

Regulation and Compatibility study of UWB radar in Japan (Proposals) in the quasi millimeter wave band

1. Interim Solution at 24GHz band (Proposal)
2. Long term Solution at 26GHz band (Proposal)
3. Summary

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22 March 2007

SARA members: Audi, Avtovaz, BMW, DaimlerChrysler, Fiat, Ford, GM, Jaguar, MAN, Opel, Porsche, Saab, Seat, Skoda, Volkswagen, Volvo, Autocruise, Autoliv, Bosch, CEL, Continental Temic, Delphi, Hella, Infineon, InnoSent, Mitsubishi Electric, Siemens VDO, s.m.s., STMicroelectronics, Takata-Petri, TDK, TRW, Tyco Electronics, ValeoRaytheonSystems, Visteon.

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日本における準ミリ波帯UWBレーダ導入 に関する運用及び共用検討（案）

1. 24GHz帯の暫定運用（案）
2. 26GHz帯の長期運用（案）
3. まとめ

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2007年3月22日

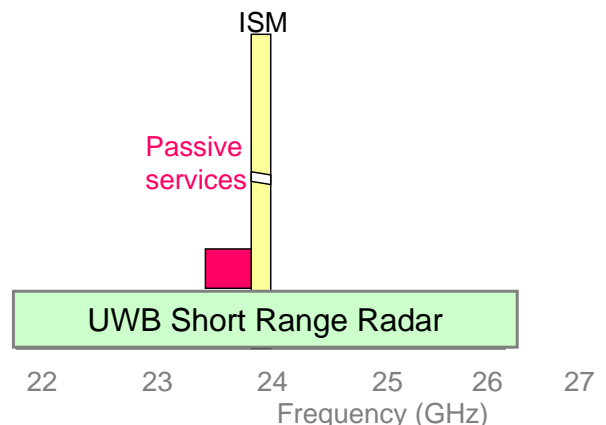
SARA members: Audi, Avtovaz, BMW, DaimlerChrysler, Fiat, Ford, GM, Jaguar, MAN, Opel, Porsche, Saab, Seat, Skoda, Volkswagen, Volvo, Autocruise, Autoliv, Bosch, CEL, Continental Temic, Delphi, Hella, Infineon, InnoSent, Mitsubishi Electric, Siemens VDO, s.m.s., STMicroelectronics, Takata-Petri, TDK, TRW, Tyco Electronics, ValeoRaytheonSystems, Visteon.

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1. Interim Solution at 24GHz band (Proposal)

1.1 Outline of Interim Solution at 24GHz band (Proposal)

- Frequency band:
24.15GHz +/- 2.5GHz
- e.i.r.p. Average PSD:
below -41.3dBm/MHz
- e.i.r.p. Peak power:
below 0dBm/50MHz
- Only automotive purpose
- Deactivation area in the vicinity of RAS,
protection radius to be defined
- Time limitation to be defined



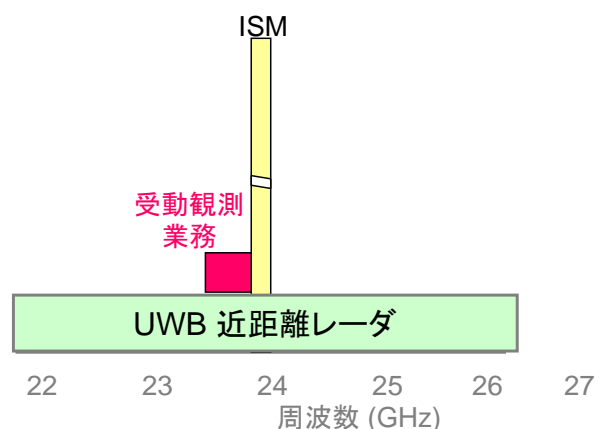
If the prediction is up to 1% based on the total number of cars in Japan, SRR density is calculated as follows:

(Total number of cars in Japan 79 million cars) x 1%	= (790 thousands cars)
(4 SRR/car in average) x (790 thousands cars)	= (3.16 million SRR)
(3.16 million SRR) / (Whole area in Japan 380 thousand km ²)	= (8.3 SRR/km ²)

1. 24GHz帯の暫定運用(案)

1.1 24GHz帯の暫定運用(案)の概要

- 周波数帯域
24.15GHz +/- 2.5GHz
- e. i. r. p. 平均輻射密度
-41.3dBm/MHz 以下
- e. i. r. p. 尖頭電力
0dBm/50MHz 以下
- 使用用途を車載用に限定
- RA基地局周辺では使用禁止エリアを定める
- 導入可能期限を設定



仮に普及限度を1%と設定すると、近距離レーダの台数密度は以下の通り、

(日本の車両保有台数約7900万車両) × 1%	= (79万車両)
(平均搭載数を4台) × (79万車両)	= (316万台)
(316万台) ÷ (日本の国土面積約38万km ²)	= (8.3台/km ²)

1. Interim Solution at 24GHz band (Proposal)

1.2 Compatibility study of Interim Solution at 24GHz band (Proposal)

	RAS	EESS	FS
Permitted UWB Radar EIRP (ITU-R TG1/8)	-91.3 dBm/MHz (100SRR/km ² , Spectral observation)	-66.6 dBm/MHz (AMSU-A, 453cars/km ² , 5% apportionment)	-41.3 dBm/MHz (Study Case 2)
UWB radar PSD EIRP	-41.3 dBm/MHz		
Required isolation	50.0 dB	25.3 dB	0.0 dB
Mitigation factors			
Equipped rate 1% 8.3 SRR/km ² *	10.8 dB (100 => 8.3 SRR/km ²)	23.4 dB (453x4 => 8.3 SRR/km ²)	20.0 dB (100% => 1%)
Activity factor (ITU-R TG1/8)	3.0 dB		
Specific study**	105.7 dB	-	-
Total	119.5 dB	26.4dB	23.0 dB
Margin	69.5 dB	1.1 dB	23.0 dB

* Average for whole Japan, car availability is not considered

** See next page (Nobeyama: 9km exclusion radius)

SARA members: Audi, Avtovaz, BMW, DaimlerChrysler, Fiat, Ford, GM, Jaguar, MAN, Opel, Porsche, Saab, Seat, Skoda, Volkswagen, Volvo, Autocruise, Autoliv, Bosch, CEL, Continental Temic, Delphi, Hella, Infineon, InnoSent, Mitsubishi Electric, Siemens VDO, s.m.s., STMicroelectronics, Takata-Petri, TDK, TRW, Tyco Electronics, ValeoRaytheonSystems, Visteon.

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1. 24GHz帯の暫定運用(案)

1.2 24GHz帯の暫定運用(案)の共用検討

	電波天文 (RAS)	地球探査衛星 (EESS)	固定局 (FS)
UWBレーダ EIRP 許容値 (ITU-R TG1/8)	-91.3 dBm/MHz (100SRR/km ² , スペクル線観測)	-66.6 dBm/MHz (AMSU-A, 453車両/km ² , 5%割当)	-41.3 dBm/MHz (検討2)
UWBレーダ輻射	-41.3 dBm/MHz		
必要な離隔	50.0 dB	25.3 dB	0.0 dB
考慮される低減要素			
装着率 1% 8.3台/km ² *	10.8 dB (100 → 8.3台/km ²)	23.4 dB (453 × 4 → 8.3台/km ²)	20.0 dB (100% → 1%)
稼働率 (ITU-R TG1/8)	3.0 dB		
個別の共用検討**	105.7 dB	-	-
合計	119.5 dB	26.4 dB	23.0 dB
必要な離隔との差分	69.5 dB	1.1 dB	23.0 dB

* 全国の平均、自動車の使用率を考慮していない

** 次頁参照(野辺山天文台: 9.0kmの離隔半径)

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1. Interim Solution at 24GHz band (Proposal)

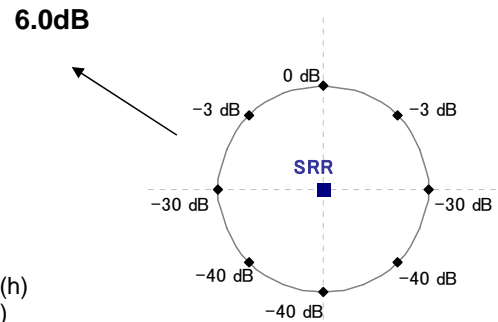
1.3 Specific study for RAS

Further Mitigation factors

Clutter loss*	7.0 dB
Bumper loss*	3.0 dB
SRR Antenna directivity**	6.0 dB
Car Availability***	13.2 dB
Diffraction loss****	76.5 dB
Total	105.7 dB

* ITU-R TG1/8 (See the link below)

** Average loss by horizontal directivity:



*** Rate of cars with Engine ON

74.7%: Rate of day time driving

35(km/h): Average speed

9807(km): Average driving distance per year

(Driving distance per day) = 9807 (km/year) / 365 = 26.9(km/day)

(Car usage time per day) = 26.9 (km/day) x 74.7% / 35(km/h) = 0.57(h)

(Car availability) = 0.57(h) / 12(h) (day time) = 4.8% (=> **13.2 dB**)

**** Specific study for Nobeyama Observatory (9km exclusion radius), See next page

Reference:

http://www.soumu.go.jp/joho_tsusin/policyreports/joho_tsusin/uwb_wlssystem/pdf/070131_1_si5.pdf

<http://www.mlit.go.jp/road/ir/ir-data/20040812.pdf>

<http://www.meti.go.jp/committee/materials/downloadfiles/g41116b40j.pdf>

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1. 24GHz帯の暫定運用(案)

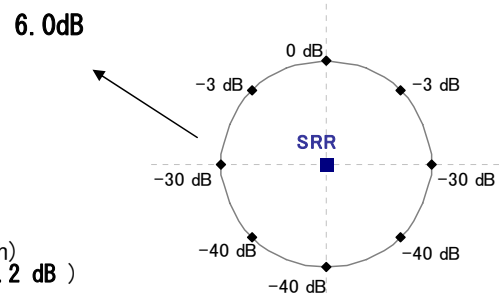
1.3 RASの個別検討

更なる低減要素

拡散損失*	7.0 dB
バンパー損失*	3.0 dB
SRRアンテナ指向性**	6.0 dB
自動車の使用率***	13.2 dB
回折損失****	76.5 dB
合計	105.7 dB

* ITU-R TG1/8 (下のリンクを参照)

** 水平方向指向性による平均損失:



*** エンジン始動車両の割合

74.7%: 日中走行の割合

35(km/h): 平均速度

9807(km): 年平均走行距離

(1日の走行距離) = 9807 (km/year) / 365 = 26.9(km/day)

(1日の使用時間) = 26.9 (km/day) x 74.7% / 35(km/h) = 0.57(h)

(自動車の使用率) = 0.57(h) / 12(h) (日中) = 4.8% (=> **13.2 dB**)

**** 野辺山天文台の個別検討(9kmの離隔半径), 次頁参照

引用元: 第2回UWBレーダ作業班配布資料「ITU-R TG1/8の干渉検討の例」

http://www.soumu.go.jp/joho_tsusin/policyreports/joho_tsusin/uwb_wlssystem/pdf/070131_1_si5.pdf

平成11年度 道路交通センサスの概要

<http://www.mlit.go.jp/road/ir/ir-data/20040812.pdf>

ディーゼル乗用車の経済分析、ガソリン車・ハイブリッド車との比較 株式会社三菱総合研究所

<http://www.meti.go.jp/committee/materials/downloadfiles/g41116b40j.pdf>

SARA members: Audi, Avtovaz, BMW, DaimlerChrysler, Fiat, Ford, GM, Jaguar, MAN, Opel, Porsche, Saab, Seat, Skoda, Volkswagen, Volvo, Autocruise, Autoliv, Bosch, CEL, Continental Temic, Delphi, Hella, Infineon, InnoSent, Mitsubishi Electric, Siemens VDO, s.m.s., STMicroelectronics, Takata-Petri, TDK, TRW, Tyco Electronics, ValeoRaytheonSystems, Visteon.

1. Interim Solution at 24GHz band (Proposal)

1.4 Specific study for Nobeyama Observatory

Diffraction loss

$$L_d = 6.9 + 20 \log \left(\sqrt{(\nu - 0.1)^2 + 1} + \nu - 0.1 \right) \text{ dB}$$

where,

$$\nu = -h_c \sqrt{\frac{2}{\lambda} \left(\frac{1}{d_1} + \frac{1}{d_2} \right)}$$

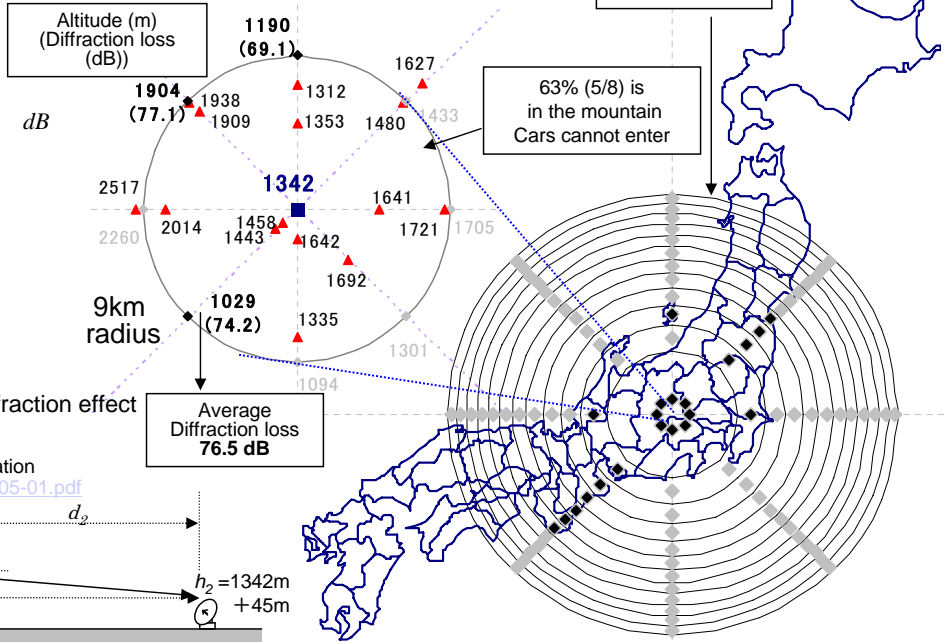
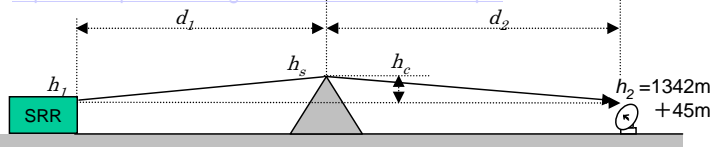
$$h_c = \frac{h_1 d_2 + h_2 d_1}{d_1 + d_2} - \frac{d_1 d_2}{2Ka} - h_s$$

Ka: 8500(km)

Effective Earth radius with refraction effect

Reference: Jun-ichi TAKADA, Basic Theory of Radiowave Propagation

<http://www.apmc-mwe.org/mwe2005/src/TL/TL05-01.pdf>



78% (75/96) is on the sea

63% (5/8) is in the mountain
Cars cannot enter

Average Diffraction loss
76.5 dB

500km radius from Nobeyama RAS

SARA members: Audi, Avtovaz, BMW, DaimlerChrysler, Fiat, Ford, GM, Jaguar, MAN, Opel, Porsche, Saab, Seat, Skoda, Volkswagen, Volvo, Autocruise, Autoliv, Bosch, CEL, Continental Temic, Delphi, Hella, Infineon, InnoSent, Mitsubishi Electric, Siemens VDO, s.m.s., STMicroelectronics, Takata-Petri, TDK, TRW, Tyco Electronics, ValeoRaytheonSystems, Visteon.

1. 24GHz帯の暫定運用(案)

1.4 野辺山天文台の個別検討

回折損失

$$L_d = 6.9 + 20 \log \left(\sqrt{(\nu - 0.1)^2 + 1} + \nu - 0.1 \right) \text{ dB}$$

ここで、

$$\nu = -h_c \sqrt{\frac{2}{\lambda} \left(\frac{1}{d_1} + \frac{1}{d_2} \right)}$$

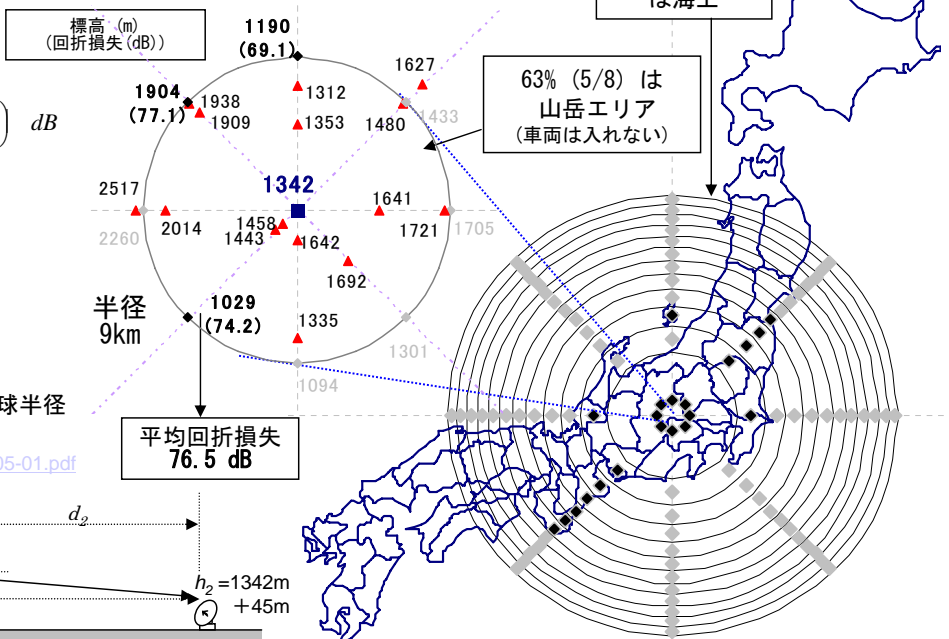
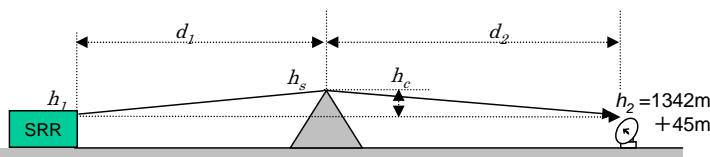
$$h_c = \frac{h_1 d_2 + h_2 d_1}{d_1 + d_2} - \frac{d_1 d_2}{2Ka} - h_s$$

Ka: 8500(km)

大気の屈折を考慮した等価地球半径

引用元: 電波伝搬の基礎理論, 著者 高田 潤一

<http://www.apmc-mwe.org/mwe2005/src/TL/TL05-01.pdf>



78% (75/96) は海上

63% (5/8) は山岳エリア
(車両は入れない)

平均回折損失
76.5 dB

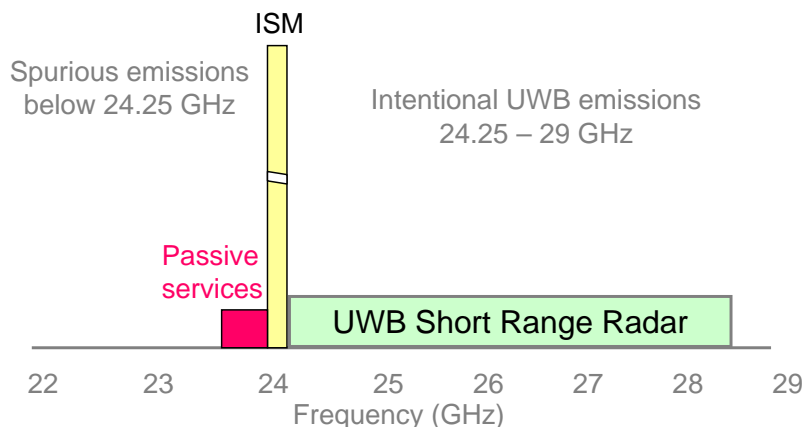
野辺山天文台から半径500km

SARA members: Audi, Avtovaz, BMW, DaimlerChrysler, Fiat, Ford, GM, Jaguar, MAN, Opel, Porsche, Saab, Seat, Skoda, Volkswagen, Volvo, Autocruise, Autoliv, Bosch, CEL, Continental Temic, Delphi, Hella, Infineon, InnoSent, Mitsubishi Electric, Siemens VDO, s.m.s., STMicroelectronics, Takata-Petri, TDK, TRW, Tyco Electronics, ValeoRaytheonSystems, Visteon.

2. Long term Solution at 26GHz band (Proposal)

2.1 Outline of Long term Solution at 26GHz band (Proposal)

- Frequency band:
24.25 – 29.0 GHz
- e.i.r.p. Average PSD:
below -41.3dBm/MHz
- e.i.r.p. Peak power:
below 0dBm/50MHz
- Only automotive purpose
- No limitation in car fleet or time



if the car penetration is up to 40% (predicted in 2030 by ITU-R TG1/8), SRR density is calculated as follows;

(Total number of cars in Japan 79 million cars) x 40%	= (31.6 million cars)
(4 SRR/car in average) x (31.6 million cars)	= (126.39 million SRR)
(126.39 million SRR) / (Whole area in Japan 380 thousand km ²)	= (335 SRR/km ²)

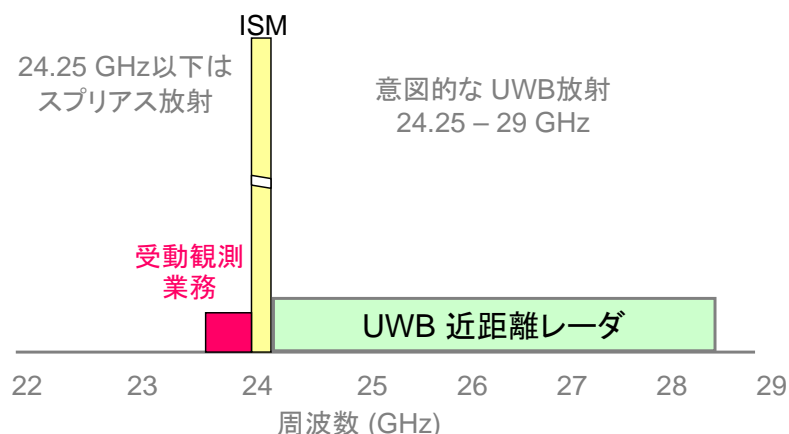
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2. 26GHz帯の長期運用(案)

2.1 26GHz帯の長期運用(案)の概要

- 周波数帯域
24.25 - 29.0GHz
- e. i. r. p. 平均輻射密度
-41.3dBm/MHz 以下
- e. i. r. p. 尖頭電力
0dBm/50MHz 以下
- 使用用途を車載用に限定
- 導入可能期限を設定しない



普及予測を自動車保有台数の40%(ITU-R TG1/8の2030年の予測値)と仮定すると
近距離レーダの台数密度は以下の通り、

(日本の車両保有台数約7900万車両)	×	40%	=	(3,160万車両)
(平均搭載数を4台)	×	(3,160万車両)	=	(12,639万台)
(12,639万台)	÷	(日本の国土面積約38万km ²)	=	(335台/km ²)

SARA members: Audi, Avtovaz, BMW, DaimlerChrysler, Fiat, Ford, GM, Jaguar, MAN, Opel, Porsche, Saab, Seat, Skoda, Volkswagen, Volvo, Autocruise, Autoliv, Bosch, CEL, Continental Temic, Delphi, Hella, Infineon, InnoSent, Mitsubishi Electric, Siemens VDO, s.m.s., STMicroelectronics, Takata-Petri, TDK, TRW, Tyco Electronics, ValeoRaytheonSystems, Visteon.

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2. Long term Solution at 26GHz band (Proposal)

2.2 Compatibility study of Long term Solution at 26GHz band (Proposal)

	FS
Permitted UWB Radar EIRP (ITU-R TG1/8 study case 2)	-41.3 dBm/MHz
UWB radar PSD EIRP	-41.3 dBm/MHz
Required isolation	0 dB
Mitigation factors	
Equipped rate 40 % (ITU TG1-8)	4.0 dB (100% => 40%)
Activity factor (ITU-R TG1/8)	3.0 dB
Total	7.0 dB
Margin	7.0 dB

- Emissions into the passive band 23.6–24.0 GHz (EESS, RAS) are reduced by at least 20 dB due to the frequency shift (spurious-emissions are below -61.3 dBm/MHz) . In comparison to the 24 GHz solution this will result in an additional margin of 4 dB (car fleet 1% => 40% =16 dB) . That means 4 dB more conservative for the RAS and EESS compatibility than that of 24GHz band.

SARA members: Audi, Avtovaz, BMW, DaimlerChrysler, Fiat, Ford, GM, Jaguar, MAN, Opel, Porsche, Saab, Seat, Skoda, Volkswagen, Volvo, Autocruise, Autoliv, Bosch, CEL, Continental Temic, Delphi, Hella, Infineon, InnoSent, Mitsubishi Electric, Siemens VDO, s.m.s., STMicroelectronics, Takata-Petri, TDK, TRW, Tyco Electronics, ValeoRaytheonSystems, Visteon.

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2. 26GHz帯の長期運用(案)

2.2 26GHz帯の長期運用(案)の共用検討

	FS
UWBレーダ EIRP 許容値 (ITU-R TG1/8 検討2)	-41.3 dBm/MHz
UWBレーダ輻射	-41.3 dBm/MHz
必要な離隔	0.0 dB
考慮される低減要素	
装着率 40%	4.0 dB (100% → 40%)
稼働率 (ITU-R TG1/8)	3.0 dB
合計	7.0 dB
必要な離隔との差分	7.0 dB

- 受動観測帯域 23.6–24.0 GHz (EESS, RAS) への輻射は20dB以上減衰(スプリアス放射は-61.3dBm/MHz以下) RAS, EESSの共用については、24GHz帯の検討に比べて (16dB:装着率1% => 40%)、4dBマージン大

SARA members: Audi, Avtovaz, BMW, DaimlerChrysler, Fiat, Ford, GM, Jaguar, MAN, Opel, Porsche, Saab, Seat, Skoda, Volkswagen, Volvo, Autocruise, Autoliv, Bosch, CEL, Continental Temic, Delphi, Hella, Infineon, InnoSent, Mitsubishi Electric, Siemens VDO, s.m.s., STMicroelectronics, Takata-Petri, TDK, TRW, Tyco Electronics, ValeoRaytheonSystems, Visteon.

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➤ Start with 24 GHz band

- Cars with 24GHz Short Range Radar are on the market in some foreign countries (in more than 50 countries incl. Europe and US), and can contribute to road safety also in Japan right now.

➤ Flexible Allocation 26 GHz band

- Any emissions into the passive band (EESS and RAS) will be minimized and will only be spurious emissions.
- More advantage than the millimeter wave band from the point of view for early market introduction.

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3. まとめ

➤ 初めに、24 GHz帯

- 24GHz帯近距離レーダ搭載車両は、既に諸外国（欧米を含む50ヶ国以上）で市場導入されており、現時点で日本の交通安全にも貢献可能

➤ 26 GHz帯の柔軟な割当

- パッシブ周波数帯 (EESS, RAS) への輻射はスプリアスレベルであり、その影響は限定的
- 早期普及の観点でもミリ波帯に比べて有利

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