

55th Meeting of the ISCWSA
Day 1

Introduction from Adrian Ledroz

First Speaker
Keith Vickery
Zupt, LLC

Inertial Navigation:
For Precise Wellbore Survey

Strapdown Inertial Navigation systems are constructed with:

- Three angular rate sensors or gyros
- Three Accelerometers
- Sensor Electronics and a processor

An IMU is an inertial Measurement Unit

An INS is an Inertial Navigation System

Defining different gyros:

- Mechanical, spinning mass, or “rotor” gyro
- Vibratory/Resonant gyro
- Optical – Ring Laser Gyro
- Micro Electro Mech Sensor (MEMS)

Pros/Cons in Accelerometer Packages

- Force Rebalance Accels
- Pendulous Rebalance Accels
- Resonant Element Accels

Performance of an INS is usually rated in terms of its position error growth rate once the INS is navigating in free inertial mode

The W-PINS project was developed in two phases:

- Phase 1 was concept testing
- Summary of W-PINS Operational Procedure
- W-PINS sample data from field use
- Modifications made for Production Work

Conclusions:

- Project ended early due to slowdown in Sag-D, loss of contracted work.
- Improvements contemplated but never completed
- Improvements to post processing software
- Wireline real time communications
- Wireline power
- Reduce the diameter

- Extend the temp spec
- Improvements still to be made

Restatement of the shortcomings:

- No downhole communications
- Battery powered
- Temperature limited
- System only delivers an absolute location of the wellbore
- Classic metrics the industry uses have to be back calculated

Thought is industry wants absolute location, not INC/AZI/Depth

What are the benefits of “navigating” the wellbore with an INS v. conventional gyro tool

- Absolute coordinates provided for the full wellbore
- Precise quality metric delivered by closing the traverse
- Can have a CCL in tool string to absolutely position all collars
- No local or regional magnetic declination issues
- No error propagated through the full wellbore
- Centralizer not critical

Does a Market exist?

- Sag-D
- Top hole prior to kick-off
- Relief well assistance

Questions:

Harald Bolt –

Is 1,000:1 what is needed? Who thinks so, and why?

Keith Vickery –

This was a spec that that we were seeing from the original tools and this is a spec we were given because we were asked to position the toe of a Sag-D well to a particular accuracy so that's what drove that spec. I think the resolution through the wellbore to confirm and the resolution through the wellbore to see what is happening with the directional process is also provided by this type of technology you have much higher resolution in movement within the wellbore. We believe that we were given that spec so we delivered to that spec.

Knut Ness –

What is the interval between the coordinates?

Kevin Vickery -

In our case we were going down the vertical fairly rapidly and then we're moving out through the horizontal fairly slowly because of the techniques used to get the tool into the well. It really depends on how often you want those intervals to be so without using a line aided real time solution your intervals are going to be every five meters in the vertical component 10 meters of the vertical component and then really in the horizontal component the work that we were familiar with they could be fairly regular so every again two to three to four meters or if you want to extend it it's how much time you want to give up access to that well to allow us to run the tool. If you're on a platform that's costing you a lot of money, you're not going to want to be sitting something too often but if you're offline and you're just running a coil tubing spread to get precise positioning of the wellbore then you consumed as often as you want. I think some of our runs were taking about 14-16 hours to deliver high-resolution data all the way through the wellbore.

Robert Estes –

In SAG-D, only ranging can provide the separations that are geologically needed over long measure depths.

Kevin Vickery –

I would suggest that perhaps we might disagree with that because if you are absolutely positioning your wellbore you've actually got the full trajectory of the wellbore, an absolute coordinate reference frame that will give depths and relative positions of those wellbores to each other.

Error Model Maintenance Committee Update

Andy McGregor

Error Model Sub-committee Meetings:

- Spring sub-committee meeting will be in 2 weeks

Since last main ISCWSA Sub-Committee Meeting:

- Sub-committee meeting (21 October 2021)
- Several meetings on side-track uncertainty working group
- Meeting of working group on breaking down models into component blocks

Revision 5:

- Major software teams are starting to implement
- Many operators keen to adopt Rev5 once software available
- Presentation created to help explain rationale for Rev5 to management
- Minor corrections to XLA term
- Conditions on SYM3/4E course length correction

Other Items:

- Effect of Rev5 on relative instrument performance models
- Addition of QA/QC terms to models
- Best practice document on handling site and slot uncertainty
- Best practice document selecting appropriate model for un-surveyed wells

PhD Thesis:

- Roger Ekseth's PhD thesis one of the foundations of the Error Model
- Along with SPE-67616 and 90408 contains a defining derivation of the mathematics
- Previously available from the university of Trondheim
- Makes it more widely and easily available

Working Group – Dynamic generation of Models:

- MWD models naturally breakdown into component groups
- Set of models is valid permutations of these
- Should we define our models this way
- Several software packages already do this
- Lengthy discussion about pros and cons from ISCWSA perspective

Working Group – Handling of errors in side-tracks:

- Collision avoidance test set includes a side-track well
- Inconsistency in handling errors for that well between software packages
- Setup a working group to recommend best practice
- 11 meetings

Calculation of side-track relative uncertainty:

- Existing method of calculating relative uncertainty will apply
- Repeatedly we found that there isn't much special about sidetracks
- Much detailed discussion over the specifics

Progress:

- Best practice document drafted
- Test cases & diagnostics
- Relative correlation
- Additional sidetrack cases

Questions:

Marc Willerth –

In addition to including QA/QC error magnitudes in the models, has there been any discussion of including weighted functions for common QA/QC criteria? Or is that still an exercise for the reader?

Andy McGregor –

We haven't really looked at putting the weighting functions into the positional tool model. I think the weighting functions themselves are detailed in the QA/QC papers. This was really about making sure that the numbers were available to drive them in the tool code itself.

Bill Allen –

Did I hear you mention RIP testing? Has the sub-committee completed any model vetting in the real world e.g., data redundancy comparisons between multiple survey systems?

Andy McGregor -

I did mention RIP testing. John Bang was looking at some RIP tests and found that rev5 seemed to loosen the criteria. We haven't completed any more model vetting in that way certainly not data redundancy comparisons. If any operator has done any of that and wants to present some results then I would be very interested in seeing that.

Harald Bolt –

Is there a reason why the error model subcommittee meeting is after the ISCWSA general meeting, rather than being before and being able to report more “RealTime”? Or is it just scheduling?

Andy McGregor –

The reason this meeting is late basically because I had COVID and in the period before the main meeting when I normally end up running around getting everything ready me and the whole family were not doing that well so I'm having that afterwards that's all. One of the things I think with online meetings is it doesn't matter quite so much when we have our meetings.

Bill Allen –

Is there a way of providing the RIP test data?

Andy McGregor –

There's nothing sorry, I was going to say there's nothing specified but I can get in touch with you if you've got some information on that and I suspect you might have, then we can maybe work out how to make it available and present it to the subcommittee.

Mohamed Elshabrawy-

Does the Rev5 error model set include GWD toolcodes? If yes, are they covering the new solid state technology tools on the market?

Andy McGregor –

I would recommend that people go to the service provider and I'm sure that they will have tool codes available. I know some of those gyro companies have been looking at updating their tool codes to be kind of rev5 compliant.

Automatic MWD Survey processing
Konstantin Bulychenkov

Vision of Automation:

- Human involving in case of issue only
- Automation goals

Visual diagram of survey workflow process

Automation cornerstones:

- Data validation
- Data filtering
- Algorithm robustness
- Quality analysis

Data Validation:

- Validation of internal data consistency
- Some cross-validation between different data classes

Data Filtering:

- MSA correction with extremely steadiness to bad surveys
- Keeping the surveys complying with standard MWD error model
- Steady to severe standing D&I errors
- Performing multi-dimensional analysis

Example of Data Filtering: Automatic MSA Filtering

Example of Data Filtering: Failed Axis Filtering and Analysis

Example of Data Filtering: Continuous Inclination Filter

Algorithm Robustness:

- MSA Correction
- High-Def Trajectory and BHA sag correction

MSA correction: Geomag:

- Reference drift causes 5-10% of total MSA issues
- Can be compensated by reference calculation along trajectory with high-def reference model

Example of MSA Correction: Novel Algorithm

Example of MSA Correction: EDI Model

MSA Correction: Steering Analysis:

- Calculates DLS performance based on BHA design
- Calculates projection and uncertainty for each station
- Provides information for linking all surveys to each other
- Verifies all survey links v MSA output based on uncertainty

Output Data QC: Dynamic FAC:

- Dynamically calculated based on MWD error model
- Reference error is global
- The base line is MSA corrected reference
- Separate QC for Total G, B, and DIP
- Provides a stricter quality control criterion

Output Data QC: Steering QC

- Calculates projected stations
- Checks if deviation of actual survey from its projection is within tolerance
- Allows to detect bad surveys
- Helps recognize poor BHA performance

External Control:

- Simple but essential check
- Controls trajectory deviation from plan in terms of inc and az
- Prevents unexpected issues

Summary:

- Full automation for the following correction route (see diagram)
- Autonomous work under normal condition with tolerating of noisy survey input, arbitrary data density, and strong DSI
- Human involved in case of non-compliance situation or issue only

Questions:

Knut Ness –

What would be the impact, if any, when we are moving to continuous MWD systems? And how do you propose to use within current IPM's?

Konstantin Bulychenkov –

It can be adapted in terms of MSA algorithm so it's not a big issue and regarding current IPM the system used I mean to propose that the standard recommendation on two codes based on actual error is the output. That totally compatible with the current software for solving collisions.

Robert Estes –

Does the “smooth inclination” curve obscure true doglegs/tortuosity?

Konstantin Bulychenkov –

Smoothing is based on dogleg constraints. it's calculated from BHA design so if you see some extremely high doglegs, it's most likely unreal because it'll keep the dogleg that can be provided by the current BHA.

Adrian Ledroz –

The size of the QC shaded area in blue seems large (slide 25). Is the size of the QC linked to an error model?

Konstantin Bulychenkov –

It's quality boundaries in terms of inclination, in other words, it's calculated or based on slide sheets. It is calculated based on the error model but between two neighbor surveys.

Harald Bolt –

Slide 14: "continuous inclination depth" and "static inclination depth" It looks like everything is logged to MD, so how does rig-state affect the outcome of the automated calculations?

Konstantin Bulychenkov –

Right now we do not address depths, but in terms of cont. inc that's aligning with static survey depths, and we understand that may be uncorrelated, but it generally does not affect our final trajectory.

Mike Attrell –

Do you have any comments on the suggested pitfalls/increased uncertainty of high definition TVD calculations that you had highlighted recently?

Konstantin Bulychenkov –

We used only continuous inclination for High-Def trajectory calculations because this issue. We don't use slidesheets, so I believe it's only one measurement I can do right now without some more complex algorithm.

Hans Dreisig –

You mentioned in the QA/QC section that it would come with a warning, so say if there's no warning from the QA/QC is there any manual intervention that is required?

Konstantin Bulychenkov –

Intervention is required only in case of some unresolved issue for instance if you if you have a failure of denied entry, and you start getting all sorts of warnings so the system will inform you that something is going wrong.

Webmaster Update –
Phil Harbidge

Website Hits:

- Events pages hit rate is comparable to October 2021
- Contact us is up
- Top 5 Pages hit rate is comparable to October 2021 hit rates

Subscribers to iscwsa.net page:

- Subcommittee chairpersons can now edit as Super Users

SPE Website:

- Links to join spe.org hosted WPTS
- You must be an SPE member to join technical sections and vote in our meetings

Education Subcommittee key words project

- Education SC project to update on Key Words project
- Increase searchability of our content, events, and training
- Education SC working on the complete set of key words

Other ISCWSA Social Media:

- No twitter traffic – to be shelved
- Small increase in membership to LinkedIn

Website Enhancements:

- Subcommittee chairs and member call for website functionality ideas
- Improvement meeting with Tendenci April 12th.

Questions:

Hans Dreisig –

Will the current sessions be archived and made available?

Phil Harbidge –

We requested that but there are some concerns about copyright, but this has all gone on live in the past using teams and I think some other system prior to. With no objections we will post the Youtube links.

COFFEE BREAK

Chained Multi-Single Station MWD Calculation Brett vanSteenwyk

Axial correction:

- Simple
- Extended

Fully Optimizing Gravity Solution

Fully Optimizing Azimuth Solution

Azimuth Errors:

- Basic
- Optimized

Chained Multi-Station run

Typical Readings at a Station

- Basic Solution

Chained Multi-Station Performance

Future Work:

- Solve "unstart" issue with Simplex sub-search
- Enable outlier determination
- Add external interference model

Questions:

Hans Dreisig –

What is the minimum number of stations needed to perform this correction? Is there a limit to how much range these surveys should be in.

Brett vanSteenwyk –

I would say seven or eight would be good enough. In this example it depends on how flexible the terms should be. You need to have a sense of how much you expect something to vary over combination of time and or distance and that is a direct input to the algorithm.

Education Subcommittee
Robert Wiley –

Agenda:

- Special sessions update
- Drillbotics competition
- PetroBowl
- ISCWSA Search functionality and documents tagging
- eBook Updates
- ISCWSA Course – Intro to Wellbore Surveying

ATCE Special Session:

- Proposal accepted for Special Session at ATCE 2022 in Houston
- Joint with DSATS
- Tuesday 4 October 2022
- How can we define a holistic set of common industry well parameters for reservoir sections that drive life cycle value?

Drillbotics Competition:

- Definition of what the competition is
- Outline of components to 2022 competition

Drillbotics Volunteer opportunities for ISCWSA:

- Competition Judges
- Table Attendants

Competition Schedule:

- Houston Texas
- Celle, Germany

Others:

- PetroBowl
- ISCWSA webpage search functionality is limited

eBooks update:

- ISCWSA hosting/copyright of eBooks
- eBook introduction to WBP Web Version is available
- eBook Well Interception transition to the web version will start soon
- Call for content updates eBook introduction to WBS
- Possible to provide feedback directly on the web version

ISCWSA Course Progress

- Course Director: Robert Wylie
- 11 Students graduated from first class

- Cohort #2 started on March 28th
- 7 modules, 1 per week
- Recommended 4 hours per week
- 14 students signed up
- Plan calls for 20 students per course
- Detailed updates to follow by Robert Wylie

Acknowledgement of attending members

Questions –

Carlos Contreras –

One the competition, can you comment on known participation of universities from South/Central America?

David Gutierrez –

Participation is from universities around the continental united states, Calgary, and a lot of the competition taking place in Europe has teams from Norway, Germany and it's quite a widespread geographic net.

Mike Attrell –

Is the course graded in a pass/fail manner, or is it graded based on completion/participation? Of those able to complete, did they have 100% completion rate?

Robert Wylie –

There was not 100% pass rate, but everyone that finished the course, passed. 11 out of 19 students passed the first course. The way we're grading the course is based on videos followed by quizzes and exercises and those are graded. The overall pass is the overall grade at the end of the course. It's set up to allow working people to participate. If someone is working offshore and can't get access, then there's a 3 week period where there's time to catch up. You can also drop the worst of your grades from the assessment. It's graded in a knowledge testing manner, continues assessment.

Harald Bolt –

Do I need to be involved in depth assignment?

Robert Wylie –

Thank you your work is a major contributor to the whole thing there and we need to review and have a look and see where this issue is with there's something Angus or yourself should be involved with over the next few weeks before the depth module is released again.

Membership Chair Update
Marc Willerth

Reminder to renew your SPE membership

Membership in 2021 is down again.
Silver lining is we may be starting to recover based off last few months.

Younger members less likely to have renewed

Breakdown by profession and regions

COFFEE BREAK

Modelling the Economic Impact of Spacing Uncertainty in Unconventional Long laterals due to Common Survey Practices
Nico Cosca

Reservoir Simulator:

- Lateral Separation
- Too close: hydraulic communication
- Too far: incomplete recovery
- Can we associate a dollar amount
- Conservative estimates

My Energy Bill is too high:

- Possible fixes
- My bill isn't going down
- What if I forgot to close the door
- Overly optimistic

Empirical Error Models:

- Error models developed by OWSG and ISCWSA
- Empirical Models based on more than 9000 Laterals
- Comparison of uncertainties with MWD, MWD+IFR1+MSA, EMPIRICAL

Example:

- Drill string interference: underestimated by more than 3X
- Separation confidence for parallel wells (10k' stepout)

Experiment:

- Create empirical MWD model
- Compare to classic MWD model recovery
- Compare to Survey Management recovery
- Other variables in simulator help compare effects of drilling procedure

Locations and Typical Azimuths

Other Variables:

- Lateral spacing
- Lateral length

North American Land average:

- Latitude 42.28°
- Azimuth 345°

Mean Production loss percentage from ideal for varying lateral lengths and toolcodes

Extreme Scenario: Canada

- Latitude 54.51°
- Azimuth 315°

The cost of optimism:

- For common spacing and lateral lengths
- MWD: Losses estimated to be 1-3% of ideal
- Empirically: closer to 2.5-5%
- Survey management and proper QC 0.5-1%

Losses increase Quickly

Increasing survey accuracy isn't just for collision or lease line avoidance

Better Surveys, better recovery

Questions:

Mike Attrell –

Is the empirical model utilizing a different set of error model terms, or is it utilizing the same framework as the ISCWSA MWD+IFR1+MS model with a modified amil term value?

Nico Cosca –

It's just a modified ISCWSA tool code. Not just the axial interference term is updated though, there are also cross-axial terms being updated. Declination you know especially latitude dependent error terms anything that has that b horizontal dependence in it is updated and all the details are in shuba's paper as well she shows how all the error models were created and updated.

Hans Dreisig –

Do you think when you say the North America empirical could some of the difference be that they're really covering surveys which have failed the basic qc test so you could say that they're covering gross error is included in them?

Nico Cosca –

The assumption here that we used is that the mwd surveys are free of gross errors. We you know made sure that there weren't any just crazy surveys that were out there. Traditionally speaking depending on our field acceptance criteria those MWD surveys could very much be failing FAC which is a really big benefit about survey management because in that case you try to make sure everything fits in those expectations.

Robert Estes –

Better wellbore positioning, including injector/producer spacing, is also very important in the now growing geothermal drilling industry.

Nico Cosca –

This is yeah just referring to the geothermal boom but yes absolutely and we're working very closely with some geothermal companies and wellbore placement is really important. It's the same thing with things like SAG-D, anything that actually requires you know placement to be more accurate. It's especially in real time while drilling it's a very powerful tool.

Konstantin Bulychenkov –

When you did the simulation could you consider absolute positional error or relative error affects relative positioning and losses. In this case IFR doesn't give any benefits.

Nico Cosca –

I believe Mike responded to part of this question just below it and that's a really good point using multi-station analysis with a low-resolution geomagnetic model that's a bad form. I would say so having an IFR geomagnetic model helps a lot for multi-station analysis. If you have incorrect declination estimates and you're now not running parallel but anti-parallel sort of how we mentioned having a better idea of declination can give us a better anticipation I would say of how those wells are going to either get closer together or drive a little further apart but that is very true so for example also I would expect the results if we were just to use that basic mwd tool code which I think the expectation there is that there's an IGRF geomagnetic model and then maybe compare those mwd results with an mwd plus a high resolution geomagnetic model we would see essentially no differences but then what's important is to then compare it to something with stringent survey corrections kind of rigorous qc methods and mark has added that the simulation is a monte-carlo simulation, so the errors are generated for the error model and stations are simulated, distances between the wells are estimated so correlation effects are accounted for. I think I actually also have a correlation that was included there too.

Robert Estes –

For the real world, where MWD tools are often swapped from run to run or well to well, it may be dangerous to assume offset errors are correlated.

Nico Cosca –

I believe that the correlated errors are more the geomagnetic terms that would stay constant run to run but that is a good point too. We wouldn't want to assume any correlation between errors that can change between bit runs.

Robert Wylie –

I saw your presentation down in Galveston. I thought it was very interesting and always very enjoyable. I love your style but the material you've got there is something that we're really trying to get to in terms of value of what we do and have you any thoughts or ideas and how we as a group can help promote that to the rest of the industry to try and get their attention to do things right or better?

Nico Cosca –

It's kind of a first step to have something to actually cite like a lot of the comments said there's certainly some improvements that could be made and some ways that we could expand the study as well. I think talking about things like TVD kind of generalizing this in

our z-axis talking potentially about survey frequency but I know there's some limitations there when it comes to error models that we talk about surveys that are spaced closer but I think it's really just a first step into actually having something to reference for the future but in terms of reaching out to a greater audience I'm not too sure.

Robert Wylie –

It kind of frustrates me when I see so many papers or presentations on frac hits and people are going well what's happening I'm thinking go talk to Nico. Where is your well really and you know how many people these frat kid presentations really understand what's going on down there.

Nico Cosca –

Well, I think that's something. Marc Willerth brings up this study a lot from back in the day, I think it was a school of mind study but they were looking at potential geo-mechanical issues because their fracs were starting to deviate way off towards the toe of their well and his point is always well they didn't even look into wellbore placement. It'd be such an easy demonstration that hey maybe your well just drifted. If you had a one degree correction for the length of your lateral and here we are it's a lot easier to explain like that and have you know really complicated 20-page geo-mechanical explanation.

Robert Wylie –

I think maybe I'll ask the education subcommittee to consider maybe doing a webinar on this topic if you'd be willing to participate.

Hans Dreisig –

I have a question or a comment which goes along the same and it's unfortunate my knowledge to statistics is common sense which quite often I'm told is not correct, but we have the problem that we know that we have shown we're assuming a normal distribution because we're talking about one two and three sigma, and at the same time we've shown that the data set shows it's not. If you want to do statistics in excel and do common distributions of two effects it's easier to do it if you assume normal distribution. What I've done that is rather than talk to the geologists where they have a 2d target and a 3d target actually start talking about well if our center to center is this then assuming we have two normal distributions with a perfect center to center of this the probability of being x feet away is this the probability of being this much away.

Brett –

Hopefully there's a central limit there to apply.

Nico –

I think at least the normal distribution typically gives us a more conservative estimate of our results. I think it's probably more prudent to always go with a conservative estimate, under promise if you will, and hopefully over deliver, but I think it's always probably a better case scenario to go a little bit more on the cautious side. There was some analysis in that paper that Shuba Love did that created the empirical model that looked at what sort of distribution some of the errors fit in and that's probably about the best information we have and what kind of distributions actually apply, but I think you get to a point where the most you can see is we probably have more results out in the tails of these distributions than you would expect from the normal distribution.

Brett –

You don't want to ask too much of it. You don't want to get way out into very low probabilities you'll be out in the tail and that's where it's going to bite you.

Hans –

I think some of the papers I've seen are showing that you have more being close and then when you get an outlier it's really an outlier.

Nico –

Especially when it comes to actual magnitude of things like drill string interference that we talk about a lot the tails are really heavy and there are some pretty wild outliers

Hans Closed Day 1 Meeting