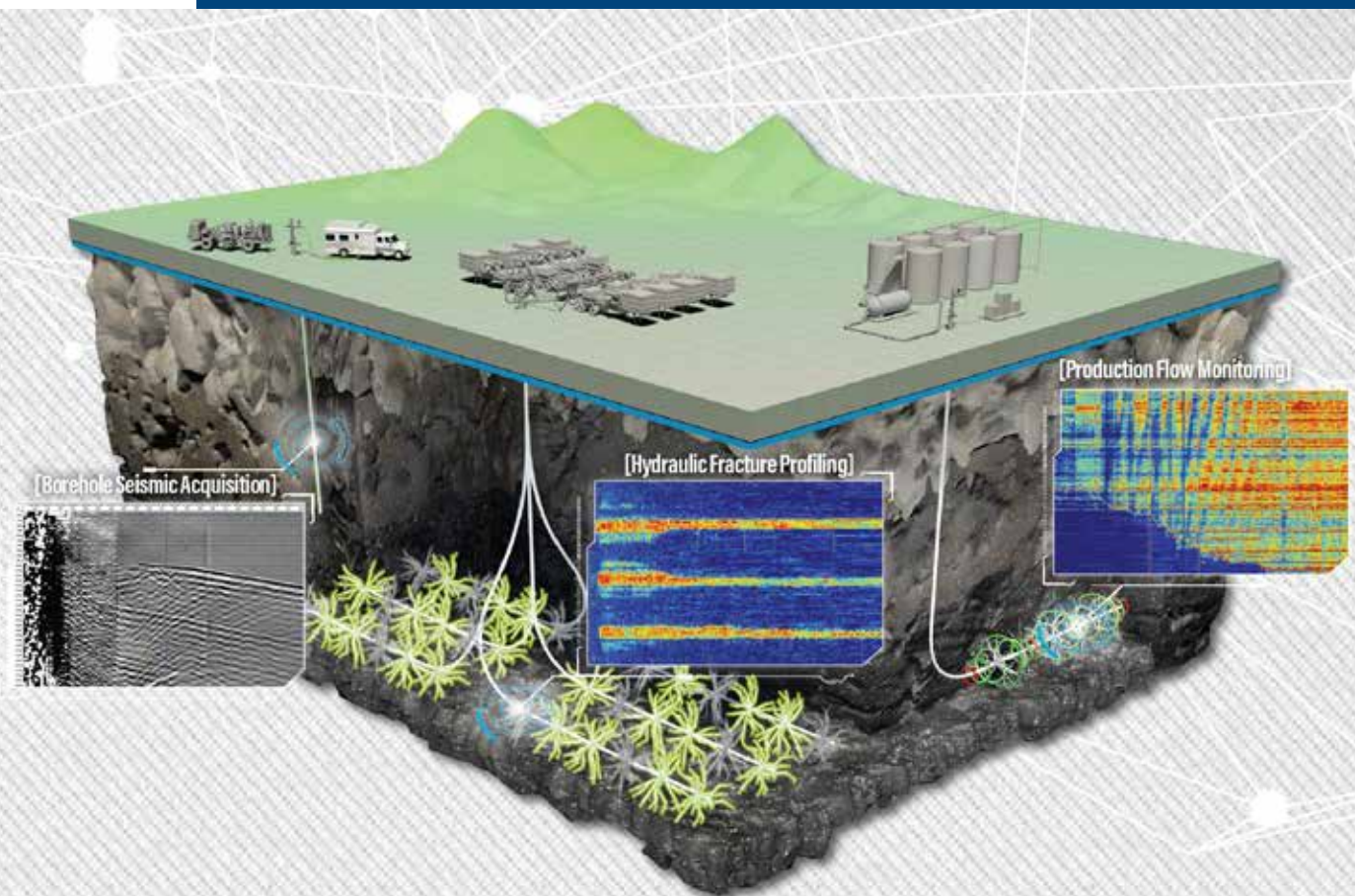


**OptaSense**<sup>®</sup>  
a QinetiQ company

## Oilfield Services

Intelligence for the life of your asset



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# Intelligence For the Life of Your Asset

## Knowledge is the first step towards understanding, and with understanding comes optimization.

For robust and actionable information that improves reservoir management and ultimate recovery, OptaSense® Oilfield Services provides distributed acoustic sensing (DAS) solutions that deliver enhanced data acquisition, monitoring and visualization of seismic activity, completion operations and production flow.

OptaSense DAS services include vertical seismic profiling (VSP), hydraulic fracture profiling and production flow monitoring. With our DAS technology, you can optimize well designs and completion models, monitor production performance, reduce operational costs and improve yields, while ensuring risks are minimized.

## Proven, Reliable and Innovative

By providing enhanced acquisition, monitoring and visualization systems to hundreds of wells around the world, OptaSense field-proven DAS technology has established a leading position in the industry.

Offering many advantages over traditional wellbore surveillance methods, DAS is a compelling new technology used to retrieve critical evaluation, completion and production information in real time, on demand.

Developed over the past decade, OptaSense DAS hardware sets the industry benchmark in terms of performance, providing high sensitivity and high spatial resolution combined with true frequency, phase and amplitude coherence across all channels.

Our DAS technology treats the entire length of existing or new downhole fiber optic cable as an array of thousands of high resolution sensors. Using permanently installed fiber optic cables enables a cost-effective downhole monitoring system that can acquire data in real time, for the life of the asset, without the need for multiple wellbore interventions.

The avoidance of well intervention eliminates the deferment of production, as well as the cost and operational risks associated with conventional seismic and logging surveys.

OptaSense continues to innovate, by complementing our technology with the experience and expertise to interpret and provide real-time data. At our Center of Excellence, located in the United Kingdom, our scientists, engineers and software programmers continue to revolutionize DAS hardware and software tools, to further extend the unique capabilities of DAS and other fiber optic distributed sensing technologies.

We continue to innovate, by complementing our technology with the experience and expertise to interpret and provide real-time data.



# Evaluation Services

## Real-time acquisition and visualization of reservoir performance data

The keystone to understanding and achieving higher rates of return on investment is feedback. Attain real-time acquisition and visualization of accurate well and reservoir performance data with borehole seismic evaluation services from OptaSense. Our borehole seismic services provide high quality information on reservoir stimulation and depletion efforts.

OptaSense DAS technology provides unrestricted access to measurements along the entire wellbore, from surface to toe. By acquiring borehole seismic data at the reservoir, our DAS technology provides the highest resolution imaging.

Our evaluation services apply DAS technology for enhanced VSP and microseismic monitoring. Seismic data collection of VSP and microseismic activity can be performed on any wellbore, even under extreme conditions such as high temperature, high pressure, or high deviation wells. When combined with our data processing and imaging analysis service, OptaSense delivers high definition subsurface images essential to optimizing reservoir management.

OptaSense DAS technology can be permanently installed behind casing, semi-permanently installed on the production string, or temporarily installed using wireline or coiled tubing—delivering repeatable borehole measurements safely and effectively in producer or injector wells.

When it's impossible or cost prohibitive to tractor in conventional instruments, wells can now be successfully monitored by placing a sensing fiber optic cable on the production string or installed using wireline or coiled tubing. With these well measurements, high resolution imaging of the surrounding geology can enhance surface or seabed seismic acquisition or can be used to minimize or eliminate the need for surface seismic, which provides significant cost savings.

Our DAS technology also alleviates the restrictions encountered when using other downhole instruments, including production down time, wellbore integrity risk, and restricted access associated with highly deviated wells and/or completion components.

### Vertical Seismic Profiling

Rely on accurate borehole seismic measurements without well intervention using OptaSense VSP acquisition services that provide enhanced imaging of the reservoir.

With OptaSense VSP acquisition services operators have easy and repeatable access to the best seismic imaging techniques for optimal mapping of reservoir stimulation and depletion efforts. This optimizes reservoir recovery planning by mapping changes in the reservoir due to production operations.

Using OptaSense DAS technology, our VSP acquisition services provide coverage along the entire length of the wellbore, using hundreds or even thousands of virtual sensing gauges that provide accurate seismic measurements.

The ability to cost effectively take repeated time-lapse measurements on an array with full well length aperture, in otherwise inaccessible wells, provides a unique capability in 3D/4D seismic acquisition. After installing the DAS fiber, there is no need for further wellbore interventions. As a result, you can perform time-lapse VSP surveys in a cost effective manner for the life of your asset, without any loss of production from your wells. You can even perform simultaneous VSP surveys on multiple wells from a single pad location.

These services can also be used and field-proven for monitoring CO<sub>2</sub> injection and enhanced oil recovery methods.

OptaSense VSP acquisition services include:

- The 4th generation DAS interrogator unit, providing industry leading DAS measurements
- Interfacing with and synchronized control of the seismic sources
- Real-time file generation of seismic data
- Real-time correlation of vibroseis measurements
- Real-time stacking of multi-shot measurements
- Fully populated file headers containing source and receiver locations
- In-field quality control of source and receiver instruments

### Microseismic Monitoring Services

OptaSense DAS can also enable permanent borehole microseismic monitoring, especially of those larger magnitude events that originate at existing fault locations. Because of the broad bandwidth and high dynamic range capabilities of OptaSense DAS technology, the large, low frequency seismic signals generated at existing fault locations can be accurately measured. In deviated wells, the long-array sensing aperture enables geolocation of recorded microseismic events.

### Borehole Imaging Services

OptaSense borehole imaging services is powered by world recognized experts in borehole seismic. This highly experienced team of geoscientists and engineers applies purpose-built proprietary processing routines to create high definition subsurface borehole images essential for decisive reservoir management. Teamed with DAS acquisition, flow and fracture profiling technologies, OptaSense delivers an integrated near-field/far-field view of the reservoir crucial for optimized operations.

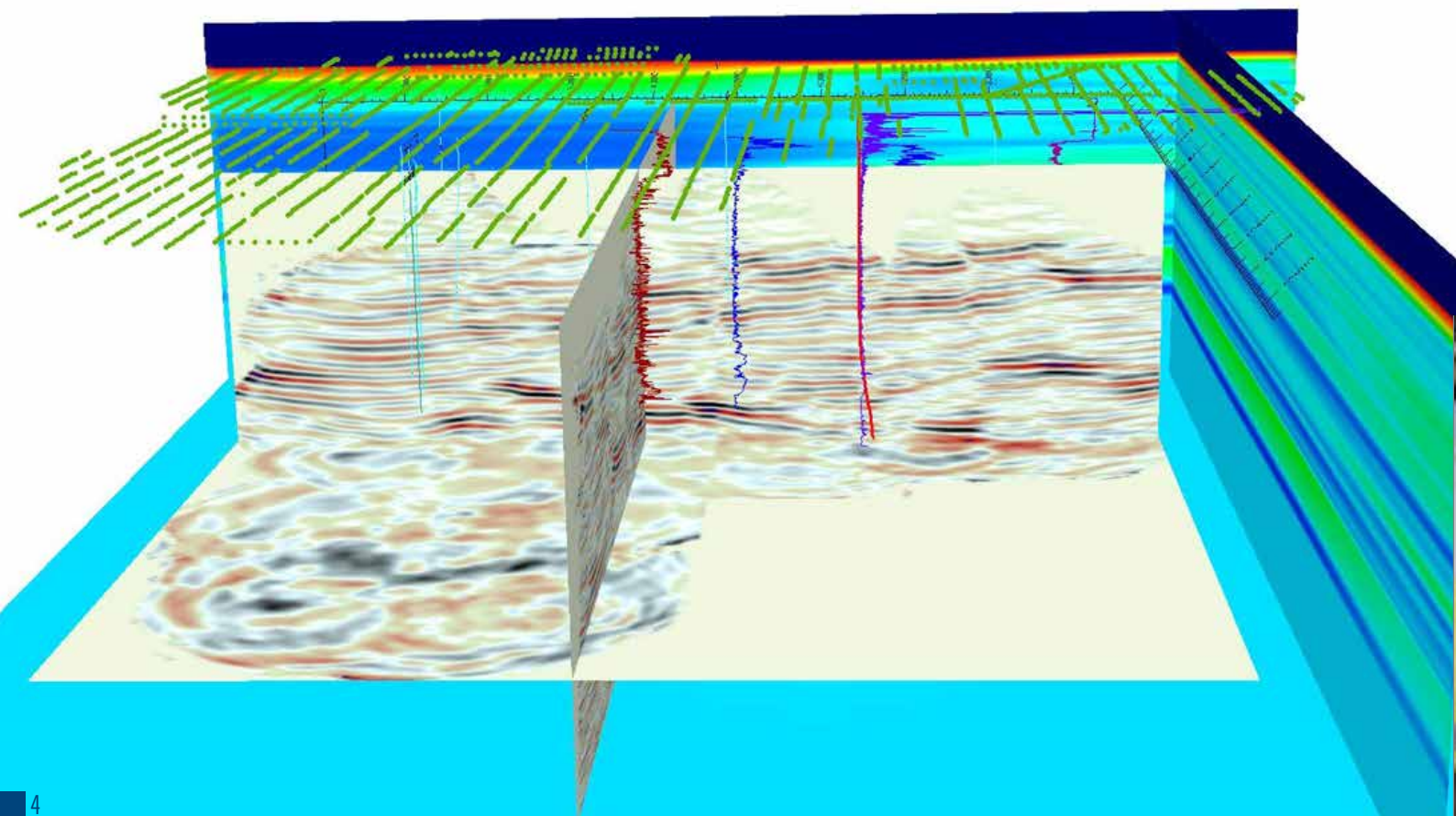
### Leading the Industry in DAS

OptaSense VSP and DAS technology is recognized as a leader in the industry. Our technology has been used in a 50,000 shot offshore 3D VSP survey in which data was collected in two wells and resulted in over 70 million seismic records.

This technology was selected as part of the long term Measurements, Monitoring and Verification (MMV) program for the Quest Carbon Capture and Storage (CCS) project in Canada. OptaSense was also awarded the prestigious Hart E&P Special Meritorious Award for Engineering Innovation in Geoscience.



For unrivaled performance in sensitivity, resolution and bandwidth, OptaSense offers the new ODH-4 interrogator unit. This 4th generation DAS recording system increases sensitivity over its predecessor by 6 dB—enabling increased production rates for VSP surveys, as well as a higher number of catalogued events for microseismic event detection. The increased sensitivity improves the signal to noise ratio providing much higher quality seismic.

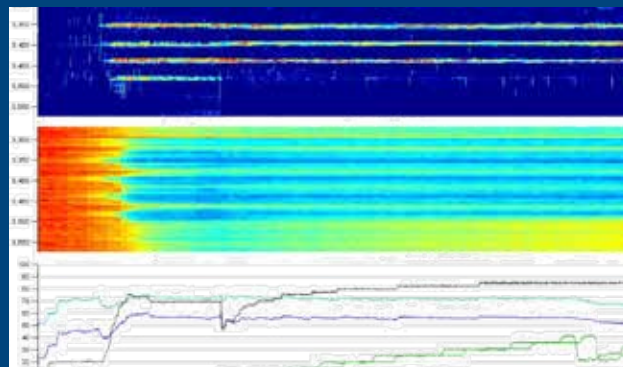


# Completion Services

Gain insight into stimulation effectiveness and ineffective zonal isolation

Ineffective or improperly designed completions can impact your bottom line. OptaSense DAS technology provides key insights that allow you to optimize fracture program designs and mitigate operational issues while completing the well.

Rest assured the stimulation services you are paying for are delivering the results you expect.



Typical report output showing high resolution DAS data

When DAS is recorded in a treatment well, it can be used to determine which stages and perforations take fluid and proppant—providing insights into stimulation effectiveness, as well as revealing ineffective zonal isolation.

The OptaSense hydraulic fracture profiling service continuously monitors and records the acoustic signals measured by DAS, temperatures measured by distributed temperature sensing (DTS) systems, and pump data provided by the pumping contractor on site.

With the unique ability to acoustically monitor the injection directly at the treatment zone, our hydraulic fracture profiling service estimates the fluid and proppant uptake at each perforation cluster, which can be used to optimize overall completions and fracture design.

In the field, all phases of the hydraulic fracturing operation can be monitored in real time, enabling you to assess the success of fracture initiation and growth, identify perforation breakdowns, and see stage bypass events as they occur.

Real-time monitoring of hydraulic fracture treatment operations include running and shot characterization of perforation guns, deployment of diversion and sleeve balls, placement of plugs, and operation of tooling on coiled tubing. Monitoring treatment operations in real time enables operators to assess the treatments' effectiveness and make changes on the fly to assure that they are achieving the best results for the investment made. This ensures quality control over operations to confirm depths and performance of downhole equipment.

Field reports that provide estimates of the fluid and proppant uptake at each of the perforations are generated after each stage and at the end of the fracture treatment. Processed data from the job can be used in post-job hydraulic fracturing diagnostics, as well as to compare hydraulic fracture effectiveness with production logs—which is valuable input for future hydraulic fracture modeling and design.



Experienced OptaSense field engineers in one of our data vans acquiring data during a fracture operation

## Optimize Hydraulic Fracture Programs

For the insight you need to extract the most value from your well, OptaSense hydraulic fracture profiling services monitor stage performance in real time at the perforation level. Using optical fibers to acquire acoustic and temperature measurements continuously along the length of your well, our technology helps you determine fluid and proppant uptake volumes per stage and perforation cluster. This service also identifies inter-stage communication leading to under and over stimulated stages. This information can be used to determine diversion techniques or alternate stage spacing, as well as to fine-tune perforation designs for optimal cluster efficiency.

## Monitor Perforation Performance and Efficiency

Our hydraulic fracture profiling services offer simultaneous application and analysis of both DAS and DTS. These combined measurements improve downhole interpretation and understanding of hydraulic fracture treatments.

When complimented by hydraulic fracturing parameters such as wellhead pressures, rate and concentrations, this novel sensing combination can offer real-time insights into:

- Perforation cluster efficiency and distribution of fluid and proppant
- Effectiveness of flow diversion
- Well integrity issues
- Initial flowback and well cleanout
- Long term production and reservoir performance

## Gain Better Control of the Completion Process and Your Bottom Line

On-demand completion data not only provides the insight you need to optimize fracture programs, it allows you to mitigate operational issues in order to save completion dollars. The hydraulic fracture profiling service monitors all operations in real time to confirm perforations, plug setting, ball drops, and sleeve actuations. It helps you identify unwanted breakdown and inter-stage communication, as well as mitigate losses associated with mechanical failures.

## Benefit From Real-Time Cross-Well Communications

Real-time assessment of the communication between neighboring wells during a fracture treatment can be used to optimize well spacing. This also helps to reduce environmental risk because of inter-wellbore communication. With dynamic pico-strain sensitivity, DAS is used to measure minute deformation on neighboring fibered wellbores due to strain changes in the formation caused by fracturing.

By providing insight on fracture lengths and complexity, DAS can be used to optimize well spacing and pumping schedules to maximize the stimulated reservoir volume. By monitoring acoustics and temperatures, near wellbore events and breakthrough to neighboring wells are clearly detected and located adding an HSE value to fiber optics.

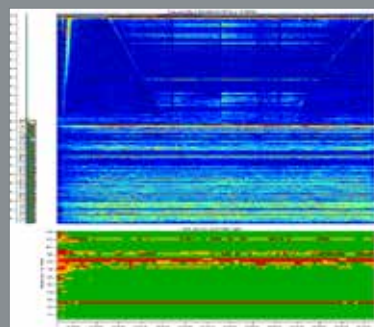


OptaSense hydraulic fracture profiling services provide operators the real-time information they need to optimize overall completions and fracture designs.

# Production Services

On-demand flow regimes for the life of your asset

It's difficult to optimize reservoir planning and management when you're unsure of the inflow profile along the reservoir. OptaSense production flow monitoring services add critical mass in your production efforts by allowing you to monitor in-flow along the production zone, artificial lift performance, and wellbore integrity for the life of your asset.



Software tools to clearly show flow/no flow at perforations

## Production Flow Monitoring

With no need for well intervention, and with minimal interference with flow, DAS permanent production logging is developing rapidly as an exciting alternative to conventional production logging tools.

OptaSense production flow monitoring services reduce the risks and interruptions associated with conventional production logging, as well as the reliance on hard to interpret and difficult to deploy production logging tools.

Using innovative DAS technology, these services help you pinpoint non-producing zones to improve future completion design or re-stimulation programs.

Ultimately, our DAS production monitoring capabilities allow you to achieve a more complete reservoir model detailing the long term reservoir response to completion and production applications.

Permanent production flow logging is now possible using DAS, with fiber installed on casing or tubing. Measurements can be taken on a continuous basis or at regular intervals using our drive-by acquisition service.

## Understanding Production Flow Across Perforations

Many operators struggle to understand inconsistent production well to well, even stage to stage. OptaSense production flow monitoring services apply DAS technology to assess flow behavior across the length of your wellbore.

Using a fracture flow profiling technique our DAS technology identifies perforations that contribute to production, in real time. We can even quantify flow through each perforation and/or port in the well.

Permanently installed fiber and topside equipment are used to provide an on-demand flow profile of your well. Flow data is generated at each perforation cluster and historical waterfall data is recorded and processed. In repeat measurements, this information can be used to monitor the effectiveness of each perforation entry point, throughout the life of your well. This tool can also be used to determine production flow across inflow control valves, to monitor the health of electrical submersible pumps, and to confirm the opening and closing of gas lift valves in smart well completions.

## The first step to understanding how to optimize operations is acquiring the right information.

OptaSense provides a complete, integrated, well surveillance solution that includes multi-point and distributed VSP acquisition, production flow monitoring and hydraulic fracture monitoring enhanced with microseismic imaging and processing—which are critical in optimizing well and reservoir performance.

Discover how our DAS technology can enhance your data acquisition and visualization with accurate well and reservoir performance data. Contact your local representative today or visit us online.

[contact@optasense.com](mailto:contact@optasense.com) | [optasense.com](http://optasense.com)

#### Americas

12709 Haynes Road  
Houston, TX 77066  
USA  
+1 713 493 0348

3060 Saturn Street, Suite 101  
Brea, CA 92821-1732  
USA  
+1714 482 1922

8, 2135 32 Ave NE  
Calgary  
Alberta T6E 6Z3  
Canada  
+1 403 265 6165

#### Europe

Cody Technology Park  
Ively Road, Farnborough  
Hampshire GU14 OLX  
United Kingdom  
+441252 392000

#### Middle East

Unit Nos. 1302, 1303, 1304  
13th Floor, Jumeirah Business Centre 3  
Jumeirah Lakes Towers  
PO Box 125674  
Dubai, United Arab Emirates  
+971 4 818 8200

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