ALL-POINTS TECHNOLOGY CORPORATI

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Inspections Division
Approved with Conditions

Date: 07/22/14

STRUCTURAL ANALYSIS REPORT
40' ROOF-TOP SELF-SUPPORTING TOWER
PORTLAND, MAINE

Prepared for
Verizon Wireless

Verizon Site: One City Center

March 4, 2014

STATE OF MAINE
ROBERT E. ADAIR, JR.
No. 7408
LICENSED
PROFESSIONAL ENGINEER

APT Project #ME1414651

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STRUCTURAL ANALYSIS REPORT
40' SELF-SUPPORTING TOWER
PORTLAND, MAINE
prepared for
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EXECUTIVE SUMMARY:

All-Points Technology Corporation, P.C. (APT) performed a structural analysis of this 40-foot self-supporting tower. The analysis was performed for Verizon Wireless's proposed installation of six Andrew LNX-6514DS and six HBXX-6516DS panel antennas, three Alcatel-Lucent RRH2x60-AWS remote radio heads (RRHs), three Alcatel-Lucent 9442 RRHs, three Alcatel-Lucent PCS B25 RRH4x30 RRHs and two Raycap DB-B1-6C-12AB-0Z power/fiber distribution boxes (D-boxes), fed by twelve 1-5/8" waveguide cables and two hybrid fiber/power lines as detailed below.

Our analysis indicates the tower meets the requirements of the Maine Uniform Building and Energy Code with the proposed equipment.

INTRODUCTION:

A structural analysis was performed on the above-mentioned communications tower by APT for Verizon Wireless. The tower is located on the roof of the building at One City Center in Portland, Maine. APT previously climbed the structure in its entirety on November 7, 2013 to record information regarding physical and dimensional properties of the structure and its appurtenances.

The analysis was performed in accordance with the Maine Uniform Building and Energy Code and TIA-222 using the following antenna inventory (proposed equipment shown in **bold** text):

Antenna	Elev. [1]	Mount	Coax.
(3) 2' x 6" panel antennas	43'	8' x 2-⅜" pipe	(3) 1/4"
Beacon	40'	Top plate	¾" conduit
(6) LNX-6514DS & (6) HBXX-6516DS panels, (3) 9442 RRHs, (3) RRH2x60 RRHs, (3) PCS B25 RRH4x30 RRHs, (2) D-boxes	**35'**	**(3) 12' sector mounts**	**(12) 1-5/8", (2) hybrid**
Vacant mounts	25'	(3) 10' sector mounts	None
(3) obstruction lights	20'	Conduit across legs	¾" conduit
8' grid dish	7'	Leg	7/8"
1' square panel	7'	On horizontal brace	1/4"
(2) 2' yagis	1'	1' standoff	1/2"

[1] Elevations listed from base of tower.

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The following equipment was assumed to be removed from the tower:

Antenna	Elev.	Mount	
Vacant mount	36'	10' x 4" tube steel horiz.	
(9) RV90-17-02DPL2 panel antennas	25'	Mounts left in place	(9) 1-5/8"
4' dish with radome	17'	Leg	3/4"
Vacant mount	11'	10' x 4" tube steel horiz.	N.A.

STRUCTURAL ANALYSIS:

Methodology:

The structural analysis was done in accordance with the Maine Uniform Building and Energy Code and TIA-222, Revision G (TIA), Structural Standard for Antenna Supporting Structures and Antennas.

The analysis was conducted using a 3-second gust wind speed of 100 miles per hour with no ice and 40-mph with 1" radial ice in accordance with the TIA-222-G standard for Cumberland County, Maine. The following additional design criteria were used:

Structure Class: II
Topographic Category: 1
Exposure Category: B

Analysis Results:

Analysis of the tower was conducted in accordance with the criteria outlined herein with antenna changes as previously described. The following table summarizes the results of the analysis based on stresses of individual leg and bracing members:

Elevation	Legs	Bracing
20'-40'	20%	29%
0'-20'	36%	36%

Bracing, Splice and Anchor Bolts:

Connection bolts were evaluated under the proposed loading. All bolts were found to be adequately sized to support the proposed loads.

Base Frame:

Evaluation of the existing base support frame was conducted based on field notes recorded by APT. The support members were found to be adequately sized for the proposed equipment.

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Factored base reactions imposed with the proposed equipment were calculated as fc

Compression:	44.8 kips
Uplift:	40.0 kips
Shear:	6.3 kips
Overturning Moment:	315 ft-kips

CONCLUSIONS AND RECOMMENDATIONS:

Our structural analysis indicates that the 40-foot self-supporting tower located at One City Center in Portland, Maine meets the requirements of the Maine Uniform Building and Energy Code with Verizon Wireless's proposed equipment.

LIMITATIONS:

This report is based on the following:

1. Tower is properly installed and maintained.
2. All members are in an undeteriorated condition.
3. All required members are in place.
4. All bolts are in place and are properly tightened.
5. Tower is in plumb condition.
6. All tower members were properly designed, detailed, fabricated, and installed and have been properly maintained since erection.

All-Points Technology Corporation, P.C. (APT) is not responsible for modifications completed prior to or hereafter which APT is not or was not directly involved. Modifications include but are not limited to:

1. Replacing or strengthening bracing members.
2. Reinforcing vertical members in any manner.
3. Adding or relocating torque arms or guys.
4. Installing antenna mounting gates or side arms.

APT hereby states that this document represents the entire report and that it assumes no liability for any factual changes that may occur after the date of this report. All representations, recommendations, and conclusions are based upon the information contained and set forth herein. If you are aware of any information which is contrary to that which is contained herein, or you are aware of any defects arising from the original design, material, fabrication and erection deficiencies, you should disregard this report and immediately contact APT. APT disclaims all liability for any representation, recommendation, or conclusion not expressly stated herein.

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Appendix A

Tower Schematic

DESIGNED APPURTENA

TYPE	ELEVATION		
(3) 2' x 6" panel	250	ALU P(	
LED beacon	250	ALU P(	
8'x2 3/8" Pipe Mount	249	RFS DE	
(2) LNX-6514DS-VTM	245	RFS DE	
(2) LNX-6514DS-VTM	245	12' T-fr	
(2) LNX-6514DS-VTM	245	12' T-fr	
(2) HBXX-6516DS	245	12' T-fr	
(2) HBXX-6516DS	245	10' sec	
(2) HBXX-6516DS	245	10' sec	
ALU 9442 RRH w/bracket	245	10' sec	
ALU 9442 RRH w/bracket	245	Obstruction light	230
ALU 9442 RRH w/bracket	245	Obstruction light	230
ALU RRH2x60-AWS w/bracket	245	Obstruction light	230
ALU RRH2x60-AWS w/bracket	245	1' square panel	217
ALU RRH2x60-AWS w/bracket	245	8' grid dish	217
ALU PCS B25 RRH4x30 w/bracket	245	(2) 2' yagi	211

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MATERIAL STRENGTH

GRADE	Fy	Fu	GRADE	Fy	Fu
A572-50	50 ksi	65 ksi	A36	36 ksi	58 ksi

ALL REACTIONS ARE FACTORED

MAX. CORNER REACTIONS AT BASE:
DOWN: 44833 lb
SHEAR: 6306 lb

UPLIFT: -39955 lb
SHEAR: 6233 lb

AXIAL 31267 lb
SHEAR 2787 lb
MOMENT 69923 lb-ft

TORQUE 886 lb-ft
40 mph WIND - 1.0000 in ICE

AXIAL 8824 lb
SHEAR 13001 lb
MOMENT 315241 lb-ft

TORQUE 6030 lb-ft
REACTIONS - 100 mph WIND

All-Points Technology Corporation
P.O. Box 504
Conway, NH 03818
Phone: (603) 496-5853
FAX: (603) 447-2124

Job: **40' ROHN SSMW Tower**			
Project: **ME1414651 One City Center**			
Client: Verizon Wireless	Drawn by: Rob Adair	App'd:	
Code: TIA-222-G	Date: 03/04/14	Scale: NTS	
Path: C:\Users\Rob Adair\Documents\Jobs\2 Verizon LTE\ME1414650 One City Center Portland\ME1414651 One City Center.eri		Dwg No. E-1	

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Appendix B

Calculations

tnxTower	Job: 40' ROHN SSMW Tower
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Tower Input Data

The main tower is a 3x free standing tower with an overall height of 250.00 ft above the ground line.
The base of the tower is set at an elevation of 210.00 ft above the ground line.
The face width of the tower is 8.50 ft at the top and 8.63 ft at the base.
This tower is designed using the TIA-222-G standard.
The following design criteria apply:

Tower is located in Cumberland County, Maine.
Basic wind speed of 100 mph.
Structure Class II.
Exposure Category B.
Topographic Category 1.
Nominal ice thickness of 1.0000 in.
Ice thickness is considered to increase with height.
Ice density of 56 pcf.
A wind speed of 40 mph is used in combination with ice.
Deflections calculated using a wind speed of 60 mph.
Pressures are calculated at each section.
Stress ratio used in tower member design is 1.
Local bending stresses due to climbing loads, feed line supports, and appurtenance mounts are not considered.

Feed Line/Linear Appurtenances

Description	Face or Leg	Allow Shield	Component Type	Placement ft	Face Offset in	Lateral Offset (Frac FW)	#	# Per Row	Clear Spacing in	Width or Diameter in	Perimeter in	Weight plf
3/8" safety cable	A	No	Ar (CaAa)	250.00 - 210.00	-36.0000	0.5	1	1	0.3750	0.3750		0.22
Climbing Ladder	A	No	Af (CaAa)	250.00 - 210.00	-40.0000	0.5	1	1	3.0000	3.0000		7.90
3/4" conduit	A	No	Ar (CaAa)	250.00 - 210.00	0.0000	0.45	1	1	0.7500	0.7500		0.40
1 5/8	C	No	Ar (CaAa)	245.00 - 210.00	0.0000	0.4	12	6	0.5000	1.9800		1.04
1.57" Hybrid fiber-power cable	C	No	Ar (CaAa)	245.00 - 210.00	0.0000	0.4	2	2	0.5000	1.5700		0.66
7/8	C	No	Ar (CaAa)	217.00 - 210.00	0.0000	0.5	1	1	1.1100	1.1100		0.54
1/4	B	No	Ar (CaAa)	217.00 - 210.00	0.0000	0.5	1	1	0.2500	0.2500		0.05
1/2	C	No	Ar (CaAa)	211.00 - 210.00	0.0000	0.5	1	1	0.5800	0.5800		0.25

Discrete Tower Loads

Description	Face or Leg	Offset Type	Offsets: Horz Lateral Vert ft	Azimuth Adjustment °	Placement ft		C_AA_A Front ft^2	C_AA_A Side ft^2	Weight lb
(3) 2' x 6" panel	C	From Leg	0.00 0.00 3.00	0.0000	250.00	No Ice 1/2" Ice 1" Ice	1.40 1.60 1.81	0.72 0.88 1.07	15.00 23.69 34.70
LED beacon	A	None		0.0000	250.00	No Ice 1/2" Ice 1" Ice	0.53 0.65 0.78	0.53 0.65 0.78	30.00 39.39 50.57
8'x2 3/8" Pipe Mount	C	None		0.0000	249.00	No Ice 1/2" Ice 1" Ice	1.90 2.73 3.40	1.90 2.73 3.40	29.20 43.54 63.16

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Description	Face or Leg	Offset Type	Offsets: Horz Lateral Vert ft	Azimuth Adjustment °	Placement ft		C_AA_A Front ft^2	C_AA_A Side ft^2	Weight lb
(2) LNX-6514DS-VTM	A	From Leg	3.00	0.0000	245.00	No Ice	8.41	4.17	30.00
			0.00			1/2" Ice	8.96	4.61	74.68
			0.00			1" Ice	9.52	5.07	125.36
(2) LNX-6514DS-VTM	B	From Leg	3.00	0.0000	245.00	No Ice	8.41	4.17	30.00
			0.00			1/2" Ice	8.96	4.61	74.68
			0.00			1" Ice	9.52	5.07	125.36
(2) LNX-6514DS-VTM	C	From Leg	3.00	0.0000	245.00	No Ice	8.41	4.17	30.00
			0.00			1/2" Ice	8.96	4.61	74.68
			0.00			1" Ice	9.52	5.07	125.36
(2) HBXX-6516DS	A	From Leg	3.00	0.0000	245.00	No Ice	5.94	3.30	15.00
			0.00			1/2" Ice	6.36	3.63	50.44
			0.00			1" Ice	6.78	4.00	90.58
(2) HBXX-6516DS	B	From Leg	3.00	0.0000	245.00	No Ice	5.94	3.30	15.00
			0.00			1/2" Ice	6.36	3.63	50.44
			0.00			1" Ice	6.78	4.00	90.58
(2) HBXX-6516DS	C	From Leg	3.00	0.0000	245.00	No Ice	5.94	3.30	15.00
			0.00			1/2" Ice	6.36	3.63	50.44
			0.00			1" Ice	6.78	4.00	90.58
ALU 9442 RRH w/bracket	A	From Leg	2.00	0.0000	245.00	No Ice	3.89	1.94	137.00
			0.00			1/2" Ice	4.15	2.14	164.58
			0.00			1" Ice	4.42	2.35	195.59
ALU 9442 RRH w/bracket	B	From Leg	2.00	0.0000	245.00	No Ice	3.89	1.94	137.00
			0.00			1/2" Ice	4.15	2.14	164.58
			0.00			1" Ice	4.42	2.35	195.59
ALU 9442 RRH w/bracket	C	From Leg	2.00	0.0000	245.00	No Ice	3.89	1.94	137.00
			0.00			1/2" Ice	4.15	2.14	164.58
			0.00			1" Ice	4.42	2.35	195.59
ALU RRH2x60-AWS w/bracket	A	From Leg	2.00	0.0000	245.00	No Ice	3.96	2.16	60.00
			0.00			1/2" Ice	4.27	2.44	84.31
			0.00			1" Ice	4.60	2.73	112.31
ALU RRH2x60-AWS w/bracket	B	From Leg	2.00	0.0000	245.00	No Ice	3.96	2.16	60.00
			0.00			1/2" Ice	4.27	2.44	84.31
			0.00			1" Ice	4.60	2.73	112.31
ALU RRH2x60-AWS w/bracket	C	From Leg	2.00	0.0000	245.00	No Ice	3.96	2.16	60.00
			0.00			1/2" Ice	4.27	2.44	84.31
			0.00			1" Ice	4.60	2.73	112.31
ALU PCS B25 RRH4x30 w/bracket	A	From Leg	2.00	0.0000	245.00	No Ice	2.57	2.25	60.00
			0.00			1/2" Ice	2.79	2.46	81.60
			0.00			1" Ice	3.02	2.68	106.28
ALU PCS B25 RRH4x30 w/bracket	B	From Leg	2.00	0.0000	245.00	No Ice	2.57	2.25	60.00
			0.00			1/2" Ice	2.79	2.46	81.60
			0.00			1" Ice	3.02	2.68	106.28
ALU PCS B25 RRH4x30 w/bracket	C	From Leg	2.00	0.0000	245.00	No Ice	2.57	2.25	60.00
			0.00			1/2" Ice	2.79	2.46	81.60
			0.00			1" Ice	3.02	2.68	106.28
RFS DB-B1-6C-12AB-0Z D-box	A	From Leg	0.50	0.0000	245.00	No Ice	2.94	1.91	27.00
			0.00			1/2" Ice	3.17	2.11	49.89
			0.00			1" Ice	3.41	2.31	75.90
RFS DB-B1-6C-12AB-0Z D-box	C	From Leg	0.50	0.0000	245.00	No Ice	2.94	1.91	27.00
			0.00			1/2" Ice	3.17	2.11	49.89
			0.00			1" Ice	3.41	2.31	75.90
12' T-frame sector mnt	A	None		0.0000	245.00	No Ice	13.60	6.80	465.00
						1/2" Ice	18.40	9.20	600.00
						1" Ice	23.20	11.60	735.00
12' T-frame sector mnt	B	None		0.0000	245.00	No Ice	13.60	6.80	465.00
						1/2" Ice	18.40	9.20	600.00
						1" Ice	23.20	11.60	735.00
12' T-frame sector mnt	C	None		0.0000	245.00	No Ice	13.60	6.80	465.00
						1/2" Ice	18.40	9.20	600.00

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Description	Face or Leg	Offset Type	Offsets: Horz Lateral Vert ft	Azimuth Adjustment °	Placement ft		C_AA_A Front ft^2	C_AA_A Side ft^2	Weight lb
						1" Ice	23.20	11.60	735.00
10' sector mount	A	None		0.0000	235.00	No Ice	10.10	5.05	300.00
						1/2" Ice	14.30	7.15	350.00
						1" Ice	18.50	9.25	425.00
10' sector mount	B	None		0.0000	235.00	No Ice	10.10	5.05	300.00
						1/2" Ice	14.30	7.15	350.00
						1" Ice	18.50	9.25	425.00
10' sector mount	C	None		0.0000	235.00	No Ice	10.10	5.05	300.00
						1/2" Ice	14.30	7.15	350.00
						1" Ice	18.50	9.25	425.00
Obstruction light	A	None		0.0000	230.00	No Ice	0.18	0.18	8.00
						1/2" Ice	0.25	0.25	10.47
						1" Ice	0.33	0.33	13.91
Obstruction light	B	None		0.0000	230.00	No Ice	0.18	0.18	8.00
						1/2" Ice	0.25	0.25	10.47
						1" Ice	0.33	0.33	13.91
Obstruction light	C	None		0.0000	230.00	No Ice	0.18	0.18	8.00
						1/2" Ice	0.25	0.25	10.47
						1" Ice	0.33	0.33	13.91
1' square panel	B	None		0.0000	217.00	No Ice	1.40	0.35	15.00
						1/2" Ice	1.56	0.45	22.91
						1" Ice	1.73	0.56	32.76
(2) 2' yagi	C	From Leg	1.00	0.0000	211.00	No Ice	0.20	0.20	10.00
			0.00			1/2" Ice	0.32	0.32	11.93
			0.00			1" Ice	0.45	0.45	15.35

Dishes

Description	Face or Leg	Dish Type	Offset Type	Offsets: Horz Lateral Vert ft	Azimuth Adjustment °	3 dB Beam Width °	Elevation ft	Outside Diameter ft		Aperture Area ft^2	Weight lb
8' grid dish	C	Grid	From Leg	0.50	0.0000		217.00	8.00	No Ice	50.27	225.00
				0.00					1/2" Ice	51.32	488.43
				0.00					1" Ice	52.37	731.43

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Solution Summary

Maximum Tower Deflections - Service Wind

Section No.	Elevation ft	Horz. Deflection in	Gov. Load Comb.	Tilt °	Twist °
T1	250 - 230	0.126	14	0.0166	0.0037
T2	230 - 210	0.047	14	0.0136	0.0027

Critical Deflections and Radius of Curvature - Service Wind

Elevation ft	Appurtenance	Gov. Load Comb.	Deflection in	Tilt °	Twist °	Radius of Curvature ft
250.00	(3) 2' x 6" panel	14	0.126	0.0166	0.0037	390199
249.00	8'x2 3/8" Pipe Mount	14	0.122	0.0166	0.0037	390199
245.00	(2) LNX-6514DS-VTM	14	0.105	0.0165	0.0036	390199
235.00	10' sector mount	14	0.064	0.0152	0.0031	130066
230.00	Obstruction light	14	0.047	0.0136	0.0027	106418
217.00	8' grid dish	14	0.014	0.0056	0.0011	278714
211.00	(2) 2' yagi	14	0.002	0.0008	0.0002	390202

Bolt Design Data

Section No.	Elevation ft	Component Type	Bolt Grade	Bolt Size in	Number Of Bolts	Maximum Load per Bolt lb	Allowable Load lb	Ratio Load / Allowable	Allowable Ratio	Criteria
T1	250	Leg	A325N	0.7500	4	1520.15	29820.60	0.051 ✔	1	Bolt Tension
		Diagonal	A325N	0.6250	3	1646.64	12425.20	0.133 ✔	1	Bolt Shear
		Horizontal	A325N	0.6250	2	1334.90	12425.20	0.107 ✔	1	Bolt Shear
		Top Girt	A325N	0.6250	2	232.91	12425.20	0.019 ✔	1	Bolt Shear
T2	230	Leg	A325N	0.8750	4	7399.75	40589.10	0.182 ✔	1	Bolt Tension
		Diagonal	A325N	0.6250	3	2654.78	12425.20	0.214 ✔	1	Bolt Shear
		Horizontal	A325N	0.6250	2	2171.38	12425.20	0.175 ✔	1	Bolt Shear
		Top Girt	A325N	0.6250	2	1568.30	12425.20	0.126 ✔	1	Bolt Shear

Section Capacity Table

Section No.	Elevation ft	Component Type	Size	Critical Element	P lb	$øP_{allow}$ lb	% Capacity	Pass Fail
T1	**250 - 230**	**Leg**	**ROHN 2.5 STD**	**3**	**-9019.83**	**45528.30**	**19.8**	**Pass**
		Diagonal	ROHN 2 STD	9	-4939.92	16869.10	29.3	Pass
		Horizontal	ROHN 1.5 STD	7	-2669.79	18513.10	14.4	Pass
		Top Girt	ROHN 1.5 STD	6	-465.83	18554.70	2.5	Pass
		Inner Bracing	L2x2x1/8	17	-2.93	6529.03	0.8	Pass
T2	**230 - 210**	**Leg**	**ROHN 3 EH**	**42**	**-34124.30**	**94459.10**	**36.1**	**Pass**
		Diagonal	ROHN 2 X-STR	48	-7964.33	22398.60	35.6	Pass

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Section No.	Elevation ft	Component Type	Size	Critical Element	P lb	$øP_{allow}$ lb	% Capacity	Pass Fail
		Horizontal	ROHN 1.5 STD	46	-4332.09	18487.00	23.4	Pass
		Top Girt	ROHN 1.5 STD	43	-3104.92	18492.20	16.8	Pass
		Inner Bracing	L2x2x1/8	78	-54.06	6511.12	0.8	Pass
							Summary	
						Leg (T2)	36.1	Pass
						Diagonal (T2)	35.6	Pass
						Horizontal (T2)	23.4	Pass
						Top Girt (T2)	16.8	Pass
						Inner Bracing (T2)	0.8	Pass
						Bolt Checks	21.4	Pass
						RATING =	**36.1**	**Pass**