CEPT ECC
Electronic Communications Committee

Addendum to ECC Report 344

Interference mitigation scenarios for outdoor Security Scanners Type #2

approved 23 May 2025

0 EXECUTIVE SUMMARY

This Addendum to ECC Report 344 [10] provides interference mitigation scenarios for outdoor usage of type#2 Security Scanners (SSc #2). It covers mitigation of interference from SSc #2 to ground based vehicular radars and to the radio astronomy service (RAS), which are not fully covered by ECC Report 344.

Automotive Radars

The studies showed that there is no risk of interference from outdoor SSc #2 to automotive radars when there is a separation distance greater than 18 meters under worst case assumptions and a separation distance greater than 5 meters with SSc #2 lower emissions by 10 dB.

Radio astronomy

The calculated separation distances for a generic case range from 35.2 km and 36.8 km depending on the occupied bandwidth. The results of the single-input case indicate the separation distance based on worst case assumptions. Sites, such as Plateau de Bure (NOEMA) and Sardinia (SRT), indicate small areas due to natural terrain shielding, while sites such as IRAM 30 m indicate a larger distance is required, approximately 45 km towards Granada city. The calculated separation distance from the Onsala site by land is approximately 5 km.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
AR	Automotive radar
BEL	Building entry loss
BW	Bandwidth
DC	Duty cycle
ECC	Electronic Communications Committee
e.i.r.p.	Equivalent isotropic radiated power
$\mathbf{G_{max}}$	Maximum antenna gain
ITU-R	Radiocommunication Sector of International Telecommunication Union
MCL	Minimum Coupling Loss
PSD	Power spectral density
RAS	Radio astronomy service
Rx	Receiver
SSc #2	Security scanner type 2

1 INTRODUCTION

This addendum to ECC Report 344 aims to assess the impact to ground based vehicular radars and radio astronomy service from outdoor security scanners (SSc), in the frequency range 76.5-80.5 GHz based on updated information of the outdoor security scanners and additional mitigation techniques.

2 TECHNICAL SPECIFICATIONS FOR OUTDOOR SSC #2

Technical specifications for outdoor SSc #2 are provided in Table 1.

Table 1: Technical specifications for outdoor SSc #2

Requirement	Limit / value / description
Functionality	Unlike security scanners based on single gates, the SSc #2 security scanner operates in open spaces and detects concealed weapons on multiple persons simultaneously.
System area coverage of each sensor	Typical operational volume is depicted in Figure 2. Distance (radius) 15 m; Azimuth angle coverage $\pm 45^0$; Height 2 m
Tx peak power *e.i.r.p.*	19 dBm
Tx mean power *e.i.r.p.* over Ton (10.4 ms)	19 dBm
Waveform	Linear FM (LFM Chirp) of 20µs time duration
Period time (signal repetition time)	100 ms
Tx Chirps sequence	Sequential 432 chirps (one after the other) within the total period of time.
Bandwidth	Minimum 1.5 GHz, maximum 4 GHz
Duty Cycle (see Annex 1)	10.4%: Mean power transmission time (on time / T_{on}) within the period: 10.4 ms. No transmission time (off time) within the period: 89.6 ms.
Tx mean power *e.i.r.p.* average over signal repetition time	9.2 dBm: 19 dBm (peak) + 10 x log(0.104) = 9.2 dBm
Antenna pattern parameter	Antenna element pattern $\pm 45^0$ in both horizontal & vertical dimension. Antenna element broadside gain ≤ 6 dBi
Installation height	Central antenna array height 1 m to 2 m
System installation structure	Two face to face sensors. Typical deployment is depicted in Figure 3
System coverage of two sensors:	Area of about 240 square meter. Volume of about 480 quadratic meter

Two insignificant parameter updates from ECC Report 344 are defined in Table 2 herein and updated in the MCL analysis of ECC Report 344, section 3.1.4:

- 3.1 The Tx chirp waveform duration Tch = 24 µs instead of 20 µs defined in ECC Report 344;
- 3.2 The number of Tx channels, hence number of chirps in single frame Nch = 432 instead of 200-400 defined in ECC Report 344.

Table 2: Updated SSc #2 parameters

SSc #2 parameters	Updated Parameter value	Report 344 Parameter value	Parameter units
Tx Chirp waveform duration (Tch)	24	20 (# 3.1.4)	µs
Number of Tx chirps in single frame (Nch)	432	200-400 (# 3.1.4)	N/A

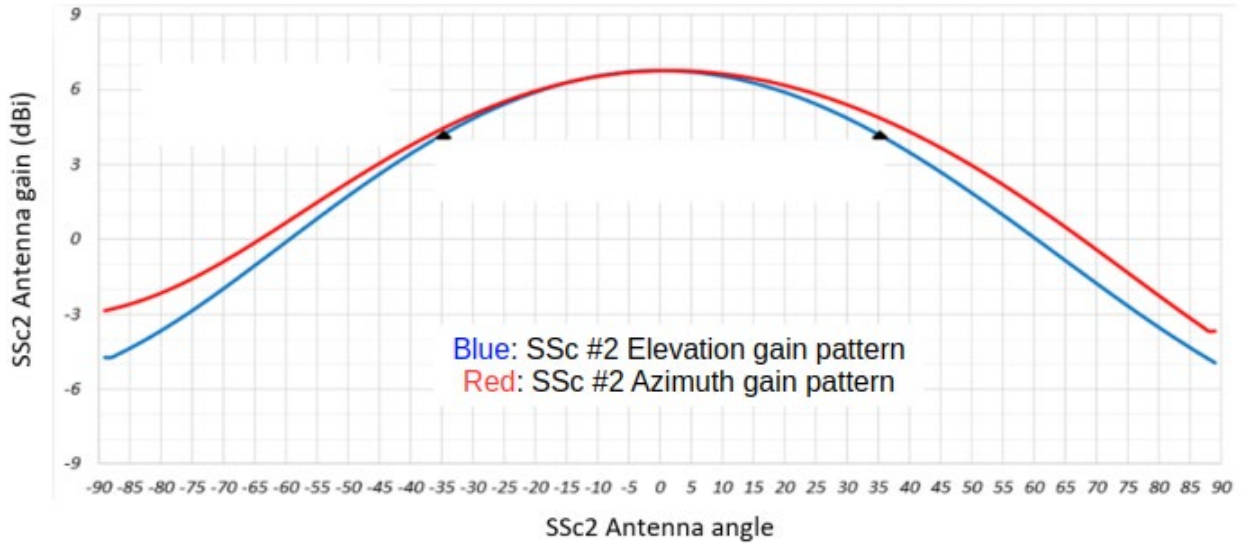


Figure 1: SSc #2 Antenna pattern

Figure 1 presents the SSc #2 antenna pattern in its front hemisphere. Back hemisphere pattern is negligible and practically zero due to SSc #2 structure and wall behind. SSc #2 transmit antenna is patch type with circular polarisation. Figure 1 has two-coloured curves present SSc #2 antenna gain in elevation (Blue) & azimuth (red). The resulted SSc #2 area coverage is given in Figure 2:

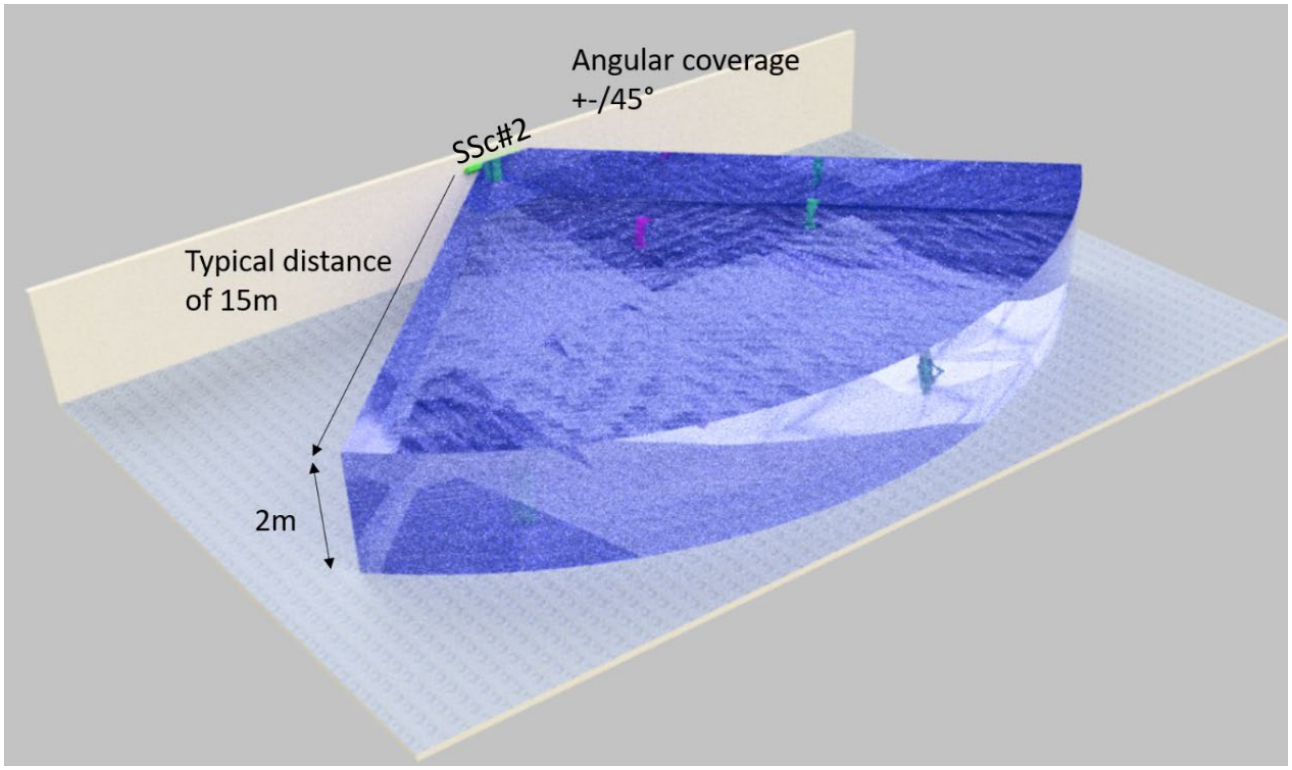


Figure 2: SSc #2 area coverage of each sensor

Figure 3 shows an illustrative example of how an SSc #2 could be deployed at a building's external entrance, or where the side walls do not provide significant attenuation.



Figure 3: SSc #2 typical deployment

3 SHARING/COMPATIBILITY STUDIES

3.1 SHARING STUDY BETWEEN SSC #2 AND AUTOMOTIVE RADAR (AR)

3.1.1 MCL Study

This study focuses on calculating the separation distance between the SSc #2 and an AR antenna using an Minimum Coupling Loss (MCL) approach. The separation distance represents the maximum separation distance at which interference between the security scanner and the AR receiver is mitigated under specified conditions.

The maximum separation distance is determined under the assumption that the SSc #2 antenna is directly oriented toward the AR, while the AR is pointing in one fixed direction. This alignment represents a worst-case scenario for interference. Only outdoor scenarios are considered. In this context, no Building Entry Loss (BEL) is applied.

The study examines two distinct types of antennas used in vehicles, referred to AR Type A and Type B whose patterns are defined in Recommendation ITU-R M.2057 [12]. For the security scanner, no antenna pattern was used. Instead, it is assumed to point at the AR. Antenna patterns are integral to the advanced MCL approach, as they influence the coupling losses and the interference thresholds at various distances.

The mean power spectral density (PSD) emission level of the SSc #2 in this study is based on information given in section 2. It is calculated to be -39.6 dBm/MHz and its derivation can be found in Table 3.

Table 3: Mean PSD derivation for SSc #2

Parameter	Value	Description / Source
Tx mean e.i.r.p over Ton	19 dBm/1500 MHz	Mean in 1.5 GHz BW
Tx antenna height	1 m	Worst case value
Tx BWtx	1500 MHz	Bandwidth
Tx DC	- 9.8 dB	= 10*log (10,4 ms / 100 ms)
Modulation gain	- 17 dB	= 10*log (2*BWrx_IF/BWtx) (ECC Report 262, section 7.1.3 [15])
Tx mean e.i.r.p over signal repetition time	-7,8 dBm/1500 MHz	= Mean *e.i.r.p.* over Ton - DC - Modulation gain
Bandwidth factor	- 31.76 dB	= 10*log(1MHz/BWtx)
Tx mean PSD	- 39,6 dBm/MHz	= e.i.r.p - bandwidth factor

Table 4 summarises the relevant receiver parameters followed up by a simple MCL calculation.

Table 4: MCL Parameters for AR study

Parameter	Value	Source / Formula
Frequency	78.5 GHz	Lowest allocated frequency in relevant range
Rx Antenna height	1 m	Worst case value
Rx BWrx	1500 MHz	Occupied Bandwidth
Rx BWrx_IF	15 MHz	ECC Report 344, table 3 [10] (worst-case value from range 200 kHz – 15 MHz)

Parameter	Value	Source / Formula
Rx NF	15 dB	ECC Report 344, table 3 [10]
Rx I/N (protection criterion)	-6 dB	ECC Report 344
Rx PSD_I_{max}	-104.9 dBm/MHz	$= 10 * \log_{10}(k * T * 1\ MHz) + \ NF + I/N$
Rx G_{max} Type A	30.0 dBi	Recommendation ITU-R M.2057 [12]
Rx G_{max} Type B	23.0 dBi	Recommendation ITU-R M.2057
MCL Type A	95.3 dB	$= PSD_{SSc} - \ PSD_{Imax} + G_{Type\ A\ Rx}$
MCL Type B	88.3 dB	$= PSD_{SSc} - \ PSD_{Imax} + G_{Type\ B\ Rx}$
Separation distance Type A	~ 18 m	Free Space Loss
Separation distance Type B	~ 8 m	Free Space Loss

The parameters used for this study deviate in comparison with the ones used in ECC Report 344 [10]. The difference is given in Table 5.

Table 5: Comparison of assumptions with ECC Report 344 [10]

Parameter	This study	ECC Report 344	Comment
Rx G_{max} Type A	30.0 dBi	25.0 dBi	
Polarisation Loss	0 dB	-3 dB	
Bandwidth factor	-31.76 dB	-31.76 dB	In ECC Report 344, both factors were regarded as the same
Modulation gain	-17 dB		BWrx_IF of 15 MHz is used as worst case in this study. In ECC Report 344, 0.5 MHz was used
DC	-9.8 dB	0 dB	
Rx PSD_I_{max}	-104.9 dBm/MHz	-107.84 dBm/0.5 MHz	In ECC Report 344, 0.5 MHz was regarded instead of 1 MHz
Separation distance Type A	18 m	217 m	

3.1.2 MCL Study Setup

To aid in understanding the setup and methodology, a schematic diagram is provided. Figure 4 illustrates a top-down view of the scenario, highlighting the relative positions of the security scanner, the AR receiver, and the surrounding area under analysis.

The antennas are positioned at the same height (1 meter), with no vertical separation. The calculations are confined to outdoor scenarios, disregarding any building-related losses. Both antenna types used in the study (Type A and Type B) are standard configurations for vehicle applications.

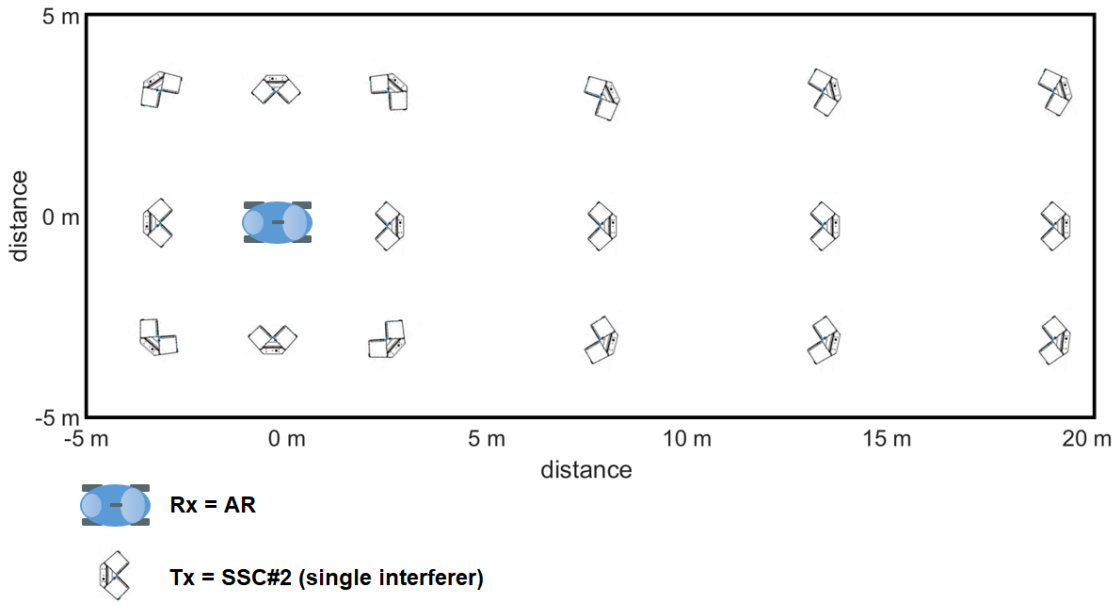


Figure 4: MCL scenario top view for AR study

3.1.3 MCL Study Calculation

The interference calculations are performed for a defined area surrounding the AR receiver. Each point within this area is individually assessed to account for the antenna patterns of both the transmitting and receiving systems. Vertical separation between the antennas is not considered, AR both the security scanner and the AR receiver antennas are mounted at a standard height of 1 meter above the ground.

The coloured areas in the resulting plots highlight the amount of exceedance of the protection criterion. A red contour highlights the potential area where protection criterion is exceeded. The parameters used and also the results are noted on the plots, respectively.

Clutter losses are not considered for this calculation.

The propagation model used is the Free Space Loss model described in Recommendation ITU-R P.525 [13].

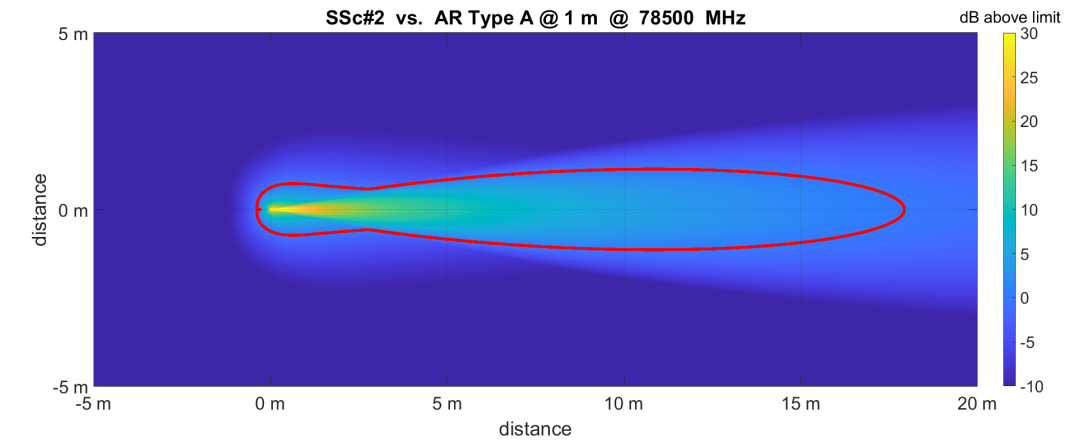
Circle radius results represent the minimum range where interference was found. This is usually located in the back lobe of the victim antenna.

Peak radius results represent the maximum range where interference was found. This is usually located in the main lobe of the victim antenna.

The maximum received *e.i.r.p.* level found on the plot and its corresponding distance is noted below the plot.

Main beam to main beam results represent the classical MCL calculation, where no vertical nor horizontal geometry was considered. In this case it is equal to the peak radius.

The result for AR type A, which are assumed to be directed in driving direction, is a pencil shaped zone (red curve) from within which interference would occur. It is shown in Figure 5. A closer look at the shape reveals that interference from the side can be excluded. In contrast to this, the separation distance in main beam direction is 18 m. This could be regarded as difficult for specific scenarios outdoors, e.g. at crossroads or bends. Therefore, a sensitivity analysis was done for a 10 dB less PSD value of SSc #2. From Figure 6, it can be seen that the separation distance would be reduced to 5 m.



Parameters Rx
B=1500.0 MHz
h=1.0 m
Gmax=30.0 dBi
I/N=-6.0 dB
NF=15.0 dB
L_Feed=0.0 dB
I_limit=-104.9 dBm/MHz

Parameters Tx
f=78.500 GHz
P=-7.8 dBm
B=1500.0 MHz
PSD=-39.6 dBm/MHz
h=1.0 m
Gmax=0.0 dBi
BW_factor=0 dB

Parameters ITU-R P.452-18
not used, FSL used instead

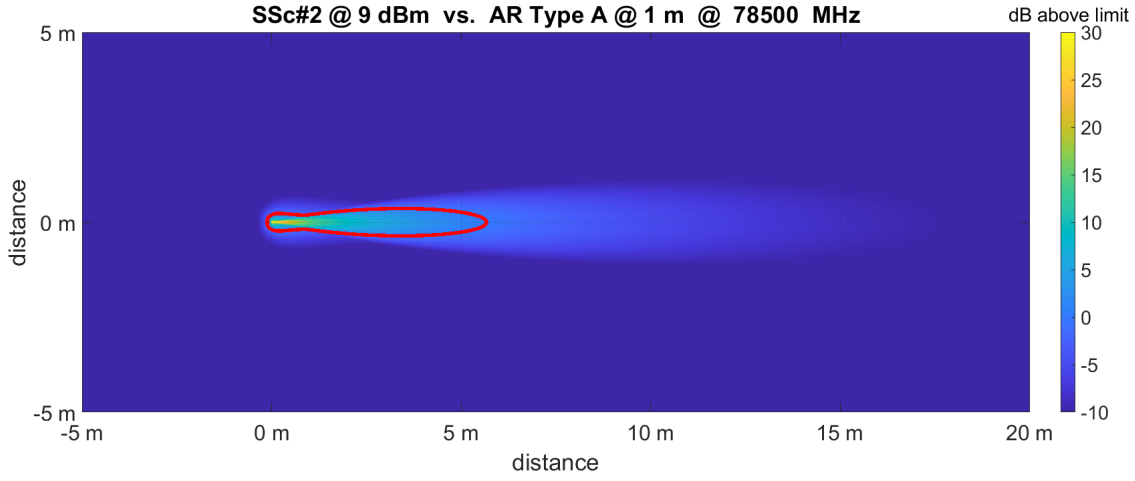
Parameters ITU-R P.2108-1
not used

Parameters ITU-R P.2109-2
not used

Results
Circle radius = 0.000 km
Peak radius = 0.018 km
max exc. = 63.1 dB @ 0.0 km

Main beam <-> Main beam = 0.018 km

Figure 5: Results for outdoor SSc #2 @ 19 dBm vs. AR type A



Parameters Rx
B=1500.0 MHz
h=1.0 m
Gmax=30.0 dBi
I/N=-6.0 dB
NF=15.0 dB
L_Feed=0.0 dB
I_limit=-104.9 dBm/MHz

Parameters Tx
f=78.500 GHz
P=-17.8 dBm
B=1500.0 MHz
PSD=-49.6 dBm/MHz
h=1.0 m
Gmax=0.0 dBi
BW_factor=0 dB

Parameters ITU-R P.452-18
not used, FSL used instead

Parameters ITU-R P.2108-1
not used

Parameters ITU-R P.2109-2
not used

Results
Circle radius = 0.000 km
Peak radius = 0.006 km
max exc. = 53.1 dB @ 0.0 km

Main beam <-> Main beam = 0.006 km

Figure 6: Results for outdoor SSc #2 @ 9 dBm vs. AR type A

The same calculations were done for AR type B antennas, which are assumed to be directed to the side of the driving direction, as victim. Results are shown in Figure 7 and Figure 8. Due to the lower antenna gain, the shape is in general smaller with a separation distance of 8 m. This could be regarded as difficult for specific scenarios outdoors, e.g. high populated areas with building entrances close to the streets. Therefore, a sensitivity analysis was done for a 10 dB less PSD value of SSc. The separation distance would be reduced to 2.5 m.

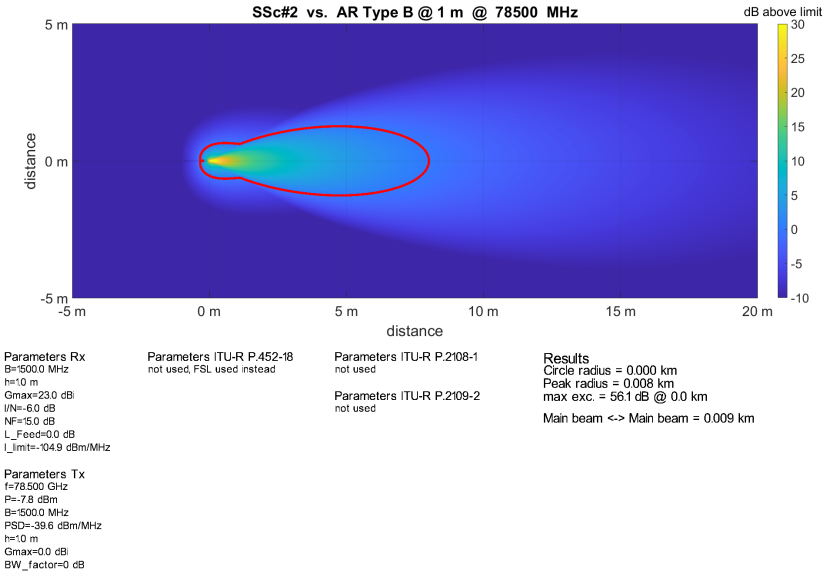


Figure 7: Results for outdoor SSc #2 @ 19 dBm vs. AR Type B

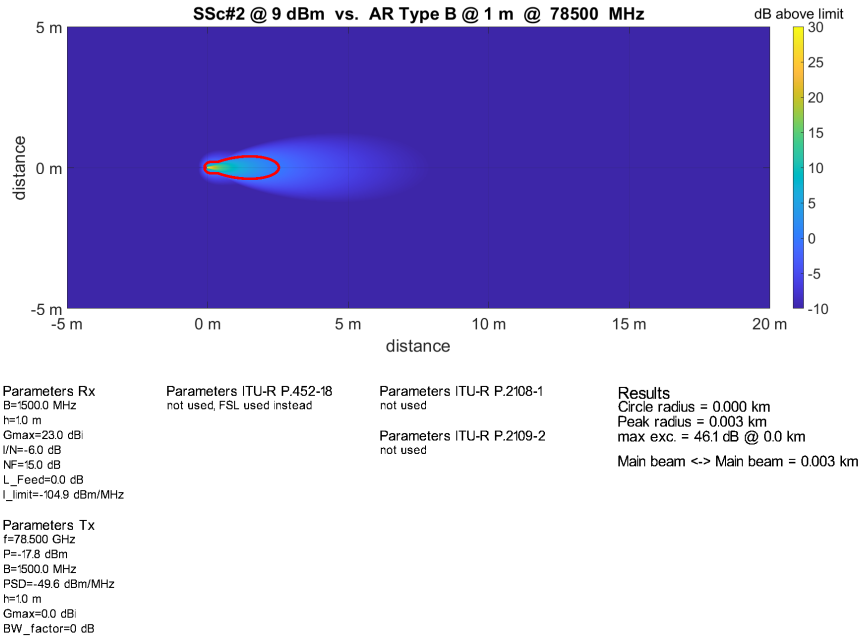


Figure 8: Results for outdoor SSc #2 @ 9 dBm vs. AR Type B

3.1.4 Conclusions

The MCL study between SSc #2 and automotive radars found a maximum separation distance of 18 m under worst case assumptions. It could happen that both devices will operate within 18 m distance and therefore a calculation was done with 10 dB lower emissions. The result led to 5 m separation distance.

4 SHARING STUDY BETWEEN SSC #2 AND RADIOASTRONOMY

Spectral lines of different molecules in the interstellar medium are observed using leading radio telescopes such as the IRAM 30 m radio telescope (Pico Veleta, Spain), the NOEMA interferometer (Plateau de Bure, France), the Onsala 20 m radio telescope (Sweden) and the 40 m radio telescope in Yebes (Spain). Observations include large prebiotic molecules such as CH3OH, CH3C5N and long carbon chains (HC3N, HC9N, C3N, C5H, etc.). Deuterated molecules such as DNC, DC3N and N2D+ (especially the N2D+ J=1-0 line at 77.1 GHz) serve as tracers of pre-stellar condensations during the phase when stars are ready to form but the interstellar gas remains cold. Exploration of the 76-81 GHz frequency range also includes the study of extra-galactic emission through highly redshifted CO lines. The analysis of these lines is important for understanding star formation within galaxies.

The frequency bands of the Radio Astronomy Service and its status according to the ERC Report 25 [1] is shown in Table 6.

Table 6: RAS allocated bands in the frequency range 76.5-80.5 GHz

Frequency bands	RAS status
76.0-77.5 GHz	primary
77.5-78 GHz	secondary
78.0-79.0 GHz	secondary
79.0-81.0 GHz	primary

As per footnote No. 5.149 of the Radio Regulations [14], administrations are urged to take all practicable steps to protect the RAS from harmful interference, includes the 76-86 GHz frequency band. The recommended protection levels are provided in Recommendation ITU-R RA.769-2 [2], with Table 7 specifying threshold levels for continuum observations, which apply here. As Recommendation ITU-R RA.769 does not specify levels for the range 76 - 86 GHz, the threshold values for 89 GHz are considered.

4.1 OUTLINE OF THE STUDY

Given the application of Security Scanners and the restriction to outdoor scenarios for this analysis, a dense distribution is not considered. Therefore, a single-entry worst-case study was considered. The calculations in this study were performed using the free open-source python package, pycraf [3].

4.1.1 SSc #2 parameters

The parameters of SSc #2 operated in the frequency range 76.5-80.5 GHz are listed in Table 7.

Table 7: SSc #2 parameters operated in the frequency range 76.5-80.5 GHz

System Parameter	Value	Remarks
Tx frequency band	76.5-80.5 GHz	
Central frequency	78.5 GHz	Used for calculations
Tx peak *e.i.r.p.*	19 dBm	The transmitter gain is already considered into *e.i.r.p.*.
Occupied bandwidth	min: 1.5 GHz max: 4.0 GHz	

System Parameter	Value	Remarks
Duty Cycle	10.4%	Percentage of time where the signal is active. Peak power transmission time (on time) within the period: 10.4 ms. No transmission time (off time) within the period: 89.6 ms.
Transmitter Height, h_{Tx}	2.0 m	

4.1.2 RAS receiver parameters

Protection criteria for RAS are defined in Recommendation ITU-R RA.769-2 [2] and summarised in Table 8. As no value is given in this table for the specific frequency bands considered in this Addendum, the thresholds for 89 GHz are used.

Table 8: Radio astronomy technical parameters.

System Parameter	Value	Remarks
Integration time	2000 s	Recommendation ITU-R RA.769-2
Side lobe gain, G_R	0 dBi	Recommendation ITU-R RA.769-2, only side lobe receptions need to be considered
Threshold power level for interference, P_{lim}	-189 dBW	Recommendation ITU-R RA.769-2, table 1 for continuum observations
Effective RAS bandwidth	8000 MHz	Recommendation ITU-R RA.769-2, table 1 for continuum observations
Antenna height, h_{RT}	Depending on the study	See Table 10 and Table 12

4.2 METHODOLOGY TO DEFINE SEPARATION DISTANCES

The calculation to determine how a RAS site can be protected is often based on defining separation distance, within which transmitters under study would not be operated. or be installed. This calculation relies on the link budget, which is expressed as the power received by the RAS station, and the protection criterion for radio astronomy observations as specified in Recommendation ITU-R RA.769.

The received spectral power at the RAS station is as follows:

$$P_R = P_T + G_R + G_T - (PL + CL + AL)$$

Where (all values in dB scale):

- P_R: the power received by the radio astronomy receiver (dBm);
- P_T: the transmitter power (dBm) into RAS bands or transmitted spectral power (dBm/MHz);
- G_R: the gain of the radio telescope in the direction of the transmitter, which is assumed to be 0 dBi (representing a mean sidelobe gain of this value) in accordance with Recommendation ITU-R RA.769-2;
- G_T: the (side-lobe) gain of the transmitter in the direction of the radio receiver (set to 0 dBi, if PT is provided as *e.i.r.p.*);
- PL: Path propagation loss according to Recommendation ITU-R P.452-17 (excluding clutter losses, but including atmospheric attenuation) (The time percentage used in the calculations is 2%);
- CL: Clutter losses (according to Recommendation ITU-R P.452-17) set to zero for single-entry worst-case scenario;

- AL: Additional loss may occur due to other contributions, such as mitigation technique like duty cycle.

For the single-input case, clutter is not considered, so it represents the worst-case scenario. It is possible that the signal reaching the RAS receiver encounters no clutter. The margin, which represents the difference between the actual link budget and the minimum coupling loss (MCL), is determined to derive separation distances around RAS sites. The MCL depends on the technical parameters listed above. The MCL formula is expressed as follows:

$$MCL = EIRP - P_{lim}\ (dB)$$

4.3 GENERIC CASE STUDY

The simplest approach is to consider a generic site in which a flat terrain (Earth curvature is considered) is assumed but otherwise the same propagation model as for the site-specific scenarios is applied (Recommendation ITU-R P.452 [11]). Considering the generic input parameters shown in Table 9.

Table 9: Parameters for generic case scenario

Parameter	Value	Note
Height RAS	30.0 m	Generic height station

Table 10: Separation distances for generic case

Scenario	Peak power	Duty cycle	Occupied bandwidth	Separation Distance (no clutter)
Outdoor	19 dBm	10.4 %	1.5 GHz	36.8 km
Outdoor	19 dBm	10.4 %	4.0 GHz	35.2 km

The separation distances for a generic case are ranging from 35.2 km and 36.8 km depending on the occupied bandwidth.

The generic site case study represents the worst-case scenario. Therefore, it is recommended that site-specific studies, where separation distances are typically smaller, are also evaluated during deployment.

4.4 SITE-SPECIFIC SCENARIO

Real terrain elevation data, Lidar or SRTM databases were considered [4]. Table 11 lists radio telescopes of CEPT counties (with geographical characteristics) which potentially operate in the frequency band 76-81 GHz according to Report ITU-R RA.2457 [8] and ECC Report 350 [9]. In this analysis, the occupied bandwidth is considered to be 1.5 GHz.

Table 11: European radio astronomy stations potentially operating in the 76-81 GHz band

Observatory Name	Administration	Longitude (E)	Latitude (N)	Altitude (m amsl)	Antenna Height (m)
Metsähovi	Finland	24°23'36"	60°13'05"	80	7
Plateau de Bure (NOEMA)	France	05°54'28.5"	44°38'02"	2553	8

Observatory Name	Administration	Longitude (E)	Latitude (N)	Altitude (m amsl)	Antenna Height (m)
Maido	France	55°23'01"	-21°04'46"	2200	2
Effelsberg	Germany	06°53'01"	50°31'29.4"	369	50
BEST	Hungary	19°31'00"	47°54'00"	240	9
Sardinia (SRT)	Italy	09°14'42"	39°29'34"	600	32
Medicina	Italy	11°38'49"	44°31'15"	28	16
Noto	Italy	14°59'20.5"	36°52'33.8"	90	16
RAEGE Santa María	Portugal	-25°07'33.2"	36°59'7.1"	247	9
Pico Veleta (IRAM 30 m)	Spain	-03°23'34"	37°03'58"	2850	17
Yebes	Spain	-03°05'13"	40°31'28.8"	980	22
Onsala	Sweden	11°55'04"	57°23'35"	18	10

This analysis is carried out at four radio observatory sites (IRAM 30 m [6], SRT [4], Onsala [7] and NOEMA [5]), where the area covers a 200 km square around the site. The path attenuation map (left) and areas having an interference potential (right) are shown in figures 9-12. For the second image, the areas having an interference potential are shown both with the duty cycle of 10.4% (solid red line) and as if it were 100% (dashed grey line).

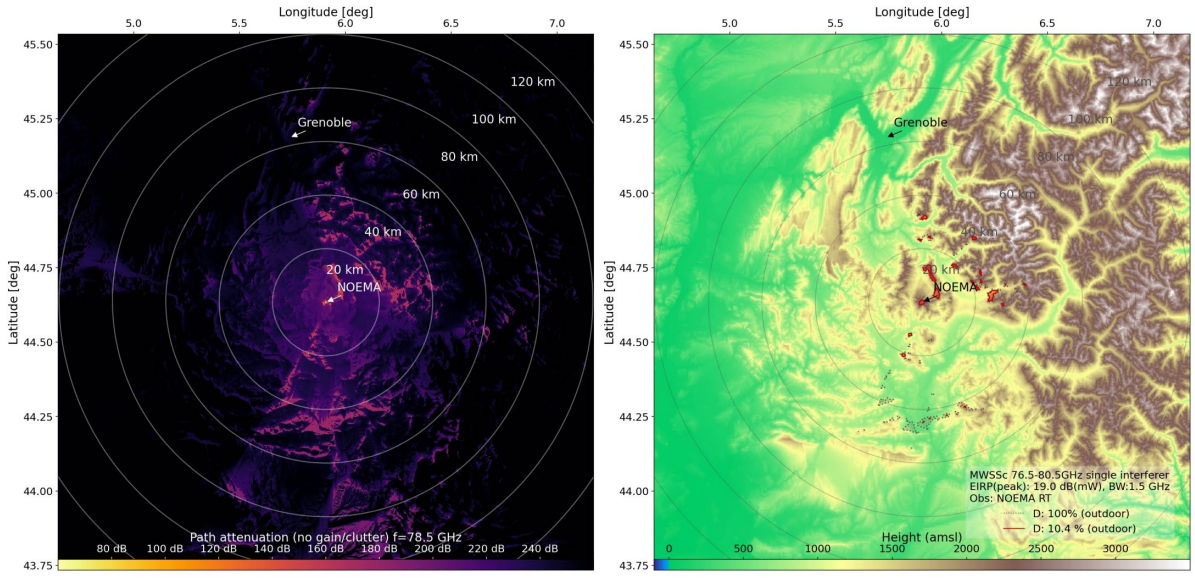


Figure 9: Areas having a single-entry interference potential around the NOEMA radio astronomy site

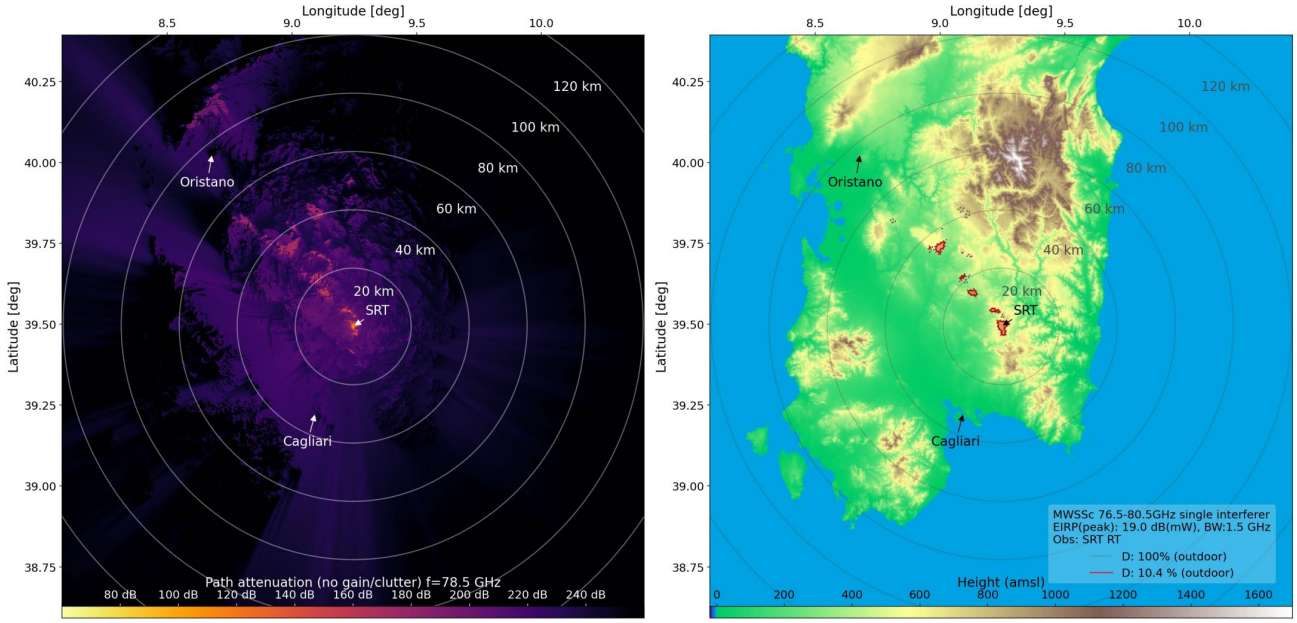


Figure 10: Areas having a single-entry interference potential around SRT radio astronomy site

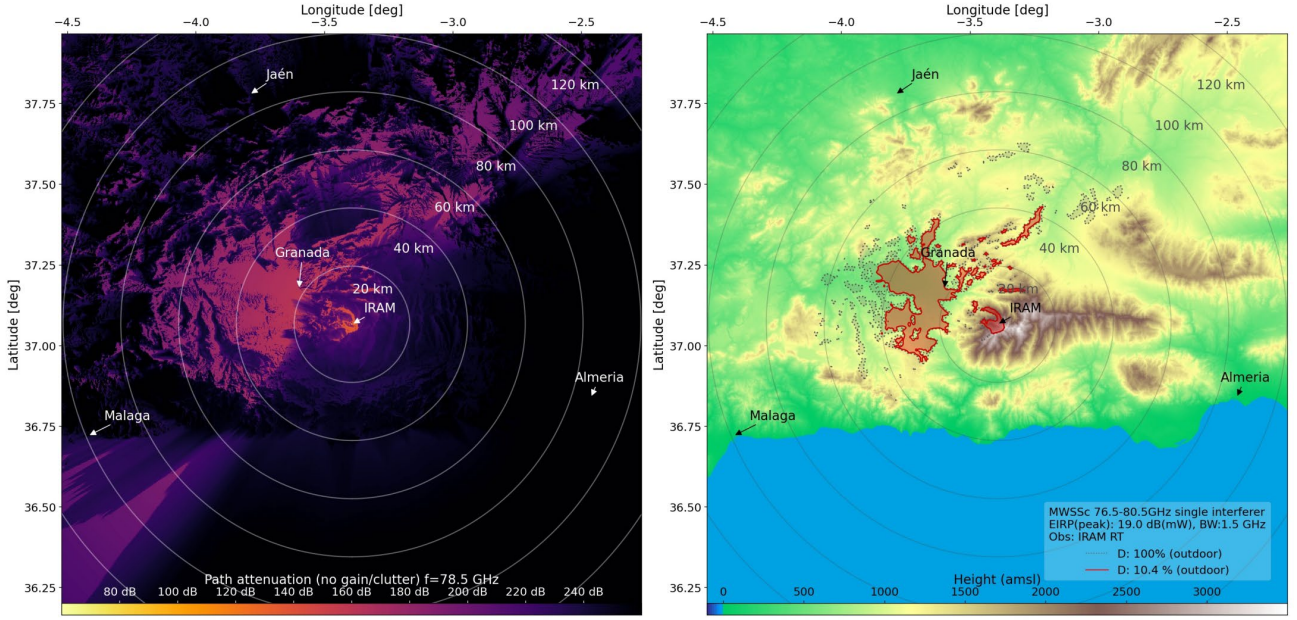


Figure 11: Areas having a single-entry interference potential around IRAM 30 m radio astronomy site

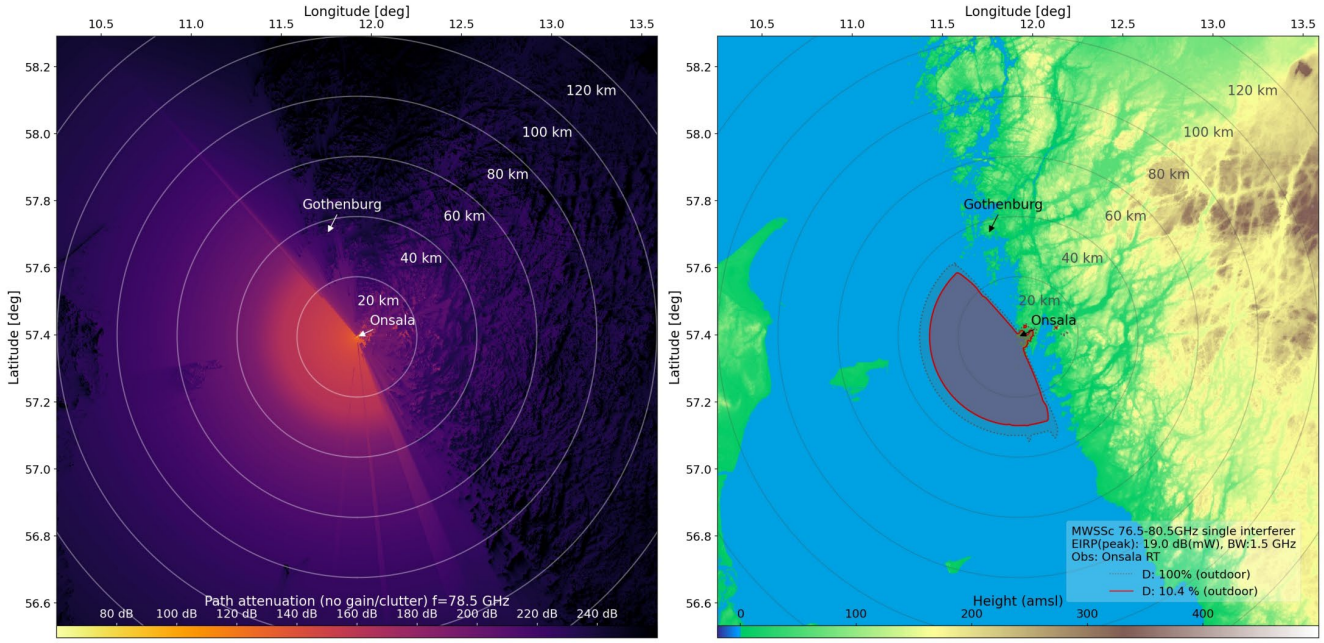


Figure 12: Areas having a single-entry interference potential around Onsala radio astronomy site

The results of the single-entry case indicate the separation distance. Sites, such as Plateau de Bure (NOEMA) and Sardinia (SRT), show small areas due to natural terrain shielding, while sites like IRAM 30 m indicate a larger area, approximately 45 km towards Granada city. The calculated separation distance from the Onsala site by land is approximately 5 km

ANNEX 1: DETAILS OF THE DUTY CYCLE

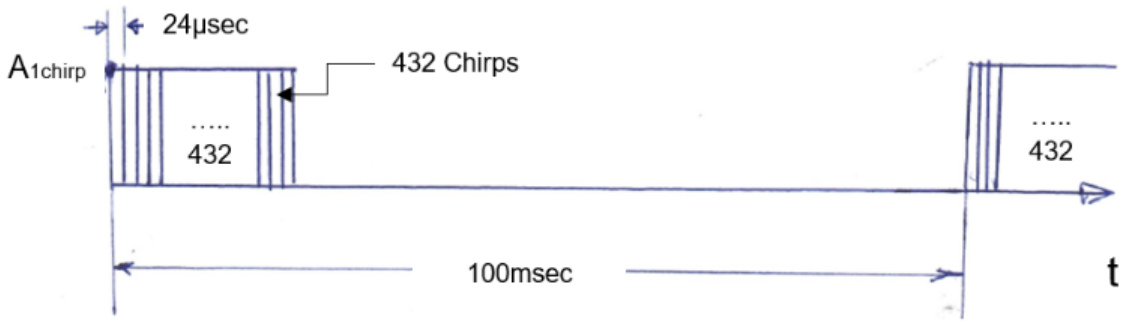


Figure 13: The SSc #2 frame waveform

1 SSc #2 waveform includes Nch = 432 transmitted chirps, each of which with duration of 24 µs, within a total period time of 100 ms.

2 Hence the SSc #2 duty cycle is:

- DCSSc #2 = 432·24{µs}/100{ms} = 10.4{ms}/100{ms} = 10.4%

ANNEX 2: LIST OF REFERENCES

[1] ERC Report 025: “The European table of frequency allocations and applications in the frequency range 8.3 kHz to 3000 GHz”, approved 1994, latest amended January 2025

[2] Recommendation ITU-R RA.769-2: “Protection criteria used for radio astronomical measurements”

[3] B. Winkel: “pycraf - compatibility studies for radio astronomy spectrum management”

[4] SRT, I: Regione Autonoma della Sardegna, Sardegna Geoportale: DTM 1 m and DTM 10 m https://www.sardegnageoportale.it/webgis2/sardegnamappe/?map=download_raster; License: Creative Commons Attribution 4.0 International (CC BY 4.0)

[5] NOEMA, F: Institut national de l’information géographique et forestière (IGN): RGE ALTI, DTM 5 m https://geoservices.ign.fr/rgealti#telechargement5m; Licence: Open License (compatible ODC-BY, CC-BY 2.0) https://www.etalab.gouv.fr/wp-content/uploads/2018/11/open-licence.pdf

[6] IRAM 30-m, E: LiDAR-PNOA assigned by Instituto Geográfico Nacional (IGN): 1) DTM05, LIDAR 1st Coverage, download month 2019-11: DTM 5m, 2) DTM02, LIDAR 2nd Coverage, download month 2019-11: https://centrodedescargas.cnig.es/CentroDescargas/; License: Creative Commons Attribution 4.0 International (CC BY 4.0)

[7] Onsala, S Lantmäteriet: “Terrain Model Download, grid 50+ https://www.lantmateriet.se/sv/geodata/vara-produkter/produktlista/markhojdmodell-nedladdning-grid-50 License: Creative Commons, CC0 1.0 Universal

[8] Report ITU-R RA.2457: “Coexistence between the radio astronomy service and radiolocation service applications in the frequency band 76-81 GHz”

[9] ECC Report 350: “Radiodetermination equipment for ground based vehicular applications in 77-81 GHz” approved February 2023

[10] ECC Report 344: “Sharing and compatibility studies of Security Scanners (SScs) within frequency range 60-82 GHz”, approved October 2022

[11] Recommendation ITU-R P.452-17: “Prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 100 MHz”

[12] Recommendation ITU-R M.2057: “Systems characteristics of automotive radars operating in the frequency band 76-81 GHz for intelligent transport systems applications”

[13] Recommendation ITU-R P.525: “Calculation of free-space attenuation”

[14] ITU Radio Regulations, edition of 2024

[15] ECC Report 262: “Studies related to surveillance radar equipment operating in the 76 to 77 GHz range for fixed transport infrastructure”, approved January 2017