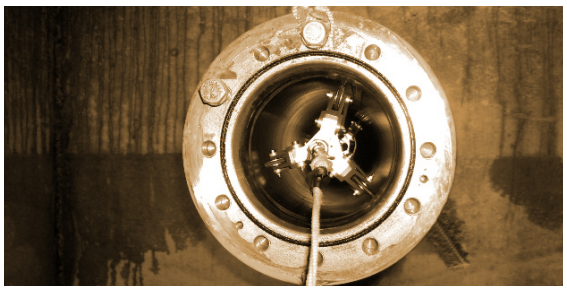
CUES AMP™ CASE STUDY



ELECTRICAL TRANSMISSION

PROBLEM OVERVIEW

CUES was approached by a leading electrical underground high voltage transmission cable installation company to help improve the accuracy of their pulling tension/sidewall pressure calculations for electrical re-cabling projects. The company was having difficulty in determining the current geometry and configuration of older conduits on many of their projects. Finding accurate data for input into their calculations was challenging due to the fact that as-built information of the pipes, if it existed, was proving to be inaccurate and incomplete.

CUES APPROACH

Drawing upon their experience providing customers with 3D positional data from the CUES Accurate Mapping Probe (AMP™), the CUES Geographical Scientists felt that traditional AMP™ data outputs (plan and profile) could be modified to also produce linear and arc segments for a specified pipeline. Additionally, it was felt that these linear and arc segments could be further defined into both the horizontal and vertical planes. Using this approach, CUES was able to modify the AMP™ software to produce this additional data to feed directly into our customer's pulling tension and side wall bearing pressure models/calculations. This approach not only saved a considerable amount of time in producing the pulling tension calculations; it also greatly increased the accuracy of the calculations.

RESULTS

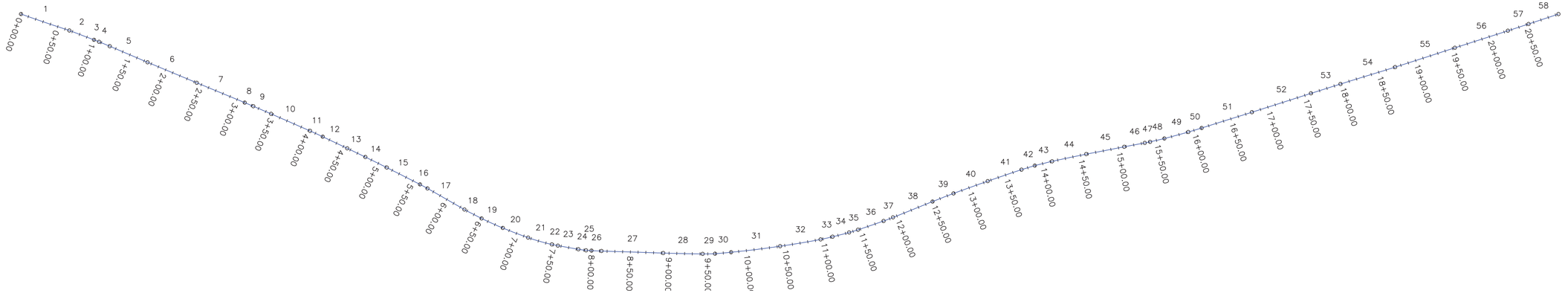
In order to confirm that the linear and arc data obtained from the AMP™ was effective and predictive, comparisons between derived pulling tensions and recorded field observed tensions would need to be made. Provided (ref. Figure 1) is the Plan view of a sampled pipeline on a Google Earth image. This particular pipeline segment was approximately 2,098 feet in length and was an 8-inch ID steel pipeline. Figure 2 details the Plan and Profile location of the mapped electrical transmission pipeline. Additionally, segment reference numbers are provided on the upper portion of both the plan and profile drawings and reference to the Line and Arc tables provided on (ref. Figure 3).

Figure 4 documents the derived pulling tension (green line) and the actual measured pulling tension (red line) during the re-cabling installation of the pipe type cable. Based on Figure 4, it can be determined that the 3D positional data collected with the AMP™ that was utilized in the tension calculation was both effective and predictive in determining pulling tension for this particular pipeline segment.

Operational range of 3.5in ID (90mm) to 58in ID (1473mm). Whether the pipeline is made of steel, concrete, PE, or PVC, this mapping system can be used to accurately locate any pipe.

IN PARTNERSHIP WITH REDUCT

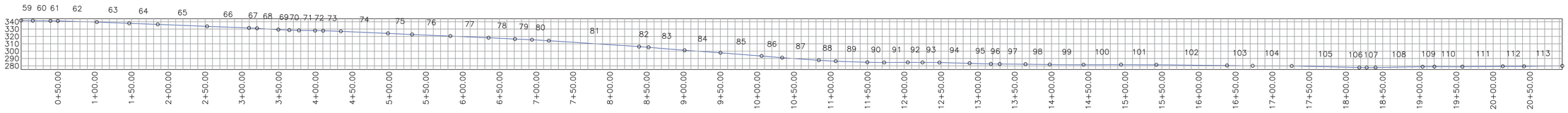
Figure 1: Plan view of the pipeline on a Google Earth image



PLAN

0 70

GRAPHIC SCALE IN FEET



PROFILE

0 70

GRAPHIC SCALE IN FEET

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DWN VUE CHK PM

PROJECT NO.

FILENAME

AS-BUILT PIPELINE LOCATION PLAN AND PROFILE VIEW

SCALE AS SHOWN | DATE MAR 2014 | SHEET 1 OF 2

HORIZONTAL PLANE LINE & ARC DATA

SEG	TYPE	HORIZ LENGTH	ARC LENGTH	BEARING	RADIUS	BEGINNING STATION	X COORD	Y COORD	ENDING STATION	X COORD	Y COORD
1	ARC		65.9668'		2079.8028'	0+00.00	550195.5300	701764.6800	0+65.97	550167.9900	701704.7400
2	LINE	33.9614'		243.4123'		0+65.97	550167.9900	701704.7400	0+99.93	550152.7900	701674.3700
3	LINE	6.9903'		242.8484'		0+99.93	550152.7900	701674.3700	1+06.92	550149.6000	701668.1500
4	LINE	14.9850'		241.5879'		1+06.92	550149.6000	701668.1500	1+21.90	550142.4700	701654.9700
5	LINE	52.9371'		241.0673'		1+21.90	550142.4700	701654.9700	1+74.84	550116.8600	701608.6400
6	LINE	68.8973'		241.4858'		1+74.84	550116.8600	701608.6400	2+43.74	550083.9700	701548.1000
7	LINE	66.9219'		241.6581'		2+43.74	550083.9700	701548.1000	3+10.66	550052.2000	701489.2000
8	LINE	11.9753'		241.3590'		3+10.66	550052.2000	701489.2000	3+22.64	550046.4600	701478.6900
9	LINE	24.9485'		240.8562'		3+22.64	550046.4600	701478.6900	3+47.58	550034.3100	701456.9000
10	LINE	54.9405'		240.5048'		3+47.58	550034.3100	701456.9000	4+02.52	550007.2600	701409.0800
11	ARC		17.9810'		672.7094'	4+02.52	550007.2600	701409.0800	4+20.51	549998.1300	701393.5900
12	LINE	34.9468'		238.7298'		4+20.51	549998.1300	701393.5900	4+55.45	549979.9900	701363.7200
13	LINE	25.9645'		238.4648'		4+55.45	549979.9900	701363.7200	4+81.42	549966.4100	701341.5900
14	LINE	30.9562'		237.9220'		4+81.42	549966.4100	701341.5900	5+12.37	549949.9700	701315.3600
15	LINE	47.9273'		237.2748'		5+12.37	549949.9700	701315.3600	5+60.30	549924.0600	701275.0400
16	LINE	10.9806'		235.8758'		5+60.30	549924.0600	701275.0400	5+71.28	549917.9000	701265.9500
17	LINE	54.9271'		234.3799'		5+71.28	549917.9000	701265.9500	6+26.21	549885.9100	701221.3000
18	ARC		24.9535'		510.9725'	6+26.21	549885.9100	701221.3000	6+51.16	549872.2200	701200.4400
19	ARC		29.9609'		444.2589'	6+51.16	549872.2200	701200.4400	6+81.12	549857.1700	701174.5400
20	ARC		34.9275'		632.9939'	6+81.12	549857.1700	701174.5400	7+16.05	549841.4600	701143.3500
21	ARC		31.9087'		265.6942'	7+16.05	549841.4600	701143.3500	7+47.96	549829.5700	701113.7600
22	LINE	7.9837'		252.8814'		7+47.96	549829.5700	701113.7600	7+55.94	549827.2200	701106.1300
23	LINE	26.9282'		253.9611'		7+55.94	549827.2200	701106.1300	7+82.87	549819.7800	701080.2500
24	ARC		9.9657'		148.4449'	7+82.87	549819.7800	701080.2500	7+92.84	549817.4600	701070.5600
25	LINE	6.9771'		260.4297'		7+92.84	549817.4600	701070.5600	7+99.81	549816.3000	701063.6800
26	LINE	12.9669'		261.9761'		7+99.81	549816.3000	701063.6800	8+12.78	549814.4900	701050.8400
27	LINE	79.7308'		262.2368'		8+12.78	549814.4900	701050.8400	8+92.51	549803.7200	700971.8400
28	ARC		50.8511'		1757.9178'	8+92.51	549803.7200	700971.8400	9+43.36	549797.4400	700921.3800
29	ARC		15.9328'		286.1327'	9+43.36	549797.4400	700921.3800	9+59.29	549796.0500	700905.5100
30	ARC		20.9243'		440.8832'	9+59.29	549796.0500	700905.5100	9+80.22	549795.7400	700884.5900
31	ARC		63.7692'		1280.5533'	9+80.22	549795.7400	700884.5900	10+43.99	549797.0100	700820.8400
32	ARC		52.8500'		1109.0129'	10+43.99	549797.0100	700820.8400	10+96.84	549800.3400	700768.1000
33	ARC		15.9762'		407.6458'	10+96.84	549800.3400	700768.1000	11+12.81	549802.1700	700752.2300
34	ARC		21.9736'		993.1428'	11+12.81	549802.1700	700752.2300	11+34.79	549805.4300	700730.5000
35	ARC		11.9861'		232.8686'	11+34.79	549805.4300	700730.5000	11+46.77	549807.7400	700718.7400
36	ARC		34.9796'		1895.5370'	11+46.77	549807.7400	700718.7400	11+81.75	549815.6200	700684.6600
37	LINE	12.9888'		284.7638'		11+81.75	549815.6200	700684.6600	11+94.74	549818.9300	700672.1000
38	LINE	54.9662'		285.9884'		11+94.74	549818.9300	700672.1000	12+49.71	549834.0700	700619.2600
39	ARC		28.9710'		1059.7798'	12+49.71	549834.0700	700619.2600	12+78.68	549841.6900	700591.3100
40	ARC		46.9679'		2794.1675'	12+78.68	549841.6900	700591.3100	13+25.65	549852.9000	700545.7000
41	ARC		45.9774'		1955.5119'	13+25.65	549852.9000	700545.7000	13+71.62	549863.1900	700500.8900
42	LINE	17.9745'		280.9036'		13+71.62	549863.1900	700500.8900	13+89.60	549866.5900	700483.2400
43	ARC		22.9930'		881.1191'	13+89.60	549866.5900	700483.2400	14+12.59	549869.7800	700460.4700
44	ARC		44.9654'		1798.1537'	14+12.59	549869.7800	700460.4700	14+57.56	549874.4600	700415.7500
45	LINE	49.9659'		275.0750'		14+57.56	549874.4600	700415.7500	15+07.52	549878.8800	700365.9800
46	LINE	26.9956'		274.8236'		15+07.52	549878.8800	700365.9800	15+34.52	549881.1500	700339.0800
47	LINE	6.9922'		275.4986'		15+34.52	549881.1500	700339.0800	15+41.51	549881.8200	700332.1200
48	ARC		18.9744'		611.8892'	15+41.51	549881.8200	700332.1200	15+60.49	549884.1500	700313.2900
49	ARC		31.9927'		1635.5524'	15+60.49	549884.1500	700313.2900	15+92.48	549889.3300	700281.7200
50	LINE	17.9688'		280.8097'		15+92.48	549889.3300	700281.7200	16+10.45	549892.7000	700264.0700
51	LINE	67.9664'		281.5083'		16+10.45	549892.7000	700264.0700	16+78.41	549906.2600	700197.4700
52	LINE	79.9440'		281.8159'		16+78.41	549906.2600	700197.4700	17+58.36	549922.6300	700119.2200
53	LINE	39.9711'		281.6332'		17+58.36	549922.6300	700119.2200	17+98.33	549930.6900	700080.0700
54	LINE	73.9437'		281.2613'		17+98.33	549930.6900	700080.0700	18+72.27	549945.1300	700007.5500
55	ARC		80.9552'		15041.9728'	18+72.27	549945.1300	700007.5500	19+53.23	549961.9900	699928.3700
56	LINE	71.9450'		281.8956'		19+53.23	549961.9900	699928.3700	20+25.17	549976.8200	699857.9700
57	LINE	27.9855'		282.2335'		20+25.17	549976.8200	699857.9700	20+53.16	549982.7500	699830.6200
58	LINE	40.7374'		282.4464'		20+53.16	549982.7500	699830.6200	20+93.90	549991.5300	699790.8400

VERTICAL PLANE LINE & ARC DATA

SEG	TYPE	LENGTH	ARC LENGTH	ANGLE	RADIUS	BEGINNING STATION	ELEV	ENDING STATION	ELEV
59	LINE	15.9962'		−1.2896°		0+00.00	341.6800	0+15.99	341.3200
60	LINE	23.9955'		−0.4059°		0+15.99	341.3200	0+39.99	341.1500
61	LINE	9.9866'		−0.9754°		0+39.99	341.1500	0+49.97	340.9800
62	LINE	52.9813'		−1.5358°		0+49.97	340.9800	1+02.93	339.5600
63	LINE	43.9716'		−2.3591°		1+02.93	339.5600	1+46.87	337.7500
64	LINE	38.9698'		−2.0147°		1+46.87	337.7500	1+85.81	336.3800
65	LINE	66.9704'		−2.3363°		1+85.81	336.3800	2+52.73	333.6500
66	LINE	56.9761'		−2.1525°		2+52.73	333.6500	3+09.67	331.5100
67	LINE	10.9908'		−2.8684°		3+09.67	331.5100	3+20.64	330.9600
68	LINE	28.9847'		−3.4218°		3+20.64	330.9600	3+49.58	329.2300
69	LINE	14.9941'		−2.5993°		3+49.58	329.2300	3+64.55	328.5500
70	LINE	12.9953'		−1.5874°		3+64.55	328.5500	3+77.54	328.1900
71	LINE	21.9896'		−0.7035°		3+77.54	328.1900	3+99.53	327.9200
72	LINE	10.9871'		−1.1473°		3+99.53	327.9200	4+10.52	327.7000
73	LINE	23.9907'		−1.8871°		4+10.52	327.7000	4+34.49	326.9100
74	LINE	63.9657'		−2.4999°		4+34.49	326.9100	4+98.40	324.1200
75	LINE	32.9791'		−2.6765°		4+98.40	324.1200	5+31.34	322.5800
76	LINE	51.9720'		−2.3599°		5+31.34	322.5800	5+83.27	320.4400
77	LINE	51.9778'		−2.4810°		5+83.27	320.4400	6+35.20	318.1900
78	LINE	35.9850'		−2.7875°		6+35.20	318.1900	6+71.14	316.4400
79	LINE	22.9914'		−2.4430°		6+71.14	316.4400	6+94.11	315.4600
80	LINE	22.9714'		−3.2192°		6+94.11	315.4600	7+17.05	314.1700
81	LINE	122.9245'		−3.7221°		7+17.05	314.1700	8+39.71	306.1900
82	LINE	12.9947'		−4.4135°		8+39.71	306.1900	8+52.67	305.1900
83	LINE	48.9819'		−4.6959°		8+52.67	305.1900	9+01.49	301.1800
84	LINE	48.9735'		−4.0748°		9+01.49	301.1800	9+50.34	297.7000
85	LINE	55.9789'		−4.4363°		9+50.34	297.7000	10+06.15	293.3700
86	LINE	27.9772'		−4.7567°		10+06.15	293.3700	10+34.03	291.0500
87	LINE	49.9764'		−3.9814°		10+34.03	291.0500	10+83.88	287.5800
88	ARC		22.9772'		999.6415'	10+83.88	287.5800	11+06.82	286.2800
89	LINE	42.9742'		−1.9336°		11+06.82	286.2800	11+49.77	284.8300
90	ARC		23.0064'		1032.1922'	11+49.77	284.8300	11+72.78	284.5500
91	LINE	31.9711'		0.3047°		11+72.78	284.5500	12+04.75	284.7200
92	LINE	19.9912'		−0.5159°		12+04.75	284.7200	12+24.74	284.5400
93	LINE	22.9822'		−0.1745°		12+24.74	284.5400	12+47.72	284.4700
94	LINE	40.9833'		−1.4261°		12+47.72	284.4700	12+88.69	283.4500
95	LINE	28.9789'		−1.6610°		12+88.69	283.4500	13+17.66	282.6100
96	LINE	11.9977'		−0.7641°		13+17.66	282.6100	13+29.66	282.4500
97	LINE	34.9732'		−0.4423°		13+29.66	282.4500	13+64.63	282.1800
98	LINE	32.9937'		−0.7294°		13+64.63	282.1800	13+97.62	281.7600
99	LINE	45.9676'		−0.3365°		13+97.62	281.7600	14+43.58	281.4900
100	LINE	50.9598'		0.1462°		14+43.58	281.4900	14+94.54	281.6200
101	ARC		47.9872'		4796.8276'	14+94.54	281.6200	15+42.53	281.4000
102	LINE	95.9221'		−0.5675°		15+42.53	281.4000	16+38.45	280.4500
103	LINE	34.9811'		−0.8026°		16+38.45	280.4500	16+73.43	279.9600
104	LINE	52.9812'		−0.1514°		16+73.43	279.9600	17+26.41	279.8200
105	ARC		91.9434'		12282.0209'	17+26.41	279.8200	18+18.33	277.7000
106	LINE	10.0011'		−0.8021°		18+18.33	277.7000	18+28.33	277.5600
107	LINE	11.9949'		0.3344°		18+28.33	277.5600	18+40.32	277.6300
108	ARC		63.9615'		3095.2275'	18+40.32	277.6300	19+04.27	278.7700
109	LINE	15.9889'		0.3583°		19+04.27	278.7700	19+20.26	278.8700
110	LINE	37.9817'		−0.1207°		19+20.26	278.8700	19+58.24	278.7900
111	ARC		54.9621'		5676.8766'	19+58.24	278.7900	20+13.20	279.3500
112	LINE	28.9832'		−0.0593°		20+13.20	279.3500	20+42.18	279.3200
113	ARC		51.7337'		3967.6642'	20+42.18	279.3200	20+93.91	279.9200

THE HORIZONTAL AND VERTICAL PLANE DATA SHOWN IS GENERALIZED AND DERIVED FROM THE APPROXIMATE LOCATION OF THE PIPELINE. THE PIPELINE MAY CONTAIN DIFFERENT GEOMETRY THAN SHOWN. THE DATA IS SUPPLIED TO AID IN THE CALCULATION OF CABLE PULLING TENSIONS AND SHOULD NOT BE USED TO LOCATE THE PIPELINE. NUMEROUS FACTORS AFFECT THE ACCURACY OF THIS INFORMATION SUCH AS, BUT NOT LIMITED TO, PIPELINE CONDITIONS, FIELD LOCATING PROCEDURES AND HUMAN ERROR. THE CONTRACTOR IS RESPONSIBLE FOR VERIFYING THE ACTUAL GEOMETRY OF THE PIPELINE. CUES INC. AND CUES MAPPING SYSTEMS DISCLAIMS ALL LIABILITIES FOR DAMAGE RELATED TO THE USE OF THIS DATA AND ANY ERRORS OR OMISSIONS IT MAY CONTAIN.

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DWN VUE CHK PM
PROJECT NO.
FILENAME

AS-BUILT PIPELINE LOCATION PLAN AND PROFILE VIEW

SCALE AS SHOWN | DATE MAR 2014 | SHEET 1 OF 2

Speed, Calculated Tension & Measured Tension Versus Distance