



Integrated Reservoir Management
Technical Section

Solutions.
People.
Energy.SM

SPE Integrated Reservoir Management Technical Section (IRMTS)

Newsletter

APRIL 2026
ISSUE 05

Editorial Team:

Shubham Patel, Reliance Industries
Sydney Nassanga, JEP A Africa
Ameen Ahmed, Anton Oil
Wamuyu Miano, Kenyatta University
Vera Dogo, TechnipFMC
Parag H. Bhoriana, Shell
Muhammad Navaid Khan, ADNOC

INSIDE THIS EDITION

1

CHAIRMAN'S MESSAGE

2

HONORING EXCELLENCE IN VOLUNTEER SERVICE

3

IRM IN ACTION: DECISIONS UNDER UNCERTAINTY — INSIGHTS FROM A MAJOR IOC SUBSURFACE LEADER

4

YOUTH IN IRM: A CONVERSATION WITH SPE LEADERSHIP

5

BRIDGING THE GAP: STUDENT INSIGHTS, BARRIERS, AND PATHWAYS FORWARD

6

SPE WEBINARS AND LIVE EVENTS: Q1 2026

7

EXPERT INSIGHTS:

- **THE BRIDGE BETWEEN CONVENTIONAL AND UNCONVENTIONAL STIMULATION TECHNOLOGIES**
- **DISTRIBUTED FIBER OPTICS SENSING MASTERCLASS: FROM THEORY TO APPLICATIONS**
- **ENSEMBLE HISTORY MATCHING AND OPTIMIZATION**

8

TRIVIA AND READS: ENERGY & ENLIGHTENMENT

9

SPOTLIGHT PUBLICATION: NEXT GENERATION COMPLETION WORKFLOW

10

SPE IRMTS IN PICTURES — THE KICKOFF OF 2026

11

OUR SPONSORS

12

FROM THE EDITORS' DESK

13

UPCOMING SPE INTERNATIONAL EVENTS

Chairman's Message



“As decisions become more complex and consequential, integration is what enables clarity and confidence at speed.”

Muhammad Navaid Khan, Chair, IRMTS

Over the past quarter, the decisions our industry faces have become harder. Energy supply disruptions are pushing producers to accelerate output, often beyond comfortable operating limits. The real challenge is not the response itself, but the uncertainty around how long it must be sustained.

That uncertainty does not lead to a single question, it leads to a cascade of them. How far can we push production without damaging reservoir performance? Which wells do we prioritize, and which do we protect? What projects should advance, and what must wait? And how do we make these calls knowing that today's decisions will shape recovery and flexibility for years to come?

In this environment, revisiting the risk matrix through an integrated lens, one that connects technical, commercial, and geopolitical variables, is not a luxury. It is the starting point for sound decisions in an imperfect world, grounded in the periodic, cross-portfolio reviews of wells, reservoirs, facilities, and projects that sit at the core of integrated reservoir management.

Integrated thinking is essential to navigating these moments responsibly, and it only delivers when applied through disciplined, cross-portfolio review. This is where IRMTS is focused, and what our community continues to demonstrate quarter by quarter.

The growth of our community is genuinely encouraging. We have now reached over 6,000 members globally. What stands out most is student participation, which has grown more than tenfold and now exceeds 1,500 members.

The next generation is not waiting to be convinced of integrated thinking. They are already adopting it, stepping in early and learning to connect disciplines before they enter the workforce.

In Q1 2026, we collaborated with **10 professional communities** and engaged SPE leadership on youth activities, and both efforts will continue to grow through the rest of the year.

None of this happens without people. I sincerely thank my team and everyone who has been building this with us, often quietly behind the scenes. Our volunteers, speakers, and collaborators are the reason this community is real and not just a network.

Moving forward, the ask is simple: work more closely across disciplines. Build a deeper understanding of each piece of the system, not just your own. **Learn to optimize for the whole rather than the component.** That shift in thinking is what integration actually means in practice, and it starts with each of us.

Remember, we are not just building a community. **We are defining how decisions are made when there is no perfect answer. That is where integration matters most.**

Regards,

Muhammad Navaid Khan



Honoring Excellence in Volunteer Service



Teodor Damian
Shell

Teodor, in his role as the SPE IRMTS Reservoir Evaluation Champion, has taken a leading hand in shaping high-quality technical sessions that elevate IRMTS standards and deepen collaboration with European societies, helping broaden SPE's presence beyond its traditional community.



Ameen Ahmed
Anton Oil

Ameen has been a driving force behind SPE IRMTS Communications, collaborating on the delivery of the 4th and 5th IRMTS Newsletters and refining insights from major technical events into clear, high-value content that enhanced IRMTS outreach.



Maryvi Martinez Santiago
ADNOC

Maryvi, serving as the SPE IRMTS Sponsorship Champion, has actively strengthened the connection between the IRMTS Board and the Section's sponsors. Her sense of ownership and forward-leaning engagement have ensured reliable fulfillment of commitments, with ongoing renewals demonstrating the confidence placed in her and the robustness of IRMTS-sponsor relationships.



Wamuyu Miano
Kenyatta University

Miano's efforts in social media and student engagement have significantly strengthened the link between academia and the technical community, translating complex ideas into clear, engaging insights that have elevated student participation.



Sydney Nassanga
JEPA Africa

Sydney has elevated the SPE IRMTS Newsletter through her work as the Newsletter Champion, shaping the 5th edition into a more engaging and insightful publication. Her attention to editorial quality, coordination with contributors, and alignment with IRMTS priorities has strengthened the newsletter's overall impact.



Elhans Imanovs
Equinor

Elhans serves as the SPE IRMTS Europe Regional Champion, actively supporting technical sessions through event leadership, strengthening student engagement, and coordinating initiatives that empower the next generation of energy leaders.

IRM in Action: Decisions Under Uncertainty – Insights from a Major IOC Subsurface Leader

Integrated Reservoir Management is often discussed in terms of data, models, and workflows. In practice, its value is not defined by the quality of these elements, but by the decisions they enable.

In this edition of **IRM in Action**, we speak with **Sam Perkins, Chief Reservoir Engineer** at **ExxonMobil**, to explore where integration truly creates value, where it falls short, and how it is evolving across global portfolios.

IRMTS: How have digital tools, AI, and machine learning transformed IRM workflows, and what impact have they had on field-level decisions?

Sam: In my experience, integration does not create value on its own. Value is created, or eroded, at the point of decision-making.

Integrated surveillance and modeling efforts provide insights for the identification and evaluation of those decisions. However, we cannot always predict what insights or uncertainty reduction will result from a proposed modeling effort or data acquisition plan. This is where things often go wrong.

By extension, many view these efforts, especially data acquisition, as a cost. One of the key challenges is communicating the relative cost-benefit of this work to decision-makers, particularly when the benefits are longer-term.

“Value is not created by models or surveillance, it is created by the decisions they enable.”

IRMTS: If you had to simplify IRM for a new asset, what level of integration is essential for reliable decisions, and what becomes unnecessary complexity?

Sam: In a greenfield asset, especially one of significant size, it is difficult to over-emphasize the importance of integrated reservoir management.



Sam Perkins, PhD
Chief Reservoir
Engineer
ExxonMobil

With 29 years of experience across reservoir engineering, planning, major projects, strategy, organizational design, and technical operations. He advises management on complex technical and commercial issues and leads capability development aligned with corporate strategy.

We are constantly making decisions under uncertainty, and one of the primary means of addressing that uncertainty is through the integration of multiple datasets and disciplines. Each organization must define its own standards for integrated decision-making, but in my experience, it is more common to go overboard with complexity than to oversimplify.

The most effective way to avoid unnecessary complexity is to ensure close alignment between technical and commercial work. Depending on the organization, this happens through a combination of people, roles, and work processes.

IRMTS: IRM often fails due to organizational boundaries rather than subsurface uncertainty. In a global IOC setup, how do you make integration work across disciplines and assets?

Sam: This is a very important consideration, especially in larger companies.

From what I have seen, with the right focus on asset performance and appropriate KPIs, integration can happen naturally across organizational groups and disciplines.

When teams are aligned around shared outcomes, collaboration becomes a necessity rather than an objective.

Where things can become challenging is the time frame. Reservoir management is a long-term discipline compared to many other organizational activities. Even the cycle of people or organizational structures can be shorter than the reservoir management time horizon, particularly in a cyclical industry.

This is why a culture, supported by governance and KPIs, that reinforces long-term thinking is critical. Shared ownership and visibility of long-term metrics, including quantification of value impact, are key to success.

IRMTS: Across your portfolio, where has IRM changed an investment decision, not just optimized it? What was different in how the decision was made?

Sam: There are many examples across both asset-level and portfolio-level decisions.

In operating assets, I would point to infill drilling decisions, changes to depletion plans, and adjustments to WAG injection cycles driven by surveillance data such as 4D seismic.

For greenfield assets, the impact is often seen at the portfolio level. Project sanction, timing, and scope are dependent on portfolio competitiveness and are tested through gated project systems to ensure that development concepts are robust to both technical and commercial uncertainty.

It is quite common for projects to return to earlier stages for further reservoir management work, either to acquire additional data or to revisit the development concept when it is not sufficiently optimized or competitive.

In several cases, I have seen projects that appeared robust under base assumptions only to wind up being deferred or re-scoped once integrated analysis exposed sensitivity to subsurface uncertainty, particularly around recovery, plateau sustainability, and facility utilization.

IRMTS: Can you share an example where integration across reservoir, well, and facility changed performance? Or a situation where unexpected results occurred due to a less integrated approach?

Sam: Lookback analysis of reservoir management outcomes that fall outside expected ranges often points to incomplete integration of available data in decision-making.

In a historical project example prior to any of our Guyana deepwater developments, recovery was lower than the expected range in a structurally complex reservoir. Faulting pushed the limits of seismic resolution and exceeded the ability of modeling to fully capture connectivity. Combined with inherent stratigraphic heterogeneity, this resulted in connected volumes that were significantly lower than predicted ranges, even when compared to nearby analog reservoirs.

Cases like this have led us to adopt a scenario-based uncertainty analysis approach to reduce bias and improve robustness in reservoir management plans. A more fully integrated approach using scenarios has enabled earlier recognition of connectivity risks and more conservative development sequencing where required in subsequent projects.

"Integration is not about combining data, it is about challenging assumptions in the framing of a decision."

IRMTS: Have digital platforms and digital twins improved decision quality, or mainly increased data volume? Where do you still see the gap?

Sam: In the subsurface domain, digital twins are often an evolution of long-established practices for performance prediction, although the data platforms supporting them have become increasingly important.

What makes reservoir management unique is the variability of each subsurface resource, which continues to require model-based decision-making.

From my perspective, the key question is where to define the boundaries between subsurface, well, surface, and commercial systems.

This is where gaps often remain, and where there is an opportunity to further optimize asset performance through better coupling of models.

Even within traditional subsurface workflows, the interaction between reservoir and wellbore physics is often oversimplified, which can limit the effectiveness of otherwise sophisticated models.

IRMTS: Looking ahead, do you see IRM evolving toward closed-loop or autonomous decision systems? What will still require human judgment?

Sam: The potential for automation in reservoir management is closely linked to the frequency of decisions.

High-frequency decisions, such as gas lift optimization, choke control, and process operations, are already well suited to automation and continue to evolve.

Most reservoir management decisions, however, are longer-term and lower-frequency in nature, which makes the benefits of automation less straightforward.

As modeling cycle times reduce and data acquisition improves, particularly with more advanced downhole measurements and control in multi-lateral wells, some reservoir decisions may move toward higher-frequency domains.

However, in my view, judgment under uncertainty will remain a key element of reservoir management.

“Automation will support decisions, but defining the right decision will remain human.”

Closing Remarks

Integrated Reservoir Management is often framed as a technical discipline. In practice, it is a decision discipline.

Its success is not measured by the volume of data or the sophistication of models, but by whether the right decisions are made, at the right time, with uncertainty properly characterized.

Further Reading

OTC-31084-MS

The Liza Field: From Discovery to Development Paper presented at the Offshore Technology Conference, Virtual and Houston, Texas, August 2021.

SPE-228228-MS

Applying Flow-Based Reduced-Physics Framework for Selection of Initial Model Ensemble Under Subsurface Uncertainty Prepared for presentation at the SPE Annual Technical Conference and Exhibition held in Houston, Texas, USA, 20 - 22 October 2025.

OTC-35413-MS

New Opportunities in Well and Reservoir Surveillance Using Multiple Downhole Pressure Gauges in Deepwater Injector Wells Prepared for presentation at the Offshore Technology Conference held in Houston, TX, USA, 6 - 9 May, 2024.

SPE-212628-MS

Abandoned Exploration and Appraisal Wells Turned into Long-Term Monitoring Wells for Enhanced Far-Field Reservoir Characterization: Lessons Learned from a Frontier Deepwater Installation Prepared for presentation at the SPE Reservoir Characterization and Simulation Conference and Exhibition held in Abu Dhabi, UAE, 24 - 26 January 2023.

Youth in Integrated Reservoir Management: A Conversation with SPE Leadership

*This article presents key insights from **Susan Howes, 2027 SPE president, Rahim Masoudi, SPE Reservoir Technical Director, and Muhammad Navaid Khan, SPE IRMTS Chairperson**, at the launch event of the Youth Wing Initiative within the IRM Technical section — **where they shared their personal experiences with SPE and highlighted the organization's potential for career growth and networking.***

The meeting introduced the **SPE Integrated Reservoir Management (IRM) Technical Section Youth Wing**, highlighting its global representation and focus on developing future technical leaders. The discussion **aimed to explore pathways for young professionals to contribute meaningfully to the industry**, moving beyond traditional roles to ownership and capability building within SPE.



**INAUGURAL EVENT:
A CONVERSATION WITH SPE LEADERSHIP**

| MODERATOR | PANELISTS | | |
|---|--|---|--|
|  Zhambyl Sarbas SPE IRMTS Youth Wing Co-Chair Reservoir Engineer Fengzhechevrol |  C. Susan Howes, PE, PHR 2027 SPE President President Subsurface Consultants & Associates, LLC (SCA) |  Rahim Masoudi, PhD SPE Reservoir Technical Director Chief Technical Lead EnQuest & Veri Energy |  Muhammad Navaid Khan SPE IRMTS Chair Senior Specialist Reservoir Engineering ADNOC |

Q1. How can students and Early Career professionals create real industry impact through SPE?

Technical sections provides great opportunity for us to find areas of common interest where we can exchange. We can be engaged in debate and dialogue about technical topics. Joining one and participating allows a student or young professional great exposure to technical knowledge and other skills that are very important.

Q2. Looking ahead in 10 years, how do you see students and early career professionals using SPE platform to influence the future of industry, and what should they start doing now to prepare for that responsibility?

Once again, technical sections provide a lot of value to all SPE members, going over how the membership criteria for these technical sections have evolved over the years, so students and young professionals have to leverage all of the opportunities that these sections offer – especially leadership roles and volunteering at conferences, presenting papers, planning events and activities, and becoming involved with the scholarship programmes offered by the organisation.

Q3. Which technical foundations and leadership behaviors do you think enable young professionals not just to succeed individually, but to influence decisions and direction within the industry?

We are knee-deep of a technical industry, so technical competency and technical kind of foundation is critical; the ability to work confidently, with additional tools like digital tools, data analytics, AI, and actually having a systems thinking mindset that understands the multidiscipline as a single system. In regards to behavioral attitudes, a young leader needs curiosity, clear and confident communication and execution

“One must have a good combination of technical competency and credibility, as well as solid communication skills, networking skills, and leadership-influencing behaviors”

Q4. Within the IRM technical section, how can the Youth Wing act as a real platform for industry impact? And where do you see the strongest opportunities for use to shape the industry?

The Youth Wing offers an opportunity for real time shadowing, where the younger ones are present at the table where decisions are made while also providing an understanding of the patterns, pitfalls and overall experience of service and leadership that years of lectures and seminars cannot provide.

It is meant to serve as a safe space for potential leaders to make mistakes faster under guidance for an overall balanced outcome at the end. Bringing young people into this conversations may provide perspective that years of experience may not allow the experts to have.

2027 SPE President Susan shared her experience with SPE's focus on both technical and soft skills, highlighting how the organization evolved to recognize the importance of leadership development. She discussed her career progression from receiving an SPE scholarship to serving in various leadership roles, including chairing the Gulf Coast section and the ATCE program committee. She went on to underscore the value of volunteering and presenting at conferences for young professionals seeking to establish credibility and long-term leadership within SPE, encouraging them to align their volunteer work with their company's interests.

“Leverage technical and geographical sections, that's where the value lies”

Dr. Rahim shared his experience as an SPE volunteer, highlighting how the platform facilitated his personal and professional growth through technical development, leadership opportunities, and global networking. He emphasized the importance of volunteering at different levels, from student chapters to technical committees, and described his journey from presenting papers to becoming a board member. Rahim stressed that SPE offers valuable connections and a strong network that can enhance efficiency in daily work and provide answers to technical and leadership questions.

“Identify opportunities and serve, that's how you deliver real impact”

Chairman Navaid discussed the role of the Youth Wing within the IRM technical section, with an emphasis on it's potential to serve as a platform for industry impact. He suggested integrating youth into decision-making processes and creating a “safe space” for them to learn and apply their skills through real case studies and project-based training. He also highlighted the importance of reverse mentoring and involving students to boost their confidence and grant them an opportunity to contribute to the industry.

“Embrace opportunities no matter how intimidating; that's where you build leadership competence”

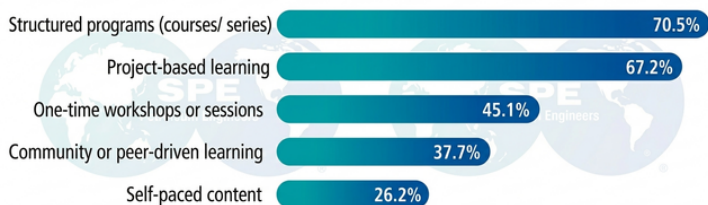
Bridging the Gap: Student Insights, Barriers, and Pathways Forward

Technical sections within the **Society of Petroleum Engineers** have long been spaces for professionals to exchange knowledge and experience. Over time, these spaces have opened to students, creating **new opportunities for learning and involvement**. Yet, student participation remains lower than expected.

To better understand this gap, the **SPE Integrated Reservoir Management Technical Section** conducted a global survey reaching over 120 students across various student chapters and regions. The findings reveal a clear pattern. Students are interested and already connected to SPE, but their level of engagement depends on how relevant, accessible, and practical the experience feels.

Most respondents are already SPE members, which suggests that the challenge is not attracting students into the community. Instead, it lies in how technical sections translate that membership into meaningful engagement. Students identified **staying updated with industry trends, access to technical learning, and career growth** as key sources of value. Networking and mentorship remain important, but they are most effective when combined with practical experience.

PREFERRED ENGAGEMENT FORMAT: TECHNICAL CONTENT

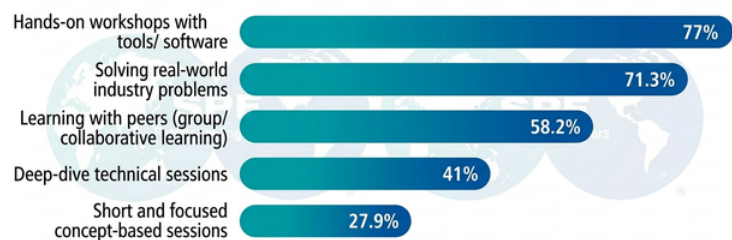


When exploring how students prefer to engage, a strong preference emerges for **structured and project-based learning**. Students are not simply looking for one-time sessions. They are looking for clear learning journeys that build knowledge and confidence over time. Structured programs provide a sense of direction, while projects allow them to apply what they learn.

This is reinforced by how students describe their learning preferences. **Hands-on workshops and solving real industry problems** rank significantly higher than traditional lecture-based approaches. Students want to work with tools, interact with data, and understand how decisions are made in real field scenarios. In their own words:

"I learn a lot better when I can see how things actually work in the field... case studies with real data, simulations, and practical problem-solving would make a big difference."

HOW WE LEARN BEST: TECHNICAL TOPICS



Despite this strong interest, participation is shaped by a number of practical barriers. **Academic workload** often makes it difficult for students to engage consistently, while **financial considerations** can limit access to certain opportunities such as conferences. In addition, many students indicated that they are not always fully aware of what is available to them.

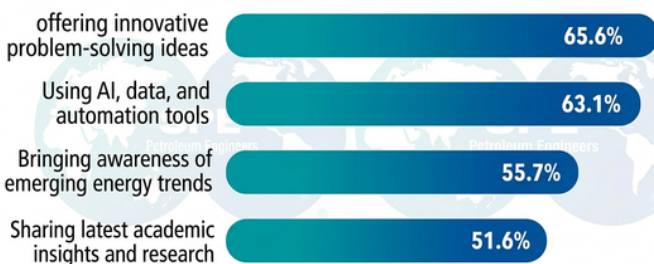
Some students also noted that timing and scheduling of technical section activities can clash with classes or exams, making it hard to attend even highly relevant events. Others mentioned that large or formal events can feel intimidating, especially for first-time participants. These insights suggest that the focus should be on improving **visibility, accessibility, and flexibility** to better support student participation.

Bridging the Gap: Student Insights, Barriers, and Pathways Forward

Another important insight is how students view their role within the technical community. Many expressed interest in contributing through **reverse mentoring**, where students share ideas, digital skills, and fresh perspectives with professionals. This reflects a shift toward a more collaborative exchange of knowledge, where students are not only learners but also active contributors.

This perspective also highlights a growing confidence among students in the value they bring to the industry. Having been exposed to **emerging technologies**, **current academic research**, and new ways of **problem-solving**, students are well positioned to complement traditional expertise. When structured effectively, reverse mentoring can create a more dynamic learning environment where both students and professionals benefit. It allows technical sections to remain **responsive to change**, while also giving students a **sense of ownership** and **relevance** within the community.

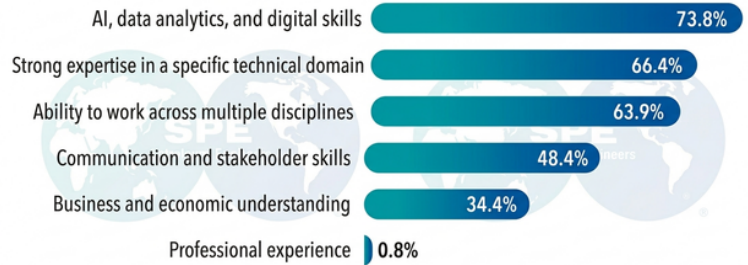
REVERSE MENTORING: STUDENT CONTRIBUTION



n=122 student respondents | Source: 2026 IRMTS Student Insight Survey

Looking ahead, students are clear about the skills that will shape their careers. **AI, data analytics**, and **digital competencies** rank highly, alongside strong technical expertise and the ability to work across disciplines. Communication and stakeholder engagement are also seen as essential. This reflects an understanding that technical knowledge must be supported by adaptability and broader awareness.

FUTURE-READY SKILLS



n=122 student respondents | Source: 2026 IRMTS Student Insight Survey

The open responses emphasize a simple but powerful message: students want experiences that feel real; field exposure, simulations, mentorship, and opportunities to tackle real challenges. They also seek structured pathways showing how learning connects to future roles.

Steps are already being taken. Through the **IRMTS Youth Wing**, student representation and participation are growing. In **April**, two **student-led webinars** will offer peer learning, knowledge sharing, and confidence building, shifting students from passive participants to active contributors.

These insights reveal that students are ready to engage, seeking practical, structured, and industry-connected experiences. For the IRM Technical Section, this is an opportunity to strengthen its role as a bridge between academic learning and professional practice. By focusing on **experiential learning, visibility**, and **clearer pathways** for involvement, technical sections can become more impactful.

The foundation exists; the next step is building experiences that allow students to engage, grow, and contribute with confidence.

SPE WEBINARS AND LIVE EVENTS: Q1 2026

Q1 2026 for the section featured an engaging lineup of webinars and live sessions, highlighted by the three webinars led by pioneers and experts in Fiber optics, Stimulation technologies and History matching. The quarter was filled with exciting key collaborations with the **SPE Hydraulic Fracturing Technical Section**, the **Offshore Completions Technical Section**, the **SPE Well Integrity Technical Section**, the **Gulf Coast Section**, the **Abu Dhabi Section** and the **Trondheim Section** as well with professionals across fields of stimulation, geophysics, reservoir engineering, and so much more.

Production Optimization Series

The Bridge Between Conventional and Unconventional Stimulation Technologies

| | | |
|---|--|--|
| | | |
| (Moderator) Stephen Schubarth President Schubarth Inc Chair (2020-21), SPE HyFTS | (Speaker) Subba Ramarao Petroleum Engineering Specialist ADNOC | (Speaker) Wissam Chehabi Managing Director (MENA & CIS) Fishbones AS |

The first webinar of 2026 explored how stimulation design can balance productivity gains with execution risk and capital efficiency in tight reservoirs. Field experts **Subba Ramarao** from ADNOC and **Wissam Chehabi** from Fishbones AS discussed advanced techniques including fishbone stimulation, Limited-Entry Liner stimulation, abrasive jetting and emulsified acid within an integrated decision framework. The session also provided guidance on candidate selection, execution diagnostics and interpreting production sustainability metrics as well as defined clear thresholds for when hydraulic fracturing becomes the preferred option over matrix acidizing.

Performance Monitoring Series

Distributed Fiber Optics Sensing Masterclass – From Theory to Applications

| | |
|--|--|
| | |
| (Moderator) Karthik Mahadev Fracturing & Stimulation SME bp Chair, SPE OCTS | (Speaker) Ge Jin, PhD Associate Professor, Geophysics Colorado School of Mines |

The webinar explored how **distributed fiber optic sensing (DFOS)** bridges the gap from well diagnostics to performance-driven decision-making. It covered the fundamentals of DFOS, including measurement physics, deployment strategies and integration with completions. The session examined applications in hydraulic fracture monitoring, production surveillance and injection monitoring across both unconventional and conventional assets. **Prof. Ge Jin, Colorado School of Mines** discussed current technology maturity, data interpretation challenges and operational limitations while the event was moderated by **Karthik Mahadev, bp**.

Reservoir Evaluation Series

Ensemble History Matching and Optimization

| | | |
|---|---|---|
| | | |
| (Moderator) Teodor Damian Senior Petroleum Engineer Shell | (Speaker) Geir Evensen, PhD Chief Scientist NORCE Research (Bergen) | (Speaker) Remus Hanea, PhD Specialist, Reservoir Technology (RAD) Equinor |

The webinar explored how **ensemble-based history matching** addresses limitations of traditional deterministic approaches in complex, data-intensive reservoir models. The session demonstrated how joint estimation of control errors and geological uncertainties enables better uncertainty quantification and improved predictive confidence. The event featured experts **Geir Evensen, PhD** from **NORCE Research**, and **Remus Hanea, PhD** from **Equinor** hosted by the SPE IRM Technical Section in collaboration with the SPE Trondheim and Abu Dhabi Sections.

WEB EVENTS DIRECTORY

Missed Our Web Events? Catch Up Anytime!

- **31 March, 2026** | Ensemble History Matching and Optimization
- **03 March 2026** | Distributed Fiber Optics Sensing Masterclass: From Theory to Applications
- **18 Feb 2026** | The Bridge Between Conventional and Unconventional Stimulation Technologies
- **10 Dec, 2025** | Production-Driven Reservoir Characterization with RTA
- **12 Nov, 2025** | From Oil and Gas Experience to Geothermal: How Reservoir Modeling Evolves
- **1 Oct, 2025** | Decision Quality and Decision Analysis—Theory and Practice
- **24 Sep, 2025** | Reservoir Management 2035—The Human + AI Alliance
- **10 Sep, 2025** | Virtual Flow Metering Data for Advanced Reservoir Surveillance and Development Planning
- **27 Aug, 2025** | PTA with Purpose: Objective-driven Interpretation and Scalable Modelling Workflows
- **23 July, 2025** | Well Performance Masterclass: Integrating PTA, DCA, & RTA for Deeper Diagnostics
- **25 June, 2025** | Field Proven Insights: 4D Seismic Application in Reservoir Management and CCS Monitoring
- **28 May, 2025** | Enhancing Forecast Reliability through Computational Intelligence in Integrated Modelling using 4D Seismic data
- **6 May, 2025** | Maximizing Waterflooding Value: Strategies, Technologies, and Future Outlook
- **28 Apr, 2025** | Real-Time Production System Optimization and the Future Role of AI
- **9 Apr, 2025** | Integrating Uncertainty with Data Analytics and Machine Learning for Subsurface Modeling
- **19 Mar, 2025** | Geomechanics in Reservoir Management: Predicting and Optimizing Reservoir Behavior
- **19 Feb, 2025** | Digital Twin for Production Optimization: Mere Hype or True Enabler?
- **21 Jan, 2025** | Leveraging Tracers for Well Optimization and Reservoir Management: Strategies and Real-World Applications
- **11 Dec, 2024** | Decode Your Reservoir: Machine Learning for Facies Prediction and Petrophysical Analysis
- **19 Nov, 2024** | Steps in Intelligent Upstream Operations: Today's Innovations for Delivering Tomorrow's Goals
- **29 Oct, 2024** | Cross-disciplinary collaboration in Integrated Reservoir Management: Integrating Geosciences, Engineering, and Economics
- **17 Sep, 2024** | Launch Event – Introducing the SPE Integrated Reservoir Management Technical Section

Access the complete archive of past SPE IRMTS webinars by visiting the **SPE Energy Stream platform**.

CLICK HERE



SPE EnergyStream
The Industry's Digital Pulse

PERSPECTIVE: EXPERT INSIGHTS

The Bridge Between Conventional and Unconventional Stimulation Technologies

*This article brings together key insights from **Wissam Chehabi (Fishbones AS)** and **Subba Ramarao (ADNOC)**, who addressed one of the most persistent challenges in Middle Eastern carbonate reservoirs: sustaining productivity and injectivity in low-permeability, vertically heterogeneous formations. Their session offered a comprehensive evaluation of advanced stimulation technologies piloted in Reservoir R, a tight carbonate system defined by layered architecture, dense intra-reservoir barriers, and limited vertical communication.*


Drawing on field pilots, comparative diagnostics, and economic benchmarking, the speakers outlined a structured and practical roadmap for selecting stimulation strategies tailored to reservoir complexity, well architecture, and long-term development objectives. Ramarao contributes 23 years of experience in offshore and onshore operations with a focus on completions, optimization, and sustainable, cost-effective solutions. Wissam brings 18 years of industry experience across LWD, well interventions, and advanced stimulation technologies, and currently leads regional strategy and technology deployment across the MENA and CIS regions.

Together, their combined expertise provided a technically rich and operationally grounded perspective on how operators can unlock performance in challenging carbonate environments.


Understanding the Reservoir: Low Permeability, Layered Carbonates

The targeted reservoir presented several challenges, as described in the webinar:


- Low permeability (0.1–1 mD).
- Seven sublayers separated by dense, low-communication barriers.
- Vertical communication limited ($K_v/K_h = 0.1 - 0.5$).



(Speaker)
Subba Ramarao
Petroleum Engineering
Specialist, ADNOC



(Speaker)
Wissam Chehabi
Managing Director
Fishbones AS



(Moderator)
Stephen Schubarth
President
Schubarth Inc.

- Presence of natural fractures contributing variably to flow.
- Short-lived response to conventional matrix acidizing.

As Wissam explained, **these dense layers needed to be penetrated to give the reservoir a better vertical connection**, underscoring the need for stimulation methods capable of bypassing barriers and enhancing connectivity.

Conventional matrix acidizing had repeatedly shown short-lived improvements, prompting ADNOC to explore more robust stimulation methods capable of:

- Enhancing vertical communication.
- Sustaining higher backpressure production.
- Improving injectivity for pressure support.
- Reducing well count through better well spacing.
- Lowering long-term development cost.

Advanced Stimulation Technologies Piloted

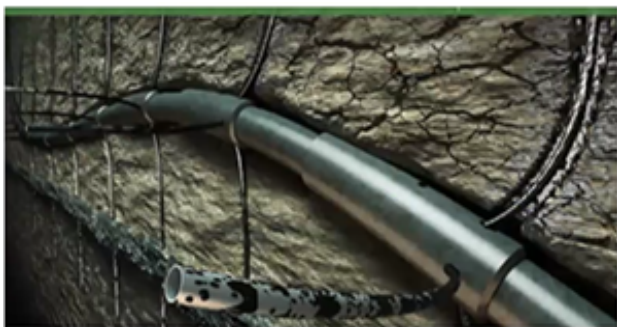
The team piloted five stimulation technologies, each targeting specific reservoir challenges:

1. Fishbone Stimulation

A mechanical diversion technology deploying 40-ft needles to penetrate dense layers and connect sublayers.

- Enhances vertical communication.
- Accesses deeper natural fractures.
- Bypasses near-wellbore damage.

Limitation: Requires needle cleanup and is unsuitable near water/gas caps.



2. Limited Entry Liner (LEL)

A precision-engineered liner with calibrated nozzles to ensure even acid distribution along long horizontals.

- Creates controlled wormholing.
- Addresses near-wellbore damage.
- Allows future re-stimulation.

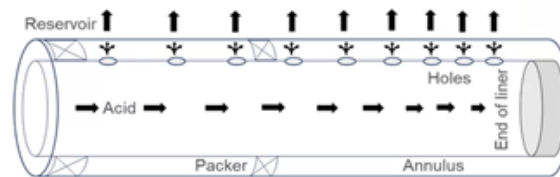
Limitation: Limited vertical reach; water shutoff is difficult.

3. Hydraulic Fracturing

A multi-stage plug-and-perf design delivering high-conductivity fractures.

- Connects sublayers.
- Provides large drainage area.
- Offers the highest productivity uplift.

Limitation: High cost, complex execution, and risk of extending the fracture into other zones.



4. Abrasive Jetting

Coiled-tubing conveyed jetting tool with 60° nozzles phasing allows 360° coverage.

- Creates mechanical diversion.
- Enables targeted acid placement.
- Useful for injectors.

Limitation: suitable for open hole completion, Limited reach in long horizontals; requires diverters near faults/fractures.

5. Emulsified Acid

Diesel-based emulsified acid designed for deep wormholing with delayed reaction.

- Enhances injectivity.
- Reduces acid volume requirements.

Limitation: Highly sensitive to mixing quality and temperature.

Pilot Results: Productivity & Injectivity Gains

Ramarao walked the audience through the **implementation, performance, and benchmarking** of five advanced stimulation pilots in a tight carbonate reservoir (Reservoir R).

Building on the earlier overview of stimulation technologies, Ramarao presented detailed results from field pilots, offering practical insights into productivity enhancement, injectivity improvement, and technology selection for layered, low-permeability carbonate systems.

Ramarao explained that the team selected Fishbone stimulation, Limited Entry Liner (LEL), and Hydraulic Fracturing for oil producers, while Abrasive Jetting and Emulsified Acid were deployed in injectors.

These pilots were designed to address the reservoir's defining challenges: poor vertical communication, dense interlayers, and near-wellbore damage.

Pilot 1: Fishbone Stimulation - Significant and Sustained Productivity Gains

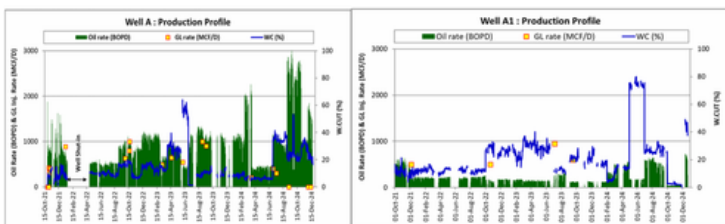
The first pilot was executed in Well A, where 40 fishbone subs were installed. After pumping the stimulation and cleaning out the needles, the well was compared to a nearby offset (A1).

Key outcomes included:

- 3.5-time increase in initial oil rate (instantaneous).
- 5-time improvement in productivity index.

As Ramarao highlighted, the fishbone pilot delivered a remarkable and sustained uplift, maintaining five to six times higher production than the conventional offset well over a three-year period, despite the natural evolution of water cut.

This long-term performance underscores the strong value of enhanced vertical connectivity in layered carbonate reservoirs.



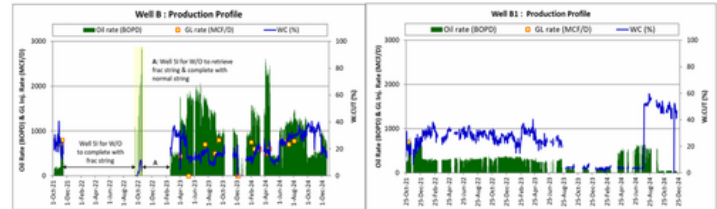
Fishbone Well A Vs Conventional Well sustainable performance

Pilot 2: Hydraulic Fracturing - Highest Productivity Boost

The second pilot involved a 14-stage plug-and-perf hydraulic fracturing treatment in Well B. Compared with offset B1.

- Oil rate increased 5-6 time.
- Productivity improved 20-time.
- Sustained high liquid rates over three years.

Ramarao highlighted that while water-cut evolution affects long-term oil sustainability, the total liquid rate from the pilot is maintained at the same initial rates, supported by nearby injectors.



Hydraulic Fracturing Well B Vs Conventional Well sustainable performance

Pilot 3: Limited Entry Liner (LEL) - Strong Early Performance

The third pilot applied LEL stimulation in Well C, with a 5,000 ft horizontal section. Compared with offset C1:

- 4-time increase in initial oil rate.
- 4-time improvement in productivity.
- 3-time sustained uplift after one year

This pilot demonstrated the effectiveness of controlled acid placement in long horizontals, especially where injectivity is moderate.

Pilot 4: Abrasive Jetting - Effective Injectivity Enhancement

Abrasive jetting was deployed in Well D, using coiled tubing to mechanically divert acid and create targeted wormholes.

Results showed:

- Injectivity increased from ~1,000 to 2,000-3,000 bpd (instantaneous).
- Sustained 2.5-time improvement over six months.

Ramarao emphasized that abrasive jetting remains a cost-effective option for injector enhancement.

Pilot 5: Emulsified Acid - Deeper Penetration, Moderate Sustainability

The final pilot applied emulsified acid in Well E, using diesel-based emulsified acid to achieve deeper wormholing.

Performance included:

- 2.5-time increase in injectivity (1,500 → 4,000 bpd).
- Sustained uplift for one year, with slight decline afterward.

This method proved effective but more temperature-sensitive than other techniques.

Technical Benchmarking: Comparing Strengths and Limitations

Ramarao presented a comprehensive benchmarking matrix evaluating all five technologies across reservoir fit, completion constraints, accessibility, water-shutoff capability, and temperature sensitivity.

Key insights included:

- Fishbone: Best for layered reservoirs with poor vertical communication; limited stimulation between subs.
- Hydraulic Fracturing: Highest uplift but costly and complex; requires proper well orientation.
- LEL: Effective near-wellbore stimulation; limited to ~10 ft penetration; permanent completion restricts future interventions.
- Abrasive Jetting & Emulsified Acid: Suitable only for open-hole completions; lower sustainability but low cost.

As Ramarao summarized, each technique cannot be applied across the entire reservoir, candidate selection is critical.

Economic Benchmarking: Cost vs. Incremental Production

A six-month post-implementation economic comparison revealed:

- Hydraulic fracturing delivered the highest incremental volume but at the highest cost.
- Fishbone and LEL offered comparable incremental production at moderate cost.
- Abrasive jetting and emulsified acid provided limited incremental volumes but were the most economical for injectors.

Selection Guidelines and Key Takeaways

Ramarao concluded with practical guidance for future development:

- LEL is preferred for injectors due to low cost and good sustainability.
- Fishbone is ideal for layered reservoirs with dense barriers.
- Hydraulic fracturing is best for wells with ~0.1 mD permeability and favorable orientation.
- Abrasive jetting and emulsified acid outperform matrix acidizing but are less sustainable.
- Hybrid LEL + Fishbone offers long-term flexibility, enabling re-stimulation after initial fishbone deployment.

As Ramarao emphasized, the benchmarking matrix will help us select the right candidate for tight carbonate reservoirs, especially for Reservoir R in the next development phase.

Interactive Insights: Audience Q&A

Q1. What is the role of real-time temperature monitoring during abrasive jetting stimulation?

A. Temperature is a key diagnostic during abrasive jetting. DTS is run inside the coiled tubing to record temperature changes, which indicate fluid movement and help confirm proper acid placement. Emulsified acid is especially temperature-sensitive, so real-time temperature trends guide both jetting and acid placement to ensure effective wormholing.

| Parameters | Fishbone Stimulation | Hydraulic fracturing | LEL Stimulation | Abrasive jetting | Emulsified acid |
|----------------------------|-------------------------------|--------------------------------|------------------|------------------|--------------------|
| Reservoir | | | | | |
| Layered Low Kv/Kh | yes | yes | No | No | No |
| Near well bore damage | Yes | Limited | Yes | yes | yes |
| Thin Reservoirs | Limited | No | Yes | Yes | Yes |
| Low permeability (<1md) | Limited | Yes | Limited | no | no |
| Natural fractures / faults | Yes | Limited | Yes | No | No |
| Completion | | | | | |
| Liner | Liner with subs | cemented liner | liner with holes | Open hole | Open hole |
| well bore segmentation | yes | yes (multistage frac) | no | no | no |
| Well bore | | | | | |
| Accessibility | With Needles removal possible | With plug dissolution possible | yes | yes | yes |
| Water/ Gas shut off | | | not possible | not applicable | not applicable |
| DIT Temperature sensitive | No | No | No | No | Yes |
| Complex Operation | Medium | yes | No | No | No |
| Well bore orientation | No | Yes | No | No | No |
| Stimulation | | | | | |
| Pumping rate (bbl/mint) | 8 to 10 | 30 -40 | 15 | 3 to 5 | 3 to 5 |
| Dosage (bbl/ft) | 0.4 to 0.6 | 60,000 lbs. / stage | 0.7 to 1 | 0.25 | 0.25 |
| Pumping pressure | below fracture | above fracture | below fracture | below fracture | below fracture |
| Operation type | bull heading | bull heading | bull heading | Coil tubing | Coil tubing |
| Diversions | no | no | mechanical | mechanical | chemical |
| Pumping duration | no | no | < 12 hours | < 12 hours | < 12 hours |
| Lab test | Rock solubility | | | | emulsion stability |
| 360-degree coverage | Yes | Bidirectional | No | Yes | no |
| Acid recipe | 15 to 28 % HCl) | proponent | all recipes | all recipes | Emulsified acid |

Technical bench marking

Q2. What type of well was the “conventional Well A” used for comparison?

A. All comparison wells in the pilots were horizontal wells with approximately 5,000 ft lateral length. They were completed as open-hole horizontals and had previously undergone conventional matrix acid stimulation.

Q3. What is the primary driver of production improvement bypassing near-wellbore damage or contacting additional reservoir?

A. Contacting additional reservoir is the dominant contributor. Removing near-wellbore damage may add 10–15% improvement but connecting deeper sublayers especially with fishbone stimulation can expose up to 50% more reservoir, resulting in much larger productivity gains.

Q4. Does fishbone stimulation provide mechanical diversion through the needles?

A. Yes. The needles act as mechanical diversion points, forcing acid into the formation and enabling penetration across dense layers.

Q5. What was the emulsified acid made of, and why is mixing critical?

A. The treatment used diesel-emulsified acid with 15% HCl. Proper mixing is essential to achieve a single-phase emulsion; poor mixing leads to phase separation, making pumping difficult and reducing wormholing effectiveness.

Q6. Why does productivity improvement appear higher than the actual production rate increase?

A. Productivity index reflects reservoir potential, but actual rates are constrained by drawdown limits, pressure maintenance, and water-cut management. Even if PI improves 20-time (as in the hydraulic fracturing case), production cannot be increased proportionally due to reservoir pressure decline and injector support limitations.

Q7. How will high-water-cut zones be managed when combining LEL with fishbone?

A. Segmentation will be incorporated into the LEL design. This allows isolating water-producing intervals and applying water-shutoff treatments.

Pure LEL without segmentation has limited water-shutoff capability because the liner exposes the entire open-hole section.

Q8. Were any casing deformations observed during plug-and-perf hydraulic fracturing?

A. No major deformation issues were reported. The fracturing design was customized to avoid vertical fracture growth into overlying or underlying layers, using minifrac calibration and optimized cluster spacing.

Q9. Were dissolvable plugs used during hydraulic fracturing?

A. Yes, dissolvable plugs were used, with milling capability available as a backup.

Q10. Is there a leading indicator of long-term fishbone stimulation efficiency?

A. PI decline is minimal, typically only 5–10% over several years. Because production is managed and constrained, the decline is not strongly visible in rate trends, but PI stability indicates sustained stimulation effectiveness.

Q11. What open-hole size is required to implement the combined LEL + fishbone system?

A. A standard 6-inch open hole is sufficient. A 4.5-inch liner is used, with customized placement of fishbone subs and LEL ports. After fishbone stimulation and needle retrieval, the same liner can function as an LEL system for future re-stimulation.

Q12. Was there evidence of connectivity to natural fractures after fishbone stimulation?

A. PLT confirmed contribution from stimulated intervals, but direct evidence of natural-fracture connection (e.g., tracer) was not obtained. However, improved PI and reduced skin suggest enhanced connectivity.

Q13. Were reservoir parameters included in the cost normalization?

A. No. Normalization was based solely on cost versus incremental production. Reservoir parameters were not part of the normalization process.

PERSPECTIVE: EXPERT INSIGHTS

Distributed Fiber Optics Sensing Masterclass: From Theory to Applications

This article brings together key insights from the SPE webinar delivered by Dr. Ge Jin, Associate Professor of Geophysics at the Colorado School of Mines, who led a clear and engaging masterclass on Distributed Fiber Optic Sensing (DFOS). With a distinguished record in seismic imaging, machine learning, and fiber optic sensing, and industry honors including the 2025 ARMA Case Study Award, AAPG-SEG Distinguished Lecturer (2024), and multiple EuroTech Best Paper Awards, Dr. Jin offered a compelling blend of fundamental physics and practical engineering relevance.

His session provided an accessible walkthrough of DFOS principles, deployment strategies, and field applications across injection monitoring, hydraulic fracturing diagnostics, production surveillance, and long-term well integrity. The result was a concise yet comprehensive overview of how DFOS is reshaping subsurface monitoring and enabling more informed, data-driven reservoir management.



(Speaker)
Ge Jin, PhD
Associate Professor
Geophysics, Colorado School
of Mines

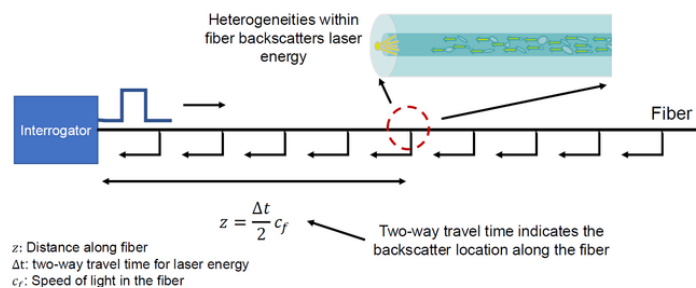


(Moderator)
Karthik Mahadev
Fracturing & Stimulation
SME, bp

Understanding Distributed Fiber Optic Sensing

Dr. Jin opened the session by grounding the audience in the fundamental physics that make DFOS possible, emphasizing that the **same optical fibers used to transmit global internet traffic can also serve as continuous sensors** when interrogated with precisely timed laser pulses.

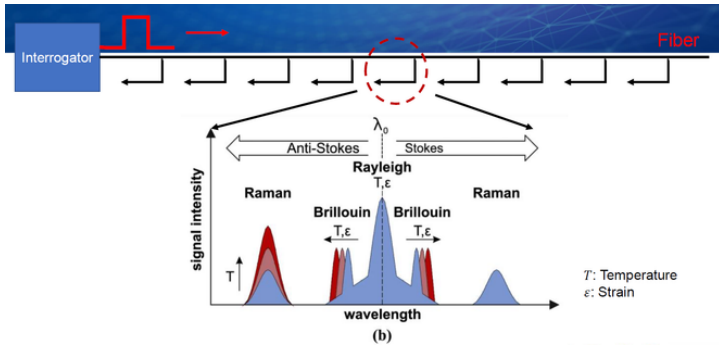
Optical fibers, manufactured with unavoidable microscopic imperfections, scatter a small portion of injected laser energy back toward the interrogator, and **by measuring the two-way travel time** of this backscattered signal, the system determines exactly where along the fiber the scattering occurred.



He explained that the fiber's core-and-cladding structure forms a waveguide that traps optical energy and allows it to propagate over long distances with minimal loss, enabling the interrogator to send thousands of pulses per second and generate continuous measurements in both space and time.

Three primary scattering mechanisms Rayleigh, Brillouin, and Raman, respond differently to vibration, strain and temperature. **By analyzing the timing and characteristics of this backscattered signal**, engineers can determine:

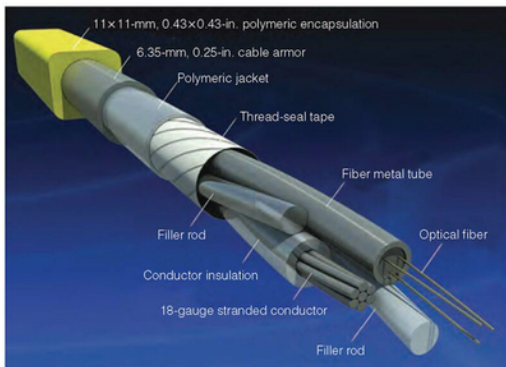
- Temperature changes (via Raman scattering).
- Strain or deformation (via Brillouin scattering).
- High-frequency vibration (via Rayleigh scattering).



To help the audience conceptualize this capability, Dr. Jin compared DFOS to human skin, noting that just as a person can feel where and when their arm is pinched or cooled, **a fiber placed in a well can “feel” changes in temperature, strain, or vibration at any point along its length**, providing a real-time, distributed awareness of downhole conditions.

Fiber Deployment Methods: Cost, Quality, and Trade-offs

A major portion of the session focused on the engineering challenge of placing such a delicate glass fiber into harsh downhole environments. Although the fiber itself can withstand high pressure and temperature, it is extremely brittle under bending, requiring protective encapsulation in metal tubes, gels, and armored layers for permanent installations.



Dr. Jin outlined three primary deployment approaches, each with distinct advantages:

1. Permanent Installation

- Fiber is strapped to casing and cemented in place.
- Highest data quality and strongest mechanical / thermal coupling.
- Enables multi-year monitoring across completion, production, and abandonment phases.

- Higher upfront cost and operational complexity.

2. Wireline / Slickline / Coiled Tubing Deployment

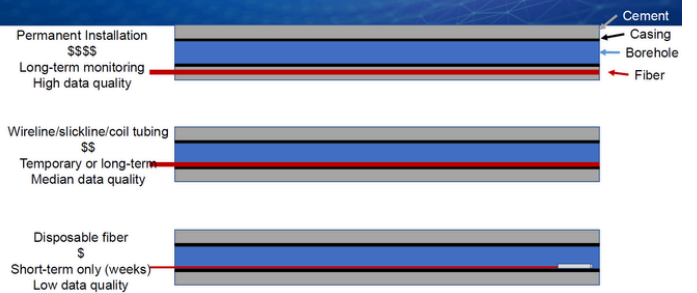
- Fiber is conveyed temporarily or semi-permanently.
- Lower cost and flexible retrieval.
- Moderate data quality due to weaker coupling.

3. Disposable / Single-Use Fiber

- Fiber is deployed via a drop-in tool that releases fiber as it descends.
- Extremely low cost and ideal for short-term diagnostics.
- Lower data quality but often sufficient for targeted measurements.

Dr. Jin emphasized that **deployment choice depends on business objectives, required data fidelity, and monitoring duration**. permanent fibers enable quantitative strain inversion and long-term monitoring, while disposable fibers are best suited for qualitative, cost-sensitive applications.

Fiber Deployment Methods



Injection and Completion Monitoring: Seeing Fluid Behavior in Real Time

One of the most compelling demonstrations involved using distributed acoustic sensing (DAS) to visualize fluid entering perforations during hydraulic fracturing.

High-rate injection forces fluid through small perforation tunnels, generating turbulence that appears as bright, localized energy on DAS waterfall plots.

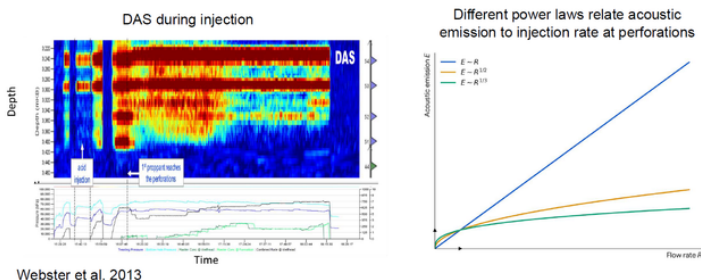
DAS captures these vibrations along the wellbore, enabling engineers to:

- Identify active and inactive perforation clusters.
- Evaluate stage efficiency.
- Detect uneven fluid distribution.
- Diagnose near-wellbore behavior in real time.

In one example, the upper perforation clusters emitted strong acoustic energy while the lower clusters showed weaker response, **revealing uneven fluid distribution** despite identical designs.

DTS provided complementary insight by tracking cooling and reheating patterns, offering an alternative injectivity estimate where acoustic signals were weak.

Injection Allocation of Perforation Clusters



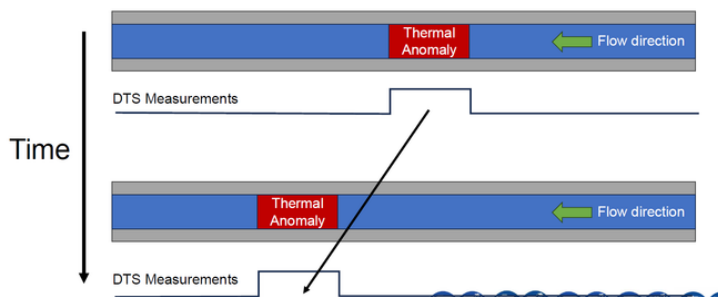
Thermal Front Tracking and Long Horizontal Injectivity Profiling

Dr. Jin introduced thermal front tracking as an elegant application of DTS, particularly in long horizontal wells. When a thermal anomaly moves along the wellbore, **the fiber records the evolving temperature field with meter-scale resolution**, allowing engineers to observe convection-driven migration in real time.

The slope of the thermal front on depth-time plots reveals local flow velocity, enabling injectivity profiling over thousands of feet.

This method is especially powerful in geothermal systems, water injectors, and long-reach horizontals where flow distribution is highly heterogeneous.

Thermal Slugging



Hydraulic Fracture Characterization Using Distributed Strain Sensing

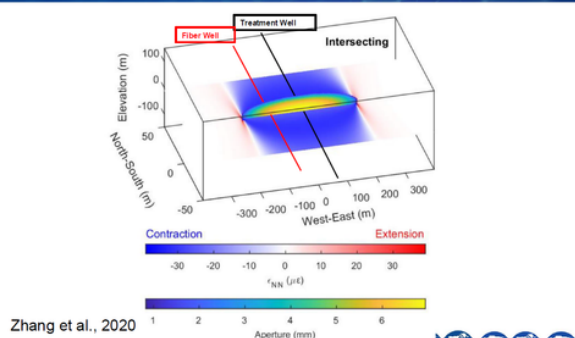
Distributed strain sensing (DSS) provides a fundamentally different perspective by capturing mechanical deformation caused by fracture propagation.

A fiber in an offset monitor well detects characteristic strain signatures often heart-shaped or double-lobed that reveal fracture arrival time, intersection depth, propagation speed, and fracture density.

Dr. Jin presented cases where only a subset of clusters generated fractures that reached the monitor well, enabling direct measurement of stage efficiency.

Geomechanical inversion techniques convert strain magnitude into fracture aperture distribution, allowing quantitative comparison of completion designs.

Strain Monitoring During Stimulation

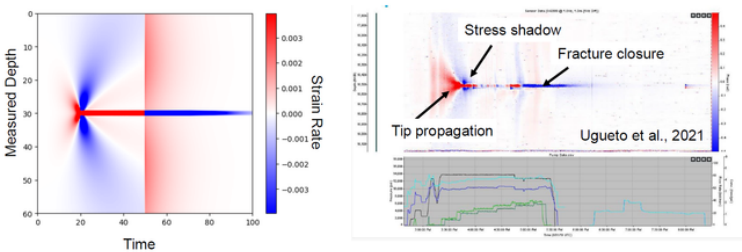


Cross-Well Strain Monitoring: A New Window into Subsurface Deformation

Cross-well strain monitoring represents one of the most significant advancements in subsurface diagnostics.

By placing a fiber in a monitor well, **engineers can observe how hydraulic fractures deform surrounding rock as they propagate.** Tensile and compressive strain signatures map fracture height, dip, and azimuth with remarkable clarity.

This technique has been used to validate fracture models, calibrate geomechanical simulations, and evaluate well-to-well interference, providing insights that surface microseismic alone cannot deliver.



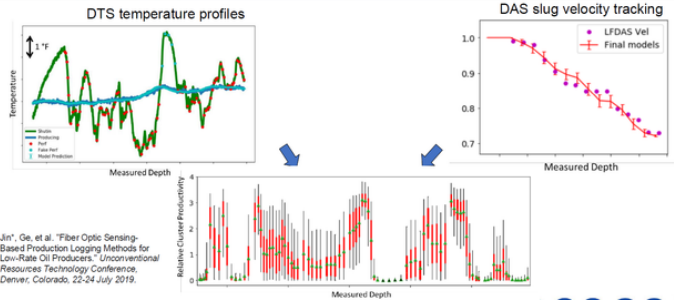
Production Monitoring: From Fracture Closure to Flow Allocation

DFOS continues to deliver value long after stimulation. Strain measurements reveal fracture closure timing and rate, offering insight into proppant placement and long-term conductivity.

DTS-based production allocation leverages residual temperature contrasts created during fracturing, enabling joint inversion of stable-flow and transient thermal data to estimate perforation-level productivity.

This provides a continuous, non-intrusive alternative to conventional production logging tools.

Production: production allocation



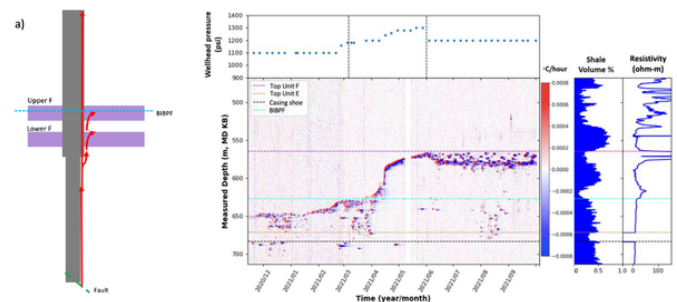
Long-Term Well Integrity and Abandonment Diagnostics

DFOS excels in long-term surveillance. **DTS can detect subtle annular temperature anomalies** indicative of fluid migration, casing leaks, or cement channelling.

In one case, a permanently installed fiber detected migrating thermal pulses years after abandonment, revealing gas movement and hydrate formation in shallower zones, an issue invisible to conventional tools.

DFOS thus becomes a permanent "nervous system" for the well, **capable of detecting anomalies long before they escalate** into operational or environmental risks.

Natural Gas Leakage along Wellbore: Alaska



Multi-Physics Integration: DTS + DAS + DSS

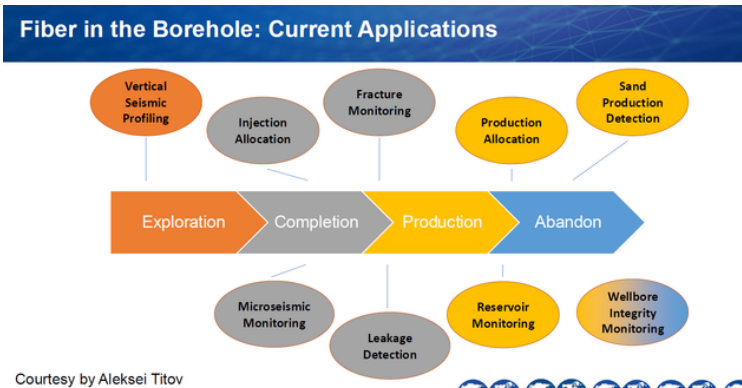
Dr. Jin emphasized that the true power of DFOS emerges when temperature, acoustic, and strain measurements are integrated into a unified diagnostic framework.

This multi-physics approach provides a comprehensive view of subsurface behavior, enabling engineers to understand not only where fluid enters the formation but how fractures propagate, how stress redistributes, and how thermal effects influence conductivity.

**Cross-Industry Implications:
Petroleum, Geothermal, and CCS**

DFOS is rapidly becoming a unifying technology across subsurface energy sectors. In geothermal systems, it tracks thermal breakthrough and fracture behavior.

In CCS, it monitors plume migration and verifies long-term containment. Its high-temperature tolerance and **multi-physics capability** make it indispensable across diverse applications.



Dr. Jin concluded by noting that DFOS is not merely a new measurement tool but a fundamentally new way of observing the subsurface, one that **provides continuous, high-resolution, multi-physics insight** into the complex and dynamic processes that govern reservoir behavior.

As interrogator technology advances and digital twins mature, DFOS will become central to **intelligent reservoir management** across petroleum, geothermal, and CCS projects.

Interactive Insights: Audience Q&A

Q1. Does cumulative noise and backscatter along long fibers reduce the accuracy of event detection toward the end of the well?

A. No, the interrogator separates backscatter signals by their arrival time, so reflections from different fiber locations do not interfere. However, measurements near the end of long fibers are inherently noisier because both the forward-traveling laser pulse and the returning backscatter lose energy over distance. This attenuation reduces signal strength and increases noise, meaning data quality is not uniform along the entire fiber.

Q2. In high shot-density perforating (e.g., 18 shots/ft for sand control), can perforation charges cut the fiber and interrupt data transmission?

A. Yes, perforation poses a risk to permanently installed fibers. Industry practice mitigates this by mapping fiber orientation and perforating in the opposite direction. While incidents have decreased, fiber damage remains possible and must be considered in completion design.

Q3. For cross-well strain monitoring, is fiber required in both the treatment well and the monitor well?

A. Not necessarily. Most cross-well strain applications rely on fiber only in the monitor well, often deployed via wireline to reduce cost. Having fiber in both wells improves quantitative interpretation, but it is optional rather than required.

Q4. Can fiber be integrated into sand-control screen assemblies, and can data be stored downhole if the fiber cannot reach surface?

A. Fiber can be installed inside or outside coiled tubing or casing, but integration into sand-control screens is highly design-specific and outside typical DFOS practice. If a fiber breaks downhole, current technology cannot recover or read data from the severed section. Memory-type downhole interrogators are not yet commercially available for borehole DFOS.

Q5. During acid stimulation, how long should engineers wait before using DTS warm-back analysis to identify fluid placement?

A. Warm-back interpretation assumes pure thermal conduction. Acid rock reactions generate additional heat, which distorts early-time temperature signals. Waiting allows reaction heat to dissipate, but even after an hour, residual thermal effects may remain. The most robust approach is to incorporate reaction-generated heat into the thermal model rather than relying solely on waiting time.

Q6. Can DFOS detect longitudinal hydraulic fractures in horizontal wells, and what are the limitations?

A. Yes, longitudinal fractures should produce measurable strain signatures. However, temperature effects during injection can mask strain responses. Joint interpretation of DTS and DSS is needed to remove thermal influence and isolate mechanical strain. Field demonstrations are still limited, but modelling strongly supports feasibility.

Q7. How can DFOS distinguish fracture mechanical closure from proppant crushing or embedment during production monitoring?

A. With DFOS alone, differentiation is difficult because all mechanisms produce strain-relaxation signatures. Co-located pressure measurements would allow separation based on elastic response. Current practice focuses on using strain to infer fracture connectivity and contribution rather than diagnosing specific degradation mechanisms.

Q8. How can geomechanics, thermal modelling, and acoustic interpretation be integrated into a single inversion framework?

A. Today, these analyses are typically performed separately and then combined qualitatively. A fully coupled multi-physics inversion is a long-term goal, but challenges include parameter proliferation, model instability, and computational cost. Research is ongoing, and early prototypes exist, but practical deployment remains several years away.

Q9. Does installing fiber behind casing affect cement integrity or allow detection of cement issues?

A. Fiber does not degrade cement integrity, but it can detect cement defects. DFOS can sense fluid migration through micro-annuli or cement cracks, producing distinct strain or temperature anomalies. This makes DFOS a powerful tool for cement evaluation and long-term integrity monitoring.

Q10. Is DAS alone sufficient for injection profiling when DTS is unavailable due to well length limitations?

A. It depends on injection rate. DAS relies on acoustic energy generated by turbulent flow at perforations. High-rate injections produce strong DAS signals, enabling reliable profiling. At low rates, acoustic energy may be insufficient, making DAS-only interpretation risky. Low-frequency DAS can approximate temperature gradients, but DTS remains more accurate for thermal diagnostics.

Q11. What sensor arrangement is ideal for monitoring CO₂ sequestration in basalts or saline reservoirs?

A. Multiple configurations are viable. DFOS can support 4D VSP, monitor plume migration, detect overburden leakage, and capture geomechanical strain. Surface fibers, behind-casing fibers, and monitor-well DSS/DAS all contribute complementary insights. DFOS should be integrated with seismic, pressure, and temperature gauges for a complete monitoring suite.

Q12. Should DTS, DAS, and DSS always be deployed together for best results?

A. Ideally yes, multi-physics sensing provides redundancy and cross-validation. However, economics and operational constraints often require selective deployment. Some applications (e.g., VSP) need only DAS, while others (e.g., warm-back profiling) rely primarily on DTS. Integrated interrogators capable of measuring all three simultaneously are emerging and may become standard in the future.

PERSPECTIVE: EXPERT INSIGHTS

Ensemble History Matching and Optimization

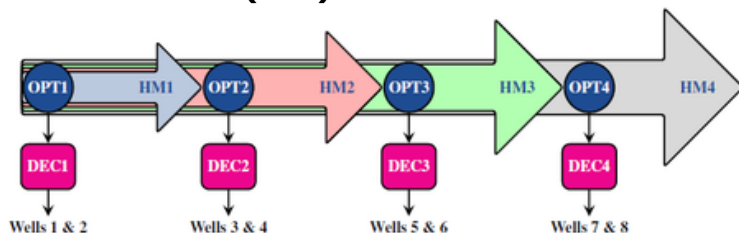
The evolution of reservoir management has reached a critical juncture where ensemble-based methods now serve as the industry's state-of-the-art workflow. In a detailed technical webinar moderated by Teodor Damian of Shell, industry pioneers Geir Evensen (Chief Scientist at NORCE) and Remus Hanea (Specialist at Equinor) outlined a comprehensive framework for moving from predictive modeling to high-value decision-making.

Ensemble Methods for Closed-Loop Reservoir Management

Ensemble methods are favored because they allow for the representation of uncertainty and the generation of ensemble predictions, which form the **bedrock of history matching (HM)**.

This integration facilitates a **Closed-Loop Reservoir Management (CLOREM)** cycle: engineers optimize future production or drilling strategies, operate the reservoir, and then use the resulting production data to update the ensemble for the next round of decisions

A prime example of this is the *2022 Chang and Evensen study*, which demonstrated optimizing the drilling order of eight alternative wells by updating the model annually to maximize **Net Present Value (NPV)**.



The History-Matching Problem: A Bayesian Perspective

The history matching problem is fundamentally underdetermined, but **Bayes' Theorem** provides the optimal starting point.



(Speaker)

Geir Evensen, PhD

Chief Scientist
NORCE Research (Bergen)



(Speaker)

Remus Hanea, PhD

Specialist,
Reservoir Technology (R&D)
Equinor



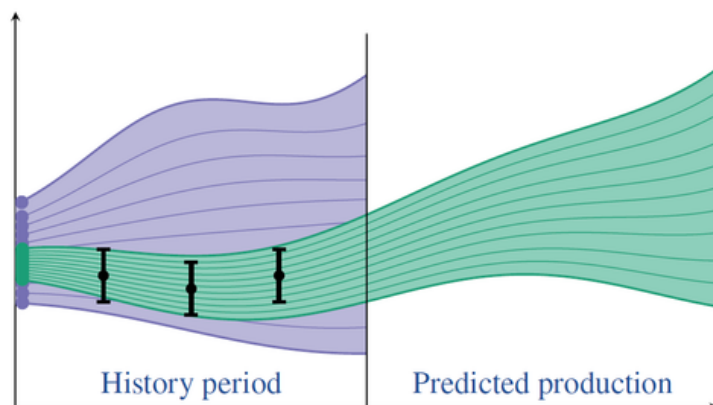
(Moderator)

Teodor Damian

Senior Petroleum Engineer
Shell

By combining a prior distribution—representing our geological knowledge—with a likelihood function representing new data, we seek to sample the posterior distribution.

This approach is not merely about finding the **"most probable"** solution but understanding the entire span of uncertainty



Methodology: RML and Gradients

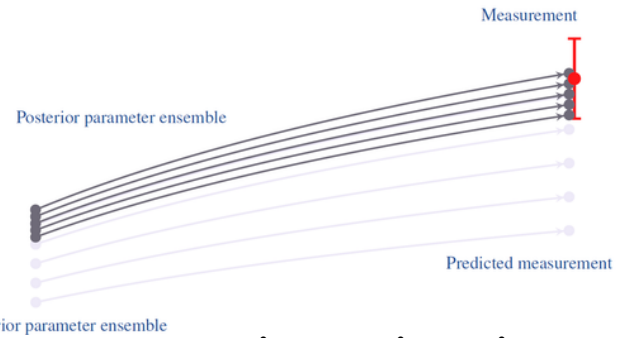
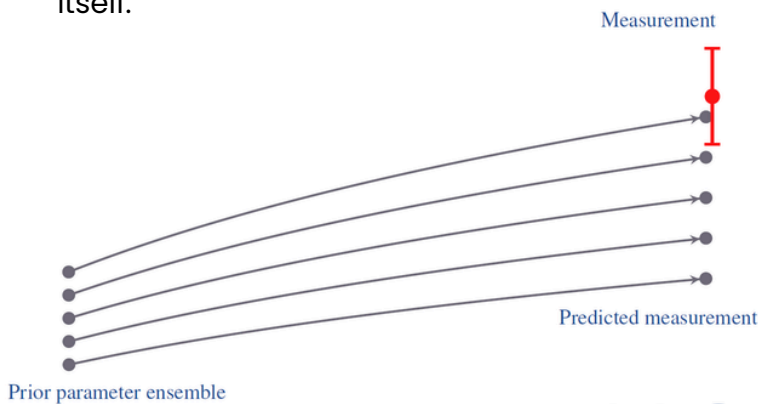
The **Randomized Maximum Likelihood (RML)** method is central to this process. It assumes Gaussian prior and likelihood distributions and minimizes an ensemble of cost functions.

While RML samples the posterior exactly for linear models, it provides a highly reliable approximation for the nonlinear problems typical in petroleum applications.

To minimize these cost functions, one typically computes a gradient and sets it to zero.

However, commercial reservoir simulators do not provide analytical gradients.

Ensemble methods solve this by using an ensemble regression approximation for model sensitivities, effectively representing huge covariance matrices through the ensemble itself.

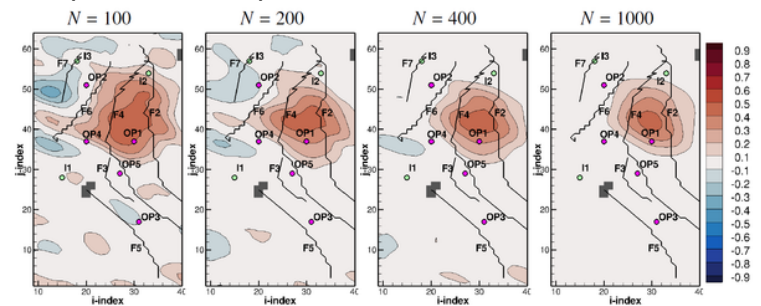


Several methods exist to achieve this:

Ensemble Smoother (ES): Linearizes the model for an explicit, though sometimes too approximate, solution.

Iterative Ensemble Smoother (IES): Solves the gradient equation exactly using Gauss-Newton iterations, making it superior for nonlinear models.

ES with Multiple Data Assimilation (ESMDA): Popular for its implementation simplicity, it introduces measurements gradually in a sequence of steps.



Managing Correlations and Sampling Errors

A major **hurdle** in **ensemble modeling** is **sampling** error, where artificial or **spurious** correlations appear, especially in small ensembles.

For example, an **oil producer's rate** might show a **strong physical correlation** with **porosity** in its **immediate drainage area**, but a small ensemble of 100 realizations might **erroneously** show a signal of equal magnitude in a **distant part** of the reservoir.

While **increasing** the **ensemble size** to **1,000 realizations** can eliminate these errors, it is often **computationally unaffordable**.

The Regression Update and Ensemble Methods

The update relies on the **correlation** between *predicted measurements* and *prior parameters*.

If a **prediction underestimates** a **measurement**, the *regression update* adjusts parameters (like porosity or permeability) to hit the target more accurately in the posterior ensemble.

Global versus Local Analysis

In a **global update**, the **posterior ensemble** is a *linear combination* of the **prior**, meaning every **measurement** can influence every **grid point**.

This often leads to **ensemble collapse**, where the **posterior variance** is **underestimated to almost zero**.

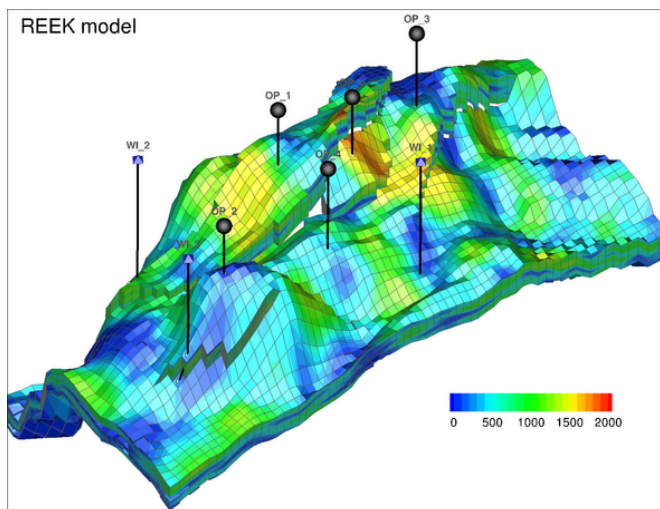
To fix this, **local analysis (localization)** is essential. By **updating grid points** using only "nearby" or significantly correlated measurements, we maintain **realistic uncertainty**.

HM REEK example

Geir illustrated the *practical challenges* of ensemble history matching (HM) using the **REEK model**, a semi-realistic test case provided by Equinor.

This model is characterized by complex geology featuring *six major faults* and a development scheme of *five producers* and *three injectors* across approximately *28,000 active grid cells*.

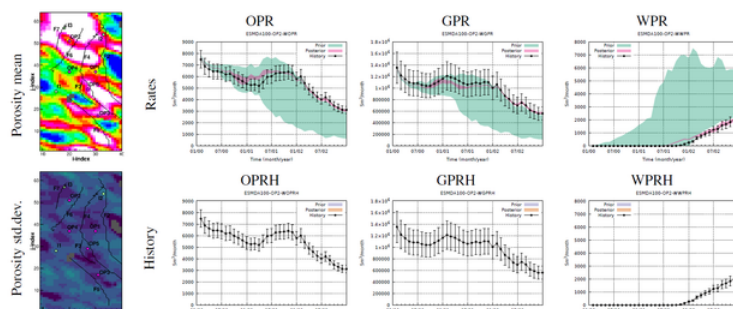
For this exercise, Geir focused on **updating porosity** and **historical forcing data**—the production data driving the model, which is itself uncertain but often ignored in traditional workflows.



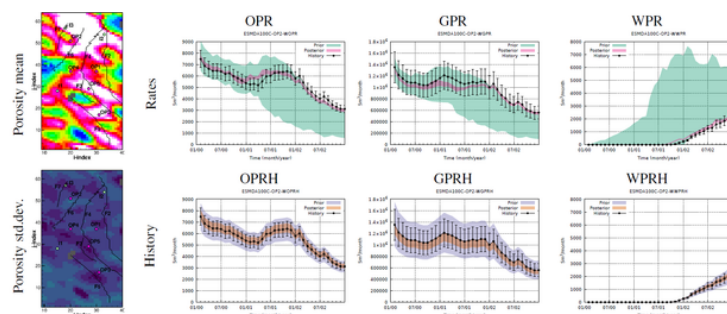
To demonstrate how *configuration errors* lead to *poor results*, Geir examined several distinct cases:

Global Analysis (N=100) with Independent Data: In this initial setup, 100 realizations were used, assuming all historical data points were independent and neglecting uncertainty in the historical forcing. The result was an ensemble that started with nearly zero error but saw uncertainty grow rapidly with production time.

However, the global update produced very strong, unrealistic porosity changes throughout the entire model domain, even in areas far from the wells. This was a clear sign of spurious correlations dominating the update. Furthermore, by treating every data point as independent information, the system "over-learned," resulting in an ensemble collapse where posterior uncertainty was underestimated to almost zero.



Introducing Control Uncertainty: By modeling the uncertainty in historical forcing data (such as gas or water rates), the team saw larger uncertainty from the initial time step. While this yellow "updated" forcing reduced gas production to better fit the data, the updates were still too strong, and the posterior uncertainty remained far too low.



The Impact of Ensemble Size (N=1000):

Increasing the ensemble to 1,000 realizations naturally reduced sampling errors, leading to a slightly larger and more realistic posterior uncertainty. In this case, uncertainty was primarily reduced in the immediate vicinity of measurements.

Accounting for Dependent Data: When Geir introduced a consistent estimate for the data covariance matrix (Cdd), recognizing that time-series production data have correlated errors and do not contain purely independent information, the results improved significantly.

Even with only 100 realizations, the magnitude of updates was reduced, meaning the data had a less aggressive impact, and the ensemble retained much more of its original variability.

The Recommended Path: Local Analysis (N=200): The final example utilized correlation-based localization with 200 realizations. By selecting only the measurements significantly correlated with specific grid points, the updates were successfully localized to the producer areas.

This approach matched the historical data perfectly while retaining significantly more uncertainty in future predictions

Geir concluded that because the **HM problem** is underdetermined, it is *easy to find a match*, but the goal should be the *minimum geological update* that **honors the data**.

Success requires **consistent error statistics** and **localization**, which he considers essential for ensuring the **posterior ensemble** remains a useful basis for **robust optimization**.

From Predictive AHM to Robust Optimization and Decisions

Remus Hanea opened his session by clarifying that his talk was not about new tools, but rather a journey of how ensemble thinking has evolved into a decision-making framework. His central thesis was provocative: **"Models are not the end product, decisions are."**

Forecasting Competence: Beyond the "Good Match"

Remus argued that the industry often treats **history matching** as the **final goal**, yet a model that **matches the past perfectly** can still be **dangerous** if it provides **misleading future predictions**.

He defined **Forecasting Competence** as the **ability** of an **ensemble** to **match data** for the right reasons while retaining a realistic spread.

To qualify a successful AHM, Remus recommended validating **predictive performance** by withholding a portion of **historical data** to see if the ensemble can accurately **"predict"** that unused segment



You can't make good decisions without embracing uncertainty.

Once an ensemble is trusted, it enables a shift from **"best case"** scenarios to robust optimization.

Unlike **classical approaches** that optimize a **single model**, **robust optimization** finds a strategy that performs best on average across the entire ensemble.

This allows engineers to express **trade-offs** and choose a **risk posture**, whether that means a **conservative strategy** to protect the **downside** or an **aggressive** one to chase the upside.

To achieve this, Remus described a **gradient-based optimization** using ensemble perturbations.

Since commercial simulators **lack analytical gradients (adjoints)**, the team uses algorithms like **Ensemble Optimization (EnOpt)** and the **Stochastic Simplex (StoSAG)** to estimate gradients from the ensemble itself.

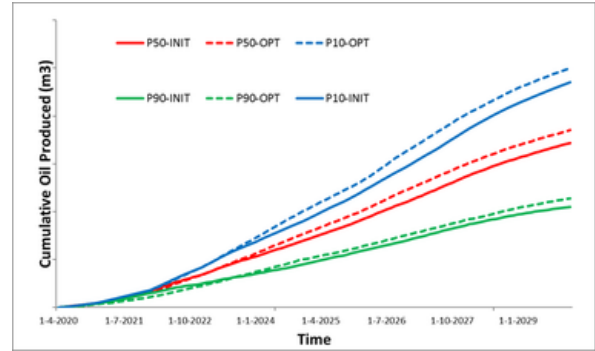
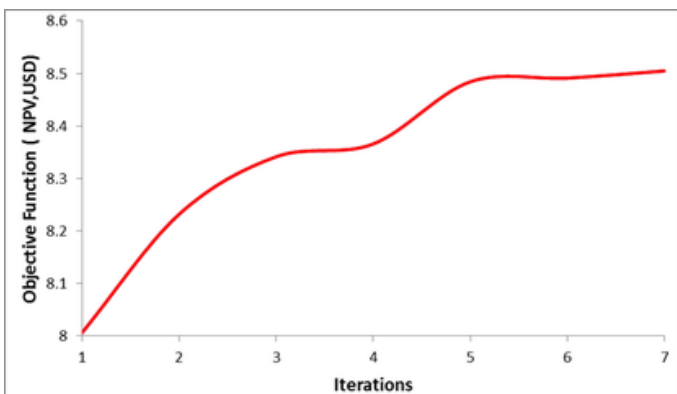
The Asset Challenge: Real-World Value Creation

Remus presented a deep dive into a **real-life asset challenge** involving a **complex reservoir** with **upper** and **lower layers**.

The team was tasked with optimizing a **10-year future drilling campaign involving 42 producers, 6 multi-laterals, and 22 injectors**.

Drilling-Order Optimization: The question was whether the sequence of wells could be improved across 30 geological realizations. After only seven iterations, the optimization converged to a new strategy that increased the **expected NPV by 6%**. This gain was visible across **P10, P50, and P90 cases**, proving that drilling order alone has measurable economic value.

What Changed? Upon closer inspection, the algorithm achieved this by delaying water injectors to improve sweep and moving multi-lateral wells earlier in the schedule to accelerate cash flow.



Multi-Objective Optimization (Value vs. Gas):

The asset also needed to reduce emissions, as gas was used only for power.

Using a weighted cost function (placing 0.2 weight on NPV and 0.8/0.98 on gas), the optimization revealed a strategy that achieved a 40% reduction in gas production with only a 2% decrease in NPV.

The Strategic Shift: To hit these targets, the algorithm prioritized lower-reservoir producers with lower gas-oil ratios (GOR) and initiated earlier water injection to maintain pressure and prevent gas liberation.

The Shift to Decision-Driven Workflows

Despite these successes, Remus noted the **limitations of current model-driven (CLOREM) workflows**. They are often **myopic**, focused on **matching current mismatches** rather than future value, and they rely on **humans to arbitrarily set weights for objectives**.

Remus concluded that the next frontier is a shift to **decision-driven reservoir management**.

This means **starting with the decision frame**: identifying the **alternatives (what can we do?)**, the **objectives (what do we value?)**, and the **uncertainties (what do we not know?)**.

In this view, **data is used primarily to inform decisions** rather than just **update models**.

“A high-quality decision is one that integrates all these factors under uncertainty to maximize total value.”

Interactive Insights: Audience Q&A

Q 1. In the RML cost-function equations, does the covariance matrix need to be diagonal? How do you handle cross-parameters?

A. The covariance matrices should, in general, be non-diagonal, representing the prior error statistics of the geological parameters and the dependencies between measurements. For example, if the uncertain parameter is the porosity field, the prior error covariance will represent both the smoothness and uncertainty of this field.

Similarly, if the measurements being conditioned on are dependent (which is typically the case if they are extracted from an allocation table), then they will have correlated errors. These error correlations appear as off-diagonal terms in the measurement error covariance matrix.

Q 2. For ensemble-based history matching approaches, is it necessary for the prior distribution to be sufficiently wide to cover the posterior?

A. It is not required that the prior ensemble strictly covers the posterior. However, it is important to have a realistic prior ensemble that adequately represents the underlying physics. In this context, history matching (HM) can be viewed as a calibration of the prior, where the ensemble is updated to better match observations through modest and physically consistent corrections.

Q 3. What practical guidelines can be followed to define appropriate measurement error statistics?

A. When using ensemble methods, it is important to properly specify the measurement error statistics. A practical starting point is to assume a realistic uncertainty, for example by specifying a measurement error standard deviation of approximately 10% of the measured value.

Furthermore, measurement error correlations should be included if the measurements are dependent, which is almost always the case for historical rate data. Properly specified error statistics help resolve the issue of selecting measurement frequency.

For example, conditioning on weekly rate data does not necessarily introduce more information than conditioning on monthly data if temporal correlations are properly accounted for. See Evensen and Eikrem (2018) and Evensen et al. (2025, Chap. 13.6) for further discussion.

Q 4. Given the high heterogeneity in carbonate reservoirs, what best practices would you recommend for designing and implementing ensemble-based history matching workflows? How should these workflows differ from those used in sandstone reservoirs?

A. We have limited experience with carbonate reservoirs. However, the prior error statistics are likely more challenging to prescribe in order to properly represent the increased heterogeneity, which typically occurs at shorter spatial scales. This may require more careful parameterization and possibly higher-resolution models or multi-scale approaches.

Q 5. What is the rationale behind selecting a specific number of iterations (e.g., 30 iterations)? Why not fewer or more?

A. For history matching, approximately 4 to 8 iterations are typically sufficient. The iterations are mainly required to resolve the nonlinearity of the model. See, e.g., Evensen et al. (2024) for a discussion of the impact of model nonlinearity on the required number of iterations.

For optimization, a larger number of iterations may be required depending on the complexity of the objective function and the convergence criteria.

The choice of the number of iterations is also related with the convergence of the gradient optimization.

One stopping criteria could be the lack of changes in the delta NPV over few sequential iterations. Also, due to the computational burden of several hundreds of simulations, one can have a maximum of iterations before the optimization stopped.

Q 6. What is the recommended strategy for defining weights in multi-objective optimization problems?

A. A common strategy is to normalize the individual objective terms so that they are comparable in magnitude, and then assign weights based on their relative importance. Alternatively, Pareto-based approaches can be used to avoid explicit weighting and instead explore trade-offs between competing objectives.

Q 7. How does computational cost influence the workflow? Is reservoir simulation time a limiting factor in determining ensemble size and number of iterations? What is the typical model scale (e.g., number of grid cells) used in such studies?

A. For both history matching and robust optimization, the main computational cost arises from running the reservoir simulations. Fortunately, ensemble simulations can be executed in parallel on computing clusters, meaning that the wall-clock time per iteration is comparable to that of a single simulation.

We have applied ensemble methods to realistically sized reservoir models, such as the Troll field operated by Equinor (Evensen et al., 2025, Chap. 14). In practice, computational resources will still limit the feasible ensemble size and number of iterations, and a balance must be found between accuracy and computational cost.

Q 8. How can we ensure that mathematical or statistical biases do not override the underlying physics, particularly in forecasting applications?

A. This can be addressed by ensuring that prior models are physically consistent and that updates introduced during history matching remain within the bounds of geological plausibility. Regularization, localization, and careful specification of prior error statistics all help prevent overfitting to data. Additionally, independent validation using blind prediction tests can help assess whether the model retains its predictive capability.

Q 9. In standard history-matching workflows, near-zero posterior variance (indicative of ensemble collapse) is often observed. How can engineers diagnose early signs of ensemble collapse during iterative history matching?

A. So-called ensemble collapse is typically caused by including too many independent measurements in the history matching problem. For example, conditioning on a long time series of dependent historical data while ignoring these dependencies (by prescribing a diagonal measurement error covariance matrix) will often lead to unrealistically low posterior uncertainties, i.e., ensemble collapse. Additionally, large data sets combined with global updates may introduce spurious correlations that further reduce ensemble spread.

To avoid ensemble collapse, one should use localization and correctly specify measurement error correlations (alternatively, subsample the measurement data).

Q 10. Even with localization, posterior variance can remain underestimated when conditioning on time-series data. Is variance or covariance inflation necessary in practice, and how should it be calibrated robustly?

A. An underestimation of the posterior variance is typically caused by one or more of the following:

1. Without localization, sampling errors from a limited ensemble size induce spurious correlations, leading to artificial updates across the model domain and reduced variance.

2. Large data sets may introduce too much effective independent information, which is difficult to match and leads to variance underestimation.
3. Neglecting measurement dependencies in time-series data gives these data excessive influence, further reducing posterior variance.

Again, see the discussion in Evensen and Eikrem (2018) and Evensen et al. (2025, Chap. 13.6). In practice, covariance inflation can be used as a corrective measure, but it should be applied cautiously and ideally in combination with proper error modeling.

Q 11. Achieving a good history match does not necessarily ensure predictive reliability. What validation workflows or diagnostic checks would you recommend to ensure robust and reliable forecasting performance?

A. The prior ensemble forms the foundation, representing the initial geological uncertainty. Without observations, predictions are based solely on this prior ensemble.

The role of history matching is to introduce small, geologically consistent corrections based on observed data, resulting in a posterior ensemble that both honors the data and remains consistent with prior assumptions.

Validation should include blind tests using withheld data, comparison of predicted and observed trends, and consistency checks across different data types (e.g., production data, 4D seismic, or gravimetry).

Such workflows help ensure that the model retains predictive capability beyond the calibration period.

Q 12. Can AI help discover new frontiers in ensemble-based decision support?

A. AI is currently being used to build proxy models that significantly accelerate ensemble optimization and history matching.

Beyond speed, AI can augment human teams by suggesting creative geological concepts or alternative strategies that help overcome inherent human biases during the decision-framing process.

Q 13. Is there a point where adding more model complexity harms decision-making?

A. Instead of asking how much complexity to add, teams should turn the question upside down. Start with the specific decision you need to make, and then work backward to determine the minimum level of model complexity and data required to inform that choice.

Q 14. What is the most common misunderstanding among practitioners regarding a "good" history match?

A. The biggest misconception is that a match of the past is the end goal. A perfect historical match is necessary but not sufficient. Success must be judged by the model's predictive performance and its ability to support high-quality future decisions.

Further Reading

Evensen, G. and K. S. Eikrem. Strategies for conditioning reservoir models on rate data using ensemble smoothers.

Computat Geosci, 22(5):1251-1270, 2018.
doi: [10.1007/s10596-018-9750-8](https://doi.org/10.1007/s10596-018-9750-8).

Evensen, G., F. C. Vossepoel, and P. J. Van Leeuwen. Iterative ensemble smoothers for data assimilation in coupled nonlinear multiscale models.

Mon. Weather Rev., 152, 2024.
doi: [10.1175/MWR-D-23-0239.1](https://doi.org/10.1175/MWR-D-23-0239.1).

Evensen, G., D. S. Oliver, and R. G. Hanea. Ensemble History Matching: Conditioning Reservoir Models on Dynamic Data.

Springer, 2025. ISBN 978-3-030-96708-6.
doi: [10.1007/978-3-031-99155-4_6](https://doi.org/10.1007/978-3-031-99155-4_6). Open access.

THE RESERVOIR CHRONICLES: TRIVIA & TIDBIT

Interested in testing your knowledge of Integrated Reservoir Management?
Or curious about the evolution of reservoir management through the years?
Then don't miss this recurring feature packed with insights, challenges, and learning!

DID YOU KNOW?



In 1947, in the vast gas-bearing stretches of the **Hugoton Field**, a modest well became the site of a transformative experiment: could mechanical stimulation outperform conventional acidizing?

The **Kelpper Well No. 1**, operated by **Pan American Petroleum Corp.** in Grant County, Kansas, had shown limited productivity despite prior acid treatment. Selected as a test candidate, it became the first well to **undergo hydraulic fracturing**—where fluid was injected at pressure to create fractures and enhance flow pathways within the reservoir.

That single treatment marked a turning point, establishing hydraulic fracturing as a far more effective stimulation method and laying the foundation for its widespread use in oil and gas production.

Source: Chapter 8: Hydraulic Fracturing (PEH – Vol IV)

SPECULATE: QUIZ ZONE

Born in 1856, I led industries beneath the earth and shaped how they are managed.

My legacy:

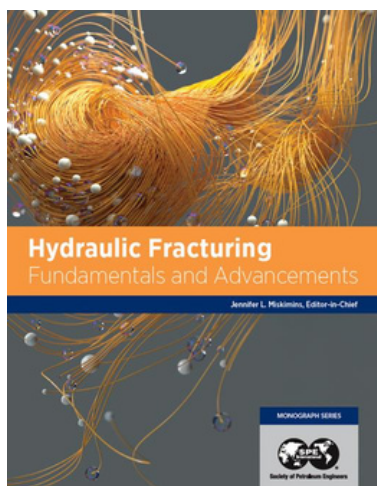
- Global leader across mining, metallurgy, and petroleum-linked industries
- Pioneer in large-scale resource development and infrastructure
- Namesake of a prestigious award honoring leadership in mining and petroleum administration

I didn't just run operations—I set the standard for leadership that continues to influence SPE and the energy industry.

Who Am I?



PETROPAGES: BIBLIOPHILE BULLETIN



Hydraulic Fracturing: Fundamentals and Advancements
Edited by **Jennifer L. Miskimins**

Society of Petroleum Engineers
DOI: <https://doi.org/10.2118/9781613993040>
ISBN electronic: 978-1-61399-904-2
Publication date: 2019

With an author team of 26 subject-matter experts representing a diversity of talent, background, and experience, **Hydraulic Fracturing: Fundamentals and Advancements** delivers a comprehensive discussion on the principles of hydraulic fracturing while also including the latest processes that have prompted the explosive growth in stimulating horizontal wells in shale and tight oil and gas reservoirs.

Spotlight Publication

Next-Generation Completion Workflow

This article contains highlights of the paper “**First Integrated Completion Operations Successfully Deployed in the UAE Shilaif Unconventional Oil Reservoir,**” authored by **O. A. Alvarado, T. Itibrou, K. H. Al Dhaheri, M. A. Mazrouei, P. Hanna, A. Cuessy-Vazquez, A. S. Negi, B. Broca, A. Alam, T. Ao, E. Kaul, D. H. Cippitelli, A. Alhosani, M. Y. Al-Ali, and M. Khan** from **ADNOC Onshore and ADNOC Drilling**. The paper has not been peer-reviewed and was prepared for presentation at ADIPEC 2025 and is published as **SPE-229622-MS** by the Society of Petroleum Engineers.

Background & Technical Challenges

The **Shilaif Formation** in Abu Dhabi is a low-permeability, high-pressure unconventional carbonate reservoir characterized by **argillaceous limestone, fine-grained packstones, and shaly mudstone-wackestones, with permeability values as low as 0.00011–0.000355 mD**. These rock properties inherently restrict reservoir connectivity, **making hydraulic fracturing**

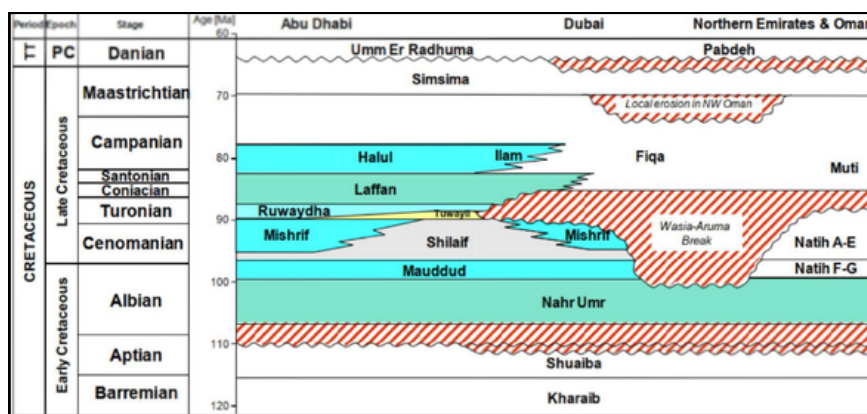


Figure 1: Shilaif in Abu Dhabi with equivalences in Dubai, Northern Emirates and Oman (Van Laer, et al., 2019)

essential to unlock commercial flow rates. Development efforts have been further complicated by the reservoir’s heterogeneous geology, variable organic content, and tight carbonate matrix, all of which require precise stimulation placement and advanced reservoir understanding. **Prior completion workflows in the region treated hydraulic fracturing, wireline plug-and-perf, and coiled tubing milling as separate operational silos, resulting in inefficiencies, higher non-productive time, and reduced operational coordination.** Additional challenges included high pumping pressures of approximately 7,300–7,500 psi during fracturing, the need for reliable proppant supply over remote pad locations, and operational risks such as wireline tool misfires, weather-related downtime, and cable-cut incidents. These geological, logistical, and operational constraints underscored **the necessity for a unified, integrated completion strategy tailored for unconventional tight-carbonate development in the UAE.**

Solutions

To address these challenges, ADNOC **deployed a fully integrated completion execution model** that combined **hydraulic fracturing, wireline plug-and-perf, and coiled tubing milling within a single real-time coordinated workflow**. The fracturing component utilized a split-stream technique that enabled simultaneous stimulation across paired wells, reducing stage time and improving fluid distribution while allowing engineers to make real-time adjustments based on pressure and rate data. Fluid systems were enhanced with high-viscosity friction reducers (HVFRs), which maintained adequate viscosity for proppant suspension while reducing frictional pressure losses.

Spotlight Publication | Next-Generation Completion Workflow

Wireline operations incorporated a **plug-and-play gun system** that **minimized on-site assembly, eliminated crossover cleaning, shortened the toolstring by 15%**, and significantly improved pump-down efficiency. Meanwhile, coiled tubing milling employed a high-performance bottomhole assembly (BHA) optimized for 4–4.5 bpm pumping rates, paired with a reverse clutch mill that produced smaller cuttings to improve debris removal and minimize the risk of bridging. Across all services, continuous diagnostics and coordinated communication enabled synchronized decision-making that minimized cycle times and enhanced overall operational reliability. This integrated approach streamlined workflows that were traditionally fragmented, providing a cohesive solution to the reservoir's technical and logistical constraints.

Implementation Details

The operational campaign consisted of four horizontal wells - A, B, C, and D - each with approximately 6,000 ft of lateral length and completed with 5½" frac strings to accommodate high-pressure stimulation requirements. Preparatory offline activities were conducted in a structured sequence, ensuring each wellsite was fully equipped and crewed before stimulation began. Fracturing operations followed a zipper frac strategy, starting with Wells A and D before progressing to Wells B and C, with each well receiving a 30-stage slickwater fracturing treatment. Rates averaged around 100 bpm, and pressures remained near 7,300–7,500 psi throughout the campaign.

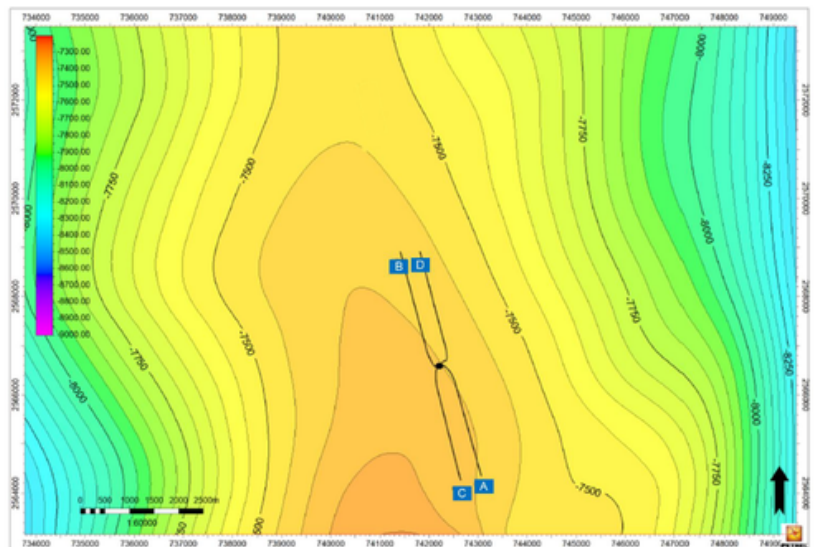


Figure 2: General Structure Map and Location of Primary Targets, Wells A, B, C & D.

Plug strategy varied by well, employing dissolvable, composite, and all-composite plugs to reduce milling burden while maintaining stage isolation integrity. Wireline operations **leveraged pump-down techniques** using the plug-and-play gun system, **achieving average run-in and pull-out speeds of 351 FPM and 346 FPM respectively**, enabled by vertical gun makeup procedures that reduced both time and crew requirements. Coiled tubing operations then proceeded with high-rate milling, supported by real-time telemetry for torque, differential pressure, and depth tracking, enabling stage-specific adjustments and efficient cuttings removal. Throughout the campaign, logistical support—including a centralized proppant staging area 15 km away, continuous 24/7 sand transfer, and dedicated shallow-water sourcing validated through rheological testing—ensured reliable fluid and proppant supply to sustain uninterrupted daily stage execution.

Results and Operational Impact

The integrated completion model delivered significant operational gains, **most notably a 56% reduction in total completion time per well**, attributed to the efficiencies created by split-stream fracturing, optimized HVFR-based slickwater designs, and reduced pump maintenance

Spotlight Publication | Next-Generation Completion Workflow

downtime as a result of smoother hydraulic profiles. The campaign set a UAE record by achieving up to nine fracture stages in a single day, **driven by streamlined logistics and coordinated execution across service lines.** Wireline performance **improved by 33%** due to reduced toolstring length, elimination of crossover cleaning, vertical equipment handling, and strong crew preparedness, **culminating in a 95% to 98% gun-firing success rate and reduced run durations of approximately 1.67 hours.**

Coiled tubing operations saw a **59% reduction in valve-to-valve milling time,** enabled by the high-rate BHA design, reverse clutch mill selection, advanced fluid systems, and real-time telemetry that supported optimal motor performance and debris management. **Collectively, these improvements not only shortened cycle times and reduced non-productive time but also enhanced overall stimulation quality and reservoir contact.** The success of the coordinated model **facilitated the transition from isolated 3,000-ft trial laterals to scalable pad-based development** with four to five wells per pad, marking a critical step forward in enabling unconventional resource development in the Shilaif reservoir.

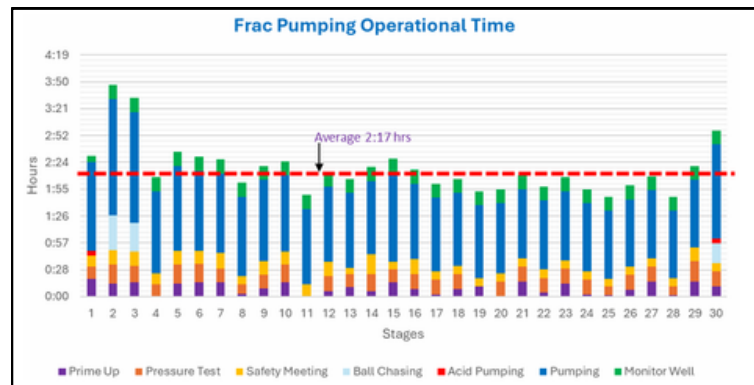


Figure 3: HVFR Rheology Profile at different concentrations, base water from shallow water wells

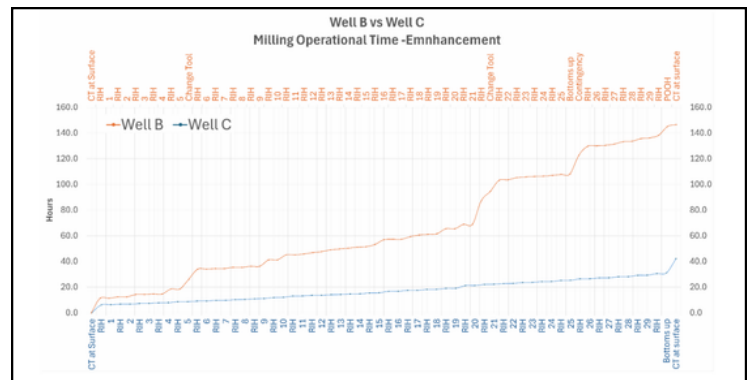


Figure 4: Reduction in Valve-to-Valve Milling Duration, Comparison of Well B Vs Well C

Forward Outlook

The achievements of this integrated completion campaign establish a **scalable and replicable model for future unconventional field development** across the Middle East. With **demonstrated reductions in cycle time, improved service-line synchronization, and validated high-performance stimulation designs,** the approach is well aligned with ADNOC’s broader strategic objectives to **accelerate unconventional resource monetization and support its 2030 vision for expanded production capacity.** Future campaigns are expected to further evolve toward enhanced digitalization, including expanded use of real-time downhole telemetry, surface automation, predictive optimization tools, and potentially greater adoption of dissolvable plug technologies to eliminate milling altogether. **The integrated model is poised to enable repeatable, pad-based developments across similar tight-carbonate formations,** ensuring **consistent operational performance while reducing cost per lateral foot.** As lessons learned continue to shape refinement of completion designs, logistics planning, and cross-discipline collaboration, **the Shilaif case study stands as a foundational reference for optimizing unconventional reservoir development in the UAE and the wider region.**

SPE IRMTS IN PICTURES

SPE IRMTS marked the start of 2026 with massive global footprints! The IRMTS held a **strong and visible presence across major global industry platforms**. During the quarter, IRMTS members actively participated in various events as highlighted by the images, reinforcing the section’s commitment to technical excellence, knowledge exchange, and global collaboration. These members had the opportunity to engage with industry leaders and pioneers in different capacities and events, spearhead innovation through their involvement in local student chapters, be recognised for their commendable work in their various sections, which underscores the section’s dedication to both foundational theory and evolving best practices and be recognised for leading the transformation in the energy sector.



The collage highlights how members of the **SPE Integrated Reservoir Management Technical Section** are making impactful contributions across their local sections, while also capturing key milestones for the **IRMTS Youth community**. Youth member **Wamuyu Miano** was recognized as the **Overall Outstanding Student at the SPE Kenyatta University Chapter**, Board member **Parag H. Bhoraniya** was unveiled as part of the **SPE Young Professionals Board**, and Youth and Board Member **Sydney Angella Nassanga** was **spotlighted** by her local section—highlighting the **growing inclusion, diversity, and leadership of young professionals within the IRMTS network**.

Together, these moments reflect the expanding global footprint of IRMTS—**spanning technical leadership, youth empowerment, and industry partnership**—as the section continues to strengthen its role in shaping the future of integrated reservoir management.

Thank You to Our Sponsors

PLATINUM TIER



GOLD TIER



Strengthening Partnerships in Integrated Reservoir Management

The SPE IRMTS Section warmly welcomes partners and sponsors to join us in our mission to advance knowledge in reservoir management, digitalisation and innovation within the energy sector. Through strategic sponsorship, organizations can play an active role in supporting initiatives that drive technical excellence, professional development, and knowledge sharing across disciplines. Your partnership enables SPE IRMTS to organize impactful programs, technical forums, and networking events that connect industry leaders, researchers, and young professionals in shaping the future of energy.

| | |
|--------------------------------|--|
| Sponsorship Opportunity | <p>Would you be interested in supporting the SPE IRMTS?</p> <p>Reach out to our Sponsorship Champion, Maryvi Martinez Santiago, to explore opportunities to collaborate with us and amplify your organization’s presence within the global energy community.</p> |
|--------------------------------|--|



From the Editors' Desk

As we progress through 2026, the **SPE Integrated Reservoir Management Technical Section** continues to evolve with a clear direction—positioning itself as a **system-level integrator** across the IRM landscape. Building on recent efforts, IRMTS is aligning its programs under a multidisciplinary framework that connects **production optimization, performance monitoring, and reservoir evaluation**, reflecting a broader shift toward **decision discipline** and **integrated asset thinking**.

Alongside this, IRMTS has initiated **youth-led efforts** aimed at shaping the next generation of energy professionals. A Leadership Dialogue and the survey **“Bridging the Gap: Student Insights, Barriers, and Pathways Forward”** highlighted a consistent theme: *students seek practical, experience-driven learning, including field exposure, simulations, mentorship, and clearer pathways linking academic knowledge to industry roles.*

In response, the **IRMTS Youth Wing** is expanding **student participation** and **representation**. Upcoming **student-led webinars** will promote **peer learning** and **active contribution**, marking a shift toward greater **student ownership** within the **SPE ecosystem**. These developments reinforce IRMTS’s role as a bridge between academia and practice, with a growing emphasis on experiential learning and structured engagement. The direction is clear. With a strong foundation in place, IRMTS will continue to **build impactful, industry-connected experiences** that enable **students** and **professionals** alike to engage, grow, and contribute with confidence.

We invite our readers to stay engaged and share ideas, feedback, and topic suggestions for future editions. You may reach the IRMTS communications team at irmtechnicalsection@gmail.com or technicalsections@spe.org as we continue to grow IRMTS as a connected, forward-looking technical community.

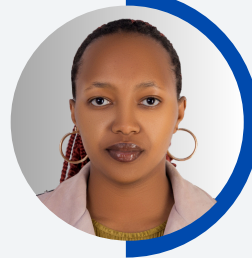
The SPE IRMTS Newsletter Editorial Team



Shubham Patel
Reliance Industries



Sydney Nassanga
JEPA Africa



Wamuyu Miano
Kenyatta University



Vera Dogo
TechnipFMC



Ameen Ahmed
Anton Oil



Muhammad Navaid Khan
ADNOC



Parag Bhoriyani
Shell

UPCOMING SPE INTERNATIONAL EVENTS



VISIT WWW.SPE.ORG/EVENTS FOR A COMPLETE LIST

Events

April 21, 2026

SPE Europe Subsurface Conference (26 BERG)

Bergen, Vestland, NOR

April 21-23, 2026

2026 SPE Improved Oil Recovery Conference (26IOR)

Tulsa, Oklahoma, USA

April 22-24, 2026

2026 SPE Argentina Exploration and Production of Unconventional Resources Symposium (26LAUR)

Neuquén, Neuquén Province, ARG

May 04-07, 2026

Offshore Technology Conference (OTC) 2026 (26OTC)

Houston, Texas, USA

May 18-20, 2026

SPE Conference at Oman Petroleum and Energy Show (26OPES)

Muscat, OMN

May 20-21, 2026

SPE Scale Symposium (26OSS)

Ardoe, Scotland, GBR

June 09-11, 2026

SPE Latin American and Caribbean Petroleum Engineering Conference (LACPEC) (26LACP)

Rio de Janeiro, BRA

Workshops

April 21-22, 2026

SPE Workshop: Strengthening Marginal and Mature Field Ecosystems: Technology, Innovation, and Collaboration (26WM08)

Kuala Lumpur, MYS

May 05-06, 2026

SPE Workshop: Full Life Cycle Water Management for Effective Resource Development (26ACA1)

Calgary, AB, CAN

May 07-08, 2026

SPE Workshop: Multiphase Metering Opportunities and Solutions (26ASA1)

San Antonio, TX, USA

Call for Papers

November 02-05, 2026

ADIPEC (26ADIP)

Abu Dhabi, ARE

Deadline: May 15, 2026

November 24-26, 2026

SPE Annual Caspian Technical Conference (26CTC)

Atyrau, Kazakhstan

Deadline: June 11, 2026