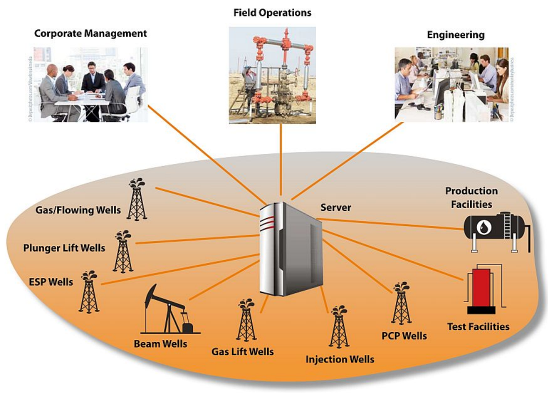
EXTREMELY STABLE SINGLE FREQUENCY LASER FOR OIL FIELD SENSING

Optical sensing is critically important in oil and gas, homeland security, and industrial markets where the measurement of distance, temperature, and/or pressure is required for a broad range of applications. These applications include finding and monitoring of oil fields in order to increase their productivity, opto-acoustic sensing in submarine-towed arrays, monitoring and securing pipelines and power lines, and border and perimeter protection. Common to these applications is the need for high sensitivity and resolution, with real-time monitoring over long distances.

Remote monitoring has been used in oil fields for decades already, but has nevertheless remained a hot talking point. Ideally monitoring should cover the entire oil field from the well all the way to the treatment facility. It should allow the operator to optimize production and minimize costs. The increasing remoteness of oil fields and ever stringent environmental regulations place increasing demands on monitoring systems.

A working oil field has several points that require monitoring. In order to get a better overall picture of the oil fields and their monitoring points it is useful to divide the fields into three parts as follows:



Wellhead
Depending on the production method used the type of data measured varies a lot. Self-flowing wells require only minor monitoring, but as soon as the well is operated with artificial lift the equipment used needs to be monitored and maintained. The most commonly used artificial lift methods are Rod Lift, Gas lift, ESP, Jet Pump and Plunger Lift. In some cases the reservoir characteristics are also measured with downhole monitoring.

Pipeline network
Each well is connected to a collector with a pipeline. A remote well normally has several kilometers of pipeline that connects it to the crude oil treatment facility.

Crude oil treatment facility
Includes separation, heating, dehydration, stabilization, storage, metering and pumping. The collector gathers the production from the wells and separates the oil, gas and water. Each oil field normally has several crude oil treatment facilities.

MONITORING THE ENTIRE OIL FIELD
From a monitoring service supplier perspective, the best approach is a simple one: the operator requires a system for remote monitoring of the entire oil field from the wellhead all the way up to the crude oil treatment facility. They also require assistance in developing their maintenance programs and in optimizing well production.

With the help of a comprehensive overall picture of the entire field, the operator gains a clearer understanding of the many problems and challenges faced. This assists the operator to develop the oil fields in order to achieve higher and more stable production levels, as well as prolonging the wells' production life cycles.

OVERCOMING CHALLENGES
Oil and gas producers always want to produce more at lower operating cost levels. In order to achieve this goal they need to overcome many challenges. Nowadays oil is produced in more remotely located oil fields than before and environmental requirements are much more demanding than before.

The challenges faced by producers include heavy oil that needs heating, paraffin problems that require chemical injection, solid production problems and extremely cold environments that limit maintenance. HSE requirements stemming from isolated locations and possible H_2S problems should also not be underestimated.

A well-designed monitoring system monitors the production process for the field operator, but also provides the proper production reports in real time.

With an up-to-date service history available, management can do much more cost effective planning as the maintenance plan and chemical injection amounts are optimized for each well separately. Having better overall information available and understanding the process is to key to produce more with less downtime.

Optoelectronics and fiberoptics technology underwent significant advances in the 1990s, driven largely by well-funded innovations in the telecommunications, semiconductor, and consumer-electronics sectors. Although some of these sectors have since lost momentum, the trickle-down effect for smaller photonic application markets has continued and, in some cases, accelerated. Fiberoptic sensors, for example, have achieved enhanced performance by integrating improvements in fiber, laser, and photodetector technology. At the same time their relative cost has come down, thanks to advances in optoelectronics manufacturing methods.

NP Photonics Offer extremely stable, single-frequency fiber laser which are insensitivity to vibrations. The company terms the laser as "The Rock" (although it looks more like a small brick). The laser's indifference to vibration is achieved without the need of active stabilization. The fiber laser is well-suited for integration into OEM laser systems, and is being incorporated into multilaser systems used for oil-field, under sea oil exploration, earthquake detetction and security markets. The Rock is based on a passive-stabilization technique recently developed by NP Photonics for DWDM (dense wavelength-division multiplexing) fiber-optic sensing systems that combine the information from a number of spectral channels. This method significantly reduces the sensitivity of the frequency noise to vibration and low frequency acoustics.

Multilaser systems are often used on ships, offshore platforms, and airplanes--all situations in which the environment introduces a large amount of vibration. To compensate for this effect, active stabilization has proven to be a useful technique that maintains the low phase noise of these lasers under typical field conditions. However, active stabilization is not without trade-offs and adds significant cost to multilaser systems. The new technology from NP is about 100 times less sensitive to vibration than conventional designs and thus eliminates the need for active stabilization and complex antivibration mounts.

According to NP Photonics, the Rock, will reduce cost and complexity of actively stabilized multilaser systems by 50% and are expected to double the productivity of oil fields and significantly increase the security of harbors.

The most obvious potential uses for these lasers are in security, military, and oil-exploration applications in which they would allow cost-effective distributed sensing for monitoring large areas or over long distances with a single laser and photodetector.

One such application is fiberoptic hydrophone sonar arrays (see Fig.). For years defense agencies have actively researched sea-bed hydrophone sonar arrays, fiberoptic bottom-mounted arrays, and towed arrays using a combination of time and wavelength-division multiplexing to achieve high channel counts. These arrays also find use for undersea oil exploration and earthquake detection.

The data from fiber sensors searching for submarine oil fields is as good or better than the data from conventional electronic sensors. The most costly portion of these electrical systems, however, is in the water—where gear is at higher risk. Optical sensors, on the other hand, keep their most expensive components shipboard and probe the depths with relatively inexpensive optical fiber.

Substituting interferometric fiberoptic sensors for the conventional electroceramic-based hydrophones in these arrays has several advantages. Besides the benefits of using photons instead of electrons noted previously, fiberoptics help reduce the weight and cross section of cables as well as the through-life cost of the sonar arrays.

The pressure resolution of a fiberoptic-based hydrophone, however, derives from the phase resolution of the sensor's interferometer. Phase resolution, in turn, is adversely influenced by relative intensity noise and frequency noise from the sensor's interferometer. The level of noise increases in proportion to the interferometer's path imbalance, hence a longer interferometer arm means lower pressure resolution.

Narrow-linewidth fiber lasers, such as those described, make excellent sources for hydrophone applications because their frequency noise can be two orders of magnitude lower than the best DFB lasers. The high output power that fiber lasers deliver—without amplifiers—eliminates all spontaneously induced noise.