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- The RvA is a signatory to the EA MLA.
- The RvA is a signatory to the ILAC MRA.
- The RvA is a signatory to the IAF MLA.

Assessment report No:
2281248.0501A-RSM

ASSESSMENT REPORT
RF EXPOSURE - MPE

(*)	Identification of item to be assessed	Radar installation
(*)	Trademark	N/A
(*)	Model and /or type reference	SMART-L
(*)	Features, other identification of the product	PSR (L-band) and MSSR (Tx=1030 MHz)
(*)	Derived model(s)	N/A
(*)	Applicant´s name / address	Ministerie van Defensie Defensie Materieel Organisatie (DMO) Directie Projecten Kromhout Kazerne | Herculeslaan 1 – 3584 AB | Utrecht Gebouw K8 | Kamer 1.A080 Postbus 90125 | 3509BB | MPC55A | Utrecht
	Assessment method requested, standard	EN 62311:2020. Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300GHz)
	Verdict Summary	IN COMPLIANCE
	Assessment / test performed by (name / position & signature)	Technical Professional EMC
	Approved by (name / position & signature)	Technical Professional EMC
	Date of issue	2024-09-18
	Report template No	TRF_RSM_EN62311 R1.0

(*) “Data provided by the applicant”

INDEX

page

COMPETENCES AND GUARANTEES

DEKRA is a testing laboratory competent to carry out the tests described in this report.

In order to assure the traceability to other national and international laboratories, DEKRA has a calibration and maintenance program for its measurement equipment.

DEKRA guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated in the report and it is based on the knowledge and technical facilities available at DEKRA at the time of performance of the test.

DEKRA is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

GENERAL CONDITIONS

1. This report is only referred to the item/system that has undergone the assessment.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or Competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of DEKRA.
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POSSIBLE ASSESSMENT CASE VERDICTS

Assessment case does not apply to test object	N/A
Assessment object does meet requirement	P (Pass) / PASS
Assessment object does not meet requirement	F (Fail) / FAIL

DEFINITION OF SYMBOLS USED IN THIS ASSESSMENT REPORT

☒ Indicates that the listed condition, standard or equipment is applicable for this report/Assessment/EUT.				
☐ Indicates that the listed condition, standard or equipment is not applicable for this report/Assessment/EUT.				
Decimal separator used in this report	☐	Comma (,)	☒	Point (.)

DATA PROVIDED BY THE APPLICANT

The following data/document has been provided by the client:

1. Information relating to the description of the system ("Identification of the item to be assessed", "Trademark", "Model and/or type reference" and Features).
2. TNO 2024 M10285 - Proposal for Periodic RadHaz Measurements of the SMART-L Radar Installation_v2.

DEKRA Certification B.V. declines any responsibility with respect to the information provided by the applicant and that may affect the validity of results.

DOCUMENT HISTORY

Report nr.	Date	Description
2281248.0501-RSM	2024-08-29	First release.
2281248.0501A-RSM	2024-09-18	Editorial corrections.

CONCLUSION, REMARKS AND COMMENTS

This is an assessment report. The assessment was done according to the EN 62311 standard.

The equipment/system under assessment meets the requirements of the applicable standard and guidelines. The measured Electric field strengths at all frequencies and all measurement points/locations are well below the limit values for the general public as advised by the ICNIRP guidelines.

1. General

Between 26 February 2024 – 28 February 2024 DEKRA Certification B.V. repeated the Electromagnetic Field measurements on the SMART-L Radar installation at Wier, province Friesland, The Netherlands. The measurements were performed according to the test plan "*TNO 2024 M10285 - Proposal for Periodic RadHaz Measurements of the SMART-L Radar Installation_v2*" provided by the applicant. The previous measurements were performed in 2021 and the results were recorded in the test report with a reference number 2251914.0501-RSM. The provided test plan was reviewed by DEKRA and discussed with the applicant. After several meetings with the applicant, the final test plan, including measurement methods, was prepared by DEKRA.

The objective of the assessment and measurements was to demonstrate the compliance of that SMART-L radar installation with the ICNIRP guidelines (ICNIRP1998 and ICNIRP2020).

1.1 Description of the equipment under assessment

The SMART-L is a combined radar system with two components: a primary surveillance radar (PSR) and a monopulse secondary surveillance radar (MSSR). The SMART-L system has two modes: rotating antenna and non-rotating antenna. Both modes have been assessed.

1.1.1 MSSR

The MSSR interrogates aircraft carrying an operational transponder. Transmission frequency is at 1030 MHz, the polarization is vertical, transponder responses are at 1090 MHz. The MSSR interrogator operates in a so-called mixed-mode, the interrogation modes A, C, S and military modes are alternated. The pulse shapes of the civilian modes are specified in the 'open literature', an example is given in the following figure. The instantaneous bandwidth is less than 12 MHz. The azimuth beamwidth of MSSR antenna is between 2 to 3°, the antenna is mounted on top of the PSR antenna and therefore rotates at the same speed (72°/s or 5 s antenna rotation time). The duty cycle is approximately 5%. In case SMART-L system operates with a non-rotating antenna, the MSSR is switched off.

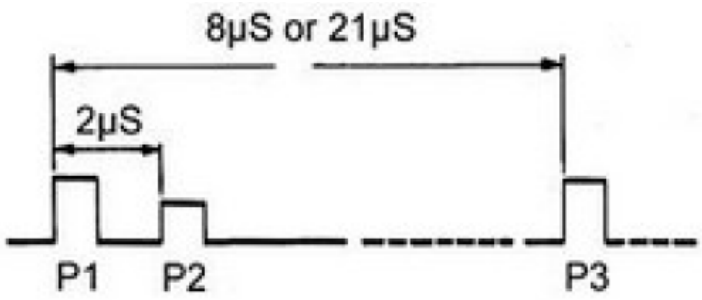


Figure 1: Transmit patterns for the modes A (requests squawk-code) and C (request barometric altitude).

1.1.2 PSR

The PSR-Primary Surveillance Radar is to observe air targets that are not necessarily equipped with a functioning transponder. The system operates in the L-band (coarsely: 1 – 1.5 GHz) and utilizes multiple frequencies in this band. The pulse duration is not constant but varies from burst-to-burst, a burst being a series of pulses. The mean duty cycle is more than 5%. The radar pulses are frequency modulated, the chirp being 2.5 MHz. The polarisation is vertical.

During the measurements the system was configured to operate in normal operation mode, not in a monochromatic mode.

1.2 Measurement locations

The measurements were performed at five different locations and two antenna heights (which represents exposures of a (tall) person and a person on the first floor of a building). The detailed test plan is given below. At each location and antenna height the electromagnetic field strength levels were measured both using max-peak and RMS detectors.

The following table which was prepared by the applicant and included in the test plan document, has been modified by DEKRA during the measurements since the MSSR and PSR transmit simultaneously in the rotating antenna mode. The MSSR cannot operate stand-alone, that's why the Radar modes AD-PSR and AD-MSSR are combined into one mode. The table given in section 2 was the final measurement table used for measurements. Since both MSSR and PSR transmit only in vertical polarisation, all measurements were performed using Vertical antenna polarisation. During the measurements of the radar system, the operation mode of the radar system was operated by the crew located at AOCS Nieuw Millingen.

Measurement number	Position	Antenna Height (m)	Radar mode (m)
1	1	2	AD – PSR
2			AD - MSSR
3			BMD
4		6	AD – PSR
5			AD - MSSR
6			BMD
7	2	2	AD – PSR
8			AD - MSSR
9			BMD
10		6	AD – PSR
11			AD - MSSR
12			BMD
13	3	2	AD – PSR
14			AD – MSSR
15			BMD
16		6	AD – PSR
17			AD – MSSR
18			BMD
19	4	2	AD – PSR
20			AD – MSSR
21			BMD
22		6	AD – PSR
23			AD – MSSR
24			BMD
25	5	2	AD – PSR
26			AD – MSSR
27			BMD
28		6	AD – PSR
29			AD – MSSR
30			BMD

1.3 Other expected RF sources

At the measurement location an overview of the other expected RF sources, in addition to the commercial RF sources like base stations, radio and TV stations, as provided by the applicant are listed below.

Frequency (MHz)	Source
1030	MSSR ATC radar, Leeuwarden airport
1090	Transponderreplies, ADS-B, FFM
2876	PSR ATC radar, Leeuwarden airport
5625	Weather radar Den Helder

1.4 Operating mode(s) used for tests

During the measurements the following operating modes have been used.

Operating mode	Operating mode description
1	Ambient noise (background) measurements
2	AD (Air Defence) mode, Rotating antenna, PSR with MSSR active.
3	BMD (Balistic Missle Defence) mode, Non-rotating. The beam is scanned electronically.

1.5 Measurement method

The measurements were done using the setup given below. In order to measure the highest electric field strength radiated by the radar system, at all positions the measurement antenna was aligned (by tilting) in the direction of the radar system. In order to verify that the measurement antenna was in the maximum field location (pertaining to the non-rotating antenna), the handheld RF exposure meter has been used.

At position 2 (150 m.) ambient noise (background) measurements were performed, at 8:30, 13:00 and 17:00 o'clock, to identify the other electromagnetic sources in the environment. During the ambient measurements, the radar system was switched off. The ambient measurements were performed at frequency range 30 MHz -18 GHz. Refer to the annex 2 for the ambient noise measurement results.

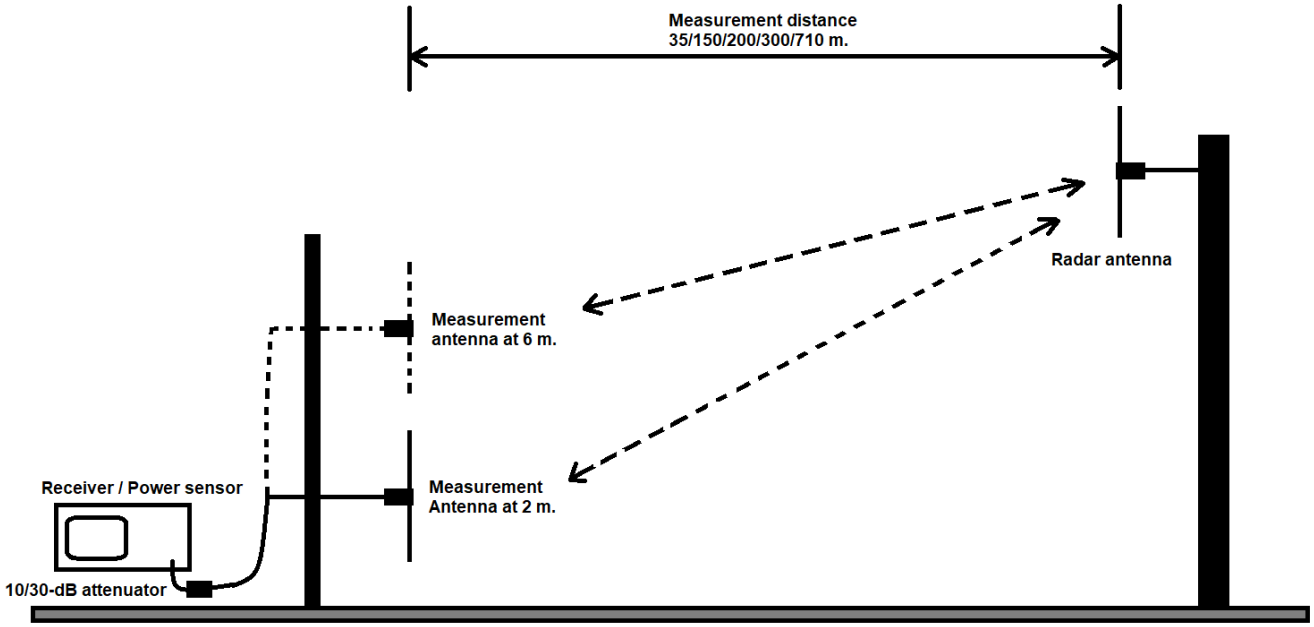
At each measurement position preliminary (pre-scan) measurements were performed using the MAX-HOLD function of the receiver. The receiver was in a continuous scan mode for a minimum of 6 minutes. Multiple scans ensure correct measurements of signals with different characteristics including pulsed signals (see figure 1.5-2 given below for further details regarding multiple scans).

At each measurement point, the measurements were performed at two different heights, 2 and 6 meters using the following methods to measure the electromagnetic field radiated by the radar system.

1. Electric field measurements using Spectrum analyser/Receiver (both with Peak and RMS detectors).
2. RF Power sensor. Both PK (peak) and RMS power values were measured.
3. Handheld RF exposure meter.

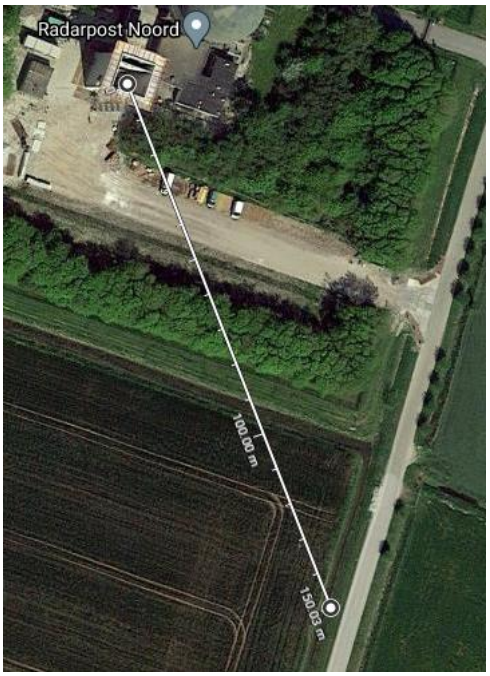
All measurements (each position and at each measurement height) were done for 6 minutes.

In order to have the worst-case scenario related to the assessment of the radar system against the ICNIRP guidelines, at all operating modes (given in the table in section 2) the highest measured values of the three measurements methods (given above) were reported.



This photo shows measurements using horn antenna and hand-held meter while the antenna and the hand-held meter are position at 2 m. height above the ground.

Position A: 35 m.



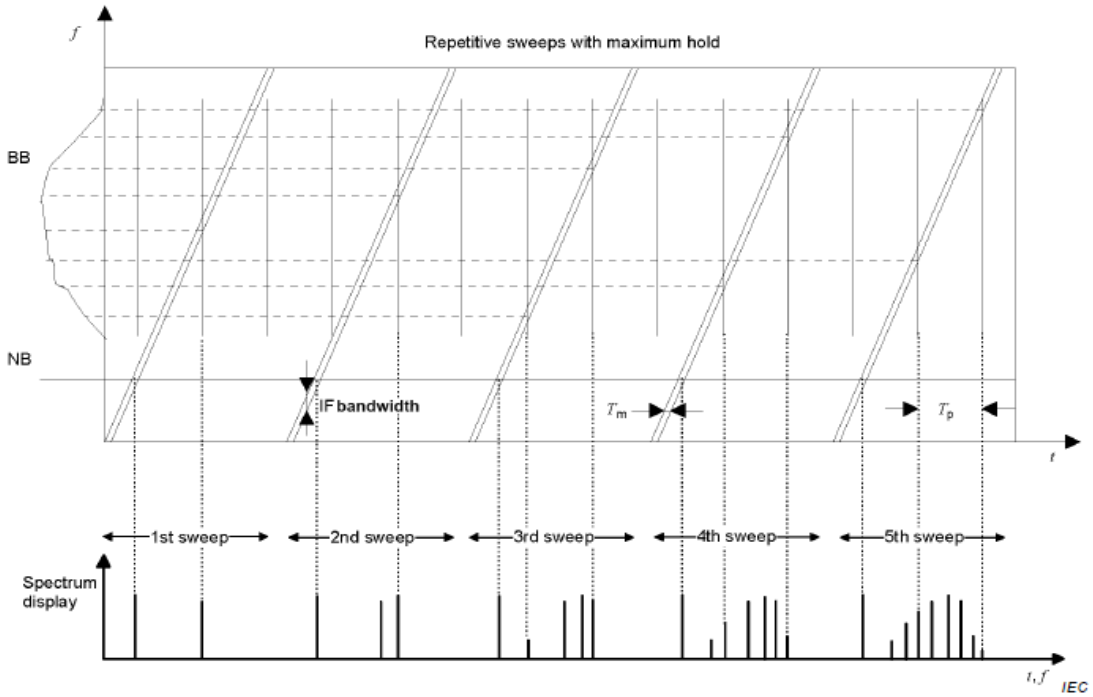
Position B: 150 m.

Position C: 200 m.

Position D: 300 m.

Position E: 710 m.

Figure 1.5-1: Test setup illustration and the measurement positions



Key:

T_o is the pulse-repetition interval of the impulsive signal. A pulse occurs at each vertical line of the spectrum versus time display (upper part of the figure).

Figure 1.5-2: The above figure is given in the CISPR 16-2-3:2016 standard to explain using the multiple scans with maximum hold method for measuring a combination of a CW signal (NB-narrowband) and an impulsive signal (BB-broadband). This method helps with minimizing the chance of missing any emissions.

Note: For further details regarding multiple scans refer to the CISPR 16-2-3 standards.

1.6 Settings of the measurement equipment (Receiver & Power sensor)

During the measurements the following receiver settings were used. The parameters were selected based on the requirements of the CISPR standards.

Receiver: FINAL measurements at the identified radar frequencies	
Parameter	**Frequency range**
	1000 – 2000 MHz
Detectors	Peak (PK) and RMS
IF/RBW Bandwidth	50 MHz
Video bandwidth (VBW)	80 MHz
Scan/measurement time	6 minutes

The following steps were taken to avoid the overload/saturation of the receiver /spectrum analyser:

- During measurements no pre-amplifiers were used.
- The receiver was used in AUTO attenuation mode.
- Additional fixed attenuators of 10 dB and 30 dB was used at the RF input of the spectrum analyser.
- The spectrum analyser is equipped with overload indication.

In addition to the Receiver all measurements were also performed using power sensor (see the equipment list).

- At all operating modes the coaxial cable coming from the measurement antenna was connected to the power sensor via 10/30-dB fixed attenuator.

The handheld RF exposure meter (see the equipment list) was only used in the default settings for ICNIRP measurements. The measurement time was 6 minutes per location and antenna height.

2. RF Exposure Assessment result and verdict

Limits to comply with standard EN 62311:2020 are defined in “1999/519/EC Council Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) for General Public”:

Measurement details				Electric field (peak)				Electric field (rms)			
Measurement number	Position	Rx antenna height (m)	Radar mode	E-field strength (Peak) [V/m]	General Public Limit E-field strength [V/m]	[%] of the limit	VERDICT	E-field strength (rms) [V/m]	General Public Limit E-field strength [V/m]	[%] of the limit	VERDICT
1	1 (35 m)	2	AD - (PSR+MSSR)	89,23	1412,16	6,32	**PASS**	8,68	44,13	19,67	**PASS**
2			BMD (PSR)	53,95	1616,66	3,34	**PASS**	12,71	50,52	25,15	**PASS**
3		6	AD - (PSR+MSSR)	92,79	1412,16	6,57	**PASS**	5,07	44,13	11,48	**PASS**
4			BMD	56,04	1616,66	3,47	**PASS**	5,31	50,52	10,51	**PASS**
5	2 (150 m)	2	AD - (PSR+MSSR)	63,75	1412,16	4,51	**PASS**	6,44	44,13	14,60	**PASS**
6			BMD (PSR)	65,92	1616,66	4,08	**PASS**	13,43	50,52	26,58	**PASS**
7		6	AD - (PSR+MSSR)	112,07	1412,16	7,94	**PASS**	10,30	44,13	23,33	**PASS**
8			BMD (PSR)	123,17	1616,66	7,62	**PASS**	19,02	50,52	37,65	**PASS**
9	3 (200 m)	2	AD - (PSR+MSSR)	155,06	1412,16	10,98	**PASS**	13,92	44,13	31,53	**PASS**
10			BMD	127,79	1616,66	7,90	**PASS**	16,50	50,52	32,65	**PASS**
11		6	AD - (PSR+MSSR)	146,89	1412,16	10,40	**PASS**	12,61	44,13	28,57	**PASS**
13			BMD	74,99	1616,66	4,64	**PASS**	10,92	50,52	21,62	**PASS**
14	4 (300 m)	2	AD - (PSR+MSSR)	63,46	1412,16	4,49	**PASS**	2,88	44,13	6,53	**PASS**
15			BMD (PSR)	41,21	1616,66	2,55	**PASS**	3,96	50,52	7,83	**PASS**
16		6	AD - (PSR+MSSR)	51,88	1412,16	3,67	**PASS**	7,76	44,13	17,59	**PASS**
17			BMD (PSR)	92,15	1616,66	5,70	**PASS**	10,22	50,52	20,23	**PASS**
18	5 (710 m)	2	AD - (PSR+MSSR)	22,11	1412,16	1,57	**PASS**	2,00	44,13	4,54	**PASS**
19			BMD (PSR)	18,05	1616,66	1,12	**PASS**	3,47	50,52	6,87	**PASS**
20		6	AD - (PSR+MSSR)	14,76	1412,16	1,04	**PASS**	1,09	44,13	2,48	**PASS**
21			BMD (PSR)	15,31	1616,66	0,95	**PASS**	1,08	50,52	2,13	**PASS**

The Limit lines are frequency dependent (changing with frequency). Since PSR and MSSR are operating at different frequency ranges, the relevant limit lines are also different. In the table given above the worst case limit lines (the most stringent limit pertaining to the frequencies of MSSR and PSR) were used, in this case the limit line relevant to MSSR mode.

The SMART-L system is the dominant contributor in the frequency bands. The objective of the assessment is to determine if the SMART-L complies to ICNIRP. Therefore, other users (sources; therefore frequencies other than listed in the tables given above) are not relevant for the assessment and do not contribute significantly to exceeding the total exposure levels.

2.1 Equipment used during measurements

Equipment	Manufacturer	Model	Cal. date
EMI Test Receiver	Rohde & Schwarz	ESW 44	10-2022
Electromagnetic Field Meter	WaveControl	SMP02	07-2022
Field Probe BroadBand E (100 kHz to 8 GHz)	WaveControl	WPF8	07-2022
Power Sensor	Rohde & Schwarz	NRP-Z81	09-2022
Horn Antenna	Rohde & Schwarz	HF 907	05-2022
BiconiLog Antenna	Schwarzbeck	Vulbane 9161-4010	02-2021
Coaxial cable (10m)	Gore	RG-214/U	09-2021
Test-Control Software	Rohde & Schwarz	EMC32 V10.60.20	N/A
Test Software	Rohde & Schwarz	Power viewer	N/A
Antenna mast	Rohde & Schwarz	5 m.	N/A

2.2 Measurement uncertainty

The table below shows the measurement uncertainty of the measurement. The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

Test name	**Uncertainty [dB]**
Radiated electric field emissions; 1 – 2 GHz (Receiver)	2.34
Radiated electric field emissions; 1 – 2 GHz (Power sensor)	2.26
Radiated electric field emissions; 1 – 2 GHz (RF exposure meter)	2.97

ANNEX 1 - EN RF Exposure Information

The device will be evaluated against basic restrictions or reference levels according to EN 62311:2020. If the reference levels are met, then the basic restrictions will also be met.

Reference levels are defined in the 1999/519/EC Council Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz),See Table as under

Reference levels: ICNIRP1998

Table 7. Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
up to 1 Hz	—	3.2×10^4	4×10^4	—
1–8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8–25 Hz	10,000	$4{,}000/f$	$5{,}000/f$	—
0.025–0.8 kHz	$250/f$	$4/f$	$5/f$	—
0.8–3 kHz	$250/f$	5	6.25	—
3–150 kHz	87	5	6.25	—
0.15–1 MHz	87	$0.73/f$	$0.92/f$	—
1–10 MHz	$87/f^{1/2}$	$0.73/f$	$0.92/f$	—
10–400 MHz	28	0.073	0.092	2
400–2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	$f/200$
2–300 GHz	61	0.16	0.20	10

[a] Note:
1. f as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. perception of surface electric charges will not occur at field strengths less than 25 kVm^{-1}. Spark discharges causing stress or annoyance should be avoided.

Reference levels: ICNIRP2020

Table 5. Reference levels for exposure, averaged over 30 min and the whole body, to electromagnetic fields from 100 kHz to 300 GHz (unperturbed rms values).[a]

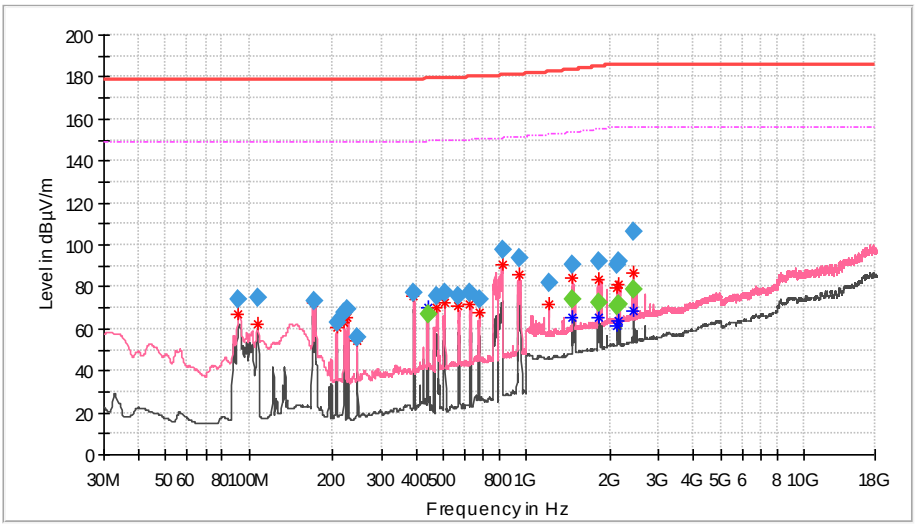
Exposure scenario	Frequency range	Incident E-field strength; E_{inc} (V m^{-1})	Incident H-field strength; H_{inc} (A m^{-1})	Incident power density; S_{inc} (W m^{-2})
Occupational	0.1 – 30 MHz	$660/f_M^{0.7}$	$4.9/f_M$	NA
	>30 – 400 MHz	61	0.16	10
	>400 – 2000 MHz	$3f_M^{0.5}$	$0.008f_M^{0.5}$	$f_M/40$
	>2 – 300 GHz	NA	NA	50
General public	0.1 – 30 MHz	$300/f_M^{0.7}$	$2.2/f_M$	NA
	>30 – 400 MHz	27.7	0.073	2
	>400 – 2000 MHz	$1.375f_M^{0.5}$	$0.0037f_M^{0.5}$	$f_M/200$
	>2 – 300 GHz	NA	NA	10

[a]Note:

1. "NA" signifies "not applicable" and does not need to be taken into account when determining compliance.
2. f_M is frequency in MHz.
3. S_{inc}, E_{inc}, and H_{inc} are to be averaged over 30 min, over the whole body space. Temporal and spatial averaging of each of E_{inc} and H_{inc} must be conducted by averaging over the relevant square values (see eqn 8 in Appendix A for details).
4. For frequencies of 100 kHz to 30 MHz, regardless of the far-field/near-field zone distinctions, compliance is demonstrated if neither E_{inc} or H_{inc} exceeds the above reference level values.
5. For frequencies of >30 MHz to 2 GHz: (a) within the far-field zone: compliance is demonstrated if either S_{inc}, E_{inc} or H_{inc}, does not exceed the above reference level values (only one is required); S_{eq} may be substituted for S_{inc}; (b) within the radiative near-field zone, compliance is demonstrated if either S_{inc}, or both E_{inc} and H_{inc}, does not exceed the above reference level values; and (c) within the reactive near-field zone: compliance is demonstrated if both E_{inc} and H_{inc} do not exceed the above reference level values; S_{inc} cannot be used to demonstrate compliance, and so basic restrictions must be assessed.
6. For frequencies of >2 GHz to 300 GHz: (a) within the far-field zone: compliance is demonstrated if S_{inc} does not exceed the above reference level values; S_{eq} may be substituted for S_{inc}; (b) within the radiative near-field zone, compliance is demonstrated if S_{inc} does not exceed the above reference level values; and (c) within the reactive near-field zone, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.

ANNEX 2 – Measurement data – Ambient background

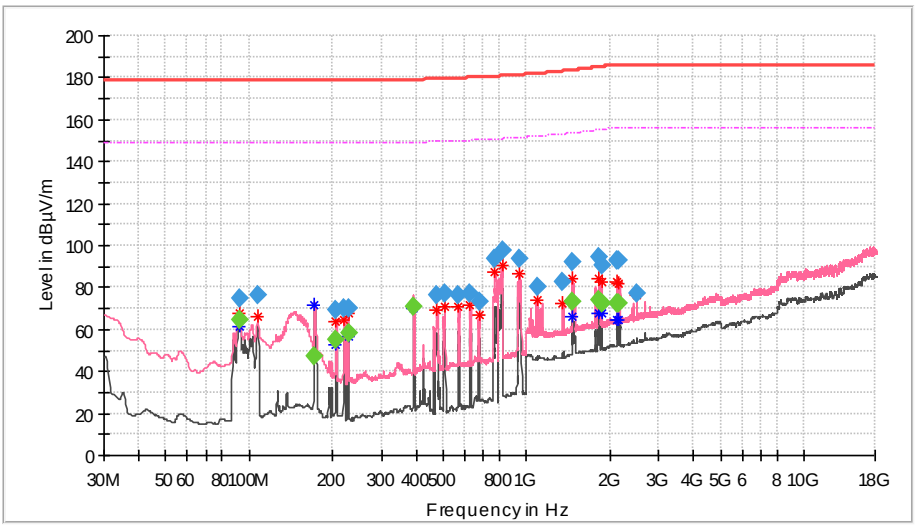
Operating mode : Background / Position B (150 m.) at 8:30.
Antenna height : 2 m.



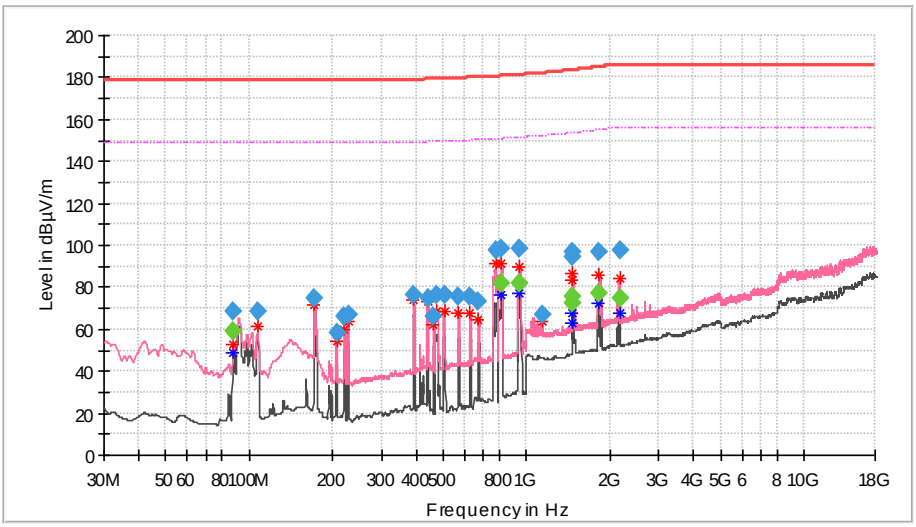
Note 1: Preview Results are the results of the multiple scan measurements.

Note 2: Critical_Freqs (RMS or PK+) are the frequencies identified for FINAL measurements.

Operating mode : Background / Position B (150 m.) at 13:00.
Antenna height : 2 m.



Operating mode : Background / Position B (150 m) at 17:00.
Antenna height : 2 m.



This photo shows the antenna position and height (2m) during ambient measurements performed below 1 GHz. At the frequency range above 1 GHz the antenna shown in section 1.5 (page 9) was used.

End of the Report