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Mobile Satellite Services and VSAT Technology: A Comparative Study

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Abstract: *Wide regions around the world specially remote and rural areas suffer from the absence of voice and data services provided by operating service providers in the country or may suffer from weak network coverage due to the small amount or the absence of built infrastructure in these areas, here comes the role of satellite communication systems as a solution for this problem due to their great abilities such as a wide reception range which means the possibility of building networks in almost any place on earth. The purpose of this article is to study VSAT technology and Mobile Satellite Services as satellite based services and comparing their capabilities from different aspects in providing communication services for people in these regions.*
Key Words*: VSAT, Mobile Satellite Services, VSAT Architecture, MSS systems, Propagation Conditions, Frequency Bands, Antenna Diameter.*

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I. Introduction

Telecommunication networks play an essential role in providing users with phone services and in connecting users to the internet, the challenges existing in presenting these services are that rural and remote regions are influenced by several factors such as the large areas that need coverage, scattered user base and the cost of implementation.

These factors lead to limited or absent last-mile connectivity infrastructure. They also create a digital divide between urban and rural regions, which results in the lack of access to telecommunications services, and leads to economic and social differences across these regions [1].

Advanced and practical technology implementation plans need to be deployed to provide last-mile broadband access in rural and remote areas by the use of telecommunication networks which should be robust, flexible, scalable, affordable, and easy to use, most implementations are based on wireless technologies due to their cost effectiveness, flexibility, and ease of installation especially in challenging regions with wide areas and low population in scattered areas, available solutions include VSAT technology and Mobile Satellite Services (MSS) [1].

Very Small Aperture Terminal (VSAT) is a small satellite transmitter and receiver that communicates with VSAT access satellites and is a fixed wireless broadband technology where customer premises equipment (CPE) at a user's site connects to a wireless network VSAT could be a good candidate for setting up broadband links in remote locations[1].

A practical and cost saving implementation of VSATs and Mobile Satellite Services is by utilizing existing operating Geostationary satellites in the targeted area by the use of their transponders in retransmitting the received signals to the users and these satellites were chosen because of the fact that they appear at a fixed point to the earth as their orbit period is close to earth acceleration period and hence the coverage will not suffer from area or time coverage gaps and the track of the satellite is reduced to a point on the equator [3], they are used to create networks between areas located at a long distance from each other, where the construction of traditional communication networks would be expensive or impossible [4].

The goal of this study is to provide a covering review and comparison of VSAT and Mobile Satellite Services technologies to come up to their differences and understand the role they can contribute with to provide voice and data service in uncovered or poorly serviced areas.

II. Background

Universal satellite companies that deploy data transceiver operations from many places have been operating since the 1970s and since the 1980s ground terminals equipped with small dishes was available on the market. At first they were dishes with only a receiving antenna, but as time went by they were developed to be dishes with both transmitting and receiving antennas. The information and telecommunication systems using them have started out to be known as VSAT (Very Small Aperture Terminal). Such systems have end up

gaining increasing popularity due to the possibility of installing them at almost every location depending on the direction of the antenna, as well as the lack of international coordination of terrestrial stations [4].

At the beginning of the 1990's many corporations have started to manufacture VSAT systems on a large scale that was designed for different purposes and thus operated on different frequencies. In 1998 about 60,000 two-way VSATs were installed and operated in the Ku-band frequency (around 14GHz for the uplink and around 12GHz for the downlink) [3], and at the beginning of 1999 there were about 300 000 VSATs operating around the world which shows a significant growth of this technology[4].

The VSAT networks provided data services to remote user terminals at rates of 192 kb/s to 2 Mb/s or even more in areas where the data services offered by Plain Old Telephone Service (POTS) lines and modems had 14.4 to 28.8 kb/s data, the continuous research and inventory in this field lead to the availability of different integrated circuits that implement the receiving part of the remote terminal, with the use of these chips for digital transmission in the long term has reduced the cost of digital receivers operating at data rates up to 90 Mb/s to less than $40 in two-way VSAT networks [4].

III. VSAT Network Architecture

The basic architecture of the VSAT communication network consists of the allocated satellites in space that are connected with many earth stations known as hub sites on the ground in the satellite communication system

The earth segment network will connect all the VSAT users in the remote sites with the earth station and this earthbound network may be a dedicated link or a telephone switch to earth station. The earth bound network will process all the base band signals that are produced by the VSAT users and transmit these base band signals to the satellite from the earth station. A significant number of repeaters in space are available with the satellite transponder which gets the modulated RF carrier signal in its uplink from all the earth stations in the system, enhances these carrier signals and retransmits them to the earth stations in its downlink frequency spectrum [2].

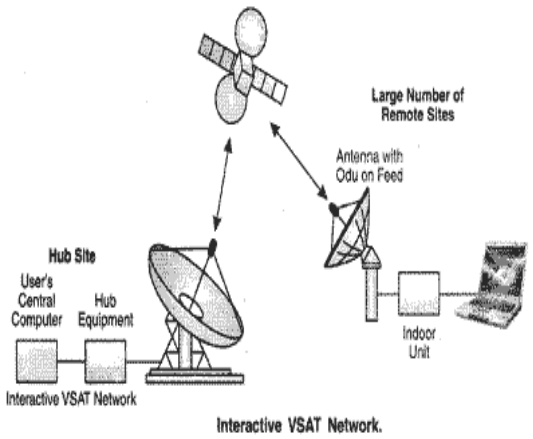

Figure 1 VSAT Network Architecture [5]

Earth Station Architecture

The architecture of the VSAT earth station consists of two fundamental parts which are the outdoor 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 user's terminals or local area network (LAN) [6].

The outdoor unit consists of the antenna and the electronics set containing the transmitting amplifier the low-noise receiver, the up- and down converters and the frequency synthesizer [6].

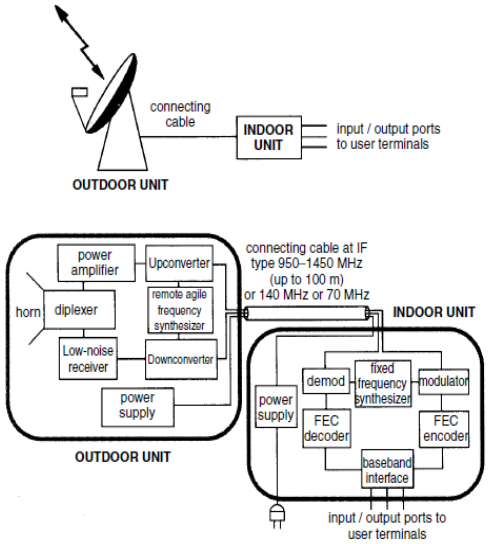

Figure 2 VSAT earth station equipment [6]

The fundamental block diagram of a VSAT earth-station outdoor unit is shown in the following figures. A VSAT earth station is made of two separate sets of equipment, the transmitter is as presented in figure 3. The fundamental block diagram of a VSAT earth-station receiver is as presented in figure 4.

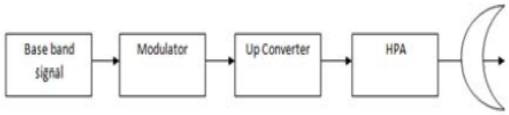

Figure 3 VSAT earth station Transmitter [2]

The transmitter will perform the process of modulating the baseband signals that are from the earthbound network and is converted to uplink frequency[2].

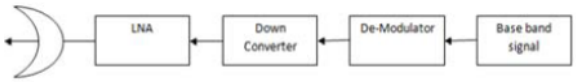

Figure 4 VSAT earth station Receiver [2]

At the receiver the Low Noise Amplifier (LNA) will process the signals that are received from the satellite to acquire the original base band signal, the signals from the low noise amplifier (LNA) are down-converted and then demodulated [2].

The Hub Station

The hub station has the similar components as the VSAT station the only difference is that the indoor unit of a hub station interfaces to either a host computer or to a public switched network or private lines depending on whether it is a dedicated or a shared hub [6].

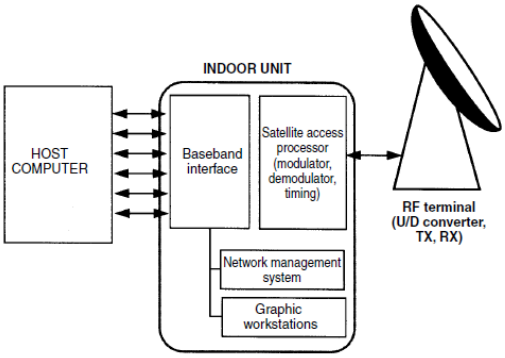

Figure 5 Hub station architecture [6]

IV. Mobile Satellite Services

The following part discusses the historical background of Mobile Satellite Services(MSS) and gives a general demonstration of this advanced technology and an explanation of the difference between it and VSAT technology in terms of propagation conditions and frequency bands.

Historical Background:

The first Mobile Satellite Services (MSS) was invented to meet the needs of the marine communication but were deployed on land for mobile users because there were still large areas of the world that were not served by terrestrial cellular or cable networks. The coverage of terrestrial wireless systems was increasing around the world but mobile satellite systems were still necessary to cover the areas that suffered from coverage gaps and to meet the increasing need for an existence of a variety of services such as global messaging, aircraft position reporting, remote area connectivity, disaster relief communications, search and rescue communications, and Internet access for portable and mobile terminals. They were designed to support smaller earth stations for air, land and sea applications [7].

The development of Mobile Satellite services was a result of the development of both satellite technology and circuit integration which led to the availability of low cost digital signal processors, the MSS abilities to provide data and multimedia access improved with the enhanced wireless technology and the growth of the internet [8].

Mobile Satellite Services:

Mobile satellite service (MSS) technology is a radio communication service between one or several satellites with mobile earth terminals. In most MSS systems the mobile to satellite links are connected to feeder link frequencies which in their turn are connected to fixed gateway earth stations. MSS systems provide voice and internet services to mobile and fixed terminals, ships, aircrafts and land vehicles and buildings.

The employed satellite serves many coverage beams with services including global messaging, aircraft position reporting, remote area connectivity, disaster relief communications, search and rescue communications, and Internet access for portable and mobile terminals [7].

Types of Mobile Satellite Services systems:

The following section describes some of the existing Mobile Satellite Services in which the satellite's antenna has multiple spot beams that diffuse cells on earth to create coverage similar to the cellular mobile network [10]:

Inmarsat:

Inmarsat satellite system was invented in 1979 for the marine industry but it provides broadband communication services to aircrafts, maritime and companies today, it uses a set of 12 satellites consisting of 4 Inmarsat 2, 5 Inmarsat 3 and 3 Inmarsat 4 providing coverage to the entire earth except the polar regions with mobile, data and fax communications [10].

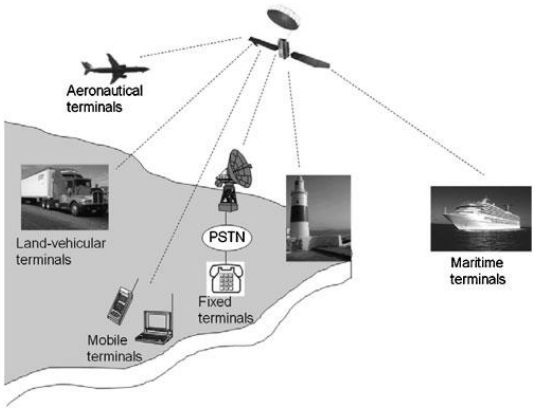

Figure 6 Inmarsat System components [10]

Iridium

Iridium is the oldest MSS existing today and the only one with complete earth coverage including the polar and oceans regions and aircrafts, it is a LEO based satellite system with 66 LEO satellites that provides voice and low data rates anytime everywhere in the world through Interlinked Satellite Links (ISL) for voice calls switching [10].

This satellite system integrates with Inmarsat terrestrial gateways and connects the users to the nearest one for data services, currently there are 5 gateways in the system[10].
The Iridium satellite system provides communication services to the Department of Defense of the USA [10].

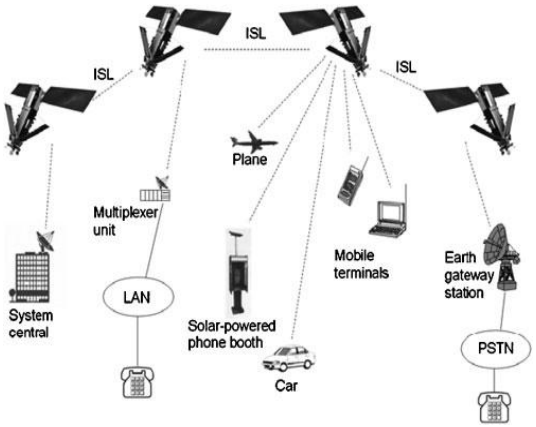

Figure 7 Iridium System Components [10]

Thuraya

Thuraya is a mobile satellite service invented in the UAE in 1997 and operates using two GEO satellites, the satellites were launched and managed by US Boeing Satellite Systems. Their services cover 110 countries in north and central Africa, the middle-east, central Asia, the Indian subcontinent and Europe [10].

There are currently two operating Thuraya satellites which are Thuraya3 and Thuraya2, Thuraya3 replaced the first Thuraya satellite Thuraya1 to expand the coverage to include China, Japan and Australia. Thuraya satellites operate using L bands frequencies through a FDMA/TDMA air interface generating 200-300 spot beams, providing communication services such as GSM voice quality, messaging, data/fax services with datarates at 2.4, 4.8 and 9.6 kbit/s [10].

One of its most important services is Internet connectivity through a small portable terminal with 144 kbit/s data rate based on Amplitude Phase Shift Keying (APSK) modulation, recently a high speed IP based service was launched with a data rate at 444 kbit/ sec [10].

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V. Propagation Conditions

The invention of mobile satellite services followed the development of Fixed Satellite Services (FSS) [8].

VSAT is a fixed satellite service and delivers point to point services with a line of sight LOS channel between the satellite and the earth station where the ground terminals are fixed and are not moving through a changing environment, this is different to Mobile Satellite Services where channel environment is more complex and the transmitted waves face many obstacles in their path such as trees, buildings and terrains which causes reflections, diffraction, absorption and scattering, this leads to that multiple rays are received at the receiving antenna at varying power levels resulting in signal fading [8].

The frequency bands in which fixed satellite services (VSAT) operate are above 10 GHz and are usually Ku and Ka bands whereas the mobile satellite services operate in frequency values below 10 GHz which are L and S bands but can operate in VHF up to Ka bands in the case of higher bandwidth demand [8].

VI. Frequency Bands

The following table shows the frequency bands classifications used in Satellite systems set by the Institute of Electrical and Electronic Engineers (IEEE) [8]:

Table1 IEEE Band Designations [8]:

Band	Frequency Range
L	1-2 GHz
S	2-4 GHz
C	4-8 GHz
X	8-12 GHz
Ku	12-18 GHz
K	18-27 GHz
Ka	27-40 GHz
V	40-75 GHz
W	75-110 GHz

VII. Antenna Diameter

The VSAT has a central dedicated large hub station which employs an antenna with a size in the range of 8–10 m, mini-hubs which are small hubs use antennas with size in the range of 2–5 m [6]. The majority of VSAT terminal antennas range from 75 cm to 1.2 m, they might vary based on the standards of regional or national regulatory bodies (ITU, ETSI, TPRA, etc.) satellite spacing and coordination agreements reached with neighboring satellite operators to avoid interference and are mostly high gain antennas [9], in the other hand Mobile Satellite Service receivers are mostly hand held mobile terminals or other types of receiver devices with built in zero or low gain antennas [10].

VIII. Results

The VSAT technology and Mobile Satellite Services (MSS) review shown in the previous parts of the study show the differences between them from different aspects which can be expressed in the following table:

Table2 VSAT and MSS Comparison

Comparison point	VSAT	MSS
User Position	Fixed	Mobile
Antenna type	Directional	Omni-directional
Antenna Gain	High gain	Low or no gain
Channel Environment	Line of Sight link	Complex with multiple obstacles in the path
Frequency Band	Ku and Ka Bands	L and S Bands
Receiver terminal	Small diameter 1-2 m antenna in a complex earth station	Hand held mobile terminals
System Architecture	Centralized with a hub station	Decentralized from the satellite to the mobile terminals directly
Payment and cost	Fixed monthly contract for unlimited use	Pay as you go
System Types	VSAT Ku Band VSAT Ka Band Mini VSAT	Inmarsat Iridium Thuraya

IX. Conclusion

In this paper a detailed comparative study between two different Satellite Communication technologies which were VSAT and Mobile Satellite Services (MSS) was delivered. First it was found that they were two distinct services depending on satellite systems able to provide two way interactive services such as voice, data and fax services to remote and uncovered areas by the deployment of LEO and GEO satellites.

Secondly it was found that they differed in many areas such as their channel environment, frequency bands, antenna characteristics, payment method and more but most importantly in the user mobility where MSS where found to be a mobile service where the user can move freely with no restrictions and has a direct link to the satellite but VSAT on the other hand was found to be a fixed service with a centralized architecture through a hub-station, these differences shows that each technology can be deployed differently depending on the circumstances of the case such as cost, coverage area and the number of users.

And last it's concluded that they are able to provide communication services in regions that lack or have weak network connectivity by making use of their flexibility in terms of both their coverage and capacity capabilities.

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