Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

THE AGGREGATE IMPACT FROM THE PROPOSED NEW SYSTEMS (ITS, BBDR AND BFWA) IN THE 5725-5925 MHZ BAND ON THE OTHER SERVICES/SYSTEMS CURRENTLY OPERATING IN THIS BAND

Budapest, September 2007

0 EXECUTIVE SUMMARY

A number of new systems is considered within CEPT in the frequency range 5725 MHz to 5925 MHz, including:

- Broadband Fixed Wireless Access (BFWA) in the frequency range 5725 – 5875 MHz;
- Intelligent Transport System (ITS) in the frequency range 5855 – 5925 MHz;
- Broadband Disaster Relief (BBDR) in the frequency range 5725 – 5925 MHz[1].

Different ECC Reports and Recommendations (ECC Report 68 [1], ECC Report 101 [2], ECC Report 110 on BBDR [3] and Recommendation ECC/REC 06-04 [4]) were developed to assess the impact of these new systems on other systems/services operating in the bands listed above. The mutual impact between these new systems is also addressed in particular in ECC Report 101 and ECC Report 110 on BBDR.

The results from ECC Report 68, ECC Report 101 and ECC Report 110 are the first elements that need to be taken into account when considering the potential introduction of the new applications within the 5725-5925 MHz band.

In addition, it was felt that it would be beneficial to consider whether the potential aggregate interference of the new applications on the existing services/systems would have an influence on the technical conditions determined by the other ECC Reports ([1], [2] and [3]).

Consequently, this report further considers the potential aggregate impact of these new applications into the other systems/services operating in the band 5725-5925 MHz:

- The aggregate impact on space services, like FSS (Earth to space), will be an increase of noise level given by all devices within the receiver footprint of the satellite. Nevertheless, since the allowable number of devices given by the individual studies is sufficiently high compared to the expected numbers of equipment provided by the market analysis, even their combined effect will not exceed the protection criterion.
- The aggregate impact on short range terrestrial services with omni-directional antennas (generic SRDs) may result in an increase of noise by up to 8 dB. However, this is purely theoretical estimate that does not take into account probabilistic considerations and possible shielding effects given by the environment. It should also be noted that this type of aggregate impact will only affect SRD which operate on a non-protected basis.
- The aggregate impact on RTTT from BFWA and BBDR is likely to be very limited due to the very low probability to have both BFWA and BBDR in the vicinity of RTTT installation according to its particular location (road toll stations) and the temporary nature of BBDR networks.
- Due to the low density and temporary nature of BBDR operations, the impact on radiolocation service from BFWA and BBDR in the 5725-5850 MHz band will result mostly from BFWA and the impact of BBDR operation will remain negligible. The aggregate impact would only decrease the number of available channels for a type of interferer (FWA or BBDR) if both are operating in the same area.
- Due to the low density and temporary nature of BBDR operations, the impact from BFWA and BBDR on the amateur service in the 5725 – 5850 MHz band will result mostly from BFWA and the impact of BBDR operation will remain negligible.
- The aggregate impact on FS was not studied in detail since fixed links are only deployed in a limited number of CEPT countries in the frequency band 5850-5925 MHz.

---

[1] CEPT is considering a number of possible frequency bands for BBDR systems: 4940-4990 MHz, 5150-5250 MHz, 5470-5725 MHz, 5725-5875 MHz and 5875-5925 MHz.

For each of the relevant sub-bands within the 5725-5925 MHz band, the outcome is summarized in the following table:

Frequency range	Systems possibly contributing to the aggregate impact	Possible impacted services	Aggregate impact
5725 - 5855 MHz	BFWA and BBDR	Radar (5725 - 5850 MHz)	No aggregate additional impact if efficient DFS is implemented in BBDR and BFWA. Reduction of available channels for BFWA and BBDR as a result of DFS.
		FSS (Earth to Space)	No aggregate additional impact
		RTTT (5795-5805 and 5805-5815 MHz)	Additional aggregate impact limited due to low probability of co-siting between BFWA and BBDR
		Amateur (5725 - 5850 MHz)	No aggregate additional effect
		Generic SRDs	Possible additional aggregate impact (up to 8 dB noise increase) with very low probability.
		FS (5850 - 5855 MHz)	Limited use of FS within CEPT
5855 - 5875 MHz	BFWA, ITS and BBDR	FSS (Earth to Space)	No aggregate additional impact
		Generic SRDs	Possible additional aggregate impact (up to 8 dB noise increase) with very low probability.
		FS	Limited use of FS within CEPT
5875 - 5925 MHz	ITS and BBDR	FSS (Earth to Space)	No aggregate additional impact
		FS	Limited use of FS within CEPT

Summary of the band by band analysis

Therefore, the existing results of the different compatibility studies between each of these systems (BFWA, BBDR and ITS) and existing services will not be significantly changed by their aggregate impact.

Table of contents

List of Abbreviations

Abbreviation	**Explanation**
BBDR	Broad Band Disaster Relief
BFWA	Broadband Fixed Wireless Access
BS	Base Station
CEPT	European Conference of Postal and Telecommunications Administrations
CS	Central Station
DFS	Dynamic Frequency Selection
DR	Disaster Relief
DSRC	Dedicated Short Range Communication
ECC	Electronic Communications Committee of CEPT
e.i.r.p.	Equivalent isotropically radiated power
ETSI	European Telecommunications Standards Institute
FS	Fixed Service
FSS	Fixed Satellite Service
FWA	Fixed Wireless Access
ITU	International Telecommunication Union
ITS	Intelligent Transport System
IVC	Inter Vehicle Communication
LBT	Listen Before Talk
ML	Main Lobe
OBU	On Board Unit
OoB	Out Of Band emissions
P-MP	Point-to-Multipoint
P-P	Point-to-Point
R2V	Roadside to Vehicle
RL	Radiolocation Service
RSU	Road Side Unit
RTTT	Road Transport and Traffic Telematics
SL	Side Lobe
SRD	Short Range Devices
TPC	Transmitter Power Control
TS	Terminal Station
UE	User Equipment
V2R	Vehicle to Roadside
WLAN	Wireless Local Area Network

The aggregate impact from the proposed new systems (ITS, BBDR and BFWA) in the 5725-5925 MHz band on the other services/systems currently operating in this band

1 INTRODUCTION

A number of new systems is considered within CEPT in the frequency range 5725 MHz to 5925 MHz, including:

- Broadband Fixed Wireless Access (BFWA) in the frequency range 5725 – 5875 MHz;
- Intelligent Transport System (ITS) in the frequency range 5855 – 5925 MHz;
- Broadband Disaster Relief (BBDR) in the frequency range 5725 – 5925 MHz[2].

Different ECC Reports and Recommendations (ECC Reports 68 [1], 101 [2], ECC Report 110 on BBDR [3] and Recommendation ECC/REC 06-04 [4]) were developed to assess the impact of these new systems on other systems/services operating in the bands listed above.

Following the studies for each of the proposed new application, this report further considers the potential aggregate impact of these new applications.

2 OVERVIEW OF THE NEW SYSTEMS (BFWA, ITS, BBDR)

2.1 Description of BFWA

Broadband Fixed Wireless Access (BFWA) is used here to refer to wireless systems that provide local connectivity for a variety of applications and using a variety of architectures, including combinations of access as well as interconnection. ECC Report 68 [1] depicts the different architectures of BFWA and provides the relevant information on these different kinds of networks including technical parameters to ensure compatibility with other systems. The table 1 below gives the main parameters for two BFWA architectures, Point to Multipoint (P-MP) and Mesh.

Parameters \ Device	**Unit**	**BFWA P-MP**	**BFWA Mesh**
e.i.r.p.	dBm	36	36
Bandwidth	MHz	20	20
Antenna Gain	dBi	18	10
Sidelobe attenuation	dB	15	15
TPC	dB	10	10
Sensitivity (at the antenna input)	dBm	-86	-86
Protection criterion	C/I	6 (BPSK)	6 (BPSK)
OoB attenuation mask (below e.i.r.p level in dBm/MHz)	dBr	40	40

Table 1: Technical parameters for BFWA transmitters and receivers

In addition, ECC Report 68 [2] provided technical conditions for BFWA to enable the compatibility with other systems. In particular,an efficient DFS mechanism is required in the 5725-5850 MHz band for the coexistence with radars.

2.2 Description of ITS

Inter-Vehicle Communication (IVC) systems have been a topic in research since the second half of the eighties. Although many technical key challenges were solved in a number of research activities, IVC systems have not been implemented in vehicles so far. Reasons for this are the absence of an appropriate frequency band which grants effective protection for road safety applications and the lack of suitable commercially available (and cheap) radio hardware.

[2] CEPT is considering a number of possible frequency bands for BBDR systems: 4940-4990 MHz, 5150-5250 MHz, 5470-5725 MHz, 5725-5875 MHz and 5875-5925 MHz.

Europe was pioneering the use of radiocommunications with the RTTT DSRC system at 5.8 GHz. The WLAN (IEEE 802.11) technology, now available as a mass product, fulfils technical as well as business requirements. Therefore, radiocommunications systems in the 5 GHz range can today offer communications with a high data rate, ranges up to 1 000 m, low weather-dependence, and global compatibility and interoperability.

The connectivity required by the ITS applications can be summarized as:

1) IVC (this includes multi-hop routing involving several vehicles):
   - Linear (e.g. for convoys of vehicles);
   - Vehicle cluster covering several lanes (e.g. for lane management, overtaking assist).
2) Vehicle to roadside (uplink, V2R) and roadside to vehicle (R2V, downlink):
   - One vehicle to beacon;
   - Beacon to one vehicle;
   - Beacon to many vehicles (broadcast, short range and long range);
   - Beacon to selected vehicles.
3) Cluster of vehicles communication, including to roadside beacon.

A certain penetration of equipped cars is required to realize the advantage of the system for traffic improvement and safety applications.

Non-safety applications would rely on data exchange between vehicles and fixed stations. Hotspot access at refuelling stations could give the possibility to get information about restaurants, sightseeing points, or traffic data along the anticipated route.

For market roll-out, it is important that the use of the communications system is available both for official (i.e. safety, public information and road management) and for commercial purposes, so that viable business cases can be established.

The standards for operation must be such that an evolutionary roll-out is possible, with backward-compatibility so as not adversely to affect early entrants.

Parameters \ Device	**Unit**	**ITS**
e.i.r.p.	dBm	33
Bandwidth	MHz	10
Antenna Gain	dBi	8
Sidelobe attenuation	dB	12
TPC	dB	8
Sensitivity (at the antenna input)	dBm	-82
Protection criterion	C/I	6 (BPSK)
OoB attenuation mask (below e.i.r.p level in dBm/MHz)	dBr	26

Table 2: ITS parameters (not exhaustive)

In addition, ECC Report 101 [2] provided ITS technical parameters to ensure compatibility with other systems.

2.3 Description of BBDR systems

Disaster Relief (DR) emergency services require efficient rapid deployment of incident ad-hoc networks. Applications are used temporarily by emergency services in all aspects of disaster situations, including disaster prevention and post-event scenarios. For instance, they provide incident communications, video or robotic data applications, telecommand and telemetry parameters, critical data base queries, field reporting, data and location information exchange.
Infrequent usage during large extraordinary local incidents may also employ broadband disaster communications. The equipment used for this is often the same as in disaster relief operations (PP2 usage as described in ITU-R M.2033) and also described in ECC Report 102.
Disaster prevention means that these systems may be temporary deployed (not necessarily used) during very exceptional and high-risk events.

Users of such systems (e.g. fire-fighters) belong to a group of people having a very high risk associated with their work. Statistics show that it is comparable only to the coal extraction industry. There is evidence that such systems will significantly enhance the security and sustainability of life of persons involved in rescue measures and therefore will provide a socio-economic benefit.

It is forecasted that up to 2400 BBDR networks/systems may exist in Europe, whereby this is the number of networks available to be deployed but not necessarily in use. A fixed/permanent installation should be tolerated for sensitive sites (e.g. at military headquarters).

The number of users per network is typically about 25 (more users per network are possible, but no impact is expected on the compatibility study, only influencing data throughput per user).

Only one equipment unit (either one UE or one BS) for one network in a given hot spot will be transmitting in one channel at a given time.

In order to increase the throughput per user in a given network, it might be advised to install a second BS operating on a different channel.

The size of the disaster relief hot spot is about 1 km². Due to the nature of the disaster relief application, the mitigation techniques used by BBDR may not completely protect the other radio services and applications within the hot spot area in general as well as outside in some cases (e.g. radars) and this is assumed to be tolerable as it will be temporary, only for the duration of the disaster.

Receiver Characteristics	**units**	**Value for BS**	**Value for UE**	**Remark**
Receiver bandwidth	MHz	10	10	Single frequency band for the whole mesh
Receiver sensitivity	dBm	-82 (-88 to -69)	-82 (-88 to -69)	Corresponding bit rate of 3 – 27 Mbps
Receiver Sensitivity at antenna input	dBm/MHz	-101 (-107 to -88)	-85 (-91 to -72)	Ignoring the cable loss
C/I	dB	6	6	
Allowable Interfering Power at receiver antenna input	dBm/MHz	-107	-91	
Transmitter Characteristics				
Bandwidth	MHz	10	10	
Transmitter e.i.r.p. (see note)	dBm	36	23	
Assumed value for TPC	dB	0	6	
Antenna Gain	dBi	9	0	
Body loss	dB	0	6	
Antenna loss due to portable usage	dB	0	1	
Note: e.i.r.p level specified is for a 10 MHz channel. For other possible channel bandwidths (between 1.25 and 20 MHz), the maximum e.i.r.p is derived from the power spectral density of 26 dBm/MHz for BS and 13 dBm/MHz for UE.				

Table 3: Technical requirements of BBDR devices

In addition ECC Report 110 [3] provided technical parameters for BBDR to ensure compatibility with other systems.

3 PROPOSED APPROACH TO ASSESS THE AGGREGATE IMPACT

In order to assess the potential aggregate impact from the combination of the proposed new applications (BFWA, ITS and BBDR) into the other services/systems operating in the band 5725-5925 MHz, the following steps are proposed:

- **Step 1 - Identification of the potential aggregate impact scenarios**:
  Considering the frequency band envisaged for each of the 3 new systems, identify for each of the relevant sub-band within the 5725-5925 MHz range those new systems that may contribute to the aggregate interference and identify the potentially impacted services/systems.

- **Step 2 – Mutual interference between the proposed new applications**:
  In order to develop scenarios to study the effect from a combination of the proposed new applications into the other systems/services, there is a need to study the mutual interference between these new applications and to determine how they can co-exist.

- **Step 3 – Considerations related to the nature of the impacted services/systems:**
For each of the potentially impacted system/service identified in Step 1 and taking into account the outcome of the mutual interference evaluated in Step 2, determine the nature of the potential aggregate impact.

- **Step 4 – Analysis by sub-band of the potential aggregate impact:**
For each sub-band identified in Step 1, use the characterisation of the potential aggregate impact developed in Step 3 to determine the impact on the other services/systems within this sub-band.

4 IDENTIFICATION OF THE POTENTIAL AGGREGATE IMPACT SCENARIOS (STEP 1)

Taking into account the results of the compatibility studies already undertaken within CEPT for BFWA, ITS and BBDR, this report considered the following 3 sub-bands for possible study relating to aggregate impact:

- 5725-5855 MHz: potential combined effect from BFWA and BBDR,
- 5855-5875 MHz: potential combined effect from BFWA, ITS and BBDR,
- 5875-5925 MHz: potential combined effect from ITS and BBDR.

Within these sub-bands, this report considered the following compatibility cases.

Frequency range	Systems possibly contributing to the aggregate impact	Possible impacted services
5725 - 5855 MHz	BFWA and BBDR	Radar (5725- 5850 MHz) FSS (Earth to Space) RTTT (5795-5805 and 5805-5815 MHz) Amateur (5725 - 5850 MHz) SRDs FS (5850 - 5850 MHz)
5855 - 5875 MHz	BFWA, ITS and BBDR	FSS (Earth to Space) SRDs FS
5875 - 5925 MHz	ITS and BBDR	FSS (Earth to Space) FS

Table 4: Aggregate impact scenarios considered in this Report

The methodology described in this Report can apply to all the possible impacted services identified in Table 4.

For the assessment of the aggregate impact, the Report considers only the co-frequency case. Therefore, victims and interferers are deployed within the same sub-band identified in Table 4.

5 MUTUAL INTERFERENCE BETWEEN THE PROPOSED NEW APPLICATIONS (STEP 2)

In order to develop scenarios to study the effect from a combination of the proposed new applications into the other systems/services, there is a need to study the mutual interference between these new applications and to determine how they can co-exist.

5.1 Mutual interference between BFWA and BBDR

The contents of the following table are based on the outcome from the ECC Report 110.

		Protection range (m) to meet the protection criterion		
	Scenario	**Urban**	**Suburban**	**Rural**
BBDR to BFWA	ML to ML	2257	5008	12739
	ML to SL	1011	2018	4473
	SL to SL	453	813	1570
BFWA to BBDR	ML to ML	485	879	1717
	ML to SL	217	354	548
	SL to SL	94	131	132

Table 5: Protection ranges for the compatibility between BFWA and BBDR

The results of table 5 apply for P-MP and mesh BFWA systems, but the results can be considered to be representative for all types of BFWA systems.

In the worst case (ML to ML), protection ranges have to be greater than few km. About one km is still needed when sidelobe rejection factor is taken into account. As a consequence, some mitigation techniques (e.g. LBT) would be necessary if BFWA and BBDR devices have to share some part of the spectrum together.

5.2 Mutual interference between BFWA and ITS in the 5855-5875 MHz band

The contents of the following table are based on the outcome from the ECC Report 101.

	Applicable			**Protection range (m) to meet the protection criterion**					
			ITS Freq->	**<5875 MHz**			**>5875 MHz**		
	RSU	**OBU**	**Scenario**	**Urban**	**Suburban**	**Rural**	**Urban**	**Suburban**	**Rural**
ITS to BFWA		X	ML to ML	1252	2570	5913	311	532	950
	X	X	ML to SL	600	1100	2250	150	220	300
	X	X	SL to SL	300	500	900	70	70	70

Table 6: Protection ranges to protect BFWA from ITS

The results of table 6 apply for P-MP and mesh BFWA systems, but the results can be considered to be representative for all types of BFWA systems.

It comes also from spectrum considerations that BFWA can interfere with ITS devices on a co-channel or adjacent channel case. As a consequence, Table 6 summarise all needed separation distances for these different scenarios.

In a co-channel analysis, protection ranges have to be greater than few km. About one km is still needed when sidelobe rejection factor is taken into account. As a consequence, some mitigation techniques would be necessary if BFWA and ITS devices had to share some part of the spectrum together.

The second conclusion is that these protection ranges decrease drastically if ITS and BFWA do not share the same frequency range. A 26 to 40 dB typical OoB rejection factor allows limiting protection ranges below a few hundred meters.

Table 7 provides figures for impact from BFWA into ITS.

	Applicable			**Protection range (m) to meet the protection criterion**					
			ITS Freq.->	**<5875 MHz**			**>5875 MHz**		
	RSU	**OBU**	**Scenario**	**Urban**	**Suburban**	**Rural**	**Urban**	**Suburban**	**Rural**
BFWA to ITS		X	ML to ML	460	800	1600	37	37	37
	X	X	ML to SL	220	370	580	8	8	8
	X	X	SL to SL	100	150	170	2	2	2

Table 7: Protection ranges to protect ITS from BFWA

In the case ML to SL, the figures are the mean of the two cases of interference assessments when considering respectively SL BFWA - ML ITS and ML FWA- SL ITS.

The figures in Table 7 show that ITS systems will not receive excessive interference from BFWA devices if they do not share the same frequency band. It means that in the frequency range 5855-5875 MHz, ITS systems may suffer from interference.

As a conclusion, mitigation techniques such as LBT are needed to be implemented in ITS in the frequency range 5855 – 5875 MHz.

5.3 Mutual interference between BBDR and ITS

The calculation of the protection distances between BBDR and ITS in the ECC report 110 leads to the following results:

		Protection range (m) to meet the protection criterion		
	Scenario	**Urban**	**Suburban**	**Rural**
BBDR to ITS	ML to ML	908	1787	3887
	ML to SL	477	863	1683
	SL to SL	214	348	536
ITS to BBDR	ML to ML	531	975	1935
	ML to SL	279	471	808
	SL to SL	125	181	228

Table 8: Protection ranges for the compatibility between ITS and BBDR

As a conclusion, it appears that the protection distances between ITS and BBDR could exceed several km in both directions. It is expected that, in many cases, only few ITS devices will be present within the area of BBDR deployment. Nevertheless, the sharing situation can be improved by the use of appropriate mitigation techniques.

6 CONSIDERATIONS RELATED TO THE NATURE OF THE IMPACTED SERVICES/SYSTEMS (STEP 3)

The purpose of this section is to consider the potential aggregate effect resulting from the use of some or all of these new applications (BFWA, ITS or BBDR) on all potential impacted services (see Table 4) in the same sub-band.

The potentially impacted systems/services can be divided in three sub-classes:

- space service: the impact is coming from different interferers and affects a space station receiver. FSS (Earth to Space) is available in the frequency band 5725-5925 MHz and may receive interference from FWA, ITS and BBDR.
- short range terrestrial systems: the impact is coming from different interferers and affects a low directivity victim device. Non-specific SRD and RTTT are concerned.
- long range terrestrial service: the impact is coming from different interferers and affects a high directivity victim device. It may concern the FS, Radiolocation and amateur service.

6.1 Impact on space service

For a given frequency, the noise increase will be given by all devices spread within the footprint of the satellite. For each of these kinds of devices, the compatibility studies of the ECC Reports 68, 101 and ECC Report 110 lead to the allowable number of equipment units. As an example for this report, the satellite A (TELECOM-2B) was chosen. The same approach can be considered with other satellites in this frequency range (see ECC Report 68 for satellite characteristics).

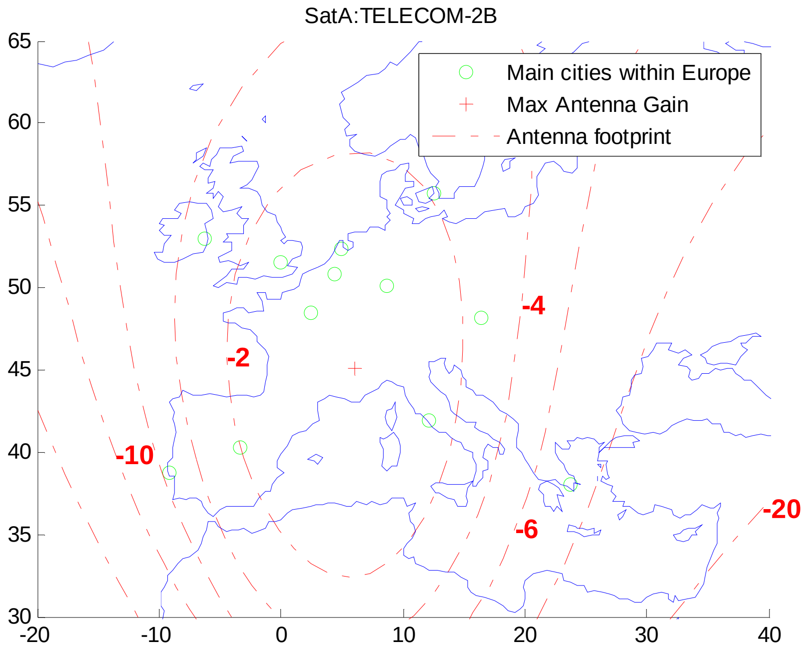

Figure 1: Antenna footprint for the satellite A

$\Delta T_{sat}/T_{sat}$	Frequency Band (MHz)	Allowable aggregate e.i.r.p. (dBW/Hz)	Number of BBDR allowable in use*	Number of ITS allowable in use	Number of FWA P-MP allowable in use
1%	5725-5855	-54.1	308		56 millions
	5855-5875		308	>300 millions	56 millions
	5875-5925		308	>300 millions	
3%	5725-5855	-49.3	923		167 millions
	5855-5875		923	>300 millions	167 millions
	5875-5925		923	>300 millions	
6%	5725-5855	-46.3	1846		335 millions
	5855-5875		1846	>300 millions	335 millions
	5875-5925		1846	>300 millions	
* Note: for BBDR, factors such as antenna discrimination, activity factor and power control were not taken into account since the acceptable number of BBDR networks within the footprint of the satellites provided with this calculation exceeds the low number of BBDR systems expected by the market analysis. Using the same assumptions as in the BFWA and ITS studies, the acceptable number of BBDR networks will be higher.					

Table 9: Results of the different compatibility studies for the satellite A

It is then proposed to compare the number of equipment predicted on the market with the acceptable numbers shown in Table 9. It will lead to a 'loading' factor of the available capacity. Therefore, an apportionment factor will be estimated showing if the summation of all these applications can exceed or not the protection criterion.

It is assumed that BFWA systems are constituted by P-MP systems (90%), mesh systems (9%) and P-P (1%). Therefore, only figures related to P-MP systems are recalled in the previous table (Table). The following elements based from BFWA market expectations are extracted from ECC Report 68:
"*Extrapolation of the market statistics to the 25 countries of the EU with 600M people, gives 265M households and 16M small businesses (or 1 SME per 17 households) Assuming that FWA market penetration reaches 10% - which is very high for a late market entrant that has to compete with wired infrastructure in most market segments and geographical areas –*

the total number of FWA systems connections deployed would never exceed 28M. FWA systems operating in the shared 5.8 GHz band would be fraction of this total. Assuming a very optimistic share of 40% that could be expected to operate in the 5.8 GHz range, this means the total number of FWA systems in this band would not exceed 11.2 M across the territory of the EU. “

Therefore, it can be assumed that less than 20% of the allowable interference margin will be used by BFWA systems even for $\Delta T_{sat}/T_{sat}$ *=1%*.

The number of vehicles in Europe is about 214 million. With an equipment penetration of 50%, estimated number of ITS is then 107 million. Therefore, it can be assumed that less than 33% of the allowable interference margin will be used by ITS systems even for $\Delta T_{sat}/T_{sat}$ *=1%*.

The initial market penetration for BBDR systems within the first 4 years is estimated to not exceed 20% of the target market in any case. This would assume 60000 users in 2400 ad-hoc systems. Considering the temporary nature of BBDR operation, a small amount of ad-hoc systems (no more than 30) is assumed to be simultaneously in operation at any time within the footprint of a satellite. It means that less than 10% of the allowable interference margin will be used by BBDR systems even for $\Delta T_{sat}/T_{sat}$ *=1%*. In addition, it can be seen that the number of BBDR devices is negligible compared with the number of ITS and BFWA systems. Therefore, the impact of BBDR devices will not be significant on FSS receiver.

Finally, it may be concluded from this study that:

- in the frequency band 5725-5855 MHz, BBDR devices will not significantly change the interference impact created by BFWA systems due to the low BBDR density;
- In the frequency band 5855-5875 MHz, the FSS protection criterion will not be exceeded by the aggregation of BBDR, FWA and ITS systems (providing that BBDR devices are deployed in this candidate band);
- in the frequency band 5875-5925 MHz, BBDR devices will not significantly change the interference impact created by ITS systems due to the low BBDR density.

These results, derived from considerations of one specific satellite (satellite A), are also applicable to the other types of satellite in operation in this band (see ECC Report 68).

6.2 Impact on short range terrestrial service

For omni-directional devices like SRDs, the different compatibility studies identified some protection distances to prevent existing services from suffering interference coming from FWA, ITS or BBDR devices.

Distance, m, to protect SRD (urban case)	FWA CS	ITS	BBDR
Main lobe interferer	295[3]	366	659
Sidelobe interferer	63	192	295

Table 10: Overview of the different results achieved to protect SRDs from FWA, ITS or BBDR devices

Nevertheless, SRDs exhibit an omni-directional antenna pattern. The following example aims to illustrate a situation where the required separation distances provided in Table 10 are achieved, but where aggregate interference may exceed the victim interference criterion.

[3] 213 from the main lobe of Terminal (TS) and 91 from sidelobe.

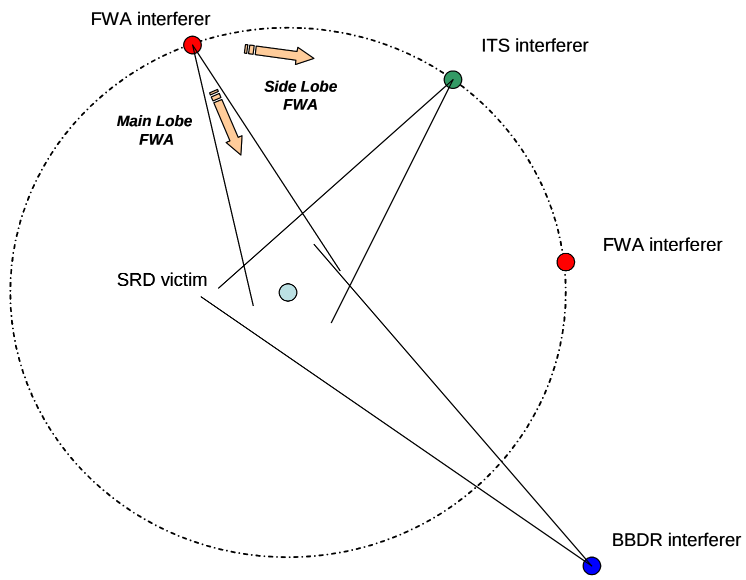

Figure 2: Aggregate impact around a SRD receiver

From a theoretical point of view, it is possible to find a situation where the separation distances between BBDR, ITS and FWA and also between each of these devices and the victim SRD are respected (see illustration above). In this illustration, the victim SRD is present in the main beam of the different interferers. The latter will interfere each other with a sidelobe to sidelobe configuration. These different separation distances are about 300m. Therefore, a separation angle from one interferer to the other would be around 60° and up to 6 devices may be located around the victim.

Therefore, the aggregate impact of these different devices will increase the ambient noise level received by the victim and the protection criterion may be exceeded by about 10Log(6)~8dB. It has to be noted that this situation may also occur with interferers of the same type.

This excess of interference brought by the aggregate impact is purely theoretical and does not take into account probabilistic considerations and possible shielding effects given by the environment. It is unlikely that the different interfering signals will add together permanently to the aggregate interference signal since it would mean that they are synchronized.

A similar approach can be developed to assess the aggregate impact into RTTT systems. However, table 4 shows that due to frequency considerations, the only aggregate impact to RTTT can be generated by BFWA and BBDR. It is worth noting that it is unlikely that both BFWA and BBDR will be present in the vicinity of RTTT installation according to its particular location (road toll stations) and the temporary nature of BBDR networks. As a consequence, the potential aggregate impact into RTTT systems from BFWA and BBDR is likely to be very limited.

6.3 Impact on long range terrestrial service

For systems operating with a high directivity such as radars, fixed links or devices of the amateur services, the different compatibility studies identified some protection distances to prevent existing services from suffering interference coming from BFWA, ITS or BBDR devices.

Nevertheless, it may be not sufficient. The figure below illustrates a situation where the protection criterion of the victim may be exceeded due to aggregate impact even if the different protection distances are respected.

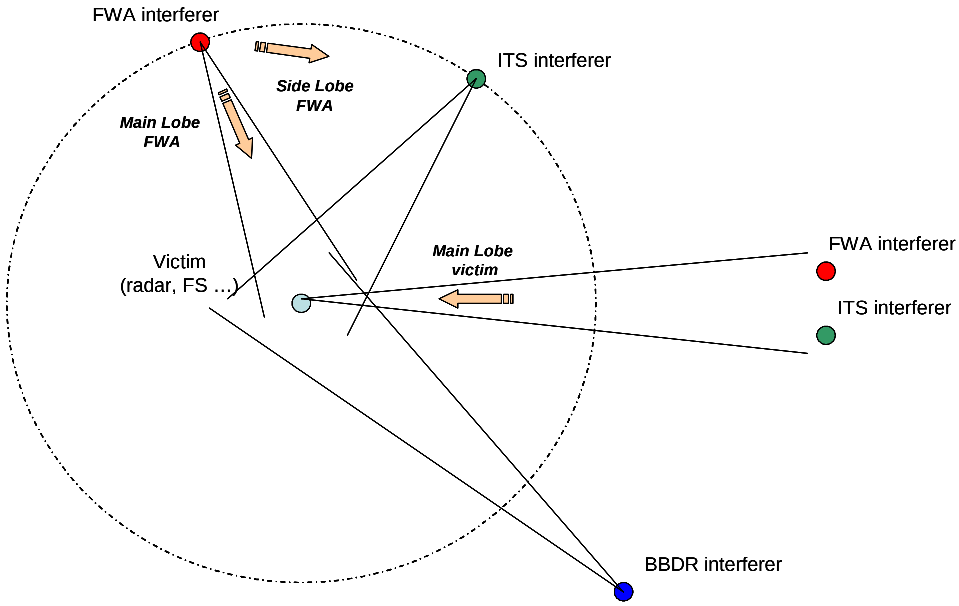

Figure 3: Aggregate impact around a long range (radar, FS…) receiver

Aggregate effect can be provided by two main factors:

- on the one hand, the aggregate impact will be given by all devices which interfere through the sidelobe of the victim. It is similar to the context described in the section 6.2.
- On the other hand, it will also be given by all devices which interfere through the main lobe of the victim. Most compatibility studies led to the conclusion that the needed separation distance between the victim and each interferer is about several hundreds of km and required a mitigation technique to ensure availability of the communication channel. In that case, one can imagine a situation where some interferers are present within the main beam of the victim even if the protection range between them is respected (since it is assumed through their sidelobes). For example, a victim with 40 dBi antenna gain will not discriminate two interferers separated by about 150 m, both located at 100 km from the victim. Therefore, the aggregate impact may increase by 3 dB.

Case of aggregate impact into radiolocation:
The aggregate impact into radiolocation in the 5725-5850 MHz band will only result from the BFWA and BBDR (see Table 4). Due to the low density and temporary nature of BBDR, the impact on radiolocation service will mostly be provided by BFWA and the impact of BBDR devices will remain negligible. In addition, a DFS mechanism is needed to protect the radiolocation service from BFWA or BBDR systems and avoid co-channel operation between radars and any potential interferer. It is necessary to assess whether an aggregate interference scenario would have any impact on the proper operation of DFS.
The DFS mechanism should be able to detect interference signals above a minimum DFS detection threshold. The detection threshold is the required radar signal strength expressed as equivalent power in dBm at the front of the interferer's receive antenna.

When a radar signal has been detected, the interferer shall cease all transmissions on the operating channel. As a consequence, any aggregate interference on the frequency used by the radar will be avoided since the operating channel frequency of either BFWA or BBDR has to be different from the one where radar is operating.

Therefore, the only aggregate impact would be a decrease in the number of available channels for a type of interferer (FWA or BBDR) if the other is also operating in the same area.

Case of aggregate impact into the Fixed Service:

The aggregate impact on FS was not studied in detail since fixed links are only deployed in a limited number of CEPT countries in the frequency band 5850-5925 MHz.

Case of aggregate impact into the Amateur Service:

The aggregate impact into the amateur service in the 5725-5850 MHz will only result from the BFWA and BBDR (see Table 4). Similarly to the case of radiolocation, the impact on the amateur service will mostly be provided by BFWA.

7 ANALYSIS BY SUB-BAND OF THE POTENTIAL AGGREGATE IMPACT (STEP 4)

For each sub-band identified in Step 1, use the characterisation of the potential aggregate impact developed in Step 3 to determine the impact on the other services/systems within this sub-band.

7.1 Sub-band 5725 – 5855 MHz

The potential aggregate impact can only be created by the cumulative effect from BFWA and BBDR. For each of the potentially impacted systems and services, the analysis in section 6 enables to quantify this potential impact:

- FSS (Earth to space): due to their low density, BBDR networks will not significantly change the impact created by BFWA systems alone.
- Radiolocation in the band 5725 – 5850 MHz: due to the low density and temporary nature of BBDR, the impact on radiolocation service will mostly be created by BFWA and the impact of BBDR devices will remain negligible. The aggregate impact would be only a decrease in the number of available channels for each interferer (FWA or BBDR) if the other system is also operating in the same area.
- Fixed Service in the band 5850 – 5855 MHz: the aggregate impact on FS was not studied in detail since fixed links are only deployed in a limited number of CEPT countries in the frequency band 5850-5855 MHz.
- Amateur Service: due to the low density and temporary nature of BBDR operations, the impact on the amateur service will mostly be provided by BFWA and the impact of BBDR devices will remain negligible.
- RTTT in the 5795-5815 MHz band: it is unlikely that both BFWA and BBDR will be present in the vicinity of RTTT installation according to its particular location (road toll stations) and the temporary nature of BBDR networks. As a consequence, the potential aggregate impact into RTTT systems from BFWA and BBDR is likely to be very limited.
- Generic Short Range Devices: The increase of noise can be up to 8dB, but it is purely theoretical evaluation which does not take into account probabilistic considerations and possible shielding effects given by the environment. It should also be noted that this type of aggregate impact will only affect SRD which operate on a non-protected basis.

7.2 Sub-band 5855 – 5875 MHz

The potential aggregate impact can be created by the cumulative effect from BFWA, ITS and BBDR in that band. For each of the potentially impacted systems and services, the analysis in section 6 enables to quantify this potential impact:

- FSS (Earth to space): considering the allowable number of BFWA, ITS and BBDR systems within the footprint of a satellite and the expected market deployment for these applications, the FSS protection criterion will not be exceeded by the aggregation of BBDR, FWA and ITS systems;
- Fixed Service: the aggregate impact on FS was not studied in detail since fixed links are only deployed in a limited number of CEPT countries in the frequency band 5855-5875 MHz.
- Generic Short Range Devices: the increase of noise can be up to 8dB, but it is purely theoretical evaluations which does not take into account probabilistic considerations and possible shielding effects given by the environment. It should also be noted that this type of aggregate impact will only affect SRD which operate on a non-protected basis.

7.3 Sub-band 5875 – 5925 MHz

The potential aggregate impact can only be created by the cumulative effect from ITS and BBDR.
For each of the potentially impacted systems and services, the analysis in section 6 enables to quantify this potential impact:

- FSS (Earth to space): due to their low density, BBDR devices will not significantly change the impact produced by ITS systems.
- Fixed Service: the aggregate impact on FS was not studied in detail since fixed links are only deployed in a limited number of CEPT countries in the frequency band 5875-5925 MHz.

8 CONCLUSIONS

The main objective of this Report is to consider whether the potential aggregate interference of the new applications on the existing services/systems would have an influence on the technical conditions determined by the other ECC Reports ([1], [2] and [3]).

The different compatibility studies lead to the observation of the fact that the aggregate impact of the studied systems (FWA, ITS and BBDR) may be different according to the type of victim system.

- The aggregate impact on space services, like FSS (Earth to space), will be an increase of noise level given by all devices within the receiver footprint of the satellite. Nevertheless, since the allowable number of devices given by the individual studies is sufficiently high compared to the expected number of deployed equipment, as provided by market analysis, even their combined effect will not exceed the protection criterion.
- The aggregate impact on short range terrestrial services with omni-directional antenna pattern (generic SRDs) may result into an increase of noise by up to 8 dB. However, this is purely theoretical evaluation which does not take into account probabilistic considerations and possible shielding effects given by the environment. It should also be noted that this type of aggregate impact will only affect SRD which operate on a non-protected basis.
- The aggregate impact on RTTT from BFWA and BBDR is likely to be very limited due to the very low probability to have both BFWA and BBDR in the vicinity of RTTT installation according to its particular location (road toll stations) and the temporary nature of BBDR networks.
- Due to the low density and temporary nature of BBDR operations, the impact on radiolocation service from BFWA and BBDR in the 5725-5850 MHz band will mostly be provided by BFWA and the impact of BBDR operation will remain negligible. The only aggregate impact would be a decrease in the number of available channels for each interferer (FWA or BBDR) if both are operating in the same area.
- Due to the low density and temporary nature of BBDR operations, the impact from BFWA and BBDR on the amateur service in the 5725 – 5850 MHz band will mostly be provided by BFWA and the impact of BBDR operation will remain negligible.
- The aggregate impact on FS was not studied in detail since fixed links are only deployed in a limited number of CEPT countries in the frequency band 5850-5925 MHz.

For each of the relevant sub-bands within the 5725-5925 MHz band, the outcome is summarized in the following table:

Frequency range	Systems possibly contributing to the aggregate impact	Possible impacted services	Aggregate impact
5725 - 5855 MHz	BFWA and BBDR	Radar (5725 - 5850 MHz)	No aggregate additional impact if efficient DFS is implemented in BBDR and BFWA. Reduction of available channels for BFWA and BBDR as a result of DFS.
		FSS (Earth to Space)	No aggregate additional impact
		RTTT (5795-5805 and 5805-5815 MHz)	Aggregate additional mpact limited due to low probability of co-siting between BFWA and BBDR
		Amateur (5725 - 5850 MHz)	No aggregate additional effect
		Generic SRDs	Possible additional aggregate impact (up to 8 dB noise increase) with very low probability.
		FS (5850 - 5855 MHz)	Limited use of FS within CEPT
5855 - 5875 MHz	BFWA, ITS and BBDR	FSS (Earth to Space)	No additional aggregate impact
		Generic SRDs	Possible additional aggregate impact (up to 8 dB noise increase) with very low probability.
		FS	Limited use of FS within CEPT
5875 - 5925 MHz	ITS and BBDR	FSS (Earth to Space)	No additional aggregate impact
		FS	Limited use of FS within CEPT

Table 11: Summary of the band by band analysis

Therefore, the existing results of the different compatibility studies between each of these systems (BFWA, BBDR and ITS) and existing services will not be significantly changed by their aggregate impact.

ANNEX 1: REFERENCES

[1] ECC Report 68: “Compatibility studies in the band 5725-5875 MHz between Fixed Wireless Access (FWA) systems and other systems”

[2] ECC Report 101: “Compatibility studies in the band 5855– 5925 MHz between Intelligent Transport Systems (ITS) and other systems”

[3] ECC Report 110: “Compatibility studies between broad-band disaster relief (BBDR) and other systems**”**

[4] ECC Recommendation 06(04): “Use of the band 5725-5875 MHz for Broadband Fixed Wireless Access (BFWA)”

[5] ECC Report 102: "Public Protection and Disaster Relief Spectrum Requirements"