ASIA VIDEO INDUSTRY ASSOCIATION

IMDA Considerations for Coexistence of 5G IMT and FSS in 3.4-3.6GHz Band

1. Introduction/Background

IMDA is proposing to re-allocate the 3.4 – 3.6 GHz band to 5G IMT services from FSS.

There are a number of licensed TVRO antennas in Singapore and neighbouring countries receiving C-band services in the 3.4 – 3.6 GHz band, more in the 3.6 – 3.7 GHz and more still in the 3.7 – 4.2 GHz "standard" C-band.

In addition to the effective elimination of inbound TV services to Singapore and possible disruption of reception in adjacent areas of neighbouring countries in the 3.4 – 3.6 GHz band, without implementation of appropriate mitigation measures, severe interference will be caused into these services both in the 3.6 – 3.7 GHz band and in the 3.7 – 4.2 GHz band, thereby jeopardizing the quality and continuity of the service as a whole.

Recognising that Singapore is not a large enough market to dictate new technical standards, CASBAA sought to investigate existing standards and best practices applied in the US (FCC), UK (OFCOM, as one example within EU that has recently auctioned similar band capacity for 5G IMT) and Hong Kong SAR (OFCA which, like IMDA cannot dictate new technical standards due to market size).

The two kinds of adjacent and proximate band effects considered in this paper are:

(a) out-of-band and spurious emissions by mobile base stations and devices in the bands above 3600 MHz; and

(b) overdrive caused by wide bandwidth LNBs receiving energy below 3600 MHz.

2. Out-of-band and spurious emissions by mobile base stations and devices above 3600 MHz

The mitigation measures broadly are for IMDA to require:

(1) an out-of-band and spurious emission mask that IMT must adopt,

(2) a guard band in which IMT is silent to protect FSS earth stations, and/or

(3) a quiet zone (separation distance) around the FSS receivers above 3600 MHz.

For any given IMT power and power spectral density, the better the out-of-band and spurious emission mask that IMT must adopt, and the larger the guard band, the smaller the quiet zone or separation distance required around the FSS receivers.

The in-band IMT power and power spectral density may be of the order of a million times greater than the wanted FSS signal power and power spectral density. Therefore at any point in front of an FSS antenna that is within line of sight of IMT base station transmitter, a combination of all three is required.

It is simpler initially just to consider the spurious emission limits for the three jurisdictions compared: US, UK and Hong Kong, though the references below include the details of the spectrum emission mask or block edge mask, as applicable.

a. US / FCC

The US, in its 3.5 GHz Report and Order[1] adopted -40dBm/MHz above 3720 MHz as the spurious emission limit for Citizens Broadband Radio Service Devices (CBSD) – see F. 1. B. Emissions and Interference Limits, paragraph 184, page 58. The guard band is effectively 20MHz, as the CBRS is permitted up to 3700 MHz – see J. 3650-3700 MHz Band, paragraph 392, page 115.

In the preceding paragraph, the Satellite Industry Association's (SIA) response to FCC is cited:

"SIA advocates for significant separation distances and OOBE limits to prevent harmful adjacent band interference. [2] SIA presents an engineering study by RKF Engineering, including an analysis of the required line-of-sight separation distances between a CBSD and an FSS earth station as a function of OOBE limit (-13, -40, and -50 dBm/MHz) and the earth station off-axis angle. [3] The study shows separation distances of tens of kilometers required to control aggregate interference with an OOBE limit of -13 dBm/MHz, while the required separation distances with a tighter OOBE limit of -50 dBm/MHz are between 100 m and 1 km, depending on the off-axis angle to the FSS earth station. [4]"

The separation distances with an OOBE limit of -40 dBm/MHz are between 300 m to 3 km depending on the off-axis angle to the FSS earth station.

b. UK / OFCOM

The UK completed its 5G IMT Award of 2.3 and 3.4 GHz spectrum by auction in 2018[5]. The spurious emission limit is -34 dBm/5MHz, above 3605 MHz, which averaged is equivalent to -41 dBm/MHz[6]. "Standard" 3GPP spurious emission limits may apply otherwise, though neither OFCOM nor the questioner clarified this point as raised by the questioner. The 3GPP TS 36.104 standard includes numerous "standards" ranging from -13dBm/MHz for Category A limits (the least stringent limits), through -30 dBm/MHz for European and some other countries, -40 dBm/MHz for US, Canada and some other countries, to -96 dBm/100kHz for wide area base stations in FDD mode[7].

TS 36.104 classifies unwanted emissions in Section 6.6 thus:

"The Operating band unwanted emissions define all unwanted emissions in each supported downlink operating band plus the frequency ranges 10 MHz above and 10 MHz below each band. Unwanted emissions outside of this frequency range are limited by a spurious emissions requirement."

The IMT industry has introduced very stringent limits for out-of-band and spurious emissions into other IMT services, especially for emissions into pre-5G IMT services and co-located services. It should be required to adopt **more** stringent limits for such emissions into non-IMT services,

[1] Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band – Report and Order and second further notice of proposed rulemaking, FCC15-47, April 21, 2015 at https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-47A1.docx
[2] *See* SIA *FNPRM* Comments at 15. https://ecfsapi.fcc.gov/file/7521384256.pdf
[3] *See id.* at Technical Annex.
[4] *Id*. at Figure 12.
[5] https://www.ofcom.org.uk/spectrum/spectrum-management/spectrum-awards/awards-archive/2-3-and-3-4-ghz-auction
[6] *See* answer to Q.8 at https://www.ofcom.org.uk/spectrum/spectrum-management/spectrum-awards/awards-archive/2-3-and-3-4-ghz-auction/q-and-a but see also Note 2 thereto, which explains this does not apply in certain circumstances.
[7] http://www.3gpp.org/ftp/Specs/archive/36_series/36.104/36104-g10.zip

particularly where the received signal levels of those interfered non-IMT services are millions to billions of times weaker than the IMT levels.

c. Hong Kong SAR / OFCA

Hong Kong's OFCA recently formalised its decision to reallocate 3.4 - 3.7 GHz to IMT services from 1 April 2020[8]. In accordance with the technical study conducted in Hong Kong[9], a frequency separation of 100 MHz has been introduced between IMT and FSS in addition to the proposed mitigation techniques discussed below. The 3.6-3.7 GHz band will remain as a guard band to minimize radio interference to FSS receiving above 3.7 GHz.

There will remain many active satellite services in Hong Kong, out of which the key areas of concern for the satellite industry are:

1. protection of TT&C Stations in the 3.4 – 3.7 GHz band
2. protection of licensed Satellite Master Antenna Television (SMATV), external fixed telecommunications network services (EFTNS) and self-provided external telecommunications systems (SPETS) receiving in the 3.7 – 4.2 GHz band

For 1., OFCA proposed significant sized restriction zones to protect the TT&C Stations in Hong Kong. For 2., OFCA engaged third party experts to perform a technical study aimed at determining what level of technical upgrades to the ~1,600 licensed SMATV systems serving around 890,000 "outlets" would be required, in conjunction with limits on out of band and spurious emissions, to enable co-existence of IMT in 3.4 - 3.6 GHz band and FSS in 3.7 - 4.2 GHz band[10].
The experts determined that an LNB upgrade alone would not provide sufficient protection, and that waveguide bandpass filters would need to be retrofitted in front of the LNB.

Taking into account the similarity in the elevation angles, antenna sizes and heights used by licensed TVROs the technical and cost parameters in this report are relevant to other Asia Pacific jurisdictions that are also in the process of re-allocating the 3.4 - 3.6 GHz band, including Singapore.

An important statement in Section 6.2.1.2 Spurious Emissions of Mobile Base Stations on page 31 is:

"As far as spurious emissions are considered, it is assumed that 5G NR base stations shall conform to the limit of -52 dBm/MHz, as prescribed in 3GPP TS 38.104 V1.0.0 (2017-12), to facilitate co-existence with other legacy mobile systems operating in different frequency bands."

From this report, OFCA distilled various requirements for SMATV systems to meet, in order to be able to benefit from its proposed protection principle which states that:

"In case a mobile base station of public mobile services operating in the 3.4 – 3.6 GHz band causes interference to an existing system of SMATV/EFTNS/SPETS in the vicinity operating in the 3.7 – 4.2 GHz band with the necessary mitigating measures implemented, the MNOs concerned should be held accountable for any necessary remedial actions."

[8] Communications Authority's Change in the Allocation of the 3.4 – 3.7 GHz Band from Fixed Satellite Service to Mobile Service, https://www.coms-auth.hk/filemanager/statement/en/upload/441/ca_statements20180328_en.pdf
[9] Consultancy Report – Assessments on and Recommendations to Enable the Electromagnetic Compatibility between Public Mobile Services and Fixed Satellite Service Operating in the C-Band, Rhode & Schwarz Hong Kong Limited https://www.ofca.gov.hk/filemanager/ofca/common/reports/consultancy/cr_201803_28_en.pdf
[10] Ibid.

The requirements (detailed for the SMATV case, but also applicable to the licensed EFTNS and SPETS) are set out in a separate Information Note[11].

The CA Statement includes a detailed summary of and discussion on the responses to its July 2017 consultation paper, including details of the restriction zones for protection of the TT&C Stations in Hong Kong (Annex B), and details of the protection principle.

3. Overdrive caused by wide bandwidth LNBs receiving energy below 3600 MHz

This has been covered to some extent in the introduction to the OFCA proposals. Essentially, LNBs are low-noise, wide-band, non-linear devices with extremely high gain (60+ dB is common).

A high power signal (recalling that IMT signals may be of the order of a million times more powerful than the wanted FSS signal in front of a receive antenna), even significantly out-of-band, can push the LNB into saturation / overdrive, causing small signal suppression and rendering the LNB incapable of boosting the lower level wanted in-band FSS signal to the required level.

Various LNBs can offer as much as 45 dB rejection at 3.6 GHz and close to zero rejection at 3.7 GHz, but OFCA's expert's report indicated that 55 dB of rejection was required, and that this could best be provided by a waveguide inserted bandpass filter.

However, even FSS earth stations that have been installed with a bandpass filter could experience interference from mobile transmissions in the adjacent band (even with a guard band) under certain scenarios. In such cases, separation distances may still be required. On this point, OFCA's experts studied the potential for this kind of interference from mobile systems in 3.4-3.6 GHz into "upgraded" SMATV systems receiving in 3.7-4.2 GHz with bandpass filters installed and found:

> "When the antennas of a macro base station of the public mobile service are higher than that of an Upgraded System in close proximity with their antennas directly facing each other, interference to the latter may occur. Under such a circumstance, the antenna of the macro base station concerned should be relocated by a horizontal distance of some 65 m in the east or west directions. In practice, moving the macro base station to an adjacent building in the respective directions will generally satisfy the requirement."[12]

Assuming that the elevation angles used by licensed TVROs in Singapore are similar or higher than those in Hong Kong, and the antenna sizes and heights in Singapore are similar to those considered for Hong Kong, OFCA's experts' report has relevance also in Singapore.

[11] Information Note – Baseline Requirements for Satellite Master Antenna Television System Operating in the 3.7 – _4.2 GHz band, https://www.coms-auth.hk/filemanager/statement/en/upload/440/i0012e.pdf

[12] Consultancy Report – Assessments on and Recommendations to Enable the Electromagnetic Compatibility between Public Mobile Services and Fixed Satellite Service Operating in the C-Band, Rhode & Schwarz Hong Kong Limited https://www.ofca.gov.hk/filemanager/ofca/common/reports/consultancy/cr_201803_28_en.pdf at last bullet, iii

Parameter	USA	UK	Hong Kong SAR
IMT designated bandwidth	150 MHz	190 MHz	200 MHz
IMT designated band	3550 – 3700 MHz	3410 – 3600 MHz	3400 – 3600 MHz
OOB & Spurious Emission Limits	FCC (per footnote 1 above)	OFCOM (per footnote 6 above)	Assumed 3GPP for 100MHz IMT (per footnote 7 above)
>40 MHz below bottom of band	-40 dBm/MHz	-50 dBm/MHz EIRP	-52 dBm/MHz
40 to >20 MHz below bottom of band	-40 dBm/MHz	-50 dBm/MHz EIRP	-13 dBm/MHz
20 to >10 MHz below bottom of band	-25 dBm/MHz	Min (Pmax-43, 13) dBm/5MHz EIRP per antenna	-13 dBm/MHz
10 to >5 MHz below bottom of band	-13dBm/MHz	Min (Pmax-43, 15) dBm/5MHz EIRP per antenna	-14 dBm/100kHz
5 to >0 MHz below bottom of band	-13 dBm/MHz	Min (Pmax-40, 21) dBm/5MHz EIRP per antenna	$-7dBm-\frac{7}{5}\cdot\left(\frac{f\_offset}{MHz}-0.05\right)dB$ /100 kHz (range -14 to -7 dBm/100 kHz)
>0 to 5 MHz above top of band	-13 dBm/MHz	Min (Pmax-40, 21) dBm/5MHz EIRP per antenna	$-7dBm-\frac{7}{5}\cdot\left(\frac{f\_offset}{MHz}-0.05\right)dB$ /100 kHz (range -7 to -14 dBm/100 kHz)
>5 to 10 MHz above band top	-13 dBm/MHz	-34 dBm/5MHz EIRP	-14 dBm/100kHz
>10 to 20 MHz above band top	-25 dBm/MHz	-34 dBm/5MHz EIRP	-13 dBm/MHz
>20 to 40 MHz above band top	-40 dBm/MHz	-34 dBm/5MHz EIRP	-13 dBm/MHz
>40 MHz above top of band	-40 dBm/MHz	-34 dBm/5MHz EIRP	-52 dBm/MHz

Table 1 IMT Out of Band and Spurious Emissions Limits in US, UK and HKSAR for 3400 – 3700 MHz IMT Frequency Range

It needs to be noted that while there is a merit in following the standards for an out-of-band and spurious emission mask for the IMT to achieve economies of scale, there are additional mitigation measures that an Administration needs to introduce on a national level to guarantee the protection of all the services in the band and adjacent bands.

An overall solution for the band is a combination of several different measures such as the one introduced by OFCA in Hong Kong: the spectrum mask is accompanied by a frequency separation of 100 MHz and technology upgrade for protection of SMATV, and a separation in geographical area for protection of TT&C Stations, with significantly smaller separation required for protection of upgraded SMATV systems.