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Satellite Communication Advancement, Issues, Challenges and Applications

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Abstract: Communication in the whole of the World is revolutionized with the advent of Satellites. Satellite Communication has served mankind in many ways e.g. to predict weather, storm warning, provide wide range of communication services in the field of relaying television programs, digital data for a multitudes of business services and most recent in telephony and mobile communication. It may not surprise world community, if satellite communication links may be used for voice and fax transmission to Aircraft on International routes in near future. GPS Navigation, Global telephony, Multimedia video and internet connectivity, Earth Imaging through Remote sensing satellites for resource monitoring, Telemedicine, Tele-education services etc. are other feathers in Satellite communication applications. Satellite communication system has entered transition from point-to-point high cost, high capacity trunks communication to multipoint -to-multipoint communication with low cost. Satellite Communication has moved in many steps ahead like frequency reuse, interconnecting many ground terminals spread over the world, concept of multiple spot beam communications, Laser beam based communication through satellites and use of networks of small satellites in low earth orbit. In this paper satellite communication advancement, different application aspect present and future is discussed. Satellite communication has many application and market if we can pool our resources, come up with innovative and low cost solutions for world community**.**

Keywords: Satellites, GPS Navigation, Remote Sensing, Telemedicine, Frequency reuse, Networks of satellites.

I. INTRODUCTION

Satellite communication [1] service industry has grown more rapidly than was forecasted in 1992.This growth has been a global phenomenon as the economies of world have increased and improved a great extent requiring increased communication services for both business and consumer markets. With this increased demand and recent large, rapid expansion of business, consumer terrestrial mobile and internet communication services has opened new opportunities for satellite communication. Mobile and Internet transport access businesses have stimulated the demand for new multi- state satellite constellation to serve this market on both the national and international scale. Growth in above areas coupled with the global increase in TV viewer ship and high data rate transport have been responsible for the recent and future anticipated growth. There is also new demand for integrated satellite, terrestrial communications that will enable the transport of information seamlessly across these transport media. These large and rapidly growing satellite based business opportunities have attracted the attention of government and industrial interests of many countries and these nations are making significant investments of new capital to enable them to participate in this growth market. Many countries have allocated funds for satellite R&D projects to ensure their long term presence in the commercial satellite industry. The expansion of satellites into new applications and the increased global demand for satellite communications services have attracted the attention of investment community. This has resulted in the formation of new satellite service providers and stimulated mergers and acquisitions, the creation of new companies, the formation of global partnership and the privatisation of formerly public satellite service organisations.

The satellite communication industry has grown tremendously and number of professionals and range of activities have grown as well [2]. In the past, commercial communication satellite manufacturing and service provider organisations tended to be conservative and to be hesitant about inserting new technology into satellites. This has changed in response to immediate need to serve customers burgeoning demand for entertainment programming TV, mobile communications and access to high bandwidth Internet data. Industry is inserting new technology into satellites at rapid pace. Recent examples includes onboard processing and switching, more efficient solar cell, higher power components, more efficient heat dissipation techniques, electric-based station keeping thrusters, inter satellite links, large antennas, phased array

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antennas, antennas with numerous spot beams and improved TWTAs.

Increasingly, Satellite is no longer being viewed as a simple 'bent pipe' but as an important component of a large global communications networking system, requiring interoperability between satellite and terrestrial communication components and thus compatible protocols and standards. This integration of satellites into the global network will require satellite industry to assume large software operations and develop new end-user services.

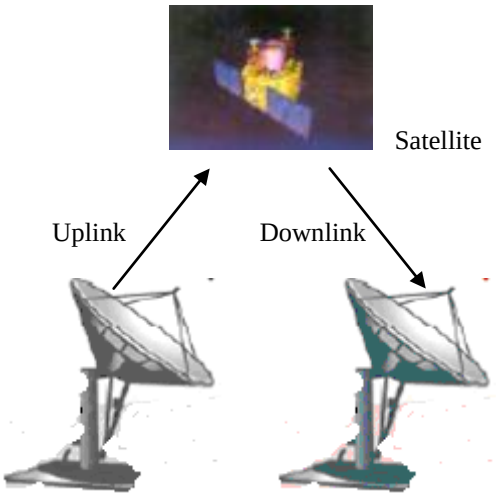

Fig.1.Basic Element of Satellite Communication

In this paper Section 2 describes the element of satellite communication. Section 3 explains advances, issues and challenges in satellite communication. Section 4 explains Applications. Section 5 describes future applications and section 6 at the end conclusion.

II. ELEMENT OF SATELLITE COMMUNICATION

Satellite communication has basic two elements [3] as shown in Fig.1 and Fig.2 general view:

The Space Segment

Satellite itself is known as space segment and comprised of complex structure. It has some major subsystem like TTC system, Transponder, Fuel Tank called thrusters tank, Antenna system and Control system etc. Satellite transponder includes the receiving antenna to receive signals from ground stations, a broad band receiver, multiplexer and frequency converter which is used to reroute the received signals through high powered amplifier to downlink the ground stations. Satellite role is to transpond the received signal in other form of signal to be re transmitted to ground stations. For example of television broad cast where TV programs are up-linked to satellite, satellite transpond it and down linked over a wider region, so that it may be received by many different customers processing compatible equipment. Another use of satellite is observation wherein satellite is equipped with cameras, various sensors and it merely downlinks any information it picks up from its vantage point.

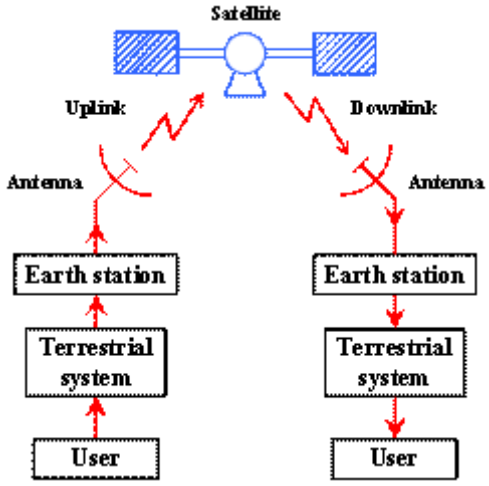

Fig.2 Satellite communication overview

The Ground segment

The earth stations are ground segment of satellite communication. Earth Station has two fold roles. In case of uplink or transmitting station terrestrial data in the form of base band signals is passed through a base band processor, an up converter, a high powered amplifier and through parabolic dish antenna up to an orbiting satellite. In case of down link or receiving station vice versa job performed and ultimately converting signals received through the parabolic antenna to base band signal.

III. SATELLITE COMMUNICATION, ADVANCEMENT AND ISSUES, CHALLENGES

A. *Advancement*

Satellite industry has undergone dramatic change since 1990 decade. There has been a virtual revolution in all aspect of industry e.g. technology, services, application, financial, management arrangement, policy and regulations. In short global revolution in satellite communication has occurred. Today's biggest present concern is not only technology advancement but policies, standards and protocols, regulatory decision, capital financing, trade arrangements, new consumer oriented digital market forces are dominating the direction and speed of change. Many key new technologies are being developed and their deployment could still redefine the landscape of satellite communications leadership another five to ten years. Some of the advancements briefly brought to notice are:

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1) Fundamental Shift in Satellite Architecture, Applications and Markets

Application and services provided by satellite communication has broadened but this is not only reason of shift of market that brings consumers and business more directly in contact with satellite service provider. Satellite services have been provided to large businesses mostly to telecommunication carriers and the TV distribution industry. Globalisation and deregulation have allowed traditional terrestrial carriers to more closely embrace satellite technology. This trend of direct-to-the consumer is seen in direct broadcast systems (DBS), mobile communications satellite system and now even in broad band, high data rate and multimedia satellite systems. DBS systems are rapidly increasing in global scale. In Europe there are numerous regional and national systems like Astra, British Sky Broadcasting (BskyB), EUTALSAT's HotBirds, TDF of France, TVsat of Germany etc. In Asia there are Apstar, Asiasat, Indostar, Koreasat, Thaisat, India's INSAT and GSAT DTH, DBS and three Japanese direct-to-home (DTH) DBS systems etc. Some other organisations also have taken global approach. In the DBS radio sphere there is Worldspace's Afristar, Asiastar and Caribstar. For global TV there is Rupert Murdoch's ambitious web of new DBS nets. There are, of course dozens of national DTH systems around the world that confirms the growth and popularity of this new service. This new trend of a direct to consumer satellite architecture is also reflected in the dozens of mobile satellite system as well. These are a combination of navigational, messaging and voice/data mobile satellite systems.

Most recently, nearly twenty new broadband multimedia satellites filings from around the world reflect the idea that satellites cannot only compete for last mile traffic with terrestrial systems. These new systems which are largely in the new Ka-band frequencies will operate to ultra-small aperture terminals (i.e.50 to 60 cm in diameter) and seek to provide a range of digital business services at competitive data rates.

2) New Applications

Competitive market, new open trade provisions and new technologies have served to create new and noted market opportunity. New applications and services particularly Internet users, and corporate Intranet, with their thrust for multimedia applications at high data rates are driving up the demand curve sharply. Fig.3 shows the shift in global telecommunications from voice-driven to video and data driven. Likewise machine-to- machine communications are raising sharply as overall percentage of human-to-human telecommunications declines. Digital video channels especially MPEG2 system, Internet and Intranet applications are rising sharply around the world and represent market increase. There are also emerging applications such as collaborative computing, distributed CAD/CAM, scientific visualisation, remote sensing data relay, messaging and navigational services, electronic publishing and others that create the demand of new telecommunications networks.

3) Common Service Platforms

The broadening of type of satellite services that can be provided from space once served to create several new families of satellites. Each of these has been allocated specific frequency band by International Telecommunication Union (ITU) such as fixed satellite services (FSS), Broad cast Satellite services (BSS), satellite networks for land, aeronautical and maritime mobile satellite services (MSS). For some time period, as shown in Fig.4, these families of satellite could be mapped in terms of utilised power. In present advanced scientific days, a new multi-purpose satellites capable of providing virtually all forms of digital satellite services from a broad band and very high power common platform are starting to emerge. In a digital system where services are defined by throughput rate and the size of transceivers, the perspective is increasingly becoming "a bit is a bit regardless of the service delivered."

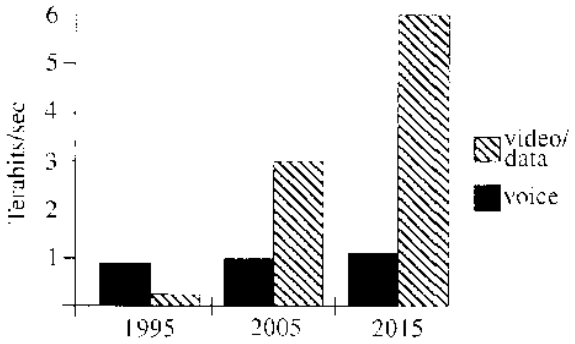

Fig.3 The shift from voice to data and video.

System such as Gigabit satellite of Japan, Euroskyways of Alenia Spazio, and most of US-based Ka-band multimedia satellites fit the profile of this new multi-purpose platform capable of delivering wide range of digital services.

4) New Architecture that provides services Direct to consumers.

Satellites have been used to primarily for the transport of thin rout traffic and distribution of TV to cable head ends and networks affiliates. This is due to ability of one satellite located at GEO in particular to provide communication continuity over one third of the globe.

In the past customers of satellite service providers have tended to be large businesses, the telecommunication carriers and TV program distributors. A major change is occurring to include the end consumer in this consumer mix with Direct to home (DTH), Direct Broadcast Service (DBS), Mobile telephony and Internet access as a primary service.

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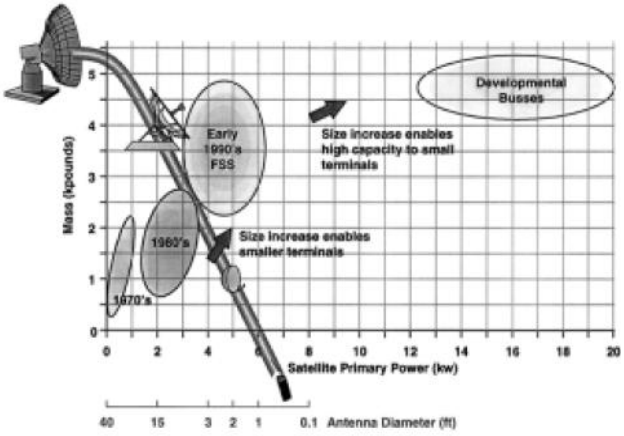

Fig.4 Satellite power/mass and terminal antenna size trends.

This change is accelerating as a result of the insertion of new technology onto satellites like increased power, phased array antenna, large diameter antennas, multi spot-beam antennas and onboard processing and switching. This change allows satellites to be cost effective competitor to cable TV, cellular telephony and high bandwidth Internet service providers in many parts of the world. The recently proposed satellite high data rate Internet services are aiming at moving target as the terrestrial network is embracing new technology at impressive rate.

5) Induction of new players in satellite communication market

Several new countries like Brazil, China, India, Israel, Korea, Spain and a resurgent Russia, all of which have specific new plans for 21st century space telecommunications have entered as new players in satellite communication market. The satellite industry is now populated by other new player like Motorola, Raytheon, Loral, Orbcom, General Electric, Boeing, Lockheed Martin, Matra Marconi, Alcatel, Alenia, Teledesic, Morningstar, Network 28, Visionstar, Echostar, Apstar, Worldspace, Afro-Asia Communication Ltd of India, Thuraya Satellite Telecommunication of Abu Dhabi etc. who have established corporations, long involved in supplying equipment. In addition to change driven by new technology and projected market growth for multimedia satellite services new pattern of acquisitions, mergers and partnership has evolved largely within national markets as well as new multi-billion dollar satellite project that involve new global partnership as in case of Lockheed Martin forming strong alliance in Russia and Motorola alliance with Marconi. These changes have been driven by rapidly emerging demand for new types of services especially those related to direct to home video, Internet and Intranet services including multimedia requirements of business.

B. Issues and Challenges

1) New paradigm for satellite design, prototyping and manufacturing

Satellite manufacturing traditional pattern of highly specialised, customised, designed and built a few at a time is now changing. More emphasis is placed now on the use of common buses and use of CAD tools to customise the communications payloads. Mass produced system is adopted and many satellites are produced at once in an assembly line environment. Integration and testing is highly automated. The extent and nature of testing is reduced after prototyping and initial production is accomplished.

2) New High Powered Platform

One of the key technical trends in response to the deployment of LEO and MEO satellites has been the design of large aperture GEO system with very high power system. Earlier commercial satellite power generation was limited to 7 to 12 KW. But new generation designers have begun to discuss large flexible of floppy solar array generating 50-60 KW. Also intensive efforts are underway to improve solar cell performance by using gallium arsenide/germanium, multi-junction cells with promise of solar cell efficiencies above 30%. There are parallel efforts to improve battery i.e. lithium ion and fuel cell technology in order to produce higher and higher powered satellites.

3) Critical Future Technologies

Critical technologies for future satellite communications are:

· Batteries
· Devices and structures for Phased
· Array and Multiple spot beam antennas on the ground and in space
· Fuels and combustion structures for launch vehicles
· High frequency (>20GHz) devices
· Materials for electronics devices
· Solar cell materials and structures
· Network technology for high data rate, integrated space and terrestrial systems
· Optical components and sub systems
· Radiation resistant device structures and circuits
· Strong and light-weight material
· Thermal dissipation materials

In addition experimental satellites are needed that can be used to test out new technology that cannot easily be tested on the ground. At the systems level, the future of satellites could also be impacted by high altitude, long endurance platforms which would operate from 65,000 to 1,00,000 feet such as airships and loitering aircraft. Such systems could be used to substitute for satellite

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communication in regional applications or could be used in conjunction with satellites as a system capacity multiplier over populated areas.

4) Policies and Regulatory issues

In international satellite trade landing rights agreements, annual licensing fees for terminals, non-tariff barriers, allocation of frequencies and orbital slots, adequacy and effectiveness of intersystem coordination procedure, security and privacy of information being relayed on satellite system etc are some issues to be resolved. Most important of all is the need to develop protocols for seamless interconnection of satellite, wireless and terrestrial fibre networks. In the 21st century inter-connection of satellite systems, particularly inter-satellite links will be a key challenge. Connecting them to low latency terrestrial network is truly a challenge.

IV. APPLICATIONS

Satellites are uniquely suited for certain application. These include broad casting, service to mobile users including ships, aircraft, land mobile and emergency services and providing nearly instant infrastructure in underserved areas. A significant factor in these plans has been the growth of the Internet which shows no sign of abating, despite the poor access that most users currently enjoy. Thus the fielding of some of these Ka-band systems could overcome, 'the last mile connection' problem encountered in most developed countries. This would be major application previously not served by satellites system. Other applications are:

1) Traditional Telecommunication

Telecommunication trend that are fuelling interest in satellite systems are direct-to-home television (DTH) or direct broadcast satellite (DBS), the enormous growth in wireless hand -held phone usage (cellular, personal communication services and paging) and the growth in the number of personal computer in the world, increasing numbers of which are multimedia ready and are being used to interconnect with Internet, maritime and aeronautical telephony, fleet broadcast communication etc.

2) Atmospheric, oceanic and terrestrial observation using Satellites

i) Atmospheric observation

Metrological satellites of major space bearing countries operating in the region are used to collect atmospheric data used in climate forecast. India's INSAT-3 series, MATSAT, China's Feng Yung-1C, European metrological satellite NOAA series etc are operational for this kind of applications.

ii) Oceanic observations

Wind speed and direction near the oceanic's surface are very important to forecast oceanic storm. India's Oceansat-1 and Oceansat-2, QuikSat of China, KOMPSAT for measuring ocean colour, Envisat to measure pigment concentrations, suspended sediments and dissolve organic matters are operational satellites for the oceanic observation purpose.

iii) Terrestrial observation

Terrestrial observation is carried through remote sensing satellite include crop management, fertility, pest and disease information to increase crop yields and profitability, flood forecast, forestry estimation, global change studies, land cover monitoring and assessment, large area mapping, cartography, search and rescue operation, emergency disaster communication and hazard mitigation, observation of environmental change occurring over land etc. India have Resourcesat constellation of four satellite, Landsat-7 of NASA, ALOS,IKONOS-2,Quickbird1,Orbview-3&4 etc satellites are providing terrestrial observation need.

3) Satellite based navigation and positioning

SPS satellites will spawn advanced applications that require very precise location and tracking such as precision mapping and surveying or tracking oil spills and hazardous icebergs. In addition the same satellites will provide advanced services for aircraft and vessel navigation and moving-map displays for motor vehicles. NAVSTAR and GLONASS constellations, GNSS-1 satellite are supporting this purpose.

4) Space Science and Solar terrestrial applications.

i) Space science application

With the construction of the International Space Station now under way, another door has opened not only to long duration examination of the space environment but also to research and manufacturing activities under microgravity conditions. Mir Space Station, the International Space Station will establish a more advanced platform to conduct space science and technology experiments.

ii) Solar –terrestrial applications

Some countries are investigating the concept of solar power from space. The Solar Power system 2000 project would involve electrical power generation from solar cells on board satellites in low, equatorial orbits for transmission by microwave to specially designed power receiving antennas in countries lying the equatorial zone.

5) Satellite-based education and training

i) Distance learning and teaching

South-East Asian Ministries of Education organisation have implemented open learning and distance education programmes in their countries via satellite-based education and training in disciplinary open learning centres located in various countries in the region. PEACESAT and other similar satellites are used in Asia and Pacific region for education and training.

ii) Engineering Research and Development

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At least nine countries are pursuing small–scale experimental missions that have the objectives of human resource and industry development. These include Badr-B, FedSat, TMSat and KITSAT series.

6) Military Application.

Space plays an increasing role in military activities. They are widely used to provide support for military or security related activities such as verifying compliances with arms and control treaties. Military uses include imagery, navigation, signal intelligence, telecommunications, early warning and metrology. There are over 270 military satellites as well as ~600 civil, commercial and multipurpose satellites. These satellites serve military as well civil applications.

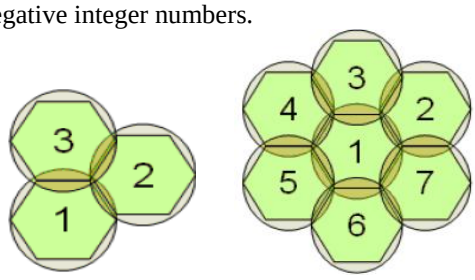
V. FUTURE APPLICATIONS

1) Frequency reuses application

Since Satellite system serve large areas such as countries or continent, a large number of beams need to share the available beam width. To circumvent this frequency reuse [4] scheme is often utilised. This is based on reusing the same frequencies in spatially isolated beams. Therefore available bandwidth is divided into a smaller number of beams in coverage area. The set of beams that share the total available bandwidth is known as cluster. The cluster is then repeated in the coverage area relaying on the fact that the beams operating at same bandwidth will be separated from each other sufficiently so that they do not interfere with each other. There are only a discrete set of possible cluster sizes, N, to accommodate a contiguous coverage of hexagonal geometry. The possible number of beams in cluster which would form tessellating shape is given by:

$$N=i^2 + j^2 + i \times j \quad \ldots\ldots\ldots\ldots (1)$$

Where N is the number of beams in cluster and i, j are non-negative integer numbers.



N=3 N=7

Fig.5 Different cluster for hexa lattice

2) Use of Spot Beam Concept and its applications.

NASA's satellite ACTS uses hopping spot beam technique to combine the advantage of frequency reuse, spot beams and TDMA. Concept of multiple spot beams is also planned in future generation satellite of Italy, Italsat with six spot beam operating at 30GHz uplink and 20GHz downlink, the satellite interconnects TDMA transmissions between ground station in all the major economic centres of Italy.

3) Other Applications.

►Laser beams based satellite communication.

►In finding Space debris solution

►Space Situational Awareness uses

►Use of constellation of spacecraft and inter satellite links for telecommunication purpose etc.

VI. CONCLUSIONS

In this paper satellite communication, its constituent's, advancement in the satellite communication, present and future applications are briefly discussed. It is lone attempt to bring brief sketch about satellite communication applications. A detail study of applications is still to carry out at length. Details study of frequency reuse in satellite and mobile cellular is matter of research in our future works.

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