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1 Scope

This document describes reference scenarios for evaluation of applicability of NR to the geosynchronous satellite networks. It includes two parts:

1. Methodology to define the reference scenarios
2. Examples of reference scenarios of calibration purposes.

2 Methodology to define the reference scenarios

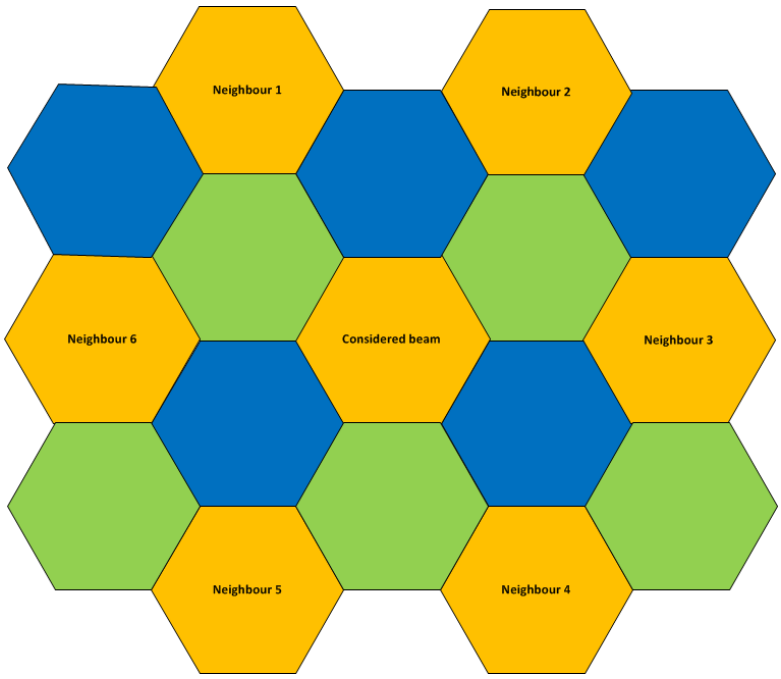
For the GEO case, a single beam from one satellite is considered. The beam foot print is a function of the equivalent reflector diameter of the satellite antenna, and is typically on the order of 175km-200 km in diameter for Ka-band. The foot print diameter refers to beams near the center in the general coverage area of a satellite, and tends to be elongated and larger for beams near the edge of the satellite coverage area due to earth curvature. The uplink beam and downlink beam is congruent. For the purpose of defining reference scenarios, 200 km diameter for Ka-band, corresponding to a 5 dB contour.

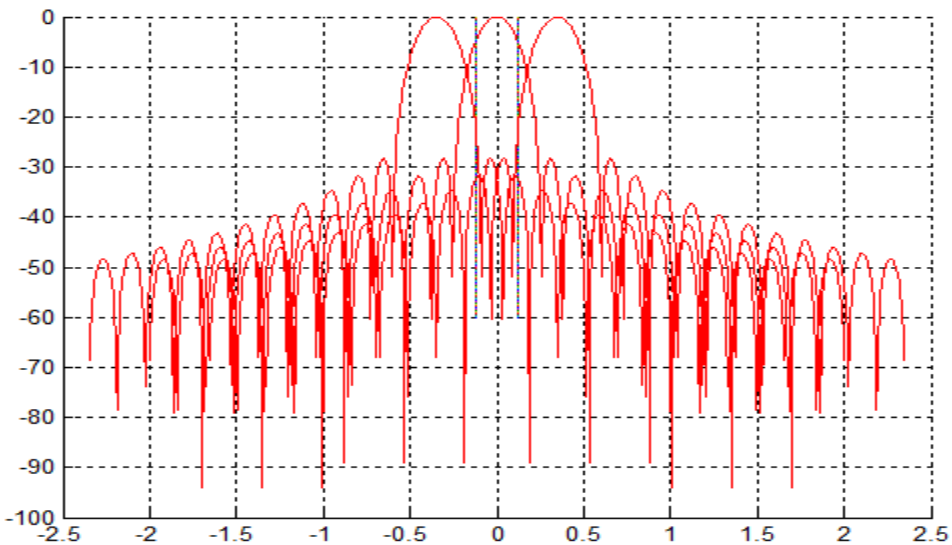
The satellite beams are typically sharing the same frequency with other beams on the same satellite with reuse factor 3 or 4. A frequency reuse 3 pattern is shown below. Circular polarization is used in Ka-band. Both right hand CP and left hand CP are often used by the same satellite to improve frequency reuse efficiency. A satellite may use only one polarization, also.

Multi-beam satellites typically illuminate multiple hexagonal cells within a service area. The far field directivity of a typical reflector antenna with a circular aperture can be approximated by

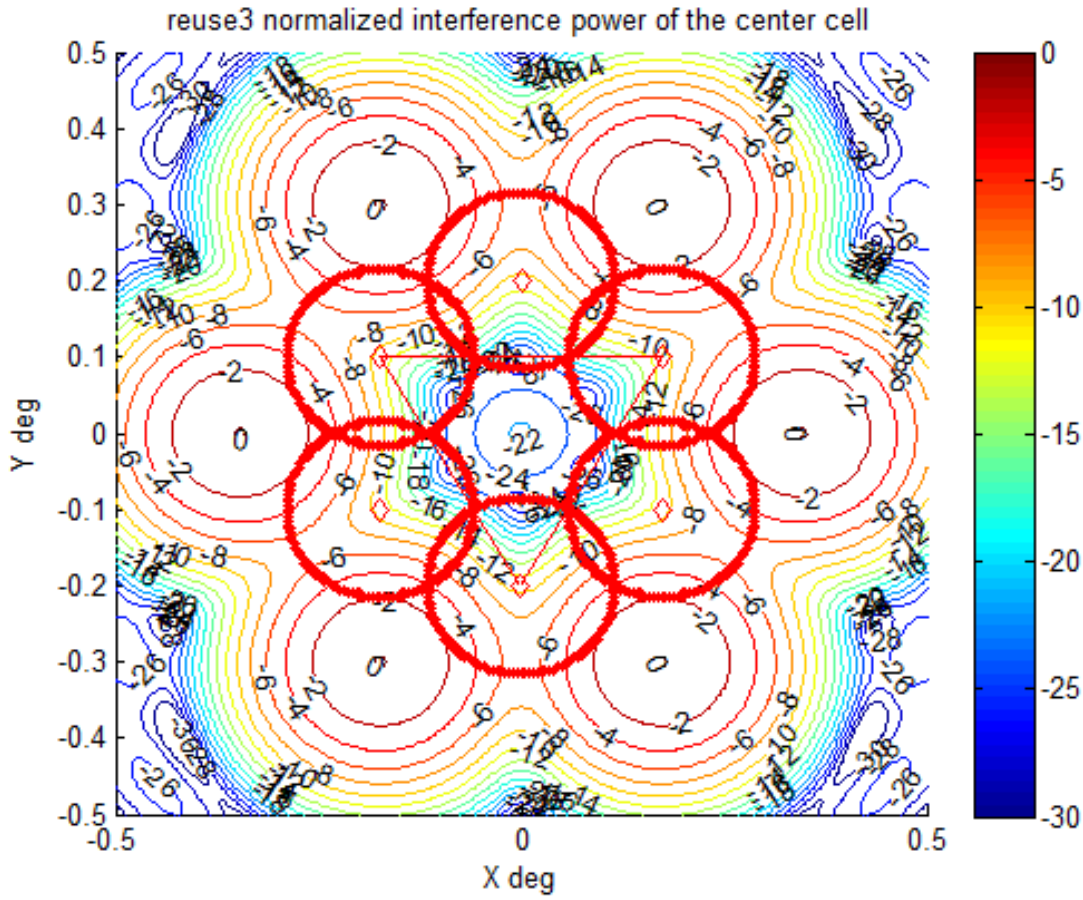
$$2G(0)J_o(k\ a \sin\theta)/(k\ a \sin\theta),$$

where G(0) is the boresight gain, $J_o(x)$ is the Bessel function of the first kind with argument x, $k = 2\pi f/c$ is the wave number, f is the frequency of operation, c is the speed of light in a vacuum and θ is the angle measured from the boresight of the antenna's main beam. Finally, a is the radius of the antenna's circular aperture. The normalized directivity is given by $2\ J_o(k\ a \sin\theta)/(k\ a \sin\theta)$,. Antenna patterns of three co-channel beams for reuse 3 are shown in the figure below. As shown, the crossover point of the two co-channel beam is about -10 dB.





A high-throughput satellite need to consider aggregated co-channel interference from all the co-channel beams. It is dominated by the nearest six co-channel beams. The following is a 2-D contour plot for reuse factor 3 with the antenna beams spaced at -5 dB crossover point. As it can be seen that the minimum co-channel interference occurs at the edge of the desired hexagonal cell. Since the center of the beam actually has the highest interference because all 6 co-channel beams contribute to it, whereas the interference at the beam edge is dominated by one or two nearest co-channel beams. The interference level, however, is relatively flat, with variation about 3 dB.



The maximum interference, or I_{max} is at the beam center. As we move away from the beam center towards the beam edge, co-channel interference contributed by the co-channel beams away starts to drop off while the interference nearest co-channel beams rise, until a minimum is reached, I_{min}. To simplify the co-channel interference model, an interference profile as a function of distance from the cell center can be assumed. We propose the interference profile in dB scale can be expressed as the parabolic function:

$$I = I_{min} + (I_{max}-I_{min})\,(1-r)^2,$$

where $0 < r < 1$ is the normalized distance from the beam center. The value of I_{min} and I_{emax} are parameters to be adjusted based on the reuse factor and crossover point between adjacent co-channel beams.

For the Ka-band UE, a high-gain antenna with circular reflector of 30-cm diameter (TBD) is considered for mobile terminals. We assume that UEs are generally mounted on vehicles. The environments are suburban and rural environments. The main impairment is blockage. The channel is AWGN without blockages. Atmospheric effects are separately accounted for as a function of elevation angle and rain zone. UE distribution within each beam is assumed to be homogeneous.

3 Examples of Reference Scenarios for Calibration Purposes

The examples are meant for calibrations purposes, not for completeness. For GEO in the Ka-band.

Parameters	**Values**
Satellite altitude (km)	35,786
Satellite position in the form (0,y,z)	(0,0,TBD)
Beam foot print diameter (km)	200
Beam centre position in the form (x,y,0)	Beam 1: (0,0,0)
UE distribution type	Homogeneous
UE density (UE/km²)	TBD
Satellite antenna pattern	$2J_o(k\ a \sin\theta)/(k\ a \sin\theta)$
UE antenna pattern	$2J_o(k\ a \sin\theta)/(k\ a \sin\theta)$
Interbeam interference	$I = I_{min} + (I_{max}-I_{min})\ (1-r)^2$ I_{min} = -26 dB, I_{max}= -22 dB
UE speed (km/hr)	100
UE direction	Homogeneous
Environment	Suburban
Channel Impairmants	AWGN+log-normal shadowing