Report on the Exposure Calculation for PervasID
UHF RFID Distributed Antenna System, Model: Space/Portal Ranger 9200
In accordance with FCC and ISED Regional Requirements

Product Service

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COMMERCIAL-IN-CONFIDENCE

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RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Natalie Bennett	30 October 2018	
Authorised Signatory	Simon Bennett	30 October 2018	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

ENGINEERING STATEMENT
The calculations shown in this report were made in accordance with the procedures described in FCC and ISED Canada Regional Requirements.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Calculation	Peter Dorey	30 October 2018	

EXECUTIVE SUMMARY
The calculation of exposure for this product was found to be compliant at 23 cm (FCC) and 34 cm (ISED Canada) for general public exposure.

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Contents

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1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	30 October 2018

1.2 Introduction

Objective	To perform electromagnetic field exposure assessment to determine the equipment under test's (EUT's) compliance with the applied specifications.
Applicant	PervasID
Manufacturer	PervasID
Model Number(s)	Space/Portal Ranger 9200
Hardware Version(s)	v5.2 FCC
Software Version(s)	N/A
Specification/Issue/Date	• FCC: CFR 47 Pt1.1310:2016 • ISED Canada: Health Canada Safety Code 6:2015
Order Number Date	PO0028 15 June 2018
Related Document(s)	• OET65:97 Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields • IEEE C95.3:2002 IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz–300 GHz • RSS-102 Issue 5 Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

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1.3 Brief Summary of Results

The wireless device described within this report was compliant with the restrictions related to human exposure to electromagnetic fields for both general public and worker/occupational exposures at the compliance distances calculated.

The calculations shown in this report were made in accordance with the procedures specified in the applied test specification(s).

1.3.1 Compliance Boundary

Regional Requirement	Configuration	Calculated Compliance Boundary (m)	
		Worker/Occupational	General Public
FCC	Exposure due to single antenna	0.103	0.230
CANADA	Exposure due to single antenna	0.128	0.340

Table 1 – Compliance Boundary Calculation Results

1.4 Product Information

1.4.1 Technical Description

UHF RFID Distributed Antenna System - intended use detection and monitoring of UHF RFID tags.

Figure 1 - Space/Portal Ranger 9200

1.4.2 Transmitter Description

The following radio access technologies and frequency bands are supported by the equipment under test.

Radio Access Technology	Antenna Port	Frequency Band	Minimum Frequency	Output Power EIRP	Duty Cycle
		MHz	MHz	dBm	%
RFID	RF1 to RF8 Note 1	902-928	902	36 Note 2	100

Table 2 – Transmitter Description

Note 1: Antenna ports RF1 to RF8 identical

Note 2: Dependent on the antenna gain, the transmitter output power level is set to maintain an output power EIRP of 36 dBm. With the Laird S9028PCR antenna listed in section 1.4.3 with gain 9 dBi, the transmitter output power level would be 27 dBm.

1.4.3 Antenna Description

The following antennas are supported by the equipment under test.

Radio Access Technology	Antenna Model	Gain	Antenna length
		dBi	cm
RFID	Laird S9028PCR	9 dBic	30.5
RFID	MT-243012	11.5 dBiL	30.5
RFID	Pervasid Tile	7 dBic	30.5

Table 3 – Antenna description

1.4.4 Equipment Configuration

The PervasID Space Ranger system is an 8-port UHF RFID reader capable of feeding eight beams using 4-element array ceiling tile antennas. Multiple non-overlapping beams transmit simultaneously and therefore as the beams are non-overlapping only the exposure contribution from a single antenna needs to be considered.

The transmitter power is set to achieve a target output power EIRP of 36 dBm.

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2 Assessment Details

2.1 Assessment Method

FCC CFR 47 Pt1.1310 refers to OET Bulletin 65 that states methods in its Section 2.

ISED Canada RSS-102 clause 3 specifies: RF exposure evaluation shall be made in accordance with the latest version of IEEE C95.3.

IEEE C95.3 Annex B specifies the calculation method and describes the quantities in clause 1.4.

The methods are summarised as follows:

The assessment method is by calculation of the power density S, electric field strength E, magnetic field strength H or magnetic flux density B.

The calculation uses the spherical model applicable under far field conditions.

$$\boldsymbol{S = E \times H = \frac{E^2}{\eta} = H^2 \times \eta = \frac{P \times G_i}{4 \times \pi \times r^2}}$$

Where:
η - Impedance of free space (377 ohm in far field)
P – Transmitter power W
G_i – Antenna gain ratio relative to isotropic
R – Separation distance m

The magnetic flux density is related to the magnetic field strength by a constant:

$$\boldsymbol{B = \mu_o \times H}$$

Where:
μ_o – Permeability of free space 4xπ E-7 H/m

The far field region boundary depends on the frequency and wavelength and also on the antenna dimension. The boundary of the far field region is calculated below to demonstrate the validity of using the spherical model.

2.2 Individual Antenna Port Exposure Results

2.2.1 Calculation of Compliance Distance

The frequencies shown in the tables below have been chosen based on the lowest possible frequency that the EUT can transmit. A full list of the regional requirements is shown in Annex A.

Regional Requirement	Antenna Port	RAT	Frequency (MHz)	Calculated Compliance Boundary (m) at Limit for:			
				S Power Density	E Field	H Field	B Field
FCC	RF1 - RF8	RFID	902	0.103	N/A	N/A	N/A
CANADA	RF1 - RF8	RFID	902	0.128	0.128	0.128	N/A

Table 4 – Calculation of Compliance Distance Worker/Occupational

Regional Requirement	Antenna Port	RAT	Frequency (MHz)	Calculated Compliance Boundary (m) at Limit for:			
				S Power Density	E Field	H Field	B Field
FCC	RF1 - RF8	RFID	902	0.230	N/A	N/A	N/A
CANADA	RF1 - RF8	RFID	902	0.340	0.340	0.340	N/A

Table 5 – Calculation of Compliance Distance General Public

The following tables show the regional requirements for the frequencies used in the RF exposure calculation. A full list of the requirements is shown in Annex A.

Regional Requirement	Frequency (MHz)	Worker/Occupational Limit				General Public Limit			
		S Power Density (W/m^2)	E Field (V/m)	H Field (A/m)	B Field (µT)	S Power Density (W/m^2)	E Field (V/m)	H Field (A/m)	B Field (µT)
FCC	902	30.07	N/A	N/A	N/A	6.01	N/A	N/A	N/A
CANADA	902	19.39	85.49	0.2268	N/A	2.74	32.14	0.0828	N/A

Table 6 – Limits

2.3 Combined Antenna Port RF Exposure Results

Exposure is assessed from a single antenna as the beams are non-overlapping. Combined exposure does not require assessment.

2.4 Far Field Region Boundary Results

IEEE C95.3 Annex B.2 specifies the far field region boundary calculation:

Near Field / Far Field Boundary
Antennas - on axis Far Field Region (Ref: IEEE C95.3 Annex B.2)
$2D^2/\lambda$ (m)
0.5594

Table 7 – Far Field Boundary

The far field boundary is 0.5594 m. The calculated compliance boundaries are within this distance (within the near field) therefore the approach described in section 2.1 is an over estimate of the exposure and therefore a conservative assessment.

2.5 Uncertainty

The basic computation formulas presented in section 2.1 are conservative formulas for the estimation of RF field strength or power density. No uncertainty estimations are required when using these formulas but there is clear guidance on where and when these formulas are applicable.

For the estimate of S, E or H to be conservative, the transmitter power P and antenna gain G_i values shall be the upper bounds of uncertainty therefore maximum values are used.

The spherical formula is valid under far field conditions which are established in section 2.4.

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ANNEX A

REGIONAL REQUIREMENTS

Frequency Range (MHz)	Power Density (mW/cm^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
0 - 0.3	-	-	-
0.3 - 3	100	614	1.63
3 - 30	900/f^2	1842/f	4.89/f
30 - 300	1	61.4	0.163
300 - 1500	f/300	-	-
1500 - 100000	5	-	-

Table A.1 – CFR 47 Pt1.1310 (2016) Worker/Occupational Limits

Frequency Range (MHz)	Power Density (mW/cm^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
0 - 0.3	-	-	-
0.3 - 3	100	614	1.63
3 - 30	180/f^2	824/f	2.19/f
30 - 300	0.2	27.5	0.073
300 - 1500	f/1500	-	-
1500 - 100000	1	-	-

Table A.2 – CFR 47 Pt1.1310 (2016) General Public Limits

Frequency Range (MHz)	Power Density (W/m^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
10 - 20	10	61.4	0.163
20 - 48	44.72/f^0.5	129.8/f^0.25	0.3444/f^0.25
48 - 100	6.455	49.33	0.1309
100 - 6000	0.6455*f^0.5	15.60*f^0.25	0.04138*f^0.25
6000 - 150000	50	137	0.364

Table A.3 – Health Canada Safety Code 6 Worker/Occupational Limits

Frequency Range (MHz)	Power Density (W/m^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
10 - 20	2	27.46	0.0728
20 - 48	8.944/f^0.5	58.07/f^0.25	0.1540/f^0.25
48 - 300	1.291	22.06	0.05852
300 - 6000	0.02619*f^0.6834	3.142*f^0.3417	0.008335*f^0.3417
6000 - 15000	10	61.4	0.163

Table A.4 – Health Canada Safety Code 6 General Public Limits