Error Model Maintenance / Collision Avoidance Joint Sub-committee for the 60th ISCWSA meeting, September 25th, 2024

Attendees

Adrian Ledroz	Andy McGregor	Aprameya Murali Dhara	Brett Van Steenwyk	Dalis Deliu
Darren Aklestad*	Denis Reynaud	Erik Blake	Jerry Codling	Jonathan Lightfoot
Kevin McClard	Koen Noy	Marc Willerth*	Mike Attrell	Mike Calkins
Phil Scott	Philip Harbidge	Will Lanigan	Xiong Li	Petter Kvandal
Kevin Sutherland	Andreas Hueper	Ian Walker	Arnaud Chulliat	Austin Pile
Danielle Cook	Batyr Amanov	Jay McLelland	Bruce Ripley	Dan Wessel
Carl Healy	Scott Appelboom	Abdullah Al-Bloushi	Augustin Ranger	Bagus Sudiro
Mohamed El Shabrawy	Leif Blake	Walter Phillips	Suzanne Hawkins	Onye Jegbefume

Introductions –

Error Model Topics

Rotating error model – Proposed tool code weighting functions

- Will there be a OWSG / ISCWSA model released?
    - The original intent was to make sure software vendors can get the new weighting functions implemented
    - It's been presented as what a complete model would look like, but there is still some due diligence on the operator and vendor, similar to the gyro tool codes
- Can this be adapted to single axis surveying?
    - Most of the terms here are related to cross-axis terms, so it would not generally apply to a single axis tool
- Are you suggesting that this is for software test? There will not be a model in the standard set?
    - The gyro test models had this issue….they did get used as real models once they were out there
    - Should we put them in a separate place?
- Have depth terms been changed?
    - No, they are the same as standard MWD
- In addition to a model we will want running guidelines
- Is there an explanatory document for error derivations?
    - Yes the historical document will be published along with a new explanatory document from the on-going work

- Some of the weighting functions will look the same as old error functions, but we wanted to make sure that they are documented distinctly
- How does it compare to a traditional MWD?
    - The EoU ends up being similar because it mainly changes cross-axis MWD terms
    - The original work from SLB was to match static survey accuracy.
    - It's an open question as to whether we should publish conservative magnitudes or keep the historical magnitudes

Action from rotating survey discussions

- Rotating Survey Group to address minor remaining questions and produce guidance document on model history, running guidelines, and limitations
- Error magnitudes to be tested for possibility of producing a conservative model
- Full "error model" will be produced to at least enable software testing

Jerry Codling Presenting on Cone-based error models

- Created a document describing a workflow and IPM for a linear cone
- The data presented matches other operators' experience
- This was to show the process for how an operator can design and construct their own cone based utility models
    - Would it be worth ISCWSA just publishing standard sizes?
- Is there a maximum inclination?
    - These are generally considered vertical
    - Often these might be un-surveyed wells
- Evidence suggests that drift happens more as you get deeper
- What makes a well vertical?
    - Is it unsteered – but you should make sure that it was actually unsteered
        - Sometimes "unsteered wells" are drilled with bent motors
    - Do we need a note that this Is not for deviated wells?
    - We must remember that there is some diligence required on the error model users and to follow recommended practices
- When we make the use case document, it should start with caveats and use cases and a lot of this clarifying before we get to this meat of how you actually build it
- There are also issues related to using blind tool codes…is this something we should be using on a projection to bit? Does XCL cover projections to bit?
    - For the AC model and it's a live well and you're drilling, there is a project ahead uncertainty, and it does include XCL
    - There's a 0.5 m project ahead uncertainty, but perhaps that could be reduced with modern technology there could be other ways to reduce it
    - Inc+trend is another option that doesn't quite cause a trumpet
- Do any companies want to weigh in on what they use? How is this in their database? There's definitely a common practice to just keep the same tool code

- Some agreement that that blind is extreme, even though some companies push for it…it's a short distance to the bit so you shouldn't deviate that much. There is a big disconnect between operators and well planners
- Blind was traditionally for historical wells with large gaps
- Some will use it for poor MWD azimuth
- Canadian operations will sometimes use it for unsurveyed rathole
- What does rp78 say about this?
  - Need to check

Actions from Cone Discussion

- Compile Jerry's work into an edited document for publication on ISCWSA website
- Check API RP 78 drafts for what guidance will be provided on blind tool codes

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Collision Avoidance Topics

Recap from the Last CA Group

- One item is standardization of reports – it is nearly nailed down, and a document is ready to send out
- There is increasing emphasis on probability of collision methods
  - We can say it's safe to drill if you don't fail separation factor, but once you fail SF, you can do more detailed analysis
  - We have a couple presentations coming up in that vein

Koen Noy - Probability of Collision

- How can we carry forward probability of collision?
- Shell and KOC are on a journey to standardize Collision Avoidance
- They are targeting all services companies using the same CA management standards and rules for their operations
- Over the years, Shell has had significant standardization, including a simplified borehole surveying standard
  - Only 5 requirements, audits are simple easy to identify problem areas
  - There is still significant difference in outcomes for different providers, even with the standards
- ISCWSA has done a lot of good work, but also added significant complexity
  - Shell would like to go in the direction of everyone using the same CA standards, and produce consistent outcomes

- They want to get all service companies on the same page…and have good outcomes even if they switch services companies in the middle of the project
- This creates extra work for folks in the office and the field
- They would also like to have special risk-based decisions, particularly in places where you can't meet the broader standard of SF 1.5, or something similar
    - What happens below 1.5? it depends on the actual risk…how much risk are we willing to take?
    - You need to do a Risk-Assessment
- Tools exist for this, like a Risk Assessment Matrix
    - Red-Yellow-Green matrix: There are many versions across industry but it's always the same idea
    - In essence, you recognize hazard, estimate consequences, assess severity, and estimate frequency and that gives you risk
- This is not something that ISCWSA can do
    - It's an operator level decision to determine their own risk tolerance
    - Estimating the frequency of occurrence is possible, usually consequence is operator dependent
- How many times does a collision happen?
    - There are methods to model this in industry
        - Sawaryn 2017 / 2018 – significant work, Technical and Stakeholder alignment
        - Codling – collision probability model
- They must tackle this at Shell, so they've decided to use it
    - Looking back at a relief well project
    - Select standards, select rules, calculate SF, calculate probability, assess consequence (For people, asset environment, reputation), use RAM, select mitigations, Decide if the RAM rating is tolerable
    - In this case – well's risk up to SF = 1.5 is green…but then at 1.5 it becomes yellow because of the offset well status
    - For the yellow case, there were additional mitigations they installed
    - Separation does not capture the whole risk story
        - Both in terms of probability of collision and consequence of collision
- What is next?
    - What is our purpose? Do we have a long-term results?
        - Where should we be 6 months from now? One year from now?
    - Do we have stakeholders, do we have an end date?
        - How long do we want to be participating in an effort like this?
    - Shell and KOC would like to see standardization on CA management standards and the method.
        - Don't want to accept variation if we're going to move forward
        - Operators should set very clear expectations
        - They need a standardized way of assessing collision probability

Discussion:

- Looking at probabilistic CA, there are many different formulas and ways different companies do it….they could get 4-5 different results…What formula do you recommend?
    - Koen- Can't remember which specific one we use…Probably one from Jerry, needs to have detailed discussion and align
- In previous documentation, SF and probability have been discussed…but when looking at different wells with same SF, there are quite different results…the probabilistic method is confusing. There's a desire to connect SF to probability and they find it difficult when they don't align
    - The questions are linked to *how* should we standardize?
- Jerry – I can understand misgivings about probability calculations, one sided vs. two sided etc.
    - Two companies with risk-based procedures, they have a psychological factor: Is it probability of a hit, or probability of avoiding an action. Equations might say 1 in 10 is viable economically, but they use 1 in 100 because they just don't like hitting wells
    - Koen: Once you pick a system you build experience…the end answer is not the probability, we need to standardize the process
- How do you tier the probabilities numbers?
    - A .2 SF might be 1 in 50,000…so is it really a risk?
    - Tiering is an operator decision
- Do we even standardize on scan methods? Is this first? These shouldn't be proprietary…probability is later in the process
    - That was the first goal of this committee
    - We polled the group on scan
    - Now doing that for probability
    - Its hard enough to get people to agree on well radius
- Can we really get an accurate probability anyway? Do we know 1 in 30 vs. 1 in 50?
    - That is an operator level decision, but we need to have some basics agreed upon, like how to use casing radius
- A Norwegian operator is using the probability approach, until there is an HSE risk. In an HSE situation there's no probability calculation. Probability can be used however in a purely economic risk situation. In that case, how they want to figure acceptable risk or calculate probability of collision is up to them.
- The common practice document, gave different ways of computing SF, but there was a probability of collision number in there…unclear to some people how we did that
    - Standard WPTS rules has a one-sided probability calculation, very close to SLB's Oriented Separation Factor. The aim was to try and get a better relationship between SF and probability
    - The scope for using one-sided probability allows for relating to SF, but it is not perfectly aligned with the risk of directly hitting the well, which is two sided. Two-sided calculations don't correlate with SF because you get dispersion at depth
    - There's a similar rule for CVX….Health and Safety risk, SF=1 is no go. Reliability and equipment, where there's no safety consequences, below 1 you don't require a mitigation as long as you've done your risk assessment.

- As a response to the question “can’t get all the service companies on the same number?” – Risk tolerance is something that the operator should manage…but the service company also has to mange their risk, so they might not all align the same number unless they get some kind of warranty
- Oxy uses WPTS separation rules – 3.5 sigma, and surface margin and casing diameters from the slot and sigma pa, and probability of collision…one differentiation if ownership of data, if it’s someone else’s data for the offset well we require additional due diligence. Even if the regulator says it’s P&A’d or similar there is additional scrutiny. This is both for collision risk and for consequence of collision. We don’t believe there’s a no-consequence collision, at the minimum there is potential to DBR a bit or plug back.
- Another proposal: Get rid of HSE wells which must pass SF>1 ACR…after that then you can do probability of collision. There was a well that each service company had a collision avoidance rule and PUMs different from each other company, so all the CA calculations gave different numbers…but the solution was to use the more conservative one. Having 2 answers is not helpful one says you can go one says you must stop…bridging discussions defining project parameters must be performed in advance. Don’t be making these decisions on the fly while drilling.
- It was mentioned that one method says it’s “easy” probability, where if everyone is using the same information, they should calculate the same answers on CA. We made the test wells, and now we can at least align on numbers for separation factor. Probability of collision is even more sensitive to small parameters, a slight difference can change 1/50 to 1/20,000. While standardization of information is important, even then if anything is slightly off, like ZDP, the EoUs can all match up and the probabilities will still be very different.
- Next task is finding a good way to extend and align on probability of collision….things like just use your conductor size?
    - It needs to be a collaborative effort, there needs to be a discussion
        - ADNOC will not use probability only SF with multiple rules for risk
        - It’s a pipe dream to get everyone aligned, we need bridging documents, companies will have their own rules
    - Could we do a sensitivity analysis on how much the probability calculations might change based on the acceptable test limits for positional and CA calculations?

Actions

- This will be a topic for future discussions in the CA sub-committee

BREAK

Mike Caulkins – Precise SF calculation proposal

- Part 2 of a presentation previously given to OWSG
- Want to see if we can use the same Chi square boundary surface for no-go boundary
- Response to SPE 200475 – Bang and Wilson
- Explicit definition of chi square – conclusions
    - Importance of a QC test, needs a p value, univariate QC limitations
- Concerns with WPTS rule

    - Pedal curve may be overly conservative – unclear to author why it's used for the statistical calculation
    - There is also a point selection issue – closet point vs. highest risk point in Pedal curve, single point problem
        - There might be different use cases for different scan methods
    - Pedal Curve distance not related to probability of direct hit
- Alternative: Ellipse Separation calculation
    - Problems that 3D closest approach method appears to be selecting the wrong point pair
- Broadly need to be scanning more point pairs
- Proposing a precise SF calculation using a chi square contour
    - At the point where collision is most likely
    - Expanding ellipsoid
    - Provides a combined survey deliverable with Bias term Mu
- Currently recreating the examples from SPE 200475
- Difference between calculations methods
    - Instead of Distance over sqrt (variance) use squared difference over variance
    - Like the ellipsoid equation
- Definition of Calculation
- Example ISCWSA test well 8
    - Can you use this to calculate probability of collision?
    - How do you know if you have the most significant statistical point pair? Need to brute force
    - There are difference between this calculation and Pedal curve (1.75 vs. 1.2)
- Questions and concerns
    - Is there operator interest?
    - Is there a better way to get covariance data out of directional software?
    - Concerns with coordinate reference frames conversions
- Benefits?
    - Simplifies inverse calculations for probability
    - Statistical distances to other hazards
    - Drilling target uncertainty improvement
    - Linear summation solution
- Is there a better way to test scanning method accuracy in directional software
- Should chi square contour be used as standard ISCWSA QC
- Anyone interested in funding further work –
    - Combining surveys appears to have been hindered by current approaches

Discussion

- Why are covariance matrices hard to get out of software –
    - This is just because folks haven't asked, it can be remedied
- NEV – HLA conversion shouldn't lose information
- Regarding pedal curve: Part of the need for pedal curve was legacy wells where you didn't know the approach angle, you might have wells in vertical where you could be on the wrong side already
    - In general, the contour method gives us better behavior in certain locations

- Have you had a chance to compare the methods like OSF or combined covariance or similar legacy methods?
    - Not yet
- As a well planner, there are times where using some separation methods you know you can get different results if you scan one well to the other as opposed to vice versa. Particularly with oblique approach angles
    - Yes, this is confusing there should be the same results going between reference to offset and vice versa
    - So – the two methods (Normal plane and 3D least distance) are inverses of each other…There is an evolution going on, even before directional wells existed…Normal plane and 3D distance are point selection, they don't account for uncertainty
    - The only time you can verify the point is the same, is the convergent point, where the minimum distance is the same each direction…you really want to use both methods in both directions
    - Another process includes scanning reference to offset, but then also go scan offset back to reference. Finally, look at closest ellipse separation or closest separation factor
- Quick responses for slide with the questions for the group–
    - Rotations should not lose information.
    - On the need from covariance data – even if you can get them easy, you will need to recalculate them in situations like a sidetrack –
    - There is a separate issue on the fact that 3D closest distance is not the point we want
        - There was a paper from Jon and Darren about converting to Mahalanobis space to find highest risk point
    - If there are challenges getting covariance matrices, there is a painstakingly worked excel example on the ISCWSA website that will calculate them for MWD models
    - This is a journey, there's a chance that we'll come up with something even better in 5 years.
    - Slides will be posted in case there's more discussion

Travelling Cylinder 3D view

- Motivation: There is frustration between operators in what is being presented:
    - We want to standardize a report
    - What about other displays? The travelling cylinder
- Quick poll how often are folks using TC?
    - Normal Plane or 3D closest approach?
    - North or High Side?
- Options for Travelling Cylinder
    - Closest approach 3D
    - Travelling Cylinder
    - TC North
- At SLB, even if you use 3D distance on scan method…the TC is normal plane
    - You need to scan both ways to produce a normal plane TC
    - You can do a 3D least distance…it's either a radar plot or radial plot…
- The challenge could be what are the assumptions?
    - Why do we use TC north?

- With Modern Software…why do we need TC North if we aren't drilling vertically
    - This is an old solution…why do we still have to use it
    - There are standards, and we like closest approach 3D…but what is this North?
    - Not trying to argue printed plots vs. virtual plots
- The committee has technically never recommended a specific TC style plot
    - There is an option to select what you want
    - Dalis thinks there is no reason for TC North
        - There are times it works better…or finds better point pairs…
    - Any display will have some situations where it is useful and others where it fails
        - Out in a long lateral with north TC it's nonsense
            - That might just be the wrong tool for that scenario
    - TC was originally used in long beach where they were kicking off fast, but then there was North Sea group who drilled vertical for a while. The DD had to go to location with pre-printed plots, and they needed a TC for the whole well. They could rotate the north plots for a given high-side in the doghouse
    - New software solutions are more dynamic. They know when to switch or can line up with an MWD tool face….it sounds like the main concern is what we want to reference the TC to.
- TC is a company policy in some software (because it's a company level policy)
- The calculation for TC is traditionally normal plane rather than 3D distance closest approach
    - Advantages and disadvantages to each approach
    - Honestly, calculation style is usually not the point of contention
- When would you want TC north?
    - Near kick-off has problems with high-side. Your reference to high side can change rapidly and you can see jumps of lines across the plot that aren't actually high-risk spots
    - Azimuth to offset well is stable compared to tool face to offset well
- Other plots – 3D solid + spider
    - Example pad with many different styles of approaches
    - Examples of different styles of travelling Cylinder
    - Other examples of dashboards

Discussion

- Discussion of some other ways on visualizing TC-like plots in compass
    - The Depth slice enables seeing the EoU for both wells, not combined
        - This can help avoid some of the point selection issues in some cases
- The North Reference is valuable at kick off, then switch to high side
    - Do we just need the smarter software?
    - The software was designed based on old plots…not best solution
    - Are options in software going to confuse people? Should we even be sending plots
    - How do we balance giving options vs. standardizing
- A comment on horizontal plane…for planning purposes if we need to get out from under a platform: you make a fake vertical well where you need to go, and then it can show you the open space, and make it like a movie. It's very nice for getting out from under a platform

- A similar plot has been used, a horizontal plot with bubbles, so the bubbles were dynamic with depth…but similar idea for identifying important space under the platform
- The TCs at THUMS in the early days were very useful and very practical, but now for a well planner, they are going to need to know what the MWD switch over is going to be, going from GTF to MTF. The MWD might not always know in advance…so that's another complication with pre-generating TCs
    - Often you can just agree on some kind of inclination, even if it's not exactly what the tool is set to
- Offshore, when the Ct-ct is 4ft…it's important to know when the switch is going to happen if you're going to safely steer
    - THUMS they were jetting – looking for the holes was very useful
- Like scan methods: the plot methods are useful in their own cases. For instance: when drilling at vertical what's the High side?
    - At vertical high-side defaults to north
    - But what about once you're at 5 degrees? Or getting to horizontal
- Is there a recommendation this group can make? A big problem in any software is that if we take something away, someone will be unhappy
- It seems like there might be a well planner competency issue – They should present the data in the best way to enable drilling the well plan. You don't want to take options away. There is a challenge in educating well planners and the rest of the crew
- Another issue though, is that with certain software systems a user might be restricted in what they have permission to make.
    - The users of some software wanted it restricted this way, which might not actually be desirable
    - There are some settings you want to have consistent, but others maybe we need flexibility. The solution is likely somewhere in between. Either way would need to retrain the well planners.
        - Most people will know how to use both
    - But if someone publishes a book saying "These are our standards" then one sub-unit says they won't follow it.

Roll call What were people looking to get out of the meeting?

- The CCP document has some discussion that certain methods may be conservative, the same might be needed for ellipse separation calculation methods
    - We might want to circulate that document and update it again
    - We could go back to the old meeting minutes so things are explained