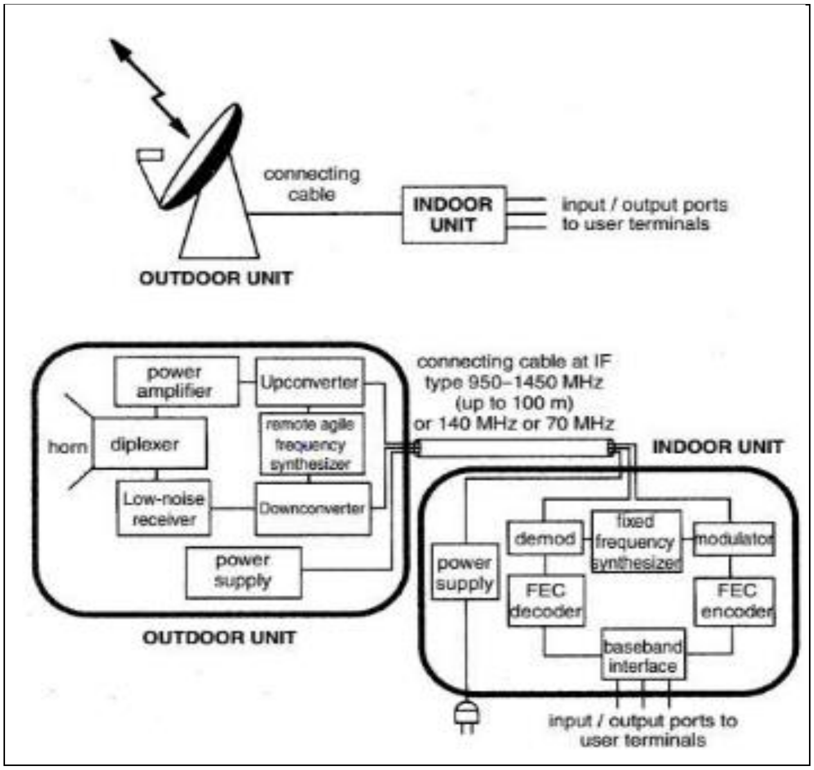

Figure 4:Vsat station

For a proper specification of the ODU, as an interface to the satellite, the following parameters are of importance:

- The transmit and receive frequency bands; the transmit and receive step size for adjusting the frequency of the transmitted carrier or for tuning to the received carrier frequency.
- The equivalent isotropic radiated power (EIRP), which determines the performance of the radio frequency uplink. The EIRP depends on the value of the antenna gain, undhence its size and transmit frequency, and on the transmitting amplifier output

power. For a proper specification of the IDU, as an interface to the user's terminals or to a local area network (LAN), the following parameters are of importance

- Number of ports type of ports: mechanical, electrical, functional and procedural interface. This is often specified by reference to a standards.
- Port speed: this is the maximum bit rate at which data can be exchanged between the user terminal and the VSAT indoor

Figure 5:Photograph of outdoor part of VSAT station

- **Noise Sources**

A carrier originating from a transmitting station and received by the satellite transponder at the uplink frequency. is amplified by the satellite transponder and frequency translated before being transmitted and received by the earth stations tuned to the downlink frequency. This carrier is corrupted by noise with different origins of noises as discussed below.

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- **Thermal Noise**

Thermal noise is present on the uplink and the downlink and is produced by natural sources. First, we have the radiation produced by radiating bodies and captured by the receiving antennas. With satellite communications, the principal sources of radiation are the earth for the satellite antenna, and the sky for the earth station antenna. Such noise is called "antenna noise". Another source of thermal noise is the noise generated by the receiver components.

- **Interference**

Some interference is to be expected from systems sharing the same frequency bands, either satellite-based systems or terrestrial ones. Interference is introduced on the uplink. Interference is also introduced on the downlink where the receiving earth station antenna captures carriers transmitted by adjacent satellites or terrestrial microwave relays This interference sets us noise if the undesired carrier spectrum overlaps with that of the wanted carrier. The problem may be of special importance on the downlink at the ma e of the VSAT station and its resulting large beam width makes it more sensitive to receptive of off axis canters. This is why it preferable that VSAT networks operate within exclusive bands. Interference is also generated within the considered VSAT network. This is sometimes called "self-interference' For example, some VSAT networks incorporate earth stations operating on two orthogonal polarization at the same frequency. It may also be that the satellite is a multi beam satellite frequency. It may also be that the satellite is a multi beam satellite, with stations transmitting on the same polarization and frequency but in different beams. These techniques are referred to as "frequency reuse techniques and are used to increase the capacity of satellite systems without consuming more bandwidth. On the end, a budget comparison for different section of VSAT is presented. Provided that desired network reliability, response time and throughput are achieved, then the economic comparison should be made on the basis of cost per month per site. In general terms, a VSAT network is a cost effective solution if the unique property of the satellite to broadcast information is well used. To illustrate the budget headings of a typical VSAT network and the impact of the number of VSAT. The cost per month per VSAT is calculated assuming a five year amortization. The $2000 equipment co of a VSAT is applicable to a station equipped with a 18 antenna, a 2 W transmitter power, and 4 output met ports. Installation cost is taken equal to one mayday plus professional expenses, or typically $700 per VSAT. Spare parts represent 10% of the equipment cost, and the annual maintenance cost is taken equal to $500 per VSAT. The access to the satellite is by time division multiple access (TDMA) and it is assumed.

CHAPTER 4

PROPOSED METHODOLOGY

4.1 Configuration And Calculation Of Link Budget

4.1.1 Introduction

In the context of future satellite communications systems, the deployment of the Ka band is a requires, particularly because of the saturation of the L, C and Ka bands. This operation will provide the advantage of wider channels that support a greater number of users; it also allows reducing the size of the user terminal and antenna [1]. Adding to this that, the realization of a satellite meets a need which results in the definition of the objectives of the space mission. Thus for example a communications satellite is the product of needs expressed by users working in fields varied such as mobile telephony, television and internet by satellite, radio navigation, and systems of localization...Etc [2]. For this, and given the complexity and the cost of space projects, their implementation is divided into phases to have a good understanding and good control on the project. The work presented in this article between in the first phase of the design of a satellite and which consists in the contribution to the analysis of mission of a telecommunications satellite for the internet or mobile phone by satellite for example, and that in geostationary orbit [3]. We will in what will follow, do the configuration of a system which consists of a link between a broadcast station and a user through a satellite in geostationary orbit, and then do the calculation of the link budget the latter in the order to see if this link can be achieved in the future

The calculation o1 the link budget 1s a very important step in the design phase to any satellite in order to ensure the proper antenna to the ate up alter the launch, our work is within this context, or we will set a link in Ka-band between a station to emission or service and a receiver (user) via a geostationary satellite and to ensure that the system normally works with these parameters we should do the calculation of the link budget in the end leaving a margin of error sufficient as a guarantee tor the proper functioning of the system.

We cannot take this margin large because this causes additional costs and an ovet-s1zing to the systole a lesser margin can lead to an excessive error rate which may caused the loss of the bond, so must adjust the parameters of entry until margin, at least 8 dB [+]

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(A).For uplink

$$
\begin{aligned}
&= \frac{\frac{EIRP_b \cdot G_{r,s}/L_{\mathrm{fow},s}}{L_f}}{kT_{s,s}} = \frac{EIRP_b}{L_f}\left(\frac{G_{r,s}/L_{f\mathrm{mols},s}}{T_{s,s}}\right)\frac{1}{k} \\
(C/N)_U &= P_{\mathrm{oat},b} - L_{j\mathrm{fw},b} + G_{t,b} - L_f + G_{r,s} - T_{s,s} - k - Ls \\
&= EIRP_b - L_f + G_{r,s} - T_{s,s} - Ls + 228.6\mathrm{dBHz}
\end{aligned} \tag{1}
$$

(B).For downlink

$$
= \frac{\frac{EIRP_s \cdot G_{r,b}/L_{\mathrm{fiwi},b}}{L_f}}{kT_{s,b}} = \frac{EIRP_s}{L_f}\left(\frac{G_{r,b}/L_{\mathrm{Adpubb}}}{T_{s,b0}}\right)\frac{1}{k} \tag{2}
$$

$$
\begin{aligned}
(C/N)_D &= P_{\mathrm{outs}} - L_{f(\mathrm{fm},s} + G_{l,s} - L_f + G_{r,b} - T_{s,b} - k - Ls \\
&= EIRP_s - L_f + G_{r,b} - T_{s,b} - Ls + 228.6\mathrm{dBHz}
\end{aligned} \tag{3}
$$

This is a basic step in the calculation of a link of communication especially satellite in geostationary orbit because of the large distance between the satellite to Earth. Losses

$$L_f = \left(\frac{4\pi d}{\lambda} \right)^2 \text{(dB)} \quad (4)$$

At the same time, it is necessary also to take into account all sources of losses that can cause degradation of the link budget. Thus, it is affected by a set of losses that will degrade it, all sources of degradation are accumulated in the term Ls, mentioned in the equations (2) and (4), and it is defined as follows:

$$Ls = L_{Em} . L_{Atm} . L_{Pol} . L_{Poin} . L_{feed} \quad (5)$$

Among these sources of degradation, we find the losses due to the depositing antenna [6], noted by Loin and defined by the following equations:

$$L_{\theta_T} = 12 \left(\frac{\theta_T}{\theta_{-3dB}} \right)^2 \quad \text{(dB)} \quad (6)$$

$$L_{\theta_R} = 12 \left(\frac{\theta_R}{\theta_{-3dB}} \right)^2 \quad \text{(dB)} \quad (7)$$

We have the atmospheric losses (Latm) due to the diverse atmospheric phenomena, we have [7]:

A. Absorption by oxygen molecules Jo (dB/km):

We cannot take this margin large because this causes additional costs and an ovet-s1zing to the systole a lesser margin can lead to an excessive error rate which may caused the loss of the bond, so must adjust the parameters of entry until margin, at least 8 dB [+] Bcater than he value of the quality of the link estimated, the calculation of the link budget consists in the determination of the ratio to signal to noise at the level of the satellite for the uplink and at the level of the reception station for the downlink, this report 1s given by the slowing equations 15]:

$$\begin{cases} \left[\frac{6.6}{f^2+0.33} + \frac{0.19}{(f-118.7)^2+2}\right] f^2 10 & \text{For } f = 57\text{GHz} \\ 14.9 & \text{For } 57 \le f \le 63\text{GHz} \\ \left[2.10^{-4} r_t^{1.5}(1-1.2\times10^{-5} f^{1.5}) + \frac{4}{(f-63)^2+1.5 r_p^2 r_t^5} + \frac{0.28\ r_t^2}{(f-118.75)^2+2.84 r_p^2 r_t^2} \right] & \text{For } 63 \le f \le 350\text{C} \end{cases} \quad (8)$$

Where: f: frequency (GHz), rp= p / 1013, rt = 288/ (273 + t), p: pressure (Pa), t: temperature (°c).

$$\gamma_w = \left[3.27.10^{-2} r_t + 1.67.10^{-3} \frac{\rho}{r_p} + 7.7\times10^{-4} f^{0.5} + \frac{3.79}{(f-22.23)^2+9.81 r_p^2 r_t} + \frac{11.73 r_t}{(f-183.31)^2+11.85 r_p^2 r_t} + \frac{4.01 r_t}{(f-325.153)^2+10.44 r_p^2 r_t} \right] f^2 \rho r_t r_p 10^{-4} \quad (9)$$

When: d̥ is the density of water vapour

B. Attenuation due to the rain:

$$\gamma = Af2M \quad (10)$$

Where: J: The weakening in dB/Km,

F: The frequency in GhZ,

M: The water content in g/m3,

A: Coefficient which depends on temperature.

We also have other sources of loss, such as: 1) LEM: Corresponds to the losses between the output of the transmitter and the antenna (line, duplexes, filters...). 2) Lfeed: Corresponds to the losses between the receiving antenna and the input of the receiver. 3) Lpol: Corresponds to the polarization losses from a bad adaptation of polarization between two antennas.

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4.1.2 Context Of Study

For our study which consists in the configuration of a communication link for a multimedia service such as the internet by satellite for example between an transmit earth station (the one that offers the service) and receiver (user service) via a telecommunications satellite on geostationary orbit, we will take the case that is shown in figure 1 which consist in a link between a ground station equipped with a fixed parabolic antenna installed on the site of Arzew (Oran, Algeria) and a user found anywhere in Algeria via a satellite in geostationary orbit telecommunication at a defined position.

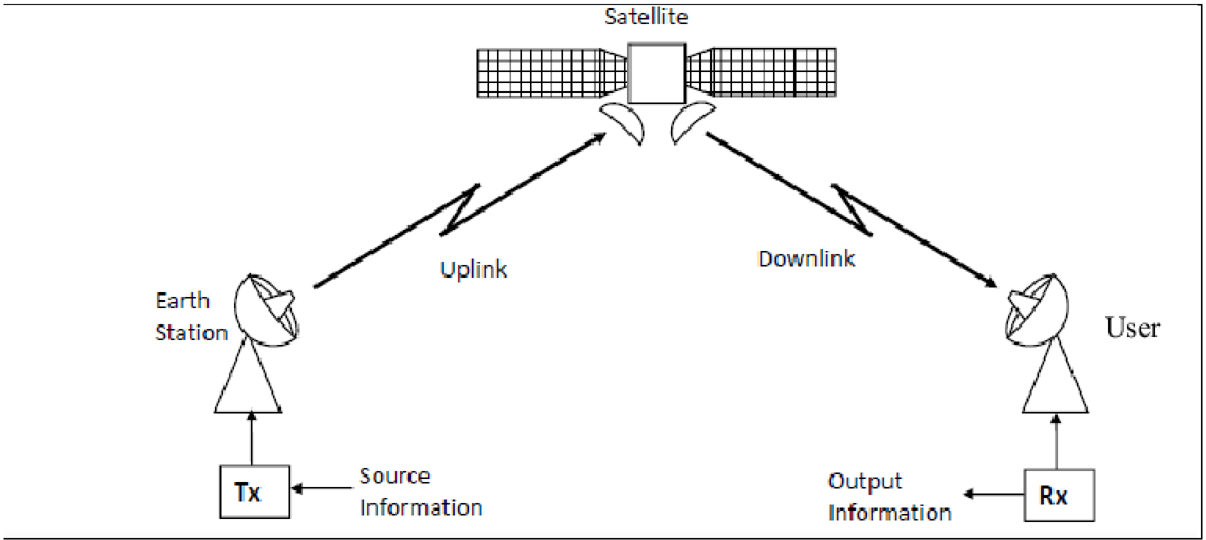

Figure 6:Connection between ground station and user

4.1.3 Working Methodology

A procedure for the design of a satellite link is given by the following steps [9]:

1) Choice of carrier frequency based on the availability and allocation of spectrum by the ITU.
2) Selection of the transmission powers.
3) Estimation of losses between the transmitter and the antenna.
4) Estimation the maximal depositing angle.
5) Calculating the gain of the antennas.
6) Calculation of free space losses.
7) Estimation of atmospheric absorption.
8) Estimation of the noise temperature of the system (clear sky).
9) Calculation of Eb/N0 for the data rate required.
10) Report search Eb/N0 required to satisfy the BER based on the type of modulation and coding.
11) Adding 1 or 2dB to compensate the errors of implementation. Calculation of the margin error of the link.

12) Calculation of the margin error of the link.

13) Adjustment of the input parameters until a margin of at least 8 dB greater than that estimated with degradation due to rain.

The margin of the system is given by:

$$M = \left(\frac{E_b}{N_0}\right)_{Calc} - \left(\frac{E_b}{N_0}\right)_{Req} \qquad (11)$$

$$\left(\frac{E_b}{N_0}\right)_{Calc} = \frac{1}{R} * \left(\frac{C}{N_0}\right) \qquad (12)$$

Where: R is the bit rate

If this margin is respected then the transmission may be made, otherwise it must either change the settings or resize some essential parameters to improve the quality of the bond.

4.1.4 Developed Software

The software developed in our study is designed under the environment Matlab 7.8; it is structured in four main parties (Figure 2), calculation of the UPLINK budget (Figure 3), and the calculation of the DOWNLINK budget (Figure 4), calculation of the depositing angle of satellite antenna, calculation of depositing losses. In addition, it has a menu that contains all the different calculations that fit into the development of the link budget as antenna settings, the Earth satellite distance, atmospheric losses, and the orientation of the antennas of the stations.

For any satellite link, we have a set of parameters that characterize it, for our case, we will configure a connection in Ka-band between a transmit earth station that is installed at Among these parameters, there are already presets such as: the coordinates of the station and the longitude of the satellite [9] to calculate the exact distance between the Earth and the satellite (this calculation is integrated in the application,the frequency...etc.

Our contribution is to find an optimal combination between these different settings in the goal to establish a link with a margin of error quite sufficient (>8dB) [4], to ensure the proper functioning of our system.

After several trials during what we have tried to take all the constraints into consideration (size, power, cost, access), we have arrived to the data summarized in the following tables:

Parameters	Value
General data	
Frequency	30 GhZ
Longitude of the satellite	35,867 N
Latitude of the station	0.321° O
Longitude of the satellite	24.8
Atmospheric losses	I dB
Binary rate	120 Mbits/s
Polarization losses	0.8 dB
(Eb/No) req	11 dB
Earth station data	
Power	100 W
Feeder losses	I dB
Diameter antenna	2.5 m
Antenna efficiency	0.65
Max depointing angle	0.25°
Satellite data	

Feeder losses	I dB
Noise factor	2.5 dB
Diameter antenna	2 m
Antenna efficiency	0.6
Max depointing angle	0.2
T° noise of the system	578

Table 1:Parameter of uplink

Parameters	Value
General data	
Frequency	20 GhZ
Distance earth satellite	40000 Km
Longitude of the	24.8°
satellite	I dB
Atmospheric losses	120 Mbits/s
Binary rate	0.8 dB
Polarization losses	11 dB
(Eb/No) req	
Satellite data	Rectanqu
Power	50 W
Feeder losses	I dB
Diameter antenna	2 m
Antenna efficiency	0.6

Max depointing angle	0.2°
Earth station data	
Feeder losses	0.5 dB
Noise factor	2.2 dB
Diameter antenna	1.2 m
Antenna efficiency	0.55
Max depointing angle	Actor ate
T° noise of the system	280

Table 2:Parameter of downlink

	UPLINK	DOWNLINK
Figure of Merit G /T (dB /K)	26.12	20.92
Signal to noise ratio C/N0(dBHz)	99.96	99.99
Margin of error (db)	8.17	8.2

Table 3:Parameter of downlink

From this, we can see that we can set up a system consisting of a link between an Earth station broadcasting and a receiver via a geostationary satellite with the parameters of the table (1) and (2), because we can guarantee and ensure the proper functioning of our system and this through the margin of error that we have left, despite the fact that it is costly in terms of weight and power but it is essential to know the sensitivity of the link in band Ka to atmospheric disturbances especially rain.

4.2 Link Margin For Wireless Radio Communication Link

4.2.1 Introduction

Radio communication link can be established by various channels such as wires, coaxial cables, fibre optic cables, wave guide, atmosphere, empty space. Radio communication through wireless systems are preferred over the wired system for long range communication as the signal power in wired communication system attenuates exponentially with distance compared to space decay resulting in reduced signal strength. Wireless communication involves transfer of information in space using sound, optical, infrared, radio frequency techniques and most widely employed is the radio frequency.

communication as it offers wider bandwidth and can penetrate fog, foliage, dust, buildings and vehicles also. Connectivity for voice, video and data communications can be provided using wireless systems such as Wireless Local Area Networks (WLANs), Direct Broadcast Satellite (DBS) television service, paging systems, Global Positioning Satellite (GPS) service, Radio Frequency Identification (RFID) systems. Present day systems employ higher frequencies to avoid spectrum crowding as well as offering wider bandwidth [1].

4.2.2 Radio Propagation Losses

In free space waves travel in straight lines but in the presence of earth and its atmosphere (an altitude of 20km) the path of the wave gets altered. Radio propagation consist of mainly three electromagnetic waves namely surface waves, sky waves and space waves. Wave propagation in high frequency region is mainly surface and sky whereas above it the propagation is primarily space waves. During radio propagation electromagnetic waves suffer several atmospheric effects that results in power loss and these effects are: Reflection and refraction, diffraction and scattering. These effects results in the large scale or small scale fading in accordance with the size of the object compared to the wavelength. In case of satellite based system the main losses are categorized are: Free space losses, Atmospheric losses Pointing losses and Inter symbol interference. These losses are detailed as below:

- **Free Space Losses**

Free space loss is the dominant component in the loss of the strength of the signal. As the radio signal travels through space, it deteriorates for two reasons:

1. The signal spreads out in space, inversely proportional to the square of the distance.
2. Absorption by the atmosphere and higher the frequency, the greater the attenuation.

$$-L = C + 20 \times \log(D) + 20 \times \log(F) \tag{1}$$

where, D is the distance (kms), F is the frequency in MHz and the constant C is 32.5

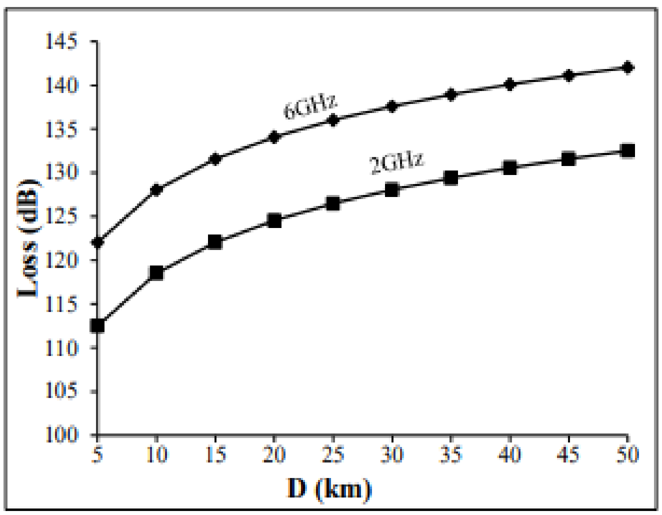

Figure 7:Graph

The plot in Fig. shows that at higher frequencies path loss is more with the distance compared to lower end of the frequency which is evident from Eq.(3).

- **Atmospheric Losse**s

Atmosphere losses can be categorized as attenuation or absorption where absorption phenomena arise in clear sky while attenuation is due to weather. Atmospheric effects in satellite transmissions increases with the increase of frequency and the effects of the atmosphere in signal attenuation become higher for frequencies above 10 GHz.

- **Pointing Losses**

The pointing losses are due to off-axis losses arise from the satellite and ground station. The misalignment of the antenna resulted in the loss of 1dB.

- **Ionospheric Effects**

All radio waves transmitted by satellites to the earth or vice versa must pass through the ionosphere containing ionized particles and these effects in satellite communication give rise to polarization rotation and the scintillation which decreases usually with the increase of the square of the frequency. Further refractive index causes scattering and multipath effects in the signal and is detected as variations in amplitude, phase, polarization.

The effect of atmospheric scintillation effect is taken into account in link margin as fade margin.

- **Tropospheric Effects**

Radio waves passing through troposphere are scattered, depolarized, absorbed and attenuated due to hail, raindrops or other atmospheric gases. Heavy rains cause severe attenuation of the signal as well as drops of rain also add to depolarization. The rain rate attenuation measured in dB is expressed below:

$$\text{Attenuation}_{(0.01)} = k.RR^{\alpha} dr \text{ (dB)} \qquad (2)$$

where, RR = 99.9% rain rate for the rain region (mm/hour), kRRα = specific rain attenuation (dB/km), d = link distance (km), r = 1/[1+ (d/do)] = (0.998), do= Effective Path Length (km) = 35e0.015RR . Rain margin for Ka-band is typically 99.6% and C-band is 99.96%. The heavy rain causes severe attenuation compared to drops of rain. Multi path fading results from varied refractive index gradient with atmospheric height. The probability of predicting the fading (pw) exceeding small time % is,

$$p_w = Kd^3(1+|\varepsilon_p|)^{-1.2} \times 10^{-0.033f - 0.001h_L - A/10} \qquad (3)$$

where, d is the path length, f is the frequency in GHz, p is the slope in mill-radians, K is radio climatic factor taking into account location, A is fade depth and hL height of the lower of two terminals. Increase in fade depth A of 10dB, the probability of link reduction reduces by a factor of 10. If an availability of 99.99% is required, an extra 10dB fade margin will be needed compared with an availability of 99.95. Fade margin at Ka-band is taken as 14dB for 99.9% availability. DE-polarization may occur when an orthogonal component is created due to the passing of the signal through the ionosphere. It can be caused by the ice layer also which is on the top of each rain area. There are two ways to measure its effect, cross-polarization discrimination and polarization isolation. As radio waves cross troposphere, radio frequency energy will be converted into thermal energy due to absorption and that attenuates signal.

Absorption is caused by the presence of oxygen and water vapour molecules. Gas absorption will cause loss of signal which can be given as,

AG (dB) = Labs|90º (dB/km) cosec. Ttrop (km) (5) Other atmospheric gases only become a problem in very dry air conditions above 70GHz. Thereby, losses caused by atmospheric absorption vary with frequency and not significant with an elevation angle of 5 or higher and for frequencies below 10GHz. Conversion from peak rain rate to the loss on a given link can be calculated as: Determine the peak rain rate Determine the loss per kilometre for the frequency and polarization Determine effective path length for the path length and rain rate Determine the peak link loss by multiplying the effective path length by loss per kilometre

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Further refractive index causes scattering and multipath effects in the signal and is detected as variations in amplitude, phase, polarization.

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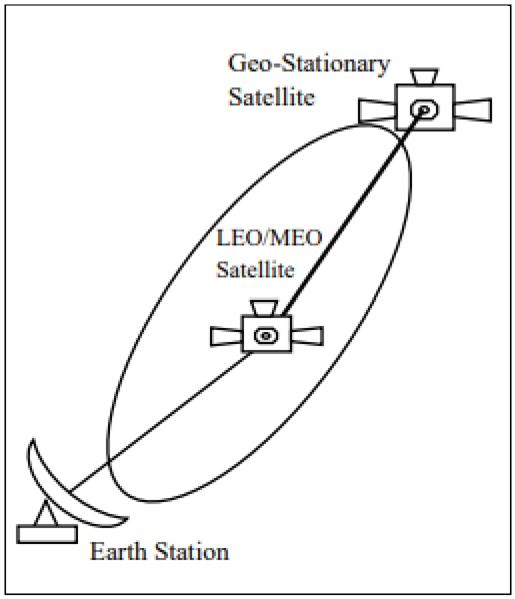

Figure 8:Geostationary satellite

Interference mitigation techniques include:

- Spatial isolation/Satellite diversity
- Time/frequency/time isolation
- Satellite antenna side-lobes/Earth
- Station antenna side-lobes
- Band planning
- Co-coverage avoidance
- Minimum look angle restrictions between earth terminals and terrestrial fixed service links

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Free Space Loss		
Atmospheric Losses	Ionospheric Effects	Faraday Rotation
		Scintillation Effects
	Tropospheric Effects	Attenuation
		Gas Absorption
		Sky Noise
		Depolarization
Pointing Losses		Antenna misalignment
		Antenna Stability

Table 4: Propagation Losses associated with Radio Signal

In satellite based system, satellite EIRP and bandwidth are important parameters and to be considered critically at the design stage.

4.2.3 Receiver Sensitivity

Receive sensitivity is dependent on the noise figure and required signal-to-noise ratio of the system. System noise comprises of the low noise amplifier (LNA) generated noise and associated noises in terms of noise temperature contributes the overall noise along with elevation angle of the antenna system above horizon. The required signal-to-noise ratio is dependent on the modulation technique. Typically, the higher the data rate of the system, the more bandwidth is needed. This means the receiver must capture more signal, which means more noise is captured. The minimum required Rx sensitivity (Pmin[dBW]) can be calculated from the minimal required receiver noise input power (Pn[dBW]) and SNR,

$$P_{min} = P_n + SNR$$
$$P_n = F + 10 \cdot \log_{10}(kT_0B) \tag{4}$$

where, F is the receiver noise figure (6 dB), K is Boltzmann's constant (1.38.10–23 Ws/K), T0 the absolute temperature (290K) and B the receiver noise bandwidth [Hz] Link performance can be affected by other factors such as Human error and equipment of satellite link design, interference may be considered as a form of noise and hence, system performance is determined by the ratio of wanted to interfering powers.

4.2.4 Noise Concept

Noise can be classified as thermal, galaxy, atmospheric, switching transistor, inter-modulation, interfering, LO phase noise and is represented in terms of noise temperature. Noise temperature provides a way of determining minimum detectable signal in receiver and generation of thermal noise in active and passive devices of the receiving system .The total noise power at the output of the receiver is due to the contributions from antenna pattern, antenna loss, transmission loss and from the receiver components. The noise power is given by the NyQuil equation as,

$$N = kT_0B \qquad (5)$$

where, Pn - delivered to load with matched impedance to source noise; k - Boltzmann constant = 1.39 .10-23 joules/K = -228.6 dBW/K/Hz; T0 - Noise temperature of source in Kelvin; B - Noise bandwidth in which the temperature is measured in Hz. A noisy component is characterized by the noise figure (F) which measures the degradation of signal-to-noise ratio between the input and output of the component. Relation between equivalent noise temperature and noise figure is given as,

$$T_e = (F - 1)T_0 \qquad (6)$$

Performance of the receiving system is characterized by the system noise temperature and desirable to be kept low. Overall noise contribution is combination from the internal system as well as from external sources which affects the G/T ratio. Quality of the signal in the reception is dependent on T and major contribution came from sky noise which is a combination of galactic and atmospheric effects. Galactic effects are due to the addition of the cosmic background radiation and the noise temperature of radio stars, galaxies, nebulae and decreases with the increase of frequency. This value is quite low and taken as 3K towards zenith and 50K towards horizon.

4.2.5 Satellite Communication Link

The elements of satellite systems are earth segment and space segment. Earth segment comprises of a network of transmit and receive earth stations whereas space segment comprises of a satellite [6-7]. The performance objectives of the satellite link is specified in terms of allowable (S/N) or BER for a given signal or as a minimum allowable carrier to noise power ratio C/N. Reliable link in satellite communication can be made by ensuring minimum signal-to-noise ratio (S/N) in the receiver base band channel, optimizing transmitter power and RF bandwidth. The S/N ratio is dependent on the carrier-to-noise ratio (C/N) of the RF or IF signal in the receiver, modulation type and the RF/IF bandwidth in the receiver. The carrier power (C) and the noise power in the earth station receiver (N) can be represented as Eq.(1) and Eq.(7):

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RF/IF bandwidth in the receiver. The carrier power (C) and the noise power in the earth station receiver (N) can be represented as Eq.(1) and Eq.(7):

$$\frac{C}{N} = \frac{P_r}{N} = \frac{P_t G_t G_r}{\left(4\pi R / \lambda\right)^2} \Big/ kT_0 B \qquad (7)$$

The above value is specified in terms of percentage of outage time and at C-band it is taken as 0.01% of a year, at Ka-band it is 0.1% of a year and for Ka-band 0.2% of a year.

$$\frac{C}{N} = \frac{P_t G_t}{kB}\left[\frac{\lambda}{4\pi R}\right]^2 \frac{G_r}{T_0} \qquad (8)$$

$$\text{So } (C/N)\ \alpha\ (G_r/T_0)$$

The ratio of G/T is known as figure of merit and is dependent on frequency and noise temperature. The noise generated in the receiver systems depends on the system noise temperature and the bandwidth used for communication.

In case of downlink, G/T (dB/K) = Receiver Antenna gain – 10 log (system noise temperature) (dB/K) System noise temperature can be shown as (antenna is followed by line and receiver)

$$T_{sys} = T_{ant} + T_{cas} = T_{ant} + T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} \qquad (9)$$

$$= \eta_{rad} T_A + (L_F - 1)290 + T_{LNA}\,(L_F/G_R)$$

Taking fixed LNA temperature of 100 K with the elevation angle of 30˚, the Table.4 provide the comparison of gain with the antenna size (□ = 55%) at 4GHz [8]

Antenna Diameter (ft)	Gain (dBi)	G/T (K)	C/N (dB)
6	35	12	4.7
8	37.5	15.1	7.8
10	39.4	17.5	10.2
12	41	19.4	12.1
14	42.3	20.8	13.5

Table5:Effect of antenna diameter on G/T

Gain and beam width of a circular parabolic dish type aperture antenna of diameter D can be approximated as

$$\text{Antenna Gain (dBi)} = 18 + 20\log(d_{mtrs}) + 29\log(f_{GHz});$$
$$\text{Beam-width } (\theta \text{ in degrees}) \sim \frac{22}{Df}; \text{ Gain} = \frac{16}{\theta^2} \qquad (10)$$

Noise can be lowered by employing better LNA with low noise figure while keeping antenna gain constant or else employing larger diameter antenna to be used to achieve the same performance. In case of uplink the noise contribution from sky and ground is prominent and changes with elevation angle. Interference from other earth stations, terrestrial microwave links is considered as noise entering the receiver. Earth station G/T can be written as

$$\frac{G}{T}\left(\frac{\deg}{K}\right) = \frac{8\pi k(Y-1)}{\lambda^2 S K_1 K_2} \qquad (11)$$
$$K_1 = K_g.K_r.K_d$$

where, K1, K2 are atmospheric and source correction factor. The values can be calculated for deep space missions using the above equation. Main satellite parameters are orbit, orbit spacing, orbital inclination, constellation size, round trip delay, polarization, beam diameter, transponder bandwidth, antenna gain, antenna diameter, half power beam width, EIRP. Satellite communication link can be divided into design of uplink and downlink communication system.

4.2.6 Link Budget Calculation

Downlink parts consist of the portion of link between the satellite and the receiving earth station (Eq.(9)). The downlink design is carried out with the following objectives:

- Minimum C/N at the receiver input to guarantee link continuity
- Carry maximum number of channels

maintain C/N ratio above the threshold. C/N ratio can be increased by decreasing the noise bandwidth at the expense of reduction in number of channels.

$$
\begin{aligned}
[C/N_o]_D &= [EIRP]_D + [G/T]_{GS} - [L]_D + 228.6 \text{ (dBHz)} \\
&= \text{On-board transmitter EIRP - (path losses + attenuation) +} \\
&\quad \text{Ground Station } G/T + 228.6
\end{aligned} \tag{12}
$$

Downlink parts consist of the portion of link between the satellite and the receiving earth station (Eq.(9)). The downlink design is carried out with the following objectives:

- Minimum C/N at the receiver input to guarantee link continuity
- Carry maximum number of channels

Main criteria to be considered in downlink are the limit on the maximum permissible flux density at the earth's surface so as to avoid interference with the terrestrial links and to maintain C/N ratio above the threshold. C/N ratio can be increased by decreasing the noise bandwidth at the expense of reduction in number of channels.

$$
\begin{aligned}
[C/N_o]_D &= [EIRP]_D + [G/T]_{GS} - [L]_D + 228.6 \text{ (dBHz)} \\
&= \text{On-board transmitter EIRP - (path losses + attenuation) +} \\
&\quad \text{Ground Station } G/T + 228.6
\end{aligned} \tag{13}
$$

Downlink data is classified as telemetry and ranging data. The telemetry function is the acquisition, conversion, multiplexing, encoding and transmission of the data necessary to establish the status of various spacecraft sub-system and payload data. Ranging data provides the range of the satellite using the on-board transponder facility.

CHAPTER 5

IMPLEMENTATION

In the context of an increasing number of satellites orbiting around the Earth, developing a vast ground stations network becomes very important in order to be able to receive the satellite transmitted data. Consequently, this paper presents the aspects related to the implementation of a ground station for LEO satellites. The paper presents a relatively simple and cost efficient ground station solution, and also offers an example of satellite data reception. As the ground station is located within city limits, whereas the antennas are omnidirectional, the paper also analyses the location's radio horizon and radio compatibility.

The main parameters in GEO satellite are orbit (circular/equatorial), satellite height, round trip delay, satellite noise temperature, Tx/Rx gain, satellite EIRP, polarization, antenna efficiency, reflector size, 3dB beam width. Round trip delay is around 500ms and noise temperature is around 600K. Radio link in GEO mission consists of transfer and on-orbit operations. Antennas employed in uplink for transfer orbit is having 11m diameter whereas for on-orbit operations 7.2m antenna is employed. Correspondingly, EIRP changes from 85dBW to 80dBW due to change in antenna diameter. The Link margin for command and tracking is calculated using link margin whereas Eb/N0 is used for calculating link margin

5.1 Technology Stack

- **Software Requirement Of The Project: -**
  1. Ide: Android Studio 2021 3.1
  2. Framework: React Native
  3. Programming Language: Dart, Node.Js
  4. Admin: React (Frontend), Javascript
  5. Algorithm: Android Libraries, Google Map Api
- **Hardware Requirement Of The Project: -**
  1. Processor: Intel(R)Core(Tm) I5-6200u Cpu @2.30ghz 2.40ghz.
  2. Ram: 8 Gb Or More.

3. Hard Disk: Minimum 8 Gb Of Available Disk Space (Ide + Android Sdk + Android Emulator)

- **User Requirement Of The Project: -**

1. Android Version: Android 5.0+
2. Ram: 1 Gb Or More.
3. Storage: 4 Gb

5.2 Flowchart

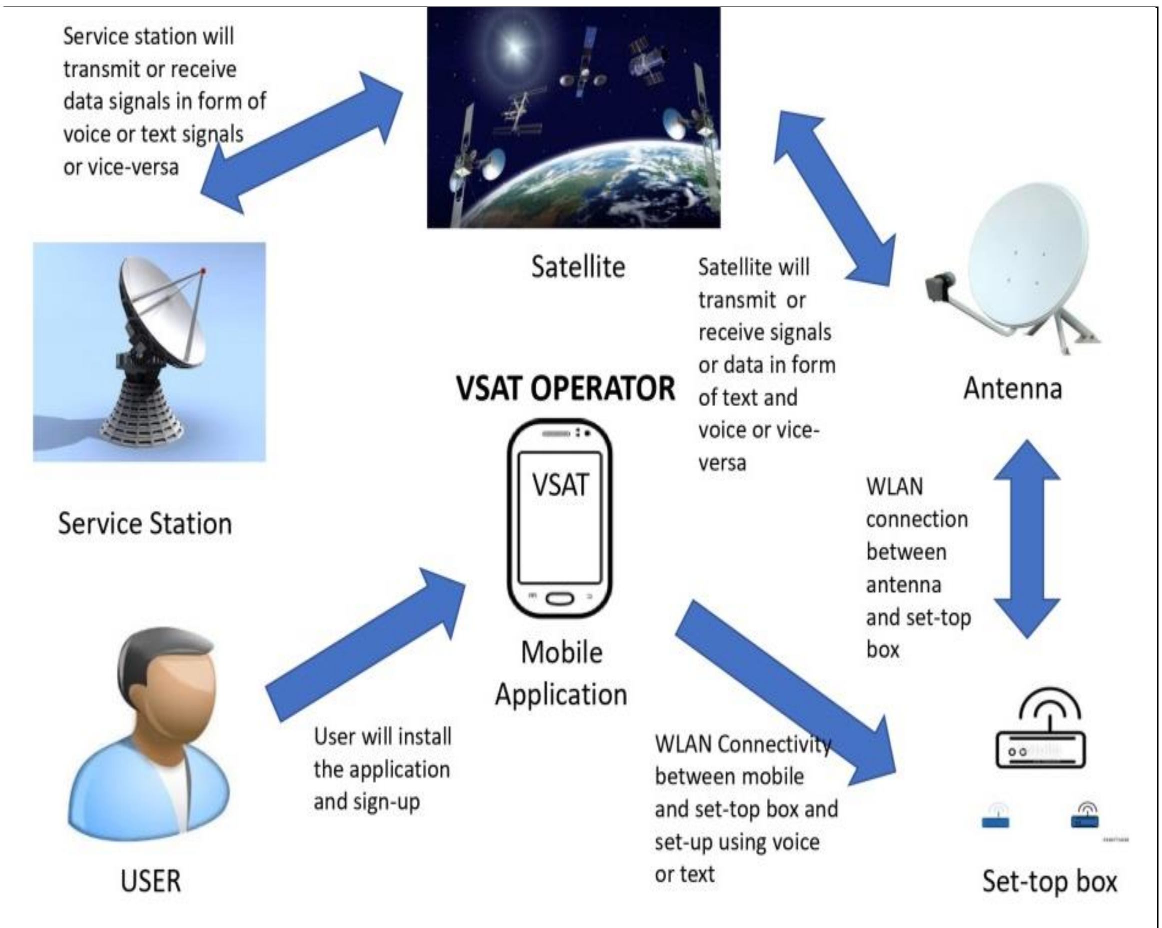

Figure 9:Implementation

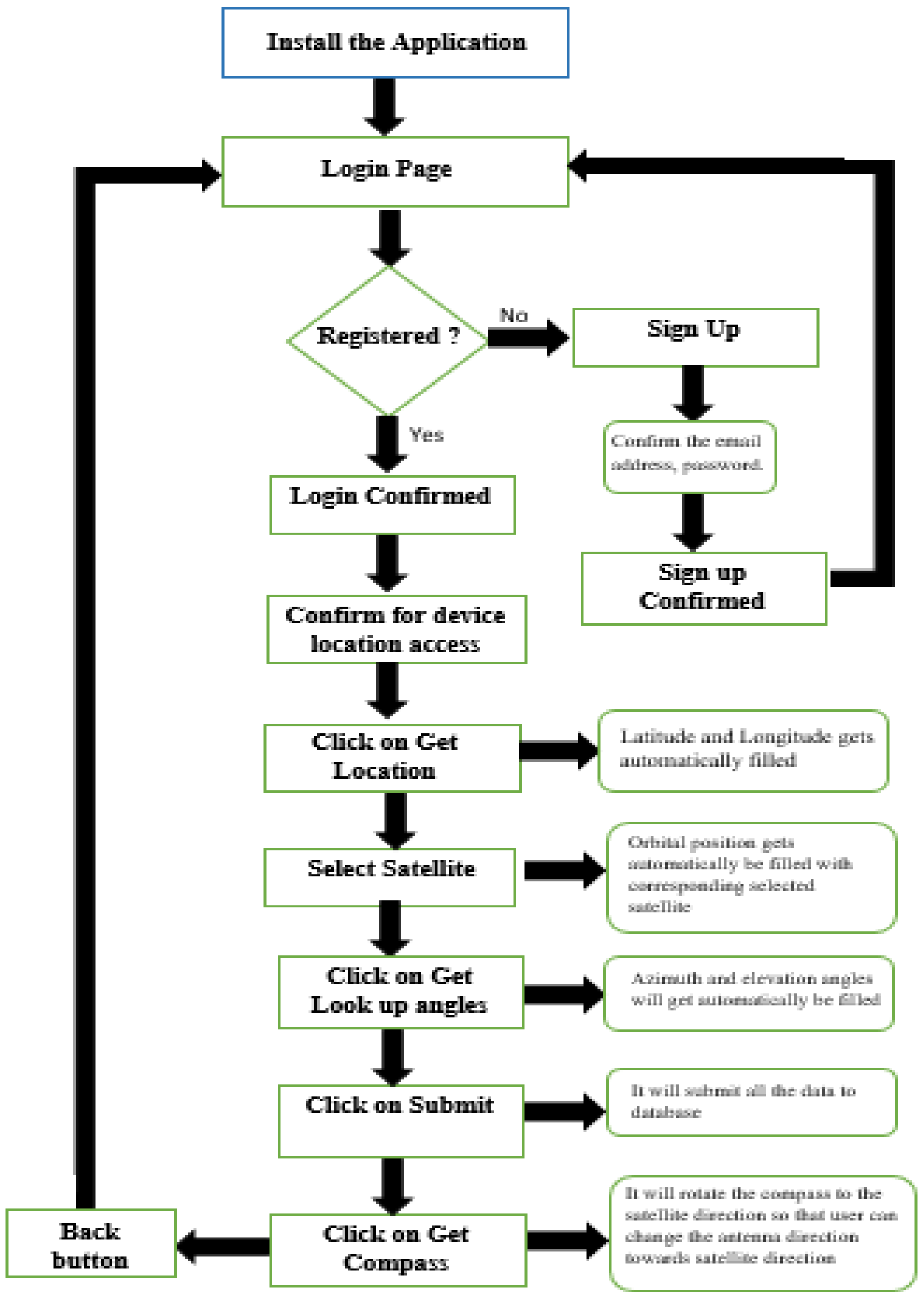

Figure 10:Flow Chart of implementation

CHAPTER 6

RESULT

- **Login Page:**

  First of all user has to install the app after that login page will open, then if the user has already registered then he has to login and if not registered then he has to sign up. After signing up, the user interface of Vsat App will open.

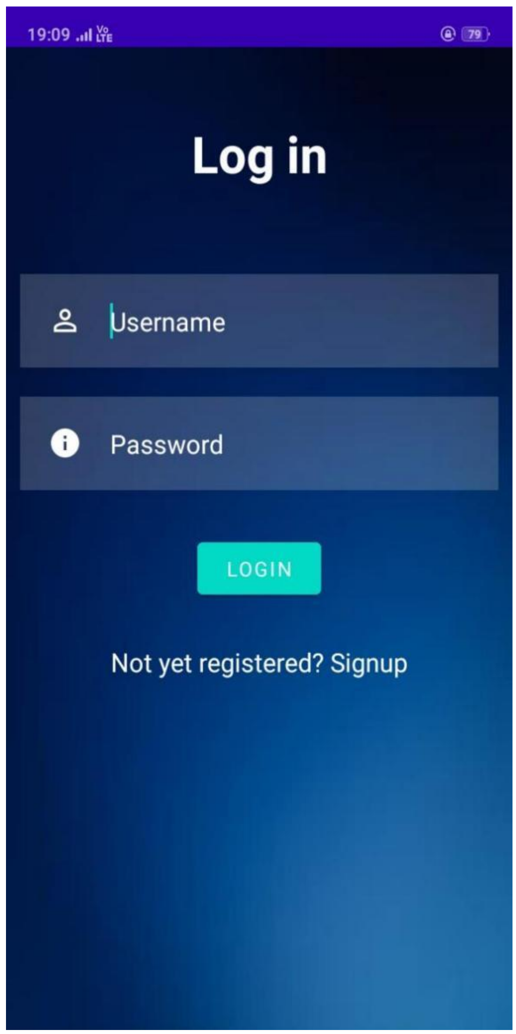

Figure 11:Login Page.

- **Sign Up Interface of VSAT app:**

  User has to make an account by putting email id & Password. After user has to confirm again by putting password for security purpose then click on sign up button for creating account.

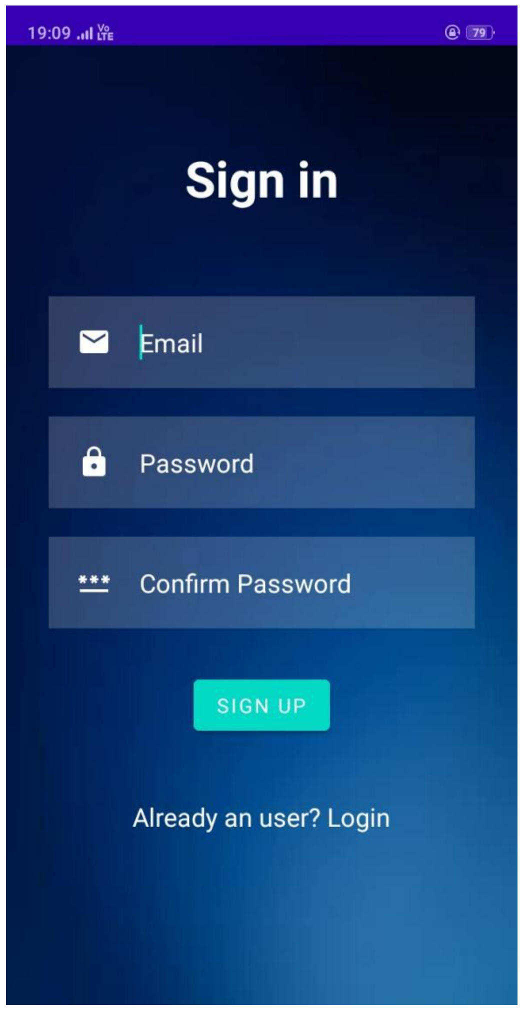

Figure 12:Sign Up Interface of VSAT app

- **UI of VSAT app:**

  After coming to the user interface page of Vsat App, we have to turn on the location of our phone. Then click on the gat location so that the values of latitude and longitude will come automatically then click on the gate location so that the values of latitude and longitude will come. After selecting the satellite, clicking on the orbital position, the value of the orbital position will come automatically. The value of azimuth angle and elevation angle will come as soon as you click on get lookup angles. After that we have to submit by clicking on the submit button and click on the get compass , after that the compass of Vsat app will open.

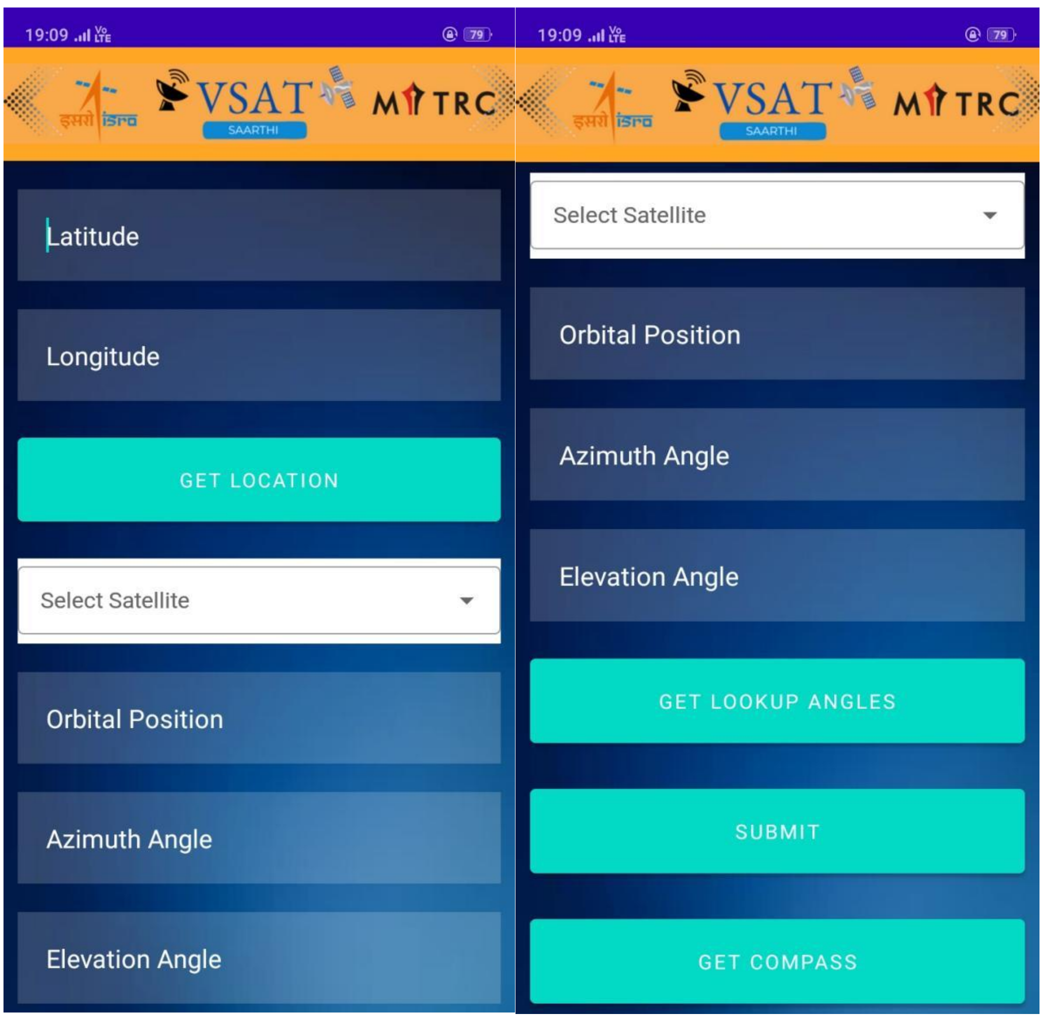

Figure 13: UI of VSAT app

➢ COMPASS of VSAT app:

Vsat app's compass shows the direction and angle to the user, with the help of which the user can correct the angle and directions of his antenna. So that proper connection is made with the satellite

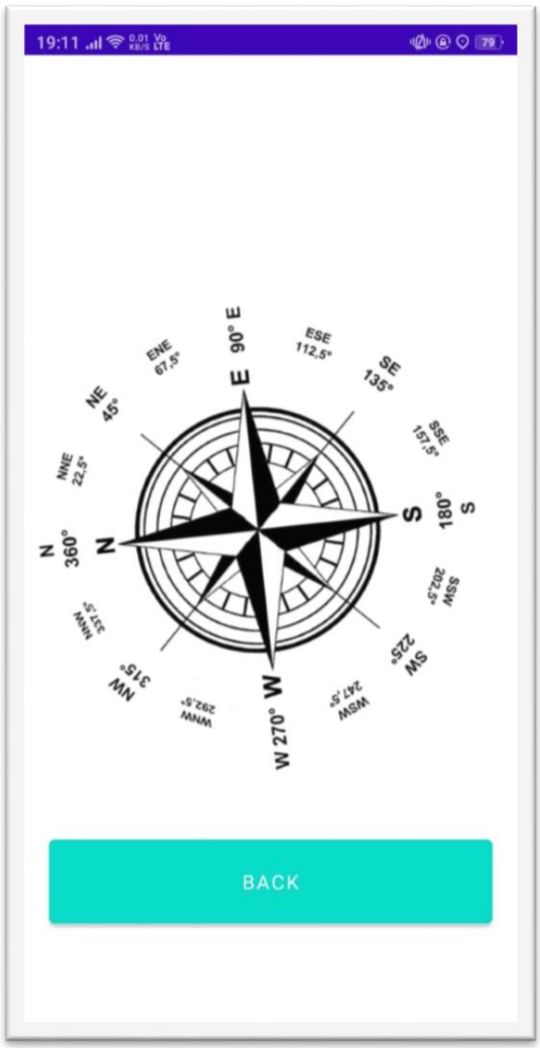

Figure 14:Compass of VSAT app

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 Conclusion

- The vsat sarthi operator app is an instant solution that simplifies the process of manually setting up antennas. It is a mobile application that can be used by anyone, adjust the antenna and connect it to the network in a matter of minutes. In conclusion, the VSAT Sarthi Operator App is a game-changing solution for the satellite communication industry. Its innovative features, ease of use, and reliability make it an indispensable tool for anyone involved in the installation and maintenance of VSAT antennas. If you are looking for a way to streamline your satellite communication operations and increase efficiency, the VSAT Sarthi Operator App is definitely worth considering. The VSAT Sarthi Operator App is an innovative solution that provides an instant and easy way to set up an antenna. It is designed to simplify the process of antenna installation and configuration, making it easier for operators to get their VSAT networks up and running quickly. Overall, the VSAT Sarthi Operator App is a useful tool for anyone who needs to install and configure a VSAT antenna. Its intuitive interface and step-by-step instructions make it easy to use, even for those who are not familiar with the process. By providing an instant solution to manually setup the antenna, the VSAT Sarthi Operator App can save time and effort for operators. This, in turn, can help to reduce costs and increase efficiency for VSAT network operators. In conclusion, the VSAT Sarthi Operator App is a valuable tool for anyone involved in the installation and configuration of VSAT antennas. It is an easy-to-use and efficient solution that can save time and effort, while also improving the overall performance of VSAT networks. In addition to simplifying the process of antenna installation and configuration, the VSAT Sarthi Operator App also provides a range of other features and benefits.
- For example, the app can help to optimize the performance of the antenna by providing real-time monitoring and diagnostics. This can help to identify any issues or problems

with the antenna, allowing operators to quickly address them and prevent downtime or service interruptions.

- The app also provides remote access and control of the antenna, allowing operators to make adjustments and updates from anywhere, at any time. This can be especially useful for remote or hard-to-reach locations, where it may not be practical to send a technician on-site.
- Overall, the VSAT Sarthi Operator App is a powerful and versatile tool that can help to streamline the installation, configuration, and maintenance of VSAT antennas. It is a valuable asset for anyone involved in the operation of VSAT networks, from small businesses to large enterprises.

7.2 Future Scope

- The VSAT Sarthi Operator app has the potential to become an important tool for satellite communication operators, as it provides an instant solution to manually set up the antenna. The app can help operators save time and resources by eliminating the need for manual antenna alignment.
- In terms of future scope, the VSAT Sarthi Operator app could be enhanced with new features and capabilities to further improve its usefulness for operators. For example, the app could include real-time monitoring and reporting tools to help operators diagnose and troubleshoot issues with their satellite communication systems.
- Very Small Aperture Terminal (VSAT) Market research report execution is becoming very vital for businesses to gain success
- Additionally, the app could be expanded to include support for a wider range of satellite communication systems and hardware, making it more versatile and useful for a broader range of users.
- Overall, the future scope of the VSAT Sarthi Operator app will depend on the needs and demands of the satellite communication industry. As the industry continues to evolve and new technologies and tools become available, the app will need to adapt and evolve to remain relevant and useful for operators.
- This offers many benefits including insights into revenue growth and sustainability initiative.

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