Minutes of the Fifth Meeting of the

Industry Steering Committee on Wellbore Survey Accuracy

RAI Congress Centre, Amsterdam
7 Mar 1997

Those present:

Hugh Williamson (Chairman and Minutes)	BP Exploration
John Turvill	Halliburton
Graham McElhinney	Halliburton
Brett Van Steenwyk	SDC/Applied Navigation Devices
Fred Watson	SDC/Applied Navigation Devices
Tim Price	SDC/Applied Navigation Devices
Alasdair Macrae	SDC/Applied Navigation Devices
Koen Noy	Gyrodata
David Roper	Sysdrill
Adam Henly	Sysdrill
Leif Jensen	Statoil
Gordon Shiells	Sperry-Sun
Wayne Phillips	Anadrill
Philippe Theys	Anadrill
Steve Mullin	Baker Hughes INTEQ
Andy Brooks	Baker Hughes INTEQ
Harry Wilson	Baker Hughes INTEQ
Torgeir Torkildsen	IKU
Alewijn van Asperen	Shell International
Steve Grindrod	Copsegrove Developments
Bill Aitken	Schoeller-Bleckmann
Herbert Aigner	Schoeller-Bleckmann

1 Introduction

The Chairman welcomed those present and thanked Alewijn van Asperen for organising the venue.

2 Actions from last meeting

A description of Andy Brooks' method of lumping sensor errors had been distributed. Later in the meeting, Andy clarified a possible misunderstanding of his method, by explaining that it lumped all measurement errors affecting a single sensor into an uncorrelated bias term, but did not attempt to further lump errors from different sensors into a single inclination or azimuth term.

Two representatives of Schoeller-Bleckmann had kindly responded to Gordon Shiells' invitation to give a talk to the Group (see below).

The forwarding of data to the survey error "focal points" had been patchy, as a result of a poorly defined process. A clear process and action list was agreed later in the meeting (see below).

Inteq's work on modelling gyroscopic errors had been absorbed into their wider efforts in error model standardisation. It was therefore considered unnecessary to discuss it in detail.

David Roper had made enquiries of the POSC organisation regarding standardisation of formats for reporting survey positional and uncertainty information. The description of position uncertainty currently defined in the POSC model is inadequate for the needs of the wellbore survey community. Moreover, since wellbore position and its associated uncertainty may be described fairly simply, there is little to be gained from defining and imposing a rigid model. Better to agree that such information will be transmitted in IBM "flat-file" format, and to decide as a Group the format of such files.

3 Proposed Standard Format for Error Models

David Roper presented the progress to date of a group comprising Sysdrill, Inteq, Statoil and BP, which had been formed with the objective of agreeing a mutually acceptable format for current and future survey tool error models.

Details of the model will be circulated to the Group as a separate action; the following is a summary of the model which had been agreed by the four parties and which was presented to the Group:

3.1 Approach

A modified Wolff and de Wardt model has been chosen.

3.2 Assumptions

1. At each station along a well, the difference between the true value of a measurement and its value as recorded by a survey tool is the sum of the effects of a known set of error sources
2. The sizes of the error sources in any survey are statistically independent of one another.

3. The errors may be combined linearly. That is, the position error when error sources A and B are present simultaneously is equal to the sum of the position errors when error sources A and B are present individually.
4. A one point calculation method is sufficient for determining the effect of each error source on wellbore position. That is, the error in wellbore position is the product of the angular error at a station multiplied by the course length between stations.
5. The correlation between the values of a single error source at different stations in a well is characterised by two values, viz.
   - the correlation between values at consecutive survey stations
   - the correlation between values at stations in different surveys

Harry Wilson pointed out the necessity, especially in anti-collision calculations, of accounting for error correlation between wells.

There was some discussion of how the concept of correlation between survey stations related to the "randomisation distance" described in the previously circulated "Survey Instrument Performance - Part 1, Survey Error Propagation".

Note: work subsequent to the meeting shows that, for a randomisation distance ρ *greater than the station interval* Δs *and much less that the length of hole surveyed, the equivalent correlation between consecutive stations is given by;*

$$\rho_{stat} \quad = \quad 1 - \frac{\Delta s}{d}$$

3.3 Method of error propagation

Errors are to be propagated in a manner similar to Andy Brooks' "tabular method" described in SPE 36863. The method, which is equivalent to that described in "Survey Instrument Performance - Part 1, Survey Error Propagation", will need to be generalised to accommodate correlation coefficients strictly between 0 and 1.

3.4 Definition of an error source

The following information was required to define an error source:

- name (unique for each separate physical cause of error)
- class (the name of the weighting function characterising the error)
- mean (zero except for "bias" errors)
- standard deviation (always quoted as 1 sd value)
- correlation between consecutive stations in a survey
- correlation between surveys in a well

3.5 Arguments of Weighting Functions

A weighting function describes how the effect on measured inclination and/or azimuth of a constant physical source of error varies under different conditions. The following arguments are considered sufficient to characterise the behaviour of most error sources:

Measured depth
Inclination
Azimuth
Toolface
X, Y, Z, offsets from surface location

Latitude
Longitude

An additional argument which may need to be introduced is “non-magnetic drill collar length above sensors”. John Turvill pointed out that in many modern drilling assemblies, it is the length below the sensors which is most significant in determining the level of magnetic interference, so this argument may need to be re-defined.

3.6 Weighting Factors

The preparation of a list of about 20 weighting factors considered sufficient for a basic description of MWD errors is nearly complete.

3.7 Status of the Error Model

Alewijn van Asperen asked about the status of the error model and its relationship to software platforms. David Roper confirmed that the intention was to publish the model, and that it would have the same status as was currently enjoyed by the Wolff and de Wardt formulation. That is, there are to be no claims of intellectual property associated with the published material.

Actions:
- The model’s developers (Brooks, Ekseth, Williamson, Roper, Henly) to complete its development in the light of feedback from the meeting, and to circulate a full description of it to the Group by 11 April.
- Members of the Group to review the model and feed back comments, including suggested modifications, to its developers.

4 Magnitudes of Individual Error Sources

4.1 Drillstring Magnetic Interference

John Turvill presented charts showing the azimuth error resulting from a magnetic pole of a given strength at a given distance from the magnetic sensors. The calculations assumed an inverse square relationship between the field at the sensors and their distance from the magnetic pole.

Gordon Shiells stated that he had evidence that this inverse-square relationship was invalid for small sensor-pole distances, and that he would investigate the possibility of sharing details of this work with the Group.

Harry Wilson pointed out that if all data were corrected for magnetic interference as a matter of course, the problem of estimating uncorrected errors would be eliminated, together with any “bias” effect. Hugh Williamson raised the difficulties of historical wells with uncorrected data and of high angle east/west wells where correction was inappropriate.

Steve Grindrod showed some cross-plots of “magnetic interference factor” (= sinI.sinA) versus azimuth error. For a significant proportion of wells, the results indicated unfeasibly large amounts of interference. Gordon Shiells suggested that toolface dependency might be the cause.

4.2 Measured Depth

Philippe Theys discussed measured depth errors in both wireline and drillpipe. He presented a list of error sources and their typical magnitudes for a 10,000 ft vertical well. [Ref. Kirkman and Seim, IMS Eastern Hemisphere Technology Committee, Thames Symposium, London 1991].

He also gave a list of "best practices" for acquiring and documenting depth, and reality checked these against current operational practices. In particular, he noted that the depth values currently used as definitive are those typed in by the directional driller.

An example from the field showed that the effects of rounding and truncation on calculated well position can be highly significant. Harry Wilson pointed out that truncation was potentially more serious than rounding and asked which was more prevalent. Philippe thought that both types of error were common.

5 Magnetic Properties and Hot Spot Testing of Non-Mag-Materials

Herbert Aigner, the Quality Manager for Schoeller-Bleckmann in Austria gave a talk on the above subject. The following is a summary of the main points of the talk.

There are two essentially different chemical compositions of non-magnetic (paramagnetic) steel: high manganese-chromium (eg. P 530, P 530 HS, P550) and high chromium-nickel (eg. AISI 316). The chemical composition determines the proportions of the crystalline structures of the steel - Austenitic (non-magnetic) and Ferritic/Martensitic (magnetic).

The non-magnetic properties of drill collars are tested in three stages during manufacture. Firstly, the relative permeability of the melt material is tested. Customer specifications range between 1.005 and 1.01. The Schoeller-Bleckmann internal standard is 1.005, but in practice, values are less than 1.001.

Second, the permeability of a restricted area of the collar is tested. Lastly, the entire collar is tested by means of a probe test or "hot-spot test". The measurement here is deviation in the magnetic field intensity gradient, with a maximum allowable deviation from a uniform magnetic field of 0.04 micro-T.

There are two possible set-ups for the probe test, since either the probe or the collar can be moved while the other is kept stationary. It is preferred to keep the collar stationary since this requires less space.

There is no direct relationship between the magnetic field gradient inside a non-magnetic drill collar and the deviation that would be seen by a compass in the same location. This is because of variations in the orientation of the collar, the direction of movement of the probe and differences in the ambient magnetic field. It is however possible to construct an envelope of possible compass deviations for a given probe reading and, in particular, an upper limit. As an example, at the testing facility in Austria, a probe reading of 0.04 micro-T would correspond to a maximum compass deviation of 1 grad (0.9 deg).

[John Turvill pointed out that a standard accelerometer/magnetometer was, in effect, a compass, and could be adapted for use as a probe to testing the compass deviation inside a collar directly].

Hotspots introduced into drill collars at the manufacturing stage are rare (in 1996, 3 bars failed the testing criteria out of a total of 2100 manufactured). They may be introduced into the steel as it is being cast into ingots, or from the machine tools used to shape the collars. The hotspot is clearly visible under the microscope by its different crystalline structure.

For drill collars in the field, magnetic indications may result from a number of causes:

- magnetic material due to abrasions (chains etc.)
- rust on ID from internal tools
- iron particles / chips from grinding / operations / “air” pollution
- storage on supports made from magnetic material
- thread protectors made of magnetic material
- gripping edges from broken out tong dies embedded in the OD

Once located by testing, magnetic indications are removed by brushing, grinding, shotpeening (blasting) and pickling.

6 Shell Survey (Processing) Software Platform

Alewyn van Asperen gave some background to and introduced a demonstration of a survey processing and manipulation platform. The platform, being developed under Shell’s guidance by a company called Eraze, is designed to be used for analysing and reporting survey data in real time. The platform itself contains no proprietary algorithms or techniques, although such functionality could be added by the user.

Shell believe that the platform could be used to advantage throughout the industry, and would like to transfer its ownership and maintenance to a suitable joint industry body, with the costs to be shared amongst the users. Phase 1 of the software is due to be ready in the second quarter of 1997.

Following the demonstration, there was some discussion on the architecture of the software, particularly on how the split between the platform and the applications/algorithms was achieved. Further discussions on the platform will take place between Shell and the survey companies individually.

7 The Operators’ Perspective of the Steering Committee

At a meeting that took place on 5th March, survey specialists from Shell, BP, Statoil and Saga Petroleum had discussed their current work and the directions which they would like the work of the Steering Committee to take. Alewijn van Asperen summarised the conclusions as follows:

The current process by which tool error models are developed and agreed with each Operator separately is slow and inefficient, and can lead to the views of each Operator being misrepresented or misconstrued. More co-operation and sharing of information was required. In particular, since all the Operators required similar information as part of their review and approval process, this information could in future be compiled and shared amongst the Operators. In spite of increased co-operation, it would not always be possible for the Operators to agree common error models for the same service because of differences in operating procedures.

Shell had not yet had the opportunity to evaluate the proposed standard format for error models, although it did not seem to be radically different from existing approaches implemented in Compass and other software.

It was conceded that some details of survey tool technology have competitive value and were not suitable for discussion with the Group. However, areas such as environmental error sources and standardising QA/QC measures could and should be progressed.

Hugh Williamson explained how he thought the current work of the Group fitted into a long-term structure for error modelling within the industry. Immediate efforts were directed towards establishing a small number of "basic" error models for MWD tools. Once the form and detail of these were agreed, the onus would fall upon individual survey vendors to develop error models for their tools in the standard format, to compile supporting data, and to seek review and approval of the models from a subset of the companies represented on the Steering Committee. A database of models would be maintained on behalf of the industry by an individual or organisation.

Koen Noy was worried about the liability of the Group in the event of an accident resulting from reliance on an "approved" error model. He stated that this was one of the reservations which his own company had in publishing the performance figures for their tools. Other members of the Group thought that carefully worded disclaimers would be sufficient protection against charges of liability.

David Roper questioned the need for a central database of error models, believing that the individual survey vendors should act as the definitive source of error models for their tools. He felt that an organisation undertaking to distribute the error models would be taking a serious risk of assuming liability for their validity.

Alewijn van Asperen expressed reservations about endorsing the long-term vision given that most of the short-term objectives were still subject to further discussion and amendment. This was generally accepted by the Group.

8 Determination of Magnitudes of Error Sources in Basic MWD Model

Since the unstructured approach to sharing data had not worked, commitment was sought from individuals who felt that had any data of value to provide it to the "focal point" on request. At least two contributors were identified for each type of error.

Actions:

1. Focal points to request data from identified contributors
2. Members to supply quantitative estimates of the magnitudes of error sources to focal points, including, where possible, a summary of the supporting evidence.
3. Focal points to collect data and relate it to the corresponding suggested weighting functions (to be circulated) and/or alternative weighting functions.
4. Focal points to present "best estimates", with a brief assessment of their reliability at the next meeting.

The Group will discuss the estimates at the next meeting, assess their quality, and either agree basic (provisional) values or initiate the further work needed to establish them.

In addition, Alewijn van Asperen offered to act as a focal point for basic quality measures for MWD surveys.

9 Other Business

There was no other business

10 Next Meeting

Bill Aitken had offered to host the next meeting to co-incide with a tour of Schoeller-Bleckmann's NMDC manufacturing facilities in Austria. This offer was accepted by the Group, with preferred dates of 23-24th June.

Action:

- Bill Aitken and Hugh Williamson to propose a program for the visit and meeting and advise members accordingly.