Compatibility Studies of IMT System and Automotive Radar in the Frequency Range 71-78 GHz

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Abstract. The millimeter waves have large available bandwidth and thus gigabit throughput can be easily achieved for future wireless communication systems. The frequency band has been identified as potentially suitable frequency band for IMT (International Mobile Telecommunications) systems. In this paper, considering ECC and Huawei relevant paper, the coexistence interference of 71-78 GHz-band international mobile telecommunications (IMT) and automotive radar is analyzed based on actual geographical and ITU-R system characteristic. Specifically, the interferences of IMT system base stations (BS) and users (UE) to automotive radar are studied, considering high frequency band radio propagation clutter loss. This paper presents the Monte Carlo results in terms of the level of compatibility interference power vs. the distances between IMT and automotive radar in the straight trajectory by using Visualyse V7.9 simulation tool. The results show that in some case the IMT BS operating in the band 71-76 GHz may be well compatible with the automotive radar, the interference power value is mainly under protection criterion value. The provided results are useful for design of future 71/80 GHz IMT-2020 (5G) wireless communications systems and automotive radar system.

1. Introduction
The millimeter waves have large available bandwidth and thus gigabit throughput can be easily achieved for future wireless communication systems. The frequency band has been identified as potentially suitable frequency band for IMT (International Mobile Telecommunications) systems [1], in dense urban areas to provide large bandwidth and high volume business [2]. In China, the 26 GHz radio is approved by Chinese Ministry of Information Industry for local multipoint distribution system access network business, this band was carried out in China Mobile, China Telecom, China Unicom, China Netcom [3]. WRC-19 agenda item 1.13 (IMT-2020) considers identification of frequency bands for the future development of International Mobile Telecommunications (IMT), between 24.25 GHz to 86 GHz. The bands of 71-76 GHz and 81-76 GHz are within the scope of the potential bands.

Considerate ECC and Huawei relevant paper [4][5], this contribution presents the initial compatibility studies of IMT system operating in the band 71-76 GHz with automotive radar in the adjacent band 76-77 GHz. In this included study, only single entry interference from an IMT base station (BS) and three user equipment (UE) to a receiver of automotive radar is addressed.

2. Allocation information in the frequency range 66-81 GHz
The Radio Regulation [6] table of frequency allocations in the band 71-78 GHz is provided below for reference. Automotive radar is one kind of the radiolocation service and allocated in the band 76-81 GHz, see table 1.

**Table 1. Allocation in the band 71-78 GHz allocation to services**

| Region 1 | Region 2 | Region 3 |
|----------|----------|----------|
| 71-74    | FIXED    | FIXED-SATELLITE (space-to-Earth) |
|          |          | MOBILE |
|          |          | MOBILE-SATELLITE (space-to-Earth) |
| 74-76    | FIXED    | FIXED-SATELLITE (space-to-Earth) |
|          |          | MOBILE |
|          |          | BROADCASTING |
|          |          | BROADCASTING-SATELLITE |
|          |          | Space research (space-to-Earth) |
| 76-77.5  | RADIO ASTRONOMY | |
|          | RADIOLOCATION | |
|          | Amateur | |
|          | Amateur-satellite | |
|          | Space research (space-to-Earth) | 5.561 |
| 77.5-78  | AMATEUR  | |
|          | AMATEUR-SATELLITE | |
|          | RADIOLOCATION 5.559B | |
|          | Radio astronomy | |
|          | Space research (space-to-Earth) | 5.149 |

3. Technical characteristics

3.1 Automotive radar parameters

According to Recommendation [7], the technical characteristics of automotive radar in the frequency band 76-77 GHz are summarized in Table 2.

**Table 2. Technical characteristics of automotive radar in the band 76-77 GHz**

| Parameter                              | Radar A          |
|----------------------------------------|------------------|
| Frequency                              | 76-77 GHz        |
| Bandwidth                              | 1 GHz            |
| Noise                                  | -69 dB           |
| Antenna height                         | 0.7 m            |
| Antenna deployment                     | Front of the vehicle |
| Antenna peak gain                      | 25 dBi           |
| Noise = RX sens (1 GHz) in dBm + RX-noise figure 15 dB (note 1) | -69 dBm ( = -84 dBm + 15) |
| Antenna azimuth scan angle (degrees)   | TX/RX:           |
| Receiver noise figure (dB)             | 15               |
3.2 IMT parameters
According to the liaison statement from WP 5D to TG 5/1 [8][9], the typical characteristics of IMT system for sharing and compatibility analyses are listed in Table 3.

Table 3. Technical characteristics of imt bs in the band 71-76 GHz

| Parameter                        | IMT (Base station) |
|----------------------------------|--------------------|
| Frequency                        | 71-76 GHz          |
| Channel bandwidth                | 200 MHz            |
| Network loading factor           | 100 % for single-entry |
| Duplex method                    | TDD                |
| BS TDD activity factor           | 100 % for single-entry |
| Antenna height                   | 6 m                |
| Antenna deployment               | Below roof top     |
| Duplex tilt                      | 10°                |
| Orientation                      | [-180°, 180°]      |
| Antenna pattern                  | Refer to Rec. ITU-R M.2101 |
| Element gain                     | 5 dBi              |
| Horizontal/vertical 3 dB beamwidth of single element | 65° for both H/V |
| Horizontal/vertical front-to-back ratio | 30 dB for both H/V |
| Antenna array configuration (Row x Column) | 16x16 elements |
| Horizontal/Vertical element spacing | 0.5 of wavelength for both H/V |
| Array Ohmic loss                  | 3 dB               |
| Conducted power (before Ohmic loss) per antenna element | 6 dBm/200 MHz |
| Spurious emissions               | -13 dBm/MHz        |

3.3 unwanted emission marks of IMT BS in the band 76-77 GHz
For the band 71-76 GHz, the maximum BS transmit power, the following spectrum mask described in Doc. 5-1/36 [8] are then used, see Table 4.

Table 4. Spectrum masks for outdoor scenarios and $P_{TX} < 30.5$ dBm for BS in the frequency range 66-86 GHz

| Frequency offset from “edge of transmission” $\Delta f$ | Emission limit (BS) | Emission limit (UE) | Measurement bandwidth |
|--------------------------------------------------------|---------------------|---------------------|-----------------------|
| 0 ≤ $\Delta f$ < 20 MHz                                | -5 dBm/MHz          | -5 dBm/MHz          | 1 MHz                 |
| 20 MHz ≤ $\Delta f$ < 400 MHz                          | -13.4 dBm/MHz       | -13 dBm/MHz         | 1 MHz                 |
| $\Delta f$ > 400 MHz                                   | Spurious domain limits* | Spurious domain limits* | 1 MHz                 |

*Note: for BS and UE, the spurious emission level is set as being -13 dBm/MHz.

3.4 Propagation models
The analyses are based on the propagation models described in Recommendation ITU-R P.525-3 [10] is used to simulate the transmission loss from an IMT system include one BS and three UE to an automotive radar device.
3.5 Protection criterion for automotive radar

As recommended in Recommendation ITU-R M.2101[9], a protection criterion I/N of -6 dB is considered in the study.

4. Methodology

4.1 Interference topology

Based on the information available in WP 5D and TG 5/1 documents, it can be assumed that IMT components operating in the 71-76 GHz will be deployed in an urban or a suburban environment.

Figure 2 illustrates a basic sketch of the interference scenario. It is assumed that there are an IMT BS operating in the band 75.8-76 GHz and an automotive radar in the adjacent band 76-77 GHz. The IMT BS is deployed at the side of the road, and serves the IMT user equipments (UEs) located in its serving sector. As recommended in Recommendation ITU-R M.2101, the range of angle for single serving sector is 120 degree. The automotive radar is installed on the front of a vehicle, which is traveling over a few meters away from the IMT BS in a straight trajectory.

Therefore, the out-of-band (OOB) and spurious emissions of IMT BS working in 75.8-76 GHz will affect the performance of automotive radar in 76-77 GHz.

Figure 1. Illustration of compatibility interference between IMT BS and automotive radar

In the simulations, the scanning in azimuth of IMT BS is considered, to emulate the action that IMT BS is serving to the UE located in different geographical locations. Therefore, 1 000 snapshots are simulated for each victim positions.

4.2 Calculations

The interference power for IMT BS and UE at the receiver of automotive radar is given as:

\[ I = Tx + G_{\text{radar}} + G_{\text{IMT}} - PL \]  

(1)

where,

- \( Tx \): the emission power of IMT BS and UE, in dB;
- \( G_{\text{radar}} \): the antenna gain of automotive radar, in dBi;
- \( G_{\text{IMT}} \): the antenna gain of IMT BS and UE, in dBi;
- \( PL \): transmission losses for the path from IMT BS to automotive radar, in dB;

5. Results and analyses

This section presents the Monte Carlo results in terms of the level of compatibility interference power vs. the distances between IMT and automotive radar in the straight trajectory by using Visualse V7.9 simulation tool.
In order to better assess the effect of the distances of IMT BS from the vehicle trajectory, i.e., R in Figure 1, this section shows the results for different distances of IMT BS from the vehicle trajectory. The horizontal scanning of automotive radar antenna is considered in the simulation. Two kinds of configurations on the distances of IMT BS from the vehicle trajectory are set, i.e., 4 m and 10 m, respectively. The corresponding results are given in Figure 2 and Figure 3.

**Figure 2.** Compatibility interference of IMT BS at the automotive radar for different distances with 4m distances between IMT BS and the vehicle trajectory

**Figure 3.** Compatibility interference of IMT BS at the automotive radar for different distances with 10m distances between IMT BS and the vehicle trajectory

It can be concluded that the interference will be reduced with the increase of the distances of IMT BS from the vehicle trajectory.

6. **Summary**
This initial study presents the potential of compatibility between IMT system and automotive radar operating in the band 76-77 GHz. The results show that in some case the IMT BS operating in the band 71-76 GHz may be well compatible with the automotive radar, the interference power value is
mainly under protection criterion value. Obviously, if the antenna horizontal ±15° angle scanning of automotive radar, it seems that both impacts will be alleviated.

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Reference
[1] Bleicher A. The 5G phones future. IEEE Spectrum, 2013, 50(7): 15-16.
[2] Tan Wang, Gen Li, Jiaxin Ding, Qingyu Miao, Jingchun Li, and Ying Wang, "5G Spectrum: Is China Ready?", IEEE Communications Magazine, pp. 58-65, 2015.
[3] S. Y. Geng, Xing Li, Wei Hong, and X. W. Zhao, “Mm-wave 26 GHz channel characterization for future wireless communications,” in 2016 International Conference on Control and Automation, 2016, pp. 475-480.
[4] “Initial compatibility studies of IMT-2020 and automotive radar in the frequency band 76-81 GHz for AI 1.13”, revision 1 to ECC PT1(17)235rev1, Dec.2017.
[5] Contribution from ITU-R TG 5/1, “Compatibility studies of IMT system and automotive radar in the frequency range 76-81 GHz,” 2018.
[6] Report ITU-R Radio Regulations, 2016.
[7] Recommendation ITU-R M.2057-1, “Systems characteristics of automotive radars operating in the frequency band 76-81 GHz for intelligent transport systems applications ,” 2018.
[8] Liaison statement from ITU-R WP 5D to TG 5/1, “Spectrum needs and characteristics for the terrestrial component of IMT in the frequency range between 24.25 GHz and 86 GHz,” 2017.
[9] Recommendation ITU-R M.2101-0, “Modelling and simulation of IMT networks and systems for use in sharing and compatibility studies,” 2017.
[10] Recommendation ITU-R P.525-3, “Calculation of free-space attenuation,” 2016.