Minutes of the Twelfth Meeting of the

Industry Steering Committee on
Wellbore Survey Accuracy

Baker Hughes INTEQ, Houston
5 Oct 2000

Present:

Hugh Williamson (Chairman and Minutes)	BP
Toby Clark	BGS
Glenn McColpin	Landmark Graphics
Rob Shoup	Gyrodata
Eduardo Ruiz	Gyrodata
Torgeir Torkildsen	Statoil
John Barlow	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
Wayne Phillips	Schlumberger
Chris Chia	Schlumberger
Ross Lowdon	Schlumberger
Darren Aklestad	Schlumberger
Greg Cellos	Baker Hughes INTEQ
Andy Brooks	Baker Hughes INTEQ
Ken Wall	Baker Hughes INTEQ
Robert Estes	Baker Hughes INTEQ
Angus Jamieson	Tech 21
Robert Wylie	MicroTesla
Herb Dunnington	Honeywell Tensor
Craig Constant	Honeywell Tensor
Aubrey Holt	Honeywell Tensor
Kim Touysinhthiphonexay	Colorado University
Tor Waag	Sensorlink

1 Introductions

Andy Brooks and Hugh Williamson welcomed the group to Houston and summarised the agenda for the day.

2 ISCWSA Error Model Implementation

Hugh Williamson showed how the various implementations of the ISCWSA algorithms and models were now achieving much closer results than at the previous meeting. Three implementations (Grindrod, Holmes, Williamson) were giving effectively identical results, the others were still converging.

Dave McRobbie's experience was that use of the word "standard" created the expectation that all implementations should achieve identical results. Hugh Williamson drew the distinction between algorithms, which should indeed be identical, and models, which could be expected to evolve with time.

It was agreed that the equations and results already published, (and to be re-published as SPE 67616 in *SPE Drilling and Completion,* Dec 2000) were the current standard, and that changes to this standard would not be made lightly. At the request of the SPE, the symbol for toolface in the published paper had been changed from τ to α.

Angus Jamieson suggested that adopting a standard of only quoting uncertainty results to the nearest foot or metre would help educate the drilling community about the limitations of the method, and forestall bickering over decimals. It was agreed that although high precision results had no practical significance, they were required to demonstrate that different implementations were identical, and would not give widely differing results for different cases.

The need to define an acceptable tolerance level on results for the standard examples was agreed.

Update: Since the meeting, it has been agreed that (a) well plan "way points" should be inserted as extra stations within interpolated files, (b) TVDs should be calculated using minimum curvature. Using these conventions, Andy Brooks, Steve Grindrod and Hugh Williamson now get identical results to 4 decimal places for all the examples. These conventions, and the revised results, are included in SPE 67616.

3 Treatment of Toolface Dependent Error Terms

Torgeir Torkildsen presented a summary of his recent paper (SPE 63275), *Directional Surveying: Rotating and Sliding Operations Give Different Wellbore Position Accuracy*.

The effect of some survey tool errors was very different depending on whether the toolface angle was constant or changing between surveys. For example, the effect of tool misalignment in a 3000m well was typically 10 times less if the toolface angle was changing between survey stations. Gyro bias errors showed a similar effect.

Torgeir and Jon Bang had observed that all known error weighting functions have a relatively simple dependence on toolface. Using this fact, any error term could be split into maximum of five "fictive" error sources, which were individually independent of toolface. In this way, the behaviour of all error sources could be modelled correctly, without any need for assumptions about specific toolface values.

4 Acceptance Values for MWD Magnetic Surveying

Torgeir Torkildsen summarised the joint Statoil/INTEQ work described in the previous meeting, and presented some updated figures. In summary, the three classical measures of MWD survey reliability: G-total, B-total and Dip, have been condensed into two: G-total and "B-vector distance". These measures are less dependent on hole angle and tool orientation than the classical ones, and, when suitable values are chosen, can be directly related to performance predicted by the ISCWSA "Basic MWD" error model.

One aim of the work had been to eliminate the "grey zone" from survey acceptance/rejection criteria. Traditionally, the grey zone of rejection started at about the 2-sigma confidence level. The approach proposed now was to use the 3-sigma level as a fixed cut-off.

Torgeir confirmed that the model for predicted G-total would need to incorporate latitude and depth.

Patrick Knight asked if the pass/fail criteria for "B-vector distance" were equally applicable when the dip angle was negative. He also warned that many surveys which would fail these criteria could still give good results when processed further with a multi-station correction: rejection under these rules should not mean complete rejection of the data. Several felt that the pass/fail criteria for checkshots and rotation shots would prove the most useful part of the work.

Torgeir described the usual sequence of events when a survey failed these criteria: the rig would typically continue drilling, while checking for disturbances in the external magnetic field. The decision to trip the tool would only be made after rejection of 2 or 3 consecutive surveys.

Hugh Williamson requested that the 3 major MWD companies present consider the proposal and the practicalities of its implementation, and send Torgeir and himself a brief response.

5 Marine Magnetic Surveying

Toby Clark described some field trials of the "MVMag" marine vector magnetometer developed by Tech 21 with help from the BGS. In an attempt to understand, isolate and eliminate all the errors in the system, a series of calibration exercises had been performed. The sensor package and mounting were first calibrated on land, then mounted on the vessel and recalibrated and at a tidal foreshore site. Mean measurements of both declination and dip made from the vessel agreed with absolute measurements made at low tide to within 0.1°.

Three short survey tracks within the Inner Moray Firth were sailed in difficult weather conditions. There was considerable noise in the individual spot measurements, apparently associated with the attitude of the boat. Despite the noise, field trends predicted by aero-magnetic data over the same area were clearly visible. The mean values for declination, dip and total field agreed with the aero-magnetic data to 0.06°, 0.09° and 6nT respectively.

Toby and Angus believe that the feasibility of the technology has been successfully demonstrated. The trials have revealed several avenues for further investigating the behaviour of the system, with a view to improving both its accuracy and practicality.

6 Immersive Drilling Environment

Kim Touysinhthiphonexay described a 3D immersive well planning environment developed within ARCO. The project team and the associated technology have recently transferred to the University of Colorado. Project data, such as well locations, geological horizons and seismic lines are displayed on four sides of a cube, inside which an operator can stand and interact with the data. As an example of this interactivity, Kim illustrated how colour-coded anti-collision tolerances could be displayed between wellpaths. A well plan could be selected and dragged away from nearby wells until the distance from them was acceptable.

Other applications of interest to the group include target selection, platform location optimisation, and wellpath optimisation under engineering constraints.

7 Passive Detection of Drillpipe

Paul Rodney showed the results of some finite element analyses he had performed to study the magnetic field disturbance caused by a uniformly magnetised drillpipe. The greatest effect was to be expected with the ambient field perpendicular to the pipe. In this case, a 120 nT effect could be expected at 10 ft distance, but this would fall to 10 nT at 30 ft distance. The conclusion was that a uniformly magnetised drilpipe would be difficult to detect with standard MWD sensors beyond a distance of 10 metres.

Responding to a question from Andy Brooks, Paul confirmed that there was broad agreement between these results and an analytical analysis of the same situation.

8 Standards for Anti-Collision

Wayne Phillips described some investigations he had been performing on minimum separation rules. He stated that a desirable property of any separation rule was that at the close approach threshold (separation factor = 1), the probability of collision should always be the same. He tested three geometric rules in current use against this criteria: (a) spheres enclosing EOUs just touching (b) EOUs just touching (c) projections of EOUs onto the well-to-well perpendicular just touching. None of these rules came close to fulfilling the criteria, although (c) came closest.

Wayne suggested that the desired property could be enforced by defining the separation factor to be unity when the probability of collision was a given maximum tolerable value. This maximum tolerable probability could be gauged by evaluating the collision probability “allowed” by current rules. Taking one example of touching 3-sigma error ellipses as illustrative, a maximum collision probability of 37 ppm was indicated.

Letting X be the combined uncertainty of the two wells along their mutual perpendicular, the resulting separation rule would be:

minimum separation = $\sqrt{2}$ (2.8 X) + well radii

separation factor = *actual separation* / *minimum separation*

= (centre-to-centre – well radii) / *minimum separation*

In this way, the separation factor is zero when the wells are apparently just touching, and unity when they are at the defined minimum separation.

Hugh Williamson extended the conversation to a discuss possible standards. He stressed the need for any separation rule to be both simple and robust (in the sense described by Wayne).

There was some discussion on whether the entire tail of the probability distribution should be considered when evaluating collision probability. That is, should the situation of wells passing on "the wrong side" be classified as a collision. Most felt that it should, although Hugh felt this was not always appropriate for deep intersections.

Depth-related safety factors were also discussed. Although unjustified theoretically, they were sometimes applied either as a safeguard against underestimated or unmodelled survey errors, or to achieve a minimum separation with which engineers (or survey specialists) were comfortable. In particular, Hugh mentioned his distrust of current position uncertainty results in vertical hole. The group felt this was an area which would repay further study.

Patrick Knight pointed out that the issue of magnetic interference was frequently ignored in discussions of anti-collision. Although the minimum separation rule might indicate a safe separation, magnetic interference from the nearby well coiuld make the surveys unreliable, and hence invalidate the rule.

Hugh undertook to advance the progress towards standardisation in minimum separation rules before the next meeting.

9 CDA / UKOOA Format for Survey Data

Hugh Williamson gave some of the history of the deviation data format that had been developed under the auspices of CDA (Common Data Access). CDA had recently been acquired by the UK Offshore Operators Association (UKOOA), whose Survey and Positioning Committee had suggested extensive revisions to the format.

He described the original format, emphasising that a conscious decision had been made to minimise the number of data items. In this way, the data could not be self-checked, hence putting all responsibility for its quality on the data provider. The revised UKOOA draft had deviated sharply from this principle, and included many more data items, particularly in the definition of the co-ordinate system.

The conclusion of the group was that it supported the initiative, but would recommend adoption of the original format, with a few minor revisions. The revised UKOOA version was felt to be inappropriate to the original CDA remit and its implementation would act as a serious disincentive to compliance, and to compilation of a complete dataset for UK wells.

The MMS (Texas), NPD (Norway) and Alaskan state authorities all have existing formats. These would be circulated amongst the group to ensure that the CDA format could either not be improved upon or could be rejected in favour of an existing format.

One specific change to the CDA format was suggested: the list of possible tool types should be expanded to allow an appropriate error model to be associated with each survey.

10 Next Meeting

The next meeting will be held on Friday 2nd March in Amsterdam, immediately following the SPE/IADC meeting. Halliburton offered to host the meeting, subject to the availability and suitability of their local facilities.