53rd General Meeting
14 & 15 of April 2021
Virtual Conference

Wellbore Positioning Technical Section

The Industry Steering Committee on
Wellbore Survey Accuracy (ISCWSA)

Fully Automated Collision Avoidance Analysis and Wellbore Quality Monitoring in Real-Time

By:

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OXY Occidental

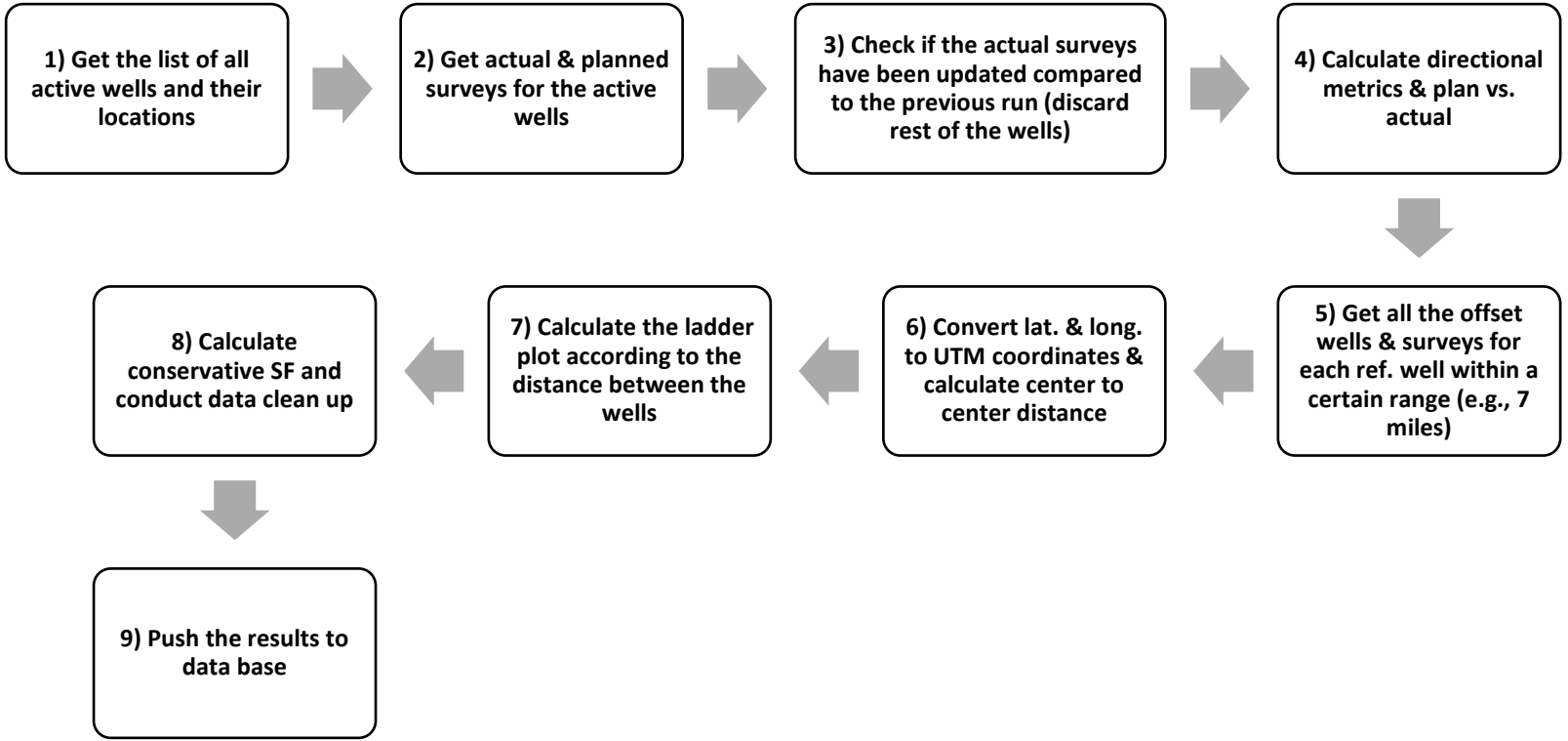
Outline

- Scope & Objectives
- Workflow
- Directional Metrics
- Automated Offset Survey Loading
- The Discreet Boundary Model
- Ladder Plot
- Summary, Future Work and Q&A

Scope and Objectives

- Phase I (current capabilities)
  - Receiving and processing the surveys in near real-time
  - Comparing planned with actual trajectories
  - Apply directional drilling metric to evaluate the wellbore quality
  - Obtain all the offset well list and surveys from several data sources
  - Calculate center-center distance to offset wells
  - Generate ladder plots & conservative SF
  - Near real-time updates

Workflow


1) Get the list of all active wells and their locations
2) Get actual & planned surveys for the active wells
3) Check if the actual surveys have been updated compared to the previous run (discard rest of the wells)
4) Calculate directional metrics & plan vs. actual
5) Get all the offset wells & surveys for each ref. well within a certain range (e.g., 7 miles)
6) Convert lat. & long. to UTM coordinates & calculate center to center distance
7) Calculate the ladder plot according to the distance between the wells
8) Calculate conservative SF and conduct data clean up
9) Push the results to data base

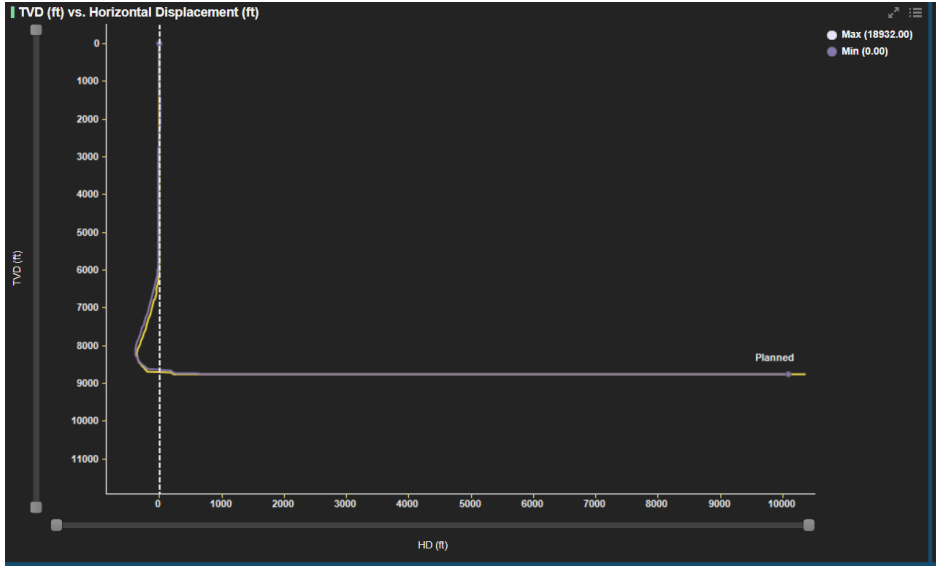
Real-Time Survey

- Real-time survey is streamed for all the active wells.
- Corrections might be needed for real-time surveys.
- When the real-time surveys are not available, planned surveys are used for the analysis.

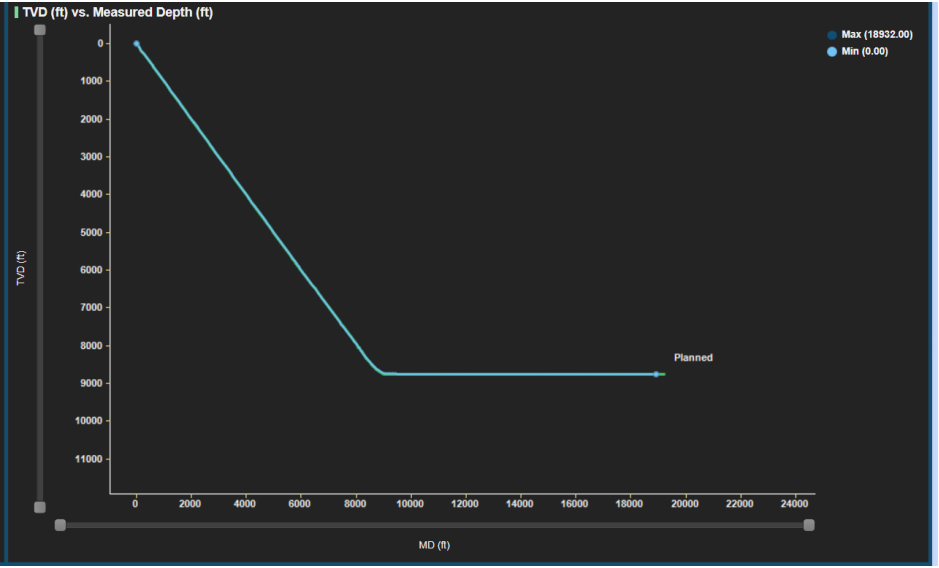
WellId	MD	Inclination	Azimuth	TVD	DLS	North	East	VerticalSection
3001547957	0	0	0	0	0	0	0	0
3001547957	93.1	0.48	273.75	93.1	0.52	0.03	-0.39	0.39
3001547957	182.6	0.78	254.24	182.59	0.41	-0.12	-1.35	1.33
3001547957	272.7	0.67	234.26	272.69	0.3	-0.59	-2.37	2.27
3001547957	367.1	0.39	291.96	367.08	0.6	-0.79	-3.11	2.59
3001547957	461.9	0.3	265.66	461.88	0.19	-0.69	-3.66	3.7
3001547957	556.3	0.36	49.89	556.28	0.67	-0.52	-3.68	-3.15
3001547957	637	0.09	24.83	636.98	0.35	-0.3	-3.46	-1.73
3001547957	725	0.04	203.01	724.98	0.15	-0.26	-3.44	1.58
3001547957	815	0.07	280.86	814.98	0.08	-0.28	-3.51	3.39
3001547957	906	0.15	271.29	905.98	0.09	-0.27	-3.68	3.67
3001547957	998	0.26	233.4	997.98	0.18	-0.39	-3.97	3.42
3001547957	1090	0.31	271.17	1089.98	0.21	-0.51	-4.39	4.38
3001547957	1182	0.31	227.28	1181.98	0.25	-0.67	-4.82	4
3001547957	1274	0.27	244.42	1273.98	0.1	-0.94	-5.2	5.1
3001547957	1366	1.18	27.14	1365.97	1.53	-0.19	-4.96	-2.43

Sample real-time survey

Plan vs. Actual

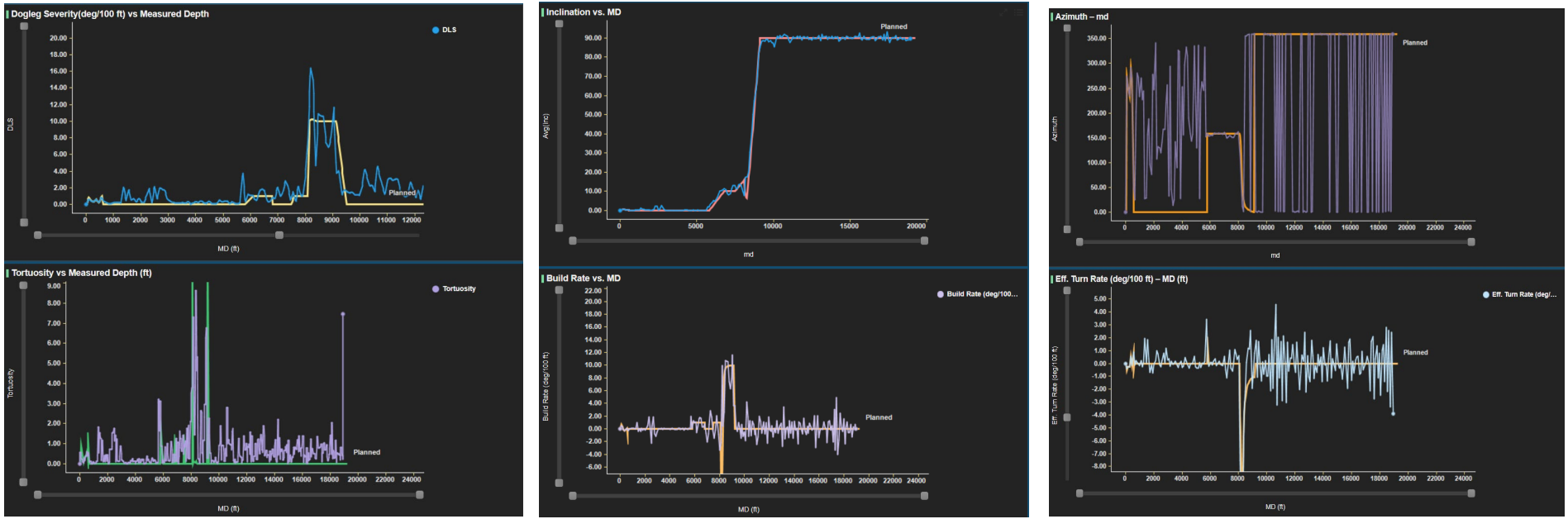


Plan vs. Actual (TVD vs HD)



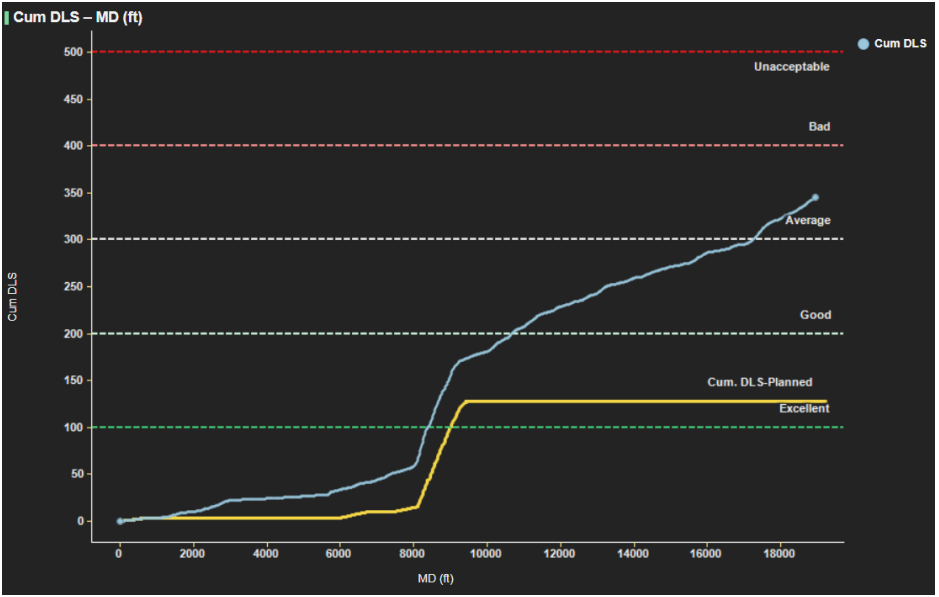
Plan vs. Actual (TVD vs MD)

Plan vs. Actual (Continued)

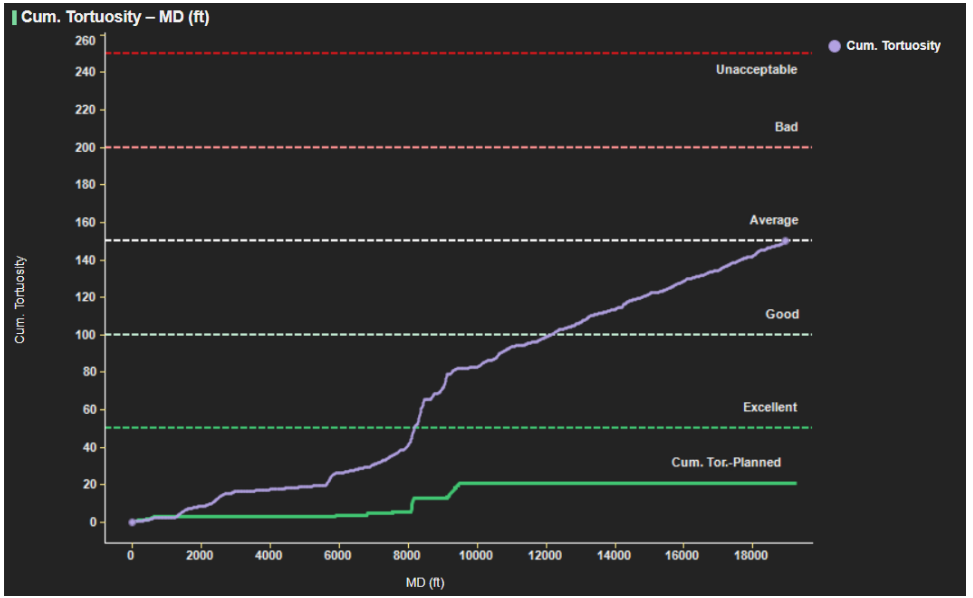


Plan vs. actual (top left: DLS, top middle: Inclination, top right: Azimuth, bottom left: Tortuosity, bottom middle: Build Rate, bottom right: Effective Turn Rate

Plan vs. Actual (Continued)

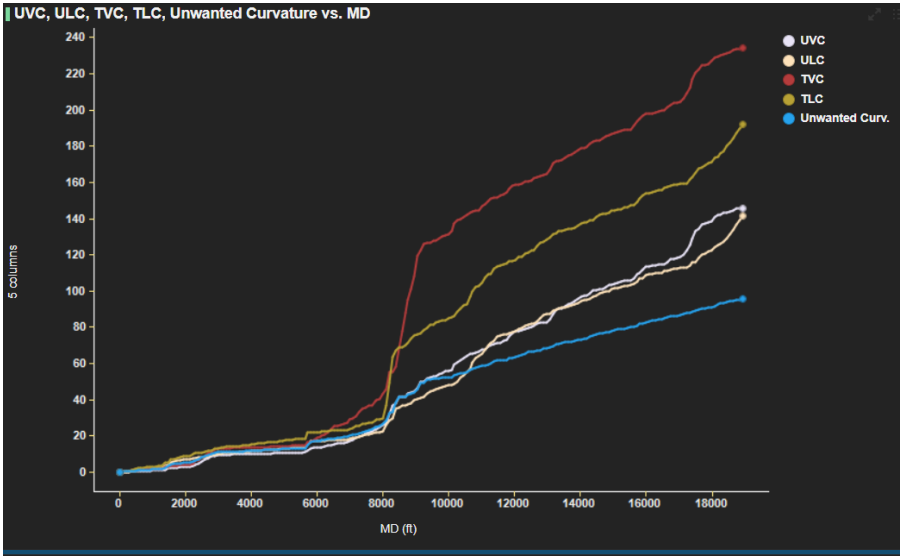


Plan vs. Actual (Cum. DLS)

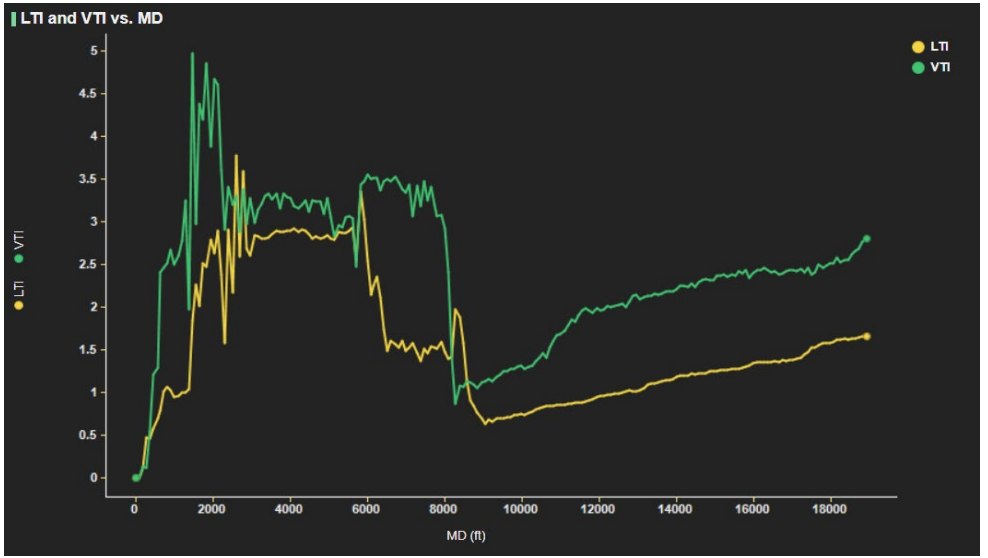


Plan vs. Actual (Cum. Tortuosity)

Directional Metrics



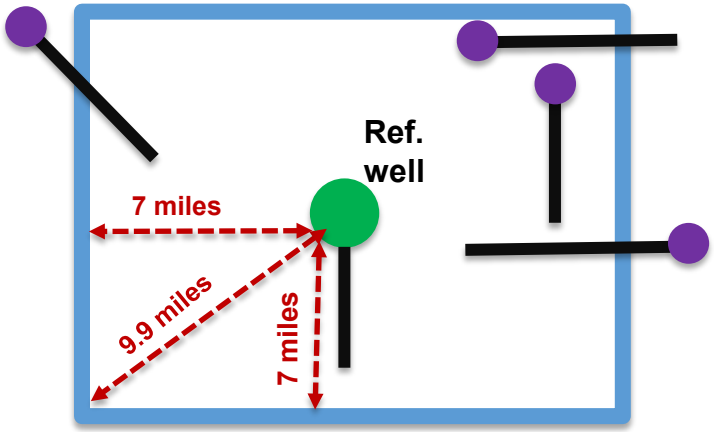
UVC, ULC, TVC, TLC, Unwanted Curvature vs. MD

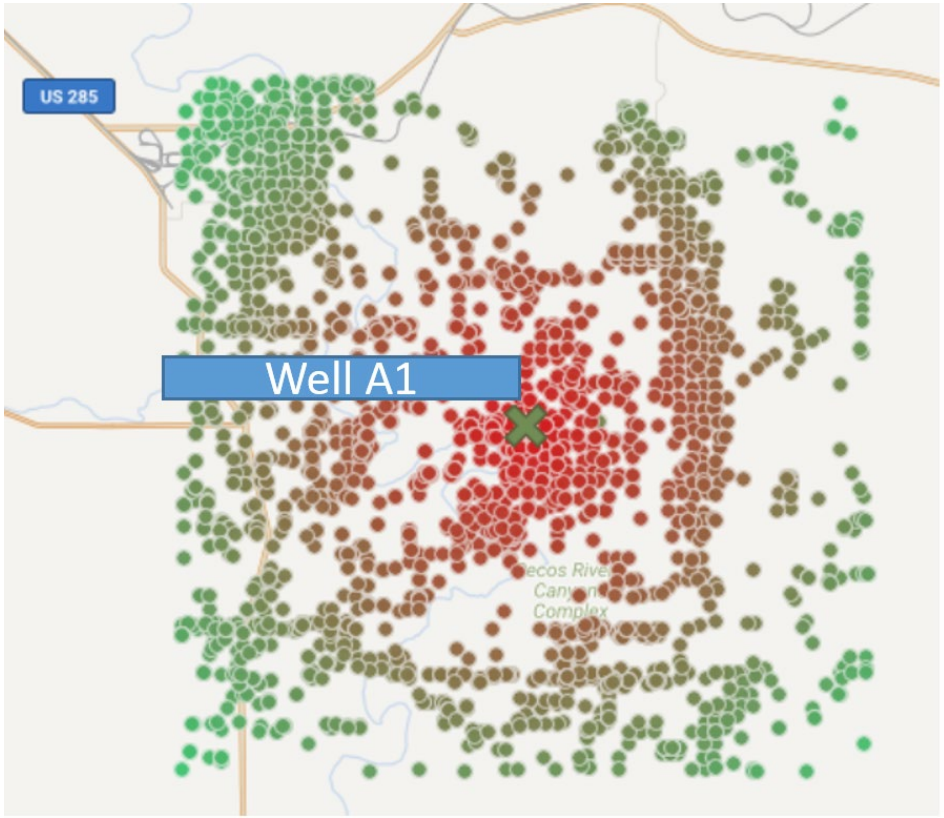


LTI and VTI vs. MD

Offset Wells - Search Box

- Initial search is conducted based on the surface location of the reference well. Default search distance is set to **7 miles**.





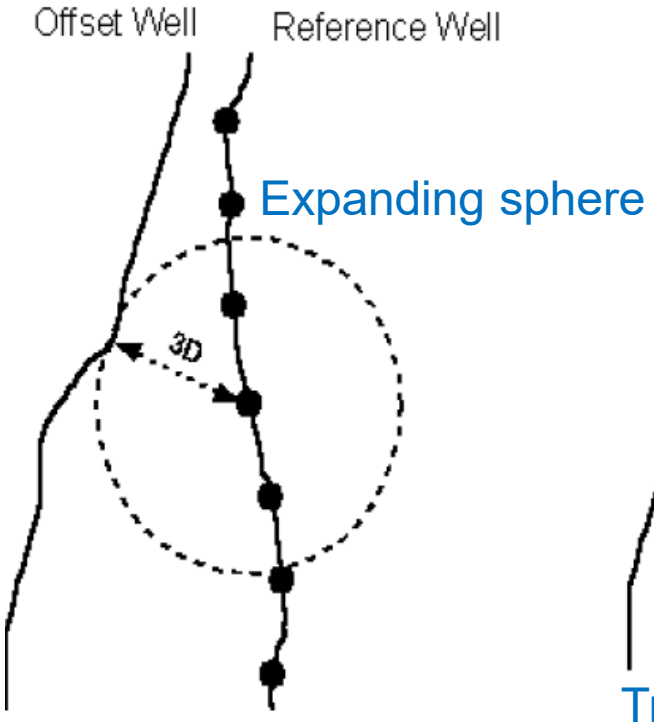
Offset Surveys

- 3 data sources are used:
  - IHS central data base (roughly, half a million surveys available)
  - Company definitive surveys
  - Company planned surveys
  - Fake surveys are automatically generated for missing wells

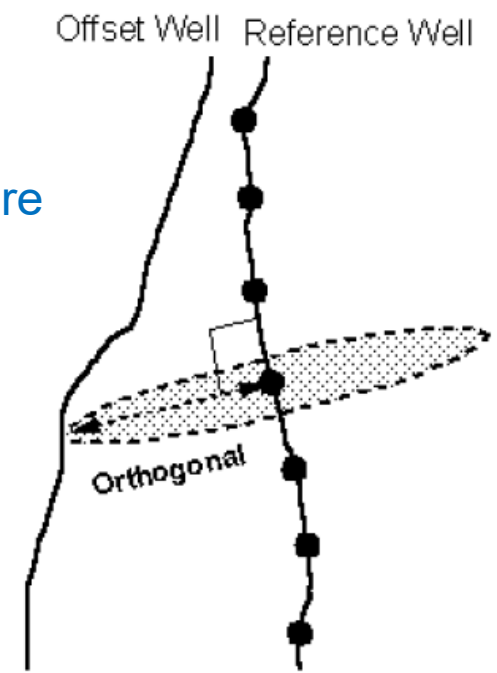
UWI	SOURCE	DIR_SRVY_ID	MEASURED_DEPTH	TV_DEPTH	DERIVED_IND	DEVIATION_N	DEVIATION_E	DEVIATION_ANGLE	DEVIATION_AZIMUTH
30025458720000	PI	1	0	0	(null)	0	0	0	0
30025458720000	PI	1	26.5	26.5	(null)	0	0	0	0
30025458720000	PI	1	104.4	104.399	(null)	0.28	0.14	0.39	183.27
30025458720000	PI	1	133.7	133.699	(null)	0.47	0.16	0.34	188.47
30025458720000	PI	1	162.6	162.598	(null)	0.64	0.2	0.37	202.27
30025458720000	PI	1	189.4	189.397	(null)	0.8	0.28	0.41	209.5
30025458720000	PI	1	214.4	214.397	(null)	0.95	0.37	0.4	212.17
30025458720000	PI	1	242.5	242.496	(null)	1.11	0.49	0.38	221.14
30025458720000	PI	1	271.5	271.496	(null)	1.24	0.62	0.37	230.01
30025458720000	PI	1	334.5	334.494	(null)	1.47	0.94	0.33	236.59
30025458720000	PI	1	43.4	43.4	(null)	0.02	0.03	0.24	240.32
30025458720000	PI	1	71.7	71.7	(null)	0.1	0.1	0.25	201.42
30025458720000	PI	1	303	302.995	(null)	1.36	0.78	0.36	233.56
30025458720000	PI	1	366	365.994	(null)	1.57	1.09	0.33	241.39
30025458720000	PI	1	397.5	397.493	(null)	1.64	1.25	0.33	248.36
30025458720000	PI	1	429	428.993	(null)	1.7	1.42	0.31	254.04
30025458720000	PI	1	460.5	460.492	(null)	1.75	1.59	0.32	251.92
30025458720000	PI	1	492	491.992	(null)	1.8	1.76	0.33	255.08
30025458720000	PI	1	523.5	523.491	(null)	1.85	1.95	0.4	256.68
30025458720000	PI	1	555	554.99	(null)	1.89	2.19	0.46	265.39
30025458720000	PI	1	586.6	586.589	(null)	1.91	2.44	0.48	265.11
30025458720000	PI	1	618.1	618.088	(null)	1.94	2.71	0.49	260.8
30025458720000	PI	1	649.6	649.587	(null)	1.99	3	0.58	260.49
30025458720000	PI	1	681.1	681.085	(null)	2.05	3.32	0.6	256.44
30025458720000	PI	1	712.6	712.583	(null)	2.14	3.63	0.59	252.99
30025458720000	PI	1	744.1	744.082	(null)	2.24	3.95	0.63	252.91
30025458720000	PI	1	775.6	775.58	(null)	2.34	4.28	0.62	251.77
30025458720000	PI	1	807.1	807.078	(null)	2.45	4.6	0.61	249.9
30025458720000	PI	1	838.6	838.576	(null)	2.56	4.93	0.65	253.69
30025458720000	PI	1	852.6	852.575	(null)	2.61	5.1	0.79	252.82

Sample survey data from IHS data base

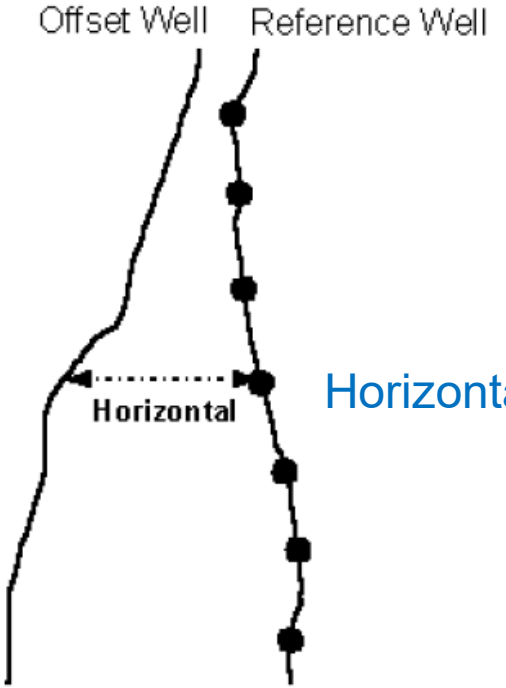
Traditional Scan Methods



Expanding sphere



Traveling Cylinder



Horizontal Plane

Approach: The Discrete Boundary Model (DBM)

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Study of Distance Computation between Objects Represented by Discrete Boundary Model

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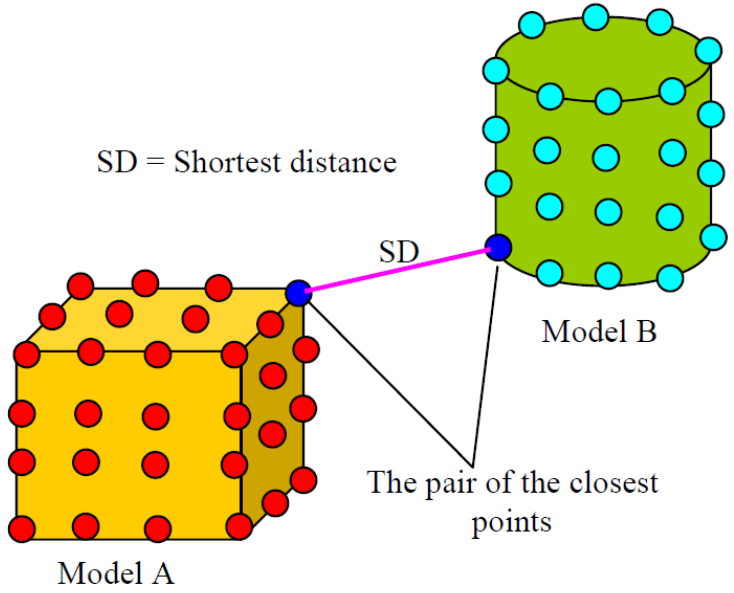
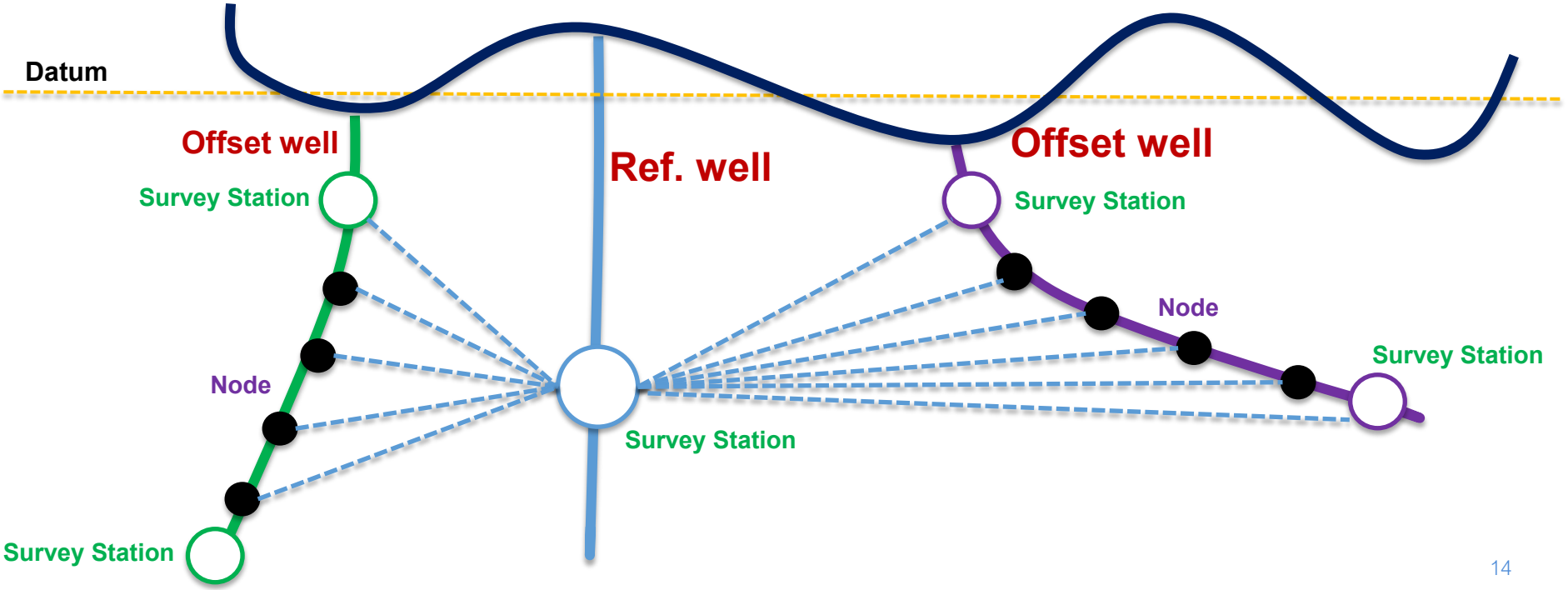


DBM Implementation



Calculating Distance Between Two UTM Points

- Approach 1: Cartesian Coordinates $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$
- Approach 2: Haversine formula

Haversine formula:

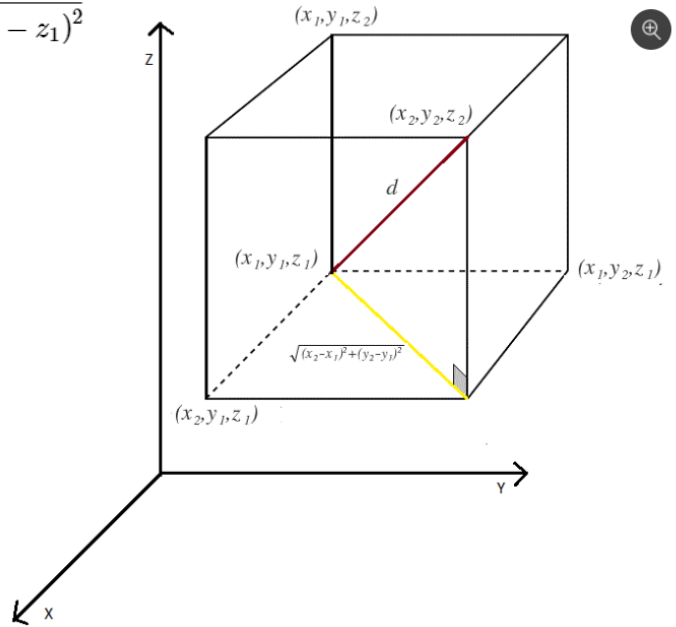
$$a = \sin^2(\Delta\varphi/2) + \cos\varphi_1 \cdot \cos\varphi_2 \cdot \sin^2(\Delta\lambda/2)$$
$$c = 2 \cdot \text{atan2}(\sqrt{a}, \sqrt{(1-a)})$$
$$d = R \cdot c$$

where φ is latitude, λ is longitude, R is earth's radius (mean radius = 6,371km); note that angles need to be in radians to pass to trig functions!

- Distance comparison from (32, -103) to (32, 103) is **11089.2** m in in comparison with **11119.49** meters: **~0.3% error**.

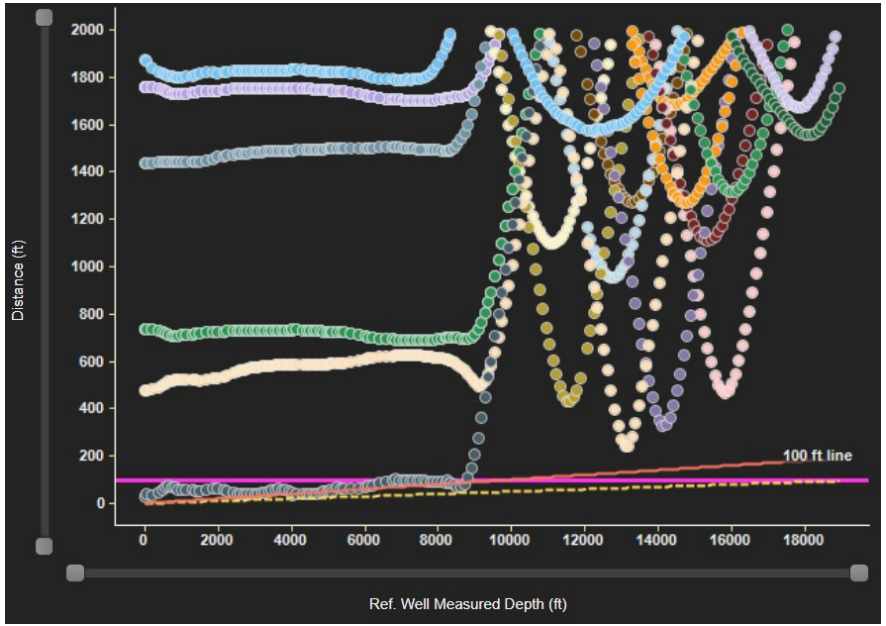
```
utm.from_latlon(32.1, -103)

(688722.178086404, 3553270.7966073537, 13, 'S')
```

```
utm.from_latlon(32, -103)
(688927.6380695379, 3542183.4911190174, 13, 'S')
```

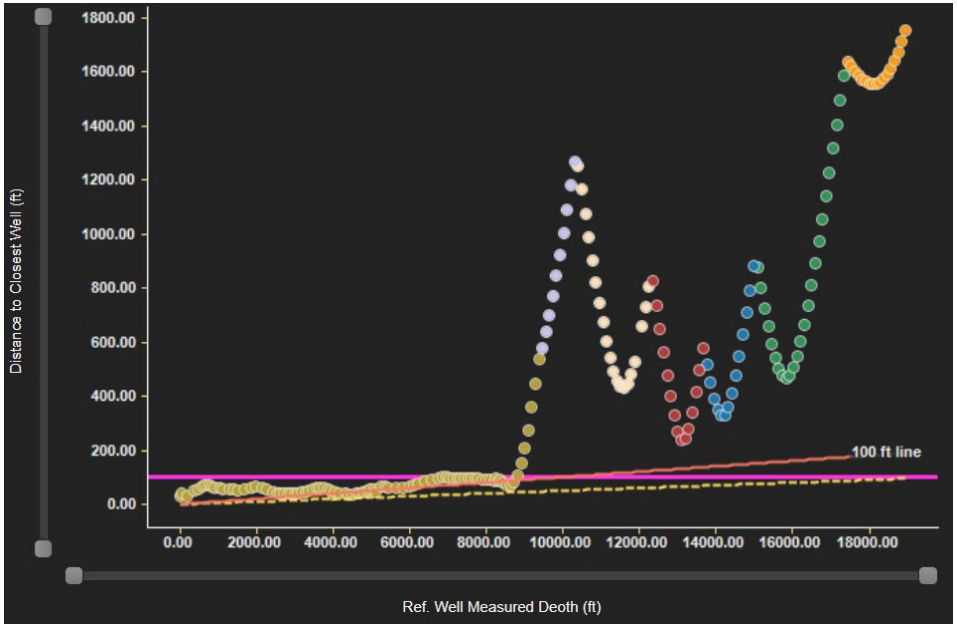


Ladder Plot

Note: Only distances smaller than 2000 ft. are displayed.

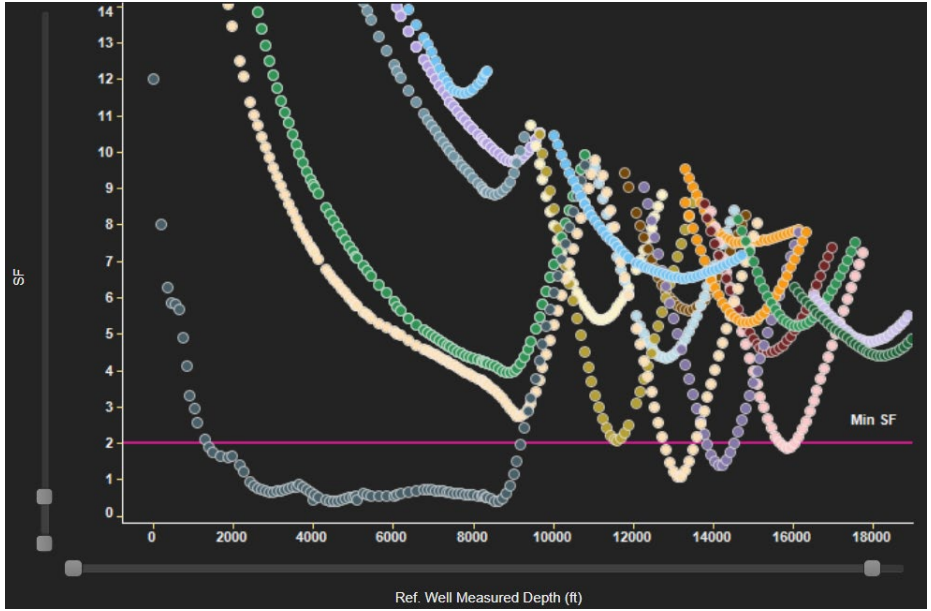


Ladder plot for all offset wells (center to center distance)

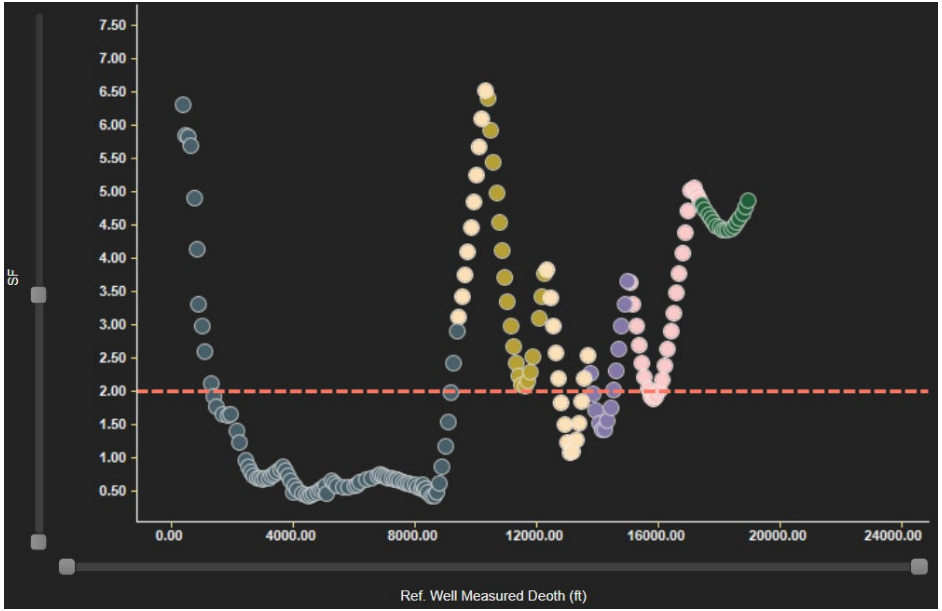


Ladder plot for the nearest offset well (center to center distance)

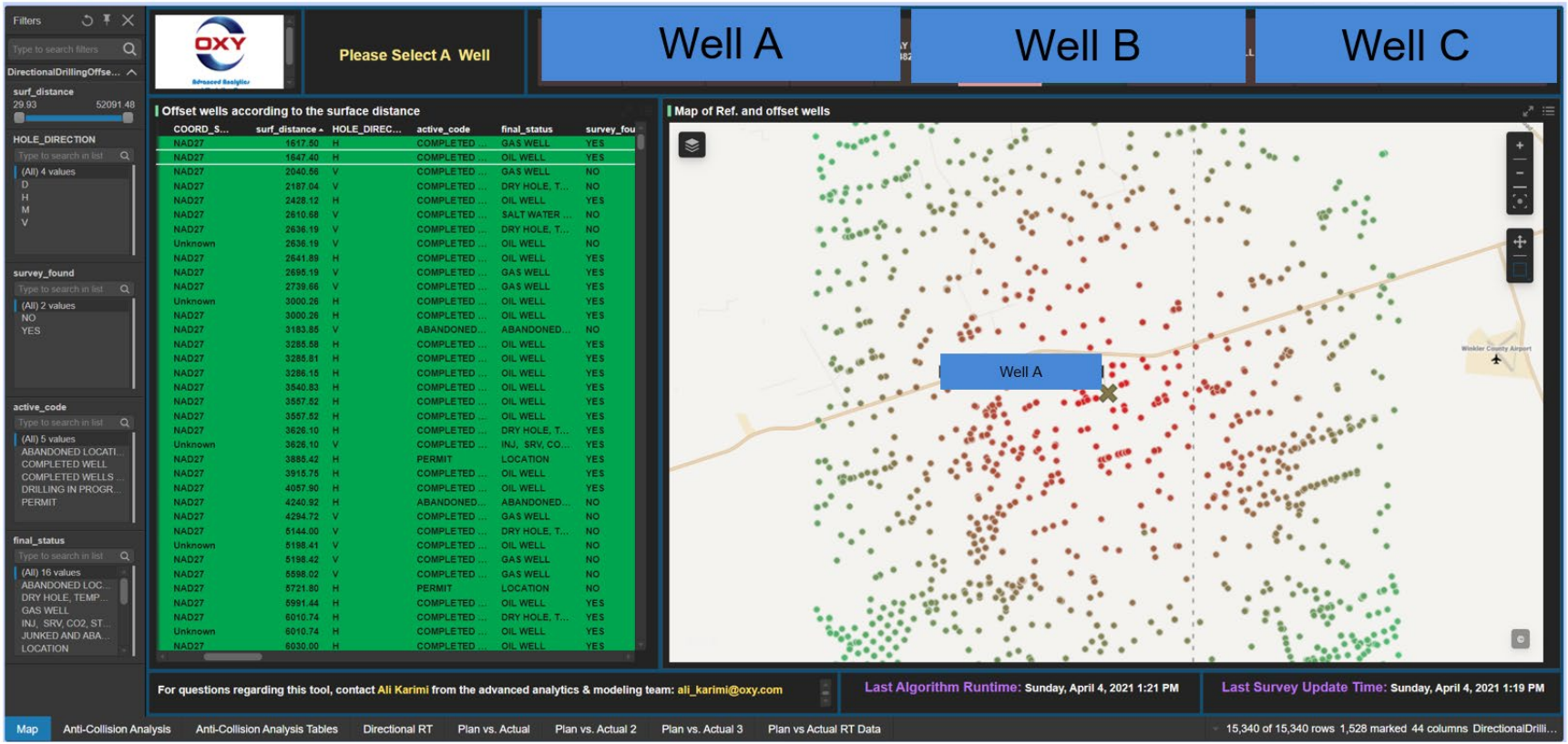
Conservative Safety Factor (SF)



Ladder plot for all offset wells (conservative SF)



Ladder plot for the nearest offset well (conservative SF)



Tool in Action: GUI Design

Summary and Future Work

Summary

- Real-time directional drilling metrics are calculated in real-time
- Offset surveys are loaded automatically
- The Discrete Boundary Model is deployed to compute the center-to-center distance
- User-friendly GUI

Future Work

- More realistic Separation Factor calculations
- Real-time alerts
- Offline version of the tool for well design
- Further validations

Thank You

Fully Automated Collision Avoidance Analysis and Wellbore Quality Monitoring in Real-Time

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