ISCWSA Error Model Revision 5 Beta – Release Notes

A beta release of revision 5 of the ISCWSA error model is now available.

By beta release, the committee has discussed and agreed the details of this release but would like users to evaluate it in practical scenarios before fully committing to its use.

Four changes have been made to the ISCWSA error model at Revision 5.

These changes are:

i) addition of long course length terms (XCLA and XCLH) which can be used in all models in order to include some compensation for inadequately surveys wells
ii) changes to the misalignment and sag terms introducing new versions, XYM3E, XYM4E and SAGE. These changes work as a package to better characterise how a survey tool may be misaligned with bore hole axis.
iii) Separation of the magnetic reference terms (DECG, DBHG, MFI and MDI) into multiple error sources to allow for the correlation of these errors between wells in collision avoidance calculations.
iv) a clarification of how the tie-on of the first survey leg to surface should be handled.

The document briefly discusses the rationale behind these changes.

Details of the specific changes and how to implement them may be found in the ISCWSA Error Model Definition Rev5.0 and in two technical supplements, one on the XCL terms and misalignments and the other on the changes to the geomagnetic reference terms. All these documents can be found at ISCWSA.net

CAUTION
The XCL term is designed to allow for some of these errors caused by longer course lengths, in a general or statistical sense. No amount of error modelling can compensate for position errors introduced by failing to adequately measure the path of a specific well. Therefore, the position of the ISCWSA is that the well should always be adequately surveyed.

The changes to misalignment have been made because the committee believe they better characterise how a BHA sits in the hole. When compared to Rev4, these changes will significantly reduce errors in long vertical sections, especially at higher survey frequencies. When planning vertical wells users should consider how well their drilling equipment can practically maintain verticality. In effect the Rev4 error model provided some buffer for drill-ability rather than true survey errors.

Long Course Length (XCL) term

In order to correctly characterise the wellbore, it is necessary to survey at a sufficiently close intervals that the features of the well are captured and that the well can correctly be represented with a smooth arc between stations (such as the minimum curvature method). Under such circumstances we can

argue that if it was possible to take error free measurements of the wellbore depth, inclination and azimuth then this would result in an error free wellbore position.

Typically, good survey practice requires that the well is surveyed at 100ft (30m) intervals and more frequently in sections where the well attitude is rapidly changing.

However, it is recognised that there exists a lot of historic data for wells which were not surveyed to this standard and also situations occur where occasional measurements may be missed or rejected. Jerry Codling conduced an empirical analysis of many high resolution wellbore surveys (described in SPE 187249) and came up with a suggested XCL term, which varies depending either on the maximum of the change in inclination or azimuth over an interval, or on the measured depth interval itself multiplied by a default tortuosity.

It is clear that the assumption that the well is a smooth arc breaks down if the survey program misses a point of inflection where the well changes attitude. Also, the use of repeated slide-rotate patterns will step the well path (the sold called Stockhausen effect).

The XCL term is designed to allow for some of these errors, in a general or statistical sense.

No amount of error modelling can compensate for position errors introduced by failing to adequately measure the path of a specific well. **Therefore, the position of the ISCWSA is that the well should always be adequately surveyed.** If in doubt, survey at higher frequency.

For this reason, no specific guidance given as to when a Blind Drilling model should be used instead of a model with the XCL term, but a suggest rule of thumb might be that the XCL should not be used for intervals above 1000ft.

The specifics of the XCL term are given in the Rev5.0 error model definition document and in the ISCWSA Error model spreadsheets.

XCL terms can be added to all tool position uncertainty models and these will replace existing models.

There will be little to no effect on wells surveyed at 100ft intervals, but progressive increases to ellipse dimensions as the survey interval rises.

Misalignments and SAG

At the previous revision of the model, the borehole misalignments were increased from 0.06° to 0.1°. This was because evidence had found that misalignment in top hole could be significantly larger than 0.06°. However, when this change was made the propagation of the misalignment was kept as systematic, meaning that the larger hole misalignment had a significant effect all down the well. Now, based on work by Jerry Codling (see SPE 187249) we have increased the misalignment of the XYM3 and XYM4 terms to 0.3° but at the same time changed their propagation to random. This means we initially have large misalignment in top hole, but that it's effect on position quickly reduces. In addition, in order to ensure that these terms do not disappear too quickly for high rate surveys, we have added a minimum interval weighting and these means that XYM3 and XYM4 are replaced by new terms XYM3E and XYM4E.

As part of the same analysis, there was a conclusion that the weighting function for our existing SAG term was incorrect and it is replaced by a new SAGE term.

All of these changes are a package and should be implemented together. They will apply to all models for tools run o within the BHA.

Expansion of Magnetic Reference Parameters

When combined covariance methods are used in collision avoidance calculations, covariance matrices from reference and offset wells are added to together. In statistical terms, this is justified and correct if the errors in the two wells are uncorrelated.

However, it is recognised that this is not the case for the geomagnetic reference errors for wells in proximity. i.e. for the declination, total field and dip error sources generally modelled with global propagation. These are commonly referred to as DECG, DBHG, MFI and MDI.

Analysis by geo-physicists has suggested that in fact there will be partial correlations (ρ has a fractional value). These correlations will depend on whether the magnetic references in the two wells are from the same or different sources.

In order to incorporate this functionality into the error model framework, a solution was proposed where the partial correlations between the existing sources are replaced with a number of new sources, which are either fully correlated or uncorrelated with each other.

For example, DECG is replaced with DEC-U, DEC-CH, DEC-CI, DEC-OS, DEC-OH and DEC-OI. Whilst this makes the tool code more complicated, it is an elegant solution for handling the partial correlations with minimal changes to the underlying mathematical framework.

These changes are details in the Error Model Definition Document Rev5.0 and in an additional document, “ISCWSA Error Models – Revision 5 Details for Software Implementers”

If a user’s software is not taking the correlation into account, then these changes will have almost no effect on error model results. The only observable changes will be due to truncation at the resolution of the term magnitudes.
However, when collision avoidance calculations using combined covariance methods (such as the ISCWSA standard collision avoidance rule) include the correlation correction, quite large corrections to separation factors may be observed.

Surface Tie-On

Some inconsistences have been noted in how different software handled the survey uncertainties over the interval from slot to the first survey. If we only evaluate the error model at the first downhole survey station then implicitly we are assuming that the slot inclination and azimuth are known perfectly and that no error accumulates over the first interval due to errors in that measurement.

Therefore, a decision was made to make an allowance for errors in the slot attitude and that the magnitude should be the same as a downhole survey. This can be accomplished in one of two ways,

either by inserting a dummy survey point a very short distance below the slot or by modifying the wellbore geometry matrix $\frac{d\Delta r_1}{dp_1}$ for the first survey interval. The method of doing this is described in section 4.7.1.1 of Error Model Definition document.

References

Definition of the ISCWSA Error Model Rev 5.0
Available at ISCWSA.net

The Effect of Survey Station Interval on Wellbore Position Accuracy
Jerry Codling, Halliburton. SPE 187249

XCL Terms and Low Angle Misalignments- Technical Supplement MWD Error Model Rev5
J. Codling & A.E.McGregor

Application of Partial Correlations Between Geomagnetic Terms - Technical Supplement MWD Error Model Rev5
A.E.McGregor
Available on the Error Model Committee page at ISCWSA.net