# CEPT Report 20

Report from CEPT to EC
in response to the Mandate on

# “the harmonised radio spectrum use for safety critical applications of Intelligent Transport Systems (ITS) in the European Union”

Final Report on 21 December 2007 by the

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

# Table of Contents

# 1. Executive summary

CEPT has considered frequency issues for the introduction of Intelligent Transport Systems (ITS) applications in Europe based on spectrum requirements from ETSI and in response to a Mandate from the European Commission "Mandate to CEPT to study harmonised radio spectrum use for safety critical applications of Intelligent Transport Systems in the European Union".

Safety critical ITS applications provide information to vehicles to avoid potentially dangerous traffic situations or to reduce the seriousness of an accident. This information, when received well in advance, provides an early warning to the driver and becomes increasingly time-critical as the vehicle approaches the site of an incident or potential accident. It can be seen, therefore, that these communications must be reliable, have a high success rate and not suffer from excessive latency.

Based on a detailed study of the spectrum requirements in the 5.9 GHz band carried out by the CEPT (see Annex 4), it was concluded that 30 to 50 MHz was necessary for "safety related applications" of which 20 MHz was needed for critical road safety applications in the frequency range 5875-5905 MHz.

Compatibility studies have been conducted between ITS and other systems/services in the 5.9 GHz band (see ECC Report 101 [1]). The general conclusions of the compatibility study are that ITS will not suffer from excessive interference from other systems/services between 5875 MHz and 5905 MHz. Between 5855 MHz and 5925 MHz, ITS is compatible with all services providing ITS complies with certain emission limits. These are set out in Section 9.1 of this report.

A study of the aggregate impact of new radio systems (Broadband Fixed Wireless Access (BFWA) Broadband Disaster Relief (BBDR), ITS) on other services in the 5.9 GHz band concluded that the existing results of the different compatibility studies between each of these systems and existing services will not be significantly changed by their aggregated impact.

Compatibility studies have also been conducted between ITS and other systems/services at 63-64 GHz (see ECC Report 113 [3]). ITS needs to implement mitigation techniques such as a guard band in their operating band in order to reduce the impact of the unwanted emissions from FS system close to 64 GHz.

In addition to the technical studies, this draft final report contains an Impact Analysis which examines in some depth the costs and benefits of designating spectrum for ITS against the possibility of other uses that may effectively be excluded by such a designation. This analysis can be found at Annex 2 and its findings have been included in the conclusions of this Report.

This final report assesses the progress that has been made so far in providing harmonised frequency use for critical road safety applications of ITS in Europe.

The frequency band 5875-5905 MHz is proposed to be designated in a first step for ITS road safety applications including critical road safety applications and traffic efficiency, while the frequency band 5905-5925 MHz could be considered for future extension of ITS applications. The frequency band 5855-5875 GHz is intended for non-safety applications and will be considered separately from the safety applications.

ITS safety critical applications are not seeking the status of a safety of life service (RR 1.59). [4].

## *2. Introduction*

This Report has been developed by the European Conference of Postal and Telecommunications Administrations (CEPT) in response to a European Commission (EC) mandate given to CEPT by the Radio Spectrum Committee (RSCOM) to study harmonised radio spectrum use for critical road safety of Intelligent Transport Systems in the European Union.

The CEPT has noted that the underlying objective of the Mandate is to provide the Commission with the necessary information to consider the introduction of one or more technical implementing measures harmonising the use of the radio spectrum in support of the timely introduction and successful take-up of new applications to improve road safety in the European Union.

In order to achieve the above, CEPT was mandated to:

- Verify the spectrum requirements for safety critical applications in the context of Intelligent Transport Systems (ITS) and Co-operative Systems;
- Define the level of protection requested and available in the various frequency bands under consideration;
- Determine the frequency range to focus upon for the safety critical applications, and justify this selection on the basis of clear criteria; study the possible use of additional frequency ranges in the future and the opportunity costs of making those bands available;
- Undertake required technical compatibility studies and consider the results of any measurement results, if available, between the safety critical applications and potentially affected radio services for the frequency ranges under consideration, based on expected interference scenarios;
- Consider optimal channel plans for the identified bands, whilst avoiding undue discrimination towards any specific technology;
- Propose a work plan for further future activities on the safety critical applications, if necessary.

This final report has been developed within SRD/MG and approved by WG FM and the ECC with contributions from administrations, ETSI and industry. An interim report was presented to the WG FM meeting in January 2007, adopted by the ECC at its meeting in Krakow, Poland on 26-30 March 2007 in accordance with the timescales of the Mandate, and passed to the EC with a covering letter explaining that it was the same as the version which had been presented to RSCOM. .

This final report assesses the progress that has been made so far in providing harmonised frequencies for use by critical road safety ITS applications in Europe. It also considers the principle that should be applied in the consideration of frequency bands to be identified for these applications.

The ITS concept covers both safety critical and commercial elements. This report concentrates mainly on the safety critical aspects.

Note: ITS safety critical applications are not seeking the status of a safety of life service (RR 1.59).

## *3. Background.*

The ITS technology provides communication both between vehicles (IVC) and between vehicles and roadside units (R2V) with general infrastructure access. An essential part of the ITS applications are safety critical aspects where the driver is warned about emerging critical traffic situations that could potentially result in an accident and thus allow the driver to react and avoid accidents and fatalities.

In general Intelligent Transport Systems go beyond the radio environment. They are a combination of Information Technology and telecommunications allowing the provision of on-line information in all areas of public and private transportation.

The ITS industry supported by the public sector is seeking for specific frequency designations for road safety applications to support the European Union's *e*Safety Initiative with its goals to reduce the number of road fatalities by 50% up to the year 2010, improving the efficiency of road traffic and promoting Intelligent Vehicle Safety Systems. The implementation of ITS is one of the flagship projects in the i2010 initiative to achieve these goals and frequency designation is an important element to facilitate an early implementation of ITS in Europe.

The expected outcome of the frequency designation is a general introduction of ITS in Europe to support road safety and minimise road fatalities. In order to achieve optimisation between costs and benefits, the automotive industry and all its partners working together in the current EU-projects of the 6th Framework Programme are developing systems based on existing 5 GHz wireless LAN technology as described in the ETSI TR 102 492 Part 1&2 [5-1, 5-2].

While the spectrum requirement for ITS in the 5.9 GHz band is new, a spectrum designation has been available for many years in the 63-64 GHz band (Recommendation 70-03 Annex 5 [6] and ECC Dec (02)01) [7]. New technologies and protocols are under development for the 63 GHz band and the technical parameters are described in the ETSI TR 102 400 [8].

## *4. Impact Assessment of Harmonisation.*

A decision to make spectrum available for ITS on a harmonised basis could have significant implications both for road safety and for other users of spectrum. An assessment of the impact of any such decision is therefore an important part of the decision-making process considering that:

- in its communication on Impact Assessment (IA), COM(2002) 276 Final of 5 June 2002 [9], the Commission endorsed the principle of producing impact assessments as an aid to better and more transparent decision-making;
- ECC Report 80 [10] likewise recommended that Impact Assessments be produced for harmonisation proposals;
- the mandate on ITS expressly requires CEPT to study the opportunity costs of making frequency bands available for ITS.

This report therefore incorporates at Annex 2 an Impact Assessment that includes a discussion of the benefits of harmonisation of a frequency designation in Europe based on an ECC Decision (and possibly a mandatory EC Decision) to the development and deployment of ITS in Europe and avoidance of frequency coordination problems in border areas. This IA also addresses the corresponding opportunity costs.

The Impact Assessment in Annex 2 concludes that the benefits of ITS in terms of improved road safety will exceed the opportunity costs of allocating spectrum to ITS on a fully protected basis as soon as ITS generates a road safety improvement in excess of just 1%.

## *5. Spectrum requirements for ITS in Europe*

In considering appropriate frequency bands for ITS to be developed in Europe the CEPT WGFM has considered a detailed explanation of the choice of frequency bands and the amount of spectrum required for the applications mentioned in the system reference documents provided by ETSI for 5.9 GHz (TR 102 492 [5]) and 63 GHz (TR 102 400 [8]).

The spectrum requirement for low latency Inter Vehicle Communication (IVC) and related Roadside to Vehicle (R2V) communication for critical road safety in the 5.9 GHz band is new. Within the 5.9 GHz band, 50 MHz to 70 MHz of spectrum bandwidth could potentially be made available for ITS applications within 5855-5925 MHz.

The 63 GHz band has been designated for ITS type of applications for many years (ERC Recommendation 70-03 Annex 5 [6] and ECC Decision 02-01 [7]) and is sufficiently spectrum wide (1 GHz) to provide communication with very high data rates. This is a particular advantage for R2V communication with large data requirements including commercial applications providing low latency, enhanced geographical reuse with minimal contention and good directionality for high traffic density.

### 5.1 Spectrum requirements for ITS in Europe at 5.9 GHz

In accordance with the System Reference Document ETSI TR102 492 [5] the frequency requirement within the 5.9 GHz band presented by industry for ITS road safety applications is visualised below in Figure 1:

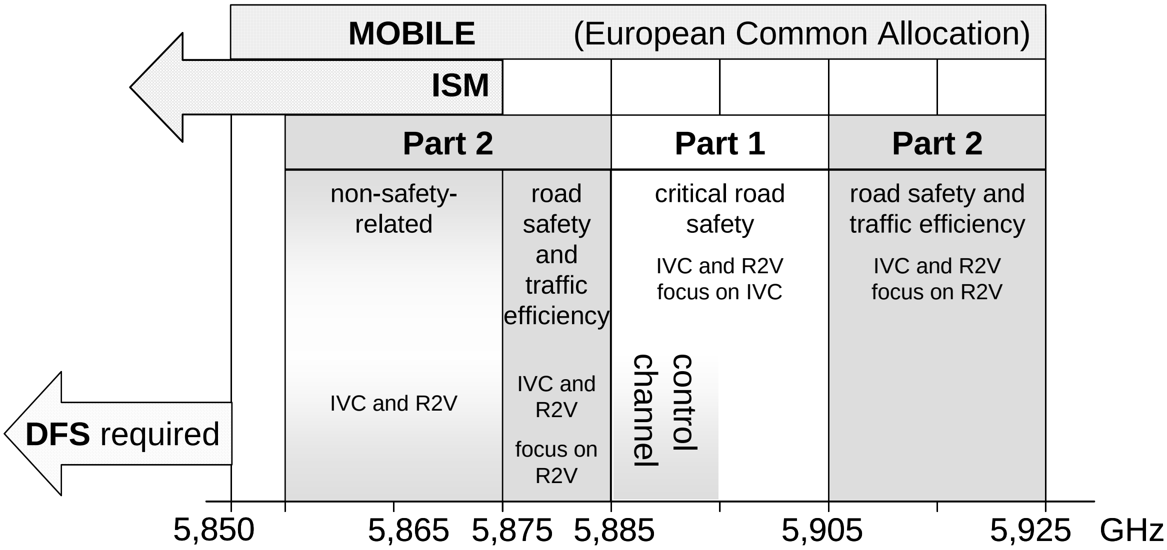


**Figure 1 – 5.9 GHz Frequency Requirement.**

The 5.9 GHz band is the optimum choice of frequency band for the highly dynamic ad hoc network communication provided with non-directional antennas for in particular IVC communication in urban as well as in rural areas.

Furthermore it should be noted that the frequency band and amount of spectrum required in the 5.9 GHz band in Europe is the same as it has already been allocated in the USA and Canada and is being considered by a number of countries world wide.

For example, in the USA 75 MHz of spectrum in the range from 5850 – 5925 MHz are assigned for Dedicated Short Range Communications (DSRC) ITS. The whole band is separated into 5 – 7 channels including a 10 MHz control channel. Two channels of 10 MHz are dedicated to safety applications only. Furthermore in the other service channels access priority is given to safety applications.

In Japan 80 MHz of spectrum from 5770 to 5850 MHz is assigned for DSRC. 20 MHz of this is currently used for electronic toll collection. How the remaining 60 MHz should be used for other ITS applications including car to car communications is currently under discussion by the Japanese Ministry of Internal Affairs and Communications and the industry.

CEPT has considered the spectrum requirements for the 5.9 GHz band with detailed analyses based on realistic traffic scenarios and has concluded that 30-50 MHz of spectrum would be needed for safety related applications dependent on the type of modulation chosen (see Annex 3). This band would include the specific safety critical applications.

The detailed results of these calculations are provided in Annex 3.

In addition it is important to mention that, in practice, some factors may reduce the spectrum efficiency compared to these calculations. They include the fact that under real conditions with moving vehicles and hidden nodes[1], the channel access is worse than in the static network considered in the study.

Based on such analysis and recognizing that frequencies below 6 GHz are highly valued by the industry and spectrum users, a two step approach is suggested where 30 MHz of spectrum would be designated for road safety applications to allow initial deployment of ITS at 5.9 GHz in Europe. An additional 20 MHz of spectrum could be designated in a second step, subject to a review process, based on future evidence of the effective market needs.

The frequency band 5875-5905 MHz is thus proposed to be designated in a first step for ITS road safety applications including critical road safety applications and traffic efficiency, while the frequency band 5905-5925 MHz could be considered for future extension of ITS applications. The frequency band 5855-5875 GHz is intended for non-safety applications and will be considered separately from the safety applications.

### 5.2 Spectrum Requirements for ITS in Europe at 63-64 GHz.

As indicated in the ETSI system reference document TR 102 400 [8] the existing frequency designation in the 63-64 GHz band can support a wide range of ITS applications within its proposed channel and protocol structure including critical road safety applications based primarily on roadside to vehicle communication which would be carried on a commercial payload. The frequency band available in the 63 GHz range is sufficiently wide to also provide for high data rate non-safety services.

## *6 Level of protection requested and available in the frequency bands under consideration.*

### 6.1 Considerations at 5.9 GHz.

The positive results of the compatibility studies demonstrate that ITS applications i.e. within the band 5875-5905 MHz could be offered protection against interference from services and applications in the band. Thus for new systems and applications within the Fixed and Mobile Service compatibility studies would have to be performed in order for these systems and applications to prove their compatibility with the ITS systems. While the possibility of new Earth stations within the Fixed Satellite Service (FSS Earth to space) is very limited in Europe in this band, it should be emphasized that ITS cannot claim protection from FSS Earth stations.

The use of the frequency sub-band 5905-5925 MHz for ITS is compatible with the FSS (E-s) but requires some restrictions including in particular the limitation of unwanted emissions from ITS equipment above 5925 MHz to -65 dBm/MHz in order to protect the Fixed Service. In addition, this sub-band may suffer interference from the Fixed Service operating above 5925 MHz. This sub-band can therefore not be offered protection but will need to operate in accordance with the conclusions of the compatibility study in ECC Report 101 [1].

---

[1] **Hidden node problem**: Nodes, which are not in the communication range, cannot listen to each other and therefore might transmit at the same time. At a receiving node located in between the two transmitters the signals interfere and the information transfer fails.

### 6.2 Considerations at 63 GHz.

In order to provide “safety critical” information from the roadside to vehicles and between vehicles, protection of this spectrum will be required based on the results of the compatibility studies for the 63-64 GHz band. It is suggested that a form of light licensing for the roadside units is considered for the 63-64 GHz band. Protection achieved by light licensing will be needed for R2V and FLANE Fixed Links to ensure that mutual interference between these services does not prevent the successful transmission/reception of safety critical messages.

For MGWS-WPAN/WLAN equipment, indoor use is not seen to be a problem but outdoor use (nomadic or mobile CPE Transmit should not operate in the band 63-64 GHz) or employ a Detect and Avoid feature for CPE.

## *7. Licensing Considerations.*

Road safety systems in the 5.9 GHz band is based on channel access technology where only one device is active on a channel at the same point in time in a given area and all mobile as well as roadside units are operating in the same network. However, a coordination mechanism of roadside infrastructure may need to be considered to ensure that different ITS operators can coexist, but it is not considered practical to license either after sales fitment or integrated vehicle ITS equipment.

For 63 GHz it is more important to impose conditions in order to ensure interoperability and achieve coordination of roadside infrastructure. This is not just to ensure that different ITS operators can coexist but also to avoid interference with other new concepts emerging in this band such as FLANE.

For both 5.9 GHz and 63 GHz this might be achieved by the use of a light licensing concept. A possible application of light licensing regime in this context could be carried out on an on-line data base providing a minimum number of characteristics, with coordination left to the parties involved and the Administration acting as technical arbiter when agreement cannot be reached.

## *8. The frequency range for critical road safety applications.*

Frequency requirements for critical road safety applications have been provided by ETSI within the 5.9 GHz frequency band and the 63-64 GHz band in documents TR 102 492 and TR 102 400.

Both ETSI documents provide a non-exhaustive list of applications for ITS in either bands. Only a few of the applications mentioned in the documents are overlapping and there are clear differences between the service offerings of the applications in particular due to propagation conditions and data rates to be provided.

The 5.9 GHz technology supports low latency communication with the focus on Inter Vehicle Communication (IVC) in highly dynamic ad hoc networks using broadcast mode and supported by R2V communication. This frequency range will therefore support road safety applications with relatively low penetration rates and limited roadside infrastructure.

With 1 GHz of spectrum available the 63 GHz frequency range could support a variety of high data rate applications including extension of road safety as well as traffic management and commercial applications. These would require a full infrastructure deployment and higher vehicle penetration rates for critical road safety operation .

From a technical and service application point of view the two frequency ranges are complementary and in order to meet the general policy requirement of the *e*Safety initiative spectrum should be made available for both the 5.9 GHz band as well as the 63-64 GHz band.

# *9. Technical compatibility studies*

## 9.1 Compatibility studies at 5.9 GHz.

The ECC Report 101 [1] provides the results of the compatibility studies in the band 5855-5925 MHz and the following table shows the conditions under which sharing would be feasible:

| **Services and applications** | **ITS as interferer** | **ITS as victim** |
|---|---|---|
| Radio Amateur | Compatibility is achieved. | Compatibility is achieved. |
| FSS | Compatibility is achieved. | Compatibility achieved in most cases taking into account the limited number of earth stations and real terrain shielding. |
| Radiolocation | Compatibility assumed with ITS unwanted power of -55dBm/MHz, below 5850 MHz. | Between 5855-5875 MHz ITS may suffer from interference. |
| SRD | Compatibility is assumed if ITS are operating above 5875 MHz. Mitigation techniques are required in the frequency range 5855 – 5875 MHz. | Mitigation techniques are needed in the frequency range 5855-5875 MHz. LBT may help avoiding interference to ITS. |
| FWA | Compatibility is achieved if ITS are operating above 5875 MHz. Mitigation techniques are required in the frequency range 5855 – 5875 MHz. | Mitigation techniques are needed in the frequency range 5855-5875 MHz. LBT may help avoiding interference to ITS. |

| **Services and applications** | **ITS as interferer** | **ITS as victim** |
|---|---|---|
| RTTT | Compatibility is achieved if ITS are operating with unwanted power less than -65dBm/MHz below 5815 MHz | Interference depend to the antenna beams alignment and is limited to the RTTT communication zone. |
| FS | Co-frequency: no study done since few systems exist[2].<br>Adjacent band: ITS unwanted power less than -65dBm/MHz, above 5925 MHz (frequency separation[1] or filtering required). | ITS within the band 5905-5925 MHz may suffer from interference. |

**Table 1 – Conclusions of 5.9 GHz compatibility studies**

The general conclusion of the compatibility study is that:

- Between 5875 MHz and 5905 MHz, ITS will not suffer from excessive interference resulting from other systems/services.
- Between 5855 MHz and 5925 MHz, ITS is compatible with all services providing
    - the unwanted emissions radiated power level below 5850 MHz is less than -55dBm/MHz;
    - the unwanted emissions radiated power level below 5815 MHz is less than -65dBm/MHz;
    - and the unwanted emissions radiated power level above 5925 MHz is less than -65dBm/MHz
    - mitigation techniques are implemented by ITS in the frequency range 5855-5875 MHz to ensure compatibility with FWA and SRD equipments.

## 9.2. BBDR compatibility.

Several frequency bands between 4950-5925 MHz are considered for Broadband Disaster Relief (BBDR). Spectrum compatibility with ITS within the frequency band 5875-5925 MHz is described in ECC Report 110.

The report concludes for the band 5875-5925 MHz:

> *‘In this frequency band, deployment of BBDR networks may be possible providing appropriate mitigation techniques are integrated in BBDR equipment to ensure compatibility with ITS. Further analysis is required on the applicability and relevance of LBT for this sharing scenario’*

The frequency band 5875-5925 MHz is not the prime candidate for BBDR.

## 9.3. Aggregate impact from various new applications.

---

[2] Some administrations currently have FS allocations for temporary use ENG OB services in the 5850 – 5925 MHz band. Although no studies have been carried out to address sharing between ITS and these services it can be concluded that interference may occur unless the appropriate steps for co-existence between these services is planned for at a national level.

ECC Report 109 looks at the impact of new systems on existing systems/services 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.

ECC Report 109 considers the potential aggregated impact of these new applications into the other systems/services operating in this band.

- 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 equipments 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 antenna pattern (generic SRDs) may result into an increase of noise of up to 8 dB. However, this is purely theoretical and 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-protection basis.
- The aggregate impact on FS is 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 aggregated impact | Possible impacted services | Aggregate impact |
|---|---|---|---|
| 5855 – 5875 MHz | BFWA, ITS and BBDR | FSS (Earth to Space) | No impact |
| | | Generic SRDs | Possible impact (up to 8 dB) with very low probability. |
| | | FS | Limited use of FS within CEPT |
| 5875 – 5925 MHz | ITS and BBDR | FSS (Earth to Space) | No impact |
| | | FS | Limited use of FS within CEPT |

**Table 2 – Summary of the band by band analysis**

In conclusion, the 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 aggregated impact.

## 9.4. Potential use of UWB and ITS devices in vehicles.

The ECC Decision (06)04 [11] defines general harmonised conditions for the use in Europe of devices using UWB technology in bands below 10.6 GHz. Following its amendment by ECC at its meeting 2-6 July 2007, ECC/DEC/(06)04 also allows the operation of UWB installations inside vehicles with the current spectrum mask subject to the implementation of Transmit Power Control (TPC) with a range of 12 dB.

## 9.5. Compatibility studies at 63-64 GHz.

SE 24 has developed a Report on compatibility between ITS and other systems. Its conclusions are as follows:

| **Services and applications** | **ITS as interferer** | **ITS as victim** |
|---|---|---|
| Fixed Service | If the unwanted emissions from ITS are limited to -29dBm in the first 200 MHz of the FS band no problem expected | ITS needs to implement mitigation techniques such as a guard band in their operating band in order to reduce the impact of the unwanted emissions from FS system close to 64 GHz. |
| Radiolocation | No NATO usage was reported however one administration reported that they are using this band for radiodetermination systems.<br>To be considered on a national basis in countries where radiolocation systems are operated (in particular to calculate the separation distances). | |
| MGWS | MGWS-FLANE vs. ITS-RSU: measures may need to be implemented to reduce the separation distances (e.g. light licensing or co-ordination)<br>MGWS-WPAN/WLAN:<br>• indoor no problem<br>• outdoor MGWS-WPAN/WLAN was not studied. | MGWS-WPAN/WLAN equipment:<br>• indoor no problem<br>• outdoor not compatible noting that compatibility may be achieved if CPE implement mitigation techniques such as Detect And Avoid feature.<br>MGWS-FLANE vs. ITS-RSU: measures may need to be implemented to reduce the separation distances (e.g. light licensing or co-ordination). |
| ISS | No problem expected | No problem expected |

Table 3 **- Conclusions of 63 GHz compatibility studies**

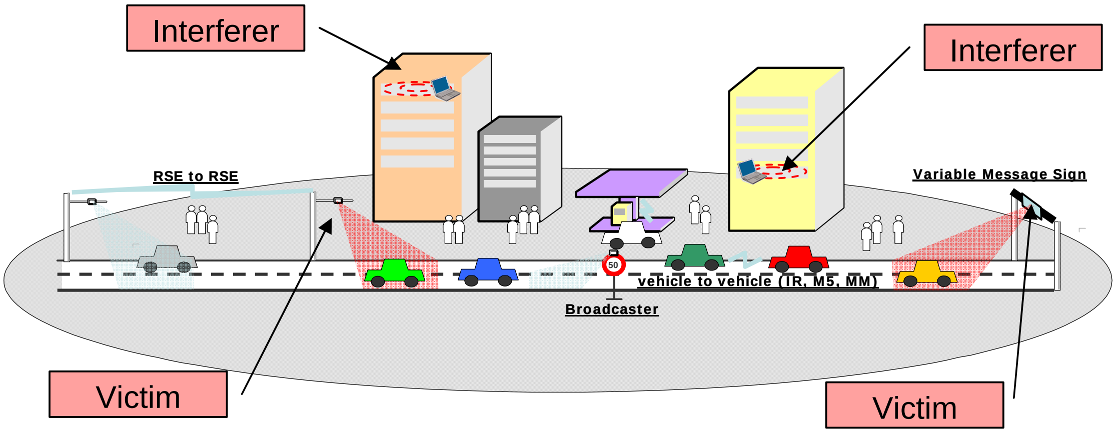


**Fig 2: ITS RSU & IVC possibly interfered by MGWS-WLAN/WPAN**

It has to be noted that the conclusions reached above are also applicable to Radiolocation systems and ISS operating in the adjacent band below 63 GHz.

The results were achieved by considering a maximum e.i.r.p of 40dBm in the ITS channel bandwidth as given in ETSI TR 102 400. This value and the limit of -29dBm in 200 MHz in the band 64-66 GHz to protect the Fixed Service may need to be reflected in the regulation for ITS.

In addition, WG SE developed initial regulatory considerations relevant for ITS and MGWS, provided in Section 7 of this report. Taking into account that the whole frequency range 57 to 66 GHz is considered for MGWS and that a harmonised regulation may also need to be considered.

In considering the issues raised for potential interference to Radiolocation systems and the mutual interference between FLANE FIXED Links and RSU, implementation of a licence system showing location and antenna direction would assist in solving these issues.

## *10. Overview of e.i.r.p. density limits for the identified bands.*

**Conclusion of compatibility studies**

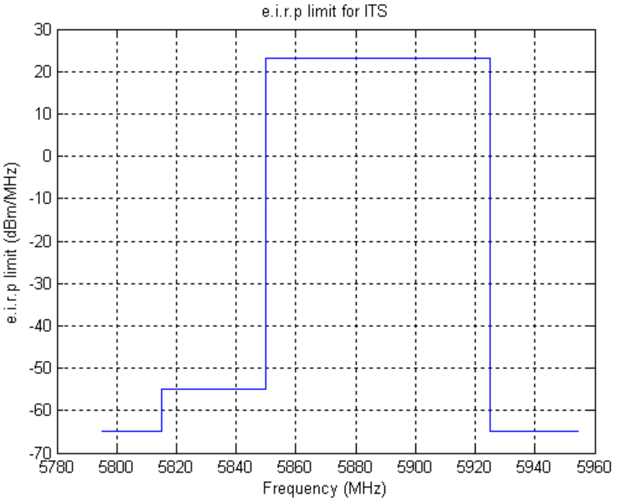


**Figure 3: Overview of the e.i.r.p density limit for ITS at 5.9 GHz**

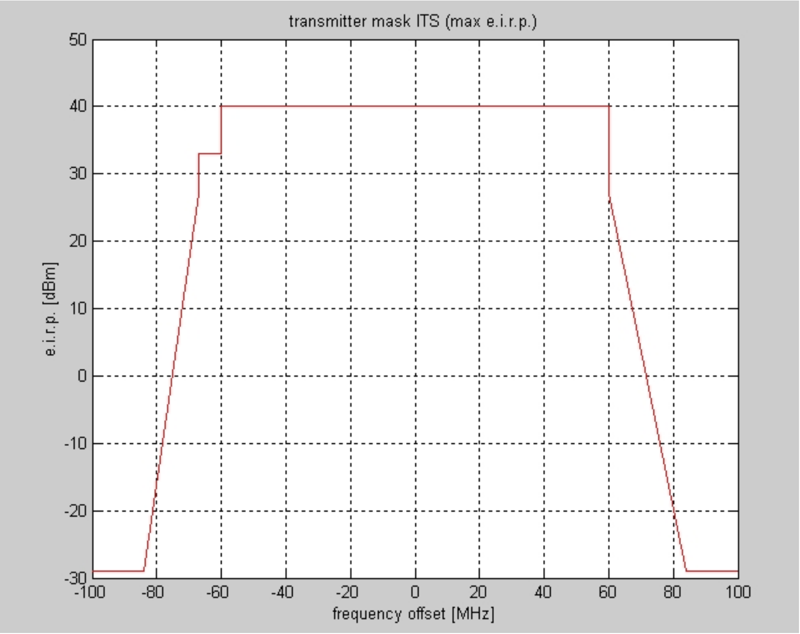


**Figure 4: Overview of the e.i.r.p. density limits for ITS at 63 GHz.**

# 11. Work plan for further activities

The following activities have been identified:

## 11.1 5.9 GHz

The CEPT has agreed a draft Decision covering the harmonised use of the 5875-5925 MHz band for the implementation of ITS. This should include a two-step approach where 30 MHz of spectrum would be designated for road safety applications to allow initial deployment of ITS at 5.9 GHz in Europe with an additional 20 MHz of spectrum being designated for a second step. This would be subject to the regular three-year review process within the ECC and would be based on evidence of future market needs.

## 11.2. 63 GHz

WG FM may need to consider the need for developing additional regulation at 63 GHz noting:

- the existing Decision ([7] ECC Dec (02)01):
- the need to protect the FS operating above 64 GHz
- taking into account the status of ITS as an application in the mobile service
- the need to consider whether 63 GHz should remain within Rec. 70-03 or be covered by a separate Recommendation/Decision.
- The need to protect ITS from FLANE Fixed Links and MGWS nomadic or mobile CPE equipment.

# 12. Conclusions and Recommendations.

## 12.1. Conclusions.

### 12.1.1. Spectrum Requirements

The frequency requirements for ITS in Europe presented by industry include spectrum for critical road safety applications in both the 5.9 GHz and the 63-64 GHz bands.

The 5.9 GHz band is required by the automotive industry in Europe for critical road safety applications to meet the *e*Safety initiative requirements and the technology is readily available as it is based on the wireless LAN IEEE 802.11 technology.

The 63 GHz band has already been designated for ITS-related applications in European Common Allocation Table and ECC DEC (02)01. The band has sufficient spectrum for R2V and IVC communications requiring a very high date rate.

The two bands are complementary due to the different propagation conditions, applied technologies and envisaged applications.

That ITS equipment should not be considered as Short Range Devices. ITS providing communication to and from mobile units can be considered as an application in the Mobile Service.

### *12.1.2. Protection Level*

The use of the frequency bands both in 5.9 GHz and 63 GHz require interference protection from other services in order to provide the low latency safety critical ITS applications.

With the positive results of the compatibility studies ITS applications within the frequency band 5875-5905 MHz could be offered protection against interference from future services and applications in the band. ITS can not claim protection from FSS earth stations.

The use of the sub band 5905-5925 MHz for ITS contains limitations to protect the Fixed Service above 5925 MHz and may suffer interference from this service. This frequency band can therefore not be offered protection but will need to operate in accordance with the conclusions of ECC Report 101.

The use of the 63-64 GHz band for safety critical applications needs protection against interference from other services in the band and it is suggested that a form of light licensing for the roadside units is considered for the 63-64 GHz band.

### *12.1.3. Frequency Range.*

The 5.9 GHz and the 63-64 GHz band are complementary for the current and future developments of ITS services in Europe.

Based on a detailed study of the spectrum requirements in the 5.9 GHz band, the ECC concluded that 30 to 50 MHz was necessary for “safety related applications” of which 20 MHz were needed for critical road safety in the frequency range 5875-5905 MHz.

The 63-64 GHz has already been designated for ITS and the frequency band will be sufficient for future developments of ITS services safety related as well as commercial.

### *12.1.4. Impact Assessment.*

The detailed Impact Assessment in Annex 2 to this report concludes that the benefits of ITS in terms of improved road safety will exceed the opportunity costs of allocating spectrum to ITS on a fully protected basis as soon as ITS generates a road safety improvement in excess of just 1%.

While some of the points below fall outside the scope of the CEPT’s study of the harmonisation of spectrum for ITS, further consideration should be given to:

- the assumptions underlying the estimated benefits from improved road safety are plausible but it would be worth gathering further evidence of the marginal effectiveness of ITS in improving road safety in addition to the benefits from existing road safety technology, e.g. anti-collision radar for which spectrum has already been made available on a harmonised basis and also from alternative road safety measures which might be more effective and economically efficient;

- whether member states are willing to commit to provide, or to finance the necessary infrastructure and to mandate its provision in vehicles
- the risk that spectrum will be unused by ITS or that higher value applications will be excluded unless workable band sharing agreements can be established for all but the control channels.

In any European harmonisation process it should be considered whether it is efficient in terms of spectrum policy to mandate spectrum for a new service throughout Europe or whether this should be left to individual administrations to decide in the light of national circumstances and priorities.

ITS in vehicles is, however, based on free movement and seamless border crossing all over Europe which supports a strong requirement for European harmonised spectrum.

### *12.1.5. Technical compatibility studies.*

The ECC Report 101 concludes on the compatibility studies for the band 5855-5925 MHz with the following:

- Between 5875-5905 MHz, ITS will not suffer from excessive interference resulting from other systems/services and is compatible with all services providing that unwanted emissions meet certain limits below 5850 MHz and above 5925 MHz in order to protect other services;
- Mitigation techniques are implemented by ITS in the frequency range 5855-5875 MHz to ensure compatibility with other services.

The ECC has also considered the possible aggregated impact of ITS and other systems at 5.9 GHz and it was concluded that the 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 aggregated impact.

The ECC Report 113 concluded on the compatibility studies for the 63-64 GHz band and found no significant interference issues and these are summarised in Section 9.5, Table 3:

### *12.1.6. The channel plans.*

Channel plans for the identified bands are indicated in chapter 10 of this report.

### *12.1.7. The Work Plan*

Further CEPT activities include:

- An ECC Decision covering the harmonised use of the 5875-5925 MHz band for the implementation of ITS.

The 5.9 GHz spectrum for critical safety applications is planned to be made available in a two step approach with 30 MHz (5875-5905 MHz) of spectrum for initial deployment and 20 MHz for the second step subject to a review process.

The FM WG may need to consider the need for developing additional regulation at 63 GHz to include the need for protection of the ITS as well as other services in the frequency range.

## 12.2. Recommendations.

This Report Recommends that:

1. Spectrum harmonisation within EU member states is essential for the implementation and deployment of ITS critical road safety applications and systems in Europe.
2. European harmonisation of frequency spectrum for ITS should be subject to a review process in order to remedy the potential market failure. Such process should allow sufficient time for development and initial deployment of ITS systems in Europe.
3. For the 5.9 GHz frequency range, a two step approach is proposed where 30 MHz of spectrum – 5875-5905 MHz - would be designated for road safety applications including critical road safety applications and traffic efficiency, to allow initial deployment of ITS systems at 5.9 GHz in Europe.
4. To consider the designation of an additional 20 MHz of spectrum – 5905-5925 MHz - in a second step. This would be subject to the regular three-year review process within the ECC and would be based on evidence of future market needs.
5. That the frequency band 5855-5875 MHz is intended for non-safety applications and should be considered separately from the safety applications.
6. Concerning the 63 GHz frequency range, ERC Report 25 entries should be endorsed and updated with protection provided in line with the SE24 conclusions.
7. That, for 63 GHz it is more important to impose conditions in order to ensure interoperability and achieve coordination of roadside infrastructure. This is not just to ensure that different ITS operators can coexist but also to avoid interference with other new concepts emerging in this band such as FLANE. This might be achieved by the use of a light licensing concept.

# *Annex 1 – Commission Mandate.*

## Mandate to CEPT to Study Harmonised Radio Spectrum Use for Safety Critical Applications of Intelligent Transport Systems in the European Union

# *Annex 2 - Impact Assessment for ITS*

## 1. Content and context.

The basic question to be addressed and illuminated in this IA is which regulatory action, including that of doing nothing, is best having regard to the costs and benefits and the policy objectives of improving road safety and securing optimal use of the spectrum. This will ideally involve an assessment of the costs and benefits. However, it might not be possible precisely to quantify all of these and estimates might be subject to a wide range of uncertainty. Nevertheless, with the appropriate caveats, even such estimates can provide useful evidence on which a decision may be based while making due allowance for any uncertainty or evidential gaps that there might be.

IAs should not disregard these evidential gaps. Their existence is relevant and should be recorded in the interests of completeness and transparency as they indicate issues on which the regulator needs to apply subjective judgment on the balance of probabilities. Moreover, noting them in the IA and including the IA in the public consultation will give stakeholders an opportunity to provide additional information that could assist the CEPT and the Commission, as well as highlighting for the benefit of the Commission, issues on which further research would be desirable before binding decisions are made on allocating spectrum to ITS.

There are a range of issues and questions raised by harmonisation of spectrum for ITS. These include the following:

- whether ITS will deliver the desired improvement in road safety and other benefits;
- if so, whether it is necessary to harmonise the use of the spectrum in order to achieve the improvement;
- if so, what form of harmonisation would be best, bearing in mind considerations of the opportunity cost if other services are denied access to the spectrum and the risk of unforeseen consequences and regulatory failure;
- the economics of the provision of ITS, i.e. securing the spectrum and provision of infrastructure;
- which candidate bands should be considered for accommodating ITS.

Some of these are outside the competence of the CEPT. They should nonetheless be included in the IA, together with any necessary caveats, as they are highly relevant to decisions on spectrum allocation and the balance between costs, benefits and risks. It is important, in the interests of transparency and better decision-making, that the IA is as comprehensive as is reasonably possible bearing in mind the principle of proportionality.

## 2. Spectrum for ITS

### 2.1 Frequency bands

The allocation of spectrum has been proposed both at 5.9 GHz and 63 GHz. It is claimed that this is required initially because of the different characteristics of the various ITS services. These two claims will need to be justified in relation to any future harmonisation.

The two bands have different characteristics in terms of bandwidth and propagation. The 5.9 GHz band can provide both short range omni-directional and non-line of sight long haul communications, while the 63 GHz band can provide directional high data rate line of sight communications.

An important requirement for critical road safety applications is the low latency information transfer, which depends on a number of issues including the data rate; the delay caused by the channel access and on the availability of direct communication links. Even short delays can have (literally) fatal consequences. A car travelling at 100 km/h travels about 28 metres every second. It follows that two cars heading towards each other in a potential 'head-on' collision close towards each other at 56 metres every second. At 200 km/h, the figures are 56 metres/sec and 112 metres/sec. Delays due to latency can reduce or eliminate the benefits of ITS and mean that the desired benefits in terms of improved road safety are not realised. Indeed, the availability of ITS might engender a false degree of security and encourage drivers to go faster so the consequences of latency will be even more serious.

It should be noted that most for ITS applications the safety related information is provided to the driver prior to and well in time before the potential accident in order to allow the driver to react. The requirement for low latency, however, becomes critical close to the potential accident/crash where driver reaction is necessary to avoid the accident.

Dependent on the particular ITS application and the surrounding conditions regarding traffic congestion, range and weather conditions the 5.9 or the 63 GHz band might provide an advantage and the bands should therefore be regarded as complementary to achieve the benefits of ITS both in the short and long term.

## 2.2 The benefits of ITS and the factors to consider

The benefits of ITS application can be conceived as the expected contribution it makes towards reducing the EU road toll, and the associated human life and cost savings. The automotive industry is seeking a specific frequency designation for road safety applications to support the European Union's *e*Safety Initiative with its goals to reduce the number of road fatalities by 50% up to the year 2010, improving the efficiency of road traffic and promoting Intelligent Vehicle Safety Systems. The implementation of Intelligent Car is one of the flagship projects in the i2010 initiative to achieve these goals and frequency designation is felt to be an important element to facilitate early implementation of ITS in Europe.

There are over 40,000 fatalities on the EU25 roads every year, resulting from 1.4 million accidents, with an equivalent cost of around €200bn/year, or 2% of EU GDP[3]. This estimate of the cost of accidents is supported by UK specific analysis of the cost of road accidents. This suggests that the average cost of a road accident[4] is €125,748. If this is multiplied by the total of 1.4 million road accidents in the EU this would suggest that the total cost of road accidents in the EU of around €176bn/year[5].

Road accidents impose substantial human and economic costs and reducing the incidence and seriousness of these is intrinsically desirable. However, it is necessary to balance these benefits against the costs incurred in achieving them. While this might ultimately be a political judgment, it is right that it is made with knowledge of the costs of accident

---

[3] EC Mandate to CEPT to study harmonised radio spectrum use for safety critical applications of Intelligent Transport Systems in the European Union. Note that the EU currently has 27 countries.

[4] Table 4a in Highways Economics Notes No.1 : 2005 (http://www.dft.gov.uk/pgr/roadsafety/ea/pdfeconnote105)

[5] This analysis assumes that the UK specific estimate of the cost of accidents is broadly indicative of the average cost incurred across the EU.

prevention. It is routine in the transport (and other) industries to ascribe a value to human life and health and compare this with the costs of various policy options. In the real world, resources are not unlimited and policy choices are rarely cost-free. This is true of spectrum as it is of other inputs. It is therefore necessary to have some basis for policy-makers to decide the costs that it is acceptable to incur in order to reduce deaths and injuries by a given amount. For example, if ITS led to a 5% reduction in road accidents within the decade, fatalities and injuries, this would represent a saving of in excess of 2000 lives a year. The total economic saving would then be in the order of €8.8bn - €10bn per year, which equates to around €109.5bn - €125bn over a 20 year period. This value can be taken as an approximation of the potential benefits of critical safety ITS. If the impact was 1% instead of 5%, this figure would amount to a figure in the region of €1.76-2.0 bn/year or €22bn - €25bn over a 20 year period. Regardless of the accuracy of these "guesstimates", we are relating to a potentially very significant equivalent 'value' in supporting ITS systems, particularly safety critical and safety advisory systems. "

It should be noted that the 5% figure is speculative. No direct evidence has been found in the time available to produce this IA to indicate whether the outcome might be higher or lower, however data concerning previous safety initiatives such as the mandatory use of safety belts, and the introduction of air-bags, indicate that 10% is a reasonable target, benefits of the proposed service.

There might be other ways of achieving improvements without bi-directional communications, which may be economically efficient. These could include existing technology such as anti-collision radar, to which spectrum has already been allocated on a harmonised basis. An important consideration is that the benefit of ITS should be assessed in terms of the additional accident reduction achieved by introducing ITS compared to alternative road safety technologies.

It is relevant in this connection to note that there is a significant variation in road accident and fatality rates among the EU27[6]. If all member states were able to improve their road safety to the standards of the best in the EU, the significant improvement desired by EU governments as a whole could be achieved without ITS. For example, France has recently achieved significant improvements in road safety without ITS to improve road safety there to closer to the rest of northern Europe, On the other hand, there has been a significant flattening of the safety improvement curve over the past decade, which leads some safety experts to doubt whether traditional road safety policies will achieve universal improvements that are demanded by EU governments.

ITS applications in the 5.9 GHz band is focused on IVC communication and therefore critical safety advantages will be achieved with these systems even with low penetration rates. The additional support from the roadside units and infrastructure will further increase the advantages but is not critical dependent for the initial operation of ITS.

The full implementation of 5.9 and 63 GHz systems and applications will take some time to achieve in particular for applications where roadside units and infrastructure communication is necessary. Full deployment of roadside units requires close cooperation between ITS industry and public sectors. This cannot be assumed unless Governments commit, or are required to ensure, that it will be rolled out. This could involve direct provision by the Government or another public agency to find a justifiable business case (which may have to use the simultaneous provision of commercial services to enable the provision of safety services), for the legislative provision for requirement of specified equipment by EU in order

---

[6] National road death rates per 100,000 population varied in the EU from 6.1 (2001 figure) to 21.0 (2000 figure). Source: UK National Statistics http://www.statistics.gov.uk/STATBASE/ssdataset.asp?vlnk=7254

to achieve the safety targets, or willingness to subsidise provision of the infrastructure. Other uncertainties include the extent to which the automotive industry makes ITS available in vehicles that it sells and the willingness of consumers to buy ITS at the prices charged by the automotive industry. Lower take-up of ITS at either the infrastructure roll-out, service provision or consumer take-up can be expected to reduce the benefits from ITS.

National ITS organisations with public authorities / traffic departments and road owners have been established in most EU member states and the first traffic management related ITS applications including variable road signs and traffic guidance have been implemented with success. It is envisaged that more focused use of ITS in the national traffic planning will be developed when the technology is available and the regulatory certainty provided on a European basis.

The investment in the development of ITS can be seen as an indication, that governments and industry are willing to implement ITS. As example the public available budgets of the national and European funded projects with a typical cost sharing by 50 % industry and 50 % public investment give a clear indication:

- Planned field operational test in Germany to start in 2007 with a budget of about € 40 million including costs for infrastructure installations funded by 3 German ministries;
- FleetNet, Network On Wheels: 2 projects funded by the German Ministry of Research and Development
- CarTALK 2000: ~ € 3.8 million, funded by the EC
- CIVIS budget ~ € 40 million, funded by the EC
- Safespot budget ~ € 39 million, funded by the EC

Further examples are available for the USA, where the Department of Transport is currently investing in the Vehicle Infrastructure Integration (VII) projects:

- US$ 100 million with 50% for the Consortium related work (OEMs and suppliers) and 50 % for infrastructure;
- US$ 25 million for the Cooperative Intersection Collision Avoidance Systems (CICAS) project
- US$ 12 million for Vehicle Safety Communication (VSC-A) focusing on vehicle-to-vehicle communications

Assessment of the road safety case for ITS and decisions of the acceptable cost are outside the responsibility of the CEPT. ITS technologies are already being implemented, but CEPT can have no influence in the speed at which ITS communications technologies will in practice be introduced, other than to help to enable the possibility, and to monitor the result in case too little or too much bandwidth has been allocated in the light of experience. Actual usage will depend on a series of factors, noted above, which are beyond the CEPT's control and are subject to considerable uncertainty. Although they are not discussed further in this IA, it is relevant to note their existence as they are highly material to the balance of costs and benefits of making spectrum available for ITS on a harmonised basis.

## 2.3 Conclusion on benefit for ITS

ITS could potentially bring significant economic benefits to EU in terms of reducing road fatalities. However, this conclusion is subject to a number of caveats and depends on a range of factors that lie outside the responsibility of CEPT.

- There might be other ways of achieving a reduction without ITS that are more effective and economically efficient.

- If all member states were able to improve their road safety to the standards of the best in the EU, the target of a 50% improvement could be exceeded without ITS.

- The full benefit of ITS depends on the penetration of equipped cars and R2V applications in support of the IVC communication. Even with relatively low penetration rates drivers will, however, benefit from a number of road safety applications and thus ITS will improve road safety. In particular infrastructure requires close cooperation between ITS industry and public sectors.

- In Europe, the EU projects CVIS, SAFESPOT, and COOPERS, have committed between €100-200m of public/private funding to take the technology forward, and trials are scheduled to begin in 2007.

  ITS is currently being developed in the USA where frequency allocation in the 5.9 GHz band has been adopted. The success of European ITS industry on the world market is therefore subject to the possibility to demonstrate and implement ITS in Europe based on regulatory certainty regarding the frequency availability in both the 5.9 and the 63 GHz bands.

# 3. Market and regulatory failure

## 3.1 Market failure

Market failure occurs where there are wider benefits to society which companies involved in providing ITS services are unable to capture from the consumers of their products or services. For example, improvements in road safety can be expected to result in reduced expenditure by society on health services because there are fewer injuries to treat. However, consumers might be unwilling to pay for ITS because the benefits to them personally are less than the cost and the value to each user does not take into account the impact of their use on others, which represents an externality. As a result, if there are alternative uses of spectrum, companies involved in providing ITS may not be able to afford to purchase sufficient spectrum even though the overall benefits to society would be greater than from the alternative uses of the spectrum. In that case, the market would fail to secure the optimal outcome.

Consumers might not be willing to pay for the roadside infrastructure or additional vehicle costs so there might need to be public provision of at least some of the infrastructure. However, this is not an argument for allocating spectrum to ITS to the exclusion of other applications. Economic theory shows that, as a general rule, it is less distorting and economically more efficient for public authorities to subsidise the provision of a public good from general taxation than by allocating to it resources, such as spectrum. On this basis, the most efficient solution would be for public authorities to make an explicit judgement of the value to society of ITS and provide funding to ITS operators that reflects this value and hence that allows them to acquire spectrum for that purpose through the market. However, this can happen only in member states that have introduced market mechanisms and in which national governments operate a policy of acquiring through the market spectrum that is required to secure public policy objectives.

## 3.2 Regulatory failure

Any regulatory decision can result in regulatory failure. Regulatory failure is the counterpart of market failure. It can result, for example, if the form of regulation is not optimal, imposes costs and delays or has unintended or unforeseen consequences. *De jure* harmonisation, like any regulatory intervention, carries a risk of regulatory failure as discussed above. For example, spectrum might be set aside for ITS but the service might not develop for a variety of reasons or might prove ineffective in improving road safety.

It is difficult to quantify these effects but the risk can be mitigated by making any harmonisation measure as flexible as possible so that other applications are not excluded to a greater extent than is strictly necessary and so that particular technologies are not mandated (subject to requirements for interoperability); by frequent regular review, which is an automatic feature of CEPT decisions; or, in the EU context, by inclusion of a review process, as has been done for some EU spectrum decisions and directives.

### 3.3 Conclusions on market and regulatory failure

There is evidence that market mechanisms will not lead to an optimal allocation of spectrum to ITS. There are wider benefits to society that companies providing ITS will find it difficult to reclaim from consumers, in which case market mechanisms would lead to an under-provision of ITS. The most efficient solution to this potential under-provision of ITS would be for national administrations to provide funding reflecting the wider benefits to society which would allow ITS operators to acquire spectrum through the market. However, this approach does not currently appear to be possible in many member states. Some of these issues would arise irrespective of whether or not the spectrum is harmonised but their existence makes reliance on market-led harmonisation problematic in the specific circumstances of ITS.

Regulatory intervention carries a risk of regulatory failure but this can be mitigated by minimising the restrictions imposed to be the least necessary to avoid interference and by providing for review and sun setting.

## 4. Benefits, costs and risks of harmonisation[7]

Harmonisation can generate benefits but also carries a risk of imposing costs. The potential benefits may be summarised not only in terms of the saving of human life and mitigation of injuries, but also as economies of scale, interoperability, promotion of efficient use of spectrum (through better management of interference), cross-border mobility, promotion of investment and promotion of intra-application competition and consumer choice. The possible risks are that spectrum is sterilised if the designated application is not successful (imposing what are termed ‘opportunity costs’ or benefits foregone from those alternative applications). As a result, alternative services or technologies are denied access to spectrum leading to delays in innovation, reduced inter-application competition and substantial loss of consumer benefits. A frequency designation should therefore be subject to a review process with sufficient time for implementation of ITS systems and applications all over Europe.

Other potential costs include delays resulting from agreement and implementation of harmonisation measures. The costs that incumbent users incur in order to vacate spectrum to accommodate ITS are also relevant. At 5.9 GHz the compatibility studies have shown the ability to coexist, at 63 GHz, where there is already a European allocation and there are currently no other users (although applicants), so it is important that any new users sharing the bandwidth do so in a way that does not threaten the life and injury saving capabilities of ITS systems.

There are examples of successful and unsuccessful harmonisation, which underscores the need for a case-by-case assessment by carrying out a proportionately comprehensive IA.

In discussing benefits, costs and risks, it is important to note that there are different types of harmonisation and to distinguish between them. Harmonisation can be mandated (i.e. *de jure*) or result from operation of market mechanisms such as spectrum trading (i.e. *de facto*); it can also be exclusive or non-exclusive. The different types of harmonisation are discussed in detail in ECC Report 80 on *Enhancing Harmonisation and Introducing Flexibility in the*

---

[7] Harmonisation refers to the common designation of frequency bands for use by a number of countries and the designation of common minimum requirements to avoid harmful interference. This definition does not include harmonisation of common standards or technologies.

*Spectrum Regulatory Framework*[8]. As discussed in that report, in certain circumstances, market mechanisms can be expected to result in industry-led *de facto* harmonisation where the benefits of harmonisation outweigh the costs. However, as discussed further below, this depends critically on absence of market failure.

## 4.1 Costs of harmonisation

The primary cost arising from harmonisation is the opportunity cost of existing (and future) uses of spectrum being displaced by ITS use. In order to assess the opportunity cost, it is necessary to predict the alternative uses that exclusive allocation to ITS would preclude.

Opportunity cost

ITS in the 5.9 GHz band has proven compatible with other services in the band with some restrictions. With the limited number of FSS earth stations in Europe within this band the ITS does not claim protection from future earth stations. As is normally the case, new future applications (other than FSS) would have to prove compatible with ITS.

The 63 GHz band may impose less opportunity cost because bandwidth is far more plentiful and the high oxygen absorption at the higher frequency would allow better geographical reuse and sharing with other services. The development of new technologies and applications in the 60 GHz range may require this spectrum for new and innovative services. An example is the requirement for 60 GHz MGWS applications to be used not only indoor but also as fixed links between buildings. This will of course influence the opportunity costs for this band as well.

In assessing the opportunity cost, it is assumed that no alternative spectrum is available for the displaced service. This might well not be realistic but serves to provide an upper bound on the opportunity cost. This can be expected to be mitigated to the extent that other suitable frequencies are available. This does not take into account, however, the effect on other new technologies that could be developed and the estimates to that extent underestimate the costs.

The most likely future use of the 5.9 GHz band is as an extension to the adjacent 5.725 – 5.875 GHz FWA band to provide a broadband wireless service. This could include mobile and nomadic use. As the demand for high data rate application such as voice and video application and converged services continue to grow, it is expected that there is demand for additional spectrum for BWA to provide backbone and access for such services.

A report by Quotient for Ofcom[9] indicates that current regulation at 5.8 GHz produces total consumer surplus in the UK (from 2005 to 2010) of €617m over 5 years. Extrapolating this to the EU countries (using ratio of UK population over EU population of 8%) this will generate a net present value (NPV) of about €7.7 billion over 5 years or €27 billion over 20 years. This is based on the assumption that similar or higher consumer surplus will be produced when additional spectrum is allocated.

The above assumes that the most likely alternative use of the 5.9 GHz band is for wireless broadband. Given the speed and unpredictability of future technical developments, it is not possible to be certain that some other alternative application will not emerge and difficult to quantify the opportunity cost associated with such a development. It could be substantial and amount to billions of €. This IA does not take this possibility into account in estimating the opportunity cost but it is relevant to note the possibility.

---

[8] http://www.ero.dk/documentation/docs/docfiles.asp?docid=2153&wd=N

[9] (http://www.ofcom.org.uk/research/technology/overview/ese/exempt/)

## 4.2 Benefits of harmonisation

The potential benefits of harmonisation of spectrum for ITS are economies of scale, interoperability and roaming capability, spectrum efficiency, promotion of investment and promotion of intra-application competition and consumer choice.

Economies of scale

Economies of scale can be important in terms of driving down production costs. It would be beneficial to harmonise on a global basis in order to secure economies of scale in equipment manufacture. The 5.9 GHz band has been allocated in the US and Japan for ITS, and is being assessed in Australia and China.

ITS at 5.9 GHz is based on 802.11a/p WLAN technology and will therefore benefit from an economies of scale effect based on a multiple of quantities as it would be given by the automotive industry only.

Harmonisation could also deliver economies of scale at 63 GHz. It is relevant to note that, if harmonisation delivers economies of scale, this could lead to higher provision and take-up of ITS and hence enhance the improvements in road safety. Japan, China and US are also considering this band.

Interoperability and cross-border roaming

Lack of interoperability will detract from the value of IVC if the ITS in one vehicle cannot communicate with that in another. Furthermore, safety will be compromised if a driver from one country where ITS is available travels into another country where it is not. The driver will arguably be at increased risk if he or she has become accustomed to relying on ITS but is deprived of it when crossing a border. However, it has not been possible to quantify this benefit, for example from data on the proportion of accidents involving cross-border traffic. Generally speaking, the greater the incidence of cross-border road traffic, the greater the gain from cross-border availability of ITS.

Spectrum efficiency

Harmonisation can be expected to reduce interference, especially across national borders. However, this can also be achieved by including suitable conditions in licences issued for alternative applications. Technical spectrum efficiency will usually be maximised where use of a frequency band is homogeneous. However, this does not necessarily equate to maximising the overall benefits from the use of the spectrum if a mix of services would generate greater economic and other benefits.

Promotion of investment

To the extent that the harmonised spectrum is utilised for ITS, this can be expected to require investment in fixed roadside infrastructure and mobile vehicle terminal equipment. However, it is not clear that this will necessarily be beneficial as the resources utilised for ITS could possibly be used more productively for some other purpose. Absent market failure, market-led harmonisation can be expected to be at least as effective as *de jure* harmonisation in promoting beneficial investment.

Promotion of intra-application competition and consumer choice

Harmonisation can promote intra-application competition although it is not clear whether this is a relevant consideration for ITS. Consumer choice is more likely to be exercised at the level of purchase of vehicles and ITS contribute only indirectly to this. ITS at 63 GHz which initially will be an “add on” is likely to enhance competition and consumer choice because it will allow competition with other mobile communications, such as cellular networks, for delivering broadband content to vehicles.

### 4.3 Conclusions on costs, benefits and risks of harmonisation

On an assumption that the effect of ITS on accident rates in Europe is conservatively estimated in the range of 5%, ITS is therefore estimated to generate benefits €10bn a year or more, within a decade. However, benefits will be lower in earlier years. Added to this are unquantified but positive gains from economies of scale and interoperability. However, this estimate is subject to considerable uncertainty and depend on the effectiveness of ITS in reducing accident rates, service and infrastructure provision and consumer take-up. Offset against the benefits are the potential opportunity costs, which are estimated to be of the order of €1.5bn a year. Again this estimate is subject to uncertainty.

It is difficult to draw firm conclusions from these figures, except to note that the benefits of ITS in terms of improved road safety will exceed the opportunity costs of allocating spectrum to ITS on an exclusive basis as soon as ITS generates a road safety improvement in excess of just 1%. Despite the lack of firm evidence for the effect of ITS on road safety, it can reasonably be concluded that an improvement of this size, which does not seem inherently improbable, will be sufficient to generate gains that exceed the opportunity cost. The benefits of ITS are therefore more likely than not to exceed the costs provided that ITS is widely available and taken up by consumers. This conclusion could be invalidated if a higher value use was excluded from the ITS bands and could not find alternative spectrum. However, there is no evidence available to suggest that this is a likely scenario.

In reaching this conclusion, however, it should be noted that there is a shortage of evidence of the extent to which making spectrum available at both 5.9 GHz and 63 GHz will improve road safety relative to a situation in which spectrum is available only in one band. Finally, it should be noted that harmonisation is necessary to secure the full benefits of ITS but might not by itself be sufficient. National administrations might also need to intervene to ensure that ITS infrastructure is available and that vehicle terminals are fitted if full benefits are to be achieved. This is beyond the scope of any decision on spectrum harmonisation.

## 5. Assessment of options.

Harmonisation can play a significant role in influencing the development of ITS services across Europe but choosing the most appropriate form of harmonisation will be critical in creating conditions most conducive to securing optimal use of the spectrum and achieving the benefits of ITS services while minimising the associated disbenefits.

Three options for harmonisation are discussed.

- Option 1: **do nothing** – this is the base case against which the other two options are compared.

- Option 2: **mandatory (*de jure*) harmonisation**, in which spectrum is allocated preferentially to ITS. This need not be to the exclusion of other applications provided that these do not interfere with ITS. The harmonisation would preferably be technology-neutral.

- Option 3: **market-led (*de facto*) harmonisation**, in which spectrum is made available for ITS on a harmonised basis across Europe but without giving preference to ITS so that other services and technologies are not excluded and can gain access on a co-equal basis.

These options may be considered separately for each of the frequency bands under consideration at 5.9 GHz and 63 GHz.

## 5.1 Option 1: do nothing

No steps would be taken to harmonise spectrum for ITS. This option would avoid the risk of regulatory failure but the absence of any provision for spectrum to be made available would carry a high risk that ITS would not be developed and the associated benefits would not be realised. There would be uncertainties about whether spectrum could be acquired, which would discourage investment, and loss of economies of scale would mean higher prices to consumers and a lower take-up.

## 5.2 Option 2: mandatory *de jure* harmonisation

Spectrum would be designated on a mandatory basis for ITS across Europe. Other applications could be allowed but only if they did not interfere with ITS and provided that sufficient spectrum was available for ITS. This would ensure spectrum availability but would not guarantee the provision of ITS absent regulatory measures by member states to provide or to finance the necessary infrastructure and to mandate its provision in vehicles.

If ITS was universally provided, the estimated benefits would exceed the estimated costs but both sets of estimates are subject to considerable uncertainty, in particular on the benefits. In the case of the benefits, there is an absence of empirical evidence about the effect of ITS on road safety and uncertainty about whether ITS will be provided or adopted by consumers. In the case of costs, it is impossible to predict which new services might seek access to the spectrum and be denied access.

The costs could be mitigated in various ways. The decision could be sunsetted or subject to frequent review; the exclusivity could be relaxed to allow sharing with short range services that would not interfere with ITS; the harmonisation could be technology-neutral (subject to requirements for interoperability).

The costs of this option would likely be higher at 5.9 GHz than at 63 GHz because of the potentially greater opportunity cost at the lower frequency.

## 5.3 Option 3: market-led, *de facto* harmonisation

This would involve a degree of harmonisation in that common frequency bands would become available across Europe on a similar timescale but on an application-neutral basis so that there would be no certainty that ITS would acquire the spectrum. This would depend on national decisions or on the unpredictable outcome of market processes in member states that chose to auction the spectrum and make it tradable.

This option would avoid many of the costs and risks, especially where market processes were used, as the spectrum would in principle be assigned to the users and applications that offered the greatest value. However, this benign outcome cannot be assumed since market mechanisms are not available in all member states.

The benefits of this option are more likely to be realised at 63 GHz because the high bandwidth available will allow the combination of safety related and commercial ITS to be carried, which makes it more likely that ITS will be commercially self-supporting.

## 6. Conclusion

With the information currently available, it is possible to reach some tentative conclusions. In view of the analysis of costs and benefits, it is possible and credible that options 2 and 3 (*de jure* and *de facto* harmonisation) would both be more beneficial than option 1 ('do nothing').

Given the existence of potential market failure and the unavailability in many member states of market mechanisms to remedy this, it would be reasonable to conclude that option 2 (*de jure* harmonisation) could be justified in the particular circumstances of ITS. However, this conclusion is subject to uncertainty and carries risks. The risks could be mitigated by allowing technology-neutrality (subject to imposing minimum restrictions needed to provide interoperability) and making harmonisation subject to review and sun-setting.

Given the difference in costs and benefits in both bands, it should be considered whether to adopt a different option at 5.9 GHz than at 63 GHz.

Although it is apparent from the foregoing analysis that there is as yet shortage of quantifiable evidence on a number of aspects and wider issues CEPT has agreed to draft a Decision covering the harmonised use of the 5875-5925 MHz band for the implementation of ITS. However, further consideration should be given to:

- the assumptions underlying the estimated benefits from improved road safety are plausible but it would be worth gathering further evidence of the marginal effectiveness of ITS in improving road safety in addition to the benefits from existing road safety technology e.g. anti-collision radar for which spectrum has already been made available on a harmonised basis and also from alternative road safety measures which might be more effective and economically efficient;

- whether member states are willing to commit to provide, or to finance the necessary infrastructure and to mandate its provision in vehicles

- the risk that spectrum will be unused by ITS or that higher value applications will be excluded

In any European harmonisation process it should be considered whether it is efficient in terms of spectrum policy to mandate spectrum for a new service throughout Europe or whether this should be left to individual administrations to decide in the light of national circumstances and priorities.

ITS in vehicles is, however, based on free movement and seamless border crossing all over Europe which supports a strong requirement for European harmonised spectrum.

Some of the above fall outside the scope of the CEPT Mandate but are highly relevant in the consideration of spectrum harmonisation for ITS though it should not block the development of a new Decision. Finally, this Economic Impact Analysis (EIA) can also be seen as a benchmark for further investigation that could be considered within the frame of a future review of the spectrum designated for ITS applications.

# *Annex 3 - Justification of the spectrum requirement in the 5.9 GHz band.*

## 1. Introduction

This Annex describes a real traffic scenario and presents the estimation of the data traffic for a realistic selection of IVC and R2V applications. The estimated data traffic is then compared with the expected data throughput of the ITS communication system.

## 2. Description of the traffic scenario

Situations will differ, but for example, a typical urban traffic scenario is considered. The following picture shows the crossing between Avenue de la Porte des Terre and the motorway ring in Paris.

The scenario includes

- 1 inner-city 6 lane motorway:
    - direction 1 reduction to 2 lanes because of road works, accident and congestion
    - direction 2 emergency breaking situation due to curious onlooker
- 1 main street with heavy traffic and bus lane
- several standard streets with speed limitation to 30 km/h
- several parking areas
- scenario dimensions: 300 x 300 m2

The number of nodes in the scenario is estimated as follows:

| **Road type** | **Total length (m)** | **Number of lanes per direction** | **Average Speed (km/h)** | **Distance between vehicles (m)** | **Number of cars** | **Comments** |
|---|---|---|---|---|---|---|
| city highway | 400 | 3 | 80 | 40 | 33 | mainly free traffic flow in one direction, but emergency breaking situation due to curious onlooker |
| city highway | 400 | 2 | 10 | 5 | 162 | work zone with reduction to 2 lanes, accident and congestion |
| main streets | 700 | 2 | 40 | 15 | 191 | heavy traffic in both directions |
| streets | 800 | 1 | 30 | 25 | 66 | speed limitation to 30 km/h |
| | | | | | **452** | total number of active vehicles |
| Intersections | | | | | 6 | |
| parking areas including roadside parking | | | | | 10 | typically more than 1 RSU per parking zone |
| roadside units | | | | | **100** | total number of roadside units |
| | | | | | **552** | total number of active stations |

**Table 1: Number of nodes in the traffic scenario**

The scenario calculations for ITS deployment resulting in a required throughput of **6.905 Mbit/s** is provided in this annex.

Crossing Avenue de la Porte des Terre and the motorway ring in Paris

## 3. Performance requirements for road safety applications

**Road Safety Applications require**

- high probability of successful message reception by all vehicles in the intended communication range.
- low latency of messages depending on the distance to the position of the incident.
-

**ITS Communications is mainly broadcast communication**

- ad hoc communications with heavily varying link conditions
- broadcast communication means there is one transmitter and several receivers
- the link quality from the transmitter to the receivers will differ, depending on the surroundings
- in the highly dynamic ITS-networks link conditions change rapidly
- the high dynamic of the node composition and the hidden node problem[10] make the CSMA/CA (channel access procedure) less effective in comparison to typical WLAN networks with the consequence of an increased collision rate on the channel

⇨ applying the most robust modulation scheme (BPSK) yields to the lowest data rate providing the highest probability of successful transmissions and where needed the highest communication range, i.e. 6 Mbit/s in a 20 MHz channel or 15 Mbit/s in 50 MHz bandwidth respectively

---

[10] **Hidden node problem**: Nodes, which are not in the communication range, cannot listen to each other and therefore might transmit at the same time. At a receiving node located in between the two transmitters the signals interfere and the information transfer fails.

⇨ associated with the lowest data rate the receiver is in the most sensitive mode and therefore allows the lowest transmission power to achieve the required communication range, which is important for the channel reuse

**Available data rate in the most robust communication mode (highest reliability)**

- for the calculation of the required data rate no splitting into different channels is considered
- 802.11p is based on 802.11a and both types apply mainly the same MAC protocol. The standardization of 802.11p is not finished yet and a performance estimation of IEEE 802.11 is therefore considered for the evaluation of the bandwidth requirements
- The document given in reference [7] provided information on performance evaluation of IEEE 802.11 standard provide analytical and simulation results:

**Simplification in the performance evaluation**

- channel characteristics are not considered, i.e. under real conditions the data throughput is less due to fading etc.
- the network is static, all nodes are in the communications range => hidden nodes and highly dynamic changing of the network topology is not considered
- the system is evaluated in the case of saturation, i.e. effects of message generation are eliminated; saturation means, that all nodes have all the time one packet to be sent
- delays up to the first position in the output queue are not considered.

## 4. Maximum data throughput.

- Even if there are only 2 communication nodes the maximum data throughput for a 6 Mbit/s channel is about 5 Mbit/s for average packet size due to the MAC protocol, which requires inter frame spacing etc.
- for IVC with typical packet size below 500 Byte the maximum throughput is less than 5 Mbit/s (Figure 1)

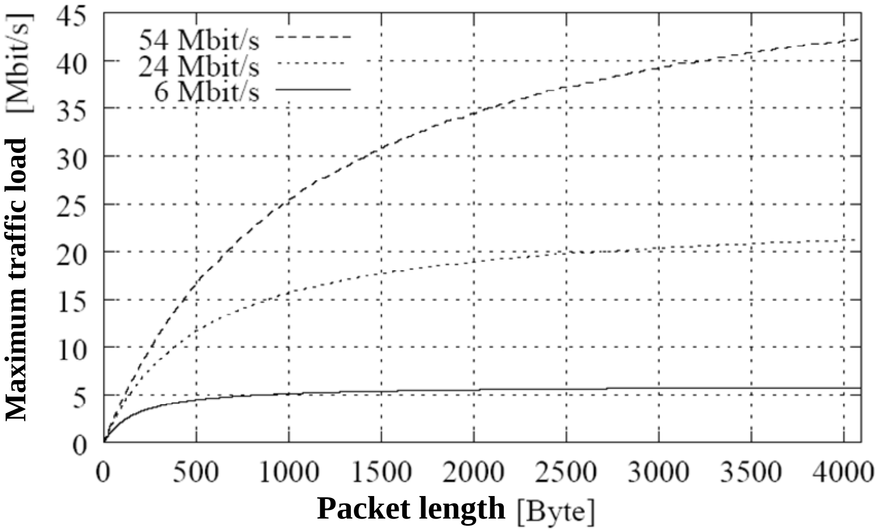
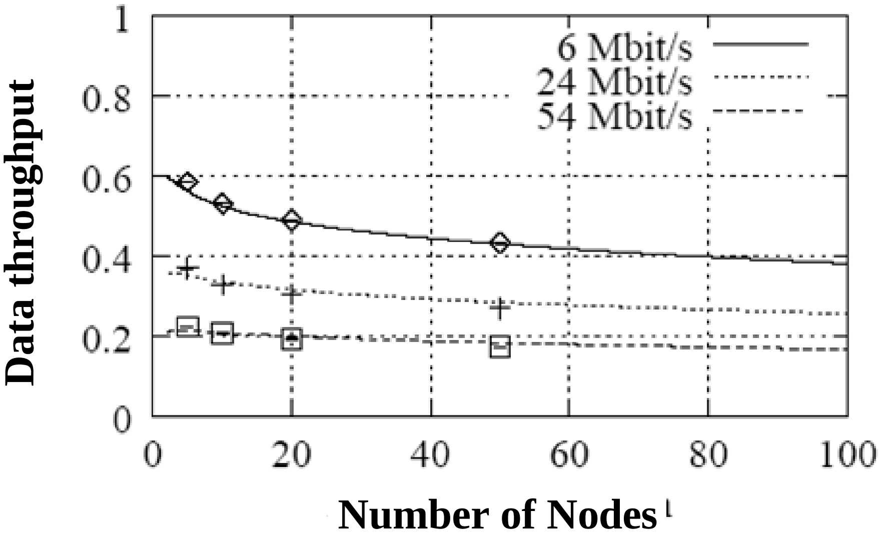


**Figure 1 Maximum traffic load subject to the packet size**

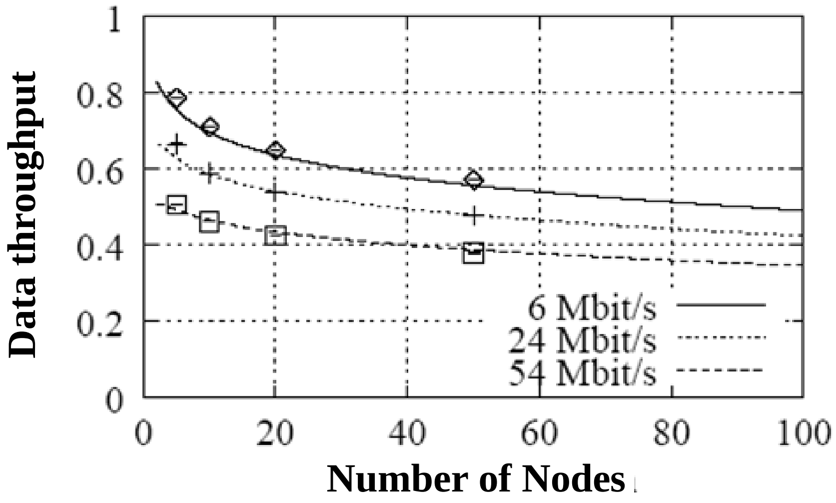
**Data throughput in subject of the number of involved nodes**

- the maximum throughput is only of theoretical value
- in practice the worst case throughput, which will occur in the case of saturation, is relevant
- figures 2 and 3 show, that the data throughput decreases rapidly with the number of communicating nodes
- the curves are calculated results and the points show the results of simulations, with a very good correlation
- for IVC the most appropriate packet size is 256 byte and in the case of 100 communication nodes a throughput of less than 0.4 is calculated for the data rate of 6 Mbit/s, which results in an effective data rate of 0.4 x 6 Mbit/s = 2.4 Mbit/s for a 20 MHz channel
- messages for R2V applications are often longer, but they are expected to be less than 1024 byte, which yields in an effective data rate of 0.5 x 6 Mbit/s = 3 Mbit/s for a 20 MHz channel and 100 participating nodes.



(b) 256 byte

**Figure 2 Data throughput subject to the number of nodes for a packet size of 256 byte**



(a) 1024 byte

**Figure 3 Data throughput subject to the number of nodes for a packet size of 1024 byte**

## 5. Calculation of the bandwidth requirement

For the calculation, three cases have been considered:

- base case: all transmissions will use the BPSK modulation,
- case 1: for each application, use of the lowest of the modulation schemes listed in the table 2 below
- case 2: for each application, use of the highest of the modulation schemes listed in the table 2 below.

It is expected that highest modulation scheme can be used in some situations (short communication range, TPC margin used to improve the SNR at the reception, lowest acceptable bit error rate…). Cases 1 and 2 reflect these points and will consider the impact of using other modulation scheme, QPSK.

Regarding the TPC margin, it should also kept in mind that, as a result of the compatibility study, there are requirements for the out of band emission at the edges of the considered spectrum. One measure to achieve this requirement is to reduce the transmission power, which reduces the margin available for the improvement of the signal to noise level and therefore the probability for applying higher modulation schemes.

It may be noted that the study does not consider any distinction of channels. The control channel, which is considered for control messages like the heart beat signal or service announcements and which should be also available for the most urgent application data should not be used to full capacity.

The spectral efficiency for the two modulation schemes used in this study is derives as follows

- **BPSK**

With 802.11a,

- 6 Mbps needs 20 MHz
- for packet size of 256 bytes, the network efficiency coefficient is about 0.4=> 0.4x6=2.4 Mbps in 20 MHz
- for packet size of 1024 bytes, the network efficiency coefficient is about 0.5=> 0.5x6=3 Mbps in 20 MHz
- Splitting the needed communication frames in 40% with 256 bytes and 60% with 1024 bytes, the average birate would be 2.8 Mbps.
- Finally, the available bitrate in 50 MHz would be 7 Mbps.

As a consequence, this network topology using only a BPSK modulation scheme presents a spectral efficiency of 0.14 bps/Hz

- **QPSK**

With 802.11a,

- 12 Mbps needs 20 MHz
- for packet size of 256 bytes, the network efficiency coefficient is about 0.35=> 0.35x12=4.2 Mbps in 20 MHz
- for packet size of 1024 bytes, the network efficiency coefficient is about 0.5=> 0.45x12=5.4 Mbps in 20 MHz
- Splitting the needed communication frames in 40% with 256 bytes and 60% with 1024 bytes, the average birate would be 4.92 Mbps.
- Finally, the available bitrate in 50 MHz would be 12.3 Mbps.

As a consequence, this network topology using only a QPSK modulation scheme presents a spectral efficiency of 0.246 bps/Hz.

| Consideration in the scenario | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Application** | **Explanation** | **Main and standard streets** | **Highway** | **IVC/R2V** | **Byte per message** | **Repetition rate** | **Number of stations in scenario** | **Safety critical or not** | **Permanent*/ Occasional** | **Needed bandwidth (kbits/s)** | **Modulation scheme** | **Needed symbol rate (kbauds)** |
| 1 | **Slow Vehicle Warning** | aids in preventing rearend collisions to slow moving vehicles | | x | IVC | 210 | 10 | 5 | Y | O | 84 | BPSK<br>QPSK | 84<br>42 |
| 2 | **Work Zone Warning** | Roadside beacons would broadcast the warning data to vehicles as they approach a work zone or construction zone. | | x | IVC/R2V | 250 | 10 | 2 | Y | O | 40 | BPSK | 40 |
| 3 | **Post-Crash Warning** | warns approaching traffic of a disabled vehicle (accident or mechanical breakdown) that is stuck in or near traffic lanes | | x | IVC | 210 | 10 | 10 | Y | O | 168 | BPSK | 168 |
| 4 | **Approaching emergency vehicle warning** | provides the driver a warning to yield the right of way to an approaching emergency vehicle | | x | IVC | 240 | 5 | 1 | Y | O | 10 | BPSK | 10 |
| 5 | **Emergency Electronic Break Lights** | when a vehicle brakes hard, the Emergency Electronic Brake light application sends a message to other vehicles following behind | | x | IVC | 210 | 10 | 10 | Y | O | 168 | BPSK<br>QPSK | 168<br>84 |
| 6 | **Traffic signal efficiency** | presents an optimal speed (to exploit green light) to the driver | x | | R2V | 440 | 4 | 20 | N | P | 282 | QPSK | 141 |
| 7 | **Traffic signal violation** | uses infrastructure-to-vehicle communication to warn the driver to stop at the legally prescribed location if the traffic signal indicates a stop and it is predicted that the driver will be in violation | x | | R2V | 200 | 10 | 30 | Y | P | 480 | BPSK<br>QPSK | 480<br>240 |
| 8 | **Emergency Vehicle Signal Preemption** | allows an emergency vehicle to request right of way from traffic signals in its direction of travel. | x | | R2V | 250 | 5 | 1 | Y | O | 10 | BPSK | 10 |
| 9 | **Heart beat signal** | create a neighbourhood table to control the ad hoc network | x | x | IVC/R2V | 150 | 1 | 500 | Y | P | 600 | BPSK | 600 |
| 10 | **In-Vehicle Signage** | provides the driver with information that is typically conveyed by traffic signs | x | x | R2V | 180 | 5 | 50 | N | P | 360 | BPSK<br>QPSK | 360<br>180 |
| 11 | **Local Hazard Map download** | Local intersection maps | x | | R2V | 5720 | 4 | 8 | N | O | 1464 | QPSK | 732 |
| 12 | **Hazardous goods routing** | routing of trucks with hazardous goods through restricted areas | x | x | R2V | 830 | 10 | 30 | N | O | 1992 | QPSK | 996 |
| 13 | **Cooperative area routing** | Find local route if street blocked | x | | R2V | 840 | 4 | 10 | N | O | 269 | QPSK | 135 |
| 14 | **Cooperative traffic control** | Traffic management<br>Information to and from specific vehicles | x | x | R2V | 1200 | 2 | 20 | N | P | 384 | QPSK | 192 |
| 15 | **Dynamic bus lanes** | bus lanes for other traffic | x | | R2V | 600 | 2 | 20 | N | O | 192 | BPSK<br>QPSK | 192<br>96 |
| 16 | **Cooperative traveller assistance** | Provide guidance to drivers | x | x | R2V | 720 | 1 | 30 | N | O | 173 | BPSK<br>QPSK | 173<br>87 |
| 17 | **Parking book and monitor** | Reserve parking and get guidance | x | | R2V | 1150 | 1 | 25 | N | P | 230 | BPSK<br>QPSK | 230<br>115 |

** In this study, an application is considered as permanent when being active all the time.*

**Table 2: Needed symbol rates for the various applications included in the considered scenario**

## Summary of the results:

| Type of application | Base Case (all BPSK) | Case 1 | Case 2 |
|---|---|---|---|
| Main, standard streets and highways | 6905 | 4711 | 3868 |
| Main, standard streets and highways reduced to critical road safety applications only | 1560 | 1560 | 1236 |
| Main, standard streets and highways reduced to permanent applications only | 2335 | 2003 | 1468 |
| Main, standard streets and highways reduced to critical road safety applications and permanent applications only | 1080 | 1080 | 840 |

**Table 3: Needed symbol rates (kbauds) taking into account apportionment between BPSK and QPSK modulation schemes**

The symbol rates can be translated into spectrum requirements.

| Type of application | Base Case (all BPSK) | Case 1 | Case 2 |
|---|---|---|---|
| Main, standard streets and highways | 50 MHz | 36 MHz | 30 MHz |
| Main, standard streets and highways reduced to critical road safety applications only | 11.5 MHz | 11.5 MHz | 9 MHz |
| Main, standard streets and highways reduced to permanent applications only | 17 MHz | 16 MHz | 11.5 MHz |
| Main, standard streets and highways reduced to critical road safety applications and permanent applications only | 8 MHz | 8 MHz | 6.5 MHz |

**Table 4: Needed bandwidth (MHz) taking into account apportionment between BPSK and QPSK modulation schemes**

## Conclusion

The scenario was presented to be a realistic scenario, which presents not the worst case concerning possible applications and number of communication nodes. All the distinctions between different categories of roads, critical safety or traffic efficiency presented here are based on this scenario. Therefore the result does not show the range of spectrum requirements from the minimum up to the worst case but different cases for a given scenario. Three cases were identified (base case, case 1 and 2).

In this scenario, taking into account the assumed packet lengths, the estimation of the spectral efficiency leads to 0.14 bps/Hz for a BPSK and 0.246 bps/Hz for QPSK.

For the base case scenario presented for IVC and R2V applications a traffic load of 6.9 Mbit/s is calculated, which leads to a 50 MHz bandwidth requirement. When QPSK modulation is used for some of the transmissions (cases 1 and 2), the bandwidth requirement decreases to 36 and 30 MHz respectively.

It is important to mention, that the calculated throughput only considers a static network. Under real conditions the channel access is worse considering the moving vehicles and the hidden nodes problem.

# *Annex 4 - List of Abbreviations.*

| **Abbreviation** | **Explanation** |
|---|---|
| BBDR | Broadband Disaster Relief |
| BFWA | Broadband Fixed Wireless Access |
| BPSK | Binary Phase Shift Keying. |
| BWA | Broadband Wireless Access. |
| CEPT | Conference of European Postal and Telecommunications Administrations |
| CPE | Customer Premise Equipment. |
| DSRC | Dedicated Short Range Communication. |
| EC | European Commission |
| ECC | Electronic Communications Committee |
| e.i.r.p. | Equivalent isotropically radiated power |
| EFC | Electronic Fee Collection. |
| ERC | European Radiocommunications Committee |
| ETSI | European Telecommunications Standards Institute |
| FCC | Federal Communications Commission |
| FLANE | Fixed Local Area Network Extension |
| FS | Fixed Service |
| FSS | Fixed Satellite Service. |
| IA | Impact Assessment. |
| ISM | Industrial, Scientific and Medical applications |
| ISO | International Organisation for Standardisation |
| ISS | Inter Satellite Service |
| IVC | Inter Vehicle Communication. |
| ITU | International Telecommunication Union |
| ITS | Intelligent Transport System |
| MGWS | Multiple Gigabit Wireless Systems. |
| NPV | Net Present Value |
| RSE | Road Side Equipment. |
| RTTT | Road Transport and Traffic Telematics |
| R2V | Roadside-to-Vehicle Communications |
| SRD | Short Range Devices |
| SRD/MG | Short Range Devices/Maintenance Group |
| V2R | Vehicle-to-Roadside Communications |
| WLAN | Wireless Local Area Network. |
| WPAN | Wireless Personal Area Network. |

# Annex 5 - List of Relevant Documents.

[1] ECC Report 101: Compatibility Studies in the Band 5855– 5925 MHz between Intelligent Transport Systems (ITS) and other Systems

[2] ECC Report 109: 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

[3] ECC Report 113: Compatibility studies around 63 GHz between Intelligent Transport Systems (ITS) and other systems.

[4] Radio Regulations (www.itu.int)

[5-1] TR 102 492-1 : Intelligent Transport Systems (ITS); Technical characteristics for pan-European harmonized communications equipment operating in the 5 GHz frequency range and intended for critical road-safety applications; System Reference Document

[5-2] TR 102 492-2 : Technical characteristics for pan-European harmonized communications equipment operating in the 5 GHz frequency range intended for road safety and traffic management, and for non-safety related ITS applications; System Reference Document

[6] CEPT/ERC Recommendation 70-03: Short Range Devices (SRD)

[7] ECC Dec (02)01: ECC Decision of 15 March 2002 on the frequency bands to be designated for the coordinated introduction of Road Transport and Traffic Telematics Systems

[8] TR 102 400: Intelligent Transport Systems (ITS); Road Traffic and Transport Telematics (RTTT); Technical characteristics for communications equipment in the frequency band from 63 GHz to 64 GHz; System Reference Document

[9] European Commission (EC) (2002a) Communication from the Commission on Impact Assessment, COM (2002) 276 Final, Brussels

[10] ECC Report 80: Enhancing Harmonisation and Introducing Flexibility in the Spectrum Regulatory Framework

[11] ECC Decision (06)04: ECC Decision of 24 March 2006 amended 6 July 2007 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz

[12] ITU-R Recommendation SM.1538-1: “Technical and operating parameters and spectrum requirements for short range radiocommunication devices”

[13] Dissertation at the TH Aachen, chair of communication networks of Prof. Walke:
Performance evaluation of the standards HIPERLAN/2 and IEEE 802.11 for wireless local networks
B. Hettich, Nov. 2000