

Predicting Hydrocarbon Pay Zones Using GPS and Automation of Published Well Data

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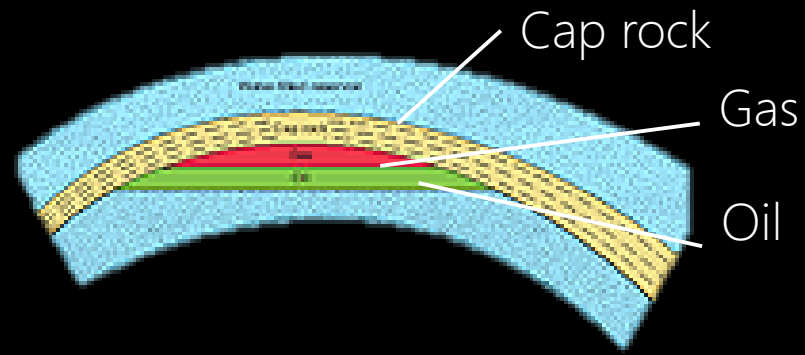
Agenda

- Project need explanation & business application
- Area of Interest
- Model Integrity & Other methods
- Technical Overview & Final product viewing
- Accuracy matrix & research reference
- Conclusions



Nature of the Problem

- It is beneficial to understand the depths of competitor wells because it can help with an understanding of target depths for land subdivisions
- Stratigraphy topographic map can be developed from a more comprehensive understanding of the formation character
- Specific depths of competitor wells needed for caprock damage avoidance and increased likelihood of drilling into target formations
 - Formation synclines & inclines
 - Avoid nearby drilling
 - Avoid formation trespassing



Area of Interest (Aol)



- Apache Corporation – Rancho Grande EF
 - #1H 42-041-32254
 - #2H 42-041-32253
- College Station Bryan area
- Eagle Ford shale target – about 8,000 12,000 ft deep

Prediction Integrity

Many technical obstacles prevent a result with high business value from being developed

1. Texas Railroad Commission provides directional well data but lacks surface elevation
2. Pre-surveyed areas are not reliable and often have cement casing elevation

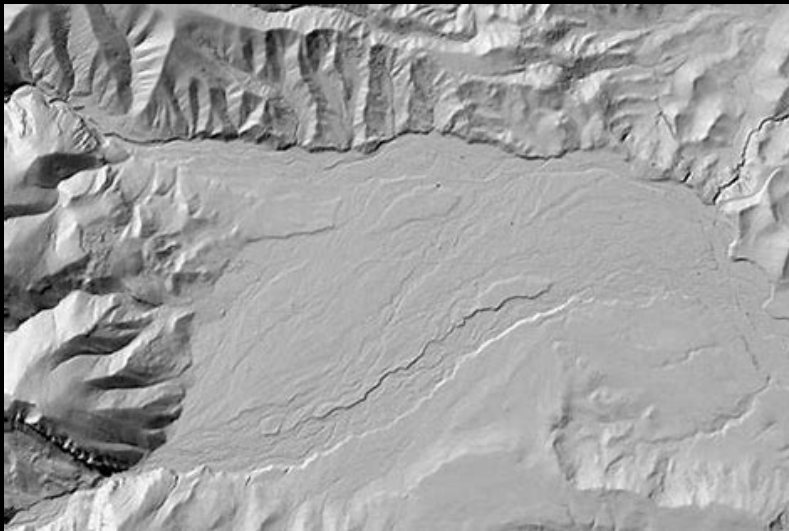
Client: Apache		M.W.D. Operators: M. Rainey / E. Scheffey/M. Dianda						
Well: Grant 1H		Directional Drillers: J. Kimball / S. Thomason						
County: Brazos		Tool Azimuth to Grid North: 1.43						
Rig: H&P 327		Job #: HO-141320						
Vertical Section Angle: 311.87		API#: 42-041-32262						
Sur #	Meas. Depth	Inc.	Azm.	T.V.D.	Ver. Sect.	+N / -S	+E / -W	DLS
Tie In	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	237.00	0.30	240.50	237.00	0.17	-0.36	-0.55	0.11
3	331.00	0.40	264.00	331.00	0.47	-0.52	-1.09	0.18
4	426.00	0.20	236.40	426.00	0.73	-0.64	-1.56	0.25
5	521.00	0.40	267.80	520.99	1.01	-0.75	-2.03	0.27
6	603.00	0.30	270.40	602.99	1.38	-0.76	-2.53	0.12
7	698.00	0.40	259.00	697.99	1.77	-0.82	-3.11	0.13
8	792.00	0.50	275.20	791.99	2.29	-0.85	-3.84	0.17
9	887.00	0.40	282.20	886.99	2.91	-0.74	-4.57	0.12
10	981.00	0.40	278.50	980.98	3.47	-0.62	-5.22	0.03
11	1076.00	0.40	278.00	1075.98	4.02	-0.52	-5.88	0.00
12	1171.00	0.60	292.20	1170.98	4.77	-0.29	-6.66	0.25
13	1265.00	0.60	271.50	1264.97	5.61	-0.09	-7.61	0.23
14	1360.00	2.60	22.50	1359.94	6.70	1.91	-7.28	3.02
15	1455.00	4.60	52.80	1454.76	6.69	6.21	-3.42	2.84
16	1549.00	5.80	56.70	1548.37	4.76	11.09	3.55	1.33
17	1644.00	5.80	56.10	1642.88	2.35	16.41	11.54	0.06

(Texas Railroad Commission)



Integrity Issues Continued

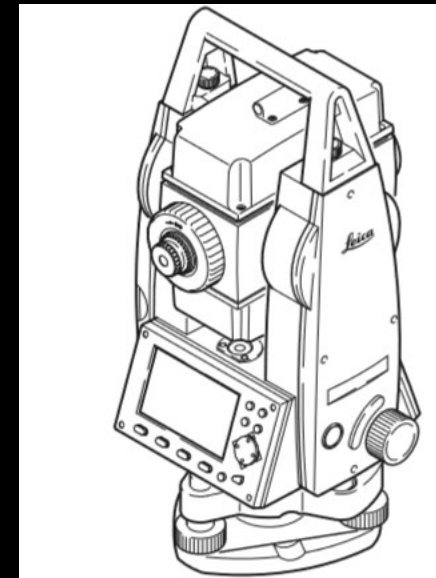
3. LiDAR DEM models do not account for the correct Kelly Bushing elevation providing a less accurate product



(TNRIS)

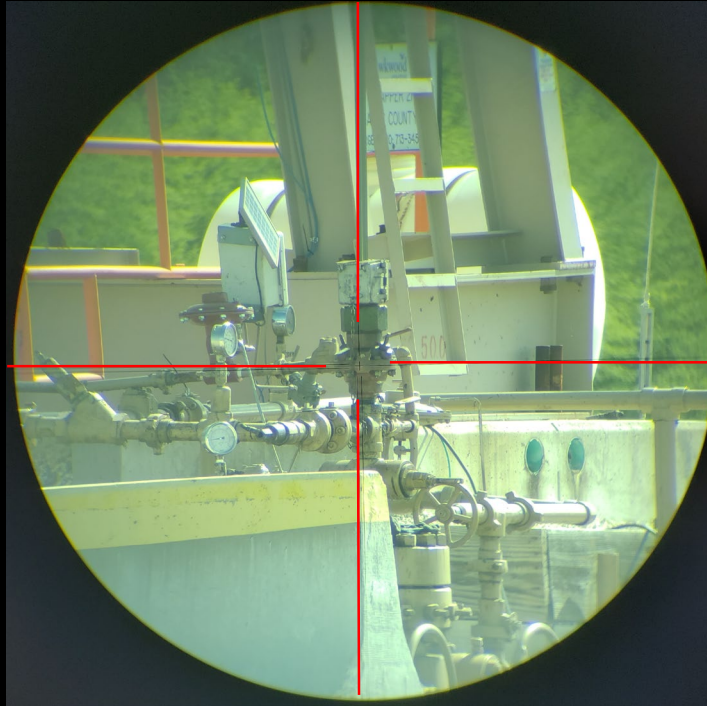
4. 'Intrinsically Safe' (IS) workplace design – voltage & atmosphere requirements prevent environmental and financial penalties & saves lives and profitable drilling projects

Leica theodolite



(Leica Geosystems)

Brief Technical Workflow



Field Work:

- Leica Total Station: determine reference point & back sight
- Reflector less target was chosen for Kelly Bushing target
- Began survey and Elevation, Easting, Northings were collected



C++ OCR & Visual Completion

- C++ Tesseract GitHub for Image to text processing, can be ran via command line for two wells, preferred in program

```
C:\Users\Pierc>tesseract PR0002378199_001.png out -l eng
```

The screenshot shows a text file with a table of numerical data. The table has 11 columns and 52 rows. The columns are labeled: Sur #, Meas. Depth, Inc, Azm, T.V.D., Var. Sects, N/E - S, +/- - W, and DLS. The data represents well trajectory measurements.

- Completed & published by an ArcGIS Pro Model Builder automation to complete the visualization process
- Competitor well data is published for increased accessibility to consumers

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CRESCENT
DIRECTIONAL DRILLING

Minimum Curvature Calculation

Client: Apache R.W.D. Operators; M. Rainey / E. Schley/M. Danda
Well: Grant 1H Directional Drillers: J. Kimball / S. Thomson
County: Brazos Tool Azimuth to Grid North: 1.43
Rig: H&P 327 Job #: HO-141322

Vertical Section Angle: 311.87 API#: 42-011-32762

Sur #	Meas. Depth	Inc	Azm.	T.V.D.	Var. Sects	N/E - S	+/- - W	DLS
1	142.00	0.20	234.50	142.00	0.05	-6.14	-0.20	0.14
2	237.00	0.30	240.50	237.00	0.17	-6.36	0.35	0.11
3	331.00	0.40	264.00	331.00	0.47	-6.52	-1.09	0.18
4	426.00	0.40	236.40	426.00	0.73	-6.64	-1.56	0.25
5	521.00	0.40	267.80	520.99	1.01	-6.75	-2.03	0.27
6	603.00	0.30	270.40	607.99	1.38	-6.76	-2.53	0.12
7	698.00	0.40	259.00	697.99	1.77	-6.82	-3.11	0.13
8	792.00	0.50	275.20	791.99	2.29	-6.85	-3.84	0.17
9	881.00	0.40	282.20	886.99	2.91	-6.74	-4.57	0.12
10	981.00	0.40	276.50	980.98	3.67	-6.62	-5.22	0.03
11	1076.00	0.40	278.00	1075.98	4.02	-6.52	-5.88	0.00
12	1171.00	0.60	250.20	1170.99	4.77	-6.29	-6.66	0.25
13	1265.00	0.60	271.50	1259.97	5.51	-6.09	-7.61	0.23
14	1360.00	2.60	225.00	1359.94	6.70	1.91	-7.28	3.02
15	1455.00	4.60	53.60	1454.76	6.69	16.21	-3.42	2.94
16	1549.00	5.80	56.70	1548.37	4.76	11.09	-3.55	1.33
17	1644.00	5.80	56.10	1642.88	2.25	16.41	-11.54	0.06
18	1738.00	5.80	55.70	1737.40	0.03	21.29	-19.49	0.04
19	1834.00	5.70	54.30	1831.92	-2.14	27.25	-27.29	0.18
20	1930.00	5.70	54.60	1925.43	-4.17	32.67	-34.89	0.03
21	2027.00	5.30	56.00	2019.95	-6.08	38.55	-42.37	0.03
22	2118.00	7.50	59.30	2114.06	-10.44	44.89	-54.25	0.45
23	2213.00	7.50	59.10	2208.27	-14.18	51.33	-65.99	0.03
24	2307.00	7.40	58.50	2301.42	-17.76	57.68	-75.54	0.23
25	2402.00	7.30	58.30	2395.64	-21.21	64.05	-85.89	0.11
26	2497.00	7.20	58.70	2489.88	-24.64	70.31	-96.11	0.12
27	2592.00	6.90	59.60	2584.16	-28.11	76.29	-106.12	0.34
28	2686.00	7.00	59.40	2677.47	-31.45	82.15	-115.87	0.19
29	2781.00	6.50	57.00	2771.80	-34.61	88.08	-125.43	0.43
30	2876.00	6.60	58.20	2866.17	-37.65	93.86	-134.69	0.04
31	2970.00	6.20	56.20	2959.59	-39.92	99.85	-143.19	1.03
32	3065.00	6.00	48.10	3054.05	-41.21	106.54	-150.83	0.32
33	3159.00	5.50	46.20	3147.58	-42.68	112.94	-157.74	0.57
34	3254.00	6.20	58.00	3242.06	-44.65	118.81	-165.39	1.46
35	3349.00	6.40	60.00	3336.51	-47.00	124.11	-174.35	0.40
36	3444.00	6.20	63.00	3430.94	-50.58	129.01	-183.35	0.32
37	3539.00	6.30	65.00	3525.36	-54.44	133.51	-192.77	0.23
38	3634.00	6.00	54.10	3619.76	-57.66	138.02	-202.04	1.50
39	3729.00	7.20	46.50	3714.08	-59.25	146.47	-210.98	1.03
40	3823.00	6.20	43.50	3807.38	-59.08	154.38	-219.52	0.84
41	3917.00	6.00	42.00	3890.86	-60.13	161.20	-225.23	0.41
42	3997.00	5.70	40.70	3963.30	-60.70	168.20	-231.39	0.98
43	4091.00	5.80	39.00	4073.90	-59.71	175.43	-237.43	0.21
44	4186.00	5.60	37.00	4168.43	-59.15	182.82	-243.30	0.24
45	4281.00	4.80	35.70	4262.93	-60.29	190.93	-251.20	2.82
46	4375.00	9.30	63.00	4353.83	-64.48	196.79	-262.97	2.31
47	4470.00	9.30	64.20	4448.53	-70.29	202.75	-273.01	0.47
48	4565.00	9.80	56.30	4543.16	-75.94	210.00	-283.55	1.41
49	4659.00	8.80	40.60	4635.94	-77.18	211.62	-302.28	2.89
50	4754.00	9.10	36.10	4728.78	-76.25	212.11	-311.44	0.88
51	4849.00	9.10	33.10	4821.59	-74.36	245.57	-319.97	0.50
52	4943.00	7.30	36.40	4916.62	-72.66	256.61	-327.57	1.88

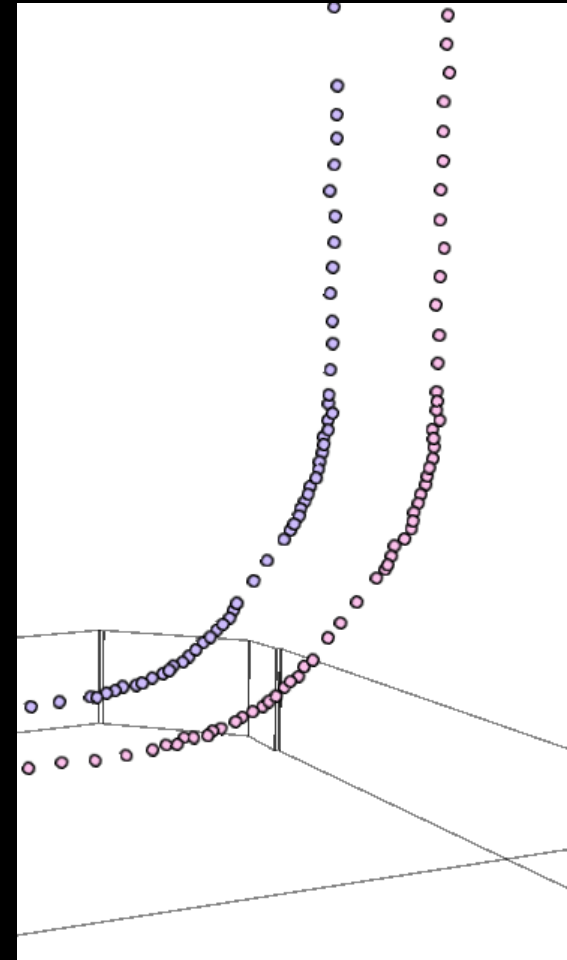
(C++ Tesseract GitHub)





Validation Matrix

- A combination of domain knowledge is used to help understand how accurate the final product is –
 - Drilling Data: TXRRC data is first vetted for accuracy:
 - Inclination & azimuth variance : varied
 - DLS variance is checked in comparison to well geometry : DLS 14.90
 - Tool face, Azimuth, and Inclination extrapolation
 - Geometric Data: Topological compliance
 - Well points, well lines, lease multi-patch
 - Correlate with drilling data
 - Formation Data:
 - Depths need to be quality checked against the known formation data



“Pre-Validation” Validation

“Modern computer vision provides tools for combining many measurements to obtain more sophisticated and accurate estimates of the 3D world [4, 10] including, for instance, ancient archeological structures [11]. However, many image only methods estimate 3D only up to a scale factor, and so do not give direct length estimates”

– Daniel D. Morris, *Robotics Institute Carnegie Mellon University Pittsburgh, Pennsylvania*

- Covariance Matrix could be used to describe the uncertainty of a 3D model through a scale factor – surface distance to first directional survey point

Value Added

Business value is generated through the competitor well depths through the following:

- An increased likelihood of drilling to the target formations exists because of the formation character information from multiple competitor wells
- Prevention of lease trespassing through the understanding of competitor locations and the formation character saving the business from fines and excess drilling costs
- Decreased chances of drilling into neighbors well also saving on drilling costs and fines
- Business value can be data driven through the maintenance of data integrity for more accurate models to render reality



References & Questions

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