Enhancement of Coexistence Prediction Between HAPS Gateway Link And Fixed Satellite Service In The Range 5 850 - 7 075 MHz

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High Altitude Platform Station (HAPS) is a new emerging type of communications stations that requires a new spectrum planning. Under agenda item 1.20 of next World Radio Conference 2012 (WRC-12) HAPS spectrum allocation is proposed to be identified in the range 5 850 – 7 075 MHz for gateway link only. However, this proposed frequency is already saturated by Fixed Satellite Service (FSS) uplink, rendering HAPS gateway to be a victim of such a scenario. In this paper a developed coexistence methodology is introduced based on the use of overlapping spectrum emission masks coupled with the additional attenuation of interfering signal due to protection from local clutter. The enhanced prediction will result in a significant reduction in the required separation distance and introduces frequency isolation.

1. Introduction

High Altitude Platform Station (HAPS) is expected to take place in parallel with terrestrial and satellite systems, and to provide wide area coverage, high data rate services, and favorable link budget [1]. HAPS system architecture consists of an airborne in a nominally fixed location in the stratosphere; from 20 km to 25 km [2], communicates directly to user terminals, and in addition a number of gateway stations on the ground which provide interconnection with the fixed telecommunications network. The frequency assigned for HAPS gateway [3] is realized to be more susceptible to rain attenuation. According to International Telecommunications Union (ITU) resolution 734, Fixed Satellite Service (FSS) earth-to-space transmissions will have signal levels much higher than those in HAPS systems and have therefore the potential for causing interference to HAPS receivers either on the ground or on the platform. However, HAPS deployment in the 5850 – 7075 MHz band will be limited by current FSS transmit earth stations while protection of HAPS receivers may limit future deployment of FSS earth stations [4].

Previously HAPS frequency allocations were predicted using strait forward formula [5-6], based on co-channel allocation, free space loss, and uncertainty of modulation and/or spectrum emissions, however the resulted separation distance were the dominant factor and it was significantly large. Therefore, this paper introduces an enhancement on coexistence prediction using the Net Filter Discrimination (NFD) coupled with the clutter loss effects. The paper is arranged as follows; Section 2 reviews the interference scenario, systems parameters, and the proposed algorithm using the NFD and clutter loss. In Section 3, results and discussions are simulated. Finally, Section 4 concluding and remarking the study.

2. Coexistence Prediction

When two communications systems are operating in the same deployment area using the same or adjacent frequency band; it is required to determine separation distance and/or frequency guard band. In a non harmful interference scenario; victim receiver protection criteria should be taken as a threshold for acceptable receiver performance. Criterion of Carrier-to-Interference Ratio

(C/I) of 27 dB was specified by ITU Working Party 5C (WP 5C) for long term interference for more than 20% [7]. Coexistence criteria at HAPS gateway receiver is specified by:

$$C - I \geq 27 \quad (1)$$

where:

C : expected received carrier level (dBW), given by:

$$C = P_{H-Tx} + G_{H-Tx} - L_f - L_p + G_{HG-Rx} \quad (2)$$

where:

P_{H-Tx} : airborne platform transmitted power (dBW),

G_{H-Tx} : gain of transmitting airborne antenna (dBi),

L_f : airborne transmitting system feeder loss (dB),

L_p : propagation loss for the path between airborne and ground gateway (dB),

G_{HG-Rx} : gateway receiving antenna gain (dBi),

I : Interference level at gateway receiver (dBW), given by:

$$I = P_{FSS-Tx} + G_{FSS-Tx}(\theta) - L_f - (L_p + Ah) + G_{HG-Rx}(\phi) - corr\_band - NFD \quad (3)$$

where:

P_{FSS-Tx} : FSS earth station transmitted power (dBW),

$G_{FSS-Tx}(\theta)$: off-axis gain of FSS antenna (dBi),

L_p : propagation loss for the path between FSS earth station and HAPS gateway (dB),

Ah : additional loss due to protection of clutter (dB),where,

$$Ah = 10.25e^{-d_k}[1 - \tanh[6(\frac{h}{h_a} - 0.625)]] - 0.33 \quad (4)$$

where d_k is the distance in (km) from nominal clutter point to the antenna for Urban Area Coverage (UAC) is 0.02 km, h is the antenna height in meter (m) above the local ground level, and h_a is the nominal clutter height in meter (m) for UAC is 20 m,

$G_{HG-Rx}(\phi)$: off-axis gateway antenna gain (dBi),

$corr\_band$: correction factor of band ratio depends on utilized bandwidth by both stations (dB),

NFD : net filter discrimination (dB), which is the ratio between the power transmitted by the interfering system and its portion that could be measured after the receiving filter of the victim [8], as shown in Figure 1.

Since FSS earth station and HAPS gateway have a variety of technical and operational specifications that affect the spectrum identification; parameters detailed in Table 1 were under consideration. The analysis will be based on the assumption that difference in antenna azimuth between the two earth stations is 180° producing a worst scenario as shown in Figure 2.

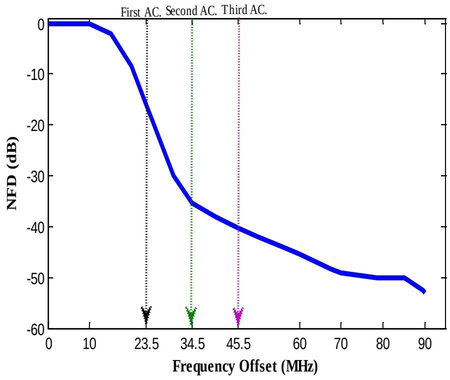

Figure 1. Net Filter Discrimination.

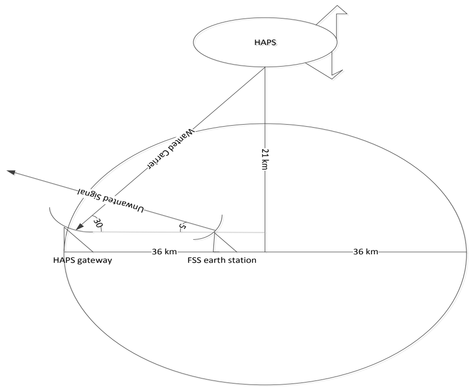

Figure 2. Interference Scenario.

Table 1. FSS and HAPS systems parameters.

Parameter	FSS earth station	HAPS
Transmitted power (dBW)	35.56	-22: Airborne
Channel bandwidth (MHz)	36	11
Antenna height (m)	15	15: gateway 21000: Airborne
Antenna elevation angle (°)	5	30
Maximum antenna gain (dBi)	39.9	47: gateway 30: Airborne
Feeder loss (dB)	0.5	4.1

4. Results And Discussions

In Figure 3, a comparison between tradition methodology and enhanced prediction in co-channel scenario is simulated. Channel spacing between the two carriers and the corresponding NFD set to zero; but discrimination is due to interferer power is not all taken by the gateway receiver due to difference in bandwidth. In the normal prediction 41.8 km is required; meanwhile, an enhancement is achieved by considering the bandwidth correction factor, which lowers the required separation to 22.9 km, and when coupled with the effect of the clutter effects only 15.6 km is required.

Figure 4, introduces the frequency isolation scenario based on the enhanced methodology. First adjacent channel scenario is simulated when the zero guard band is assumed, resulting in a 23.5 MHz channel spacing between the two carriers, and a 3.5 km separation. The use of the NFD combined with the clutter protection will result in an interference coupling loss and a distance of 2.4 km. For more explanation Figure 5 shows the co-channel and first adjacent channel corresponding to the frequency offset when NFD and clutter loss are used.

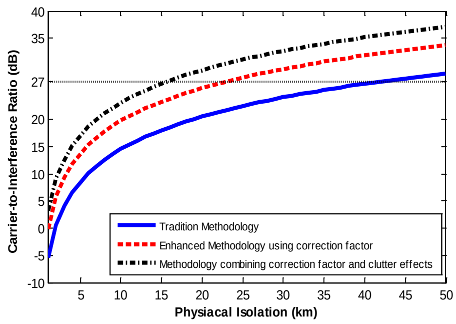

Figure 3. Required separation distance in co-channel.

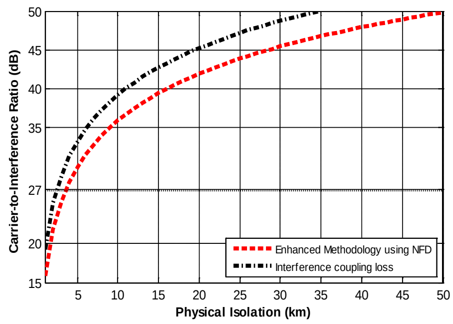

Figure 4. Required separation distance in first adjacent channel.

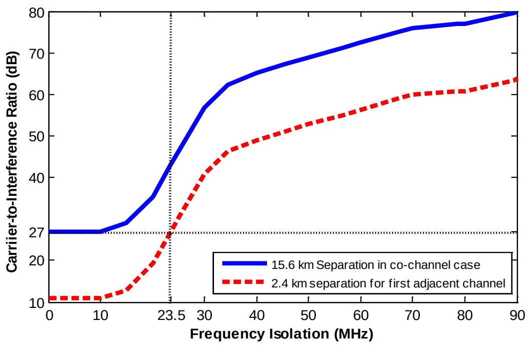

Figure 5. Enhanced prediction corresponds to the NFD and C/I.

5. Conclusion

The coexistence study for appropriate frequency allocation for HAPS downlink in the range 5 850 – 7 075 MHz is required and it was under investigation of this paper. The methodology proposed is based on NFD and protection from the local clutter, to produce an interference coupling loss. The proposed method would be saving spectrum resources, and therefore leads to interference mitigation during the initial frequency planning. A future work is targeting to determine the HAPS gateway uplink in the same range in a prospective to protect the platform from FSS uplink transmission.

Acknowledgments

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