50th ISCWSA Meeting – Calgary, Alberta – October 3, 2019

Introduction

(Jonathan Lightfoot)

- Welcome statement, special thanks to the sponsors for the event, H&P Technologies, Superior QC, Schlumberger, and GMW Associates. We appreciate all of your contributions very much.
- Safety instructions provided by staff from BMO Centre

Schedule and Program Review

(Ross Lowdon)

- Overview of the agenda
- Again, thank you to the sponsors for their contributions
- There are some last-minute changes to the agenda, David Gibson will be presenting on the ERD Database (Nose Plots)
- Voting for new officers will be conducted today
    - Program Chairperson
    - Director at Large (2)
    - Membership Chair (New Position)

Keynote Presentation – ISCWSA – 50 meetings and, where are we?

(Steve Sawaryn)

- We have 25 Years of progress, What's Next?
- The mission statement from the website, has a word that is repeated. Standards.
    - We are not meant to be a standards body, as we continue to make progress, we need to evaluate our current influence in the Oil Industry.
- In 1995 was the first informal meeting (ISCWSA was founded)
    - Relies on volunteers from Operators, Service Companies and other Volunteers
- Affiliation with the SPE as the WPTS became effective in 2003
    - Recognition to the members who are present today that were also present in the very first meetings.
- The main purpose of this group was to create an Error Model so that there was some commonality on how performance of surveys and tools are used in the industry, even though competition remains between these volunteer bodies
- Technology timeline history
- Sub Committee timeline history
- We have 2 e-Books, in joint venture with the University of the Highlands and Islands
    - Thousands of downloads of these reference documents have been conducted
- What other things do we do?
    - The Hits and Misses Technical Workshops – people from all over the world have attended these workshops

    - Topical Luncheons
    - SPE Technical Papers
    - Networking Events
- Highlights
    - General Cooperation
        - Humor
            - Airline Interview
            - Pub Quizzes
            - Liquidity
            - Acronym
            - Angus
        - Networking Events
        - Poetry Reading
- What's Next?
    - Drivers
        - Costs, Quality, Efficiency, Environmental Impact, Reliability, Resilience, Diversification
- Characteristics of our Work
    - Our work is highly technical
    - Well defined activities that are well documented
    - Specialist practitioners available
- Geology and Petrophysical Link
    - Quality of the position of the well is key, working with Geo is a primary focus
- Algorithms
    - Efficiency and storage management of the data we are processing is till important today as it was when starting out.
- Office Based Directional Engineers/Automation
    - JPT 2017 highlights this potential.
    - Directional Drillers are being replaced by Remote Centers.
    - Safety Improvements are obvious
    - We are likely missing Quality Control Tools, The QAQC SC could help address these gaps
- Reliability and Resilience
    - Additional understand from this room is critical as we tackle this.
    - Analysis of combined surveys or 4 axis magnetic sensors shows promise
    - Twin Gyros and MEMS and a combination of these systems
    - Ideally, we would run both of these on every run for the improved information gain
- Diversification and Inclusivity
    - Water is becoming an increasing rare resource on the planet; we will likely be called on here
    - Geothermal wells are treated much the same as the boreholes we drill now
    - Extra-Terrestrial, such as the moon, will we be called upon here?
- Gaps/Challenges
    - Technology/Process/People – most of the HSE and Collision events come down to Human Factors

    - Can we measure spatial separation between wells in real time?
    - Minimum Curvature has served us well in the past, will this continue as we move forward? Looking at 3D Curves, Spline may be a benefit
    - She we create a book about the omission of data from the Advanced Drilling and Well Technology?
- Summary
    - We have fulfilled our mission and have adapted as needed. We have kept pace with the industry and had fun while doing it!
    - We need to continue to adapt and refresh our talent pool and knowledge base from new and young engineers

(Questions) – None

Collision Avoidance Subcommittee Update

(Steve Sawaryn)

- Agreed Focus Areas
    - Development of a Collision Avoidance Management Presentation Pack, and Report including the means for Electronic Exchange
    - Adoption of the Global Error Model terms.
    - We need to establish and document a revision control process and administration, including the CA bibliography
    - We need to focus more on the communication side, and looking at the relationships with the other Error Model/Data/QAQC Sub Committees
- Slide Pack and You Tube Video
    - We are about 50% done, and committed to getting this done by next meeting
- What is the progress and adoption of the CA Rule?
    - Broad adoption across operators and service companies have been reported.
    - Further vetting is required about which side is more conservative in the use of these documents and how should this be handled
    - Ohio and other legislative bodies are beginning to take interest in our areas of work
    - Plans to advance the first draft of APIRP78
- Other Actions
    - Develop draft of the standard CA report (2020)
    - Tie in mode for the ISCWSA sidetrack example (2020)
    - Root Cause Analysis, like Human Factors at some future date
    - Collaboration with the other SC's as needed
    - Update the list of CA related papers and state whether peer or non-peer reviewed, for the website

(Questions)

Q) David Gibson – talking with some of the guys from Energistics, they have been working a lot with some of the state governments on accepting digital information on wellbore trajectories. This may not pertain to collision avoidance or error models, but they are starting to get the regulatory bodies to look at more of the digital data than just pdf files or log files.

-20 min break-

Error Model Maintenance Subcommittee Update

(Andy McGregor)

- Attendance
    - Yesterday there were 34 attendees in the meeting, looking back over the last several meetings the attendance has grown regularly since London
    - This is the 10th Working Sub-Committee meeting that Andy has Chaired.
    - There are 83 different people in this timeframe, and 3 of the same people over the same timeframe: Stefan Mous, Jerry Codling, and Adrian Ledroz
- There is an agreement on Revision 5
    - Will add the XCL Terms, expand the Geomagnetic Terms for Correlation, and tentatively have agreed on Misalignment and SAG changes
- XCL Models
    - The formula for the terms have been proposed, along with a new weighted function for SAG, and changes in the magnitude for misalignments
- Several changes are coming at one time
    - If we look at the Global Declination term, it is now being split out into 6 different components
- Actions
    - The main discussion around this meeting focused on resolving the misalignment terms. We looked at a few test cases, we looked at high rate (10' survey data) to extended regular survey data in order to ensure similar results.
    - There was concern that data at a high rate would cause random misalignment terms to disappear, so we are looking at a modification to the weighting function
    - There is still some concern that this change in the error model will make EOU's considerably smaller is some wells, and this may take away some of the comfort zone that people are used to for Anti-Collision
- OWSG Models
    - This has fulfilled the need for standardization and to provide a basis for those that don't come to these meetings, and they are continuing to be accepted across the industry.
    - OWSG has offered to pass responsibility over to the EMM SC, and we have accepted that responsibility. Now the EMM SC will now be in charge of managing these error models
    - This should help clarify some misconceptions in the industry about using either the ISCWSA or OWSG error models (One name moving forward?)
    - One of the main problems is that there are 100+ models in the OWSG set

        - Now that we are moving to ISCWSA Rev 5, all of the OWSG Models will need to be updated and diagnostics will need to be run, and this will take considerable work. May not just be the voluntary activity that we rely on now.
        - We will work with the Main Committee to seek funding to support individual(s) to perform that maintenance work.
        - Once the maintenance of these models is done, they will be hosted on our website. We are also discussing have a separate web page where you can find links to external websites in order to help keep track of models (such as contractors and service companies)
- Parent Side-Track Tie-Ons
    - There was an issue raised by Total about sidetracking out of a parent wellbore, and how exactly should the tie on be handled.
    - This was an interesting discussion where there were several opinions expressed on how to properly handle this
- Consistency of Modeling the Gyro
    - There was some discussion brought up by Equinor about having two overlapping gyro surveys where the 2nd gyro is actually initialized higher up in the borehole but tied into the bottom of the first a bit deeper. There is agreement that most commercial software cannot handle this properly, so we will draft a proper way to handle this.
- BGS now has an open web service where you can get error model terms for a particular location.

(Questions)

Q) Robert Wylie – can we get into a little bit on why the misalignment terms are being improved, is this physics based or a mathematical abstract?

A) Andy McGregor – a little bit of both, in Rev 4 we have increased the misalignments from 0.06 to 0.1 based on some analysis, but for some time now the misalignments have been cropping up as systematic having the same effect all the way down the well (constant Toolface). We think the combination of increasing the value and systematic was overly conservative. Operators have expressed their concern with this. To fix it, we are taking on a more evidence-based analysis of survey data. Our new solution is physics based and we think it's a reality of what's going on, at some level we have to assume a randomized Toolface.

Q) Harald Bolt – Is there any talk about what you've done to look at the along hole depth uncertainty that would be associated with these EOU's?

A) Andy McGregor – there will be no change to the along hole depth uncertainty from Rev 4 to Rev 5 because of this, we have certain terms for along hole depth, and we have not changed those terms.

Q) Harald Bolt – is there a reason for that?

A) Andy McGregor – we have not done a review of the along hole depth terms as we introduce some of the other parts of this (Rev 5)

Q) Phil Harbidge – Andy, great presentation and great work. Just to try and demystify the industry's error models, are you as a Sub Committee documenting any of the operator's specific error model sets or are you testing them and providing results?

A) Andy McGregor – We have not taken responsibility of any Contractor's error models, and the same is true for Operator's models. If we are going to add space, we could do the Contractor models and the Operators too, in order to share some of what their doing (when we can).

Q) Angus Jamieson – The Matrix that you developed for the Magnetic Reference Uncertainty, that is a major step forward, which is great. I was just wondering on 2 very brief questions. One was I saw there was no difference whether you applied IFR1 or IFR2, they are still the same terms, and the other question was is there any guidance on what you would do with legacy data where it is really not very well documented what the source was of the magnetic reference information which is a worst case scenario as well

A) Andy McGregor – On the IFR1 and IFR2 part, we have a completely separate random source, DECR for instance, which changes when you are doing IFR2. Because it is a random component there is very little difference in positional uncertainty. The second question of worst case, if you do not know the source of the model then the software would have to have a way to handle that, because it is not always the most conservative estimate.

Q) Jerry Codling – If we can go back to the misalignment graph, my contention with needing to increase Sm in the Anti-Collision Rule, I would actually argue the opposite. Sm is only really for near surface and I think it was put in there by various companies mainly because there was a loss in confidence in the error models near surface so what this new uncertainty term does is actually add more into the error in that first interval. If you look between 0 and 2000 we actually have more error, which actually qualifies that you need to decrease Sm or get rid of it all together.

A) Andy McGregor – I actually think you are right here Jerry, I think the point being that the error models in this case is that some people worry about errors that were smaller down in the well and will lose some of the comfort zone for the planning and execution phase, so this is something that we have to consider goes hand in hand with the Anti-Collision rule.

An Empirical Analysis of Survey Errors in North American Land Operations

(Shuba Love)

- Data Summary
    - This data set includes a little over 9000 wells, 35,000 survey sets or runs covering 90 operators. More importantly this covers 50 service companies
    - The idea behind this is to give you a window to what we have been able to see with all of this data instead of giving a solution, this is what the data tells and is the story about it.
    - When it comes to the Error Models, and looking at SPE Papers, some of the numbers came from looking at maybe 50-300 wells. Drilling has since moved more to the Shale Boom areas and now gives us insight to these specific regions.

- Drill String Interference and Axial Magnetometer Bias
    - 540nT was the 1-sigma estimate from this data set, while the expectation is 231nT.
    - If we look at the 2 and 3-sigma values, because this is not Gaussian Distribution you see the variation of what we expect to be a lot more. The 2-sigma value is expected to be 462nT, while what we saw was 1400nT. At 3-sigma this is much worse and goes to 4840nT.
    - We also looked at how much of the data actually falls within the 1-sigma value which we expect, and where it should be 68% the number we saw was 37%
- Cross-Axial Magnetometer Bias
    - The numbers we found here are much more favorable. The 1-sigma value we saw was 57nT when we expect to see 70nT, 2-sigma is 130nT, when we expect 140nT, and by the time it reaches 3-sigma we see this on every single plot; the numbers are way higher that what you expect.
- Cross-Axial Magnetometer Scale Factors
    - The skew to the right of the data is a possible indicator of magnetic mud
    - Very high variance, and fat tails
    - The values we see in the data here are not what we expect, but not as bad as what we have seen at fist (Bias plots)
    - Most of the values at 1-sigma and 2-sigma are just a little over the expected values, 3-sigma values are at least 2 times if not more
- Gravity Cross Axial Bias
    - Again we are seeing that the 1 and 2 sigma values are just a little higher than what we expect to see and the fat tails at 3-sigma.
    - This plot only includes the lateral portion of the data
- Gravity Cross Axial Scale Factors
    - The data is skewed to the left, indicating the possibility of sensors being calibrated to 1g.
    - The scale is basically trying to correct for the calibration error
    - Very similar to the previous charts where it is not as bad, still a bit high, and obviously the fat tails (2x expected value)
- Basin Summary
    - To explain what the Pseudo 1-sigma value column is:
        - The first number is the 1-sigma value
        - The second number is if you take 95% of the data and divide it by 1.96 what do you get
        - The third number is if you take the 3-sigma value
    - One of the problems with this data set is that you cannot really call this Gaussian.
        - We looked at movement in the Bottom Hole Location and Direction
- Conclusion
    - Compared to the error model expectation, the drill string interference observed is significantly larger and was true for all basins
    - Cross Axial Bias estimates were closer to the error model expectation, but still has fat tails
    - Scale magnitudes might reflect running procedures and calibration issues.

(Questions)

Q) Andy McGregor – First, excellent piece of work Shuba. I've wanted to see that kind of analysis for a long time. I think you are right with the numbers going back to the original MWD paper (says something Scottish that cannot be translated). I just wondered with obviously the headline news being the drill string interference term being larger than the error model did you have both vertical and lateral sections in that analysis?

A) Shuba Love – Yes, the green (from the plots) is all the data not just the vertical and the red was the lateral sections only

Q) Andy McGregor – and the laterals still made up a much higher volume (of the data)?

A) Shuba Love – Yes, so all values (reported) are only from the laterals. When people are running vertical BHA's, they don't care as much.

Q) Andy McGregor – First, did you look at the angular error and compare it to the way we used to do the drill string interference model?

A) Shuba Love – No, we did not

Q) Andy McGregor – I would be interested in seeing that, because we did change how we do drill string interference, and therefore I don't think what we are doing now works for the generic model. Lastly, was this data from customers where you were performing Multi-Station Analysis

A) Shuba Love – That is true, yes. There are people who call us not knowing that (the MWD not knowing) that corrections will be performed, or they haven't been informed by the client. We don't see them changing their BHA much after they find out that we are going to be doing the corrections. So the BHA pretty much stays similar whether we know it or not.

Q) Mahmoud ElGizawy – Thank you very much for the interesting analysis, I have a question about the data set that you are using to come up with your conclusion. Did this data pass the field acceptance criteria against the error model (MWD Standard)? Because if it doesn't, or if you did not check this, then this data set is invalid.

A) Shuba Love – So we always check the field acceptance criteria, and the thing is when we do corrections, we look at what the raw value looks like. In most of these cases the BHA does actually fail the acceptance criteria, but the idea behind this is they (field) still use the MWD tool code for their surveys, they are still applying it.

Q) Mahmoud ElGizawy – Usually the thing is with the service companies you have to stick to the field acceptance criteria, or you cannot put the MWD Standard tool code, so this is very subjective to the BHA that you are running. If it doesn't pass the field acceptance criteria then it is not MWD standard, I wanted to verify that.

A) Shuba Love – I see where you are coming from, and having worked with companies like Schlumberger, Baker, and Halliburton, there are companies that do care about surveys field acceptance criteria and who do check it. There are a lot of smaller companies who do not, and it is not necessarily that this information gets communicated to the operators and there is a knowledge gap probably where you are still using MWD standard.

Q) Mahmoud ElGizawy – I still think for the value of the analysis you should run a filter on the data that passes the field acceptance criteria, and then recheck the numbers and see if it matches the error model papers.

A) Shuba Love – I do see where you are coming from, but if you use only the accepted values the number will be truncated and you will be within 231nT, but yes, we will try and do something.

Q) David Gibson – Excellent presentation, my question is did you look at the data in terms of who the service companies were? Be it an Independent, Major, Publicly Traded, etc. and also did you look at the operator side to see if they were a large or super major vs the smaller independent operators?

A) Shuba Love – Specifically those numbers we do not have, the way the data came that could easily be done by operators and service company but was not a focus for this presentation. Something that could be added later on if you would like to take a look at that.

Q) David Gibson – I would love to see that data and the fact that the data here obviously with the drill string interference is surprising to all of us. This is from companies that have hired you guys and there are still 2/3rd's of the market that is out there that hasn't. Or hasn't hired companies like Superior QC or some of the other companies out there, so those numbers are going to potentially get exponentially worse with the companies that are not hiring survey management.

Q) Chad Hanak – In terms of passing FAC, there is certainly a window closer to east/west that is fairly large where you can easily pass FAC from the error model but be very out of spec with regard to drill string interference specifically. Great analysis, the one question I did have because we have done similar studies internally. For error sources like AMI, like Cross Axis Magnetometer Scale Factor Error where it is a little less observable and there is some ambiguity there; for example, Cross Axis Scale can be misinterpreted as reference field uncertainty and things like that. We try to look for data where we have gyro's overlap so we can validate the numbers we get or even refine them further. How much of this data is like this, is that something that you filtered for?

A) Shuba Love – It is all the data that we have, its not just that we have an overlapping gyro. Those data sets would be really small. We have generally looked at how data compares to a gyro, we have done different studies, but that was not part of this study.

Q) Neil Bergstram – Just an observation that I made of the data on the drill string interference is that there is a slight skew of that data and that it is not centered around zero. The original version 1 of the error models were biased and said that drill string interference was actually in that direction and biased to the north, so we are seeing a little bit of that bias. My hypothesis is that while that is a small effect, a much larger effect is the residual magnetism in the drill string that comes from magnetic particle inspection of the components and that it is randomly distributed because they pay no attention to which direction they magnetize when doing inspections.

A) Shuba Love – Thank you, we didn't consider that but can always look back at that.

Q) Mike Attrell – Thanks for the presentation, thanks for sharing. What reference model was used to determine the magnetic interference?

A) Shuba Love – A lot of the data uses IFR as the model, but there is also HDGM. They were not separated out by magnetic model but something that we could go back and take a look at. There was a general representation we were trying to get all of the data into.

Q) Mike Attrell – The reason I ask is up here in Western Canada, IFR can often be very different even when compare to Global Models such as High Definition and that might have contributed to some of the high error.

A) Shuba Love – When we looked at Canada wells and we looked at the direction and location changes, we see the bottom hole location move quite a bit because we see MWD using 15 degrees for declination (HDGM) vs IFR may be 17 degrees so you have almost 2 degrees. This does make quite a bit of difference.

Q) Mike Attrell – So the positional error is also including declination error?

A) Shuba Love – Yes, that is correct.

Q) Harry Wilson – This is a very useful analysis, 2 questions. Axial interference which everyone seems to be latching onto (when it is out of spec), Axial Corrections are very popular and when that is applied we are not looking for 220nT (for example), so did you filter the data at all for runs that were having Axial interference applied to remove those from the data set or where they included in the data set? When people are setting up the job correctly, modeling the BHA for the model they are going to run, so in the case of the standard model you would hope that you have enough spacing to ensure that you have no more than 660nT. If you were to run Axial correction, (and different companies have their own rules), we would allow actually thousands of nT. All we are isolating for is X/Y interference and may space the magnetometers within a few meters of a magnetic pole and that could mean that the raw data has thousands of nT of Z axis interference, but that ok if you are going to correct for it. If you include that data in your analysis you will definitely end up with a very large 1-sigma AMIL term. Axial corrections are really popular in North America, should be less popular in Horizontal wells but we are not sure that it isn't still heavily used.

A) Shuba Love – So this data is from any customer or service company and they may or may not have run an analysis on that BHA before they ran it.

Q) Harry Wilson – Without that analysis when designing the BHA with the intent of Axial Corrections, that would skew your results significantly so, almost to the point of that analysis (presentation data set) useless. This is such a big thing, and that is ok if you are intentionally running short spacing with the intent of Axial corrections then that data wouldn't be flagged as an out of spec condition and as a first pass filter should be removed from this analysis.

A) Shuba Love – Unfortunately we don't have the data on which run was intentionally run with this setup or isn't. We all see a lot of the BHA's were designed without any knowledge, this room has all of the knowledge, but when we give it to the field or the people that are running these BHA's they are not exactly thinking about this.

Q) Harry Wilson – I agree 100% and am sure that you will still see something larger than the 660 nT 3-sigma. In order to have a meaningful result we have to extract the runs that were intentionally run on short collar corrections. One other point, at least run two evaluations. One, remove the data that would

fail the standard QC data tests or have standard QC test based on the ISCWSA error model, that would be useful I would say; because there are two questions here, there are like what you have here the performance of the industry and that is really useful but we are also concerned and one of the points was, is the error model valid? The error model is only valid if the data is tested against that model. Some people think that when you assign an error model to the data, magically the data will now all conform to the model when this is exactly the other way around. You have to ensure thru pre job QC and while drilling QC tests that you only post what you accept of the data that conforms to the model. So, both of those things are of interest to us, what you've got here is an interesting summary of the performance generally of our industry in North America and it is out of spec.

A) Shuba Love – I completely agree with you, but again when you look at the field is doing especially with 50+ service companies in this data set the reality is that most of the smaller companies out there are not analyzing magnetism. There might be some tools out there but there is quite a bit of questions that leads us to think that this analysis is not happening with the smaller service companies

Q) Jonathan Lightfoot – An example I have from my experience when we talk about what we are using for field acceptance criteria, on one rig it was 5000nT and 5 deg of Dip Angle. Since this is a pretty big number I asked why are you using that? The answer was, well that is the default in the software and any time I change it, it automatically goes back to the default so I just keep it at that. He pointed out that he never had a failed survey. That is the reality folks, that is what is happening and so again I really appreciate H&P Technologies for sharing that work and that should lead us to similar works in the future, and we are looking forward to seeing that.

SPE Wellbore Positioning Technical Section – Treasurer's Report

(Robert Wylie)

- Revue of the registrations and details from the 49th meeting in The Hague, Netherlands from March
    - Since Gyrodata sponsored everything for the main meeting we had very little costs, and MagVAR provided the sponsorship for the networking reception, both of which we are very thankful for.
    - For the 50th meeting today, we had 102 registrations
        - Revenue for registrations was $15,575
        - Sponsorships was $4,500
    - Now that we are using the website to collect registration fees (Stripe) we are paying much less to collect the money for each event. Also, because Stripe deposits the money straight into our bank we are receiving the funds much quicker.
- Accounts as of 31-Aug-2018
    - Bank Balance $114,915.55
    - ISCWSA 49 revenue $8,859.91
    - ISCWSA 50 est revenue $13,960
    - Approx. Expenses:
        - ISCWSA 50 $1,255
        - Website upgrades $15,532

    - Bank Balance as of 3-Oct-2019 is $120,952.62
- We will take a minute to recognize SPE and Shasta Foy who helps make sure that all of our meetings are possible. Shasta is our representative in SPE and does a wonderful job, so thank you very much.
- Liabilities
    - Any ISCWSA 50 costs to SPE
    - Additional Website Hosting fees
    - Upcoming Drillbotics Sponsorship
        - We will be a Platinum Sponsor $5k
    - Possible Sub Committee expenditures, for example the Error Model Maintenance may need to propose some spending for adopting ownership of all error models
    - Technical Writers for various other Sub Committees
- Summary
    - We are still in a very healthy position, we are being seen more as a respected body in the industry.

(Questions) – None

Practical Method to Benefit from the Improved Accuracy of Combining Overlapping Wellbore Surveys

(Jon Bang)

- SPE Publication SPE-195621-MS; Jon Bang, Tarig Ali, Adrian Ledroz - Gyrodata
- This paper was presented in a conference earlier this year, SPE Norway One Day Seminar in Bergen, Norway
- Benefits of Overlapping Surveys
    - What are overlapping surveys? There are almost always areas of a well where we have surveys that can overlap, different runs or tools for example.
    - You can use them for mutual quality checks and validation, and gross error detection.
    - If the surveys are both accepted as passing the QC checks, then you can do more than just keep the best of them. If you average them, then you can really utilize all of the information that you have originally paid for.
    - If you average them in the correct way by assigning weights, that can improve the accuracy of both surveys.
        - This provides optimal positional estimates and improved positional accuracy
            - If you have two surveys that are uncorrelated and with approximately the same accuracy, then you can have up to a 30% reduction of the EOU size.
        - Weighting averages and how this is implemented is the topic of this paper.
- Weighted Averaging Procedure, for Uncertainties
    - The procedure was published in 2003 (SPE-85111-PA), and this is the rigorous way to analyze the two surveys separately and derive a weighted average in the result.
    - This is a rather cumbersome method, and this averaging is not part of any standard software.

    - So our idea a few years ago was to take this processing and put all of the averaging into the input file so that the IPM file that describes the tool model is actually a combination of the two tool files of the descriptions that I have used here. (Slide 5)
    - 2016 (SPE-178826-PA)
    - We put corresponding weights into those two descriptions so that we can average the IPM file, and the idea is that running it though the standard processing we get out the averaged results directly and they should match as close as possible to these rigorous results.
    - There is nothing wrong with the mathematics here, this is just the way to implement it in a way that facilitates the calculations. However, because the weights are constant in this method the validity of the averaged IPM file is limited.
- The updates that we have done this year is that we let the weights vary with inclination and azimuth. This means instead of the constant value over all of the inclinations and azimuths, you have a surface shown on Slide 6 depicting the weights of Azi terms for a Magnetic MWD tool and the corresponding weight for the other tool (in this case a Gyro).
    - By implementing in this way we obtain an average IPM file that is valid for all of these possible inclinations and azimuths and that allows us to get valid results for curved wellbores in any directions over several possible oil fields.
- Results
    - Looking at three model wells where we have applied this technique
        - A designer well, and two traditional horizontal wellbores (one north, one east)
            - The EOU's on Slide 7 have been amplified to show you the results and are perpendicular to the wellbore.
                - Green EOU is the Magnetic MWD (Standard)
                - Blue EOU is the 2nd survey set (Gyro)
                - Black EOU is the Rigorous averaging
                - Red EOU is the Averaged IPM File (North Sea)
        - We added another example for this particular field in Oklahoma (Woodford)
            - We applied this Averaged IPM file to other various locations around the US, the well profile used for the comparison is a 2D well just off cardinal direction to the Northeast.
            - When plotting the degradation all of the results are 1% or less Averaged IPM/Rigorous. (Very small)
            - The EOU improvement is a 20% reduction and the IPM Average matches the Rigorous very well.
- Summary
    - The benefits of averaging overlapping surveys you have a systematic procedure to use all of the information available in the surveys.
    - You get optimum positional estimates and improve the positional accuracies.
    - With two surveys you can obtain up to a 30% reduction and as shown in the last example was 20%, more surveys could indicate more reduction (in EOU).
    - By using this implementation and weights that vary with inclination and azimuth we are a step closer to making this practically achievable procedure.

    - We have demonstrated that we can make one IPM profile that is valid for all well profiles, and or at least an entire oilfield. Of course this needs more examples to verify, but the whole procedure means that the application of this could be used to optimize the survey process to reach small geology targets on long extended reach wells and in highly congested fields it is essential that you have an efficient way to analyze collision risks. To avoid collisions, you are required to have high position accuracies and practical and efficient calculation procedures.
    - We also mention that development of new survey tools like we have seen in the last few years, this way of averaging IPM files may be a way to produce IPM tool models for these tools.
- This completes the presentation and I would like to thank Gyrodata for the opportunity to present this and for the SPE ISCWSA for the opportunity to come and present

(Questions)

Q) Marc Willerth – Very good presentation and I am excited to see how these processes have developed over the last few years. One thing as we talked about for instance is QC criteria and the way you validate error models and IPM's, does this combination process come with any additional acceptance criteria to show that not only the individual surveys are valid, but their combination is also valid?

A) Jon Bang – No, I wouldn't say that. First of all, you should validate that each of the surveys are as correct as possible so that you actually accept them as individual surveys, and that is when you should start thinking about averaging them. There is nothing special in the averaging process that really goes back and verifies any of them.

Q) Marc Willerth – I am just curious, what might happen when you have a case where either individual surveys passed their own QC but disagree for instance?

A) Jon Bang – Well I consider that to be a matter of the initial QC, so if you accept a large spread between them and you don't have any more QC test that would make any of them invalid, can you do anything better than just average them and accept that? On their own they are different, if you don't accept that then you have to do something before you start averaging.

Q) Mike Attrell – Very cool presentation, I had a question on the survey depth and Toolface variation tolerance. Obviously on depth there is some tolerance and needs to be close, but on Toolface variation is there any tolerance on that between two different surveys?

A) Jon Bang – I think that also goes back to the initial validation and acceptance of the initial surveys. In this process you are basically using the output uncertainty reports in terms of covariance matrices or EOU's. So that is what goes into this averaging procedure. So am I not sure I understand you, but the Toolface issues are more related to the initial validation of the original surveys.

Q) Mike Attrell – I guess what I am trying to wrap my head around is that you are taking multiple surveys around the same point, so you are trying to cover the spread similar to a roll test. So, if you have two surveys in the same spot they have to match. Is it because the Toolface is the same so the BHA is aligned the same way or maybe that is irrelevant for this procedure?

A) Jon Bang – That is another issue than the topic of this procedure, in a more simple way can implement the actual averaging. The theory about this is ok and this is more about implementing and carrying out an averaging. The particular details about the discrepancies and similarities between the surveys is not part of this procedure.

Q) Andy McGregor – Thank you for that presentation I think that was another excellent piece of work. I think the idea of having one IPM file covering an entire oil field is one big step forward. I just wondered beyond doing this with IPM's which is basically product specific, is this something you think we need to consider in the Error Model Sub Committee? Some kind of work in a generic or standardized way of providing these weightings?

A) Jon Bang – I haven't thought that far yet, first of all, this Averaged IPM file is fairly flexible in their application but still you make them for those particular tools that you have already applied. So that is the question, whether you should or have two typical tool combinations that you often run so that you have overlapping surveys.

Q) Andy McGregor – If you are doing this in a Compass database, and then you have to use someone else's database, how can you accommodate? I am wondering if we need to start looking at that.

A) Jon Bang – Well yes, the IPM files follow the normal format. We just introduce a few more lines with the weighting factors so these can be transferred across the industry as are the other IPM files.

Q) Andy McGregor – So did you create a new formula in the IPM file?

A) Jon Bang – I updated some of the weighting functions, yes, but they are specified in the same way (sine and cosine) of inclination and azimuth as all weighting functions. There are a few coefficients with the sines and cosines necessary to describe the surface. The surface must be defined as a mathematical function and that is what goes into the IPM files but it is very straightforward once you have the mathematical description.

Q) Andy McGregor – Perhaps my question lies in standardizing the weighting functions because not all software can read in generic formulas for weighting functions and parse it, so that might be something that we need to think about.

Q) No Name Given - It's a very interesting presentation, and I had the same idea and published them for free and for approval. There are two questions, as Andy said the weighting function I know because in these overlapping data sets you have a lot of redundant data. From the data you can develop a very good weighting function and you can improve the performance. So, with redundant data you can improve the precision of the performance, but the problem is the difference between the precision and accuracy. Precision means the data variances are very small and sometimes very constant to one point. Accuracy means it is close or tight from the redundant surveys. I don't know if this survey data is from the same sensor system or from a different sensor system. If from the same sensor system yes, if you're filled with redundant data sets you take the average of whatever weighting functions then you can get very precise performance, but how do you make sure that result is accurate? Do you have accurate references?

A) Jon Bang – Well what I used as a reference here is the result from this implementation. We have implemented this and used the theory from this paper. What we have then is what are the Rigorous

results, the Averaged results are what we consider the true results because this is just the mathematical procedure to obtain them from the surveys you have available. So there is nothing wrong in this procedure and the mathematics, therefore you get out what I would say is the true result that I can compare to. For practical implementation this is not the way to do it, that is what we are trying to simplify. In doing this and I get out some results I can only compare them to this result. As long as these surveys are reliable and pass the QC test, then you should also rely on these results and you should try to come as close as possible to them and that is what I showed in the comparison.

Q) Mike Calkins – You focused on decreasing the ellipse of uncertainty I assume that you focused on MWD and Gyro survey sets as your two surveys sets that you want to increase certainty, I am curious if your ellipse of uncertainty actually increased on any one or wasn't great in agreement, whether it was a high side disagreement potentially a TVD issue greater than the ellipse of uncertainty where the azimuth was good or potentially both were just completely out of agreement.

A) Jon Bang – I not sure if I follow all of that, but in this comparison, I have just looked at the lateral and maybe some discrepancies also in…

Q) Mike Calkins – Let's say an MWD with SAG is applied, but the Gyro comes in 30' TVD higher on the center line and places it just outside of the MWD EOU or towards the edge, I am just curious if any incidents like that were looked into or potentially something like this in the future

A) Jon Bang – If you are talking about the wellbore trajectories then first, you have to estimate each one from each survey set and you average that together also weighted so that the most precise individual survey is given the most weight. Then you can use that as your trajectory and this average of the uncertainties is always done with both EOU's centered at the same position and then the result is also centered on the new average trajectory.

SPE Wellbore Positioning Technical Section – Webmaster's Report

(Phil Harbidge)

- The website scope of work including identifying a couple of vendors that might be able to design, build and maintain our new website. They had a look at our old website that wasn't particularly functional, so we worked on a scope and the vendors came up with a price and we moved forward with Tendenci.
    - We are working on directly interfacing with the SPE.org site
    - We may have to allocate more funds to clean up our WPTS SPE site, the primary focus of this mission was to update the ISCWSA website
    - Many hours were spent developing, testing, and working through the new site with Tendenci (Houston based company)
    - Phase 1 is complete ($3K for upgrade, and $1K/annual for hosting), we are already looking into what else we need to start Phase 2
    - We will come up with cost estimates and in agreement as a committee will decide on a plan forward, there will be a vote.
- New Content
    - The e-Books are now easier to find

    - The YouTube and LinkedIn accounts are being looked at as well
    - All documents are now on the new site.
        - Meeting minutes, Presentations, Documents, etc.
        - Part of this project was to improve the searchability of these items.
        - With the help of the Education Sub Committee we have divvied up about 180 documents for assigning a Category, whether it is peer reviewed, and if it was produced by ISCWSA, a Sub Committee or if it was non peer reviewed.
            - Tags will also be assigned to improve the search function.
- If you are a member of the SPE you can sign up to be a member of the WPTS SPE.org website
    - You can sign up for email blasts, Ryan spends a lot of time using the SPE Informz system and we also have another way of tracking all the members so we don't miss anybody who is participating but may not be a member of the SPE.
- LinkedIn group currently has 1,778 members and this maybe on of the easier ways of getting messages out to people.
    - https://www.linkedin.com/groups/4788969/
- Statistics from the new site
    - Only been up and running for about 20 days
        - 1,403 hits on the main page, total visits of 3,332
- For the Website, the plan is to get everyone who is attending today to get on the website and logged in. Every member will have the ability to sign up for items like sub committees and download documents, etc.
- Membership Statistics
    - Progressive membership is growing steadily
    - Large participation from Gulf Coast North America (395), Middle East and North Africa (380), and South East Asia (216)
    - Age Groups show a large participation for under 35 (901)
    - Job Classification show half to be Engineers
- Thank you very much again for the sponsors of the ISCWSA 50th
- Live Demo of the new Website

(Questions)

Q) Benny Poedjono – There are many older versions of the e-Book that pop up when you look on the UHI website linked from our website, this is something that we need to look into.

Deriving Wellbore Quality Metrics from Trajectory Calculations

(Angus Jamieson)

- This is actually quite an old subject that we are going to be introducing again. It is one of the performance metrics that we have traditionally measured in about 13 different ways. Now that we are emboldened to become more of a standards body, we might actually agree on a way of measuring tortuosity and qualifying it.
- Tortuosity questions:
    - Does your lateral look like a winding road, and does it matter?

    - What about the surface and intermediate? Is it different in the shape and quality?
    - Why is it important to achieve exceptional steering control?
        - Is the best smooth wellbore one that is not steered?
        - Should we steer 100% of the lateral or should we focus on steering only when needed?
- We work in an industry that has typically rewarded speed, and in fact it might be rewarding the wrong thing. When an operator wants to get maximum return on investment, they really want to make sure that the production is good. If we want good production, then part of that is going to be having smooth holes in the right place.
- Undulating Tortuosity
    - What is meant by undulations in the Lateral?
        - How can you measure it, does it affect production, drilling, cementing, and quality of the stimulation?
        - Is this costing me money?
    - We sometimes think that tortuosity within certain constraints is actually perfectly acceptable, but perhaps it is compromising the quality of our cement jobs. When moving from one side to the other, maybe our zonal isolation isn't as efficient as we think it might be.
- 12 reasons why Tortuosity is important:
    - Slide 6, tortuosity is bad news and yes it does cost money.
    - There has been an interesting paper by Theresa B, and excellent piece of work where multiple wells were looked at. There is some correlation with twists and turns in the well and the quality of the production you get. Even though there is only some correlation it doesn't take much loss of production before you overcome any costs of drilling a smoother wellbore.
- Ways to measure tortuosity
    - Originally all we used to plot was DLS vs MD, it is easy to calculate and uses the survey data.
    - The less you survey the better you look, but you may miss key points. There is no simple comparison in performance of one part of the well to any other.
- Ways to measure tortuosity – improvement
    - Differentiate the DLS, so basically looking at the change in DLS per foot of measured depth. It is better in that it measures consistency and doesn't penalize planned curvature.
    - There are still drawback like before and now more difficult to explain.
- Ways to measure tortuosity – expanded
    - If we double integrate the differentiation, take the rate of change of DLS
    - Dog Leg Severity is the Degrees per foot, if we take the rate of change it becomes the Degrees per foot squared. If you integrate this, you get back to degrees per foot, integrate this again and you get back to Degrees.
        - What this actually does is accumulate the unwanted curvature in the wellbore, which is really useful.
        - In the example given of a well that is 15,000' deep, we double integrated the differential and we end up with about 26.5 Degrees of unwanted curvature.

    - This is very easy to calculate in Excel
    - It is easily defined as “Unwanted Curvature”
    - It only uses surveys and may miss some key points, but we will come back to that later on.
- Traditional Tortuosity Index
    - A lot of companies already use the double integral approach, because it is so easy to calculate.
    - The Tortuosity Index is the Unwanted Curvature divided by the Planned Curvature.
- Planned Curvature is not always available
    - So, Tortuosity Index could be the Unwanted Curvature divided by the Total Accumulated Curvature minus the Unwanted Curvature.
        - You are left with something that is approaching what you were supposed to do.
- 3D Tortuosity Index – A more revealing approach
    - A lot of people want to move towards a 3D TI and not just a 2D TI that is just based off of DLS.
    - If we were to have a curve that looks like the image on Slide 11 where the surveys where on the red dots, we might have a BHA that is designed to give a constant DLS and might produce good consistency when 3D arcs are assessed for curvature.
    - What if one survey interval was a drop followed by a build?
        - This would assess as a consistent DLS over the two surveys
        - So, if we assess a TI for Build and Turn consistency separately and then combine them to a 3D TI.
- Introducing Effective Turn
    - This is what Directional Driller’s use to figure out what Toolface to drill with.
    - Consider turn as the Horizontal Plane, Effective Turn (ET) is turn across the wellbore, so as you look down the wellbore Build is up and down, and turn is laterally across.
    - ET is the curve required to change the Azi, and is easy at low inclination but much harder at higher inclinations.
    - Effective Turn is the actual Azimuth change multiplied by the Sine of the inclination.
- Toolface and Dogleg Calculations
    - Toolface is the arctangent of the effective turn divided by the build
    - Dogleg is the root squared sum of the effective turn and build
- Examples
    - I am in the field and we are sitting at an inclination of 25 degrees and azimuth of 100 and I am told can you get up to 35 degrees of Inc and an Azi of 124?
        - What Toolface do we drill on?
            - That is a Build of 10 deg and a Turn of 24 deg
            - ET=24 sin(30) = 12, using the average inclination
- Calculating the High Side and Lateral Tortuosity
    - First of all, calculate the Build and Turn rate for each interval
    - Convert the TR to Lateral DLS (ET)
    - Then, calculate the change in the BR, and the change in ET from one interval to the next as absolute values (we want to accumulate them)

    - The total Build is the sum of the BR multiplied by the change in Measured Depth, and the Unwanted Build is the sum of half of the change in BR multiplied by the change in Measured Depth
    - So the Total ET is the sum of the ET rate multiplied by the change in MD accumulated over the whole well, and the Unwanted ET is the sum of half of the ET rate in one survey to the next multiplied by the change in MD
    - The High Side TI is the Unwanted Build divided by the Total Build minus the Unwanted Build, and the Lateral TI is the Unwanted ET divided by the Total ET minus the Unwanted ET
- This takes us to the possibility that we can have a combined 3D TI (most companies do this already)
    - Take the two components, the Highside and the Lateral and take the sum of the squares and then the square root and that gives you the Combined 3D Tortuosity Index
- Vertical Curvature
    - Looking at a typical offshore well on Slide 24 we see a Total Vertical Curvature in the upper half of the plot building up to 80 degrees, and the Unwanted Vertical Curvature in the bottom half of the plot accumulating up to about almost 40 degrees.
        - This is fairly good and gives us a Vertical TI of 0.9, and anything less than 1 and you are doing pretty well. Between 1 and 2 is normal
    - Looking at the Lateral Curvature on the same well we see a Lateral TI of 1.91, so the 3D TI is 2.11.
- Traditional TI based on DLS alone
    - A sample well from Norway which accumulates an Unwanted Curvature of 30 degrees, and if you looked at the old methods of calculating tortuosity you would get a 0.45.
    - If we refer back to the formula for calculating the Toolface, we could use that to look at the actual Toolface drilled between one survey and another.
        - When we split the data and look at the Highside and Lateral Toolface we find that it is very erratic. So though at first it looked quite good, based on just the consistency of the Dogleg, actually the well has a Vertical TI of 1 a Lateral TI of 2.23 and a Combined 3D TI of 2.44!
- Measuring a High-Resolution Tortuosity
    - If we have a lot of data (downloaded MWD memory data), from this we can get a much better assessment of the true motor yield functions.
        - We can model a truer trajectory in 3D, without missing key points and can derive better Torque and Drag/Hydraulics calculations.
    - This can help DD performance (training), or Automation (Learning) to minimize tortuosity, and allows the proper assessment of impact at two important thresholds
        - If you are running casing in open hole, you can have an example where a tortuous wellbore doesn't impact the casing but may compromise the cement job
        - Stressing of Drill Pipe
- Loch Ness Test Trajectory in Inverness, Scotland
    - The TI analysis was run on this test well to see if it was a typical well under the analysis already performed.

- Looking at 24 surveys for one of the MWD company tool tests, using those measurements we get the following:
    - Vertical TI was 1.77, and the Lateral TI was 0.46 for a Combined 3D TI of 1.83

(Questions)

Q) Adrian Ledroz – I think this is great work and would like to go back to one of the first questions that you posted. Does it matter? It would be good to get some information from several operators to see if certain wells have problem with casing for example, and we could analyze the data. Otherwise the 1.8 or 1.2 TI is going to be subjective. We could divide up this work and it would be good to have several cases in which we could analyze and perhaps identify a pattern or a number.

A) Angus Jamieson – I would like to think that between now and the next meeting we might be able to do a more detailed analysis. One of the operators have already offered us 1,500 wells that we can go and do some analysis where they've got details about production, tool failures, where the casing difficulties were and so on. We need to see if we can correlate that to some band of tortuosity index using this formula. I don't think we can always say that between 1 and 2 is good, and over 3 is bad because there might be some regional definitions of what is normal. We don't really know that yet.

Q) David Gibson – Is there any way to be able to use other measurements besides survey, for example if a tool could measure downhole bending moment, would that be able to help support the equations that we are using? Having some other way to be able to measure this other than just surveys.

A) Angus Jamieson – Yes, as a short answer, whether that is quite practical or cost effective I'm not sure. You would have to be measuring bending moment at multiple places, the stresses are not constant at one point in the well. You can't put stress against a measured depth unless you put the pipe stationary so you have a dynamic situation, so I think it could be quite complicated. At least we could model in advance if we have drilled the well and surveyed with enough information we can model in advance where the troubled area points are going to be. A lot of companies have a policy of just reaming every single section they drill to avoid tortuosity, maybe we could decide you don't actually have to ream as you've just drilled a smooth hole in that section. So if the MWD guys can pulse up the TI from the high resolution data that it recorded while it was drilling that section, that would be really useful to us.

Q) David Gibson – I would also like to add to this at a previous IADD meeting that there were a couple of operators that said that if there was a technological way forward as they were drilling to be able to get some sort of TI, that is something that they would be willing to pay more for.

Continuous 6-Axis Drilling Mode Surveys – Case Studies

(Mahmoud ElGizawy)

- Motivation
    - The motivation for this is obvious when you consider that we stop at every stand to take a survey. When we stop for a connection, we either take a survey before or after, maybe work the pipe for a couple of minutes and then recycle the pumps in order to obtain the

survey. This averages out to about 5 minutes to survey, just drilling 1000 feet (10 surveys) we are adding approximately 50 minutes to an hour.
    - This is a focus of many operators and is getting a big push in the industry to decrease the amount of time surveying wellbores. We need to reduce the cost and deliver more wells, so this time is a major key performance indicator for many operators.
- Reducing Invisible Lost Time
    - While the Rig is running and drilling this is perceived as uptime or productive time. Any other time spent is perceived as non-productive time (NPT). NPT can be downtime related to equipment, for example the top drive or downhole failures.
    - When we look at the actual productive time, not all uptime is productive. We have to take the time for connections, reaming a drilled section, and for service, and this is classified as invisible lost time (ILT).
        - Focus now is on how can we improve the ILT, so this is one of our motivations. We wanted to reduce the ILT of the Rig in order to deliver the well in a faster time with reduced cost.
        - The other motivation here when we look at drilling in depleted formations, when we stop to take a survey and stop for too long, a lot of time there is now considerable force on the BHA to overcome this issue. This can create stuck pipe/BHA issues.
            - There are some operators who have adopted a 1 survey attempt only procedure in areas like this, if the service company has to recycle the pumps and the rig becomes stuck then the NPT falls on the service side (1000 Hours of NPT in a recent case)
- Measurement While Drilling Evolution
    - 1979 began the MWD service offering, fast forward to 2001 and we find the first continuous single axis surveying tool (this is the transmission of the along hole axis accelerometer and magnetometer). These measurements are used to calculate the continuous inclination and azimuth with the previous static MWD surveys.
    - In 2019 (this year) a disruptive technology was introduced in the form of Dynamic Measured Surveys or Drilling Mode Surveys (DMS). We can rotate 100-200 RPM while taking Dynamic surveys and we will look at some examples here.
- Continuous 6-Axis Surveys – DMS
    - Challenges
        - Phase compensation, shock and vibration create some complications in the accelerometer and magnetometer processing. However, the magnetometers also have Eddy Current Losses.
        - When the collar is rotating at a very high rate, the earth magnetic field is deviated (some bias). There are several parameters to observe and resolve in order to overcome this challenge.
- Case Study 1
    - This is a section drilled with RSS. Inclination changes from 10 degrees to 90 degrees over a 3600-foot section while the Azimuth changes from 300 degrees to 340 degrees.

    - The green dots on the chart are the stationary surveys while the red line is the continuous surveys (inclination), for azimuth the grey dots are stationary and blue line is continuous.
    - The update interval on the DMS is not dependent on footage but rather time. This particular example was 30 second DMS.
        - This data set is comprised of 38 stationary surveys and 335 DMS with a 3+ hour rig time savings.
- Case 1 continued
    - When we compare the positioning of the well when looking at the stationary surveys vs the DMS we can make a few observations.
        - The first chart shows the lateral displacement in footage and TVD
        - The second chart shows the ellipses for both, standard MWD EOU in red for the static survey stations and the DMS EOU in blue. There is significant overlap on both here.
- Case 2
    - This is another build section, but the azimuth is much smoother (10-20 degrees).
    - 24 Static surveys were captured while 328 DMS were, this results in a 2+ hour rig time savings.
        - On this particular section the ROP was less than the first case and this results in more surveys from 0-5’ and 5-10’ apart.
    - Comparing the position of these two surveys logs again we see that the TVD disagreement is less than 3’ and the lateral displacement is less than 4’.
    - Both ellipses have good inclusion again.
- Case 3
    - Is another build section, 26 stationary and 201 DMS with 2 hours of rig time savings over this section (2300 feet).
    - TVD disagreement is negligible, and the lateral displacement is just above 13’.
- Summary
    - This is a work in progress and there is more work on the way for this disruptive technology. DMS are taken while drilling and when there is movement downhole (rotating). DMS can be used as definitive surveys with the objective to classify these as MWD standard (EOU). We are moving now to have an error model with better accuracy. Over the case studies that we have there is good enclosure of the EOU’s, but the DMS is anticipated to have tighter EOU’s with the adoption of the ISCWSA rev 5 model (for sections with high DLS).
    - Higher frequency of surveys defines the wellbore trajectory better (this will help define a tortuosity index), while increasing the rig time savings (ILT) and minimizing the potential for stuck pipe (NPT)

(Questions)

Q) Stephane Menand – Thank you for the presentation, very interesting. I wanted to see if you had some comparisons between Rotary Steerable Systems or Steerable Mud Motors to see if the continuous inclination is as robust? The simple thought is can we create a quality control condition because which level of vibration is acceptable for that system because the shock and vibration creates a lot of noise?

A) Mahmoud ElGizawy – Thank you, the continuous inclination when it comes to the RSS, that tool has its own sensor module. We did not compare the continuous from the RSS, but from my experience the continuous inclination matches the MWD quite well and continuous azimuth is usually a little off. Here we are using the survey sensor data and downhole filtering and processing for calculate the DMS surveys. We did perform extensive testing when looking at shock and vibration. A lot of specifications have been put into place and we always try to look at the worst case.

Q) Mike Attrell – Thanks for the presentation, looks like really good data there. I was curious when you were touching on that last slide when you talked about increased survey frequency better defining your trajectory, but you also talked about the positional differences between the stationary and the real time surveys. Did you look into taking real time surveys that were close to the stationary to use those to compare and see if they were close enough to match or was this positional difference due to the high density of real time surveys?

A) Mahmoud ElGizawy – Those are very good questions, what I presented was all of the surveys. When we look at the histogram of the DMS some of them are 5, 15, 30, since we are still in the early stages of development yes, we do look at the stationary surveys and the DMS that is closest to it. That is not something that we presented here but yes we do look at that in this stage of development.

Q) Mike Attrell – So did you see let's say the same 12 foot difference between real time and stationary just being the surveys themselves?

A) Mahmoud ElGizawy – Yes, and they are very close.

Q) Marc Willerth – I think this is very exciting, this gets us back to the concept of almost having a true survey log of the well. I am curious in that there is a common practice in other logs to do repeat sections where we model effect like time after bit on response in properties, did you do any repeat sections or reaming back to the surveys where we compare how our mapped trajectory might change based on when we surveyed the well relative to drilling?

A) Mahmoud ElGizawy – Not with these tools, I agree and totally understand your point. We didn't have a chance yet to look at this, but it is something very interesting that we want to look at.

Q) Pete Clark – Interesting presentation, Can you talk to QA QC and what data is being transmitted? When you look at the static surveys in that presentation, I assume at the end point you don't have the static surveys at all, but how do you tell the rotational surveys are good?

A) Mahmoud ElGizawy – Basically it comes from the rig, the 6-axis data, and we use the same FAC. For DMS the corrections and compensations are done downhole. So, what we get is an equivalent 6-axis, and it goes through the same FAC as stationary.

Q) Neil Bergstrom – When you showed that inside of the non mag drill collar that the magnetic vector was actually shifted a little bit or rotated, which should be proportional to the rotation speed of the collar. Did you also see that the amplitude of the cross-axial vector change?

A) Mahmoud ElGizawy – This is very interesting that you caught this. Actually, as RPM increases this (the movement of the vector) increases as well, and with every single different collar size you also get a different effect. The difference between ID and OD makes a difference. So yes you get a larger magnitude with a larger collar or higher speed, and this is very challenging to properly model.

Q) Adrian Ledroz – I was at the presentation this week of the new rotary steerable tool from Schlumberger, so I was wondering on the horizontal can this tool really match the others and give you a very straight well, or is this part of the measurements of the new rotary steerable?

A) Mahmoud ElGizawy – So is the question about the new RSS tool or DMS?

Q) Adrian Ledroz – Well, about the new tool yes and the DMS with respect to the lateral and highside discrepancy with continuous data and the stationary if you have a rotary steerable or is that why you picked out the build section only?

A) Mahmoud ElGizawy – We picked out the build sections because we were running this tool (DMS), not because of anything else. We are expecting to get more runs with this, the new RSS does not have this capability yet. We are expecting to develop a smoother and we would like to try it out, but we haven't had the chance yet to try out the new RSS with DMS yet.

SPE Wellbore Positioning Technical Section – Survey QA/QC Update

(Phil Harbidge)

- This is a reboot of a committee from about 10 years ago where some of the old guard wrote some papers defining QC processes and values. Alongside of the work that has been done with the error model committee and the collision avoidance committee, it is useful to have QC to be able to validate our error models.
- A quick overview of our mission statement, we are defining practices that promote the task of defining the required data which may be used to validate and potentially enhance the wellbore position (and reduce uncertainty)
    - We have had many operators and service companies participate in our sessions.
    - We originally started with about twenty-four members and five of which were operators, but yesterday's session only had one operator. We would like to invite at least one other operator to join us in our work. We typically hold conference calls about 7AM Houston time at least three times between each meeting.
- There are some times where collision avoidance or error model sub committees clash with our own schedule (for onsite meetings) in that some people want to attend all three committees.
- Our next project was to produce and review some API RP 78 documents.
    - There has been a lot of effort to produce some fantastic material, but it was just too long. The API wanted a prescriptive document and wanted to remove the "may, should, could, etc." so we stripped this away to the bare bones of each document.
    - There are three documents that have been produced:
        - Along Hole Depth – with Harald Bolt who was the pioneering force behind that subject. He and his group produced the master document and we as a subcommittee have condensed that down into just under two pages.
        - Gyro – Adrian Ledroz, Ben Hawkinson and many others who were involved in producing the master document, and we have also condensed that down into less than two pages.

        - MWD – much of the same, many hours were spent condensing this document as well. We will have at least another two conference calls to finish this up, so if anybody wants to join and if you know anything about MWD, please join. We are asking for more operators please, because these are going to be rules that operators and vendors will be complying with as strong recommended practices very soon.
    - After we deliver the final documents, the API will have to also review and then consult with a technical writer to consolidate and finish the project. There will be some costs involved with that. We are still in the discussion stage if ISCWSA will be paying for that, partially paying for it, or paying nothing at all. This is an action for the committee to decide upon.
- All of our documents will be placed on the ISCWSA website, and each member of the sub committee will be able to view and edit them.
- The original documents that were more than 60 pages long will all be combined together to form a new eBook. This may become and addition to the current eBook which will take some work but this is vital information that we should not lose.

(Questions) – None

The Impact of Human Factors on Procedural Discipline

(Bill Allen)

- Let me first just preface by saying I really don't want anybody to be disappointed. At the end of my presentation I really don't have any answers, instead I am posing a challenge that I am really hoping this group is ready to tackle.
    - 50 meetings is quite the celebration. We should recognize the models developed and the ongoing training with the education committee with the efforts of the "hits and misses". The Anti-Collision methods being released are another big milestone.
    - I do want to recall the first time I was invited to my first session. I was told to show up, the whole group would show up at some hotel and sit at two small tables and then basically argue for the whole day and I would just sit in the back and keep my mouth shut. I remember that these people would pride themselves on the fact that the color of the coveralls were left at the door. Everybody worked as a really good team, very open and honest and critical, but all in the spirit of moving the whole team forward. I hope we never lose that.
- Today I want to talk about a list of error sources that can lead to a well collision, the controls that we put in place to prevent those errors and what the common approaches are.
    - We will look at a three well program where the controls failed miserably.
- We are starting with a scenario that had a collision (being the undesired event), in which there are a number of things that can feed into and cause this.
    - Anti-Collision tolerance was wrong on the plan. What are the drivers here?

        - Inappropriate error model on the planned well, short of selecting the wrong error model to assign this group (ISCWSA) has done a lot of work to ensure that our library of options are good.
        - Could be a poorly designed error model (ruled out).
        - Could be the assigned separation rule, there are HSE versions and Non-HSE versions.
        - There are about 20+ different error sources here (Slide 5)
- How good are the industry controls?
    - We need to get some people with human factors or human performance background to attend our meetings.
    - We assign controls to prevent bad things from happening and in our industry most of them are administrative controls. This means that people are performing them (the control) as opposed to a machine.
- How organizations enforce control
    - Set organizational policies or requirements (documents), then there has to be an agreed upon procedure to follow with some conformance process or sign off process.
    - Competency programs, we have to train these people as well.
- 3 Well Program AC Event Example
    - The team had a new platform and maintained an area risk tracker which in this case included the probability of well collision during the drilling program.
        - Was listed as "never happened in the industry"
    - They were not familiar with congested will drilling, but were trained and aware of well placement requirements and procedures.
    - This example is a Non-HSE example there were no other wells on the platform.

- Well #1
    - This team was used to conductors only being 100' deep so these wells were twice as deep than normal for them getting started. These were all 30" conductors on 10' centers. Dummy wells were inserted into all unused slots in the plan.
    - Even though they were certified some of the people involved in certain roles were not familiar with the AC methods.
    - Perception was that collision would never occur in this plan and that the wells were vertical.
    - There were 2 survey programs that conflicted with each other, one plan had survey intervals with GWD followed by MWD, while the other (starting at a different depth) and uses MWD only.
        - The Rig didn't challenge this discrepancy (or use either one of the survey programs)
        - The traveling cylinder plots that were used cant be based on both of them, only one.
    - The initial TC plot was not even acceptable to the plan in that in had no depth control. The other example the different colors represent depth.

- All of this work was done, the team had a plan and everything looked fine. When it went to the rig a risk assessment was performed and people identified some AC issues and keep the ADP to only 2.9'.
    - Then the AC report that went to the rig stated there is no AC risk in the surface hole.
    - The leadership teams didn't dive into the engineering work, they saw everything was signed off and looked good, so in turn they signed off and gave the ready to go.
- Execution of this plan went poorly in that they drilled 450' out of the shoe before using any survey data (mag interference). Instructed to drill on contingency that a gyro would be dropped.
    - After they TD the section they found the well to be in poor position against the remaining plan.

- Well #2
    - Lessons learned, they decided to start with GWD, and all other planning and review processes went fine. However, while drilling they couldn't stay away from another planned offset well. They had already been told, even though they had planned tolerance lines to just try not to cross them but if you do it is ok.

- Well #3
    - Escalation attempts were made but effective communication was not really happening both ways. Tolerance line crossings had no consequences, so behavioral decisions compounded this problem. Both wells 1 and 2 did cross lines from plan, but nobody got hurt and it didn't cost any time.
        - Caveat, each well was intended to be drilled and completed before moving to the next well in the sequence, something didn't go as planned so to keep everything moving, they adopted a batch drilling program.
        - Because of the batch drilling well 2 was slightly behind schedule which placed constraints on well 3 to get it done quickly.
    - During execution of drilling once they drilled out of the conductor and projected ahead, they were to cross another tolerance line. Decision was made to drill ahead unless cement was seen in returns and then we will stop drilling.
        - Drill ahead one stand, cross the tolerance line and see cement. Drilling stopped, and the decision was made to drill ahead further.
        - Cement returns increased to 20% from trace. Drill farther.
        - Drilling finally stopped at 800' with 90% cement returns.

- Summary of Findings
    - 17 to 18 of the process controls in place we talked about in the beginning rely on people. People being trained, confident, having the courage to speak up, and had enough time to have the right experience.
    - Easy to blame the team but looking through this activity they did most of the steps to follow the controls.
        - They developed their own rules on the fly when the situation escalated in that if they see cement, they will stop drilling, but when the cement came they just could not stop.

        - Is termination plausible? Should they be turned into teachers? Should we just remove the controls and take away the opportunity to make poor decisions?
    - They had a survey program initially with gyros, then they expected to have magnetic interference, and a survey interval requirement which was less than 200'. They had to assign some kind of survey program to the conductor.
- What if we had monitoring software that knew what the survey program was from a technical perspective, and it was monitoring the well drilling and when the depth interval exceeded the threshold of no new survey it would have alarmed the team that you are not meeting the design of the well?
    - We need to system to have the requirements built in to it (this can be too much for people), the software at the planning stage should make use of all of the lessons we already have, and maybe suggest the survey program based on the inputs or the constraints.
    - In the execution phase have the monitoring and alerting systems in place to improve the decision making
    - Look at what SpaceX is doing with software controls to land a rocket back on a pad, this is not people doing it, it is software.

(Questions) – None

Operator Wellbore Survey Group & API RP 78 Update

(Pete Clark)

- OWSG Update – We are going to transition the ownership of the error models from the OWSG to the error model maintenance group, which is quite an important thing. The EM SQ is far better to promote both their use and for casual users looking to adopt some the most obvious place is to look at our website. On the ISCWSA website under the error model section is where we plan to have them, and this is a far better place to maintain them.
    - Big thanks to Andy and his team for offering to do that and also to Steve Grindrod for his contribution and how he helped us create the workflow.
- What now for the OWSG?
    - Tortuosity – we have a variety of metrics, which for individual companies may work but we want to drive a common language in the industry.
    - Boundary Lines
    - My expectation or hope is that by next year before we reform another OWSG, but the primary action is on the API RP 78
- API RP 78 – I understand that we haven't made the progress that we wish, and that we sense that we are using up the goodwill of this group and those who have contributed. Jonathan reminded me that we have a good body of work and we appreciate the work other teams, especially Phil with QAQC and Andy with the error model sub committees.
    - We are effectively stalled on the first draft, which has over 200 pages and is available on the API site.
    - In order to re-establish the ongoing work what we have done is to look at what remains

        - Will Tank has offered to come in as a deputy (Vice Chair), he has an interest and enthusiasm for the subject. He is already familiar with interfacing with the API and this is something that will really help.
        - Bill Coco our connection in the API, he is currently reviewing the document and going over the language to ensure it is consistent with the API recommendations
        - Technical Review is the vision for the next stage, and this is where the most help is needed. Steve Sawaryn may provide some assistance here along with myself
    - The Collision Avoidance content is core of this document, this is at the center and the remaining content is supportive of this. We are seeing that we have regulatory bodies who are staring to get into this space and take on some collision avoidance.

(Questions) – None

Update on the ERD Database

(David Gibson)

- Database can be found here: https://public.tableau.com/profile/gibsonreports#!/vizhome/IADDERDDatabase5-1-19/ERDPLOT
- I think around 2015, BP stopped being the administrator of the ERD data set and then with the downturn and other happenings it sort of fell to the wayside. About a year ago the dataset was turned over to the IADD, who reached out to me to help work on this to see if there is something special we could do with it.
- A data visualization was created which has a nose plot of all of the wells that were created in the prior database, there wasn't much in the form of data validation on wells in the system. So we had wells that said the water depth was 300' but they were land based jobs, or the TVD was greater than the MD. There are still some data points that aren't correct, but we are working on cleaning this up so if you see something wrong please let me know.
- This is hosted publicly with Tableu Online, with interactive charts and filtering. This is similar to PowerBI, Spotfire, etc.
- There is a YouTube Video that is a basic tutorial of the dataset and how to interact with it.
- There are filters for new vs historical datasets. There is a website for data entry to add more wells to the system. Data validation is on the front end now to prevent false entries. You will have to request an account to get set up and provide data to the site. (This is free)

(Questions)

Q) Pete Clark – David, I am presuming the data will be fed in actively by someone?

A) David Gibson – So, the way that we have it working now is that we have taken all of the data out of the excel sheet that it was in and we put it into the Cloud living in AWS, so as things are added in through the website it will update the database. I go in there once a week and update the data visualizations, which is usually done on Mondays. Of the 15 or so people that have contacted me and asked for permissions to put in wells, I have only had 1 person send stuff directly to me and then I added

it in. Currently we have nothing for West Texas (Permian), not one single well. Most of this data is North Sea, Africa, etc. We are looking for data to get added to the system and it is completely free for the industry.

Q) Pete Clark – I guess the point I am getting at is, there is nobody scraping data from public sources but rather you (IADD) is expecting the industry to contribute to this?

A) David Gibson – That is exactly right, and as you submit there is a spot for comments so that if you want to put in there it was a challenge or whatever, the board of the IADD wants to be able to spot some challenging wells to highlight. This could be for any region; we aren't scraping anything we are looking for the industry to add to this. This is for educational purposes.

Q) Shuba Love – What useful decisions have people been able to make using this data?

A) David Gibson – I have no idea, I made the visualization part possible, but as far as the decision making part, I think you all are more qualified could probably answer that better than I could.

Q) Shuba Love – This looks great and you did a great job, what is the minimum set of data you are looking for that people can contribute to this?

A) David Gibson – We wouldn't say that there is a minimum, we could scrape say Texas Railroad Commission data and public data to cram this database full. That isn't what we want to do however, we wanted the industry to say this is the success that we had. Whether it is a service company that has access to data that is going to become public, or any other of a number of examples.

(Q) Jonathan Lightfoot – I think this is great, and I think this could be expanded here. There are a number of times where we hear from some company that they have the record in the Permian. One of the things that would be really nice is that you have days and you have depth, but when you talk about quality like some of the things that Angus mentioned, could you consider to allow some of these milestones or significant achievements (best in class wells), submit it. Maybe some of it is undisclosed or some of it can be disclosed, but where you could start to collect some of this data in the areas that need it. Now we could compare some wells that are considered record wells in a region, this is a great portal to test and see if a record really was broken.

(Q) Benny Poedjono – I cannot understand where this data is coming from. Most of this data is not released. When I check on the company name or whatever, I think we have a data issue here now and I want to understand this. Even in Schlumberger some of this data is not supposed to be public about certain parts of the well path, so I don't know the situation right now and what is the impact.

(A) David Gibson – the data that exists currently is mostly from what was already on the original spreadsheet, we have talked about adding service companies but we've decided to not do that. In order to prevent record bragging, over what the point of this actual data set was designed for.

(A) Jonathan Lightfoot – Prior to BP managed this internally it was turned over to K+M which is a SLB company, but this is a really good point and should be taken up with the IADD. This kind of visualization is useful because it shows us what is achievable.

SPE Wellbore Positioning Technical Section – Officer Elections

(Ross Lowdon)

- The positions up for election are:
    - Program Chairperson
    - Membership Chairperson
    - Director at Large (2)
- The election results are as follows:
    - Program Chairperson: Adrian Ledroz
    - Membership Chairperson: Marc Willerth
    - Director at Large 1: Heather Vannoy
    - Director at Large 2: Matthew Weber
    - Chairperson: Ross Lowdon, succeeding Jonathan Lightfoot at the end of his term.

Education Subcommittee Update

(Robert Wylie)

- First of all, I would like to pass on Carol's apologies, she was unable to attend this meeting. I would like to thank Angus as stepping in as co-chair, and for David on taking notes.
- The education subcommittee mission statement is no up on our website, traditionally we have been an advisory committee raising awareness in the industry and not in the business of running a school.
- Over the last couple of years, we have been involved in several topical luncheons and joint initiatives with the DSATS group and a couple of other technical sections. On the automation of the well construction process, Carol has been a co-moderator of that.
- In this SC meeting we discussed that next year that DSATS is going to have an onsite Drilling Confidence meeting in the Spring, we are looking at giving a topical luncheon.
    - Unfortunately, the SPE does not host topical luncheons any longer
    - We will propose a special section for the SPE WPTS to give a presentation
        - Topics we are considering are Anti-Collision, or the Role of Big Data / Analytics on Survey Management. We will use this as the foundation for other educational outreach efforts throughout the year.
        - We have discussed developing some videos, that we could perhaps broadcast throughout the year. We are trying to reach a wider audience than just our own special committee here. We want to attract more people into why they should be using survey management practices.
- Outreach remains a key focus for our subcommittee
    - One of the projects we identified last meeting was to determine university programs, and we managed to get those lists from SPE.
- Drillbotics Competition – in combination with DSATS
    - We have agreed as a wider committee to become a Platinum Sponsor ($5k)
        - What this gets us is advertising during the competitions, gets our names in front of the student bodies all over the world, and gives us the ability to start spreading our message in this young group

    - We have volunteers that will participate in helping design the challenge for the teams and also helping evaluate the results (as judges)
- eBook translation updates
    - Intro to Wellbore Positioning has the Spanish version coming soon, the translation is complete, but the graphics also have to be translated which turns out to be a bigger task.
    - Version 2 of the Ranging Technologies for Intercept are now available on the ISCWSA website
- Back to the mission statement, there has been a proposal from the University of Highlands and Islands that we should take over or basically purchase the online course around the material that UHI has developed around our topics in the eBooks. This is an effort to make it more available to the public, decrease the charge for the course to reach a wider audience.
    - This is something that we are going to consider over the next few months.
    - The idea is to host this content and testing on our website for a reduced cost, but still have the UHI provide a certificate (stamped and signed).
    - Challenges involved are how do we purchase this, host this, maintain this, monitor the quality, etc?
- More details on the UHI course (Angus Jamieson):
    - There are about 120 people that have already gone through the course and have taken the exam. Some operators like BP and ConocoPhillips have put dozens of people through the course. The target was for the companies that are not BP and COP who already have subject matter experts, at the time it was designed to educate the people that don't know that what they don't know. We find the challenge of that has been doing it through the University is actually being really quite expensive, so I suggested to UHI that if they were willing to sell the course we could just make it available to everyone for free through the ICWSA website.
    - Getting feedback from operators that have used the course, they say don’t make it free people don’t value free. We could make it a couple hundred dollars or something like that, and that money would just go to the administration of the course through the ISCWSA. There might be an exam fee, as it might be good to keep a foot in the UHI as an independent academic body so that the certificate at the end of the course is then validated by a formal university.
    - We have actual already been offered by several companies here all of the funding that we would need. So for sponsorship and if you would like to contribute, just let us know and this reduces the amount other companies would have to commit to.
    - Traditionally this is a 7-week course at the university with about 4 hours of online video lectures that you have to work through each week with some challenges as well. This covers most of the topics within the eBook (which is the reading material)
        - Any feedback please direct to Angus, Robert, or Carol

SPE Wellbore Positioning Technical Section – Distinguished Service Award Announcement

(Angus Jamieson)

- I am very pleased to say that this is one of my friends and I had no influence in this whatsoever, but Steve Sawaryn has been elected by the committee to receive the Distinguished Service Award. I am particularly honored here because Steve is one of my heroes. Steve graduated from Cambridge with two university degrees, that tells you all you need to know right away. He graduated sometime near the first world war and went to work in the field of science but very quickly was snapped up by BP, where we first met. He is a genuine polymath, mathematics and engineering, software and algorithmic work. You name it and he can do it, but he is also and innovator who thinks outside of the box and has made huge contributions to this industry over the years. In the early adoption of Compass, I wrote the algorithms that went into the well planning side, and ran into some problems early on but then Steve would say, well if you had just done it this way… Isn't that frustrating?
- Steve has published more papers for the SPE than anyone else that I know. I think he has a machine at home where he just pulls the handle and another one comes off the printer. Steve became obsessed with a direct solution for optimum length (algorithms), that is the curve-hold-curve that will get you from any position in attitude to any other position. He did it, and it is a rigorous solution. There is a reason we asked him to be our keynote speaker this morning, not only has he made an enormous contribution to this society (SPE), but to this group as well. Most recently with the Collision Avoidance work and also as our elected distinguished lecturer last year. I think Steve perhaps more than anyone else has pushed us in a direction that maybe anyone else didn't want to go. We didn't want to be a standards committee; we didn't want to take any responsibility for our recommendations. We just wanted to be able to publish documents and hope that people walking past might see it. Steve pushed us and said if you are not the standards committee, who should be? We are the experts, so he embolden us in this new direction and I will always be grateful to him for that.
- So without further ado, after 40 years after no being recognized you get 2 awards in 1 week! Please come up and collect this award.

(Steve Sawaryn)

- It is not often that I don't have at least something to say, but I am completely humbled and immensely grateful to the committee for providing something towards the tail of my career. This is not the end, but it is near the end, but is the tail end of a career that I have aspired to for many years, this is a wonderful surprise and thank you from the bottom of my heart for doing it. On the way in my career I have been very fortunate, I have had some great friends and colleagues in the likes of Angus Jamieson, John Thorogood who vociferously tell you that you are wrong when you're wrong. They also tell you to make progress on that, and those are the sorts of mentors and friends that you need as you progress through your career. I would actually like to say thank you, and this would not be possible of course without the company that I originally worked for BP. The amount of freedom and latitude that I got in the whole of my career was extraordinary and I am immensely grateful. To the people that have continued to work in the company after I departed please take this message back with you. Last but not least I need to thank my family, Angus talked about this problem that was solved about six months ago and

hopefully there will be a paper written on it. The people take the brunt end of all of this would be my long-suffering wife and all of my three children who refer to Dad's math's as "the problem". Getting up in the middle of the night to try and get an idea to work then going back to bed, etc. It has been huge fun and I really am very happy thank you very much again.

SPE Wellbore Positioning Technical Section – Secretary's Report

(Ryan Kirby)

- The new website still requires a few things before everyone here can begin to log in and start applying themselves to the subcommittee pages. I will take the document of attendees here today and start enrolling you all on the backend so that you will have to opportunity to login and begin that journey. Please bear with us and we work with Tendenci to resolve a few remaining items that are outstanding.
- The next item on my agenda is to take a vote on the new revision of our constitution that I am responsible for keeping. This is designed to be a living document that can adapt and change as we adapt and change to the challenges that crop up in our industry and body of work. With that we will take a vote by a show of hand in favor of, and against adopting this revision of the constitution.
    - Constitution Revision was voted in and accepted.

SPE Wellbore Positioning Technical Section – Closing Statements from the Chairperson

(Jonathan Lightfoot)

- For me in the past for years I would like to first off say thank you to Occidental for giving me their full support to be in this role and travel to all of the international locations. It took them a bit of effort to support me so I really want to thank them. When I was a kid my Dad used to always make the comment I am not as dumb as I look, and I adopted that and realized that being around most of you guys I am actually not as smart as I thought I was. I have glasses now so maybe I can say I am not as smart as I look. It has been a lot of fun and I have been really honored to have served in this role and be around some of the brightest people and meet people whom I have read their papers such as; Hugh Williamson, Angus Jamieson, Steve Sawaryn, and Steve Grindrod.
- I did attend the leadership workshop for SPE Technical Sections on Sunday, I wasn't invited but I went because I figured we are also a technical section so maybe I should go, and learned a lot there and have some ideas that could really help take the burden off the subcommittee chairs. For instance they have study groups and additional people that serve in those study groups and we could have an opportunity to do that and reach a little bit deeper into the group. You might be a person that could be the secretary of say the error model maintenance subcommittee, or you might have another job responsibility, so there could be more opportunities to volunteer and don't be afraid to raise your hand and say I would like to help with this part.
- Another thing that was interesting is that I went to the R&D dinner and there is 4,000 members in the SPE that are part of their membership, and I think our number is about half of that and

when you register for SPE you can go and sign up for all of these technical sections and for some reason R&D is getting a lot more clicks than wellbore positioning. I encourage each one of you to go back and especially those young professionals who are 35 or under because that is the future of our industry and encourage somebody to join this technical section. If they are not a member of the SPE, encourage them to join that as well. I see this more and I heard a comment this week that SPE is really the Society of Professionals in Energy, so it is not just about Oil and Gas, it is not just about engineering. There are a lot of disciplines that are important to our organization and our industry which includes data analytics, human factors, marketing, and there are just so many different facets. Try to think about our society just a little more broadly and open it up a little bit, reach out to those other drillers who do trenchless work, river crossings, geothermal, all these other folks who are boring holes in the earth and might need to have some aspect of safe separation.

- I just wanted to thank you very much for being patient with me, I know I am just a dumb Cajun from south Louisiana and I kind of stumble at times. I really have had a lot of fun, and I can't say enough thanks really to everyone. If I have not met you personally I apologize but I would like to thank all of you and feel free to come up afterward. Please always know that you can reach out to me going forward. It would be nice to see some younger faces in here so I encourage you all to keep reaching out, nothing against us older seasoned guys, but surely there is someone in your organizations that would benefit from coming to these meetings. Encourage them to write a paper and mentor them on part of that and let them stand up here and present, that is an important skillset to develop and learn. I hope I can inspire you all to do that and I am definitely looking forward to future meetings and I will turn it over to the new Chairperson, Ross Lowdon.

(Ross Lowdon)

- Jonathan, I would like to thank you for your patience in tutoring me and helping me get on my feet and hopefully I will be able to do the same from Adrian as he steps into my role now. I think we need to look back over your tenure here Jonathan and go over just what has been accomplished over the last few years. We have managed as a section to produce 2 Journal of Petroleum Technology (JPT) published articles which have been very well received, we have managed to produce a new MWD error model, and we have a brand-new fantastic website. You have brought a level of professionalism to this committee that we have never had before, and we are going to build on because it is truly fantastic. We now have a brand-new constitution, with great SPE recognition and I could go on and on. Your leadership and tenacity and enthusiasm has led all of us down this journey to get us to all of the fantastic things that we have done so far. My only comment and my only real criticism is that I have to follow that, and it is difficult. I will do what I can, and personally I am extremely honored to be the next Chair of this technical section. There is an awful lot to do but you guys are there, and are the leading minds in wellbore surveying for the industry and I hope together we can all carry on this fantastic work that you (Jonathan) have been leading us on for the last couple of years.

(Attendees and Affiliation)

Adam Morse - Phoenix Technology Services

Adrian Ledroz - Gyrodata Inc.

Alan Vasicek - Apache Corporation

Alan Gosse - Halliburton

Andrew Lamacraft

Andy McGregor - H&P Technologies

Angus Jamieson - H&P Technologies

Anne Holmes - Halliburton

Aprameya M. Dhara - Weatherford

Aric Presley - IPM Magnetics Ltd

Ben Hawkinson - Scientific Drilling International

Benjamin Hartzell - GMW Associates

Benny Poedjono - Schlumberger

Bill Allen - British Petroleum

Bin Wang - Halliburton

Brett van Steenwyk

Brian King - Scientific Drilling International

Carl Healy - Scientific Drilling International

Chad Hanak - Superior QC

Corey Kanzing - Icefield Tools Corporation

Cornel Dinica - QCD Technology Inc.

Curtis Fleischhacker - H&P Technologies

Dalis Deliu - ConocoPhillips

Danielle Cook - H&P Technologies

Darren Aklestad - Schlumberger

David Gutierrez - Superior QC

David Gibson - Gibson Reports

David Erdso - Erdos Miller

David Moran - Optimax

Denis Reynaud - PathControl

Douglas Ridgway - Scientific Drilling International

Dukhwa Hong - Round Lab Inc

Erik Nyrnes - Equinor ASA

Geoffrey Dorn - CGG GeoSoftware

George Colbert - H&P Technologies

Greg Belbin - Gyrodata Inc.

Gunnar Tackmann - Baker Hughes

Gustavo Romero - Seven Generations Energy

Guy Le Breton - DrillScan US, Inc.

Harald Bolt - Depth Solutions

Harry Wilson - Baker Hughes

Harry Schaepsmeyer - StromTech Energy Service Ltd.

Heather Vannoy - EOG

Huan Liu - University of Calgary

Ira Shankar - JAE Electronics

Jaswinder Pawa - Optimax

Jeremy Codling

John Mejia - ConocoPhillips

Jon Bang - Gyrodata Inc.

Jonathan Lightfoot - Occidental Oil & Gas Corp.

Kim Ducante - Schlumberger

Lee Randell - Icefield Tools Corporation

Levi Smith - Icefield Tools Corporation

Mahmoud ElGizawy - Schlumberger

Manoj Nair - NOAA/University of Colorado

Marc Willerth - H&P Technologies

Matt Bell - Strategic Piece

Matthew Weber - Shell

Matthew Rhodes - British Petroleum

Michael Donahue - Devon Energy

Michael Calkins - Three Sigma Well Design, LLC

Mike Attrell - Mostar Directional Technologies

Mike Fretwell - Mission Surveys

Mike Carter - Round Lab Inc

Neil Attwood - MAXLRAIN

Neil Bergstrom - H&P Technologies

Nicholas Brown - Noralis

Patrick Knight - Halliburton

Paul Pierron - H&P Technologies

Paul Strohmeier - ConocoPhillips

Pete Clark - Chevron

Philip Scott - Dynamic Graphics, Inc.

Philip Harbidge - PathControl

Pola Cifuentes - H&P Technologies

Rick Ryan - Round Lab Inc

Rick Tachuk - Halliburton

Rob Shoup - Gyrodata Inc.

Robert Dufield - Superior QC

Robert VanBostelen - OptiMax

Robert Wylie - xnDrilling

Rocky Mottahedeh - United Oil & Gas Consulting

Roopa Dattani - Pacesetter Directional Drilling Ltd.

Ross Lowdon - Schlumberger

Ryan Kirby - Superior QC

Ryan Quigg - Weatherford

Ryan Wilgers - Superior QC

Ryan Zallas - Halliburton

Scott Ellis - H&P Technologies

Sergey Shabanov - Total

Shaun St. Louis - IPM Magnetics Ltd

Shuba Love - H&P Technologies

Stefan Maus - H&P Technologies

Stephane Menand - DrillScan US, Inc.

Stephen Grindrod - Copsegrove Developments Ltd

Stephen Smith - Phoenix Technology Services

Steve Sawaryn - Independent Consultant

Steve Thompson - Gyrodata Inc.

Stuart Sargeant - Agilis Software Solutions

Sue-Ann Marquis - Total

Susan Macmillan - British Geological Survey

Timothy Paton - Superior QC

Timothy Allen - TALLENTECH

Tony Russell - QCD Technology Inc.

Tyler Marr - Halliburton

Warren Keshan - OptiMax