Radiocommunication Study Groups

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France[1]

AGENDA ITEM 1.1 – VIEWS ON SHARING STUDIES BETWEEN IMT INDOOR SYSTEMS AND RADAR SYSTEMS IN THE BAND 3 300 – 3400 MHz FOR WRC-15 AGENDA ITEM 1.1

A Introduction

Joint Task Group 4-5-6-7 is currently studying the sharing between LTE indoor system and radar system

France proposes JTG 4-5-6-7 to consider the following sharing study addressing the impact of small cells indoor onto airborne radar operating in 3 300-3 400 MHz band.

[1] This document has been developed and agreed within the framework of CEPT ECC CPG PTD.

B Systems characteristics

a. IMT systems

TABLE 1

IMT systems parameters

BS characteristics / Cell structure	Small cell indoor (100%)
Antenna height	3 m
Sectorization	single sector
Antenna pattern	Recommendation ITU-R F.1336 omni
Indoor BS Penetration Loss PL	12dB[2]
Maximum BS output power (5/10/20 MHz)	24 dBm
Maximum BS antenna gain	0 dBi
Maximum BS output power (e.i.r.p.)	24 dBm
Average BS activity	50 %
Average BS power/sector (to be used in sharing studies)	21 dBm

Each building contains an IMT small cell indoor system comprising multiple IMT small cells.

The IMT small cell indoor system topology is distributed in buildings of 6 floors, the topology of each floor is based on the below figure from the 3GPP specification 3GPP TR 36.814. As shown in figure below:

- IMT small cell indoor system buildings size: $\boldsymbol{L} \times \boldsymbol{l}$=120 m x 50 m, including rooms and corridor;
- the number of indoor IMT small cell BSs within each floor *NS*=2[3];
- the average number of floors per building *NF*=6,
- average penetration loss: 12 dB,
- street width: *W*=20m.

b. Radar systems

In this document, the considered radar for the sharing study is the airborne radar. Airborne radars purpose is for long range surveillance, target tracking and Air Traffic Control. The spectrum characteristics for typical airborne radar found in this band are depicted in Figure 2, extracted from Recommendation ITU-R M.1465-1. The antenna of this system is a large, slotted waveguide array assembly mounted atop of the airframe. If surveillance aircraft makes the radar (embedded on the aircraft operating at altitude *h*= 9 000 m) pointing to the horizon, the vertical scanning process of the radar antenna concerns as aircrafts surveillance for higher altitudes as air and sea surveillance mode for lower altitudes, resulting in ±60° elevation angle.

[2] Corresponds to an average value whose distribution is featured by a 17 dB median and 7 dB standard deviation proposed by the US input for RLANs in higher frequencies (5 GHz band).

[3] Four small cell base stations are considered in each floor instead of the two base stations per floor considered in 3GPP TR 36.814.

This airborne system can be operated for extended hours of up to 12 h depending upon aircrew availability. In some situations constant surveillance is maintained on a 24 h per day basis by replenishment aircraft.

Recommendation ITU-R M.1465-1 contains in particular the interference criterion, *I*/*N*, that is used to protect Radar systems from other services with the *I*/*N* = –6 dB recommended value (see *recommends* 3 of Recommendation ITU-R M.1465-1).

TABLE 2

Radiolocation system

Parameter	**Airborne system**
	A
Use	Surface and air search
Tuning range (GHz)	3.1-3.7
Antenna gain (dBi)	40
Beamwidth (H,V) (degrees)	1.2, 6.0
Vertical scan type	Not available
Maximum vertical scan (degrees)	±60
Interference criterion (dB)	I/N=–6dB
Vertical scan rate (degrees/s)	Not available
Horizontal scan type	Rotating
Maximum horizontal scan (degrees)	360
Rx noise figure (dB)	3

c. Methodology

A Minimum Coupling Loss approach is used, modeling multiple interferers-victim pair (as to be smallcells indoor within the surface covered by the main beam of the radar system-to-Radar). From this method, we derive the InBand restricted emissions of IMT systems when they share the same band as radar systems in 3 300-3 400 MHz band.

According to the nature of the airborne radar, the propagation model separating the radar receiver from the smallcells indoor within the urban area is assumed Free Space Loss (FSL) for distances lower than horizon distance d.

Aggregation factor calculation requires assessing the density of smallcells indoor per km^2 as well as the surface which is covered by the main lobe of the airborne radar.

From the previous information, the density of smallcells indoor per area (km^2), denoted D, is equal to: D= $(\boldsymbol{W}(\boldsymbol{l}+\boldsymbol{L}+\boldsymbol{W})+\boldsymbol{L}\times\boldsymbol{l})\times\boldsymbol{NF}\times\boldsymbol{NS}$.

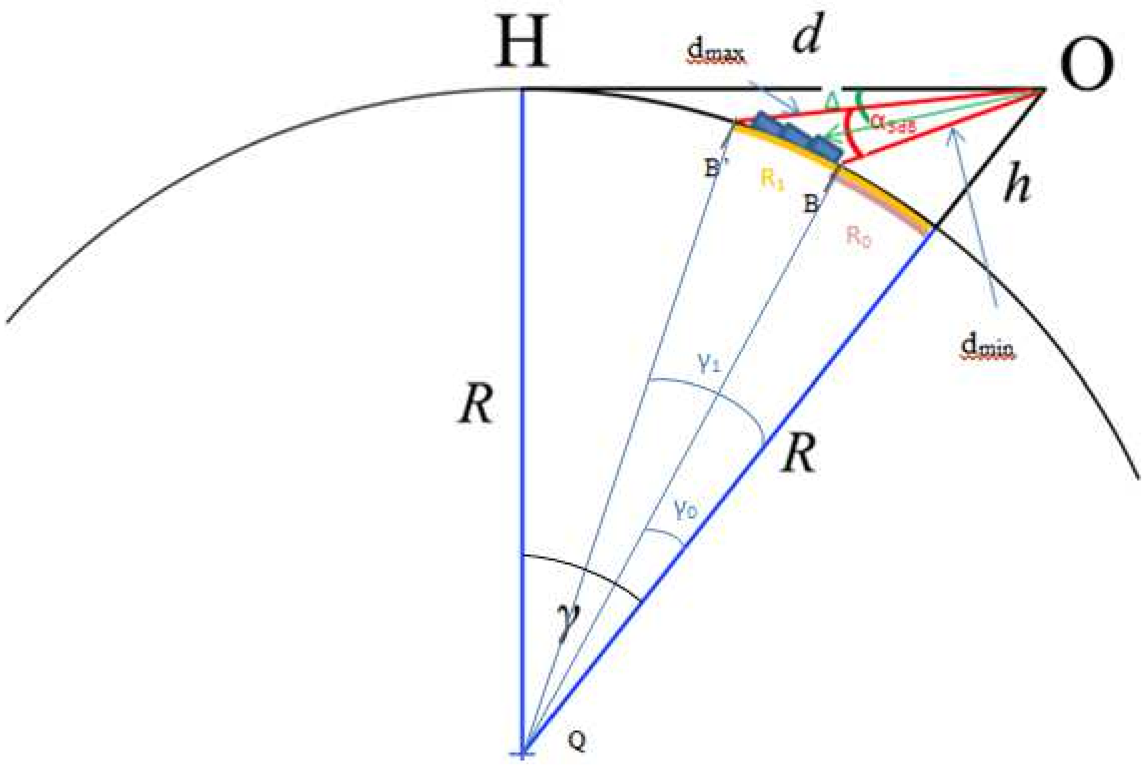
In the deployment scenario shown in Figure 1, IMT-Advanced smallcells indoor of the buildings that are covered by the main beam of the airborne radar are potential main[4] interferers.

4 IMT smallcells in the sidelobes of the airborne radar are not considered in this study.

As the aggregated interference, interferences from smallcells stations located (in buildings) **in the area delimited by ground distances R_0 and R_1 are** summed up, as indicated in Figure 1.

FIGURE 1

Radar and IMT-Advanced deployment model for aggregate interference consideration



1 Parameters d_{max} and d_{min} may be derived as follows:

In the triangle (QBO): $QB^2 = QO^2 + OB^2 - 2QO.OB.cos\widehat{BOC}$

which is equivalent to: $R^2 = (R+h)^2 + d_{min}^2 - 2(R+h)d_{min}.cos\left[\frac{\pi}{2} - \gamma - (\Delta + \frac{\alpha_{3dB}}{2})\right]$

The identification of the polynom of the d_{min} variable leads to the following (valid) root expression:

$$d_{min} = (R+h)cos\left[\frac{\pi}{2} - \gamma - \left(\Delta + \frac{\alpha_{3dB}}{2}\right)\right] - \sqrt{(R+h)^2 cos^2\left(\frac{\pi}{2} - \gamma - (\Delta + \frac{\alpha_{3dB}}{2})\right) - 2Rh + h^2}.$$

In the same manner, d_{max} value can be derived:

$$d_{max} = (R+h)cos\left[\frac{\pi}{2} - \gamma - \left(\Delta - \frac{\alpha_{3dB}}{2}\right)\right] - \sqrt{(R+h)^2 cos^2\left(\frac{\pi}{2} - \gamma - (\Delta - \frac{\alpha_{3dB}}{2})\right) - 2Rh + h^2}$$

Where: $\gamma = Acos\left(\frac{R}{R+h}\right)$.

In the same manner, we get: $\gamma_0 = Acos\left(\frac{{d_{min}}^2 - R^2 - (R+h)^2}{-2R(R+h)}\right)$ and $\gamma_1 = Acos\left(\frac{{d_{max}}^2 - R^2 - (R+h)^2}{-2R(R+h)}\right)$.

(considering respectively triangles (QBO) and (QB'O)).

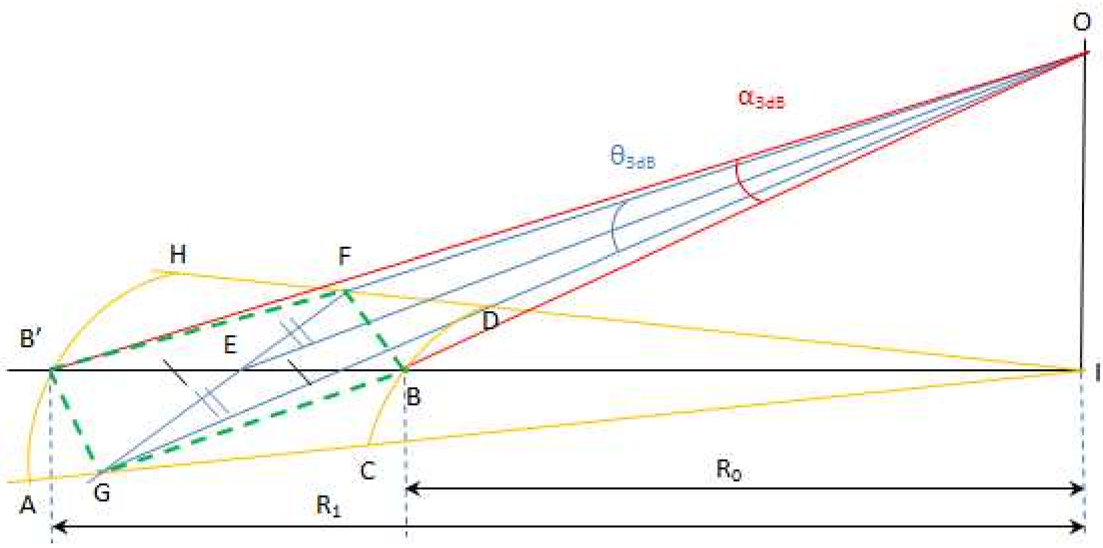
which leads to: $R_0 = R\gamma_0 = R\ Acos\left(\frac{{d_{min}}^2 - R^2 - (R+h)^2}{-2R(R+h)}\right)$ and $R_1 = R\gamma_1 = R\ Acos\left(\frac{{d_{max}}^2 - R^2 - (R+h)^2}{-2R(R+h)}\right)$.

R_0 and R_1 are similar (and small) when elevation angle Δ is close to the maximum (in absolute) value.

2 Number of smallcells indoor in sight of airborne radar antenna main beam

FIGURE 2

Surface covered by the airborne radar antenna main beam



The surface which is covered by the airborne radar antenna main beam is modelled as the surface of the angular sector portion (HDCA), denoted Σ, depicted in the Figure 2. **This surface is down bounded by the surface of the (B'FBG) kite shaped quadrilateral**, delimited with dashed green line. It is then proposed to calculate the (B'FBG) surface in this contribution.

Figure 2 shows that: $\widehat{\text{EI}} = R_0 + \frac{R_1 - R_0}{2}$.

In the triangle (EIQ[5]), $\gamma_{med} \triangleq \frac{\widehat{\text{EI}}}{R} = \frac{R_0 + \frac{R_1 - R_0}{2}}{R}$ (1)

In the triangle (EOQ), EO=$\sqrt{R^2 + (R+h)^2 - 2R(R+h)cos(\gamma_{med})}$ (2)

$$Surface(B'FBG) = \frac{AD \times GF}{2} = (R_1 - R_0) \times EF = (R_1 - R_0) \times EO.\tan\left(\frac{\theta}{2}\right)$$

From (1) and (2), we thus obtain:

$$Surface(B'FBG) = (R_1 - R_0) \times \sqrt{R^2 + (R+h)^2 - 2R(R+h)cos\left(\frac{R_0 + \frac{R_1 - R_0}{2}}{R}\right)}.\tan\left(\frac{\theta}{2}\right).$$

The considered urban surface is that one from Ile-de-France region which gathers Paris as well as its suburb[6].When the airborne radar antenna points at the horizon, the solid angle covers the largest

5 Q point being the center of the earth, as depicted in Figure 1.

6 Corresponding to 12000km^2

terrestrial zone. According to The table X, the largest area is lower than the Ile-de-France region, which leads to conclude that previous assumptions on smallcells indoor deployment within the urban area may apply in the whole area.

We then derive the number of smallcells indoor (NSI) in sight of the main beam of the airborne radar: $\mathrm{NSI} = \Sigma \times D$.

3 Restricted inband emission level for IMT smallcells indoor

This parameter refers to the aggregation factor in the following link budget:

Isolation= e.i.r.p.(dBm/MHz)+PenetrationLoss+PathLoss[7]+AggFactor+G_R-I/N+Noise(dBm/MHz)

= e.i.r.p.(dBm/MHz)+PL+FSL+10$\log_{10}$(NSI) +G_R -I/N+Noise(dBm/MHz).

Additional isolation is required when Isolation<0dB. In such a case, restricted Inband level could be required in order to ensure the protection of the airborne radar:

InBand Emission level (dBm/MHz)= e.i.r.p.(dBm/MHz)+ min(Isolation,0).

d. Results

We derive for different elevation angles the required Inband emission level which would ensure the protection of the airborne radar embedded on aircraft. Some observations can be made, emphasizing this studied case as not a worst case:

– the lower absolute value of elevation angle, the most stringent the inband emission level. The best case corresponds to the maximum elevation angle (-60°), where

– -40.9dBm/MHz is required. For lower absolute value of elevation angle, the requirement of Inband emission level for smallcells is expected to be more stringent.

– Aggregation interference was derived on surface[8] lower than the Σ surface covered by the airborne radar antenna main beam

– Aggregation interference only addressed the impact of the smallcells indoor pointing in the main beam of the airborne radar and thus did not account the impact of the smallcells indoor pointing to the sidelobes of the airborne radar.

– Free space Pathloss is derived for d_{max} distance (which overestimates by some dBs the propagation loss as it would depend on the location of the smallcells in d_{min},d_{max} range).

Elevation angle of the airborne radar (°)	-3	-5	-10	-20	-30	-40	-50	-60
Surface covered by the airborne radar (km^2)	583	56.2	9.2	1.6	0.6	0.3	0.2	0.1
Nb smallcells indoor in sight of the main lobe of the airborne radar within (B’FBG) surface	713850	68791	11216	1903	685	346	214	109
Nb smallcells indoor in sight of the main lobe of the airborne radar	>713850	>68791	>11216	>1903	>685	>346	>214	>109
R_1 (km)	338.4	113.4	52	24.8	15.6	10.7	7.5	0.5
Required InBand Emission level (dBm/MHz) (IMT e.i.r.p)	<-47.5	<-46.8	<-45.6	<-44	<-42.8	<-42.1	<-41.5	<-40.9

7 Free Space Loss

8 (B’FBG) kite quadrilateral

In addition, this table shows that:

– not only are the Inband restricted emission levels[9] required for R_1 short distances less than 10 kms which could reflect "cross-border" situations where the aircraft performs sea and/or earth surveillance, these restricted emissions levels are also required for very long distances (more than 100km) when airborne radar operates with low elevation angle (less than 5°).
– the most stringent Inband emission level (-47.5 dBm/MHz) is required for low elevation angle case corresponding to the common scenario where the aircraft operates far from the cross-border .

E Conclusions

This document analyses the sharing studies between IMT systems indoor and airborne radar systems within 3 300-3 400 MHz band in urban area.

In the best case, it is shown that IMT smallcells indoor Inband emission levels are restricted to -40.9 dBm/MHz which corresponds to a short distance (high elevation angle) between IMT and radar. Such constraint makes the deployment of the IMT smallcells indoor within urban area in the same band as radiolocation unfeasible from a national perspective.

The results also pointed out that these constraints become more stringent when airborne radar gets far away from the smallcells indoor because the resulting aggregation factor of the smallcells in line of sight of the airborne radar increases faster than the pathloss does with distance. These constraints make the deployment of the IMT smallcells indoor within urban area in the same band as radiolocation unfeasible from a cross-border perspective.

This concludes that sharing between IMT smallcells indoor and radar within 3 300-3 400 MHz is not possible, leading to the non-feasibility of IMT systems deployment in this frequency range.

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[9] for IMT smallcells indoor