HEADQUARTERS: 914 WEST PATAPSCO AVENUE • BALTIMORE, MARYLAND 21230 • PHONE (410) 354-3300 • FAX (410) 354-3313

April 16, 2021

Lat-Lon, LLC
2300 S. Jason St.
Denver, CO 80223

Dear Benjamin Jull,

Enclosed is the EMC Wireless test report for compliance testing of the Lat-Lon, LLC, X15500 as tested to the requirements of the FCC Certification rules under Title 47 of the CFR Part 1 1.1310 RF Exposure.

Thank you for using the services of Eurofins Electrical and Electronic Testing NA, Inc. If you have any questions regarding these results or if Eurofins Electrical and Electronic Testing NA, Inc. can be of further service to you, please contact me.

Sincerely yours,
EUROFINS ELECTRICAL AND ELECTRONIC TESTING NA, INC.

Arsalan Hasan
Wireless Laboratory

Reference: (\Lat-Lon, LLC\WIRS111810-FCC-RF Exposure Rev. 1)

ACCREDITED
TESTING CERT #0591.02

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Electromagnetic Compatibility Criteria
Test Report

for the

Lat-Lon, LLC
X15500

Tested under
FCC Certification Rules
Title 47 of the CFR, Part 1 1.1310

Report: WIRS111810-FCC RF Exposure Rev. 1

April 16, 2021

Prepared For:

Lat-Lon, LLC
2300 S. Jason St.
Denver, CO 80223

Prepared By:
Eurofins Electrical and Electronic Testing NA, Inc.
3162 Belick Street
Santa Clara, CA 95054

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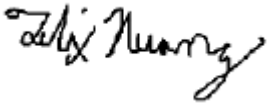
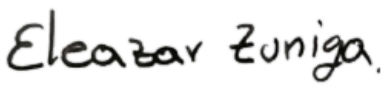


Felix Huang
Engineer, Wireless Laboratory

Arsalan Hasan
Manager, Wireless Laboratory

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of Part 1 of the FCC Rules under normal use and maintenance.



Eleazar Zuniga, PhD.
Director, Wireless Technologies

Report Status Sheet

Revision	Report Date	Reason for Revision
∅	April 13, 2021	Initial Issue.
1	April 16, 2021	Revised to updated company name to Lat-Lon, LLC. Also amended the addressed and model name.

Table of Contents

List of Terms and Abbreviations

AC	**A**lternating **C**urrent
ACF	**A**ntenna **C**orrection **F**actor
Cal	**Cal**ibration
d	**M**easurement **D**istance
dB	**D**eci**b**els
dBµA	**D**eci**b**els above one **micro**amp
dBµV	**D**eci**b**els above one **micro**volt
dBµA/m	**D**eci**b**els above one **micro**amp **per m**eter
dBµV/m	**D**eci**b**els above one **micro**volt **per m**eter
DC	**D**irect **C**urrent
E	**E**lectric Field
DSL	**D**igital **S**ubscriber **L**ine
ESD	**E**lectro**s**tatic **D**ischarge
EUT	**E**quipment **U**nder **T**est
f	**F**requency
FCC	**F**ederal **C**ommunications **C**ommission
GRP	**G**round **R**eference **P**lane
H	Magnetic Field
HCP	**H**orizontal **C**oupling **P**lane
Hz	**H**er**z**
IEC	**I**nternational **E**lectrotechnical **C**ommission
kHz	**k**ilo**h**er**z**
kPa	**k**ilo**pa**scal
kV	**k**ilo**v**olt
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
MHz	**M**ega**h**ertz
µH	**micro**henry
µ	**micro**farad
µs	**micros**econds
NEBS	**N**etwork **E**quipment-**B**uilding **S**ystem
PRF	**P**ulse **R**epetition **F**requency
RF	**R**adio **F**requency
RMS	**R**oot-**M**ean-**S**quare
TWT	**T**raveling **W**ave **T**ube
V/m	**V**olts **per m**eter
VCP	**V**ertical **C**oupling **P**lane

I. Executive Summary

1.1 Purpose of Test

An EMC evaluation was performed to determine compliance of the Lat-Lon, LLC X15500 , with the requirements of Part 1. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the X15500 . Lat-Lon, LLC should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the X15500 , has been **permanently** discontinued.

1.2 Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 1, in accordance with Lat-Lon, LLC, purchase order number PO020667.

Reference	Description	Compliance
§1.1310	RF Exposure	Compliant

Table 1. Executive Summary of EMC ComplianceTesting

II. Equipment Configuration

2.1 Overview

Eurofins Electrical and Electronic Testing NA, Inc. was contracted by Lat-Lon, LLC to perform testing on the X15500 , under Lat-Lon, LLC's purchase order number PO020667.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Lat-Lon, LLC, X15500

Model(s) Tested:	X15500	
Filing Status:	Original	
EUT Specifications:	Primary Power: 120/240VAC	
	FCC ID: W54-X15500	
	Module Original Report Number(s): Report: RF Exposure Analysis	
	Type of Modulations:	GFSK, QPSK, 16QAM
	Equipment Code:	DTS, PCB
	Technology	TX Frequency Range
	WCDMA Band V	824 – 849 MHz
	WCDMA Band II	1850 – 1910 MHz
	LTE Band 2	1850 – 1910 MHz
	LTE Band 4	1710 – 1755 MHz
	LTE Band 5	824.7 – 848.3 MHz
	LTE Band 12	699 – 716 MHz
	LTE Band 13	777 – 787 MHz
	BLE	2402 – 2480 MHz
	WiFi	2412 – 2462 MHz
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35º C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Arsalan Hasan	
Date(s):	April 16, 2021	

Table 2. EUT Summary Table

2.2 References

CFR 47, Part 22, Subpart H	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 22: Rules and Regulations for Cellular Devices.
CFR 47, Part 24, Subpart E	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 24: Rules and Regulations for Personal Communications Services
CFR 47, Part 27	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 27: Rules and Regulations for Advanced Wireless Services
KDB 996369 D04	Modular Transmitter Integration Guide – Guidance For Host Product Manufacturers
ANSI C63.4:2014	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.26: 2015	Compliance Testing of Transmitters Used in Licensed Radio Services
ISO/IEC 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories
EIA/TIA-603-A-2001	Land Mobile FM or PM Communication Equipment Measurement and Performance Standards
KDB 971168 v02r02	Measurement Guidance For Certification Of Licensed Digital Transmitters

Table 3. Standard References

2.3 Test Site

All testing was performed at Eurofins MET Labs, 3162 Belick St., Santa Clara, CA 95054. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Eurofins MET Labs is a ISO/IEC 17025 accredited site by A2LA, California #0591.02.

2.4 Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
RF Frequencies	±4.52 Hz	2	95%
RF Power Conducted Emissions	±2.32 dB	2	95%
RF Power Conducted Spurious Emissions	±2.25 dB	2	95%
RF Power Radiated Emissions	±3.01 dB	2	95%

Table 4. Measurement Uncertainty

2.5 Description of Test Sample

Solar/Battery powered asset tracking device. Determines location and monitors sensor and then sends this information, by way of cellular modem, to servers that that the customer can access to see the asset tracking information.

2.6 Equipment Configuration

Ref. ID	Slot #	Name / Description	Model Number	Part Number	Serial Number	Revision
1	N/A	DUST and CELL	X15500	94000	PB1	B
2	N/A	BLE and CELL	X15500	94000	PB2	B
3	N/A	BLE, DUST, and CELL	X15500	94000	PB3	B
4	N/A	Engineering Unit 1	X15500	94000	PB4	B
5	N/A	Engineering Unit 2	X15500	94000	PB5	B

Table 5: Equipment Configuration

2.7 Support Equipment

Support equipment necessary for the operation and testing of the EUT is included in the following list.

Ref. ID	Name / Description	Manufacturer	Model Number	*Customer Supplied Calibration Data
1	Laptop with Test Software and Power adapterInstalled	N/A	N/A	N/A
2	Power Cables	N/A	N/A	N/A
3	Extra MX5000s	Lat-lon	MX5000	N/A
4	Two DUST Sensors	Lat-lon	X200	N/A

Table 6: Support Equipment

2.8 Ports and Cabling Information

Ref. ID	Port name on EUT	Cable Description or reason for no cable	Qty	Length as tested (m)	Max Length (m)	Shielded? (Y/N)	Termination Box ID & Port Name
1	DUST USB	USB for DUST module Interface	2	1.6	1.6	No	N/A
2	BLE USB	USB for BLE module Interface	2	1.6	1.6	No	N/A
3	CELL USB	USB for CELL module Interface	2	1.6	1.6	No	N/A
4	DUST POWER SWITCH	Power SWITCH for DUST Radio Module	2	3.6	3.6	No	N/A
5	BLE POWER SWITCH	Power SWITCH for BLE Radio Module	2	3.6	3.6	No	N/A

Table 7: Ports and Cabling Information

2.9 Mode of Operation During Testing

There are 3 modes of operation: Cellular data being sent and received from the EUT. There are 2 wireless sensor protocols used as sensor inputs to the device which are DUST and Bluetooth. Once these radios are powered on. They will start operating in normal operation.

For our typical application, there are no power or communication cables available nearby. So the EUT has all wireless communication and Solar panels for energy harvesting.

The cellular radio will be paired with a call box (CMW500) to exercise the desired radio channels.

2.10 Method of Monitoring EUT Operation

The radio transmissions from each radio will be measurable. The device is in operation if the batteries are draining from normal operation. When a power supply is attached to the charging cable coming out of the box (lab use only), the power supply will show a current draw.

Signals will be displayed on a spectrum analyzer.

2.11 Modifications

2.11.1 Modifications to EUT

No modifications were made to the EUT.

2.11.2 Modifications to Test Standard

No modifications were made to the test standard.

2.12 Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Lat-Lon, LLC upon completion of testing.

III. Electromagnetic Compatibility Criteria for Intentional Radiators

Maximum Permissible Exposure

RF Exposure Requirements: **§1.1307(b)(1) and §1.1307(b)(2):** Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

RF Radiation Exposure Limit: **§1.1310:** As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(i) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*(100)	≤6
3.0-30	1842/f	4.89/f	*($900/f^2$)	<6
30-300	61.4	0.163	1.0	<6
300-1,500			f/300	<6
1,500-100,000			5	<6
(ii) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	<30
1.34-30	824/f	2.19/f	*($180/f^2$)	<30
30-300	27.5	0.073	0.2	<30
300-1,500			f/1500	<30
1,500-100,000			1.0	<30

Table 8. RF Exposure Limits

$$S = PG / 4\pi R^2 \quad \text{or} \quad R = \sqrt{(PG / 4\pi S)}$$

where, S = Power Density (mW/cm^2)
P = Power Input to antenna (mW)
G = Antenna Gain (numeric value)
R = Distance (cm)

For Antenna Gain → **dBi = 10log(Numeric)**

Technology	TX Frequency Range (MHz)	Peak Gain (dBi)	Type
WCDMA Band V	824 – 849 MHz	3.50	FPC Self Adhesive 3M 468P
WCDMA Band II	1850 – 1910 MHz	3.80	FPC Self Adhesive 3M 468P
LTE Band 2	1850 – 1910 MHz	3.80	FPC Self Adhesive 3M 468P
LTE Band 4	1710 – 1755 MHz	3.80	FPC Self Adhesive 3M 468P
LTE Band 5	824.7 – 848.3 MHz	3.50	FPC Self Adhesive 3M 468P
LTE Band 12	699 – 716 MHz	3.50	FPC Self Adhesive 3M 468P
LTE Band 13	777 – 787 MHz	3.50	FPC Self Adhesive 3M 468P
BLE	2402 – 2480 MHz	1.86	Embedded Chip
ZigBee	2405 – 2480 MHz	1.70	Embedded Chip

Table 9. EUT Antenna Gain Specification

Technology	TX Frequency Range (MHz)	Maximum Conducted Output Power (dBm)
WCDMA Band V	824 – 849 MHz	23.5 (-3 ~ +1dB) = 24.5
WCDMA Band II	1850 – 1910 MHz	23.5 (-3 ~ +1dB) = 24.5
LTE Band 2	1850 – 1910 MHz	23 (-3 ~ +1dB) = 24
LTE Band 4	1710 – 1755 MHz	23 (-3 ~ +1dB) = 24
LTE Band 5	824.7 – 848.3 MHz	23 (-3 ~ +1dB) = 24
LTE Band 12	699 – 716 MHz	23 (-3 ~ +1dB) = 24
LTE Band 13	777 – 787 MHz	23 (-3 ~ +1dB) = 24
BLE	2402 – 2480 MHz	9 (-3 ~ +1dB) = 10
ZigBee	2405 – 2480 MHz	8 (-3 ~ +1dB) = 9

Table 10. Tune up Power

Bands covered under FCC Part 22 / FCC Part 24

Test Results:

Band	Frequency (MHz)	Maximum Conducted Power (dBm)	Conducted Power (mW)	Antenna Gain (dBi)	Antenna Gain (Numeric)	Power Density (mW/cm2)	Limit (mW/cm2)	Margin	Distance (cm)	Result
WCDMA V	836.6	24.5	281.83	3.5	2.238	0.125	0.557	-0.431	20	Pass
WCDMA II	1852.4	24.5	281.83	3.8	2.398	0.134	1	-0.865	20	Pass
LTE Band 2	1880.0	24	251.18	3.8	2.398	0.119	1	-0.880	20	Pass
LTE Band 5	848.3	24	251.18	3.5	2.238	0.111	0.565	-0.453	20	Pass

Table 11. MPE Calculation for Bands under Part 22 and Part 24

The safe distance where Power Density is less than the MPE limit listed above was found to be 20 cm.

Bands covered under FCC Part 27

Test Results:

Band	Frequency (MHz)	Maximum Conducted Power (dBm)	Conducted Power (mW)	Antenna Gain (dBi)	Antenna Gain (Numeric)	Power Density (mW/cm2)	Limit (mW/cm2)	Margin	Distance (cm)	Result
LTE Band 4	1720.0	24	251.18	3.8	2.398	0.119	1	-0.880	20	Pass
LTE Band 12	715.3	24	251.18	3.5	2.238	0.111	0.476	-0.364	20	Pass
LTE Band 13	782.0	24	251.18	3.5	2.238	0.111	0.521	-0.409	20	Pass

Table 12 MPE Calculation for Bands under Part 27

The safe distance where Power Density is less than the MPE limit listed above was found to be 20 cm.

Bands covered under FCC Part 15.247

Test Results:

Band	Frequency (MHz)	Maximum Conducted Power (dBm)	Conducted Power (mW)	Antenna Gain (dBi)	Antenna Gain (Numeric)	Power Density (mW/cm2)	Limit (mW/cm2)	Margin	Distance (cm)	Result
BLE	2442.0	10	10	1.86	1.534	0.003	1	-0.996	20	Pass
ZigBee	2462.0	9	7.94	1.70	1.479	0.002	1	-0.997	20	Pass

Table 13. MPE Calculation for Bands under Part 15.247

The safe distance where Power Density is less than the MPE limit listed above was found to be 20 cm.

Note: Results are based on KDB 447498 D01 (Section 7.2) Transmitters used in mobile devices exposure conditions for simultaneous transmission operations.

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density. The MPE ratio of each antenna is determined at the minimum test separation distance required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to the MPE limit at the test frequency.

Cellular & ZigBee & BLE can transmit simultaneously, the formula for calculating the simultaneous MPE is

CPD1/LPD1 + CPD2/LPD2 + „„ CPDn/LPDn < 1

CPD: Calculated Power Density
LPD: Limit of Power Density

Simultaneous MPE =	**Cellular**	**+**	**ZigBee**	**+**	**BLE**
	= 0.111/0.476	+	0.002/1	+	0.003/1
	= 0.233	+	0.002	+	0.003
	= 0.238				

Result: 0.238 < 1 (Pass)

IV. Test Equipment

Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2017.

Asset #	Equipment	Manufacturer	Model	Last Cal Date	Cal Due Date
1S4075	RADIO COMMUNICATION TESTER	ROHDE & SCHWARZ	CMW500	09/20/2020	09/20/2022
1S2399	TURNTABLE/MAST CONTROLLER	SUNOL SCIENCES	SC99V	SEE NOTE 1	
1S2600	BILOG ANTENNA	TESEQ	CBL6112D	03/19/2019	03/19/2021
1S2733	BILOG ANTENNA	TESEQ	CBL6112D	06/05/2019	06/05/2021
1S3826	DRG HORN ANTENNA	ETS-LINDGREN	3117	12/03/2020	12/03/2022
1S2198	DRG HORN ANTENNA	ETS-LINDGREN	3117	10/07/2019	10/07/2021
1S2000	SPECTRUM ANALYZER	AGILENT	E4448A	11/06/2020	11/06/2022
1S2587	PRE AMPLIFIER	AML COMMUNICATIONS	AML0126L3801	SEE NOTE 1	
1S2653	AMPLIFIER	SONOMA INSTRUMENT	310 N	SEE NOTE 1	
1S2486	5 METER CHAMBER	PANASHIELD - ETS	5M	SEE NOTE 2	
1S3824	SIGNAL GENERATOR	ROHDE & SCHWARZ	SMA100B	11/06/2019	05/06/2021

Table 14. Test Equipment List

Note 1: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.
Note 2: Latest NSA and VSWR data available upon request.

End of Report

