OWSG GENERAL MEETING

February 7, 2023

8:00 am CDT Start Time

Jonathan Lightfoot

Sub-Committee Chair

AGENDA

- OWSG Mission & Anti-Trust
- API RP-78 Update
- AADE Intro Paper to RP78
- Featured Topic: Maximum Survey Interval
- Topics & Questions (T & Q's)
  - Models-Movement-Data-Dispensation
- Upcoming Events
- Open Discussion Session

Our Mission

To promote practices that provide confidence that reported wellbore positions are within their stated uncertainty.

Anti-Trust

We are meeting to help develop and promote good practices in wellbore surveying necessary to support wellbore construction which enhance safety and competition.

The meeting will be conducted in compliance with all laws including the antitrust laws, both state and federal. We will not discuss prices paid to suppliers or charged to customers nor will we endorse or disparage vendors or goods or services, divide markets, or discuss with whom we will or will not do business, nor other specific commercial terms, because these are matters for each company or individual to independently evaluate and determine.

Introductions

- Name
- Company Affiliation

Attendees – Feb 7, 2023

Name	Operator Affiliation	Email
Jonathan Lightfoot	Oxy	Jonathan_lightfoot@oxy.com
Will Tank	Oxy	Willard_Tank@oxy.com
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Tim Paton	Superior QC	timothy.paton@superiorqc.com
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Jerry Codling	Halliburton	Jerry.Codling@hallibrton.com
Adrian Ledroz	Gyrodata	AdrianI@GYRODATA.com

API RP78

SPE-204027-MS

Some Technical and Economic Consequences of Directional Drilling and Surveying Progress and Success

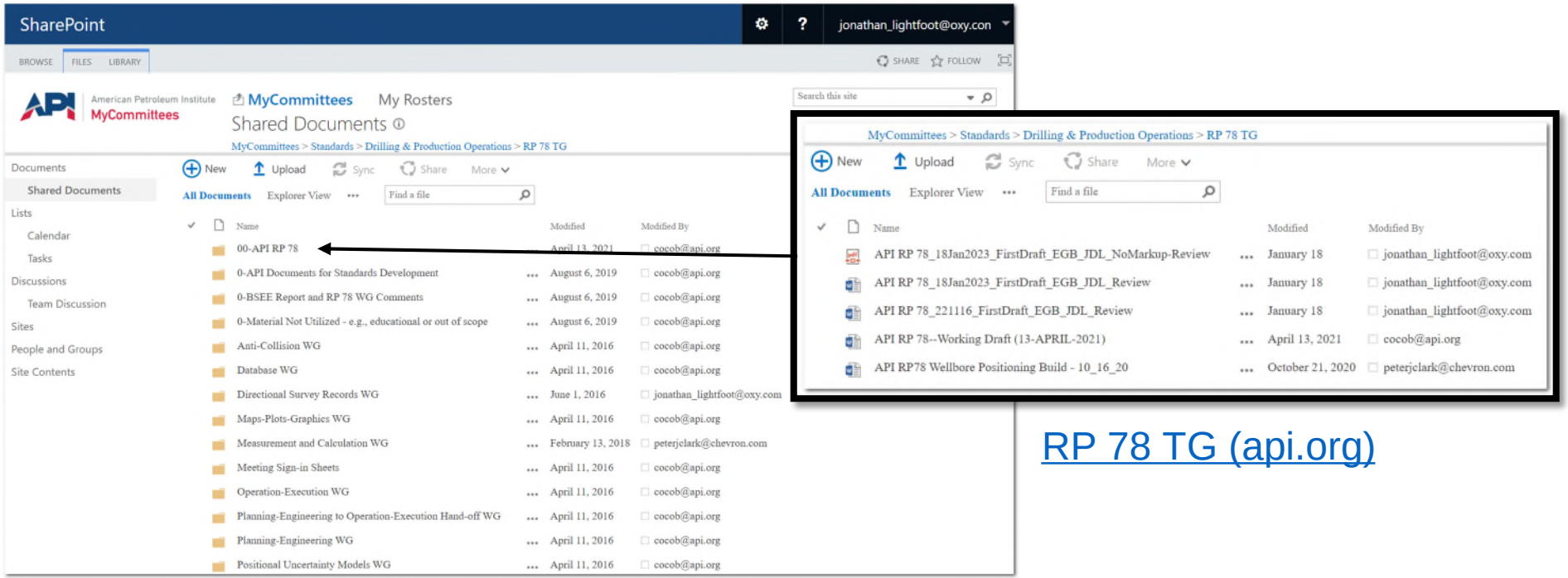
Steven J. Sawaryn; Ross Lowdon; John L. Thorogood

Paper presented at the SPE/IADC International Drilling Conference and Exhibition, Virtual, March 2021.
Paper Number: SPE-204027-MS
https://doi.org/10.2118/204027-MS
Published: March 08 2021

The Operator Wellbore Survey Group (OWSG) was established as a sub-committee in 2012 to table and prioritize operator needs. One of the early deliverables was a larger set of generic error models covering a wider range of tools. The set is now under the control of the Error Model sub-committee and is documented, together with implementation notes and test cases on the website (McGregor 2020). The latest sub-committee to be formed is the Survey QA/QC in 2019, recognizing the need for QA/QC and survey data standards, including nomenclature, service records and data transfer formats. This sub-committee is building on the ideas of a WPTS working group which was established in 2005 and then disbanded after publishing its findings (Ekseth et al. 2009). The sub-committee's aim is to publish a survey QA/QC e-book, adding further to the technical section's maintenance commitment. This maintenance burden increases in proportion to the number of sub-committees and the constantly evolving technical content.

API RP78 – Editing for Ballot

API RP78 TG – Technical Group TeamSite



[RP 78 TG (api.org)]

WELLBORE POSITIONING API TG SHAREPOINT

https://mycommittees.api.org/standards/scdpo/rp78tg/default.aspx

Introduction to API RP 78, Wellbore Surveying and Positioning

Abstract

The American Petroleum Institute (API) recently undertook development of a document called Recommended Practice 78, *Wellbore Surveying and Positioning*, (RP 78), a modern technical industry standard for wellbore placement that can be applied to all wellbore construction applications. The standard is intended to serve as the primary technical reference for proven engineering practices in the application of oil and gas, geothermal, carbon sequestration, coalbed methane (CBM), horizontal directional drilling (HDD) trenchless boring, mineral ventilation and extraction, scientific coring, and all other subsurface borehole construction applications.

API RP 78's development was led by a group of independent consultants, industry experts, academia, and representatives from public and private energy operators. The Operator's Wellbore Survey Group (OWSG), that later became an official sub-committee of the Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA), initiated the project after a poll of operator members showed the need for a set of minimum industry requirements for wellbore construction, safe-separation, and positioning. The ISCWSA is equivalent to the Society of Petroleum Engineers (SPE) Wellbore Positioning Technical Section (WPTS). The establishment of this standard, made available through API's standards development process, will provide modern practices for all subsurface boring industries, beyond just oil and gas applications.

AADE-23-NTCE-073

AADE AMERICAN ASSOCIATION OF DRILLING ENGINEERS

Introduction to API RP 78, *Wellbore Surveying and Positioning*

Jonathan D. Lightfoot and Will Tank, Oxy; Ben Coco, API

Abstract

The American Petroleum Institute (API) recently undertook development of a document called Recommended Practice 78, *Wellbore Surveying and Positioning*, (RP 78), a modern technical industry standard for wellbore placement that can be applied to all wellbore construction applications. The standard is intended to serve as the primary technical reference for proven engineering practices in the application of oil and gas, geothermal, carbon sequestration, coalbed methane (CBM), horizontal directional drilling (HDD) trenchless boring, mineral ventilation and extraction, scientific coring, and all other subsurface borehole construction applications.

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We are meeting to help develop and promote good practices in wellbore surveying necessary to support wellbore construction which enhance safety and competition. The meeting will be conducted in compliance with all laws including the antitrust laws, both state and federal. We will not discuss prices paid to suppliers or charged to customers nor will we endorse or disparage suppliers' goods or services, divide markets, or exclude with whom we will or will not do business, nor other specific commercial terms. Decisions about these matters for each company or individual are independently evaluate and determined.

Introduction

In 2012, the OWSG was formed to bring oil and gas operators together for more frequent collaboration. The group aimed to prioritize operator needs and initially met monthly in Houston, Texas, with operators taking turns as hosts. The OWSG established a mission statement and an anti-trust statement which remain unchanged today.

The mission of the OWSG is to enhance confidence in wellbore positional accuracy by promoting best practices in directional surveying. This involves calculating wellbore positional uncertainty, also known as error models, using directional survey software programs.

To comply with anti-trust laws, the following anti-trust statement is read at the start of every OWSG meeting to ensure attendees understand the rules and regulations governing the meeting:

- Virtual meetings are now held online every other month and are open to anyone as opposed to previously being exclusive to oil and gas exploration and production operators. Presentations and past meeting minutes are posted on the ISCWSA website, and those interested in participating can request to be added to the distribution list through the website.

OWSG Focus Areas and Initiatives

The need for a standard set of position uncertainty models, also known as error models, became a priority at early meetings. Error models, also called instrument performance models (IPM) play a crucial role in the management of directional survey operations (Thorogood et al, 1990). Another common name for an error model is a positional uncertainty model (PUM). Examples of instruments that require error models include conventional legacy film-based instruments, modern electronic magnetic tools, and gyroscopic survey systems.

Some of these models serve only a utility purpose and are not based on survey instruments. These include:

- Inclination-Only Planning – A method for near-vertical wellbore paths based on departure trend analysis from field studies.
- Blind Model – A conservative model applied to long intervals without directional survey data.
- Unknown Model – A conservative instrument performance model used when data is available but key attributes are missing.
- Zero-error Model – A utility commonly used for wellbore paths which need to avoid subsurface hazards or follow specific boundaries such as hardlines.

Separation Factor (SF) is a ratio of separation distance to combined uncertainty of subsurface proximity analysis for drilling and planning. Error models generate ellipsoids and are included as the denominator of the SF calculation The closest distance between wellbores is used as the SF numerator and termed the center to center least-distance or closest approach. The WPTS Error Model Maintenance Sub-Committee previously maintained a set of error models based on the industry standard Accuracy Prediction for Directional MWD (Williamson et al, 1999).

In addition, another challenge presented itself because of unintentional reliance on invalid and inconsistent models from various sources. Before the MWD model, uncertainty calculations were based on the now retired Wolff and de Wardt (WdW) systematic model (Wolff et al, 1981). Developed in the 1990's, the WdW systematic method was still used in the application of modern gyro instruments. However, these advanced gyros were different from the conventional film-based gyros covered in the systematic method. WdW continued to be used for modern gyro instruments like advanced inertial and true north-seeking earth-rate gyros until a new key industry paper was authored establishing a framework for all gyros (Torkildsen et al, 2004).

The elementary half-percent calculation method is another separation rule used in the industry. This method calculates the separation distance based on one-half percent of the measured depth (MD) resulting in a linear slope of five feet of separation per thousand feet of depth along the borehole but does not consider wellbore position uncertainty and is based on practical experience rather than engineering theory or measurement. For example, at 10,000 ft MD, the separation distance would need to be at least 50 ft, while at 15,000 ft MD, it would need to be at least 75 ft. While still in use today, depth-based rules are secondary to SF rules and are mainly used to complement them.

Another important issue raised by operators focused on the improper application of the standard MWD model. It became apparent that because the industry had been using this model with low-resolution references, unrealistic position confidence was occurring, and a need existed to take advantage of the improved magnetic models. The MWD error model was modified to accommodate both the low resolution (LRGM) and high resolution (HRGM) geomagnetic models. The original MWD model assumes the use of a standard resolution geomagnetic model (SRGM). The common SRGM is the BGGM crustal field model developed by BGS, and it determines local magnetic reference values. Geomagnetic models are used to calculate the magnetic declination correction crucial for directional and horizontal well surveys and is the primary source of lateral uncertainty. The date-sensitive reference values, including magnetic dip angle and total magnetic field strength, are crucial for quality control and meeting field acceptance criteria.

The industry faced a new challenge with the need to adopt improved magnetic models such as NOAA's HDGM (Maus et al, 2012). This new model contains detailed information on the Earth's main magnetic and crustal fields derived from satellite and sea vessel measurements and is updated annually to correct for changes over time. However, at the time the MWD model was not designed to accommodate a LRGM and HRGM such as WMM or IGRF and HDGM, respectively.

A vital need arose to adopt the improved magnetic models. Most operators relied on magnetic models supplied by vendors or software providers leading to inconsistency between planning and drilling operations.

OWSG Error Models

The OWSG set of error models (Rev2) was developed to establish consistency among operators and service providers (Grindrod et al, 2016). The paper defines five primary sets:

Set A: Standard
Set B: Extended
Set C: Vendor-supplied
Set D: In-house validation
Set E: Prototypes in development

The OWSG models were updated in June 2015 with a model selection guide and standardized naming structure. Meanwhile, the ISCWSA MWD models were updated to Rev4 from the original Rev0 in 1999 and were included in OWSG Rev2.

The OWSG models were handed over at the 50th ISCWSA meeting and are now stewarded by Error Model Maintenance Sub-Committee (EMM_SC). The latest revision (updated September 2022) is referred to as ISCWSA Revision 5-1, and the OWSG is no longer used in the model naming. The latest ISCWSA generic tool codes are available on the ISCWSA website in Excel workbooks for easy download. The update includes generic reference names for low, standard, and high-resolution reference models, and details for five primary geomagnetic reference categories can be found on the ISCWSA EMM_SC website including power spectrum degree and update rate requirements.

The OWSG meetings continued discussions related to the need for establishing standard engineering practices survey data management, directional planning, collision avoidance, and drilling near offset wells. Conversations centered around the need for joint survey operating and reporting procedures (JSORP) to confirm calculated wellbore position and estimated uncertainty. The requirement for raw sensor measurements (RSM) to independently process surveys was discussed because service providers were not consistently reporting RSM. This led to improved survey reporting requirements with more reference information. Desired post-job reports included BHA details, steering reports, tool calibration, estimated uncertainty, and quality control plots. A final survey program with a specified error model was required for loading into a survey management database.

AADE National Technical Conference and Exhibition

Original RP78 Contributions

Section	Leader	Technical
Anti-Collision	Steven Sawaryn	Pete Clark
Database	Jordon Meyer / Mary Malihpour	Maria French
Directional Survey Records	Jonathan Lightfoot	Michael Long
Glossary	Son Pham	Maria French
Maps, Plots and Visualization	William Allen	Kevin McClard
Operation / Execution	Ed Dew	Benny Poedjono
Planning / Engineering	Pete Clark	Julie Cruse
Purpose and Scope	Ben Coco	Jonathan Lightfoot
QA/QC Depth	Roger Goobie	Harold Bolt
QA/QC Gyro	Roger Goobie	Adrian Ledroz
QA/QC Magnetic	Roger Goobie	Andy Brooks
Software	Bill Allen	Stuart Sargent
Survey Mathematics	Pete Clark	Chad Hanak
Survey Program	Lisa Grant	Ross Lowdon
Transition / Handover	Will Tank	Benny Poedjono
Well Origin / Surface Location	Bert Kampes	John Connor

Missing RP78 Contributors Missing?

Special recognition for Steven J. Sawaryn, Pete Clark and Lisa Grant for their invaluable contributions.

The authors recognize and are grateful for the significant contributions of the many other individuals who made API RP 78 possible. In alphabetical order, the authors would like to acknowledge Adrian Ledroz, Alba Arroyo, AnaS Sikal, Andy Brooks, Andy McGregor, Andy Sentance, Angus Jamieson, Aprameya Murali Dhara, Avinash Ramjit, Ben Hawkinson, Benny Poedjono, Bert Kampes, Bill Elks, Brett Van Steenwyk, Carol Mann, Chad Hanak, Chris Chia, Collins Nwaneri, Dalis Deliu, Darren Aklestad, David Barker, David Forsynth, David Gibson, Deepak Gala, DJ Gonzalez, Ed Dew, Edgard Castillo, Erik Nyrnes, Fauzia Waluyo, Gary Skinner, Grant Ohlms, Hans Christian Groenlund Dreisig, Harold Bolt, Harry Schaepsmeyer, Harry Wilson, Heather Vannoy, Hoimero Castillo, Ian Mitchell, James Towle, Jeanne Perdue, Jerry Codling, Jim Stolle, John Banks, John Conner, John Thorogood, John Weston, Jon Bang, Jonathan D. Lightfoot, Jonathan Ruszka, Jordan Meyer, Jose Perez, Josh Weston, Julie Cruse, Keith Kenny, Keith Modesitt, Kevin Armstrong, Kevin Corrigan, Kevin McClard, Knut Johannes Ness, Lee Pendegraft, Lee Roitberg, Ludovic Macresy, Mahmoud ElGizawy, Marc Willerth, Maria Elizabeth Sanchez, Maria French, Mark Mitchell, Martin Emery, Martin Storey, Mary Malihpour, Michael Carney, Michael Donahue, Michael Long, Mike Attrell, Mike Nero, Mike Terpening, Mohammed Sabeti, Nathaniel Burger, Neil Bergstrom, Nestor Sanchez, Nicholas Rigard, Nicholas Robertson, Nicolas Rigard, Patrick Walker, Paul Daley, Paul Lampert, Paul Pierron, Paul Strohmeier, Penny Dailey, Pete Schiermeier, Peter Kowalchk, Philip Harbidge, Philippe Theys, Richard Matthews, Rick Gade, Rob Shoup, Robert Estes, Robert Wylie, Roger Goobie, Roland Goodman, Rolando Suarez, Ross Lowdon, Ryan Carlson, Ryan Kirby, Scott Birse, Scott Farmer, Serko Sarian, Shaun St. Louis, Shawn Deverse, Son V. Pham, Stefan Maus, Stephen D'Aunoy, Steve Grindrod, Steve Mullin, Steven Stith, Stuart Sargent, Sue-Ann Marquis, Sven-Erilk Foyn, Ted Koon, Tim French, Tim Price, Tod McKenzie, Torgeir Torkildsen, Ty Mitschke, Vishwas Paul Gupta, Walter Jardine, Weiwei Wu, Will Tank, and William T. Allen.

Topics & Questions

1. Survey Interval Discussion
2. Plans for implementing Revision 5-1
3. Moving data from one system to another
    1. P7-17 Exchange Format
4. Using Industry data sources for validation / checks
5. The Geosteering Anti-Collision Dispensation
    - Practice – Challenges – Concerns

SURVEY INTERVAL

SURVEY INTERVAL
How is implementation going?

Sawaryn, S. J., Wilson, H.. , Allen, W. T., Clark, P. J., Mitchell, I.. , Codling, J.. , Sentance, A.. , Poedjono, B.. , Lowdon, R.. , Bang, J.. , and E.. Nyrnes. "Well-Collision-Avoidance Management and Principles." *SPE Drill & Compl* 33 (2018): 335–350. doi: https://doi.org/10.2118/184730-PA

SPE Paper Number: SPE-184730-PA

Surveying Interval. The following recommendations for the maximum-survey interval are intended only for safe-separation and collision avoidance (**Table 3**). They do not address the requirements for routine drilling and meeting other well objectives such as targets. To be valid, all surveys are required to pass the defined quality-control criteria for the survey tools used and the applied IPMs. In general, the survey frequency increases with increasing dogleg severity (DLS) and decreasing SF. The intervals may be adjusted for nonstandard tool joints or stands (Double, Triple, Quad, and Range I, II, III). For details of pipe lengths, see *API RP 7G* (2015). The intervals may also be extended where the continued divergence of the reference well from all the offset wells has been firmly established.

Maximum-Survey Interval (ft)		DLS (degrees/100-ft MD)		
		<1	1–5	>5
SF (-)	>2	200	100	33
	1.5–2	100	100	33
	<1.5	33	33	33

Table 3—Recommended maximum survey interval for safe separation and collision avoidance.

For any steered section, a maximum survey interval of 100 ft is recommended. Consideration should be given to taking additional surveys at the end of a steered interval to ensure that trajectory trends and BHA directional tendency are understood. Note that these trends might change as the well profile, drilling parameters, or formation changes, or the BHA wears. If a survey indicates unexpected magnetic interference, then it is prudent to pull back and survey rather than drill forward and survey. The ladder plot showing the equivalent magnetic field contributed by the adjacent wells, referred to later in this paper, can be helpful in assessing the situation. A detailed study of the variation of survey accuracy with respect to survey interval over a wide range of conditions is presented by Codling (2017).

A recent report commissioned by the US Department of the Interior Bureau of Safety and Environmental Enforcement (BSEE) has recommended a blanket maximum survey interval of 100 ft (ICF International 2016).

Maximum-Survey Interval (ft)		DLS (degrees/100-ft MD)		
		<1	1–5	>5
SF (-)	>2	200	100	33
	1.5–2	100	100	33
	<1.5	33	33	33

Table 3—Recommended maximum survey interval for safe separation and collision avoidance.

SURVEY INTERVAL – Challenges & Barriers

- Implementation Strategy
- Barriers
- Success
- Change Management
- Error Models
  - Continuous
  - Modeled / Synthetic
  - Motor / RSS
  - MWT (MW-Trip)
- Operator Needs
- Recommend CA_SC Perform a Fresh Look at the Table & Guidance Prior to final RP78 Publication
- Balloting will likely flush out further opinions on this guidance.

Maximum Survey Interval [ft]		DLS [deg/100ft MD]		
		<1	1 - 5	>5
SF [-]	>2	200	100	33
	1.5 - 2	100	100	33
	<1.5	33	33	33

Table. 2 - Recommended maximum survey interval for safe-separation and collision avoidance

SURVEY INTERVAL – HOW ARE WE DOING?

- Implementation Strategy
- Barriers
- Success
- Change Management
- Error Models
  - Continuous
  - Modeled / Synthetic
  - Motor / RSS
  - MWT (MW-Trip)
- Operator Needs

4.9.7.2 Surveying Interval

The following recommendations for the maximum survey interval are intended only for safe-separation and collision avoidance, Table 7. They do not address the requirements for routine drilling and meeting other well objectives such as targets. To be valid, all surveys are required to pass the defined QC criteria for the survey tools and positional uncertainty model being used. In general, the survey frequency increases with increasing dogleg severity (DLS) and decreasing SF. The intervals may be adjusted for nonstandard tool joints or stands (Double, Triple, Quad, and Range I, II, III) as detailed in API 7G (2015). These intervals may also be extended when there is firmly established and continued divergence of the reference well from all HSE risk classified offset wells.

Table 7—Recommended Maximum Survey Interval for Safe Separation and Collision Avoidance

Maximum Survey Interval [ft]		DLS [deg/100ft MD]		
		< 1	1 – 5	> 5
SF [-]	> 2	200	100	–3
	1.5 - 2	100	100	33
	< 1.5	33	33	33

For any steered interval of hole, a maximum survey interval of 100 ft is recommended. Consideration should be given to taking additional surveys at the end of a steered interval to ensure trajectory trends and BHA directional tendency are understood, as these may change as the well profile, drilling parameters, or formation changes or if the BHA wears. If a survey indicates unexpected magnetic interference, then it is recommended to pull back and perform additional survey(s) rather than drilling forward and surveying. The ladder plot showing the equivalent magnetic field contributed by the adjacent wells, referred to later in this section, is recommended in this situation.

STD / JSORP EXAMPLE TABLE w/ Mgmt. of Change

Example of RMSI Implementation

- Approval Levels
- Per Tool Joint rather than 33ft.
- SF>4, Reg. / Rules

Required Maximum Survey Interval (RMSI) for Collision Avoidance

Separation Factor (SF)	DLS [deg/100ft MD]			MOC Level
	< 1.0 Tangent	1.0 to 6.0 Long Radius	> 6.0 Medium Radius	Approval Level Required to break RMSI
SF > 4.0	As per Regulatory Requirements			5
2.0 < SF ≤ 4.0	200	100	per joint	2
1.5 < SF ≤ 2.0	100	100	per joint	3
1.0 < SF ≤ 1.5	100	100	per joint	3
SF ≤ 1.0	100	per joint	per joint	4

RMSI STD or JSORP Example Table

Survey Interval Discussion Points

- The maximum surveying interval (course-length) is necessary from the surface to the planned crossing, intercept or closest approach point. The survey interval may be extended once the divergence of the reference well from all the offset wells is firmly established and the separation factor exceeds 1.5. The separation factors listed in table represent the lowest separation factor for the planned well and should be applied to all sections of the wellbore, both ahead of and during the close approach section.
- A maximum survey interval of 100ft is recommended for any steered section, and surveys should either be taken or modeled (synthetic) at the end of the interval to understand trajectory trends and BHA directional tendency while steering and not-steering. It is important to note that trends may change due to changes in well profile, drilling parameters, BHA wear, or formation changes***. If magnetic interference is detected, it is advisable to pull back and survey instead of drilling forward.***
- In general, the survey frequency increases with increasing DLS and decreasing SF, and intervals should be adjusted for non-standard tool joints or stands. Continuous high-definition MWD or MWT magnetic or earth-rate gyro surveying is acceptable as a means of reducing the survey interval.

Stored (Memory) Survey Interval – An Option

- Stored surveys from downhole tool memory may also be used to meet the RMSI requirements, so long as the wellbore section using memory surveys is ahead of the close approach interval (SF<2). Memory data should be incorporated before the close-approach interval when used in conjunction with static surveys or used instead of actual stationary surveys.

Alternative Survey Interval Option - Modeling

- An alternative method to meet the RMSI is the use of synthetic or simulated directional surveys, which is an acceptable method for adding additional projected surveys to the survey program while drilling. Simulated surveys are added by examining steered and non-steered intervals for rotary steerable or steerable motors and using advanced data analytics modeling to create computer-generated surveys.

Topics & Questions (T&Q)

1. Plans for implementing Revision 5-1
    1. 2023 Q2 & Q4 and some Operators with no plans at this time. Discussed Grindrod's model comparisons available on the Error Model Maintenance Sub-Committee Portal
2. Moving data from one system to another
    1. P7-17 Exchange Format
    2. RP78 Directional Survey Records
    3. Database exports with scrub features for removing engineering and operational data

Topics & Questions

1. Using Industry data sources for validation / checks
   - Drift Studies discussed using Physical Records with OCR & Code
   - Database secondary validation
   - Regulatory / Subscription Data Verification Checks
2. The Geosteering Anti-Collision Dispensation
   - Practice – Challenges – Concerns
   - Technical Publication Search & Workgroup to draft recommended dispensation guidance for this process

Geothermal Seminar 2023

Aberdeen Section
www.spe-uk.org

- **Webinar hosted by the Aberdeen Section**
  - Wednesday February 22, 2023 at 8:00 am
  - Thursday February 23, 2023 at 5:00 pm
- After the success of the inaugural event in 2022, SPE Aberdeen's Geothermal Seminar will return in February 2023. Building on the content of the last event and the opportunity it provided to explore the role of geothermal in the energy transition, this year's event will delve deeper into realizing the ambitions of the sector. The Seminar will feature a combination of case studies, panel sessions, and technologies and will be relevant to a broad range of people from energy professionals, thought leaders, those looking to transition, to those just eager to learn more.

- ISCWSA Mtg. # 57
- Stavanger, Norway
- Hosted by Equinor at their Business Center in Stavanger
- March 9th – Sub-Committee Mtgs.
- March 10th – General Meeting

- AADE National Technical Conference and Exhibition
  - April 4th & 5th – Midland, TX | NTCE

Discussion
Future Topics
Questions

Thank you

Next Meeting: March 28, 2023