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Future Use of V- Band in Satellite Communication

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Abstract- Satellite operations at V-band in tropical and equatorial regions are constrained as a result of attenuation from rain. The use of v band in satellite communication can enhance the communication capacity in GEO satellite system. Up to the past few years, geostationary telecommunication satellite systems have kept taking advantage of the satellite natural wide area coverage capability in a context broadband was the major issue. Now a day's situation has changed long term perspectives for geostationary satellites are challenged by their capability to remain competitive, in terms of capacity versus cost and supported services, it should offer wide capacity, good availability, high flexibility, and guarantee the required quality of service in a cost efficient way. The major limitation is the effect of radio-wave propagation through the lowest layers of the atmosphere. As the operating frequency is increased, the attenuation and scintillation effects of atmospheric gas, clouds and rain become more severe.

Keywords - Rain attenuation, V-band satellite communication system, Fade duration.

I. Introduction

In the 1970s and 1980s there was a drastic development of GEO satellite systems for international , regional, and domestic telephone traffic and video distribution. However the demand for satellite system grew steadily through this period and the available spectrum in C band was quickly occupied, leading to expansion in to Ku band. At that time the video distribution was rapidly increased, so Ku band would soon be filled, and Ka band satellite system would be needed to handle the expansion of digital traffic, especially wide band delivery of high speed internet data.

For further enhancing the communication capacity C band was introduced in satellite communication system, when it comes to address the capacity issue in satellite communication, the first technique to consider is the multi-beam coverage, with a high number of beams that allow a high degree of frequency reuse. In order to increase even more that capacity, the second step is to utilize higher frequency bands such as Ka (20-30 GHz), Q/V (40-50 GHz) or EHF (20-45 GHz) bands, where respectively, 1 GHz, 3 GHz and 2 GHz are allocated to the Fixed Satellite Service (FSS). The first commercial satellites with Ka-band transponders are today in operation, and it is expected that the congestion in lower frequency bands like Ku-band will push new systems into moving progressively to Ka band and, in a longer term, to Q/V band. Depending on the type of mission, Ka-Q/V band satellite could be envisaged as, for example, for two way broadband access

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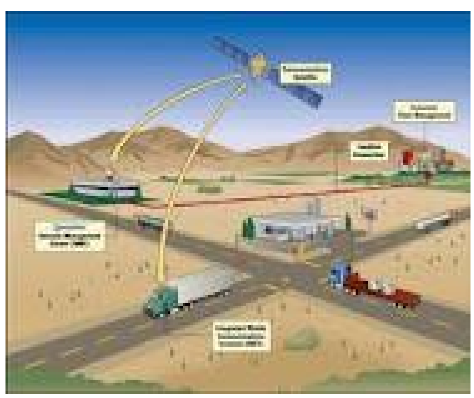
services characterized by a high asymmetrical traffic, using part of the Ka-band for user access while data distribution service could take most advantage of wider bandwidth in Q/V band.

Although Ka and Q/V bands are attractive from the point of view of the amount of frequency bandwidth that the satellite can potentially use, some important limitation could moderate the enthusiasm of using them if specific techniques were not implemented in the satellite system to guarantee the capacity, the availability and the quality of service. The major limitation is the effect of radio-wave propagation through the lowest layers of the atmosphere. As the operating frequency is increased, the attenuation and scintillation effects of atmospheric gas, clouds and rain become more severe [1], the direct consequence is the need to implement high system static margins, in order to insure a minimum outage duration of the service, for a given objective of link availability. However, technology limitation (on both terrestrial and space segments) combined with cost efficiency requirements refrain from considering fixed static margins as the only mean to compensate propagation impairments at high frequency bands, and push towards the implementation of Fade Mitigation Techniques (FMT) [2]. Those techniques allow systems with rather small static margin to be designed, while overcoming in real time cloud attenuation, some fraction of rain attenuation, scintillation, and depolarisation events.

Among those techniques, adaptive modulation/coding are of high interest as they allow the performance of individual links to be optimized, and the transmission characteristics to be adapted to the propagation channel conditions and to the service requirements for the given link. Those techniques are expected to be promising in particular in point-to-point service scenario.

The aim of this paper is to present the main issues in designing FMTs for Ka-Q/V band satellite communication systems. The conventional design of the physical layer of a satcom system is outlined and review of FMT concepts.



II. FREQUENCY BAND IN SATELLITE COMMUNICATION

Table -1 Font Sizes for Papers

S.No.	Name of Band	Frequency Range
1	L Band	1 to 2 GHz
2	S Band	2 to 4 GHz
3	C Band	4 to 8 GHz
4	Ku Band	12 to 18 GHz
5	Ka Band	26 to 40 GHz
6	Q Band	30 to 50 GHz

7	U Band	40 to 60 GHZ
8	V Band	50 to 75 GHz

A. *C-Band*

The use of C-Band frequencies in the early days of the industry had a combination of benefits. A major one was the relative immunity to rain degradations. However, the sharing of the band with terrestrial microwave facilities meant that frequency coordination was required for every transmit earth station, and the resolution of potential interference made the avoidance of interference a key element of establishing sites for the C-Band earth stations, the size of a typical C-Band very small aperture terminal (VSAT) antenna was in the range of 2.4 meters.

With the attendant cost limitations of frequency coordination and shielding, the economics were not in favor of high volume C-Band VSAT networks where the VSAT was placed on the Premises of the end user. There have been alternative approaches to this problem. One of these was the use of spread spectrum techniques to mitigate the interference by spreading. From a technical perspective, spread spectrum techniques work well when the incoming interference is narrowband relative to the satellite signals. This is normally not the case in the microwave band, and this probably explains the lack of success for Equatorial.

Today, C-Band is still in use because the rain immunity allows high operational availability operations, but the limitations on large VSAT networks remain. The Cable Industry recognized as far back as the early 1970s that C-Band earth stations at the head end of their system enabled satellite delivery of programming to reach thousands of cable subscriber without the necessity of building more than one or two C-Band earth stations.

B. *Ku-Band*

The first Ku-Band only satellite was launched in 1980.7 The Ku-Band markets took too long to develop, and SBS went into bankruptcy, but in the intervening years, Ku-Band has become the mainstay of the industry. This is primarily because the domestic bands of (11.7-12.2 GHz)/ (14.0-14.5 GHz) are not shared, and do not require frequency coordination. Blanket licensing of Ku-Band VSAT stations has helped, and today, thousands of these stations are in use. The band does have vulnerability in rain outage, being substantially higher than comparable links at C-Band. It also brings the antenna size down into the range of 1m to 1.8 m in diameter.

C. *Ka-Band*

While the adoption of Ku-Band took several years, it did happen, and the FCC made provision for logical growth of the industry. The next allocation set aside for satellite communication in 1996 was the Ka-Band 8 at (17.7-20.2 GHz)/ (27.5-30.0 GHz). The first orbital assignments came in 1997. In 2003 the Ka band had become more popular like, pointed throughput, smaller spot beams, dynamic band width allocation and smaller antennas, as key elements of Ka band system, and envisioned better satellite broadband service. Today, Wild Blue is offering high speed Internet access using Ka-Band technology, with download speeds up to 1.5 Mbps and upload speeds up to 256Kbps.

D. *Q/V-Band*

In 1998, the FCC took another step to ensure logical technological development of the satellite industry, with preliminary allocations at Q/V-Band. 16 17 in 2003, these frequency allocations (37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz) were finalized. There is some variation in terminology as many publications refer to Q-Band as (36–46 GHz) and V-Band as (46–56 GHz). In that sense, formally, the V-Band actually has the uplink bands while the downlink bands are located at Q-Band. However, some FCC documents refer to the collective allocation as a V-Band allocation.

The major limitation is the effect of radio-wave propagation through the lowest layers of the atmosphere. As the operating frequency is increased, the attenuation and scintillation effects of atmospheric gas, clouds and rain become more severe, for utilizing the V band in these conditions we have to adopt a technology like FMT (Fade Mitigation Techniques). This technique allows system with rather small static margin to be designed, while overcoming in real time cloud attenuation, some fraction of rain attenuation, scintillation, and depolarization events. Among those techniques, adaptive modulation/coding are of high interest as they allow the performance of individual links to be optimized, and the transmission characteristics to be adapted to the propagation channel conditions and to the service requirements for the given link. Those techniques are expected to be promising in Particular in point-to-point services.

As far as Q/V band is concerned, it may be used in the future either for star network feeder links or for backbone applications. In both cases, target availability between 99.95 % and 99.99 % of the time could be required. For these time percentages, in a conventional system design, several tens of dBs would have to be compensated with a static margin, which is not possible due to technology limitations, leading to low availability only, even for a European coverage. Therefore FMTs will have the following objectives at Q/V bands: on the one hand, how to improve system availability? On the other hand, how to increase system throughput?

The high attenuation experienced in tropical areas is caused by significantly higher rainfall rates compared to other parts of the world. Due to the intensification in the use of frequency spectrum, new and existing satellite operators in the tropics may soon have no other alternative but to progress up to frequencies as high as the V-band. Nonetheless, the effects of rainfall on satellite signals at such high frequencies in the tropical region have not yet been fully detailed. Additional measured data, researches, experiments and investigations are considered essential in order to obtain more insights in this issue. Measurements acquired from a microwave link establishment should be able to offer some initial impressions of the V-band link's characteristics in the absence of an actual satellite-Earth link. The information is deemed very critical for future Earth space communication link design and can be exploited as preliminary groundwork plan for the researchers as well as engineers.

III. FADE MITIGATION TECHNIQUE

Making use of Fade Mitigation Techniques involves adapting in real time the link budget to the propagation conditions through some specific parameters such as power, data rate, coding etc. However, this real time adaptivity has an impact not only on carrier-to-noise ratios but also on carrier-to-interference ratios and on upper layers. Both aspects have therefore to be carefully studied. A lot of publications have been written up to now on the subject [3-7] and a review of FMTs has been realized in the framework of COST 255 [2].

FMT layer can be divided into 4 types:-

1. Power Control: transmitting power level fitted to Propagation impairments,
2. Adaptive waveform: fade compensated by a more efficient modulation and coding scheme,
3. Diversity: fade avoided by the use of another less impaired Link,
4. Layer 2: coping with the temporal dynamics of the fade.

A. *Power control:*

Four types of Power Control FMT can be considered: Up-Link Power Control (ULPC), End-to-End Power Control (EEPC), Down-Link Power Control (DLPC) and On-Board Beam Shaping (OBBS).

The aim of ULPC, the output power of a transmitting Earth station is matched to uplink impairments. Transmitter power is increased to counteract fade or decreased when more favorable propagation conditions are recovered so as to limit interference in clear sky conditions and therefore to optimize satellite capacity. In the case of transparent payloads, ULPC can prevent from reductions of satellite EIRP caused by the decreased uplink power level that would occur in the absence of ULPC.

EEPC can be used for transparent configuration only. Indeed, the output power of a transmitting Earth station is matched to up-link or down-link impairments. In the case of regenerative repeaters, up and down links budgets are independent, so the concept of EEPC can not exist anymore. EEPC is used to keep a constant overall margin of the system. As for ULPC, transmitter power is increased to counteract fade or decreased when more favorable propagation conditions are recovered to limit interference and optimize satellite capacity.

With DLPC, the on-board channel output power is adjusted to the magnitude of downlink attenuation. DLPC aims to allocate a limited extra-power on-board in order to compensate a possible degradation in term of down-link C/N0 due to propagation conditions on a particular region. In this case, all Earth stations in the same spot beam benefit from the improvement of EIRP. OBBS technique is based on active antennas, which allows spot beam gains to be adapted to propagation conditions. Actually, the objective is to radiate extra-power, and to compensate rain attenuation only on spot beams where rain is likely to occur.

B. *Adaptive waveform*

These FMTs could be split into Adaptive Coding (AC), Adaptive Modulation (AM) and Data Rate Reduction (DRR).

The introduction of redundant bits to the information bits when a link is experiencing fading, allows detection and correction of errors (FEC) caused by propagation impairments and leads to a reduction of the required energy per information bit. Adaptive coding consists in implementing a variable coding rate matched to impairments originating from propagation conditions.

As Adaptive Coding, the aim of Adaptive Modulation is to decrease the required energy per information bit required corresponding to a given BER, which translates into a reduction of the spectral efficiency as C/N0 decreases. Further reduction can be obtained by a decrease of the information data rate at constant BER. The technique is called Data Rate Reduction. Here, user data rates should be matched to propagation conditions: nominal data rates are used under clear sky conditions.

C. *Diversity*

The objective of these techniques is to re-route information in the network in order to avoid impairments due to an atmospheric perturbation. Three types of diversity techniques can be considered: site (SD), satellite (SatD) and frequency FD) diversity. These techniques are very expensive as the associated equipments have to be redundant.

Frequency Diversity is a technique based on the fact that payloads using two different frequency bands are available onboard. When a fade is occurring, links are re-routed using the lowest frequency band payload, less sensitive to atmospheric propagation impairments.

D. *Layer 2*

FMT at layer 2 level are techniques which do not aim at mitigating a fade event but instead rely on the re-transmission of the message. Two different techniques can be envisaged at layer 2: Automatic Repeat Request (ARQ) and Time Diversity (TD). With ARQ, the message is sent regularly untill the message reaches successfully the receiver. ARQ with a random or predefined time repetition protocol would be an alternate solution.

Time diversity can be considered as a FMT that aims to re-send the information when the state of the propagation channel allows to get through. In this case, most often, there is no need to receive the data file in real time and it is acceptable for the user point of view to wait for the end of the propagation event (in general some tens of minutes) or for a decrease of traffic. This technique benefits from the use of propagation mid-term prediction model in order to estimate the most appropriate time to re-send the message without repeating the request.

IV. CONCLUSIONS

In this paper we present the view of Q/V bands in satellite communication system. By using V band we can increase rapidly the communication capacity and provide the wide coverage over terrestrial and tropical regions. It can also provide the good communication to marine, aviation and industry purpose communication. Along with providing good communication, the major limitation is the effect of radio-wave propagation through the lowest layers of the atmosphere. As the operating frequency is increased, the attenuation and scintillation effects of atmospheric gas, clouds and rain become more severe. These effects can be reduce the technique like FMT (Fade Mitigation Technique) which have been identified in this paper: power control, adaptive Waveform, diversity and layer 2 FMT Although different in their principles, these FMT are complementary and combined use of different FMT is required when high impairments have to be mitigated, first of all to improve system availability, secondly to limit interference and thirdly to increase system capacity.

REFERENCES

[1] Salonen E. et al.: *"Modelling and calculation of atmospheric* attenuation *for low-fade-margin satellite communications"*, ESA Journal, Vol. 16(3), pp. 299-317, 1992.

[2] COST 255: *"Radiowave propagation modelling for new satcom services at Ku-band and above",* COST 255 Final Report, Chapter 5.3, ESA Publications Division, SP-1252, March 2002.

[3] Willis MJ., Evans BG.: "Fade countermeasures at Ka-band for OLYMPUS", Int. Jour. Sat. Com., Vol. 6, pp. 301-311, June 88.

[4] Tartara G.: "*Fade countermeasures in millimetre-wave satellite communications: a survey of methods and problems*", Proc. Olympus Util. Conference, Vienna, Austria, April 1989.

[5] Gallois A.P.: "*Fade countermeasure techniques for satellite communication links*", Int. Symp. on Comms Theory and Applications, July 1993.

[6] Acosta R.J.: "*Rain fade compensation alternatives for Ka-band communication satellites*", 3rd Ka-band Utilization Conference, Sorrento, Italy, 15-18 Sept. 1997.

[7] Castanet L. - Lemorton J. - Bousquet M.: "*Fade Mitigation techniques for New SatCom services at Ku-band and above : a Review*", Fourth Ka-band Utilization Conference, Venice, 2-4 November 1998.