

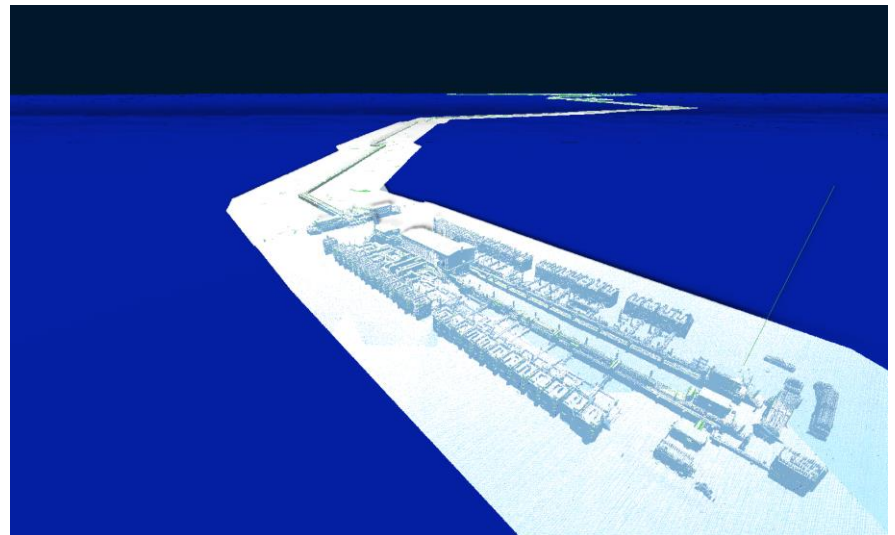


Cartesian Coordinates Approach to Geolocation Challenges (ECEF)

Geodetic Integrity of 3D Subsurface Data

ISCWSA Alaska 2025

Eric Marchand



LiDAR of Alaska's Pipelines in Earth Centred Earth Fixed (ECEF)



What we do



- Bringing Geodetic Integrity to 3D Data

Validate — Correct & certify positional accuracy across surface, subsurface, and aerial data.

Amalgamate — Fuse seismic, survey, LiDAR, GIS, and legal datasets into a single geodetic framework

Visualise — Deliver 3D models above, below & on the ground with quantified uncertainty: Across Silos → One Truth

Make location data geodetically compliant for AI, Digital Twins, and automated Decision-making & Reporting.

Enable traceability & auditable reporting for safety, carbon, and regulatory compliance.

Opening Question

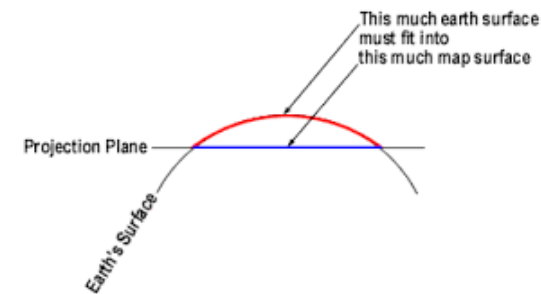
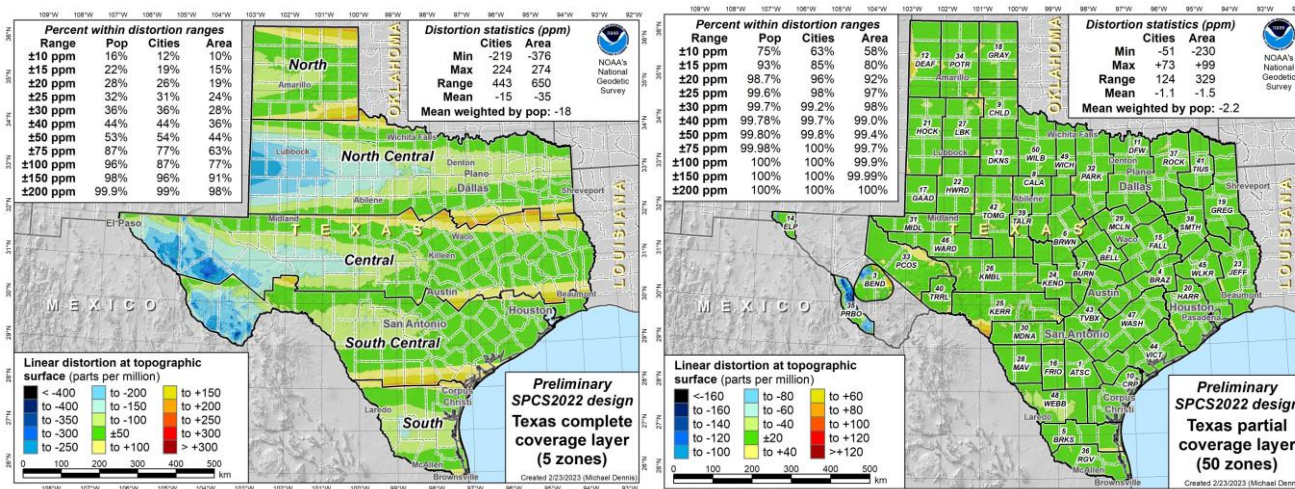
- If you walk from where you are **the same specific distance “x”** (like 1000 ft or 100 km):
 - North (“x” amount ft, km, ...)
 - East (“x” amount ft, km, ...)
 - South (still the same “x” amount ft, km, ...)
 - West (Again the same “x” amount ft, km, ...)

Where are you ending your journey?



Cartographic Reference Systems (CRS) Complexification

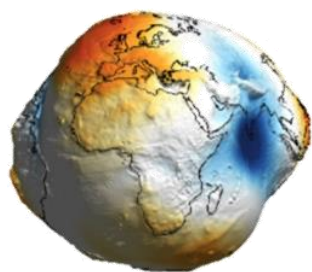
- Over 10,000 CRSs (April 2025) exist in the latest EPSG and are multiplying.
- Mixing datums, projections, and units causes misalignments.
- Errors range from meters to kilometres, with a high financial cost
- CRS fragmentation undermines wellbore positioning and increases risks



To Limit Ground
Surface to Grid
Surface Distortion

Why A Projected CRS Distort

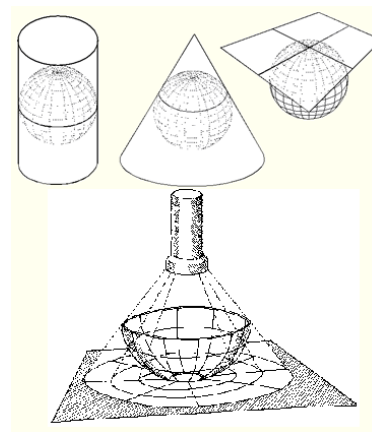
- A 3D object cannot be rendered in 2D without deformation
- A CRS = datum + projection.
- All map projections distort shape, area, distance, or direction.



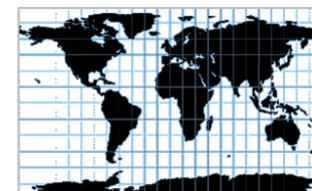
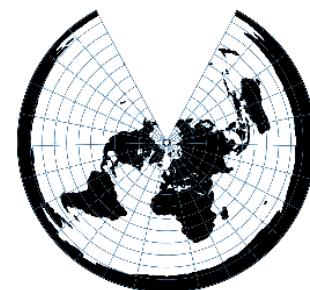
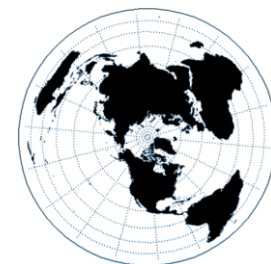
Geoid



Oblate
Spheroid

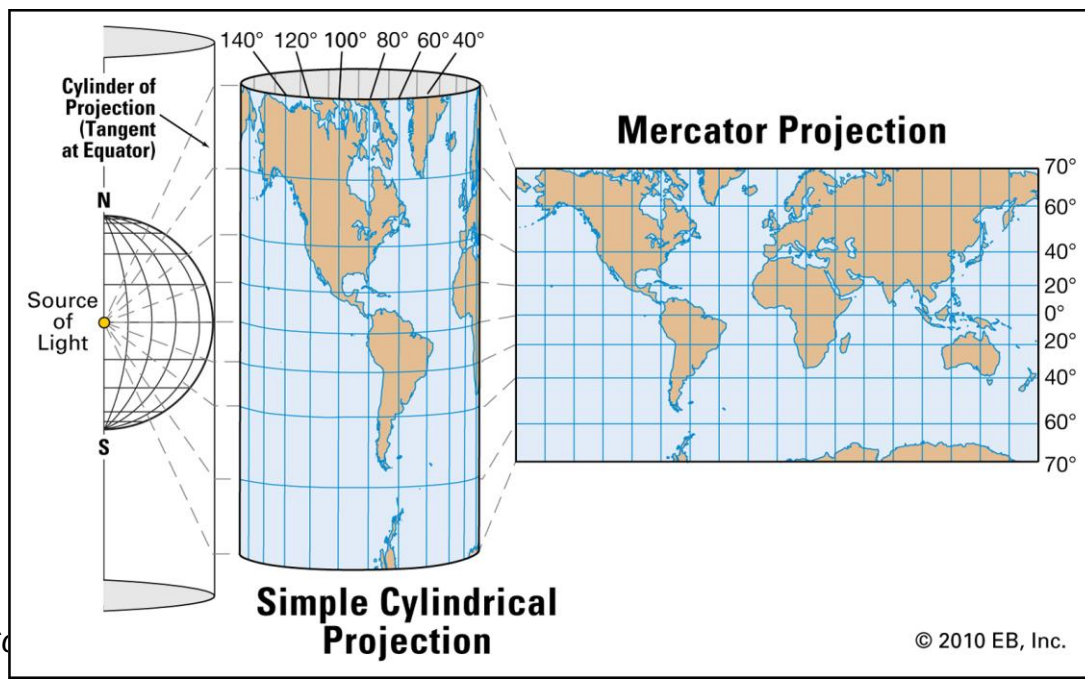


Reference Ellipsoid
Projected

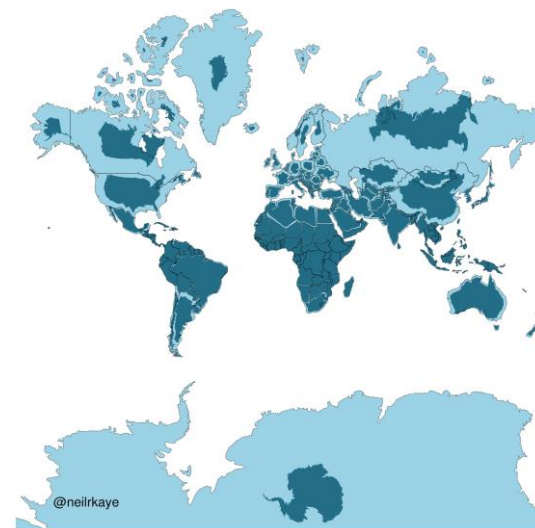


No effective Global Projections

- Local CRS fixes (custom grids) do not scale globally.
- GIS & Geoscience solution needs to select one local CRS
- Cannot work across multiple CRS
- Mercator is an example among many

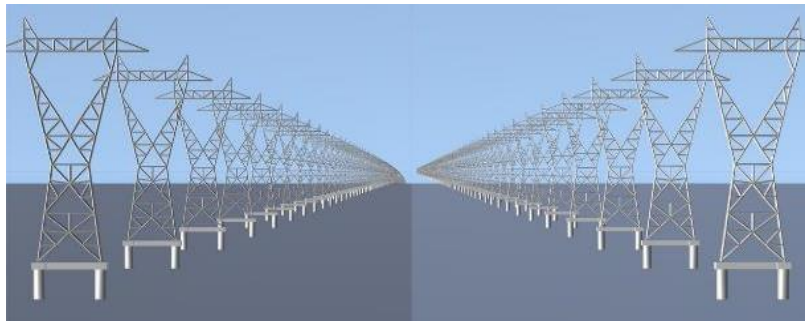
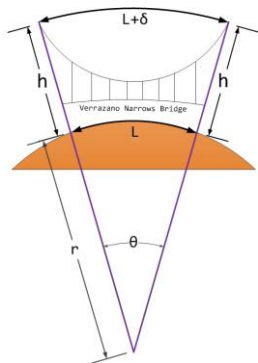


World Mercator projection with true country size and shape added

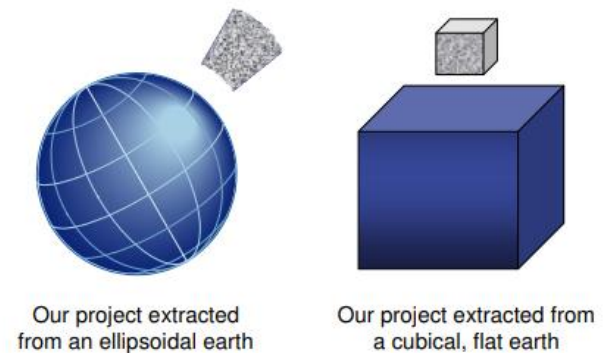


Cartesian (ECEF) Coordinates

- Earth-Centred, Earth-Fixed: a 3D Cartesian X,Y,Z system centred at Earth's mass.
- Native output of GNSS – globally consistent
- CRS transformation foundations are Cartesian Coordinates.
- Earth Curvature is accounted for.
- Distortion-free, no projection, no Grid North convergence issue
- Ideal pivot for all spatial data integration.



Engineering CRS ("Flat-Earth")



ECEF Workflow

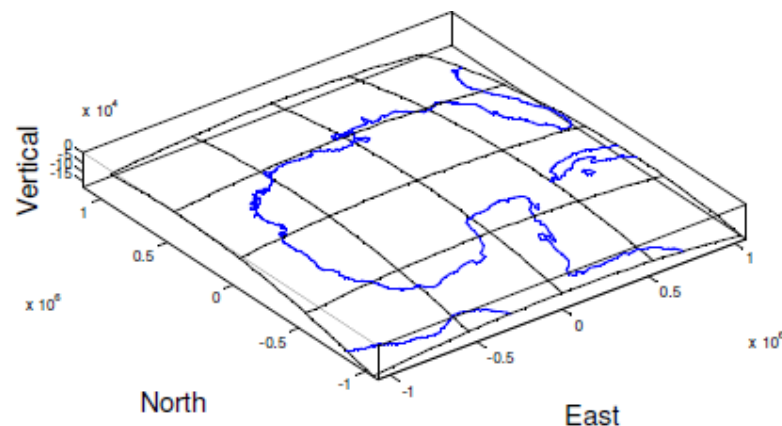
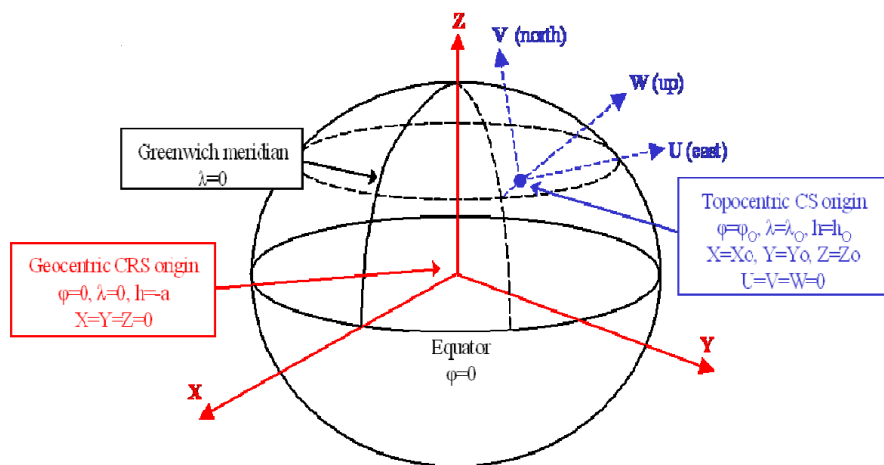
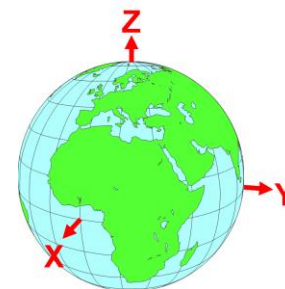
Input: data in various 2D and 3D formats: geology, seismic, and deviated surveys, etc.

Step 1: Convert all into ECEF pivot.

Step 2: Validate, align, and log transformations.

Step 3: Transform into the required CRS for operations.

Output: validated any 3D Data/2D Data: wells trajectories, leases etc...



Problems simplified: No longer a flat 2D Map but a 3D Virtual Earth with Subsurface

Detect CRS mismatches and unit errors.

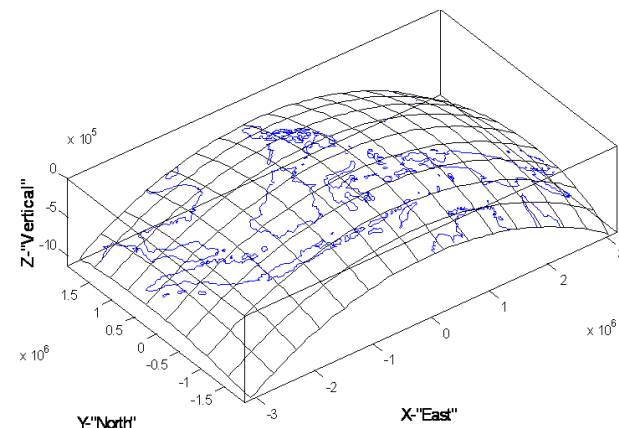
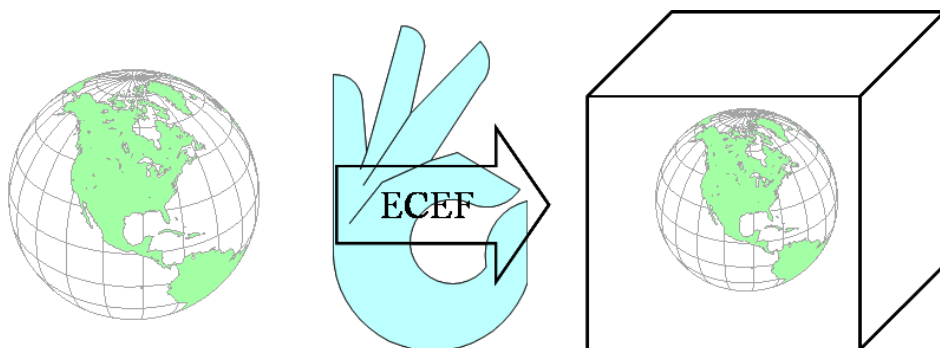
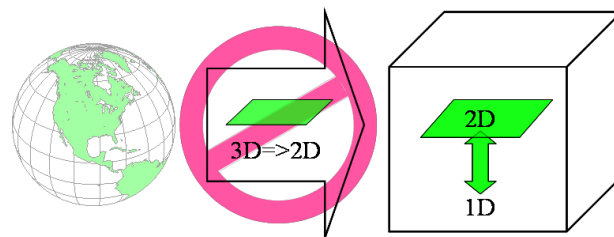
Remove Projection distortions and scale drift.

Correct Grid North convergence.

Avoid Vertical datum inconsistencies.

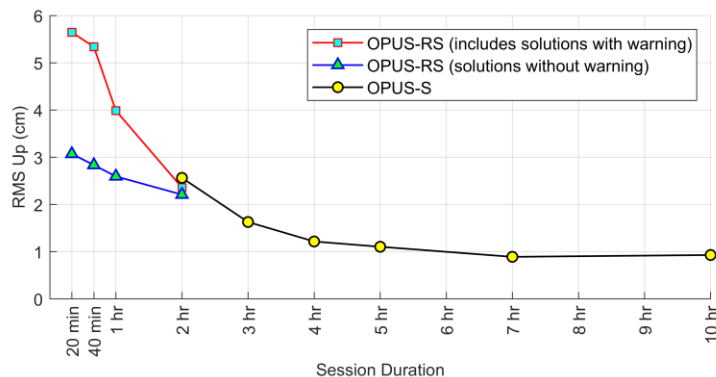
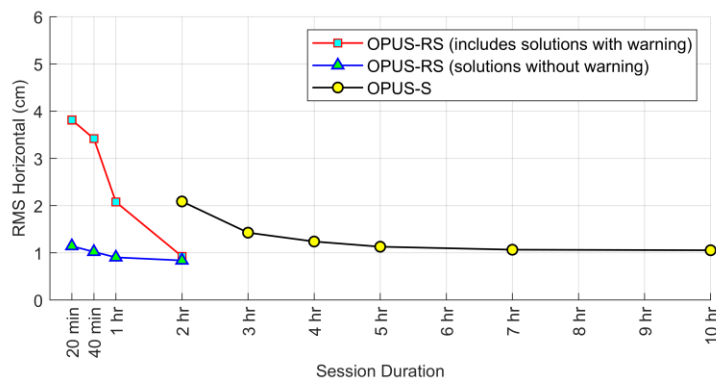
No Loss of data granularity (scales maintained).

Allow interactions of data from diverse CRS without reprojection



Already a requirement for centimetric precision Online Positioning User Services (NOAA's OPUS)

Centimetric precision

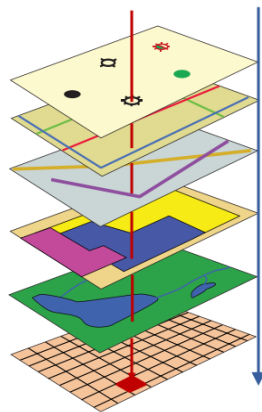


REF FRAME: NAD_83(2011)(EPOCH:2010.0000) ITRF2014 (EPOCH:2022.1554)	
X: 1342663.281(m) 0.002(m)	1342662.331(m) 0.002(m)
Y: -4680480.882(m) 0.006(m)	-4680479.449(m) 0.006(m)
Z: 4105726.867(m) 0.005(m)	4105726.841(m) 0.005(m)
LAT: 40 19 37.75141 0.003(m)	40 19 37.78518 0.003(m)
E LON: 286 0 22.68025 0.004(m)	286 0 22.65829 0.004(m)
W LON: 73 59 37.31975 0.004(m)	73 59 37.34171 0.004(m)
EL HGT: -30.128(m) 0.006(m)	-31.395(m) 0.006(m)
ORTHO HGT: 2.554(m) 0.049(m)	[NAVD88 (Computed using GEOID18)]
UTM COORDINATES	STATE PLANE COORDINATES
UTM (Zone 18)	SPC (2900 NJ)
Northing (Y) [meters] 4464554.902	165960.156
Easting (X) [meters] 585486.862	193023.668
Convergence [degrees] 0.65126667	0.32765833
Point Scale 0.99968996	0.99992278
Combined Factor 0.99969468	0.99992751
US NATIONAL GRID DESIGNATOR: 18TWK8548764555(NAD 83)	

Aligning Data in 3 dimensions

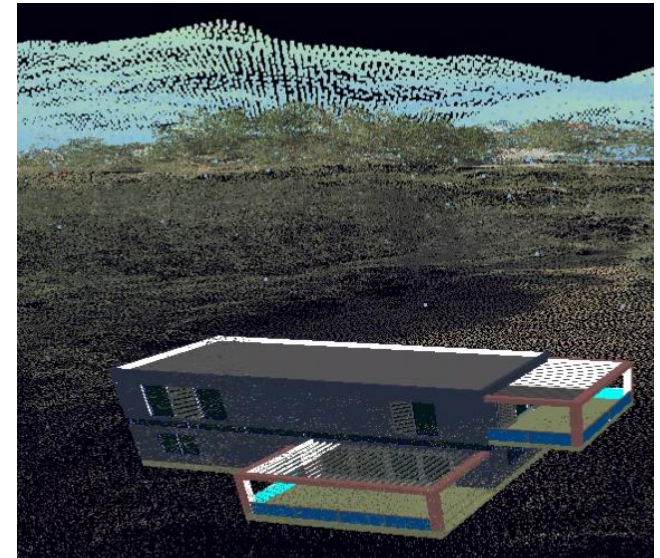
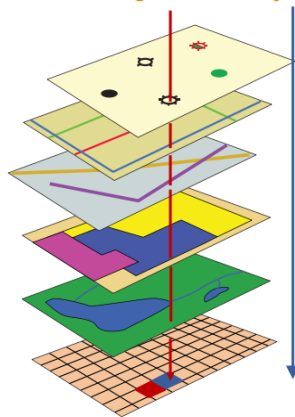
- No Projection, No Flattening, No Distortion
- Anchoring different CRS and Engineering Data together
- No distinction between global and local: ECEF can display around the world and zoom locally
- Multi-domains data integrated/no siloed

All layers with same georeferencing



2D elements aligned

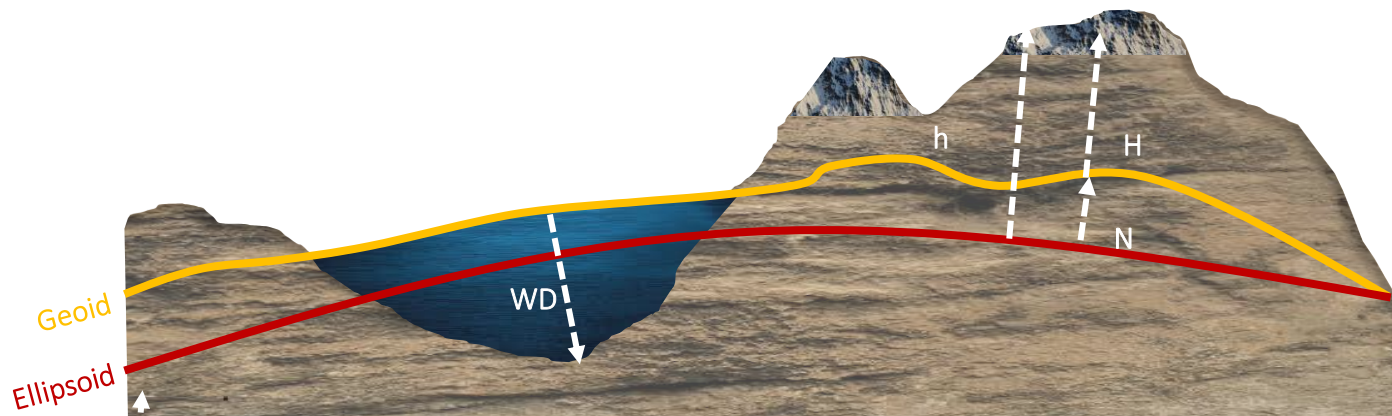
Misalignment of layers



3D elements imbricated

Vertical Datums: Depths, Details, Drilling Data

- Awareness of Vertical datums: sea-level, ellipsoidal, rig-based.
- Vertical dimension handled by not flattening in 2D and working truly in 3D:



h = Ellipsoidal height (positive up)

H = Gravity related (positive up)

N = Geoid height (positive up)

WD = Water Depth (positive down)

Visualising Vertical Datum Data Issues

- By not flattening in 2D and working 3D: Vertical dimension, subsurface depth and height are fully accounted
- No more fear of heights
- Any X,Y, Z data points in many coordinates simultaneously

Surface
X: 451918.39 m
Y: 208782.72 m
Z: 9.01 m

WGS84

Local

Selected

Focus

File SP5008_P_10967_20161130_2016113
0.laz

Points 10600269

Name OSGB 1936 / British National Grid

Surface
Latitude: 51° 46' 31.12"N
Longitude: 1° 14' 56.04"W
Elevation: 56.61 m

WGS84

Local

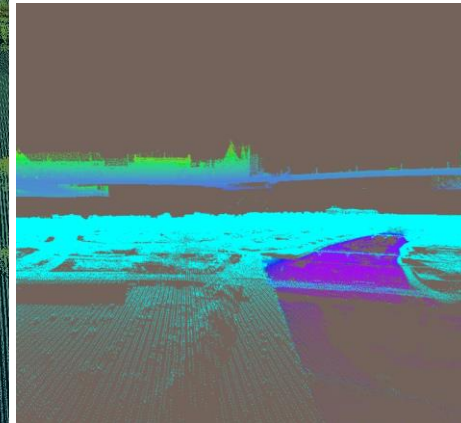
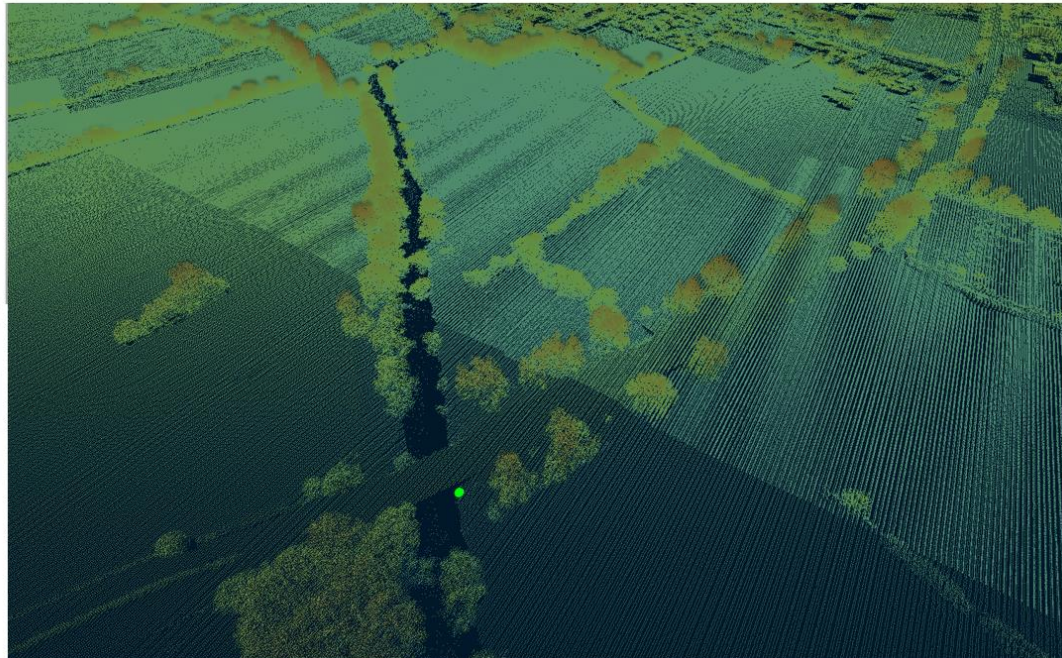
Selected

Focus

File SP5008_P_10967_20161130_2016113
0.laz

Points 10600269

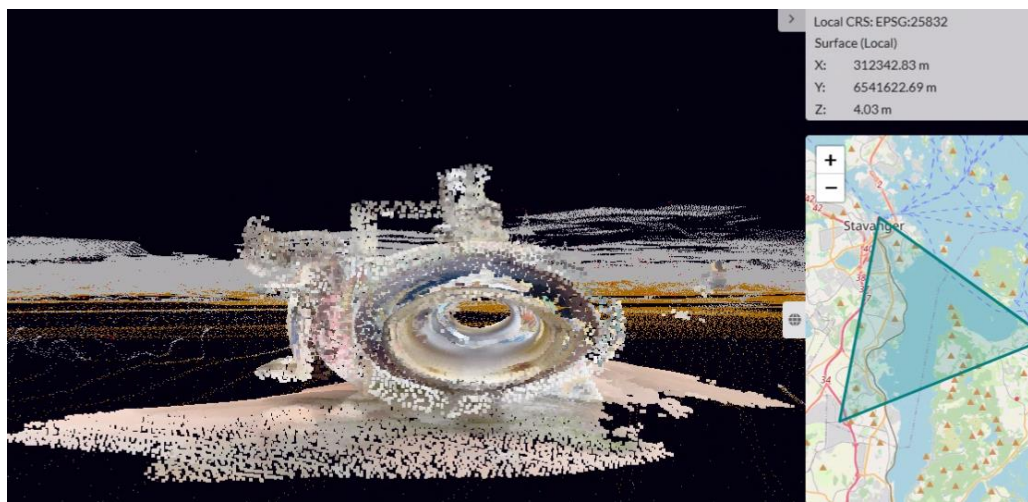
Name OSGB 1936 / British National Grid



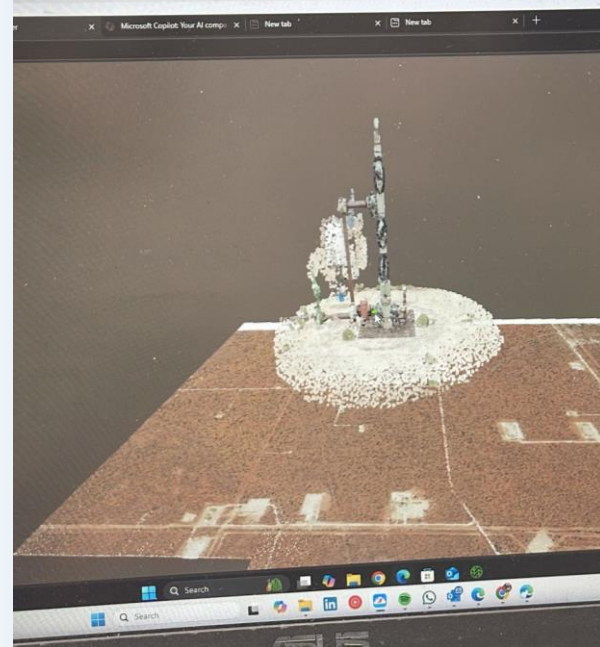
Lidar Vehicle 200 ft too high

Preserving Scale & Granularity

- Original scale of data preserved – no stretching or compression.
- Multi-scale, multi-source data integrated seamlessly.
- Resolution, Accuracy, and Granularity of Subsurface Data Preserved (across silos)



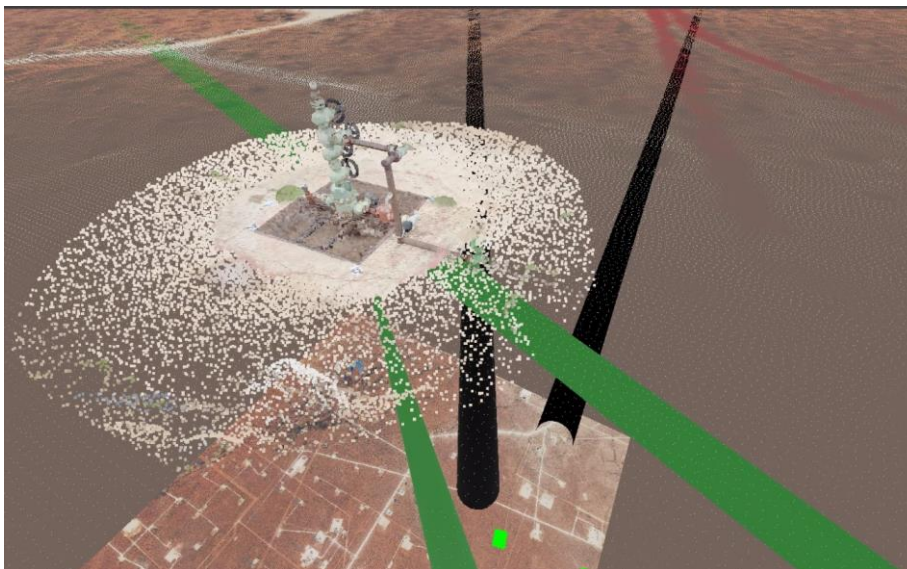
From inside the tubing to the full globe without distortion



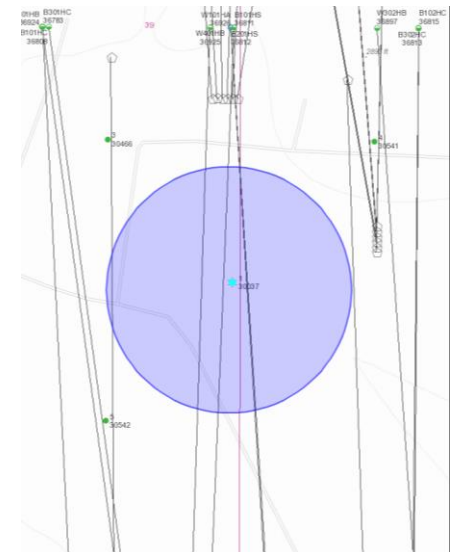
Units mismatch visibility (ft vs m)

Cones of Incertitude

- Survey errors propagate into 3D error volumes.
- Subsurface risks (Including “subsurface trespassing”. Emphasis on 3D, vertical, geological, & engineering data
- Encroachments, Collisions & Well communications (“frac hits”) Risks
- In ECEF: cones are globally consistent, true-scale, and aligned.



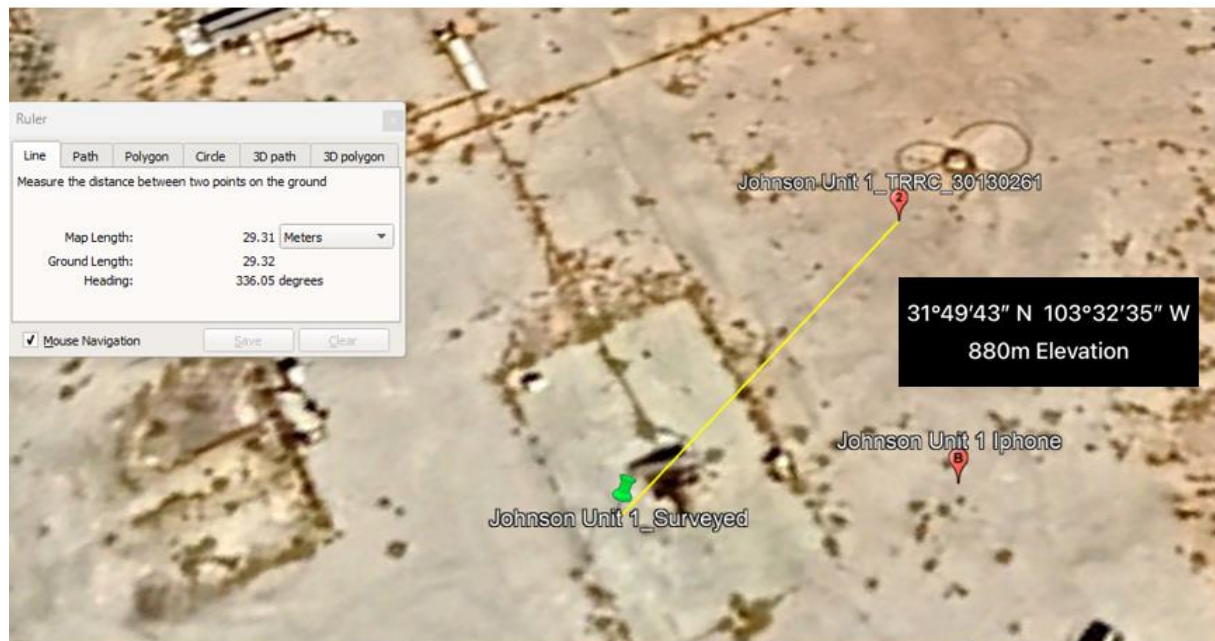
Below the surface



Texas Railroad Commission 2D GIS

Future-Proofing Data

- Once aligned in ECEF, data is future-proof.
- Stable despite new CRSs being introduced.
- Scales from wells → reservoirs → global monitoring.
- Traceability & Standards
- Metadata preserved (EPSG IDs, WKT/PROJ strings, transformation logs...)



Seismic – 15-20% misplaced
Surface Well – 26% misplaced by > 100 ft
Sub-surface Well – 25% misplaced by >200 ft
Boundary – 30-50% misplaced

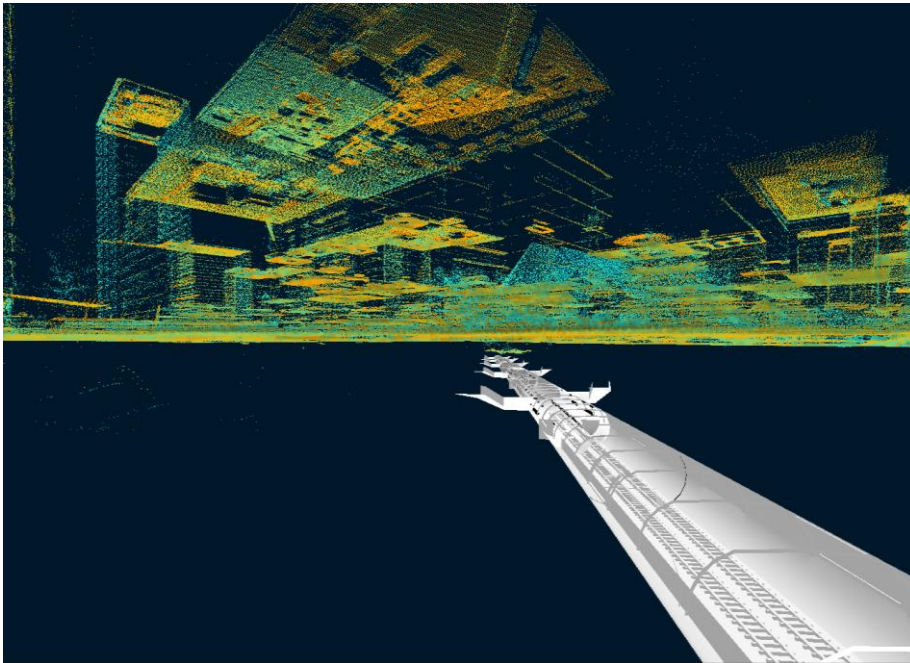
Courtesy Jonathan Stigant



Digital Twin and AI Ready

AI require a single source of truth: reliable data sets to avoid Garbage In Garbage Out insights

A digital twin doesn't just reflect reality—it *structures* it. What goes in becomes trusted. What comes out becomes actionable.



- ECEF = machine- and AI-ready data backbone.
- Preserves fidelity across scales, enabling predictive modelling.
- Geodetic integrity ensures trustworthy digital twins.
- Main users of geolocation data are increasingly silicon-based
- All 3D data/data base described as a cloud or string of x,y,z points (with time t and attribute 1,2, etc...)



Key Takeaways

- CRS discrepancy is the #1 geodetic challenge.
- Cartesian (ECEF) coordinates provide one consistent backbone (AI Requirement).
- Simplify issues: CRS, projection, vertical, convergence.
- Make True 3D Digital Twins and Remove Data Silos
- One scale. One frame. One (source of) truth.
- Way forward considering the granularity and volume of geodata generated



Lidar Capture Courtesy Robert Young



Thank You

