

# FCC PART 15.211 CERTIFICATION TEST REPORT

for the

SubSurface Profiler (SSP) FCC ID: YSD-5840-SS-1122

### **REPORT# 15412-01 REV 2**

Prepared for:

Reutech Mining PO Box 686

Stellenbosch, Capetown 7599

Prepared By:

Washington Laboratories, Ltd.

7560 Lindbergh Drive Gaithersburg, Maryland 20879



Certificates and reports shall not be reproduced except in full, without the written permission of Washington Laboratories, Ltd



## FCC Part 15.211 Certification Test Report

for the

## **Reutech Mining**

### SubSurface Profiler (SSP)

FCC ID: YSD-5840-SS-1122

## DECEMBER 12, 2018

WLL REPORT# 15412-01 REV 2

Prepared by:

Mulal 7. Colitte

Mike Violette Test Engineer

Reviewed by:

St. D.Y

Steven D. Koster President



## ABSTRACT

This report has been prepared on behalf of Reutech Mining to support the attached Application for Equipment Authorization. The test report and application are submitted for an Intentional Radiator under Part 15.211 (09/2018) of the FCC Rules and Regulations. This Certification Test Report documents the test configuration and test results for the Reutech Mining SubSurface Profiler (SSP).

Testing was performed in an abandoned turnpike tunnel located near 3300 Pump Station Road, Waterfall, PA. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory.

The Reutech Mining SubSurface Profiler (SSP) complies with the limits for a Tunnel Radio Station FCC Part 15.211.

Revision History	Description of Change	Date
REV 0	Initial Release	DECEMBER 12, 2018
REV 1	Comments addressed	DECEMBER 18, 2018
REV 2	Comments addressed	May 29, 2018



# TABLE OF CONTENTS

Abstract	iii
Table of Contents	iv
List of Tables	v
List of Figures	v
List of Photographs Error! Bookmark not def	fined.
1 Introduction	1
1.1 Compliance Statement	1
1.2 Test Scope	1
1.3 Contract Information	1
1.4 Test Dates	1
1.5 Test and Support Personnel	1
1.6 Abbreviations	2
2 Equipment Under Test	3
2.1 EUT Identification & Description	3
2.2 Test Configuration	5
2.3 Test Location	5
2.4 Measurements	8
2.4.1 References	8
2.5 Measurement Uncertainty	9
3 Test Equipment	11
4 Test Results	12
4.1 Radiated Emissions: (FCC Part §15.211)	12
4.1.1 Test Procedure	12
4.2 AC Conducted Emissions	23



# LIST OF TABLES

Table 1: Device Summary	3
Table 2: Clocks and Oscillators	4
Table 3: Expanded Uncertainty List	9
Table 4: Test Equipment List	.11
Table 5: Spectrum Analyzer Settings	.15

# LIST OF FIGURES

Figure 1. System Diagram.	5
Figure 2. Tunnel Entrance	6
Figure 3. Tunnel Entrance	7
Figure 4. Tunnel Entrance	8
Figure 8. 3m Pre scan Maximum EUT orientation Horizontal (Peak)	
Figure 9. 3m Pre scan Maximum EUT orientation Vertical (Peak)	14
Figure 10. Horizontal Emissions. EUT positioned 364m Inside Tunnel	16
Figure 11. Vertical Emissions. EUT positioned 364m Inside Tunnel	17
Figure 12. Ambient Vertical.	
Figure 13. Spurious Horizontal Radiated Field Strength 30-200MHz	19
Figure 14. Spurious Vertical Radiated Field Strength 30-200MHz	20
Figure 15. Spurious Horizontal Radiated Field Strength 1-10GHz	21
Figure 16. Spurious Vertical Radiated Field Strength 1-10GHz	
- · · ·	



## **1 INTRODUCTION**

#### **1.1 COMPLIANCE STATEMENT**

The Reutech Mining SubSurface Profiler (SSP) complies with the requirements for a Tunnel Radio Station under FCC Part 15.211.

#### **1.2 TEST SCOPE**

Tests for radiated and conducted emissions were performed. All measurements were performed in accordance with the 2014 version of ANSI C63.4. and the 2013 version of ANSI C63.10. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

#### **1.3 CONTRACT INFORMATION**

Customer:	Reutech Mining
Address	PO Box 686
	Stellenbosch, Capetown 7599
Purchase Order Number:	Invoice request - Refer to PO44384
Quotation Number:	70341

#### **1.4 TEST DATES**

Testing was performed on the following date(s): 20 September 2018

#### 1.5 TEST AND SUPPORT PERSONNEL

Washington Laboratories, LTD	Mike Violette
Customer Representative	Jan de Beer



#### **1.6 ABBREVIATIONS**

А	Ampere
ac	alternating current
AM	Amplitude Modulation
Amps	Amperes
b/s	bits per second
BW	BandWidth
CE	Conducted Emission
cm	Centimeter
CW	Continuous Wave
dB	deciBel
dc	direct current
EMI	Electromagnetic Interference
EUT	Equipment Under Test
FM	Frequency Modulation
G	<b>g</b> iga – prefix for 10 <sup>9</sup> multiplier
Hz	Hertz
IF	Intermediate Frequency
k	kilo – prefix for 10 <sup>3</sup> multiplier
LISN	Line Impedance Stabilization Network
М	Mega – prefix for 10 <sup>6</sup> multiplier
m	Meter
μ	<b>m</b> icro – prefix for 10 <sup>-6</sup> multiplier
NB	Narrowband
QP	Quasi-Peak
RE	Radiated Emissions
RF	Radio Frequency
rms	root-mean-square
SN	Serial Number
S/A	Spectrum Analyzer
V	Volt



# **2** EQUIPMENT UNDER TEST

### 2.1 EUT IDENTIFICATION & DESCRIPTION

#### **Table 1: Device Summary**

Item	Radar sensing device for determining subsurface features in
Manufacturer:	Reutech Mining
FCC ID:	YSD-5840-SS-1122
Model:	SubSurface Profiler (SSP)
Serial Number of Unit Tested:	2017B1/012
Model:	5840-SS-1000V01.00
FCC Rule Parts:	§15.211
Frequency Range:	278.125 MHz to 1.001 GHz
Maximum Output Power:	58.9 mW (17.7 dBm)
Modulation:	Swept Frequency CW
FCC Emission Designator:	N/A
Keying:	Manual
Type of Information:	None
Number of Channels:	N/A
Power Output Level	Fixed
Highest TX Spurious Emission:	<40dBuV/m
Highest RX Spurious Emission:	<40dBuV/m
Antenna Connector	• Antenna boresight gain 4.65 dB
	• 60° half power beam width
Antenna Type	Integrated
Interface Cables:	None
Maximum Data Rate	N/A
<b>Power Source &amp; Voltage:</b>	15VDC Battery Supply



#### Table 2: Clocks and Oscillators

Frequency (MHz)	Source
40MHz	Vectron VC-820-EAE-FAAN-40M000000 Crystal Oscillator (XO) Used by the DDS and CC3100 Wi-Fi
10MHz	Vectron VC-820-EAE-FAAN-40M000000 Crystal Oscillator (XO) via AD9513 800 MHz Clock Distribution IC Used by the STM32F407 Processor
1.25MHz	Vectron VC-820-EAE-FAAN-40M000000 Crystal Oscillator (XO) via AD9513 800 MHz Clock Distribution IC Used by the LT8601 DC/DC converter





#### Figure 1. System Diagram

#### **2.2 TEST CONFIGURATION**

The SubSurface Profiler (SSP) was set up in an abandoned turnpike tunnel in Waterfall, PA. The unit was set up 363 meters from the opening of the tunnel and arranged for maximum emissions at the tunnel opening. The device was set for continuous transmission and was communicating with a companion tablet that receives the image data from the SSP. The EUT sweep could not be stopped for testing.

Both the swept signal and the WiFi transmitter were operating simultaneously.

#### 2.3 TEST LOCATION

Measurements herein were performed in an abandoned turnpike tunnel in Waterfall, PA. Images of the tunnel entrance are shown in the following figures.





**Figure 2. Tunnel Entrance** 





**Figure 3. Tunnel Entrance** 





### **Figure 4. Tunnel Entrance**

#### **2.4 Measurements**

#### 2.4.1 References

ANSI C63.2 (Jan-2016) Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 (Jan 2014) American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

ANSI C63.10 (Jun 2013) American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices



#### 2.5 MEASUREMENT UNCERTAINTY

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 (R2002) with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

**Equation 1: Standard Uncertainty** 

$$u_{c} = \pm \sqrt{\frac{a^{2}}{div_{a}^{2}} + \frac{b^{2}}{div_{b}^{2}} + \frac{c^{2}}{div_{c}^{2}} + \dots}$$

Where u<sub>c</sub> = standard uncertainty

a, b, c,.. = individual uncertainty elements

 ${\rm Div}_{a, b, c}$  = the individual uncertainty element divisor based on the probability distribution

Divisor = 1.732 for rectangular distribution

Divisor = 2 for normal distribution

Divisor = 1.414 for trapezoid distribution

#### **Equation 2: Expanded Uncertainty**

$$U = ku_c$$

Where U	= expanded uncertainty
k	= coverage factor
	$k \le 2$ for 95% coverage (ANSI/NCSL Z540-2 Annex G)
uc	= standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is <u>not</u> used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 3 below.

### **Table 3: Expanded Uncertainty List**



Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	CISPR11, CISPR22, , CISPR32, CISPR14, FCC Part 15	±2.63 dB
Radiated Emissions	CISPR11, CISPR22, , CISPR32, CISPR14, FCC Part 15	±4.55 dB



# **3 TEST EQUIPMENT**

Table 4 shows a list of the test equipment used for measurements along with the calibration information.

#### **Table 4: Test Equipment List**

Test Name:	Conducted Emissions Voltage	Test Date:	09/20/2018
Asset #	Manufacturer/Model	Description	Cal. Due
823	AGILENT - N9010A	EXA SPECTRUM ANALYZER	4/21/2019
125	SOLAR - 8028-50-TS-24-BNC	LISN	5/23/2019
126	SOLAR - 8028-50-TS-24-BNC	LISN	5/23/2019
53	HP - 11947A	LIMITER TRANSIENT	2/1/2019
Test Name:	Radiated Emissions	Test Date:	09/21/2018
Asset #	Manufacturer/Model	Description	Cal. Due
823	AGILENT - N9010A	EXA SPECTRUM ANALYZER	4/21/2019
626	ARA - DRG-118/A	ANTENNA HORN	10/7/2018
26	ЕМСО - 3110В	ANTENNA BICONICAL	1/5/2019
28	ЕМСО - 3146	ANTENNA LOG PERIODIC	12/13/2018
558	HP - 8447D	AMPLIFIER	2/9/2019
885	UTUTIFLEX Micro Coax	0.5m SMA-SMA RF Coaxial Cable	04/09/2019
892	SMA-SMA RF Coaxial Cable	SMA-SMA RF Coaxial Cable	04/09/2019



## 4 TEST RESULTS

The plots below show the results of testing for compliance with a Tunnel Radio System in accordance with FCC Part 15.211 (9/2018).

### 4.1 RADIATED EMISSIONS: (FCC PART §15.211)

Emissions must meet the general radiated emissions of 15.209.

Per guidance received from the FCC, restricted band frequencies do not apply to 15.211

#### 4.1.1 Test Procedure

Pre-scans were performed at a distance of 3m to determine worst-case orientation of the device, which was with the roller long dimension perpendicular to the tunnel opening as shown in the test setup photo.

The procedure was to monitor the emissions at the tunnel entrance until the quasi-peak levels dropped below the 15.209 limit. This distance was found to be 1193 feet or 364 meters. The measurement antenna was set up at the same location during the pre-scan and the final data measurement.





Figure 5. 3m Pre scan Maximum EUT orientation Horizontal (Peak)





#### Figure 6. 3m Pre scan Maximum EUT orientation Vertical (Peak)

The EUT was placed 364 meters inside the tunnel and oriented for maximum emissions that were determined at a 3m scanning distance.

Receiving antennas were mounted on a tripod. The height of the antenna was set to 2 meters. The height of the antenna was scanned, but the emissions did not noticeably vary.

Both the horizontal and vertical field components were measured.



The emissions were measured using the following resolution bandwidths:

#### **Table 5: Spectrum Analyzer Settings**

Frequency Range	<b>Resolution Bandwidth</b>	Video Bandwidth		
30MHz-1000 MHz	120kHz	>100 kHz		
>1000 MHz	1 MHz	1MHz (Peak)		

Cable correction, pre-amplifier and antenna factors were input into the spectrum analyzer. The spectrum analyzer readings in dBuV represent the actual field strength in dBuV/m.

Peak readings are shown in the following figure. The peak-to quasi-peak difference was determined to be approximately 6.2 dB. The maximum level of emissions was found at 293.5 MHz with a quasi-peak value of 41.2 dBuV/m. The remaining marker represent the Peaks in the remainder of the transmit band.

Regrettably the display table was not 'turned off' when the scan was saved, however, the market table shows the peak emissions.



SUBSURFACE PROFILER (SSP)

CH   RF   SUQ   AC   CORREC   ENDELINT   ALLANATO   DBESTALALAN Bog 20, 2018   Recall     Marker 6 878.345083488 MHz   Trig: Free Run   Avg Hold>100100   Trid: Free Run   Avg Hold>100100   Trid: Free Run   Avg Hold>20,0010   Trid: Free Run   Avg Hold>100100   Trid: Free Run   Avg Hold>20,00100   Trid: Free Run   Avg Hold>20,00100   Trid: Free Run   Avg Hold>20,00100   Trid: Free Run   Avg Hold>20,000   Trid: Free Run   Yet Pinter	Agilent Spec	trum Ar	nalyzer - Swe	ept SA								
FAIL   PMO: Fast IFG ain.Low   Ing: Free Run #Atten: 20 dB   Avg/India: 25.00 dB   Ing: Free Run Ext Gain: 25.00 dB   Ing: Free Run Ext Gain: 25.00 dB   State     10 dB/div   Ref 90.00 dBµV   43.825 dBµV   43.825 dBµV   43.825 dBµV   Freq   293.537 MHz   Frace   1 Peak   47.39 dBµV   Freq   293.537 MHz   1 Peak   47.39 dBµV   Freq   1 Peak   41.18 dBµV   2 Quasi Peak   41.18 dBµV   3 EMI Avg   18.87 dBµV   Data   (import)   Limit 1     30 0   0 <t< td=""><td>(X) Marker (</td><td>RF 6 878</td><td>= <u>50 Ω</u> 3.345083</td><td>AC COR 3488 MH:</td><td>REC Z</td><td></td><td>NSE:INT</td><td>Avg Type</td><td>ALIGNAUTO</td><td>08:51:41 A</td><td>M Sep 20, 2018 E 1 2 3 4 5 6</td><td>Recall</td></t<>	(X) Marker (	RF 6 878	= <u>50 Ω</u> 3.345083	AC COR 3488 MH:	REC Z		NSE:INT	Avg Type	ALIGNAUTO	08:51:41 A	M Sep 20, 2018 E 1 2 3 4 5 6	Recall
10 dB/div Ref 90.00 dBµV 43.825 dBµV   10 dB/div Trace 1 Fail Image: Comparison of the state of the sta	FAIL	- PNO: Fast Frig: Free Run Avg Hold>100/100 Pre[ WWWWWW IFGain:Low #Atten: 20 dB Ext Gain: 25.00 dB DET PNNNN Mkr6 878.35 MHz										
70.0 Freq 293.537 MHz (+ State)   60.0 1 2 3 4 1 Peak 47.39 dBµV   90.0 1 2 3 4 1 Peak 47.39 dBµV   2 Quasi Peak 41.18 dBµV 3 EMI Avg 18.87 dBµV 3 EMI Avg 18.87 dBµV   90.0 10.0 <td< td=""><td>10 dB/div Log 80.0 Tra</td><td>Re ce 1 F</td><td>f 90.00 d <sup>-</sup>ail</td><td>IBµV</td><td></td><td></td><td></td><td></td><td></td><td>43.82</td><td>ο αθμν</td><td>Trace</td></td<>	10 dB/div Log 80.0 Tra	Re ce 1 F	f 90.00 d <sup>-</sup> ail	IBµV						43.82	ο αθμν	Trace
30.0   30.0 <th< td=""><td>70.0 60.0 50.0 40.0</td><td></td><td></td><td>Å</td><td><math>2^2</math></td><td></td><td>4</td><td>Freq 1 Peak 2 Quas 3 EMI A</td><td>i Peak Vg</td><td>293. 47. 41. 18.</td><td>537 MHz 39 dBµV 18 dBµV 87 dBµV</td><td>(+ State)</td></th<>	70.0 60.0 50.0 40.0			Å	$2^2$		4	Freq 1 Peak 2 Quas 3 EMI A	i Peak Vg	293. 47. 41. 18.	537 MHz 39 dBµV 18 dBµV 87 dBµV	(+ State)
Start 30.0 MHz   Stop 1.0000 GHz     Res BW (CISPR) 120 kHz   VBW 910 kHz   Stop 1.0000 GHz     MKE MODE TRE SEL   ×   Ý   FUNCTION WIDTH   FUNCTION VALUE     1   N   1   f   293.48 MHz   47.559 dBµV   Function   Function width   Function value     2   N   1   f   334.74 MHz   42.098 dBµV   42.707 dBµV   44.707 dBµV   44.707 dBµV   44.707 dBµV   45.232 dBµV   44.707 dBµV   45.232 dBµV   43.825 d	30.0 20.0 10.0 0.00											Data (Import) ► Limit 1
MKR   MODE   TRC   SCL   X   Y   FUNCTION   FUNCTION WIDTH   FUNCTION VALUE     1   N   1   f   293.48 MHz   47.559 dBµV   42.098 dBµV   42.098 dBµV   42.098 dBµV   42.098 dBµV   42.098 dBµV   42.098 dBµV   42.097 dBµV   44.0167 dBµV   42.007 dBµV   44.0167 dBµV   45.232 dBµV   45.232 dBµV   45.232 dBµV   43.825 dBµV   43.	Start 30. Res BW	0 MH (CISF	z PR) 120 k	(Hz	VBW	910 kHz			Sweep	Stop 1.0 109 ms (1	0000 <b>GH</b> z 6171 pts)	
	MKB MODE 1 N 2 N 3 N 4 N 5 N 6 N 7 8 9 10 11 12	TRC   SC     1   f     1   f     1   f     1   f     1   f     1   f     1   f     1   f     1   f		× 293.4( 334.74 390.0( 565.1)( 636.2)( 878.3)( 878.3)	3 MHz 4 MHz 5 MHz 5 MHz 9 MHz 5 MHz 5 MHz	¥ 47.559 dB 42.098 dB 42.707 dB 45.232 dB 41.167 dB 43.825 dB	μV μV μV μV μV μV			FUNCTIO	N VALUE	

Figure 7. Horizontal Emissions. EUT positioned 364m Inside Tunnel





Figure 8. Vertical Emissions. EUT positioned 364m Inside Tunnel





#### **Figure 9. Ambient Vertical**

Spurious emissions were measured from 30 MHz to 10 GHz. Emissions over-the-limit were identified as ambient emissions.





#### Figure 10. Spurious Horizontal Radiated Field Strength 30-200MHz

Spurious emissions were measured from 30 MHz to 10 GHz. Emissions over-the-limit were identified as ambient emissions.





#### **Figure 11. Spurious Vertical Radiated Field Strength 30-200MHz**

Spurious emissions were measured from 30 MHz to 10 GHz. Emissions over-the-limit were identified as ambient emissions.



Agiler	it Spectr	um Ana	alyzer - Sv	wept SA									
LXI Mor	kor 1	RF	50 \$	Ω AC			SE	NSE:INT			09:26:11 / TRA	AM Sep 20, 2018	Marker
FAII	- J	Ref	55.00	dBuV	<u>UGN</u> PNO IFGa	Z D: Fast G in:High	Trig: Fre #Atten: 0	e Run ∣dB	Avg Hold: Ext Gain: 3	56/100 30.00 dB	۳ Mkr1 2.8 44.02	BO9 GHz 29 dBµV	Select Marker
<b>Log</b> 45.0	Trace	e 1 F	ail Myyanowityk	1 1	hlunh prove	and the second	paintonente	in the of the second	personal her have	minun	www.ung.huntertak	wither the state	Norma
35.0 25.0													Delta
15.0 5.00													Fixed▷
-5.00 -15.0													Ofi
-25.0 -35.0													Properties▶
Star #Re:	t 1.00 s BW	0 GH 1.0 N	iz AHz			VBW	50 MHz			Sweep	Stop 10 15.0 ms	).000 GHz (1001 pts)	More 1 of 2

#### **Figure 12. Spurious Horizontal Radiated Field Strength 1-10GHz**

Fundamental emission of WiFi device present on the plot at 2.4 GHz.



Agilen	t Spectr	um Anal	yzer - S	Swept SA									
LXI Mor	kor 1	RF	50	Ω AC			SEN	ISE:INT			09:25:17 A	M Sep 20, 2018	Save
FAIL		2.003	5000	000000	PNO: Fa IFGain:Hi	st ⊊⊃ gh	Trig: Free #Atten: 0	e Run dB	Ext Gain:	30.00 dB	TY D		State▶
10 dE Log	3/div	Ref	55.00	) dBµV							45.8	88 dBµV	
45.0	Trace	e 1 Fa	il I	<b>♦</b> <sup>1</sup>	rde miter Hindredd aws	بيوممها	all when the second second	Wenterster	the for the line of	monterman	nyah jun ili alah	he with a start of the	Trace
35.0	understande	Nyar <sup>ty Nyu</sup> N	lige of the second s	at lehe level at a	month of all of								(+ State)
25.0													
15.0													
5.00													Data (Export) ► Trace 1
-5.00													Screen Image
-15.0													
-25.0													
-35.0													
Star #Re:	t 1.00 s BW	0 GHz 1.0 M	<u>z</u> Hz	1	v	'BW 1	.0 MHz	1	1	Sweep	Stop 10	).000 GHz (1001 pts)	
MSG											s		ι <u> </u>

#### **Figure 13. Spurious Vertical Radiated Field Strength 1-10GHz**

Fundamental emission of WiFi device present on the plot at 2.4 GHz.



### 4.2 AC CONDUCTED EMISSIONS

The EUT is powered by rechargeable batteries. The charger was measured for compliance to the conducted emissions requirements of FCC Part 15B. The device does not operate while charging.