REVOLUTION IN SATELLITE COMMUNICATIONS

Ravi Baweja
Rakesh Rajan

ABSTRACT

A Brief view on the study, design and Evolution of digital satellite communication is the focus of this paper. Starting from the past of satellite Communications, we go through the current and future phase of satellite communication. We address basic aspects related to the satellite communications in the attempt of providing the Reader with an overview of the whole journey of communication using satellites.

Keywords: Communications, transmission, orbit, technology.

INTRODUCTION

In recent years, the wireless communication world witnessed an unbelievable change in the way of communication. From those heavy wired telephones to those which uses satellite link for communication and communicate wirelessly. Straight from our past we understood that satellite is our future.

The world's first commercial communications satellite "Early Bird," was placed by NASA into a geosynchronous orbit above the Atlantic in 1965. Early Bird helps in establishing over 230 Voice connections between the United States and Europe, this only satellite had a capability almost equal to that of all the RF/coaxial cables under the Atlantic at that time. Since 1965, hundreds of communication satellites have been launched to provide both domestic and international communications services.
Satellites today are the most common and efficient way of transmitting television pictures around the globe, using cables or directly to subscribers (DTH). Satellites are also being used by corporate sectors to provide private data networks for companies (such as banks, industries) that have widely distributed offices.

Early development in satellite communications is briefly explained in Section 2, and Section 3 describes current position of global satellite systems providing personal communications (voice, fax, email and paging) services to users having cellular phone. Section 4 represents proposed future plans which are announced by large corporations to establish satellite systems which can transmit data at extreme speed using Laser communication technique

1. EARLY STAGE

The space has always surprised the people on the earth and communication through space gives an idea for space travel. The first idea of using artificial satellites for communications is found in a science fiction Brick Moon by Edward Evert Hale, published in 1869-70. While the early stages of satellite and space communications faces little challenges to the technology as it exists today, these are initial steps towards satellite and space communications since they represent the origins of the idea from which the technology eventually grown. In the area of satellite communications, the technology has been responsive to the imaginative dreams. Hence it is also expected that technological innovations will lead the evolution of satellite communications towards the visions of today.

1.1 Realization of concept to reality

In October 1957, the first artificial satellite called Sputnik -I was launched by former Soviet

Union now Russia in the earth's orbit and in 1963 USA also launched their geosynchronous satellite SYNCOM which was successfully launched by NASA. The realization of the concept of satellite communications from an unimaginable idea to reality has been possible only due to a large number of technological failures and practical experiments of devices and systems, which are undergoing during and after the World War II. The pressures of international military opponents during cold war period were also able to push scientific and technological research and development faster than it would have been possible if applied for peaceful purposes. The successful launching of communications satellite in earth's orbit was possible because of deep interests shown by specific group of people along with the developments in the areas of science and technology. Some of these factors, which are considered important in the realization of satellite communications, are:-

- Development of high power rocket technology and propulsion systems capable of delivering satellites in high altitude orbits.
- Scientific and military interests in Space Research.
- Development of Solar Cells for providing natural energy source for the satellite.
- Development of ultra speed computers for calculating and tracking orbits.
- Financial support of government in Space Technology Development for Scientific Experiments.

1.2 Sputnik 1

Sputnik 1 was the first artificial Earth satellite. Its diameter was 58 cm and it was a metal sphere coated with some shiny substance and has four external radio antennas to transmit radio signals. The Soviet Union launched it into Earth's orbit on 4 October 1957. It covers all the Earth and its radio pulses were detectable. Surprise success of Sputnik 1 started the space race between USA and Soviet Union. Sputnik itself provides scientists valuable information. Sputnik 1 was launched during the international Geophysical Year. The satellite travelled at approx 29,000 Kilometers per hour and it takes 96.2 minutes to complete one revolution. The signal from sputnik continues to reach Earth for 22 days until the transmitter batteries ran out of power on 26 October 1957. Sputnik 1 completed its journey on 4 January 1958, as it is de-orbited upon reentering Earth's atmosphere, after completing its lifetime journey of about 70 million km and spending 3 months in orbit.

TABLE - 1

MAJOR ACHIEVEMENTS IN SPACE RADIO COMMUNICATIONS

Category	**Year**	**Activity**	**Person/Agency/ Country.**
Geostationary concept	1945	Suggestion of Geostationary satellite communication feasibility.	A. Clark (U.K)
Moon Reflection	1946	Detection of Lunar Echo by Radar	J. Mofenson (U.S.A.)
	1954	Passive relaying of voice by moon reflection.	J.H. Trexler (U.S.A.)
	1960	Hawaii-Washington, D.C. Communication by Moon Reflection.	U.S.A. Navy.
Low altitude orbit.	1957	Observation of signals from Sputnik -1 Satellite.	U.S.S.R., Japan and others.
	1958	Tape-recorded voice transmission by Satellite SCORE.	U.S.A. Air Force.

	1960	Meteorological facsimile Trans mission by Satellite Tiros-1.	U.S.A. NASA
	1960	Passive relaying of telephone and television by Satellite Echo-1.	U.S.A. Army.
	1963	Active relaying of communication by Satellite Relay 1.	U.S.A. NASA, Japan.

2. CURRENT STAGE

Satellite technology is moving toward providing services to individual customers. The earliest advances in this direction have been satellite systems that deliver television direct to the home (DTH). Another contributor to the success of these systems, has been the development of powerful digital tools that permit 10 TV channels to be transmitted via a single transponder, and the picture to be recovered in a set-top box containing very-large-scale digital integrated (VLSI) circuits which are known to be low cost technology.

Next to be developed were satellite systems that provide cellular Services-like voice

Talk to mobile users equipped with small terminals. These such systems with worldwide

Coverage is under development. Market Studies have identified four potential markets: international business travelers (primarily business travelers from the developed world visiting less-developed countries), national roamers (primarily business travelers needing mobile communications in their own countries, but who travel beyond the reach of terrestrial cellular systems), national rural fixed service (an extension of the national fixed services to regions where they are presently unobtainable), and government agencies (law enforcement, fire, public safety, and other services). The designs of the global systems discussed represent different assumptions concerning the business to be attracted from these four segments. The subsections that follow discuss the five proposed systems that are proceeding.

3. PROPOSED FUTURE STAGE

In little more than two decades, communications satellite technology has gone from being revolutionary to ordinary place, from an idea to worldwide service. In both industrialized and developing countries, economic and social progress depends on improved telecommunications.

Like other means of transport, telephones, computers, satellites and fiber optic cables and their proper interfaces are essential for moving commercial goods and services. Benefits of satellite communications should be extended to users in each parts of the world through the use of smaller, inexpensive and less complicated Earth stations for two way (voice and data), and one way (video, data) use.

While earlier satellite systems have been designed and implemented using C and S band communications with satellites in geostationary orbits (GEO), K band communications using VSATs (Very Small Aperture Terminals) have enabled the communications across areas of the US and the world where extensive telecommunications networks did not exist or were not affordable. In addition, several systems have been proposed (under construction) to provide for the global communication of the mobile users using clusters of smaller, less complex satellites in low Earth orbit (LEG) and medium Earth orbit (MEO). Mobile satellite systems are the future of the satellite communications technology applications. In this paper, we will briefly explain the status for satellite communications and then present a comparison of the enabling mobile satellite communications technologies and mobile satellite systems currently being developed. We will also review applications of these systems in public and commercial areas in this paper.

3.1 SATELLITE COMMUNICATION USING LASER

On Oct. 18, NASA's Lunar Laser Communication Demonstration (LLCD) made history, transmitting data from lunar orbit to Earth at a rate of 622 Megabits-per-second (Mbps). That download rate is six times faster than previous state-of-the-art radio systems flown to the moon.

LLCD is being flown aboard the Lunar Atmosphere and Dust Environment Explorer satellite known as LADEE, currently orbiting the moon. LADEE is a few days robotic mission designed and operated by a team from NASA's Ames Research Center in Moffett Field, Calif. Its primary mission is to investigate the exotic atmosphere that exists around the moon.

LADEE, with LLCD onboard, reached lunar orbit 30 days after launch from NASA's Wallops Flight Facility on Wallops Island, Va., on Sept. 6. During the trip, the LADEE team provided an opportunity for LLCD to make post-flight calibrations of its pointing knowledge. A critical part of laser communication is being able to point the narrow laser beam at a very small target over a great distance.

LLCD not only demonstrated a supersonic download rate but also it has an error free data upload rate of 20 Mbps. The laser beam was transmitted the 239,000 miles from the primary ground station at NASA's White Sands Complex in Las Cruces N.M., to the LADEE spacecraft in lunar orbit.

This latest technology has a laser-based space terminal that uses 25 percent less power and is half the weight of a traditional radio-based terminal. These first tests of the weeks-long demonstration have included the successful LLCD transmission, by pulsed laser beam, of two simultaneous channels carrying HD video streams to and from the moon. It proved that it is possible to communicate with multiple locations; LLCD successfully transmitted its beam several times to

NASA's Jet Propulsion Laboratory's Optical Communications Telescope Laboratory in California. Soon testing will also include transmissions originating from the European Space Agency's (ESA) Optical Ground Station in Tenerife, Spain.

LLCD's is also capable of providing continuous measurements of the distance from the Earth to the LADEE spacecraft with a great accuracy of less than half an inch. LLCD has also transmitted large data files from the LADEE spacecraft computer to Earth. Now we have the ability to transmit huge amounts of data that would take minutes instead of days. Laser-based communications is the next step towards space communications.

Some of the future testing will include how well the system operates in optically stressed conditions such as daytime (all operations have been done under moon), full moon verses new moon, and different pointing positions for the ground terminals.

NASA's laser communications between LLCD and Earth ground stations is the longest two-way laser communication ever done. It is the first step and part of the agency's Technology Demonstration Missions Program, which is working to develop unbelievable technology capable of operating in the difficulties of space.

The Laser Communications Relay Demonstration (LCRD) is the follow-on mission, scheduled for launch in 2017. Also managed at Goddard, LCRD will demonstrate laser relay communications capabilities for Earth-orbiting satellites continuously over a period of two to five years.

3.2 Advantages of Laser Communications

Laser-based data transmission has several advantages over conventional radio links. Due to the shorter wavelength, lasers can achieve higher data rates than radio signals for the same given aperture. Some of the advantages are listed below: -

- Frequencies 7 - 8x higher
- Higher bandwidth
- Smaller beam divergence
- Smaller antennas ➢ Higher data rates ➢ Highly efficient.

3.3 Applications of Laser Communications

Among many other applications, laser communication is currently being considered for:-

- Data relay services for unmanned aerial vehicles (UAV): UAV inspecting remote areas can send their observation data to a data relay satellite in geostationary (GEO) orbit via an optical link.
- Data relay services for satellites: High-speed laser communication can be used to replace an expensive network of ground stations needed to constantly receive low earth orbiting (LEO) satellites` data. The data gathered by the LEO satellites can by transmitted to a relay satellite in GEO orbit by means of laser communication. The relay satellite then transmits the data to a single ground station thus offering cost savings in operations and infrastructure.
- Inter-satellite links between GEO satellites can be used to share resources and/or route traffic around a satellite network. They are also of interest for intra-continental communications (e.g. between satellites providing services throughout Europe with satellites providing services to Western Europe being linked to satellites providing services to Eastern Europe) and inter-continental links (e.g. between satellites providing services in Europe linked to satellites providing services to the US and / or Asia Pacific rim).
- Deep space data transmissions: The amount of data being collected on exploration missions, such as those to Mars, and is increasing and will soon become limited by RF capacity. This increase may require on-board data processing and coding be introduced, with the resulting loss of access to the raw scientific data. In addition, an increase in the long data transmission times increases operation costs and severely reduces the time available for scientific tasks. By using optical links, the data rate can be dramatically

increased, thereby allowing the raw scientific data to be received and resulting in the increased scientific value of future missions.

3.4 Laser Terminals

Some of the Laser terminals are discussed below: -

- OPTEL 02

  The Optel 02 is short-range terminal and capable of transmitting data at Gbps rates upto the distance of 2,500 km. This class of terminal is of interest for applications such as the short range GEO - GEO crosslink's.

- OPTEL 25

  The OPTEL 25 is a medium range terminal and capable of transmitting data at Gbps rates over distances of, typically, 25,000 km to 45,000 km. This class of terminal is of interest for applications such as LEO - GEO inter satellite links and medium range GEO - GEO crosslink's.

- OPTEL AP

  The OPTEL AP terminal has been designed for the atmospheric communications between either high altitude (stratospheric) platforms (HAP). The communications links between HAPs are defined at a data rate of 155 - 622 Mbps over a distance of around 400 km.

CONCLUSION

Communication using satellites is the most common and efficient way of communication. Straight from the launch of first satellite it has been proven that satellite is the future of communication.

Way of communication using satellites will continue in the direction of advancement from the use of large metallic balloon to the use of Laser in communication.

Satellites are very important for modern communications. Radio Frequency communication reaching the end of its usefulness Laser Communications will eventually be the method of choice for satellites.

REFERENCES

[1]. The future of public satellite communications Mangir, T.E. ; TM Associates, Santa Monica, CA, USA.

[2]. The past, present and future of satellite communications. By John V. Evans

[3]. Satellite communication: An Overview

[4]. The Future of Satellite Communications, Joel Klooster , May, 2002

[5].http://www.ruag.com/space/Products/Satellite_Communication_Equipment/Optical_Communication

[6]. http://www.nasa.gov/content/goddard/historic-demonstration-proves-lasercommunicationpossible/