Vertical CRS
IOGP Guidance Note

IOGP, IMCA and THSiS Industry Day April 2016

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IOGP Geodesy Subcommittee
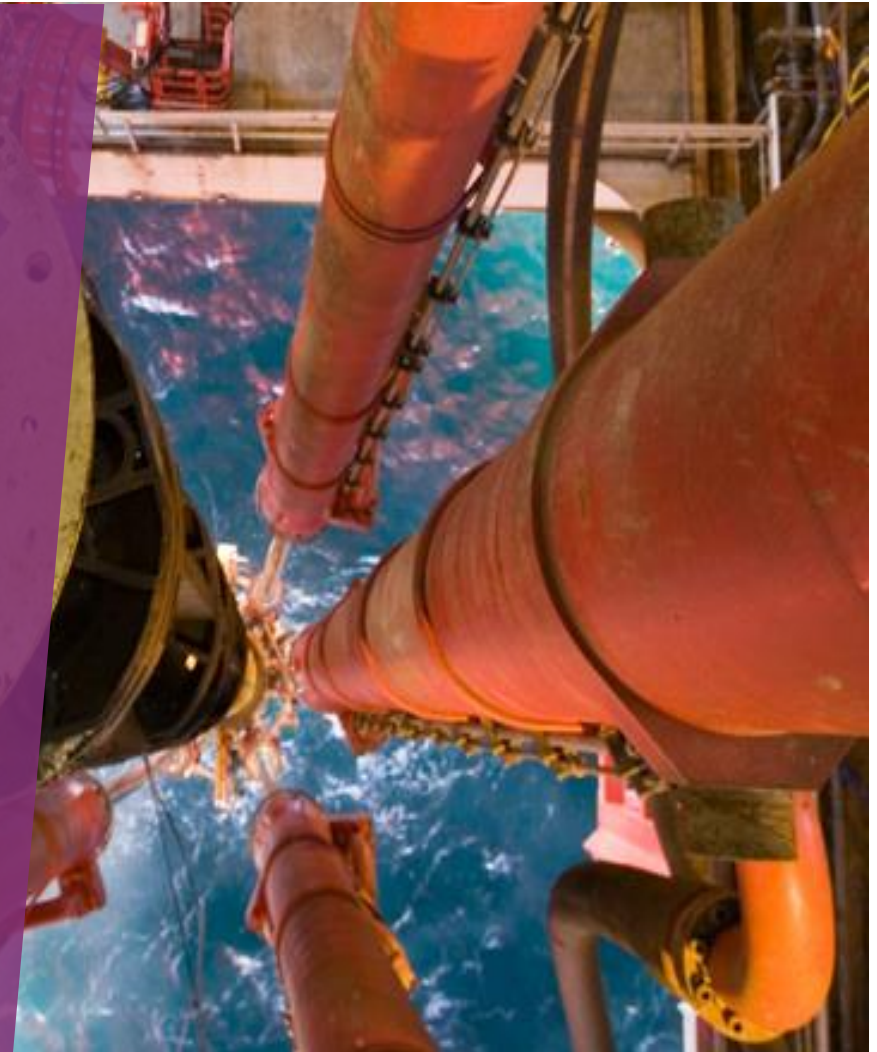
Vertical CRS - Introduction

- Current practice for referencing vertical data generally lacks a robust process and can be ambiguous
  - Transformations can be applied upon data import/export (depth to height or height to depth, or applying a vertical offset).
  - Incomplete or incorrect reference information (ambiguous CRS definition).
  - No facility to record audit trail of coordinate operations applied.

- IOGP recognise the requirement for improvements in industry practice in this area
  - Need to preserve vertical accuracy of our data, as we do with 2D accuracy
  - Software functionality for handling vertical reference data could be improved – needs to be driven by the industry.

Vertical Data in Oil and Gas

- Land seismic example
- Removal of timing distortions:
    - Careful analysis of data.
    - Elevation information.
    - 'Statics'.

- Source and receiver location coordinates include vertical, usually referenced to a geodetic vertical CRS.

- Processed land seismic is generally referenced to an arbitrary 'seismic datum' based on average topography, which can/should be referenced to geodetic vertical CRS.
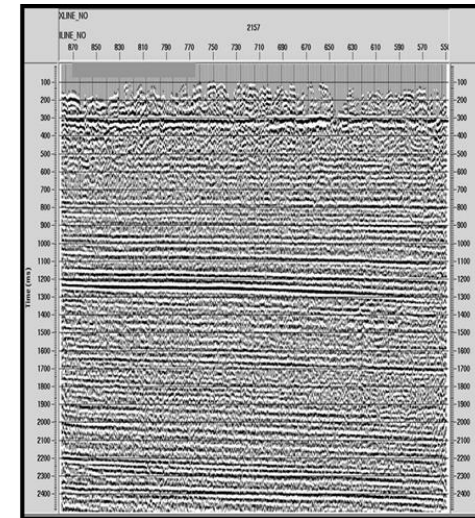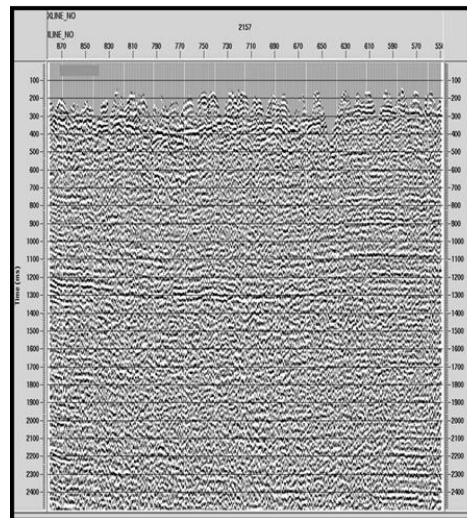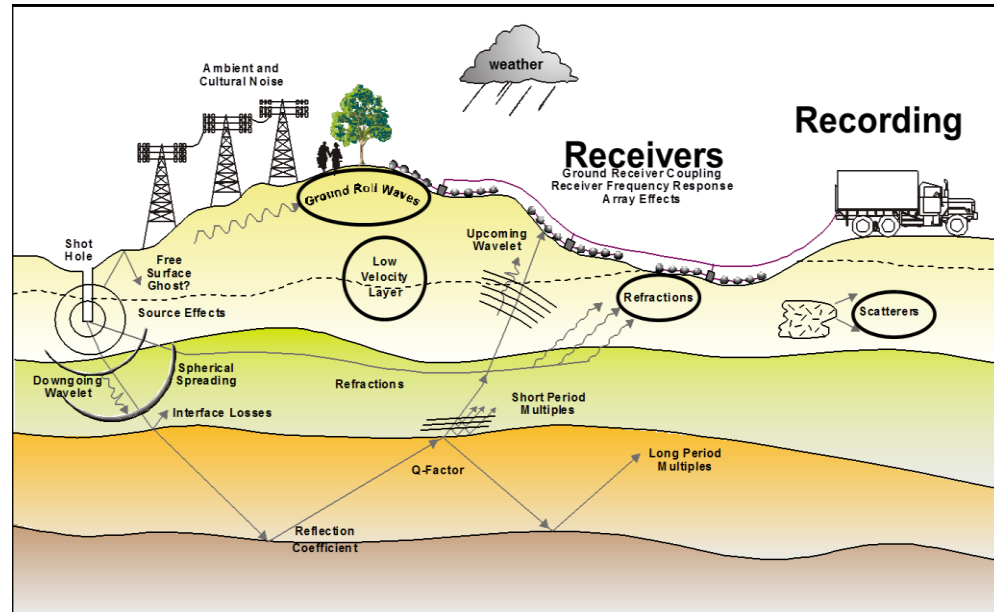
Vertical Data in Oil and Gas

- Marine seismic is almost always referenced to MSL.
- Water depth needs to be known to correctly position data vertically (and for seismic velocity time/depth conversions).
  - Various towed streamer acquisition methods.
  - OBC / OBN acquisition with surface source.
  - OBC / OBN with seabed source.

Seabed Seismic Receivers

Fault

Oil Water Contact

Downhole Well Surveillance

GeoQuest, Jun. 2000, 03002053.

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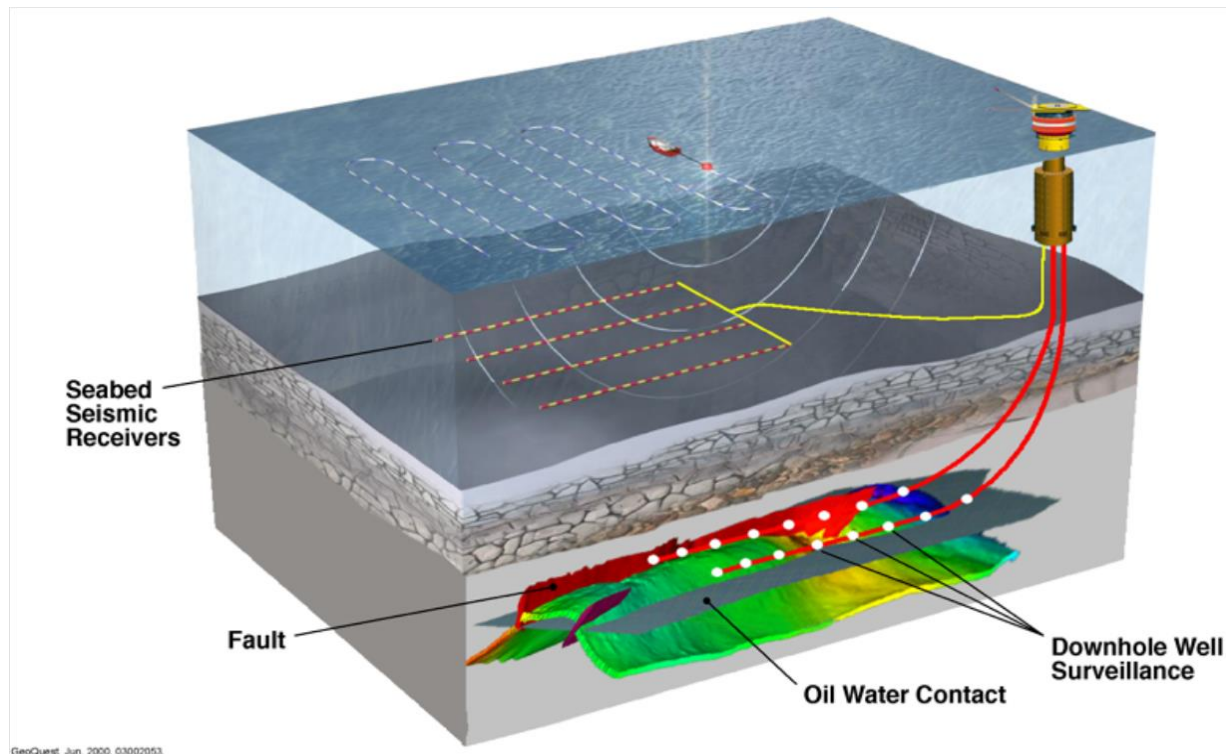
Vertical Data in Oil and Gas

- Drilling example
- Generally uses an Engineering datum as the drilling reference (rotary table or Kelly Bushing).
  - Relationship to MSL or LAT offshore is established.
  - Relationship to other various references can be established (national height datum, ellipsoidal height, etc).
- Similar case for facilities engineering activities.
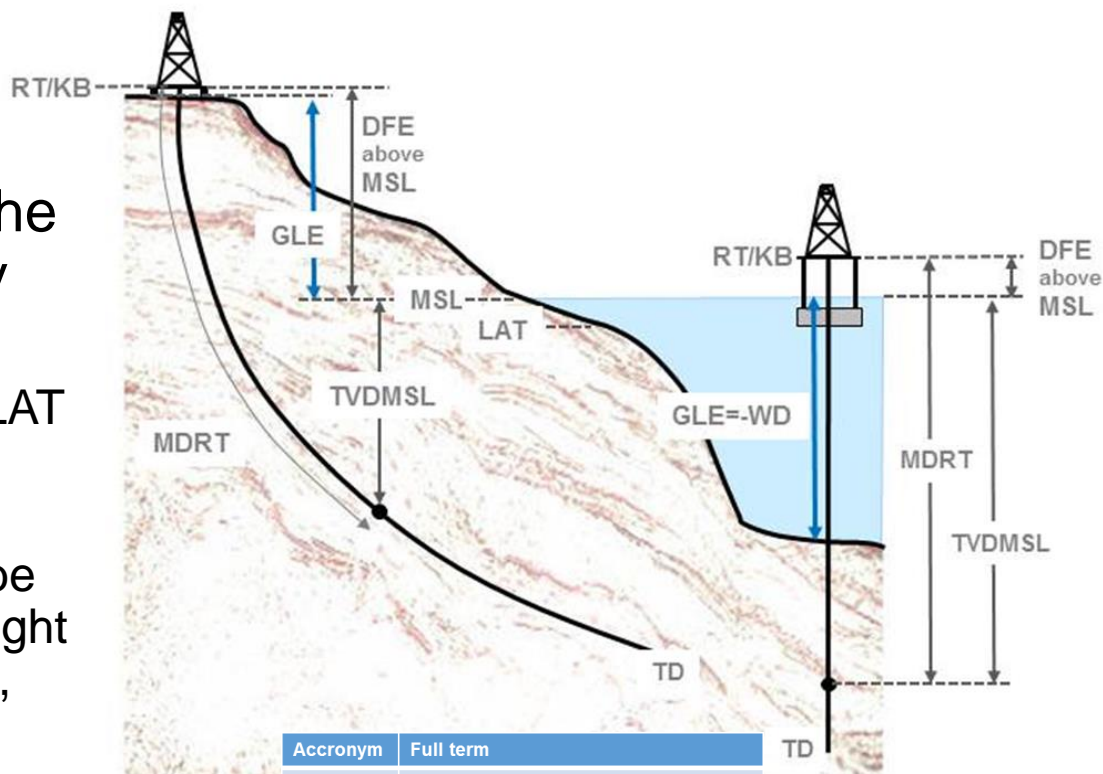
Accronym	Full term
RT	Rotary table
KB	Kelly Bushing
GLE	Ground Level Elevation
WD	Water Depth (always positive)
DFE	Drill floor elevation
MD	Measured Depth
TD	True Depth
TVD	True Vertical Depth

Vertical Data – Integration

- Integration of discrete datasets can be complex in any environment – correcting relative position of datasets requires a common vertical reference.

- Integration can be complex.
  - Data acquired with different vertical references, at different times
  - Integration to a single reference can be arbitrary, with offsets applied to discrete data sets to 'make them fit'.
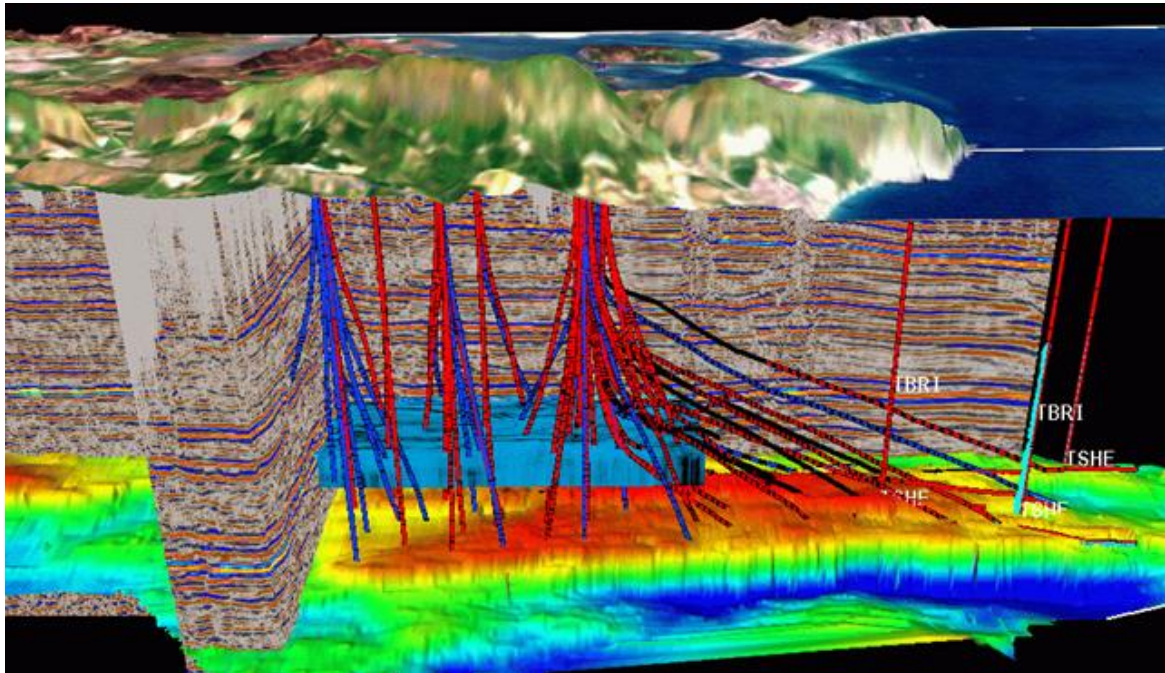
Vertical CRS - Background

- A vertical CRS is a 1D gravity related coordinate reference system with a defined axis orientation and unit of measure relative to a datum surface.
  - Positive up axis direction for 'Height' systems
  - Positive down axis orientation for 'Depth' systems
  - Unit of measure can vary between different CRS (International ft, Metre, ftUS, etc).

- Several 'variants' of a vertical CRS can exist – all are separate valid CRS in their own right. Four 'variants' of the NAVD88 vertical CRS…..
  - NAVD88 Height
  - NAVD88 Depth
  - NAVD88 Height (ftUS)
  - NAVD88 Depth (ftUS)

Vertical CRS use in practice

- **3D CRS (ellipsoidal heights).**
  - Unambiguous definition and possible as a vertical reference.
  - Ellipsoidal heights can be transformed to gravity related heights using a geoid model (global or national models exist).
  - Seldom used - may be more suitable to open areas where little existing data (otherwise data integration with other datasets may be an issue).
  - Perhaps difficult to implement due to regulatory requirements for data delivery in a specific CRS (host governments and partners).

- **2D CRS + 1D CRS – separate versus compound definitions.**
  - Compound CRS are seldom used - less flexible and bind the vertical component to the horizontal. If any changes are required to either the horizontal or vertical component, a full new CRS definition is required.
  - 2D + 1D approach allows flexibility to handle horizontal and vertical components in isolation, and changes can be made to either with updates to CRS definition of that component only.
  - Perhaps more suitable in mature areas, where data integration is common – can build a compound CRS with common elements

Vertical CRS – Recommendations

- Ensure unambiguous reference for 2D *and* vertical data.
  - Type of vertical CRS is not really important ('3D' versus '2D+1D'), as long as the definition is correct.
  - 2D CRS + 1D CRS – pragmatic approach in many cases.

- Audit trail recorded for operations on vertical data.

- CRS definition (2D *and* vertical) should be issued with any data transfer.
  - Data appropriately tagged with CRS names
  - CRS definition to accompany data (WKT, GML?).

- Consistency in the industry?
  - Standards for applications – should 'up' or 'down' be positive?

Vertical transformations

- Currently we have the four following populated vertical transformation methods in the EPSG dataset:
    - Geographic 3D to gravityRelatedHeight (127)
    - Vertical Offset and Slope   (39)
    - Vertical Offset   (39)
    - Vertcon   (3)

- Two new vertical transformation methods will be added:
    - Change of Vertical Axis Direction
    - Change of Vertical Unit of Measure

Vertical Transformations

The intention is to use the new transformation methods in a concatenated manner where necessary, to transform between source and target vertical CRS.
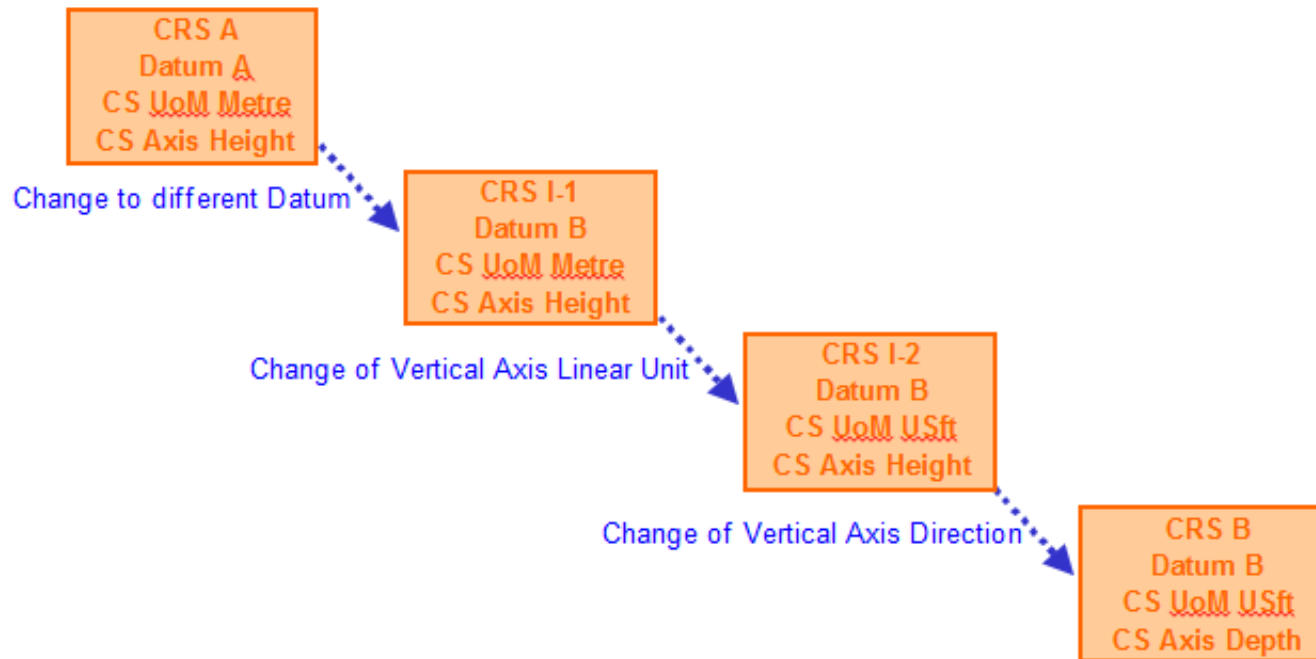
Vertical CRS – EPSG Population Strategy

Vertical CRS:

Vertical CRSs will be added upon request.

By default:

Vertical CRS relating to geodetic datum will be added as height CRS

Vertical CRS relating to hydrographic datum will be added as depth CRS

(both variants will be populated where specific requirements justify it).

New vertical transformation methods:

Vertical transformations for 'change of vertical axis direction' and 'change of vertical axis unit' will not be added to the EPSG dataset upon request – only a small number of example cases will be included.

These basic transformations are routinely applied to data currently in software, often not suitable for publication through the EPSG dataset. They do provide generic methods for audit trails to be maintained.

Vertical CRS – Guidance Note

- New IOGP Vertical CRS Guidance Note discuss the issues and sets out recommendations for pragmatic use of vertical CRS to safeguard data accuracy.

- Final draft of the guidance note to be considered at May subcommittee meeting, with publication expected later in the year.

Questions?

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For more information please contact:

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