THE REGULATORY ASPECTS OF SCP-RPSC TECHNOLOGY – COULD THEY SOLVE THE VMES PROBLEMS

D-r Veselin Demirev

Radio Communications and Video Technologies Department, TU-Sofia, Kl. Ohridski blv. № 8 , 1756-Sofia,
e-mail:demirev_v@tu-sofia.bg

Abstract

The new satellite interactive broadband communication systems use high gain satellite tracking antennas, installed on vehicles. Vehicle-Mounted Earth Stations (VMES) currently can operate on conventional Ku-band frequencies (14 GHz Uplink, 11-12 GHz Downlink) but only on a secondary basis. Regulation on VMES in the co-primary status is not without challenges. There are several primary concerns of allowing VMES to share co-primary status in Ku-band - Ability to maintain pointing accuracy; Danger of using ultra small antennas and Ability to track potential interference.

The unique properties of the SCP-RPSC (Spatial Correlation Processing – Random Phase Spread Coding) technology were demonstrated by the author with examples of co-located same frequency sharing conventional and RPSC satellite systems. In the particular case of total number of antenna array elements 2500, the Protection Ratio of the conventional satellite system will be better than 17 dB for 86,4% of the time and better than 12,2 dB for 99,9% of the time. It means that the transmitted random poly-phase spread signals will not cause significant harmful interference to the conventional satellites, using the same frequency channels.

An analysis of the VMES SCP down links protection from neighbour satellite interferences is given in the report too. It is negligible due to the full electronic principle of operation, pointing the maximum of the Space Cross-Correlation Function (SCCF) to the cooperative satellite without time delay and due to its low side-lobes.

1. INTRODUCTION

Historically, connectivity services for mobile vehicles have been delivered through the use of satellites transmitting in L-band (out of which only a few tens of MHz are assigned to satellite use from regulatory authorities), beginning with Marisat in 1976. Targeted to telephone communication at first, these services have evolved towards IP connectivity and, more recently, the delivery of IP broadband. The use of L-band gives important benefits, such as small onboard antenna size and little or no attenuation due to rain. However, the amount of L-band available, and more specifically the portion allocated to MSS, is limited. Moreover, frequency reuse due to different orbital slots is extremely limited. Broadband applications require a much greater amount of bitrate for the final user than normally available. One technical solution has been to create small spots of coverage, so that the same frequency can be re-used in different spots, thus increasing the total amount of available bandwidth. The lack of the bandwidth in L-band has consequences on the costs to the users. For example, the cost of a minute of Inmarsat communication can range from several Euros to tens of Euros. These costs are hardly compatible with a ‘broadband’ user experience at reasonable prices. To definitely overcome the problems due to the scarcity of L-band, the only choice is to move to a higher frequency band [1]. Ku-band (frequencies between 11 and 14 GHz, out of which 2+2 GHz assigned to satellite use) is an ideal candidate to offer broadband services. Although only a part of the overall Ku spectrum is usable in a mobile environment (in particular, only 500 MHz – from 14 to 14.5 GHz – can be used in the uplink direction from a mobile vehicle), bandwidth can be augmented by frequency reuse at different orbital positions.

2. THE VMES REGULATORY PROBLEMS IN KU - BAND

Vehicle-Mounted Earth Stations (VMES) currently can operate on conventional Ku-band frequencies but only on a secondary basis. This means VMES can not claim interference protection from primary services such as fixed satellite systems and Earth Station on Vessels (ESV).

Regulation on VMES in the co-primary status is not without challenges. There are several primary concerns of allowing VMES to share co-primary status in Ku-band [2]:

- *Ability to maintain pointing accuracy*: Vehicles can abruptly accelerate and decelerate as well as travel in rough terrain. Under these conditions, VMES may find it difficult or impossible to maintain their pointing accuracy. Of greater practicality may be the ability of the antenna systems to automatically mute transmissions upon deviation from the target satellite.

- *Danger of using ultra small antennas*: Vehicles can not accommodate the larger antennas that can be installed on ships. Thus ultra small stabilized antennas are more practical for VMES. However, smaller antennas have greater potential for interference to adjacent satellites because they have wider main and side lobes that can radiate more energy to satellites on either side of the intended satellite.
- *Ability to track potential interference*: Because of the ubiquity of vehicles and their unpredictable driving patterns, a method to identify and correct interference issues is paramount.

3. SCP-RPSC APPROACH

The SCP-RPSC principle of operation [3,4,5,6] is based on the use of random phased antenna arrays and correlation signal processing. It was developed for receive (SCP) and transmit (RPSC) modes. A block scheme of a SCP-RPSC satellite system is shown in fig.1:

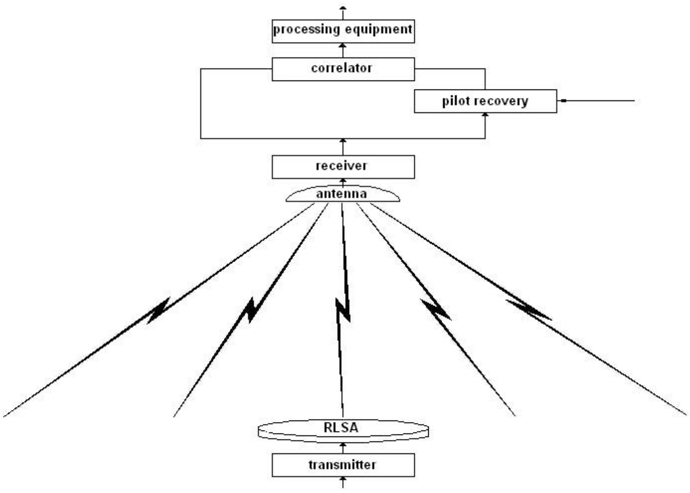

Fig. 1. Block scheme of a SCP-RPSC system

4. POSSIBLE IMPROVEMENTS OF REGULATORY STATUS OF VMES

The unique properties of the SCP-RPSC technology were demonstrated with an example of co-located same frequency sharing conventional and RPSC satellite systems. The case, considered in [6], included a situation, where a conventional antenna, placed near to transmitting random phased antenna array and having the same gain, transmits towards a conventional receiving satellite system with the same parameters as that of the receiving RPSC system. It was shown, that the output signal of the conventional system receiving antenna will be sum of the own signal and the interference from SCP-RPSC system. The Protection Ratio (PR) of the conventional system was defined and calculated by means of the Probability Theory of the Random Gaussian Processes as:

$$PR_{conv}^{86,4\%} = \frac{P_{rec.conv.}}{P_{\text{int.}}} = \frac{\sigma_y^{\;2}}{\sigma_y} = \sqrt{\sigma_y^2} \qquad (1)$$

$$PR_{conv}^{99,9\%} = \frac{P_{rec.conv.}}{P_{\text{int.}}} = \frac{\sigma_y^{\;2}}{3\sigma_y} = 0{,}33\sqrt{\sigma_y^2} \qquad (2)$$

Where $\sigma_y^2 = n\sigma_x^2 = n\frac{A^2}{2}$ is the variance of the full interference, caused by the transmitting random phased antenna array and $\sigma_x^2 = \frac{A^2}{2}$ is the variance of the interference, caused by single antenna element.

Bearing in mind that the number of the antenna elements of a random phased antenna array is in order of 2500 [7], the PR will be better than 17 dB for 86,4% of the time and better than 12,2 dB for 99,9%of the time.

The conclusion is that the transmitted random poly-phase spread signals will not cause significant harmful interference to the conventional satellites, using the same frequency channels. The interference will be similar to that, caused by the side-lobes of a circular, phased in another direction antenna array with random inter elements spacing. The transmitted random poly-phase spread signals are uniformly radiated in the space above the antenna. Several satellites, equipped with the same SCP receivers and providing space diversity, could receive them. The knowledge of the receiving satellites positions for the transmitting equipment is not necessary (as it is for a conventional satellite earth station).

Several mitigation techniques have been used until now in order to solve the VMES regulatory problems. One of them uses CDMA techniques to reduce the transmitted spectral power density in order to satisfy ITU transmitting masks. This is a temporally solution for low speed mobile up-links with poor directivity patterns. As it was shown above, the interference of RPSC up-links over conventional up-links is in order of that, caused by the side-lobes of random spaced antenna array, phased in another direction. This property is direct result of the principle of operation, so the additional expenditures to realize it are not necessary. To support the above mentioned, in fig.2 the amplitude distribution, and in fig.3 – the phase distribution of a 57 cm in diameter RP-RLSA (Random Phased – Radial Line Slot Antenna) are shown.

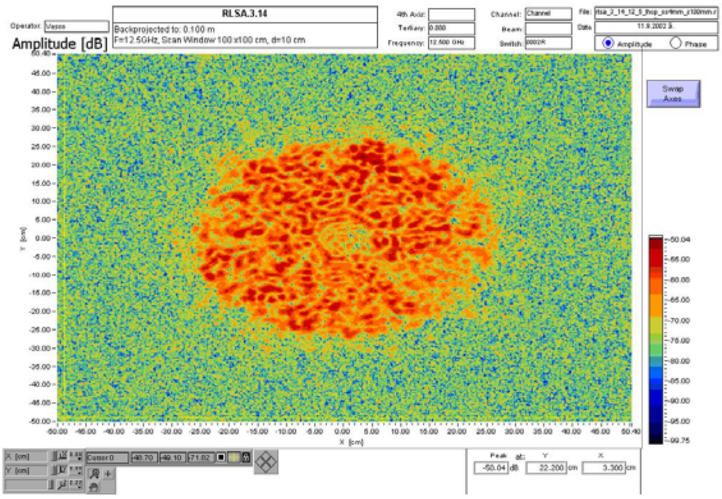

Fig. 2. RP-RLSA amplitude distribution

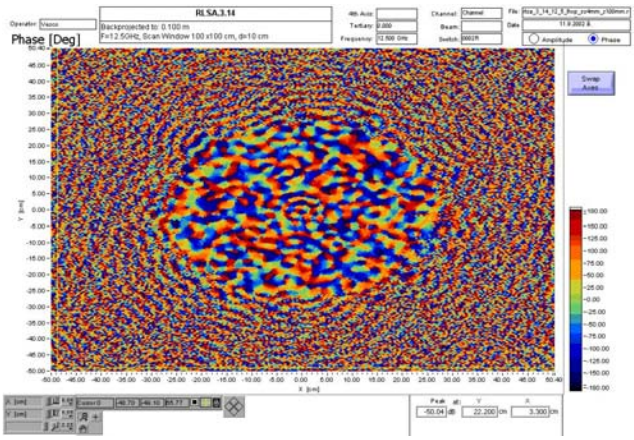

Fig. 3. RP-RLSA phase distribution

The VMES,s SCP down links are protected from neighbor satellite interferences due to the full electronic principle of operation, pointing the maximum of the SCCF to the cooperative satellite without time delay.

5. CONCLUSION

In summary, a co-primary allocation of VMES in the conventional Ku-band would be in the public interest, as it would address a growing commercial demand for on the move services. However, a co-primary allocation would also have to be conditioned on strict adherence to interference avoidance mechanism, which in the best way obviously is satisfied by the RPSC technology.

References

[1] A. Arcidiacono, D. Finocchiaro, S. Grazzini, "Broadband Mobile Satellite Revolution: the Ku-band Revolution", EUTELSAT SA, Internet, Paris.

[2] R. Magallanes, "Regulatory Status of Satellite Service Using Vehicle-Mounted Antennas", *Via Satellite, January,* 2009.

[3] V. Demirev, "SCP technology – the new challenge in broadband satellite communications", *ICEST,04 Conference Proceedings, pp.159-162*, Bitola, Macedonia, 2004.

[4] V. Demirev, "Review of SCP-RPSC technology", *ICEST,05 Conference Proceedings* , vol. 2, pp.630-633, Nis, Serbia and Montenegro, 2005.

[5] V. Demirev, "The Probability Theory with Application in SCP Technology", *ICEST,04 Conference Proceedings, pp.167-168*, Bitola, Macedonia, 2004 .

[6] V. Demirev, *"The Probability Theory of SCP-RPSC technology", Telecom,06,* Varna, 2006 г.(in Bulgarian).

[7] V. Demirev, "SCP-RPSC Technology – a Possible Solution of VMES Regulatory Problems", *Telecom,09,* Varna, 2009 г.(in Bulgarian).