Minutes of the Fourteenth Meeting of the

Industry Steering Committee on
Wellbore Survey Accuracy

Denver, Colorado
7 Jun 2001

Present:

Hugh Williamson (Chairman and Minutes)	BP
Matthew Rhodes	BP
David Kerridge	BGS
Roger Ekseth	Gyrodata
Steve Mullin	Gyrodata
John Barlow	Gyrodata
Torgeir Torkildsen	Statoil
Jim Towle	Scientific Drilling
Brett Van Steenwyk	Scientific Drilling
Dave McRobbie	Sperry-Sun Drilling Services
Patrick Knight	Sperry-Sun Drilling Services
William Allen	Sperry-Sun Drilling Services
Paul Rodney	Sperry-Sun Drilling Services
John Weston	Sperry-Sun Drilling Services
Wayne Phillips	Schlumberger
John McCullagh	Schlumberger
Chris Chia	Schlumberger
Darren Aklestad	Schlumberger
Greg Cellos	Baker Hughes INTEQ
Andy Brooks	Baker Hughes INTEQ
Harry Wilson	Baker Hughes INTEQ
Angus Jamieson	Tech 21
John Turvill	GeoNet
Jerry Codling	Landmark
George Smith	Chevron
Aubrey Holt	Honeywell
Olli Coker	Conoco

1 Introductions

Steve Mullin and Hugh Williamson welcomed the group to Denver and introduced the agenda for the day.

2 UKOOA / CDA Format for Deviation Data

Hugh Williamson summarised the history of and latest developments concerning the UKOOA P7/2000 Data Exchange Format, which covers deviation data.

A new revision of the format (rev. 3) had been devised by Richard Wylde of ExxonMobil and Hugh Williamson, with help from Pat Boswell of Phillips. The revision was a compromise between the original CDA proposal (minimal, concise) and the later UKOOA Surveying & Positioning Committee revision (comprehensive, complex). The compromise had been achieved by introducing some flexibility into the format, particularly in the way geodetic systems were described. The data section of the format could now contain calculated surveys as well as MD, Inc, Azi data.

Olli Coker felt that such formats should support only a single way of presenting data, and that introducing options was a recipe for trouble. He also felt that there was no place in such a format for calculated or interpolated values, such values constituting opinion, rather than data. Data entry should be controlled by pick-lists, rather than free text. Three digits was unlikely to be sufficient to adequately describe survey tool types – Conoco experience had been that nine digits were in fact required. Olli's experience was that there was typically little opportunity to fine-tune formats – once a proposal was perceived as a "90%" solution, it would be adopted spontaneously and widely "as is".

Wayne Phillips mentioned the similar initiative being kicked off by the US Minerals Management Service (MMS) and suggested that they be encouraged to adopt the proposed UKOOA format.

Jerry Codling and Chris Chia pointed out the overlap between the UKOOA format and the WITS FM rig data exchange format currently under development.

Harry Wilson thought that establishment of common formats was primarily the responsibility of Operators, especially where the data was being exchanged between Operators, or between Operators and government agencies.

3 New Vessel for Marine Magnetic Surveys

Angus Jamieson described the vessel *Cable and Wireless Adventurer* which Tech 21 and the British Geological Survey had chartered to perform marine magnetic surveys in the North Sea over the coming Summer. The boat is well suited to the task, being made of fibreglass and aluminium and having a triple-hulled construction which makes for excellent stability.

4 Acceptance Values for MWD Magnetic Surveying

Torgeir Torkildsen discussed the latest version of the Statoil / INTEQ proposal. Based on a modified version of the ISCWSA MWD error model, the acceptance levels for the combined B-total / Dip quality measure had been increased slightly to:

Standard referencing	– no magnetic correction	700 nT
	– with magnetic correction	450 nT
Enhanced referencing	– no magnetic correction	525 nT
	– with magnetic correction	300 nT

The G-total quality measure remained at 0.018 ms^{-2}

Torgeir raised the issue of correlation between delta-B and delta-Dip, stating that correlation coefficients between –0.5 and +0.5 had been seen. No-one at the meeting felt this was a particular concern.

Patrick Knight was not comfortable with the values proposed for interference corrected data. He thought delta-B and delta-Dip should always be small in these cases, since the assumed values for B and Dip were used in the calculation of the correction

John Turvill was interested in the relative contribution of crustal, disturbance and sensor errors to the error budget, and hence to the acceptance values.

Harry Wilson invited other directional companies to provide data to help validate the acceptance values. Both "raw" and interference corrected data would be useful. He arranged to provide Wayne Phillips, Patrick Knight and Jim Towle with copies of the spreadsheet which had been developed in connection with the work.

The question was raised as to whether "bad data" (in the sense of being outside the acceptance values) should be provided. John Turvill thought that this was necessary in order to properly understand where the QC limits break down.

Note: Subsequent to the meeting, it was agreed between Statoil, BP and INTEQ that it was inappropriate for INTEQ to co-ordinate this activity centrally. Instead, they would produce a brief report describing the method of analysis and the results obtained from a sample of their MWD data. Once this had been digested by the group, other MWD companies would be invited to undertake a similar study.

5 Modelling of Gyroscopic Tool Errors

Roger Ekseth presented a basic theory of continuous gyro azimuth errors. He identified five terms for inclusion in an error model:

- Initialisation error
- Random gyro noise
- Drift tune error
- Calibration drift error
- Misalignment error

and showed how the cumulative effect of each depended on the time between drift checks and the time since the last drift check. By defining error terms based on these dependencies, some terms related to specific causes, such as mass unbalance, could be dispensed with. He thought that environmental errors were generally unimportant, except in the case of drop-gyros.

Roger pointed out some minor queries and inconsistencies in the document presented by Torgeir at the previous meeting and noted that the model did not currently distinguish between frequent and infrequent drift tunes – an extra term is required if drift tunes are infrequent.

Chris Chia asked if drift tuning too frequently could degrade gyro accuracy. Roger thought not.

Harry Wilson wanted to know how two models (for frequent and infrequent drift tunes) would be used in practice. Roger responded that all gyro error models are dependent on specific procedures. The infrequent drift tune error term would be included to account for a variance in the standard procedure. Hugh Williamson pointed out that this would enable an engineering decision to be made regarding a trade-off between accuracy and survey time.

Harry also observed that depth would typically be used as a surrogate for time, which would require important assumptions about tool running speed.

Wayne Phillips wondered if any terms other than the "t-squared" error terms would contribute significantly to the error budget. Roger thought that the drift tune error and the initial gyrocompassing error were likely to dominate.

John Weston questioned whether drift tune errors could be treated as random. Roger explained that the proposed model made no assumptions about how individual terms behaved in terms of propagation.

Roger concluded by proposing a three phase work programme for the group:

- Finalise mathematical error model
- Create guidelines for determination and documentation of error parameters
- Create a system for audit of error parameters

Brett van Steenwyk made some remarks concerning the practical application of Torgeir's proposed model. He pointed out that the Scientific Drilling gyro tool had larger random errors than some others and its rotation within the borehole was dependent on the way it was run. Running procedures were therefore important for modelling this tool's errors.

Emphasis should be put on definition of QC checks for gyro tools which confirmed their adherence to the error model. Hugh Williamson asked if it were feasible to define QC checks which would be common between different tools. Brett thought that there could be common sets of checks within classes of tool, but that different classes would require different checks.

Brett also thought it possible that some wells would, by their shape, grossly violate the assumptions underlying the error model, thereby invalidating it. Harry Wilson wondered, if the tool performance was so problematic to model, whether the tools should be used at all.

It was agreed that the group was only concerned with defining a common set of error terms. The values which were assigned to each term could be tool-specific. Indeed, Hugh pointed out that the same was true of MWD error models – only no MWD company had yet developed a specific set of error term values for their service.

In response to the gyro survey companies, Torgeir highlighted some corrections to his original gyro error model and showed where particular assumptions had been made. He also proposed renaming "gyro random walk" to "azimuth random walk" and "gyro drift" to "azimuth drift" and agreed with Roger on the need for an extra "calibration drift" term.

Torgeir stated that he was ready to collaborate in an effort to establish common standards for gyro error modelling, but that Statoil was not prepared to do this alone. He asked each company represented to consider whether it would commit to joining in such an effort, and if they were, to revert to him within two weeks.

6 Well Proximity Detection with MWD

Jim Towle described a technique that had been applied in the Bakersfield area of California for passive detection of nearby wells using MWD. The wells concerned were vertical and needed to be drilled at a given stand-off from existing wells.

The method relies on predicting the general level of interference to be expected from the existing well. This produces an envelope of expected B-total values, which expands as the well separation decreases. As drilling proceeds, the number of surveys which fall inside and outside the envelope is monitored. A series of surveys outside the envelope indicates that the wells are approaching more closely than planned. The technique does not at present have any directional capability.

Jim showed a plot displaying the probability of detecting various casing strings over a 90ft interval within which 3 surveys are taken. At a 50nT detection threshold, 9-5/8" casing could be detected with over 99% probability at 25ft separation, falling to about 70% probability at 60ft separation.

Jim ended by posing the question: should the variously available detection methods be included in collision risk calculations?

Chris Chia asked whether the technique would work in the presence of more than one nearby well. Jim thought it would – the inverse square law of magnetic influence would enable the effect of individual wells to be isolated.

7 Latest Developments with the BGGM

David Kerridge summarised the data that had been included in the recently released 2001 BGS Global Geomagnetic Model (BGGM). He pointed out how the model was a better fit to the available satellite data than the 2000 version had been (RMS misfit of 5.5nT for the 2001 model compared with 6.3nT for the 2000 model). The RMS misfit could be reduced by a further 0.3nT by including spherical harmonic terms up to degree 18 and some external terms in the model.

The secular variation model update was based on data from 192 observatories, 296 repeat stations and 235 locations with values from two satellite-based main field models.

David summarised the BGGM2001 as follows:

- Complete model (main field + secular variation) spans 1945.0 – 2003.0
- All models for 1990.0 onwards have been revised
- Data newly available in past year are incorporated
- Most recent main field model based on a new selection of recalibrated Orsted satellite data
- Better selection of surface data for main field models

David mentioned that there was an approximate 20nT variation in the external field associated with the 11-year solar cycle. This could potentially be included in the BGGM. Wayne Phillips asked about modelling the diurnal variations caused by the equatorial

electrojet. David responded that studies into the feasibility of modelling diurnal variations had shown them to be too irregular to make a model valuable.

8 Standardisation of Anti-Collision Rules

Hugh Williamson presented some work he had done on collision rules following Wayne Phillip's presentation in Houston. First, he described the existing rules based on "separation factor" (SF) and pointed out some of their shortcomings:

- Many variations in details of definition
- No consistency in "sigma values" or threshold levels
- No direct relationship between SF and probability of collision

He then proposed a risk-based separation factor calculated as the ratio of the "casing-to-casing" separation of the wells to a particular dimension of the combined uncertainty ellipsoid. The only flexible part of the definition was the confidence level at which the uncertainty ellipsoid should be calculated.

Hugh presented three options for defining the ellipsoid confidence level, the last being 2.81-sigma, which corresponded to nominal risks of collision of 1 in 400 at SF=1.0 and 1 in 80,000 at SF=1.5.

Wayne Phillips suggested that the SF values could be dispensed with altogether and collision risk values used in their place. Hugh agreed with the principle, but felt that this would blur the distinction between nominal collision probability (as defined by the rule) and actual collision probability, which was a more complex, and unknowable value.

Adopting the 2.81-sigma value for illustration, Hugh showed how the BP "major risk" rule, which incorporates a safety factor, would translate in terms of the newly defined separation factor. The minimum allowable value for SF would reduce from about 4.0 to below 2.0 as well depth increased. Exact values would depend on well geometries and uncertainties. He also suggested a program of further work:

- Compare existing rules against this new "standard" separation factor.
- Approximate existing rules (where necessary) with a stepped function regulating how minimum SF decreased with depth.
- Establish a "constant risk" rule with a stepped function of SF.

He pointed out that the last of these was ambitious, since it would require proper account to be taken of gross errors, perhaps through probabilistic modelling of collision frequency.

Harry Wilson supported the new definition of separation factor but was concerned that there was no efficient means of promoting its adoption.

Olli Coker couldn't see the need for rules based on derived factors – surely the ubiquity of computers meant that all anti-collision decisions could now be made using a precise calculation of collision risk. Hugh agreed that this was desirable, but pointed out that several attempts had already been made to devise an algorithm for calculating collision risk – without success.

10 Next Meeting

Schlumberger agreed to host the next meeting on a date in November to be decided. The probable venue will be their facility in Gatwick Airport, near London.