Recommendations on Side-track Wellbore Clearance Scanning

Rev 1.0

1. Purpose

The handling of Side-tracks in clearance scans is inconsistent across the Industry, and it is therefore desirable that consensus on best practice be achieved. This document is the result of discussion amongst a Working Group formed from the ISCWSA Error Model and Collision Avoidance subcommittees. It provides recommendations on best practice and validation examples for use by SMEs and well planning software developers.

2. Definition of a Side-track

A Side-track is a planned or drilled wellbore that originates from an intermediate point in another wellbore (the "Parent" or "Motherbore" of the Side-track). A Side-track's Parent may be a sidetrack itself. The terminology of Parent and Side-track merely defines the drilling sequence.

The Side-track point is the deepest point common to the two wellpaths being considered.

To best define the trajectory, the sidetrack point should be interpolated at the MD of intended exit from the Parent wellbore. The sidetrack point may be revised during drilling, using an interpolated station at the MD of actual exit.

3. Calculation of relative position uncertainty between wellbores

3.1 Base case: independent wellbores

The Working Group first evaluated the efficacy of current practice in quantifying relative uncertainty between independent wells, this being the starting point for evaluating the special case of Side-tracks.

The ISCWSA general error model provides four propagation modes at error term level

- *Random* (uncorrelated station to station and therefore uncorrelated in all circumstances)
- *Systematic* (correlated station to station within a survey leg (ISCWSA Collision Avoidance lexicon), otherwise uncorrelated)
- *Well by Well* (correlated station to station and leg to leg within a wellbore, otherwise uncorrelated)
- *Global* (correlated in all circumstances, including well to well)

Correlation Coefficients			
Propagation mode	Stn to Stn	Leg to Leg	Well to Well
Random	0	0	0
Systematic	1	0	0
Well by Well	1	1	0
Global	1	1	1

Table 1

To allow a valid estimation of relative position uncertainty, error models must identify all errors that are correlated between wells and assign them the *Global* propagation mode. Some error sources may justify either *Well by Well* or *Global* propagation depending on circumstances, in a way that

cannot be captured by a generic error model. In such cases, *Well by Well* is preferred since it results in a more conservative outcome in most situations.

Where greater precision is required, SMEs may wish to use bespoke variants of the standard error models that better reflect the actual correlations. An example of how different situations might affect MWD error term correlations is provided in the appendix.

The ISCWSA rev5 general error model (*Definition of the ISCWSA Error Model*) provides sufficient delineation for the calculation of valid estimations of relative position uncertainty, with only one exception. The model's single MD Stretch term (DST) has *Global* propagation, which is appropriate for drillpipe conveyed systems, but not for wireline conveyed systems. Off-bottom drillpipe stretch is dominated by buoyed pipe weight and downhole temperature, variables that are reasonably consistent between wells in the same field development for a given MD and TVD (MD and TVD being the two parameters used in DST's weighting function). Wireline stretch is more variable and less predictable between legs, because of variations in such things as cable history, running conditions and correction method. Therefore, *Systematic* propagation is a more appropriate mode***.*** **We therefore recommend the addition of a *Systematic* DST term (DSTS) for use in error models for wireline conveyed systems**.

A method of calculating relative position uncertainty that properly accounts for *Global* correlations is described in SPE 67616 and the *Definition of the ISCWSA Error Model* document. However, Industry common practice has been to use simplified methods that do not properly account for *Global* terms. In most cases, this practice overestimates relative position uncertainty.

We consider that correctly specified ISCWSA rev5 error models with the new DSTS term, used in conjunction with the correct calculation method, provides a fit-for-purpose quantification of relative uncertainty between independent wells.

3.2 Special case: Side-track and its Parent or between Side-tracks with same Parent

3.2.1 Error model

For the published set of ISCWSA rev5 error models, only the measured depth stretch term (DST) and certain geomagnetic reference field terms have *Global* or *Well by Well* propagation. These are the terms that must be considered with regard to the special case of Side-tracks.

Our review found no situations where these terms required special consideration for Side-tracks as compared to independent offset wells.

3.2.2 Error propagation through the Side-track point

Since it is certain that the Side-track point is common to the Parent and the Side-track, their relative position uncertainty at the Side-track point is zero. The Side-track must be tied to the Parent's wellpath so that they share coordinates and the same position uncertainty at the Side-track point. This means that all errors are fully correlated in the shared wellbore resulting in zero relative position uncertainty down to, and including, the Side-track point.

To achieve this outcome, the Side-track situation must be recognised as a special case and treated in one of two ways:

a. **Treat all error terms as fully correlated in the shared wellbore**
   Propagate all error terms from surface as normal, but treat **ALL** terms in the shared wellbore as being correlated, per the equation in Appendix A of SPE 67616, Accuracy Prediction for Directional Measurement While Drilling.
b. **Subtract the covariance matrix at the Side-track point from the covariance matrix at all depths below Side-track point in both the Parent and the Side-track**

Proximity between the two wellpaths over the shared interval down to the Side-track point should not be evaluated.

Continuous gyro error terms must initialise at the correct depth and accumulate down the well to and beyond the side-track point as normal. They must not be zeroed at the side-track point.

Both MD stretch (DST and DSTS) and MD scale factor (DSF) terms have station MD in their weighting functions, therefore consideration was given as to whether the weighting function MD (for Parent and Side-track) should be measured from the Side-track origin rather than from surface when calculating relative uncertainty with the Parent wellbore. It was agreed that this would be the correct procedure if the Side-track MDs are benchmarked to the Parent MD at the Side-track origin (e.g. using a CCL log or radioactive pip-tag), but that resetting of Side-track MDs is very rarely done, so should be treated as a special case requiring special treatment. **Standard side-tracking practice does not require re-zeroing of depth term weighting function MD at the Side-track origin.**

NOTE. Where special treatment of the Side-track with respect to the Parent is required, it must be restricted to that application, and not accidently applied to clearance calculations between the Side-track and independent offset wells.

3.2.3 Increased risk of magnetic interference from offset well

Magnetic interference from the Parent well is almost certain if it is cased or contains a fish. As for independent Offset wells, it is necessary to ensure that this is managed correctly, preferably by running gyro surveys, or by applying valid error models to degraded magnetic surveys.

4. Relevance of Side-tracking to Anti-collision Rules (ACRs)

Most ACRs are based on the relationship between nominal well separation and the uncertainty associated with that distance. Neither parameter is affected by the reference well being a Side-track, other than as discussed in the error model section.

The SPE/ISCWSA recommended ACR has two additional components, Surface Margin and Project Ahead uncertainty. The user may see Surface Margin as fulfilling one of several functions, but in most cases it will not apply to a Side-track junction in the way that it applies to a surface Slot location. It might therefore be reasonable to set Surface Margin to zero when scanning with the standard ACR from Side-track to Parent, but this requires additional programming logic or management processes. **Therefore, in the interest of achieving standardisation, it is recommended that Surface Margin is not zeroed at the Side-track**. This has little operational effect and results in more conservative outcomes, which is acceptable from a safety perspective. **Side-tracking does not remove the need to include Project Ahead uncertainty.**

Some ACRs include a cone of safety that reduces the nominal separation as a percentage of MD. MD is normally relative to the drill floor or the Well Reference Point, at or near surface. In the case of scans from Side-track to Parent, the MD used for this purpose should be re-zeroed at the Side-track origin.

4.1 Managing ACR failure at kick off

In starting from a common origin, the Side-track is certain to fail the clearance scan against the Parent well for some distance, whichever ACR is applied.

To reduce confusion, the rig crew should be given clear instructions on how far they can drill below Side-track point while accepting ACR failure. It is good practice to formalise a rule for automatic dispensation over the initial interval based on a criterion such as distance drilled (e.g. 30m), nominal separation distance (e.g. 3m), MD at which the Plan passes, or similar. Such a rule might be easily decided on when the cost of collision is low, but more difficult if the cost is high. Thankfully, early collision with a Parent well rarely represents a HSE risk.

5. Summary

A new DST term with Systematic propagation (DSTS) will be added to the ISCWSA set of terms, applicable in all circumstances, not only Side-tracks. The term will normally be applicable to wireline conveyed survey systems.

Correctly specified ISCWSA rev5 error models with the new DSTS term, used in conjunction with the correct calculation method, provides a fit-for-purpose quantification of relative position uncertainty between independent wells, between Side-tracks, and between Side-tracks and their Parents.

To achieve the correct outcome, the Side-track situation must be recognised as a special case and treated in one of two ways:

a. Treat all error terms as fully correlated in the shared wellbore.
   (SPE 67616, Accuracy Prediction for Directional Measurement While Drilling, Appendix A)
b. Subtract the covariance matrix at the Side-track point from the covariance matrix at all depths below Side-track point in both the Parent and the Side-track.

Standard side-tracking practice does not require re-zeroing of depth term weighting function MD at the Side-track origin**.**

The standard ACR's Surface Margin term should not be set to zero when scanning between a Side-track and its Parent.

Side-tracking does not remove the need to include Project Ahead uncertainty.

Where special treatment of the Side-track with respect to the Parent is required (e.g. benchmarking of MD or zeroing a cone of safety), it must be restricted to that application, and not accidently applied to clearance calculations between independent offset wells.

It is good practice to formalise a rule for automatic dispensation for ACR failure over the interval immediately below the Side-track point.

6. Tests Data

Cases to be finalised and added to the existing Standard Set of Wellpaths for Evaluating Clearance Calculations.

Appendix

The following table is an example evaluation of MWD terms.

	MWD Same job	**MWD Different job**	**MWD vs Gyro**
	(MULTI LATERALS)	(RE-ENTRY etc.)	
DREF (systematic)	Correlated	Not Correlated	Not Correlated
DREF (random)	Not Correlated	Not Correlated	Not Correlated
DSFS	Correlated	Not Correlated	Not Correlated
DSTG	Correlated	Correlated	Not Correlated
DECG	Correlated	Correlated	Not Correlated
DBHG	Correlated	Correlated	Not Correlated

Definitions:

Same job: A number of sidetracks are drilled by the same rig on the same well in a number of sequential operations.

a) Multi-lateral completions with whipstock re-entry (different TAML levels).
b) Open hole laterals (coal bed methane, fishbone laterals etc.)
c) Unintentional or remedial Side-tracks for 'fish in hole' if both surveyed by MWD.
d) Pilot holes

Different Job: A Side-track drilled from a Parent hole at a different time.

a) Slot recovery – potentially different rig /contractor/equipment (cut and pull or mill out casing)

Gyros are not correlated with MWD or other Gyros in the context of anti-collision.

Typically, software cannot differentiate between *Same* and *Different* jobs, so the default assumption should be *Different job* since that is the more conservative option.