

Surface and Wellbore Positioning Errors and the Impact on Subsurface Error Models and Reservoir Estimates

Ed Stockhausen

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Speaker Information

- Ed Stockhausen
- Horizontal Wellpath Planning and Geosteering Specialist
- March 4, 2016
- SPE, AAPG, SPWLA



Speaker Bio

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 - Upstream Capability/D&C/G&G Ops/Chevron
 - 35 years with Chevron
 - University of Florida / MS Geology 1981
 - Houston, TX
 - Development and Operations Geology
 - Horizontal Wellpath planning and Geosteering since 1992
 - Directional drilling and surveying focus since October 2000
 - Formation Evaluation in High Angle and Horizontal wells since 2004

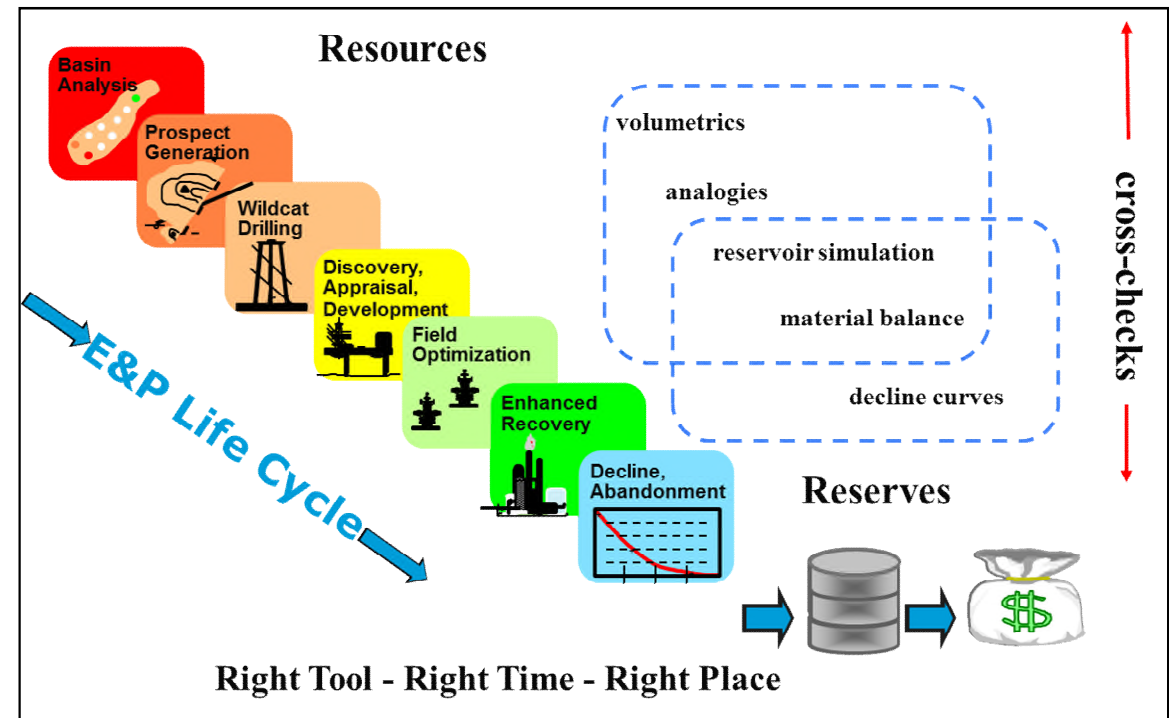


All Methods for Building Subsurface and Reservoir Models are Dependent on Geospatial Data

Overview of the impact of positioning errors by Ed Stockhausen

Limited Data Accuracy and Gross Errors Erode Value

- Surface position errors with seismic and well data
 - Datum and elevation errors
 - Surface Location errors
- Limited Directional Survey Data Accuracy - Ellipse of Uncertainty
 - Current errors models as defined by current ISCWSA models do not gross errors into account
 - Accuracy can be improved by applying corrections and additional services
- **Unrecognized Gross Errors Can Have a Huge Negative Impact**



Value and Success of Wells

Overview of the impact of positioning errors
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- Depends on effective wellbore placement within the target reservoir
- Significant incremental value can be obtained through more precise placement
 - Within stratigraphic lobes
 - across stratigraphic lobes
 - relative to fluid contacts - particularly with strong bottom water-drive reservoirs
- Impact of 1-Foot TVD error
 - *10,000 to 100,000 Bbls of oil lost for each foot of TVD misplacement*
 - *10,000 Bbls X \$30/Bbl = \$300,000*
 - *100,000 Bbls X \$30/Bbl = \$ 3,000,000*

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What Happens When Directional Survey Uncertainty and Gross Errors are Overlooked?

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- Wells are poorly placed in reservoir or miss the reservoir entirely
- Footage in reservoir is forfeited
- Fracture stages may be lost or non-effective
- Lost Production
- Early breakthrough of water or gas
- Hidden severe doglegs may be missed leading to
 - MWD tool failures
 - Casing wear and completion equipment failures
- **Operators don't learn what really happened (mistakes are repeated)**

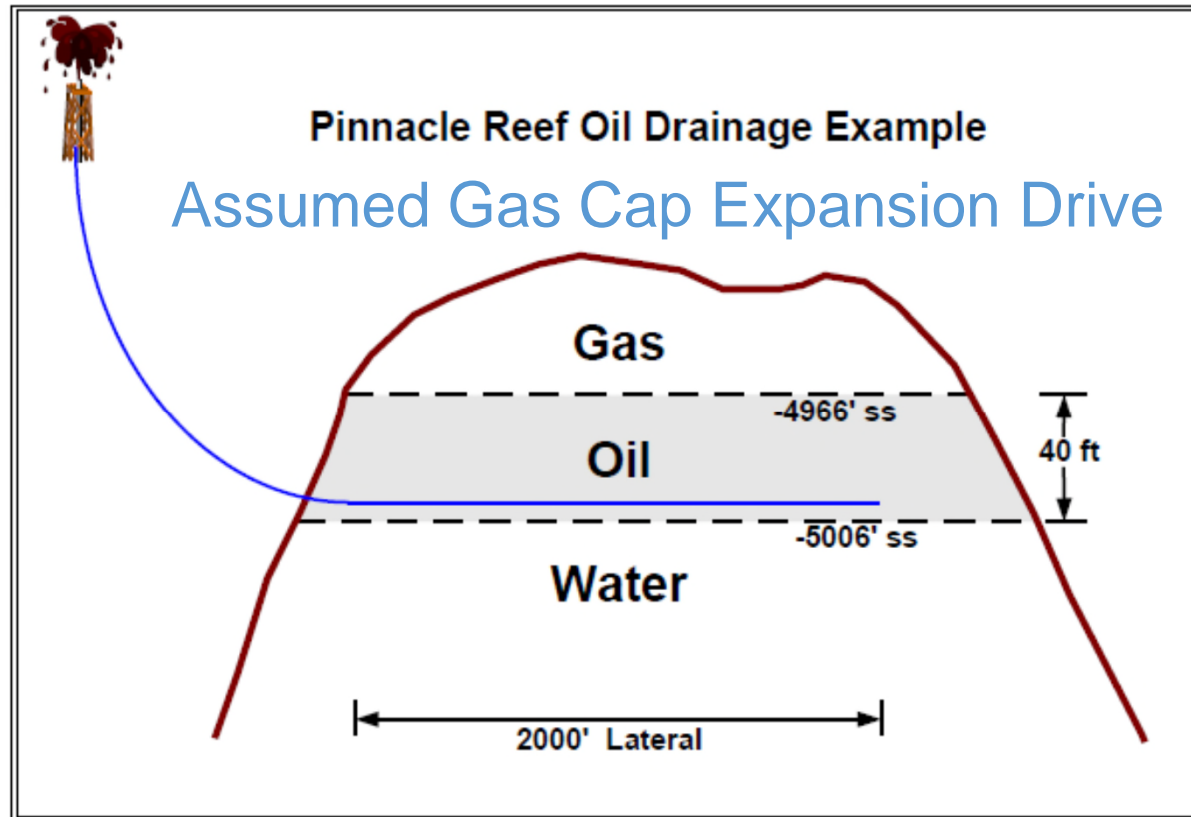
The result is lost value – and Reserves.

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Need to Take Directional Survey Uncertainty Into Account When Planning Wells

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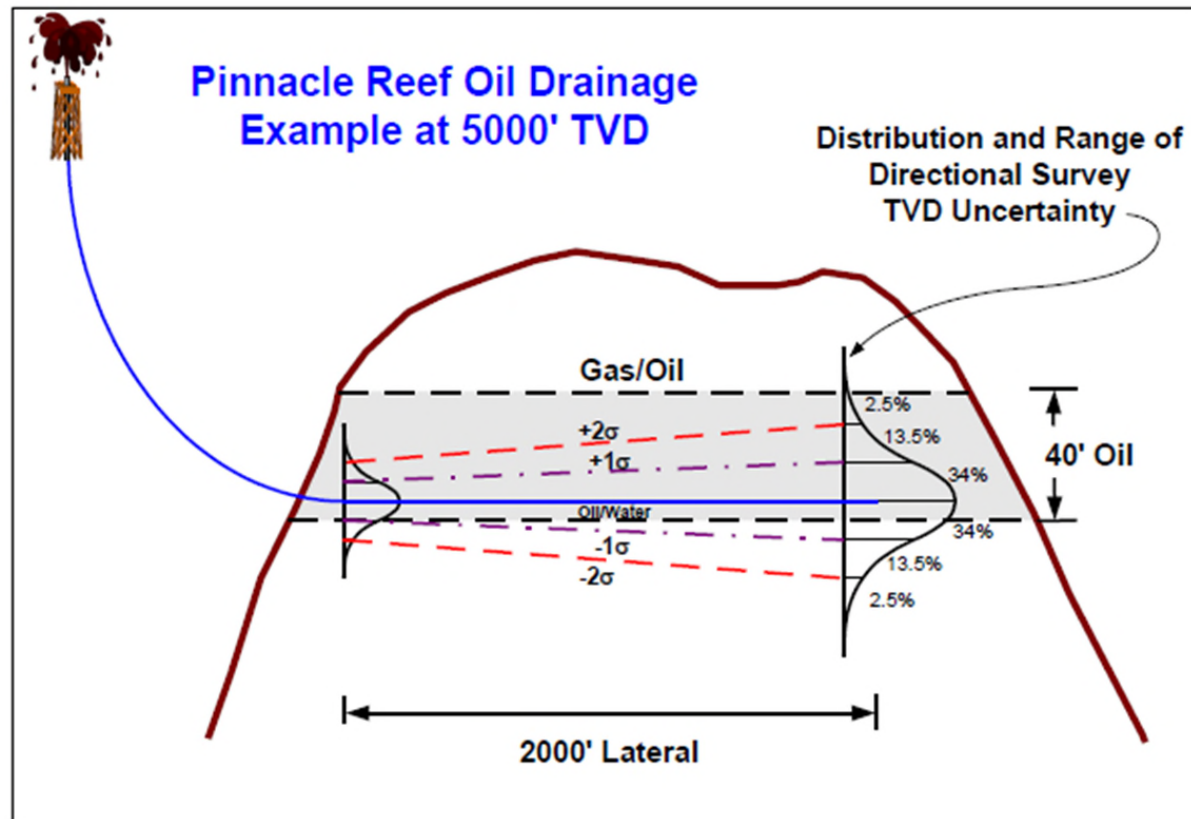


After Stockhausen 2003, AAPG Paper Flexible Well-path Planning for Horizontal and Extended-reach Wells

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Assessing the Risk of Survey Uncertainty

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After Stockhausen 2003, AAPG Paper Flexible Well-path Planning for Horizontal and Extended-reach Wells

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Sources of Gross Positional Errors

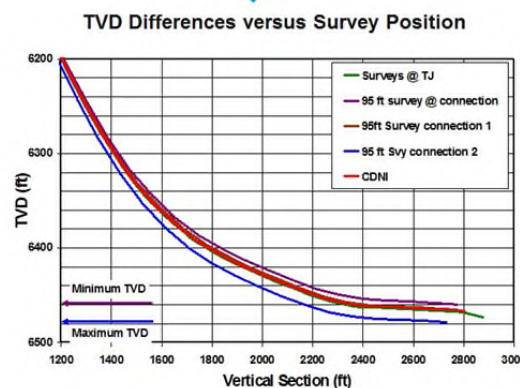
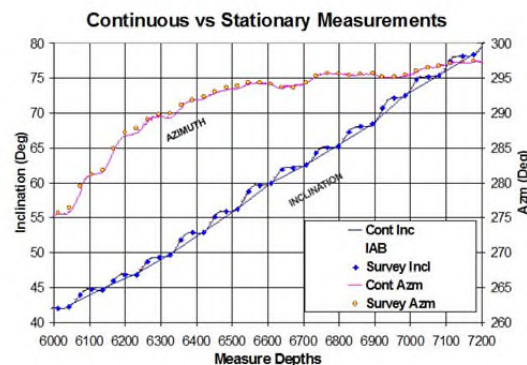
See SPE/IADC Paper 79917

Overview of the impact of positioning errors by Ed Stockhausen

Using patterned slide/rotate drilling practices in the build section

Short slide intervals when drilling lateral or tangent section to correct for build/drop/walking tendencies

Changing drilling parameter settings with rotary steerable systems in the interval between long-spaced survey points



The “Stockhausen Effect”
Describes how wells are often misplaced as a result of not taking enough surveys to accurately define the true curvature of a given wellbore.

After SPE 79917, Stockhausen 2003



Sources of Gross Positional Errors

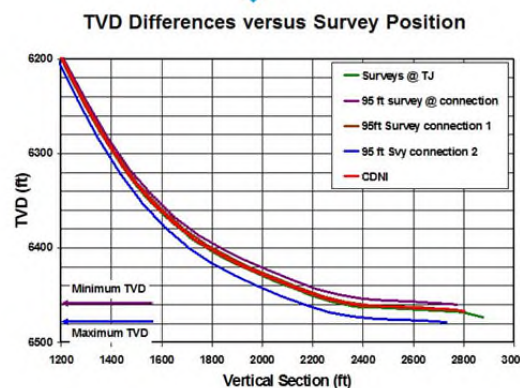
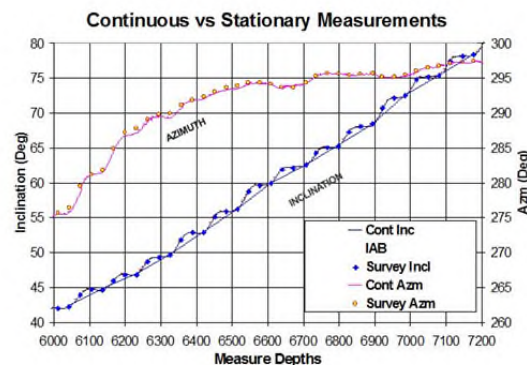
See SPE/IADC Paper 79917

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Directional changes resulting from changes in lithology – particularly when encountering tight streaks at low incident angles

Can be extreme and lead to MWD tool failure

Casing exits with large survey gaps – particularly when sidetracking wells



The “Stockhausen Effect”
It also implies a failure to know that the well is misplaced - with the belief that the definitive surveys provided are accurate and that they are free of gross error.

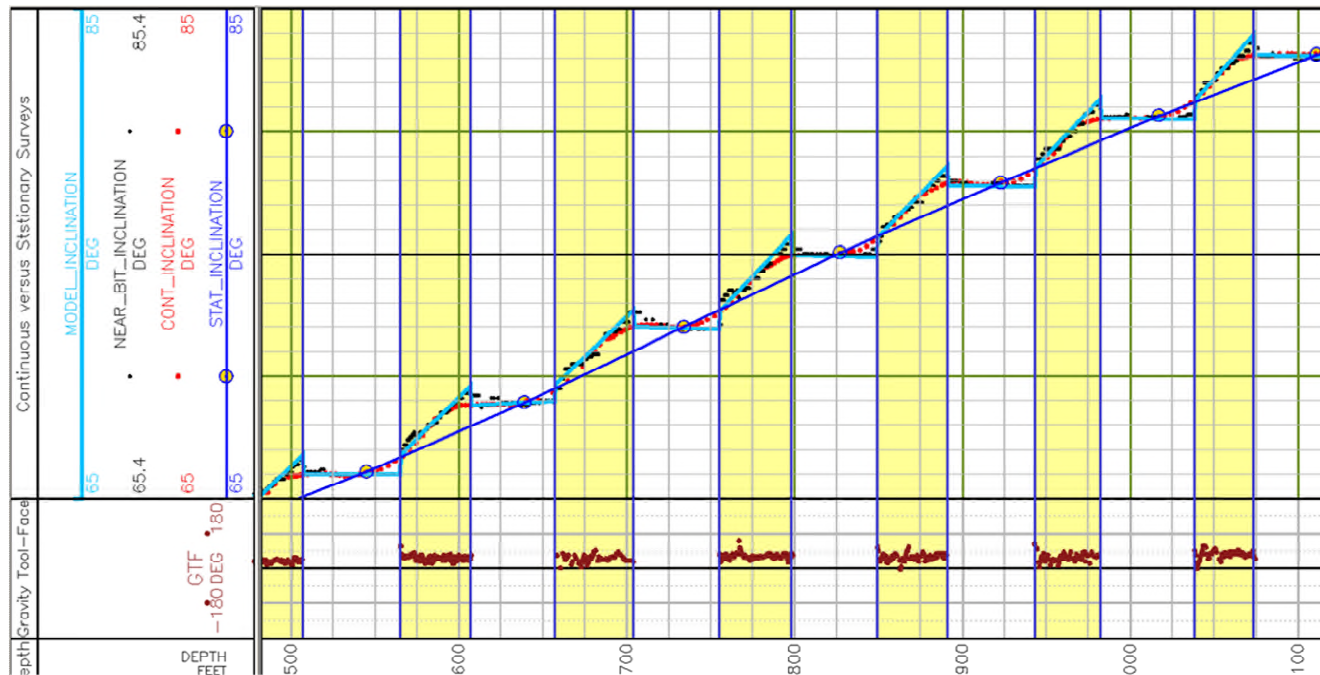
After SPE 79917, Stockhausen 2003

The Value of Research – See

SPE/IADC Paper 151248

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Step-up – Step-down model



(After SPE /IADC Paper 151248, Fig. 1)

SPE/IADC Paper 151248

Provides concrete proof of the discontinuous nature of drilling with PDM motors

That is, there is a formation of a step and an instantaneous change the trajectory angle at the start of a slide interval

and a slightly different effect but loss of angle at the end of a slide interval

The Value of Research

See SPE/IADC Paper 151248

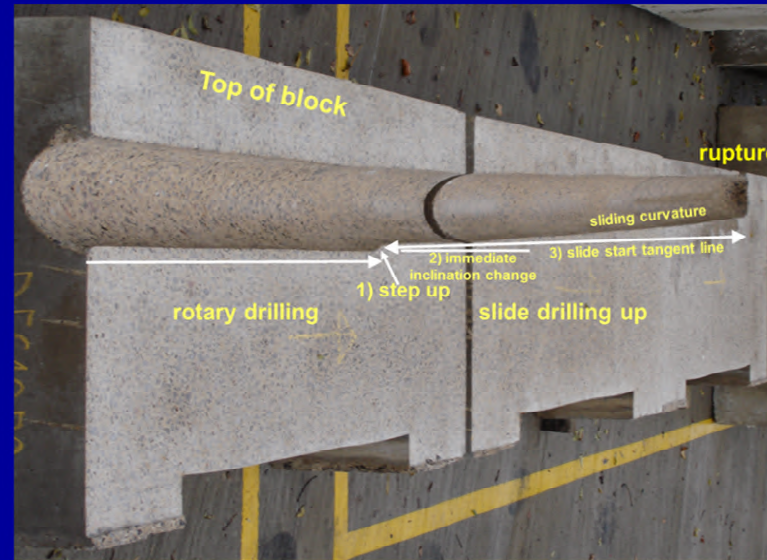
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Slide 14

Proved immediate angle change and step formation at start of slide



(After SPE/IADC Paper 151248, Fig. 5)



(After SPE /IADCPaper 151248, Fig. 10)

10 Key Points to Think About

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Geospatial on positional errors often get compounded as we go from the first well within a basin forward to making detailed maps on specific reservoir units.

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10 Key Points to Think About

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As we attempt to knit together the framework of our reservoir models, the data from one well is compared and contrasted to the next well and is often tied into seismic data to connect or separate various reservoir units.

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10 Key Points to Think About

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When positional errors are present, they begin to unravel the fabric and framework and our confidence in our models

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10 Key Points to Think About

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As additional wells are drilled the existing errors and the newly created errors show up as:

- geologic markers coming in shallower or deeper than anticipated
- as apparent differences in gas/oil, gas/water, or oil/water contacts between wells
- as apparent differences in fluid pressure gradients

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10 Key Points to Think About

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Any discrepancies, even the smallest, causes frustration and confusion

- This can lead to bad decisions and lost value

Additionally reservoirs often being incorrectly broken up into compartments

- This can lead to wells not being drilled

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Infill wells, particularly horizontal wells can miss large sections of the reservoir, or can be accidentally placed closer to fluid contacts when gross errors are present;

- resulting in early breakthrough of water or gas
 - resulting in significant lost value
- often delaying or sometimes stopping entire development program

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Both Geologists and Reservoir Engineers are for the most part unaware of or do not know how to deal with the standard positional error models.

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10 Key Points to Think About

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The amount of time that I have spent in my career frustrated by positional errors and attempting to identify the sources and prevent future mistakes can be measured in years and years and years of work.

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You all,
as part of ISCWSA,
are well aware of the sources of positional errors.

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10 Key Points to Think About

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Gross positional errors, such as, the so called
"Stockhausen Effect"

are preventable

but who is responsible?.....

Combining continuous and stationary survey data can
provide an accurate solution.

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Through continued knowledge sharing and the education work being done by the ISCWSA Committee, and through the development of new surveying tools and software

We can continue to move the industry forward



Questions?

43rd General Meeting
March 4th, 2016
Fort Worth, Texas



Wellbore Positioning Technical Section



The Industry Steering Committee on Wellbore
Survey Accuracy (ISCWSA)