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Compatibility and sharing studies between the radio astronomy service and IMT systems in the frequency bands 608-614 MHz, 1 330-1 400 MHz, 1 400-1 427 MHz, 1 610.6-1 613.8 MHz, 1 660-1 670 MHz, 2 690-2 700 MHz, 4 800-4 990 MHz and 4 990-5 000 MHz

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***Note**: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

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REPORT ITU-R RA.2332-0[1]

Compatibility and sharing studies between the radio astronomy service and IMT systems in the frequency bands 608-614 MHz, 1 330-1 400 MHz, 1 400-1 427 MHz, 1 610.6-1 613.8 MHz, 1 660-1 670 MHz, 2 690-2 700 MHz, 4 800-4 990 MHz and 4 990-5 000 MHz

(2014)

1 Introduction and background

The aim of WRC-15 agenda item 1.1 is to consider additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions, to facilitate the development of terrestrial mobile broadband applications, in accordance with Resolution **233 (WRC-12)**. At present, the agenda item targets a number of frequency bands from ~410 MHz up to ~6 GHz.

As observations made by the radio astronomy service (RAS) are highly susceptible to detrimental interference from unwanted emissions by active services, it is necessary to determine the conditions under which they can be protected in accordance with the relevant ITU-R Recommendations, e.g. Recommendation ITU-R RA.769 on RAS protection criteria and Recommendation ITU-R RA.1513 on acceptable levels of RAS data loss. In particular, these studies should determine the separation distances between RAS antennas and IMT systems necessary to protect the RAS.

Listed in Table 1 are the frequency bands where proposed IMT allocations may cause detrimental interference to RAS observations.

The results of compatibility and sharing studies concerning the RAS and IMT systems have been provided for the following nine RAS frequency bands: 608-614 MHz, 1 330-1 400 MHz, 1 400-1 427 MHz, 1 610.6-1 613.8 MHz, 1 660-1 670 MHz, 2 690-2 700 MHz, 4 800-4 990 MHz, 4 950-4 990 MHz and 4 990-5 000 MHz – see Table 1 for a summary of these RAS bands and the relevant potential IMT frequency bands involved.

For the frequency band 1 400-1 427 MHz three independent compatibility studies were received. Based on the major differences in the assumptions made, they have been divided into two cases:

– Case A concerns studies in which the assumed unwanted emission levels are linked directly to those considered in the on-going studies on the protection of the EESS (passive) (see Report ITU-R RS.2336), where an generic flat terrain profile is used in Case A-1 and detailed terrain maps in Case A-2.

– Whereas in Case B measured unwanted emission levels were used of existing IMT equipment and the use of a guard band was assumed.

Of date, the studies for the other bands were all made under Case A-1 assumptions.

[1] This Report was approved jointly by Radiocommunication Study Groups 5 and 7, and any future revision should also be undertaken jointly.

TABLE 1

Bands for which RAS-IMT compatibility or sharing studies have been submitted

RAS frequency band	RAS status	RR No.	RAS use	Potential IMT proposal
608-614 MHz	Secondary; primary in Region 2 and some countries in Regions 1 and 3	**5.149** **5.304** **5.305** **5.306** **5.307**	Broadband, VLBI	In band sharing or adjacent
1 330-1 400 MHz	Secondary	**5.149**	Broadband, narrowband, VLBI	In band sharing
1 400-1 427 MHz	Primary	**5.340**	Broadband, narrowband, VLBI (e.g. neutral hydrogen line)	Adjacent (both sides)
1 610.6-1 613.8 MHz	Primary	**5.149**	Narrowband, VLBI (e.g. Hydroxyl line)	Nearby (below 1 525 MHz)
1 660-1 670 MHz	Primary	**5.149**	Broadband, narrowband, VLBI (e.g. Hydroxyl lines)	Nearby (below 1 525 MHz)
2 690-2 700 MHz	Primary	**5.340**	Broadband, VLBI; also, RAS techniques used by SRS	Adjacent (above 2 700 MHz)
4 800-4 950 MHz	Secondary	**5.149**	Broadband, narrowband, VLBI	In band sharing or nearby (above 5 350 MHz)
4 950-4 990 MHz	Secondary, primary in some countries in Regions 2 and 3	**5.149** **5.443**	Broadband, narrowband, VLBI	In band sharing or nearby (above 5 350 MHz)
4 990-5 000 MHz	Primary	**5.149**	Broadband, narrowband, VLBI	In band sharing or nearby (above 5 350 MHz)

NOTE 1 – RR No. **5.340**: The frequency bands 1 400-1 427 MHz and 2 690-2 700 MHz are not shared with active services and subject to footnote No. **5.340** of the RR, which states that “All emissions are prohibited” in these bands. Thus, all in-band transmissions, including those of IMT, are forbidden in these bands.

Emissions from other bands into these two bands should remain below the thresholds for detrimental interference listed in Recommendation ITU-R RA.769, at any RAS site.

NOTE 2 – RR No. **5.149** states “In making assignments to stations of other services to which the frequency bands (band list omitted) are allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see RR Nos. **4.5** and **4.6** and Article **29**)”.

NOTE 3 – In column (4), the term "Broadband" corresponds to "continuum" observations (see Table 1 of Recommendation ITU-R RA.769) and "narrowband" to "spectral line" observations (see Table 2 of Recommendation ITU-R RA.769), respectively.

Both in-band emissions in these RAS bands and emissions from outside these RAS bands falling into them should remain below the thresholds for detrimental interference given in Recommendation ITU-R RA.769, subject to Recommendation ITU-R RA.1513 which provides with 2% data loss to the RAS due to interference by all stations of one service, and with an aggregate data loss of 5% in any band from all services.

2 Technical characteristics

2.1 Radio Astronomy Service characteristics

Recommendation ITU-R RA.769 provides threshold levels for interference detrimental to radio astronomy observations, for both continuum (broadband) and for spectral-line (narrowband) observations. The threshold levels are for an integration time of 2 000 s and for an RAS antenna with 0 dBi gain.

Case A-1:

RAS antenna gain: 0 dBi gain

Case A-2 and B:

RAS antenna pattern: Recommendation ITU-R SA.509

2.2 IMT systems characteristics

The IMT system characteristics used are given in Report ITU-R M.2292.

As radio astronomy is a passive service, only the transmitter characteristics of the IMT systems are of importance for compatibility and sharing studies.

2.2.1 IMT user equipment

Transmit antenna height: 1.5 m

Case A-1:

Channel bandwidth:	1.4, 3, 5, 10, 15 or 20 MHz
transmit e.i.r.p.:	23 dBm
Antenna gain:	0 dBi
Human body absorption:	8 dB
Terrain:	average suburban
Ground clutter attenuation (user outdoor):	–19.6 dB
Mitigation (user outdoor):	–19.6 – 8 = –27.6 dB
Propagation calculations:	Recommendation ITU-R P.452

Case A-2:

Antenna gain:	–3 dBi
Antenna pattern:	omnidirectional
Human body absorption:	4 dB
Propagation calculations:	SRTM terrain profiles

Case B:

Antenna gain:	–3 dBi
Antenna pattern:	omnidirectional
Human body absorption:	4 dB

2.2.2 IMT base station

Case A-1:

Transmit antenna height:	45 m (macro rural)
Channel bandwidth:	1.4, 3, 5, 10, 15 or 20 MHz
Average base station power/sector (10/20 MHz) (e.i.r.p.):	58 dBm (macro rural) 37 dBm (small cell outdoor) 21 dBm (small cell indoor)
Average activity factor:	100%
Propagation calculations:	Recommendation ITU-R P.452
Mitigation (user outdoor):	0 dB

It is assumed that only Category B base stations will be applied for commercial networks. For Category B base stations the spurious emission levels are the same as for user equipment (see Table 1).

Case A-2:

Transmit antenna height:	45 m (macro rural)
Antenna sectors:	two sectors of 120° each
Antenna gain:	17 dBi
Antenna pattern:	Recommendation ITU-R F.1336-3
Antenna elevation:	–6° (downward tilt)
Average activity factor:	50%
Propagation calculations:	SRTM terrain profiles

Case B:

Transmit antenna height:	30 m
Antenna sectors:	three sectors of 120° each
Antenna gain:	17 dBi
Antenna pattern:	*Recommends 3* of Recommendation ITU-R F.1336
Antenna elevation:	–3°(downward tilt)
Propagation calculations:	Recommendation ITU-R SM.2028

3 Analysis

3.1 Assumptions

3.1.1 Unwanted emission compatibility studies

Case A:

Unwanted emission levels, for both base stations and user equipment: –30 to –64 dBm/MHz.
It should be noted that the selected unwanted emission level of –50 and –64 dBm/MHz are directly linked to the ongoing compatibility studies for the EESS (passive) in the frequency band 1 400-1 427 MHz, which indicate levels necessary to protect the EESS (passive) of about –50 dBm/MHz (= –66 dBW/27 MHz) for user equipment and about -64 dBm/MHz (= –80 dBW/27 MHz) for base stations (see Report ITU-R RS.2336).

Case B:

Unwanted emission levels, for both base stations and user equipment: use measured values of existing IMT material.

The measured unwanted emission levels of an IMT LTE user equipment transmitting in the frequency band 1 447.9-1 462.9 MHz and of an IMT base station transmitting in the frequency band 1 495.9-1 510.9 MHz are given in Tables A1.1 and A2.1 of the Annex, respectively.

Guard bands: guard bands between the RAS and IMT frequency bands of various widths, including the case with no guard band, are considered when evaluating the necessary separation distances (see, e.g. Tables 5-1 and 5-2).

3.1.2 In-band sharing studies

Concerns only Case A-1:

An e.i.r.p emission level of 10 dBm/MHz for mobile user equipment with a 20 MHz channel bandwidth, and of 45 dBm/MHz for base stations.

4 Methodology

4.1 Terrain profiles and propagation calculations

Case A-1:

No detailed terrain profiles around RAS antennas were included, and a generic flat terrain profile was assumed.

Propagation calculations were made according to Recommendation ITU-R P.452-12 and included LOS, diffraction over spherical earth (Recommendation ITU-R P.526-14 or P.452-12) and troposcatter (Recommendation ITU-R P.452-14).

The detrimental thresholds in column 4 of Table 3 were taken from Recommendation ITU-R RA.769 and adjusted to the prescription in Recommendation ITU-R RA.769 cases where bandwidth deviates from the reference bandwidth.

Case A-2:

To determine terrain elevation profiles around 14 selected RAS antennas, Shuttle Radar Topography Mission (SRTM) data with a 90 metre resolution were used.

Propagation calculations were made according to Recommendation ITU-R P.454-12 to estimate natural losses, depending only on the configuration of the propagation path and antenna heights. Under these assumptions, in practice only two local terrain relief situations have to be simulated: low (h<100 metres) and medium/high (h>100 metres) relief.

Case B:

No detailed terrain profiles around RAS antennas were included, and a generic flat terrain profile was assumed.

Propagation calculations were made according to Recommendation ITU-R SM.2028, Modified HATA model (open area).

4.2 Aggregate emission

Case A-1:

The following assumptions were made:

IMT base stations: average deployment density = 0.11 km^{-2}

average activity factor = 100%

duty cycle = 50%

IMT user equipment: average deployment density = 0.377 km^{-2}

average activity factor = 0.5%

duty cycle = 50%

Statistical Monte-Carlo estimate using 15 000 trials with 500 devices

Case A-2:

The following assumptions were made:

Table 2, which is extracted from Report ITU-R M.2292, provides the average cell radius of IMT base stations (macro and micro cells) as function of base station location.

Each location type is characterized by a range in Population Density (PS) (expressed as inhabitants per square kilometre), as follows:

- Urban: PS >10^3 inh/km²
- Suburban: 10^3 inh/km² <PS <100 inh/km²
- Rural: 100 inh/km^2<PS < 1 inh/km²
- Deserted: PS < 1 inh/km². For a deserted location, cell deployment is assumed to be insignificant.

TABLE 2

Mobile service base station deployment

	Macro rural	Macro suburban	Macro urban	Small cell outdoor / Micro urban	Small cell indoor / Indoor urban
Cell radius / Deployment density (for bands between 1 and 2 GHz)	> 3 km (typical figure to be used in sharing studies 5 km)	0.5-3 km (typical figure to be used in sharing studies 1 km)	0.25-1 km (typical figure to be used in sharing studies 0.5 km)	1-3 per urban macro cell <1 per suburban macro site	depending on indoor coverage/ capacity demand
Cell radius / Deployment density (for bands between 2 and 3 GHz)	> 2 km (typical figure to be used in sharing studies 4 km)	0.4-2.5 km (typical figure to be used in sharing studies 0.8 km)	0 0.8 km (typical figure to be used in sharing studies 0.4 km)	1-3 per urban macro cell <1 per suburban macro site	depending on indoor coverage/ capacity demand

Report ITU-R M.2292 states that the distance between each IMT base station is three times larger than the cell radius, and the following distances between base stations were adopted:

- 1.5 km in the macro urban case
- 3 km in the macro suburban case
- >10 km in the macro rural case

Case B:

The following assumptions were made:

One IMT base station deployed per 100 km^2

Two sectors for each IMT base station are interfering sources

Two IMT user equipment connected to each IMT base station are interfering sources

Outdoor terminals in visibility of the satellite = 10%

Outdoor terminals with blocking (10 dB attenuation) = 20%

Indoor terminals (12 dB attenuation) = 70%

Exclusion zone radius around an RAS antenna: variable (10-50 km)

Maximum ring diameter around an RAS antenna: 100 km

5 Summary of results

Case A:

See Table 3 for a summary of the results for studies made under Case A for the single-interferer (SE) scenario, for both IMT system mobile user equipment (user) and base stations (base). MCL stands for Minimum Coupling Loss.

TABLE 3

RAS bands: Summary of results for studies under Case A - MCLs, RAS-IMT system separation distances and spectral power density limits for a single interferer (SE) scenario, for IMT system mobile user equipment (user) and base stations (base)

RAS band (MHz)		Obs. use	Ref. bw (MHz)	Rec RA.769 (dBW)	SE MCL (dB)		SE separation (km)		SE limit (dBm/MHz)	
					user	base	user	base	user	base
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
In-band sharing:										
608-614		Cont.	6	–202	162	224	116	735	–73	–100
1 330-1 400		Cont. Line	70 0.02	– -202 -220	175 172	240 229	52 52	133 129	– -73 -64	-99 -89
4 800-4 990 & 4 990-5 000		Cont.	190	–213	188	216	84	409	–98	–126
Unwanted emission level –30 dBm/MHz:										
608-614		Cont.	6	–202	127	150	14	68	-78	-106
1 400-1 427		Cont. Line	27 0.02	–205 -220	136 120	156 143	20 45-85[1] 9	69 70-200[1] 55	-79 -63	-108 -92
1 610.6-1 613.8		Spectr.	0.02	–220	115	143	9	48	–59	–86
2 690-2 700		Cont.	10	–208	134	157	18	62	-71	-100
4 800-4 990		Cont.	190	–213	148	176	42	71	–98	–126
4 990-5 000		Cont.	10	–207	134	157	13	58	-66	-95
Unwanted emission level –50 dBm/MHz:										
608-614		Cont.	6	–202	107	130	5	44	-78	-106
1 400-1 427		Cont. Line	27 0.02	–205 -220	116 100	139 123	6 15-60[1] 1	50 45-85[1] 25	-79 -63	-108 -92
2 690-2 700		Cont.	10	–207	114	137	2.4	46	-71	-100
4 800-4 990		Cont.	190	–213	128	156	22	50	–98	–126
4 990-5 000		Cont.	10	–207	114	137	1	33	-66	-95

NOTE 1 – The separation distances listed for unwanted emissions in the frequency band 1 400-1 427 MHz for Case A-2 (lower line) are for the low terrain relief (h<100 metres) scenario, whereas all other values in Table 3 are for Case A-1, assuming generic flat terrain.

See Table 4 for a summary of the results for studies made under Case A for the aggregate interference (AG) scenario, for both IMT system mobile user equipment (user) and base stations (base).

TABLE 4

RAS bands: Summary of results for studies under Case A - RAS-IMT system separation distances and spectral power density limits for an aggregate emission (AG) scenario, for IMT system mobile user equipment (user) and base stations (base)

RAS band (MHz)	Obs. use	Ref. bw (MHz)	Rec. RA.769 (dBW)	AG separation (km)		AG 2% limit (dBm/MHz)[2]	
				user	base	user	base
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
In-band sharing:							
608-614	Cont.	6	–202	136	>1000	–58	–111
1 330-1 400	Cont. Line	70 0.02	–202 -220	85 85	502 499	–55 -46	–95 -86
4 800-4 990 & 4 990-5 000	Cont.	190	–213	325	>1000	–70	–118
Unwanted emission level –30 dBm/MHz:							
608-614	Cont.	6	–202	17	98	–60	–103
1 400-1 427	Cont. Line	27 0.02	–205 -220	25 9	89 75	–61 -46	–104 -89
1 610.6-1 613.8	Spectr.	0.02	–220	3	86	–42	–95
2 690-2 700	Cont.	10	–207	21	76	–54	–97
4 800-4 990	Cont.	190	–213	43	341	–70	–118
4 990-5 000	Cont.	10	–207	20	68	–49	–92
Unwanted emission level –50 dBm/MHz:							
608-614	Cont.	6	–202	1	73	–60	–103
1 400-1 427	Cont. Line	27 0.02	–205 -220	6 1	71 56	–61 -46	–104 -89
2 690-2 700	Cont.	10	–207	1	62	–54	–97
4 800-4 990	Cont.	190	–213	13	83	–70	–118
4 990-5 000	Cont.	10	–207	1	57	–49	–91
Unwanted emission level –64 dBm/MHz:							
1 400- 1 427	Cont.	27	-205		105-140[1]		

NOTE 1 – The separation distances listed for unwanted emissions in the frequency band 1 400-1 427 MHz for Case A-2 are for the low terrain relief (h<100 metres) scenario, whereas all other values in Table 4 are for Case A-1, assuming generic flat terrain.

NOTE 2 – The aggregate emission limits in columns 7 and 8 have been calculated using Monte-Carlo simulations, so that the detrimental interference level is not exceeded for more than 2% of the time (cf. Recommendation ITU-R RA.1513).

Case B:

See Tables 5-1 and 5-2 for a summary of the results for compatibility studies in the band 1 400-1 427 MHz under Case B for both IMT system mobile user equipment and base stations.

Based on study Case B, it could be concluded that compatibility between IMT user equipment (measured unwanted emission level: –64.8 dBW/27 MHz, as given in Table A1.1) and an RAS observatory site can be achieved with a separation distance of around 10 kilometres. Meanwhile, to achieve compatibility between IMT base stations and an RAS observatory site, it is necessary to establish a larger separation distance (such as 20 kilometres, on condition that a guard band of 20 MHz is implemented, for the measured –113.8 dBW/27 MHz unwanted emission level of existing equipment as given in Table A2.1) compared to those for IMT user equipment; however, such compatibility conditions can be improved by employing a larger guard band size and/or additional filtering for IMT base stations to reduce unwanted emission levels (see also Annex 3).

TABLE 5-1

Summary of results of study for IMT user equipment (Excess level (in dB) compared to the interference criterion of the RAS)

User equipment	Guard band	Exclusion zone radius: separation distance		
		10 km	20 km	50 km
Modified HATA model (open area)	0 MHz	–8.8	–15.5	–30.3
	0.9 MHz	–11.3	–18.0	–32.8
	5 MHz	–15.6	–22.3	–37.1
	10 MHz	–25.5	–32.2	–47.0
	20 MHz	–42.1	–48.8	–63.6

TABLE 5-2

Summary of results of study for IMT base stations (Excess level (in dB) compared to the interference criterion of the RAS)

Base stations	Guard band	Exclusion zone radius: separation distance		
		10 km	20 km	50 km
Modified HATA model (open area)	0 MHz	81.7	76.6	61.3
	0.9 MHz	69.9	63.8	48.5
	5 MHz	61.0	54.9	39.6
	10 MHz	30.0	24.0	8.7
	20 MHz	0.5	–5.5	–20.1

6 Conclusions

Studies indicate that in-band sharing between the RAS and IMT systems will be very difficult, if not impossible, to achieve in practice. For the four cases studied (RAS bands 608-614 MHz, 1 330-1 400 MHz, 4 800-4 990 MHz and 4 990-5 000 MHz), separation distances of about 500 to a thousand kilometres are indicated between an RAS antenna and IMT macro rural base stations, and of order 80-300 kilometres for user equipment, assuming a flat terrain profile.

Studies for the RAS band 1 400-1 427 MHz, which assume an unwanted emission level of –64 dBm/MHz[2] (= –80 dBW/27 MHz) indicate that compatibility between RAS stations and IMT base stations operating in an adjacent band can be achieved using separation distances of order 120 kilometres from an RAS antenna. These studies assumed a low terrain profile (h<100 metres), whereas for medium/high terrain profiles (h>100 metres), separation distances are found to be about 10 times smaller.

Another study for the frequency band 1 400-1 427 MHz allocated to the RAS, which uses measured unwanted emission levels of existing IMT user equipment and base stations, indicates that compatibility with RAS stations can be achieved using a separation distance of about 10 kilometres for IMT mobile terminals (measured unwanted emission level: –64.8 dBW/27 MHz) , whereas for base stations separation distances of order 20 kilometres are required, on condition that a 20 MHz wide guard band is employed (measured unwanted emission level: –113.8 dBW/27 MHz).

For the frequency bands 608-614 MHz, 2 690-2 700 MHz, 4 800-4 990 MHz and 4 990-5 000 MHz allocated to the RAS, studies indicate that compatibility between RAS stations and IMT systems taking into account IMT unwanted emissions can be achieved using separation distances of order 60-80 kilometres between an RAS antenna and IMT macro rural base stations, and of order 1-20 kilometres for a mobile terminals, assuming an unwanted emission level of –50 dBm/MHz and a flat terrain profile (for results obtained assuming a level of –30 dBm/MHz see Table 4).

In general, compatibility conditions can be improved by employing a guard band and/or additional filtering in IMT base stations. Possible mitigation measures are listed in Annex 3.

Annexes: 3

[2] It should be noted that the selected unwanted emission levels of –50 and -64 dBm/MHz are directly linked to the ongoing compatibility studies for the EESS (passive) in the frequency band 1 400-1 427 MHz, which indicate levels necessary to protect the EESS (passive) of about –50 dBm/MHz (= –66 dBW/27 MHz) for mobile terminals and about –64 dBm/MHz (= –80 dBW/27 MHz) for base stations (see Report ITU-R RS.2336).

ANNEX 1

Measured unwanted emission levels of IMT user equipment

For the studies performed under Case B, unwanted emission levels of real IMT user equipment were measured. A number of different transmission powers and guard band sizes were considered as shown in Table A1.1 below.

TABLE A1.1

Measured unwanted emission levels of an IMT user equipment (in dBW per 27 MHz)

		Guard band (Frequency separation from the measured 27 MHz bandwidth)				
		0 MHz	**0.9 MHz**	**5 MHz**	**10 MHz**	**20 MHz**
Transmitting output power of an IMT user equipment	23 dBm	–49.6	–49.5[3]	–52.5[4]	–57.6	–76.2
	0 dBm	–64.8	–67.3	–71.6	–81.5	–98.1
	-9 dBm	–77.9	–80.1	–84.3	–93.9	–100.5

The measurement conditions used are as follows:

– two commercial LTE user equipment of different vendors were used for the measurement. The terminals had the capability to transmit LTE signals in the band 1 447.9-1 462.9 MHz (measurements were made in the band 1 420.9-1 447.9 MHz);
– the transmitting bandwidth of the LTE signal was 15 MHz using full resource block assignment;
– the measured averaged values were used;
– the transmitting output power of 23 dBm corresponds to the maximum output power for a single user equipment, 0 dBm corresponds to a typical output power value of multiple user equipment in a rural area and -9 dBm to a typical output power value of multiple user equipment in a suburban/urban area . (Note that the measured unwanted emission levels in case of a transmission power of -9 dBm or 0 dBm do not exceed the current unwanted emissions level of -60 dBW/27 MHz provided in Resolution **750 (Rev.WRC-12)**)

3 Using the specifications in 3GPP TS 25.101 yields an unwanted emission level of -30.2 dBW/27 MHz, which is about 19 dB higher than the measured value listed here.

4 Using the specifications in 3GPP TS 25.101yields an unwanted emission level of -32.8 dBW/27 MHz, which is about 20 dB higher than the measured value listed here.

ANNEX 2

Measured unwanted emission levels of IMT base stations

For the studies performed under Case B, unwanted emission levels of IMT base stations were measured. A number of different guard band sizes were considered as shown in Table A2.1 below.

TABLE A2.1

Measured unwanted emission levels of an IMT base station (in dBW per 27MHz)

		Guard band (Frequency separation from the measured 27 MHz bandwidth)				
		0 MHz	**1 MHz**	**5 MHz**	**10 MHz**	**20 MHz**
Transmitting output power of an IMT base station	42.8 dBm	–31.6	–44.4	–53.3	–84.3	–113.8

The measurement conditions used are as follows:

– one commercial LTE base station was used for the measurement. The station had the capability to transmit LTE signals in the band 1 495.9-1 510.9 MHz;

– the transmitting bandwidth of the LTE signal was 15 MHz using full resource block assignment.

ANNEX 3

Possible mitigation measures to be applied to IMT systems

Possible mitigation measures	Expected effect and assessment
Frequency arrangement related matters:	
- To adopt a guard band between the frequency edge of the RAS band and the nearest IMT operating frequency;	- This measure further reduces unwanted emission levels from IMT stations into the RAS band. It will become more effective using additional filtering in IMT base stations, while reducing the frequency band usage efficiency of IMT systems. - It reduces the efficiency of IMT band usage, since certain frequency bands cannot be used in IMT systems.
- To assign an IMT up-link direction to the frequency range adjacent or closer to the passive band.	- By this assignment, the compatible operation of the both systems could be facilitated. - It limits the IMT frequency arrangements employed in the frequency band.
Equipment related matters:	
- To employ additional or improved filter devices to reduce unwanted emission levels;	- This measure further reduces the unwanted emission levels from IMT stations. It is more applicable to IMT base stations than IMT user equipment for which equipment cost and size restrictions are more stringent.
- To apply a deep antenna down tilt to IMT base stations	- It could further reduce unwanted emission levels from IMT stations. - It may have a negative impact on the coverage of IMT systems.
Regulatory matters:	
- To limit the number of IMT base stations to be deployed within a certain distance from an RAS observatory site.	- It could further reduce the aggregated unwanted emission levels from IMT stations. - It would restrict IMT system deployment in certain areas.