ISCWSA / SPE Wellbore Positioning Technical Section

Error Model Maintenance Work Group

Minutes of the Meeting at ISCWSA#43, Fort Worth, 4th March 2016

Present

Andy McGregor	Tech21	Will Lanigan	Sperry Drilling
Jerry Codling	Landmark	Kevin McClard	PDT
Darren Aklestad	Schlumberger	Harry Wilson	Baker Hughes
Andy Sentence	DGI	Erik Nyrnes	Statoil
Andy Brooks	Schlumberger	Jon Bang	Gyrodata
Adrian Ledroz	Gyrodata	Steve Grindrod	Copsegrove
Neil Bergstrom	Independent	Stefan Maus	MagVar
Pete Clark	Chevron	Jonathan Lightfoot	Occidental
Lee Roitberg	Benchtree	Anas Sikal	Pathcontrol
James Ang	Benchtree	Brett Van Steenwyk	Scientific Drilling
Shelley Peterkin	Sperry Drilling	Marc Willerth	Scientific Drilling

Verification

The anti-collision committee has created 11 test scenarios that are specific for anti-collision analysis. There was some discussion about also using these wells for error model verification and for having a complete end to end worked example. In the end, it was decided to keep these separate since they have different purpose i.e. anti-collision well paths were design for testing anti-collision rules and standard ISCWSA set were designed for testing error models .

However this group does need test data sets for MWD-MWD tie-ons valid for the latest model revisions, for inclination only models and also for Gyro+MWD tie-ons.

There were also comments that a real world example might be useful, where well curvature etc. is not smooth.
Actions – Darren Aklestad and Andy Sentance.

Gyro Model Verification

As a continuation of the discussion about verification data sets , concerns were expressed that it has been difficult to replicate the test results for Test Gyro Model #3 on ISCWSA Test Well#3 as detailed in the gyro model paper. This should be clarified and further guidance provided if necessary.

The issue is thought to be with the handling of gyro transitions and re-initialisation of the model. It is possible that the gyro model authors entered additional survey points to the profiles in order to come to their results. There were also questions as to whether the complexity of the re-initialisations are needed and would they ever be used.

Action: Adrian Ledroz to discuss with John Weston and investigate. Question Steve Grindrod to see if he has any insights.

Inclination Only Surveys - Tie-ons

The guidance document on inclination only surveys has been published. Jerry Codling to add some further detail on how to handle tie-ons to regular surveys.
Action: Jerry Codling

Error Model Documentation

Andy McGregor has made some limited progress on the error model write up.

Andy Brooks/Sentence have a spreadsheet with example calculations for MWD and gyro models which could be made available along with the documentation to act as an example for implementers. It may need some modification because does not seem to correctly model the gyro test cases
Action: Andy McGregor to complete draft and circulate for comments.
Action: Andy Brooks/Andy Sentence to find this spreadsheet and check.

Effect of Error Correlation on Uncertainty Value

BGS reviewed Stefan Maus' work on correlation values between various combinations of global and IFR magnetic models. They took a slightly different view on the some of the estimates which were used in determining the correlations values, and for which values are not well agreed in the scientific literature. This means that some of the non-integer correlations might vary, dropping from around ~0.4 to perhaps ~0.2.

Harry Wilson and Andy Sentence had evaluated some test cases, calculating the relative uncertainties by running up well and down the other. They looked at the impact for parallel wells, opposing wells and 50 deg incident wells, in combinations of single leg MWD surveys, single leg MWD+IFR, four survey leg MWD runs and four leg MWD+IFR wells.

Their work showed some significant changes to EOU sizes depending on whether the magnetic error terms were considered to be uncorrelated or fully correlated. They did not evaluate non-integer correlations. As might be expected, the results were very much dependent on the relative importance of the geo-magnetic terms within the overall uncertainties. In the larger differences, the ellipse dimensions changed ~50%. The uncorrelated results were conservative in most cases, except where wells were in opposing in directions.

This work shows the very extreme cases from fully correlated to non-correlated – but it was questioned if this is truly representative.

Jon Bang described an alternative method for handling correlations coefficients via a series of matrix operations. This allows non-integer correlations to be handled. It was agreed that Jon's method

should be used to verify Harry/Andy's calculations and then extended to non-integer situation and review.

Action: Andy McGregor and Jon Bang to implemented his method and evaluate non-integer correlation results.

Course Length

Jerry Codling presented some further work including a course length term in the model – this was presented in detail at the main meeting. He includes an additional error source based on the observed change in wellbore attitude (inclination and azimuth) over each survey interval. This includes a delta angle squared 'penalty term'.

In the discussion which followed there was a generally consensus that such terms might be useful but questions at this stage as to whether there could be unexpected side-effects. For example, could the penalty term blow up under any circumstances? We don't want to end penalising users who surveying at higher frequencies for example.

Also Jerry's analysis was achieved by removing surveys and re-analysing wells surveyed at high frequency. In this case a driller had seen the properly surveyed data and was controlling the well – therefore does this analysis truly represent wells with no survey data over intervals.

Also there was not much build to horizontal data in the analysis and the suggestion was that this might ~20% worse. Use of this type of term would also require and assumed minimum angle/dog leg term for use in planning. Would this blow up in corkscrew wells?

Pete Clark showed some suggested course length, angle change and dogleg criteria for applying on long course length model like this and a suggested cross over to Blind Drilling.

The consensus of the group was that we would need to evaluate Jerry's suggestion in the context of an error model and check that some of these concerns did not create a problem. This would need to be done some real data and not only smooth test wells.

Steve Grindrod is working on a similar concept but by scaling the ellipses rather than having an error source. This would require an IPM or a software option to add in the effect

OWSG

Pete Clark gave an overview of the current work being doing by the OWSG on error models. They are looking to create models for interpolated azimuth and extended course lengths.

There was some discussion to clarify the roles of this committee and the OWSG where it comes to error models.

This group defines the mathematical framework for error modelling which provides the generic basis for consistent modelling of borehole survey uncertainties by the industry. This includes model terms,

weighting functions, error summation, propagation modes and correlations. Also guidance on the consistent handling of inclination only tools. Only in the case of certain variants MWD of models, do we define specific uncertainty models for specific tools.

The OWSG has created several sets of models (A/B/E/C) which allow for a systematic approach to modelling of tools and which are compatible with the framework created by this group. These are described in SPE178843. These are not linked to any particular provider. Adoption is voluntary and that is a decision for the individual users or companies. They are not warranted or validated beyond the comments in SPE178843.

New tools are added to the E (experimental) list and to be adopted required in the main set must be initially approved at an OWSG meeting, then this group will be consulted for comments and finally the model will only be adopted after agreement at a further OWSG meeting.

Although the OWSG explicitly state that their models are not ISCWSA certified or mandated, concerns were raised that could be viewed in that way by parts of the industry. To that end, agreements were made that the experimental (E) and contractor (C) models would not be published by OWSG on the web, in case implicit ISCWSA approval or recommendation of these models was inferred by users.

AMIL Magnitude

Benny Poedjono presented some measured drill string interference values to compare to the MWD model revision 4, AMIL term value (220nT). His presentation largely supported the 220nT value. However, it appears that SLB procedure is space their BHAs to better than 0.5 deg anticipated azimuth error. Therefore this is not necessarily a direct comparison.

There was interest in why his drill string interference terms were heavily biased towards positive values.

Singular Weighting Functions When Vertical

Chad Hanak has done some work on clarifying the derivation of MWD weighting functions which are singular when vertical. This supported the existing formulations, with one proviso – when using the older toolface dependant terms (i.e. prior to revision 3) the vertical accelerometer bias terms don't work correctly with random toolface i.e. in rotating (random propagation) mode. However, this was rarely if ever applied and the later rev3 onward weighting functions are correct.

These derivations will be included in the forthcoming error model documentation.