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Industrial Adoption of Distributed Acoustic Sensing (DAS) in Petroleum Engineering and Geosciences: Real-World Evidence

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ABSTRACT

Distributed Acoustic Sensing (DAS) has emerged as a key technology in subsurface monitoring, transforming fibre-optic cables into dense acoustic sensor arrays capable of providing real-time, continuous data across extensive distances. This paper reviews the industrial applications of DAS in petroleum engineering and geosciences, highlighting its role in hydraulic fracturing diagnostics, production monitoring, well integrity assessments and geophysical studies. Case studies from active oil and gas operations and research institutes' collaboration with industries demonstrate how DAS enhances fracture propagation analysis, optimizes production flow monitoring and improves seismic event detection. The review also addresses existing gap between academic research and industrial adoption of DAS in petroleum industry related applications. Overall, the widespread adoption of DAS is enhancing subsurface monitoring capabilities, driving operational efficiency and contributing to more informed decision-making in the petroleum and geosciences industries.

Keywords: Distributed acoustic sensing (DAS); Subsurface monitoring; Petroleum engineering; Reservoir surveillance

Introduction

Distributed Acoustic Sensing (DAS) is a fibre-optic sensing technology that has revolutionized subsurface monitoring by transforming standard telecommunications fibre into a dense acoustic sensor array[1]. This technique relies on the principle of Rayleigh backscattering, where an interrogator unit sends laser pulses through the fibre and minute backscattered signals are analysed to detect acoustic and vibrational disturbances along its entire length[2]. Unlike conventional geophysical and wellbore monitoring methods that rely on discrete sensors, DAS provides continuous, real-time data over extensive distances, making it a highly efficient and cost-effective solution for various industrial applications. Initially developed for security and perimeter monitoring, DAS has gained significant traction in the oil and gas industry, where it offers novel insights into reservoir dynamics, well integrity and fluid flow behaviour[3].

In petroleum engineering, DAS has been successfully employed in applications such as hydraulic fracturing diagnostics, production monitoring and well integrity assessments. Its ability to capture acoustic signatures enables operators to track fracture propagation in real time, optimize proppant placement[4] and detect potential failure points in wellbore structures. Additionally, DAS-based production monitoring allows for the detection of multiphase flow behavior, sand production and artificial lift performance without requiring intrusive downhole sensors[5]. Beyond wellbore applications, DAS has played a pivotal role in geophysical and geomechanically studies, particularly in passive seismic monitoring and micro seismic event detection. Its ability to detect small-scale seismic events makes it a valuable tool for understanding induced seismicity in unconventional reservoirs, monitoring CO_2 storage sites and assessing geohazards such as fault reactivation and landslides[6,7].

The growing adoption of DAS in petroleum and geoscience applications is driven by its ability to provide real-time, high-resolution data over large areas at a lower cost compared to traditional sensor networks. In this review paper, we provide evidence of the industrial applications of Distributed Acoustic Sensing (DAS) in petroleum engineering and geosciences. By compiling real-world case studies from various sectors, including well integrity monitoring, hydraulic fracturing diagnostics, production optimization, seismic and micro seismic surveillance, CO_2 sequestration and pipeline integrity assessment, we highlight the practical benefits, challenges and future potential of DAS technology. This review aims to bridge the gap between theoretical advancements and industry adoption, offering insights into how DAS is transforming subsurface monitoring, enhancing operational efficiency and improving safety across the energy sector.

Understanding DAS Technology

Distributed Acoustic Sensing (DAS) is a fiber-optic technology that enables real-time acoustic monitoring by utilizing standard optical fibers as a dense array of distributed sensors. Unlike traditional point sensors, DAS provides continuous, high-resolution data along the entire length of the fibre[5], making it a powerful tool for subsurface monitoring. The technology is based on the principle of Rayleigh backscattering, where a laser pulse is sent through the fiber and the backscattered light is analyzed for phase and intensity variations caused by acoustic or vibrational disturbances. These variations are then processed to extract meaningful information about the subsurface environment or infrastructure being monitored.

A key advantage of DAS is its ability to transform pre-existing fiber-optic infrastructure into a sensing network without the need for additional downhole instrumentation. This makes it a cost-effective alternative to conventional sensors, especially in applications requiring continuous spatial coverage over long distances, such as along pipelines, wellbores and seismic arrays[8]. The sensitivity of DAS systems is influenced by factors such as fiber quality, interrogation frequency and signal processing techniques. Modern DAS interrogators can achieve spatial resolutions ranging from a few meters to sub-meter precision, allowing for detailed characterization of dynamic processes such as fluid flow, fracture propagation and seismic wave propagation[9].

The performance of DAS largely depends on the interaction between acoustic waves and the fiber-optic cable, which can be influenced by its installation environment. For example, fibers embedded in cemented wellbores provide better coupling with the formation[10], enhancing signal fidelity, whereas loosely deployed fibres may introduce noise or signal attenuation. To improve data reliability, advanced processing techniques such as machine learning algorithms and noise filtering methods have been developed to distinguish meaningful signals from background noise. Furthermore, integration with other fiber-optic sensing technologies, such as Distributed Temperature Sensing (DTS) and Distributed Strain Sensing (DSS), enables a more comprehensive understanding of subsurface conditions[1,11].

Despite its numerous advantages, DAS has limitations, including high data storage requirements, complex signal interpretation and sensitivity to environmental conditions that may degrade fiber-optic performance over time[12]. However, ongoing advancements in interrogator design, data analytics and fiber-optic materials continue to enhance its applicability across various industries. In petroleum engineering and geosciences, DAS has proven to be a game-changing technology, providing real-time insights that were previously difficult or impossible to obtain using conventional monitoring methods. Its ability to deliver high-resolution, non-intrusive and cost-effective sensing makes it an invaluable tool for optimizing energy production, improving safety and advancing geophysical research[13].

Industrial Applications of DAS In-Petroleum Engineering And Geosciences

The industrial adoption of DAS in petroleum engineering and geosciences has expanded significantly due to its ability to provide real-time, high-resolution data for various subsurface and infrastructure monitoring applications. Unlike traditional sensor networks, DAS enables continuous and distributed measurements along existing fiber-optic cables, making it particularly valuable for large-scale and remote operations. The versatility of DAS has led to its implementation across the upstream, midstream and downstream sectors of the oil and gas industry, as well as in geophysical applications such as seismic monitoring, geohazard detection and carbon sequestration[14].

In petroleum engineering, DAS has revolutionized well integrity monitoring by detecting casing deformation, cement bond failures and sand production. The continuous nature of DAS measurements allows operators to identify anomalies before they lead to costly failures, reducing downtime and enhancing operational safety. Another critical application is hydraulic fracturing monitoring, where DAS is used to track fracture propagation in real time, optimize proppant placement and assess the effectiveness of stimulation treatments. By analyzing acoustic emissions along the wellbore, engineers can gain valuable insights into fracture geometry, fluid distribution and micro seismic activity, enabling better reservoir management and production optimization[15,16].

DAS also plays a crucial role in reservoir surveillance, particularly in enhanced oil recovery (EOR) operations, where it is used to monitor fluid flow behavior during steam-assisted gravity drainage (SAGD), CO_2 injection and waterflooding. By capturing acoustic signals associated with fluid movement, DAS provides a non-intrusive means of assessing sweep efficiency, identifying breakthrough zones and optimizing injection strategies. Similarly, in production monitoring, DAS enables real-time flow profiling in multiphase systems, detecting gas lift efficiency, slug flow dynamics and wellbore instability without the need for costly downhole sensors. This capability is especially beneficial in mature fields where conventional production logging tools may be impractical or uneconomical[10].

Beyond wellbore and reservoir applications, DAS has been widely adopted in geosciences for passive seismic monitoring, geohazard assessment and carbon capture and storage (CCS). In seismic applications, DAS converts fiber-optic cables into dense seismic arrays capable of detecting natural and induced seismic events with high spatial resolution. This has proven particularly useful for monitoring hydraulic fracturing operations, geothermal energy projects and tectonic fault activity. Additionally, DAS has been employed in geohazard detection, providing real-time insights into landslides, subsurface subsidence and fault reactivation, which are critical for ensuring the stability of infrastructure such as pipelines, offshore platforms and underground storage facilities[17,18].

Another emerging application of DAS is in the monitoring of CO_2 sequestration sites, where it is used to track the movement of injected CO_2, detect potential leakage pathways and assess caprock integrity. The ability of DAS to provide continuous, high-resolution subsurface monitoring makes it a valuable tool for ensuring the long-term safety and effectiveness of CCS projects. Furthermore, its deployment along pipelines allows for early detection of leaks, mechanical stress and third-party interference, improving pipeline integrity management and reducing environmental risks[19].

The growing use of DAS in petroleum engineering and geosciences is driven by its ability to enhance operational efficiency, reduce costs and improve safety. However, challenges such as data interpretation complexity, signal-to-noise ratio limitations and infrastructure constraints remain. Despite these challenges, advancements in data analytics, artificial intelligence and fiber-optic technology continue to expand the capabilities of DAS, making it an indispensable tool for modern energy and geoscience applications. As industrial case studies continue to demonstrate its value, the role of DAS is expected to grow, paving the way for more innovative and data-driven approaches to subsurface monitoring[20]. In subsequent sections, case studies from industries and research institutes working on real word problems utilizing DAS technology will be outlined.

The following sources cited in **Figure 1** has been used to find evidence of DAS adoption in Petroleum industry.

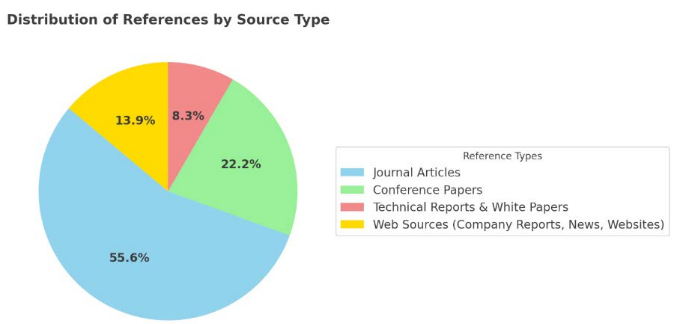

Figure 1: Type of sources utilized to collect evidence for the study

Industrial Evidence of DAS In-Petroleum Engineering

Distributed Acoustic Sensing (DAS) has been increasingly adopted in the oil and gas industry for real-time well integrity monitoring, offering practical solutions in areas such as casing deformation detection, cement bond integrity assessment and sand production monitoring. The detail discussion is tabulated in **Table 1**.

Evidence in well integrity

Casing deformation detection: DAS has been effectively utilized in geothermal applications in Iceland, particularly in monitoring the integrity of well casings. A notable example involves the use of a 15-kilometer-long fiber-optic cable on the Reykjanes Peninsula in southwest Iceland. Originally installed for data transmission between two geothermal power plants, this cable was repurposed in 2015 by researchers from the GFZ German Research Centre for Geosciences in Potsdam to detect seismic waves and monitor subsurface deformations. The DAS system measured tiny phase changes in laser pulses reflected along the fiber, allowing the detection of seismic activities and ground deformations, which are critical for assessing the mechanical coupling between well casings and surrounding formations. This approach provided real-time insights into potential casing deformation issues, enhancing the monitoring capabilities of geothermal wells in the regions[21].

Cement bond integrity assessment: In a geothermal well in Iceland, researchers from the GFZ German Research Centre for Geosciences implemented Distributed Acoustic Sensing (DAS) technology to assess cement bond integrity. The study focused on Well RN-34, located in the Reykjanes Geothermal Field. A fiber-optic cable was installed behind the 18⅝-inch anchor casing and DAS data were continuously acquired during drilling and injection testing operations. By analysing the average axial strain-rate profiles obtained from the DAS data, the researchers identified trends similar to those observed in conventional cement bond logs (CBL). This similarity suggests that DAS can be used to monitor the mechanical coupling between cemented casings and surrounding formations, providing a real-time, qualitative assessment of cement bond integrity without the need for additional well intervention programs[21].

Sand production monitoring: In the Azeri-Chirag-Gunashli (ACG) field in Azerbaijan, operated by BP, DAS technology was deployed to monitor sand production in horizontal wells. The implementation aimed to identify sand ingress locations and assess the effectiveness of sand control measures. By analyzing the acoustic data collected along the wellbore, the team successfully detected zones contributing to sand production. This real-time monitoring enabled targeted interventions, such as adjusting production parameters and enhancing sand control strategies, leading to optimized production rates and reduced equipment erosion[22].

Evidence in hydraulic fracturing monitoring

Distributed Acoustic Sensing (DAS) has been effectively utilized in the oil and gas industry for monitoring hydraulic fracturing operations, providing real-time insights into fracture propagation, micro seismic event detection and proppant placement.

Real-Time Fracture Propagation Tracking: In the Chalk Bluff field within the Denver-Julesburg (DJ) Basin in Colorado, DAS technology was employed to monitor hydraulic fracturing in horizontal wells targeting the Niobrara and Codell formations. Fiber-optic cables were permanently installed along the wellbores, allowing for continuous acquisition of DAS data during fracturing operations. The high spatial resolution of DAS enabled the detection of strain changes along the wellbore, providing real-time tracking of fracture propagation. This application facilitated immediate assessment of fracture growth and geometry, allowing operators to adjust treatment parameters to optimize reservoir stimulation[23].

Micro seismic Event Detection: In the same Chalk Bluff field study, DAS was utilized for passive seismic monitoring during hydraulic fracturing. The system successfully detected low-frequency seismic signals associated with micro seismic events induced by the fracturing process. By analyzing these DAS-recorded micro seismic events, researchers could map induced fractures and gain insights into the reservoir's response to stimulation. This approach demonstrated DAS's effectiveness in capturing micro seismic activity, offering a cost-effective alternative to traditional micro seismic monitoring methods[23].

Proppant placement monitoring: At the Hydraulic Fracturing Test Site (HFTS-2) in the Midland Basin, Texas, a comprehensive study was conducted to monitor proppant placement during hydraulic fracturing. Fiber-optic cables were installed along the wellbore to collect Distributed Acoustic Sensing (DAS) data during the fracturing process. By analyzing the high-frequency acoustic signals generated by the proppant slurry flow, researchers developed a correlation to interpret proppant placement in individual perforation clusters. This approach allowed for a detailed understanding of proppant distribution, enabling optimization of fracturing treatments[24].

Evidence in EOR and reservoir monitoring

DAS has been effectively utilized in the oil and gas industry for Enhanced Oil Recovery (EOR) applications. Below are specific industrial case studies demonstrating DAS applications in CO_2 injection monitoring and waterflooding surveillance:

DAS for CO_2 injection monitoring: The Midwest Regional Carbon Sequestration Partnership (MRCSP) conducted a study to assess the effectiveness of DAS-based Vertical Seismic Profiling (VSP) technology for monitoring CO_2 injection in the Chester 16 reef, Otsego County, Michigan operated by Core Energy, LLC. Fiber-optic cables were installed in the monitoring well to acquire continuous seismic data. Baseline and repeat surveys were conducted before and after injecting approximately 85,000 tons of CO_2 into the A-1 Carbonate and Brown Niagaran Formations. The DAS system provided high-resolution images of the subsurface, enabling detailed tracking of the CO_2 plume's migration within the reservoir. This application demonstrated DAS's effectiveness in providing cost-efficient and high-fidelity seismic monitoring for CO_2 sequestration projects[25].

DAS in vertical seismic profiling (VSP) for reservoir monitoring: OptaSense has implemented DAS technology in Vertical Seismic Profiling (VSP) to enhance reservoir monitoring. By permanently installing fiber-optic cables in wells, they enable repeated 2D and 3D acquisition of high-quality seismic data with reduced rig time and minimal production interruption. This approach allows for time-lapse imaging and characterization, providing insights into reservoir production, injection processes and compaction. OptaSense's DAS VSP services have been deployed in various fields, offering operators a cost-effective solution for continuous reservoir monitoring[26].

DAS for permanent reservoir monitoring: Research conducted at the University of Southampton's Optoelectronics Research Centre has led to the development of distributed optical fibre sensing technology, which has been adopted by companies such as OptaSense, Stingray Geophysical and Schlumberger. This technology has been applied in permanent reservoir monitoring, enhancing oil recovery by providing continuous, real-time data on reservoir conditions. The implementation of DAS allows for improved extraction efficiency and better management of environmental risks in oil and gas operations[26].

Evidence in production monitoring

Distributed Acoustic Sensing (DAS) technology has been effectively applied in the oil and gas industry for production monitoring. Below are specific industrial examples demonstrating the utilization of DAS in this context.

Flow monitoring and production profiling: OptaSense has implemented DAS technology to provide real-time flow monitoring and production profiling in oil and gas wells. By deploying fibre-optic cables along the wellbore, DAS enables continuous acoustic data acquisition without the need for well interventions. This approach allows operators to monitor flow regimes, detect anomalies and optimize production strategies effectively. The robustness and cost-effectiveness of DAS make it a powerful tool for permanent well monitoring[27].

Integrated production profiling analyses: A study published in OnePetro discusses the integration of DAS with other monitoring techniques to enhance production profiling in unconventional reservoirs. The model extends the scope of a thermal production profiling software with DAS production profile analysis **(Table 1)**. This integrated approach allows for a more comprehensive understanding of production dynamics, leading to improved reservoir management and optimization strategies[28].

Table 1: Industrial Applications of DAS in Petroleum Engineering

Application Area	Specific Use Case	Industrial Example	Operator / Research Institution
Well Integrity Monitoring	Casing Deformation Detection	Reykjanes Peninsula, Iceland - Fibre-optic DAS monitoring for geothermal well casing integrity	GFZ German Research Centre
	Cement Bond Integrity Assessment	Well RN-34, Reykjanes Geothermal Field, Iceland - DAS used for cement bond assessment	GFZ German Research Centre
	Sand Production Monitoring	Azeri-Chirag-Gunashli (ACG) field, Azerbaijan - DAS for sand production monitoring	BP
Hydraulic Fracturing Monitoring	Real-Time Fracture Propagation Tracking	Chalk Bluff Field, Denver-Julesburg Basin, Colorado - DAS for fracture propagation tracking	Unspecified
	Micro seismic Event Detection	Chalk Bluff Field, Denver-Julesburg Basin, Colorado - DAS for micro seismic event detection	Unspecified
	Proppant Placement Monitoring	Hydraulic Fracturing Test Site (HFTS-2), Midland Basin, Texas - DAS for proppant placement	Unspecified

EOR and Reservoir Monitoring	CO_2, Injection Monitoring	Chester 16 Reef, Otsego County, Michigan - DAS for COâ,, injection monitoring	Core Energy, LLC
	Waterflooding Surveillance	Seismos Inc. projects in U.S. oil fields - DAS for waterflooding surveillance	Seismos Inc.
	Vertical Seismic Profiling (VSP)	OptaSense deployments - DAS in VSP for reservoir monitoring	OptaSense
	Permanent Reservoir Monitoring	University of Southampton research - DAS for permanent reservoir monitoring	University of Southampton
Production Monitoring	Flow Monitoring & Production Profiling	OptaSense - DAS for continuous production flow monitoring	OptaSense
	Leak Detection in Gas Wells	OptaSense - DAS for early leak detection in gas wells	OptaSense
	Integrated Production Profiling Analyses	OnePetro study - DAS integration with production profiling software	OnePetro Research

Case Studies In Geoscience Applications

Seismic and Micro seismic Monitoring

Distributed Acoustic Sensing (DAS) technology has been effectively utilized in the oil and gas industry for seismic and micro seismic monitoring, particularly in unconventional reservoirs. The detail discussion is tabulated in **(Table 2)**.

DAS for passive seismic monitoring: The Goldstone Optical Fibre Seismic (GOLFS) experiment, conducted in Goldstone, California, assessed the viability of Distributed Acoustic Sensing (DAS) for passive seismic monitoring. A 20-kilometer segment of a 50-kilometer-long fibre-optic cable was utilized to record tele seismic events. The DAS system successfully detected seismic waves from distant earthquakes, demonstrating its potential for passive seismic monitoring over extensive areas. This experiment highlighted DAS's capability to serve as a valuable tool in seismic studies, providing high-resolution data for monitoring seismic activity[29].

Induced seismicity monitoring in the Montney shale, British Columbia, Canada: DAS technology has been effectively utilized in the Montney Shale play in British Columbia, Canada, for monitoring seismicity induced by hydraulic fracturing operations. A notable case study is presented in the paper titled "DAS Micro seismic Monitoring with Multiple Fiber Optic Arrays," published in the EAGE Geotech 2021 Second EAGE Workshop on Distributed Fiber Optic Sensing. In this study, multiple DAS fiber-optic arrays were deployed in the Montney formation to monitor micro seismic events during hydraulic fracturing. The deployment of multiple fiber-optic arrays allowed for comprehensive spatial coverage and improved detection capabilities. The DAS system successfully detected and mapped micro seismic events in three dimensions, providing valuable insights into fracture propagation and reservoir behavior. This application demonstrated the effectiveness of DAS technology in real-time monitoring of induced seismicity, contributing to enhanced understanding and management of hydraulic fracturing operations in unconventional reservoir[30].

Subsurface CO_2 sequestration and monitoring

DAS technology has been effectively utilized in the oil and gas industry for subsurface CO_2 sequestration monitoring. Below are specific industrial examples demonstrating the application of DAS in CO_2 injection plume tracking and fracture detection in storage sites:

CO_2 Injection monitoring at the CO_2CRC Otway project, Australia: The CO_2CRC Otway Project in Victoria, Australia, implemented DAS technology to monitor CO_2 injection processes. Fiber-optic cables were installed along the injection well to acquire continuous seismic data. A 3D vertical seismic profile (VSP) was obtained using DAS on tubing installations, providing high-resolution images of the subsurface. This approach enabled effective tracking of the CO_2 plume and assessment of reservoir integrity during and after injection[19].

Minami-aga pilot CCUS project, Onshore Japan: In the Minami-Aga pilot CCUS project in Japan, DAS technology was employed to monitor CO_2 injection processes. Fiber-optic cables were installed along the injection well to acquire continuous seismic data. The DAS system provided real-time monitoring of the CO_2 plume migration and enabled the detection of potential leakage pathways. This application demonstrated DAS's effectiveness in ensuring the safety and efficiency of CO_2 storage operations[31].

DAS application in pinnacle-reef reservoir, Michigan, USA: In a pinnacle-reef reservoir in Michigan, DAS technology was employed to monitor CO_2 injection. Fibre-optic cables were deployed to capture seismic responses during the injection process. The DAS system successfully detected amplitude and phase changes associated with CO_2 movement, allowing for detailed analysis of plume migration and fracture development within the reservoir. This application demonstrated DAS's effectiveness in providing real-time monitoring and ensuring the integrity of CO_2 storage sites[32].

Fracture detection in CO_2 storage sites: The Aqui store project in Saskatchewan utilized DAS technology to monitor CO_2 injection and storage. Fiber-optic cables were deployed along the injection well to capture continuous acoustic data. The DAS system successfully detected micro seismic events associated with CO_2 injection, enabling the identification of fracture development and growth within the reservoir. This real-time monitoring capability provided valuable insights into the geomechanically behavior of the storage formation, ensuring safe and effective CO_2 sequestration[33].

Geohazard and pipeline monitoring

Distributed Acoustic Sensing (DAS) technology has been effectively applied in the oil and gas industry for geohazard and pipeline monitoring, particularly in detecting landslides, fault movements and pipeline leaks. Below are specific industrial examples demonstrating these applications:

Landslide and fault movement detection: In Switzerland, DAS technology was utilized to monitor landslide activity. Fibre-optic cables were installed along a slope prone to landslides, enabling continuous real-time monitoring of ground vibrations. The DAS system successfully detected micro seismic events associated with soil and rock movements, providing early warning signs of potential landslides. This application demonstrated DAS's capability in geohazard monitoring, allowing for timely interventions to mitigate risks[34].

Pipeline leak detection and integrity assessment: OptaSense implemented DAS technology for pipeline monitoring in Mexico. Fiber-optic cables were deployed along a 200-mile oil pipeline to detect leaks and third-party intrusions. The DAS system provided real-time acoustic monitoring, enabling the identification of leak-induced vibrations and unauthorized activities near the pipeline. This approach enhanced the pipeline's integrity management by allowing rapid response to potential threats[35].

Pipeline leak detection and integrity assessment: OptaSense implemented a fibre-optic cable leak detection system for PETRONAS in Malaysia on a 2 km spur gas pipeline. The DAS system provided real-time acoustic monitoring, enabling the detection of leaks and assessment of pipeline integrity **(Table 2)**. This installation enhanced the pipeline's safety and operational efficiency by allowing rapid response to potential leaks[36].

Table 2: Industrial Applications of DAS in Geosciences.

Application Area	Specific Use Case	Industrial Example	Operator / Research Institution
Seismic & Microseismic Monitoring	Fracture Imaging Using DAS-Recorded Microseismic Events	Chalk Bluff Project, DJ Basin, Colorado - DAS for microseismic monitoring of hydraulic fracturing	Unspecified
	DAS for Passive Seismic Monitoring	Goldstone Optical Fibre Seismic (GOLFS) Experiment, California - DAS for passive seismic detection	NASA & USGS
	Induced Seismicity Monitoring	Montney Shale, British Columbia - DAS microseismic monitoring for hydraulic fracturing	EAGE- GeoTech Research
Subsurface CO_2 Sequestration	CO_2 Injection Monitoring	CO_2CRC Otway Project, Australia - DAS for CO_2 injection plume tracking	CO_2CRC
	CO_2 Injection Monitoring	Minami-Aga Pilot CCUS Project, Japan - DAS for CO_2 storage integrity assessment	Minami-Aga CCUS Research Team
	DAS in Pinnacle-Reef Reservoir	Pinnacle-Reef Reservoir, Michigan - DAS monitoring of CO_2 migration and fractures	Unspecified
	Fracture Detection in CO_2, Storage Sites	Aquistore Project, Saskatchewan - DAS-based microseismic monitoring of CO_2 storage	Unspecified
Geohazard & Pipeline	Landslide & Fault Movement Detection	Switzerland - DAS monitoring for landslide activity and fault movement detection	Swiss Research Institutes
	Pipeline Leak Detection (Mexico)	Mexico - DAS leak detection on a 200-mile oil pipeline	OptaSense
	Pipeline Leak Detection (Malaysia)	PETRONAS, Malaysia - DAS leak detection on a 2 km spur gas pipeline	OptaSense & PETRONAS

Overview of Leading Industries Adopting Das In-Petroleum Engineering and Geosciences Application

DAS technology has been adopted by several leading companies in the petroleum engineering and geosciences sectors. Notable examples include:

- **Schlumberger Limited:** A global leader in oilfield services, Schlumberger utilizes DAS for various applications, including well integrity monitoring and seismic data acquisition.
- **Halliburton Co:** Halliburton employs DAS technology to enhance reservoir characterization and optimize production monitoring.
- **Baker Hughes Company:** Baker Hughes integrates DAS into its service offerings to improve subsurface imaging and wellbore monitoring.
- **AP Sensing:** Specializing in distributed fiber-optic sensing, AP Sensing provides DAS solutions for pipeline monitoring and leak detection in the oil and gas industry.
- **Silixa Ltd.:** Silixa has implemented the world's first permanent subsea DAS system in the Gulf of Mexico, enhancing seismic monitoring capabilities.
- **Seismos Inc:** An AI-driven acoustic technology company, Seismos has deployed DAS-based solutions in various U.S. oil fields to monitor waterflooding operations.
- **Hifi Engineering Inc.:** Based in Alberta, Canada, Hifi Engineering specializes in high-fidelity dynamic sensing systems for monitoring pipelines and wellbores. Their DAS technology enables clients to detect leaks and monitor critical infrastructure effectively.
- **Sintela:** Sintela provides advanced DAS solutions tailored for various industries, including oil and gas. Their technology is applied in pipeline monitoring, perimeter security and geohazard detection, delivering real-time insights for asset protection.
- **Geospace Technologies:** Headquartered in Houston, Texas, Geospace Technologies manufactures specialized electronics and seismic data acquisition equipment. They utilize DAS technology for seismic monitoring and reservoir characterization in the oil and gas sector.
- **OptaSense (A Luna Innovations Company):** OptaSense specializes in DAS technology for well integrity monitoring, hydraulic fracturing diagnostics, production optimization and seismic data acquisition. They provide real-time subsurface insights through fiber-optic sensing, with notable applications in production monitoring and pipeline integrity assessments.

Gap Between Academic Research and Industrial Applications in DAS

The gap between academic research and industrial applications in DAS arises from differences in focus, scalability and implementation challenges. While academic studies explore novel signal processing techniques and new applications, the oil and gas industry require field-proven, cost-effective and standardized solutions that integrate seamlessly into existing workflows. Bridging this gap requires collaborative research, large-scale field trials and advancements in real-time DAS data interpretation to ensure its broader adoption in industrial settings.

Technology maturity and field validation

One of the major gaps between academic research and industrial application of DAS lies in technology maturity and large-scale field validation. While academic studies often focus on controlled experiments or small-scale field trials, the oil and gas industry require robust, field-proven solutions that can withstand the challenges of real-world reservoir conditions. Researchers have successfully demonstrated the potential of DAS for subsurface fluid flow imaging, seismic monitoring and fracture detection, but large-scale implementation remains limited due to the need for long-term performance data. Industries hesitate to fully integrate DAS until comprehensive field validation proves its reliability under various operational conditions, particularly in complex formations and offshore environments.

Data Standardization

Data processing and interpretation present another challenge in the transition of DAS from research to industry. Academic studies have proposed advanced signal processing techniques, including machine learning algorithms, to extract meaningful information from DAS signals. However, the industry requires standardized, real-time data interpretation protocols that can be seamlessly integrated with existing production monitoring systems. In many cases, the high volume of DAS data, combined with noise from environmental and operational factors, makes it difficult to derive actionable insights. While researchers continue to refine data processing techniques, the oil and gas sector needs solutions that provide quick, reliable and decision-ready insights rather than complex, computationally expensive algorithms that may not be feasible for real-time applications.

Infrastructure and cost barriers

Cost remains a significant hurdle in the widespread adoption of DAS technology. Academic research often assumes access to fiber-optic infrastructure, but in practice, retrofitting existing wells with DAS-enabled fiber is both expensive and logistically challenging. Offshore fields, in particular, face additional difficulties due to deepwater installation costs and the need for long-distance fiber connectivity. While researchers explore cost-effective alternatives such as hybrid sensing approaches, industries remain cautious about investing in DAS without a clear return on investment. Moreover, many operators still rely on conventional well logging tools, as they are well-established and trusted, making the transition to DAS slower than expected.

Bridging the gap: What's needed?

To bridge the gap between research and industrial application, stronger collaboration between academia and industry is essential. Large-scale pilot projects, backed by oil and gas operators, can provide the necessary validation to encourage broader adoption. Standardization efforts for DAS data interpretation will also be crucial in making the technology more accessible and reducing the complexity of real-time processing. Furthermore, continued advancements in AI-driven DAS optimization can help industries transition from research-based models to fully integrated real-time monitoring systems. Finally, reducing the cost of fiber deployment, particularly in brownfield projects, will be a key factor in making DAS a commercially viable solution for widespread industry adoption. Addressing these challenges through coordinated efforts will accelerate the transformation of DAS from an emerging research tool into an essential industrial monitoring technology.

Conclusions

Following conclusion can be drawn from this study

- DAS technology is increasingly being used in petroleum engineering and geosciences for well integrity monitoring, hydraulic fracturing diagnostics, production surveillance and seismic monitoring.
- It provides continuous, real-time data over long distances, improving subsurface characterization and enhancing reservoir monitoring.
- Stronger collaboration between academia and industry is needed to validate and standardize DAS solutions for broader field implementation.
- Future advancements in artificial intelligence and data analytics will further improve DAS efficiency, making it more cost-effective and widely applicable in oil and gas operations.

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Declaration

The authors would like to declare the utilization of ChatGPT4.0 in paraphrasing and proof-reading the language of this study.

Conflict of Interest

The authors do not have any conflict of interest to declare.

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