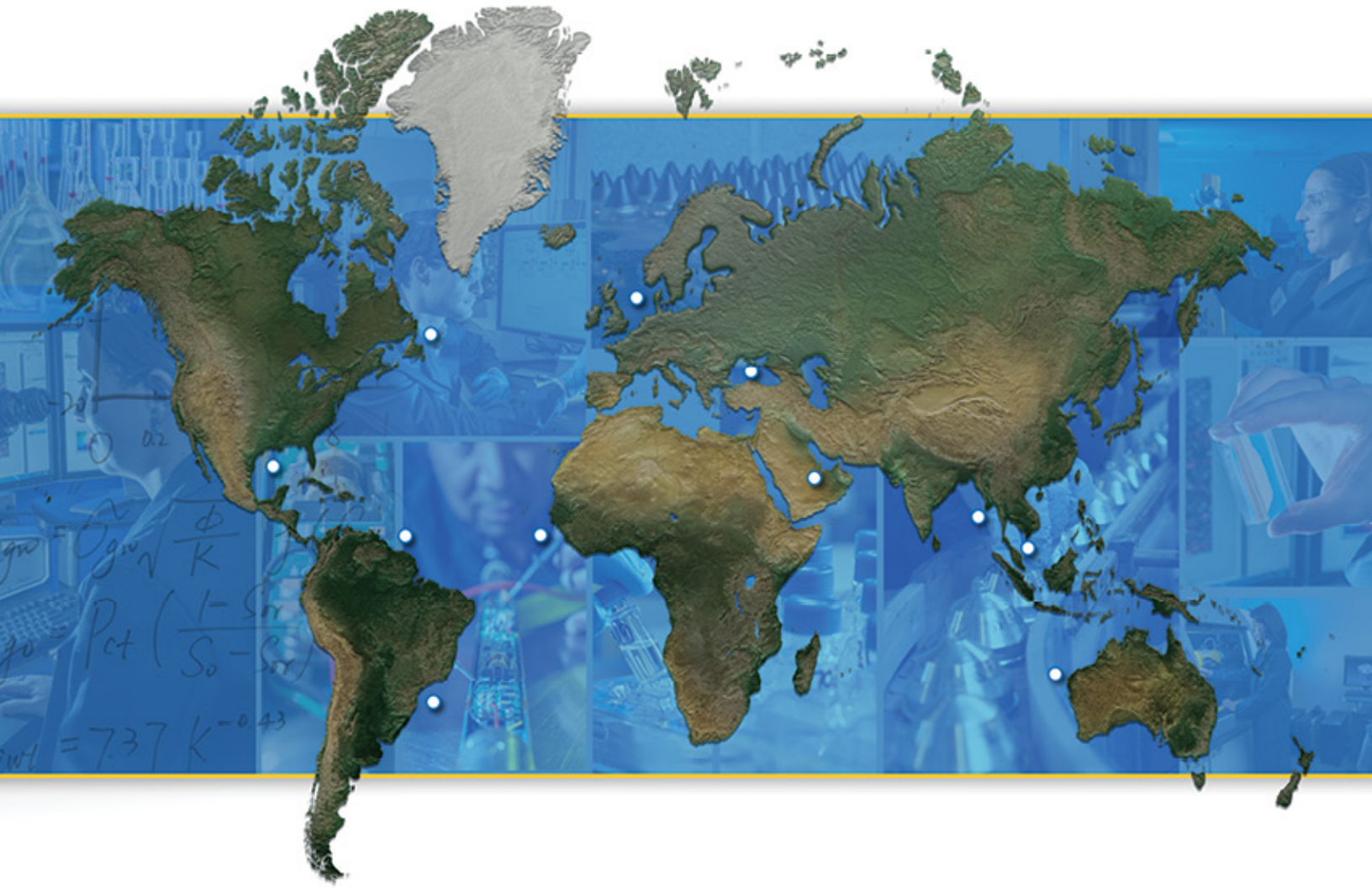
Core Lab
RESERVOIR OPTIMIZATION

Core Laboratories

2018 ANNUAL REPORT



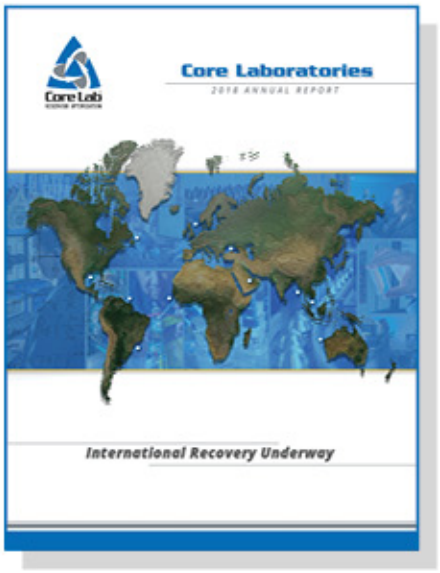
International Recovery Underway

Core Laboratories is *The Reservoir Optimization Company*™

Core Laboratories is a leading provider of proprietary and patented reservoir description and production enhancement services and products. These services and products enable the Company's clients to optimize reservoir performance and maximize hydrocarbon recovery from their producing fields. The Company has over 70 offices in more than 50 countries and is located in every major oil-producing province in the world. Core Laboratories provides its services to the world's major, national and independent oil companies.

Front Cover

After five years of muted investment in international, offshore and deepwater projects, oil companies announced more than 30 upstream Final Investment Decisions ("FIDs") in 2018, an increase of more than 20% from 2017. The renewed investment at a global level is critical in order to meet future supply needs. Recognition of the need for investment is evidenced by the discoveries and FIDs announced over the last two years. Highlighted locations represent some notable upstream crude oil and gas capital projects in regions around the world.



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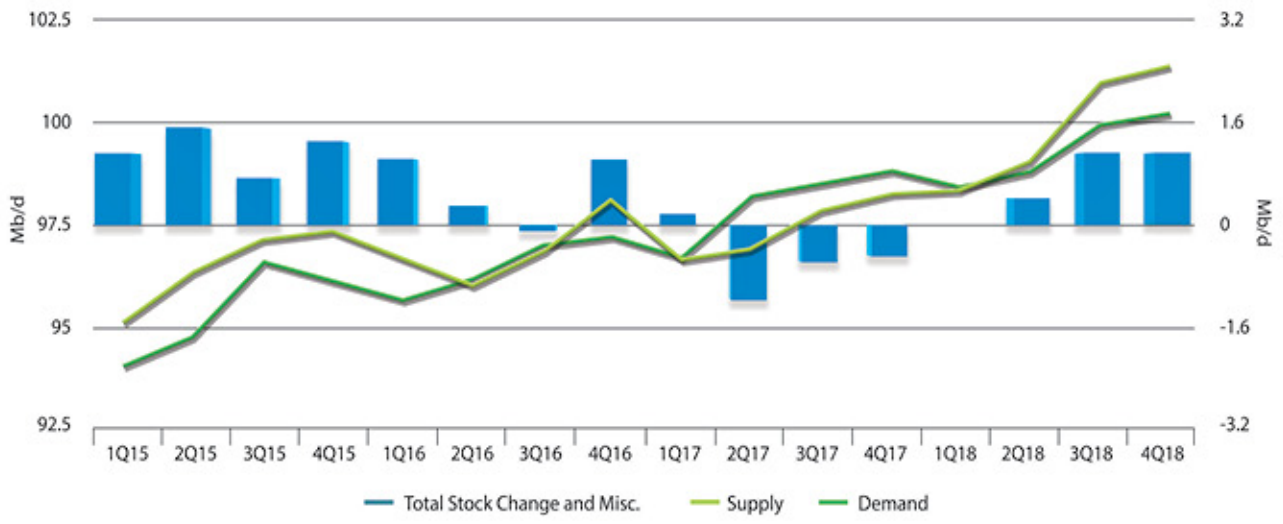
Investor Update

2018

2018 was a multifaceted year for the global oil and gas industry as geopolitical and industry specific events influenced supply and demand of crude oil and associated industry activity levels. For the better part of 2018, Core Lab benefited from the continued, although moderated, activity in onshore North America. After five years of muted investment in international, offshore and deepwater projects, oil companies announced more than 30 upstream Final Investment Decisions ("FIDs") in 2018, an increase of more than 20% from 2017. Core Laboratories' worldwide operations continued to focus on positioning its business to thrive in both the North American recovery and the anticipated recovery of international activity by advancing and delivering reservoir optimization technologies to help its oil company clients achieve higher returns and cash flow from their investments.

Figure 1 **- Global Demand / Supply Balance**



Note: For scenario purposes only, IEA assumes OPEC production remains unchanged to end - 4Q18

Source: International Energy Agency

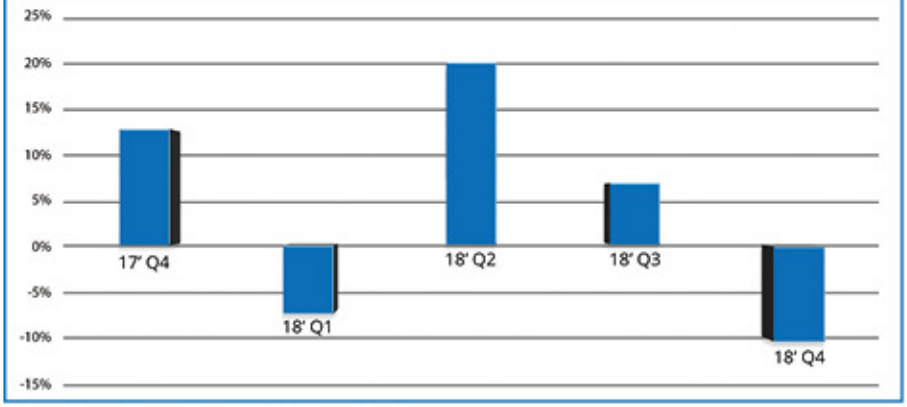
Due to the fundamentals of crude oil supply and demand, crude oil prices continued to rise through the first three quarters of 2018 (Figure 1), which led to an increase in U.S. onshore activity levels. However, U.S. onshore activity was negatively impacted by logistical bottlenecks and take-away capacity constraints in the Permian Basin which moderated the growth of wells drilled and wells completed.

During the fourth quarter of 2018, there was a sharp increase in supply in the worldwide crude-oil market, likely in anticipation of the Iranian sanctions. Consequently, during November and December, the per-barrel price of crude oil fell by more than 40% from the year's peak in October 2018. However, global crude-oil inventories remained at approximately 38 days of consumption at the end of 2018, continuing a multi-year trend of declining global crude-oil inventories as a function of demand. The International Energy Agency's most recent estimated worldwide projections for demand remain strong with 1,400,000 additional barrels of oil per day anticipated to be needed in 2019.

As the year unfolded, the industry logistical bottlenecks subsided, however, take-away capacity limitations specific to the Permian Basin began to impact some operators in the second half of 2018.

While the takeaway capacity limitations did not impact all oil and gas producers, it did moderate the completion activity growth rate as shown in Figure 2.

***Figure 2* - 2018 Onshore Completion Activity**



Source: Energy Information Administration, Rystad

Core was encouraged by the increased focus of its major clients on investments in technology that can help yield higher shareholder returns. The E&P companies adopting value versus volume metrics tend to be the more technologically sophisticated operators and form the foundation of Core's worldwide client base. Core's clients continued to plan international and offshore projects; however, the pace at which these projects have progressed after approval has been slower than in previous recovery cycles.

In addition to celebrating our 23rd year as a publicly traded company, Core Lab celebrated the 20th anniversary of the company's listing on the New York Stock Exchange ("NYSE") in 2018. The Core Lab executive management team (Figure 3) marked the accomplishment by ringing the opening bell at the NYSE on July 10, 2018. The opening and closing bell ringing is an honored tradition dating back to the 1870s with the advent of continuous trading.

Figure 3 - Core Lab executive management team ringing the opening bell on the NYSE, July 10, 2018

Core Lab's industry-leading share performance since its initial public offering ("IPO") in 1995 (Table 1) is the result of its strict adherence to the following three financial tenets.

1 Maximize Free Cash Flow Through Fiscal Discipline

Core Lab follows a strict, disciplined, approach for allocating capital for investment in growing its business, which is focused on generating high returns and positive free cash flow ("FCF"). The quality of a company's earnings is typically supported with cash flow from operations, and value is created through generating cash flow in excess of what is required for capital investments to maintain and grow their FCF.

We believe measuring the ratio of FCF generated from revenue is an important metric for shareholders when comparing companies' financial results, particularly for those shareholders who utilize discounted cash flow models to assess valuations.

This capital discipline produced a Revenue to Free Cash Flow Conversion Ratio of 12.9% during 2018, placing Core Lab at the top of its peer group (Table 2). Core Lab also maintained a higher conversion ratio than any other company in its peer group throughout the two industry downturns that began in 2008-2009 and starting in 2014. Further, as shown in Table 3, Core Lab's FCF has exceeded Net Income in 13 of the last 17 years. Core Lab will continue to demonstrate fiscal discipline in 2019 and beyond.

***Table 1* - Annualized Total Shareholder Return, %**

Company	10-Year	15-Year	Since CLB IPO
Core Laboratories	**7.8%**	**15.5%**	**15.0%**
Oceaneering International	-0.3%	5.2%	8.6%
Fugro	-9.3%	-0.2%	8.5%
Schlumberger	0.2%	4.0%	6.3%
Halliburton	5.2%	6.7%	6.0%
Baker Hughes	0.4%	1.2%	4.0%
Superior Energy Services	-14.2%	-5.8%	2.5%
Nabors Industries	-14.3%	-12.8%	-0.8%
Weatherford International	-27.9%	-17.9%	-4.2%
John Wood Group	10.9%	9.4%	N/A
TechnipFMC	4.9%	9.3%	N/A
Oil States International	3.6%	4.7%	N/A
Helix Energy Solutions	-3.4%	-4.6%	N/A
CARBO Ceramics	-19.2%	-12.5%	N/A

Source: Bloomberg, 12 months trailing as reported through 26 March 2019

***Table 2* - Revenue to Free Cash Flow Conversion Ratio, %**

Company	2018
Core Laboratories	**12.9%**
Schlumberger	10.8%
Helix Energy Solutions	8.1%
Halliburton	4.7%
Baker Hughes	3.4%
Average	**2.0%**
John Wood Group	1.4%
Oil States International	1.4%
Forum Energy Technologies	-2.0%
Superior Energy Services	-2.6%
Fugro	-3.0%
Oceaneering International	-3.8%
Nabors Industries	-4.4%
TechnipFMC	-4.4%
Weatherford International	-7.5%
CARBO Ceramics	-11.2%
Frank's International	-17.1%

Source: Bloomberg, 12 months trailing as reported through 14 March 2019

***Table 3* - Annual Net Income vs. Free Cash Flow**

Year	Net Income	Free Cash Flow
2018	**80,000,000**	**90,000,000**
2017	83,000,000	105,000,000
2016	64,000,000	121,000,000
2015	115,000,000	196,000,000
2014	257,000,000	267,000,000
2013	243,000,000	263,000,000
2012	216,000,000	206,000,000
2011	185,000,000	174,000,000
2010	145,000,000	178,000,000
2009	114,000,000	165,000,000
2008	144,000,000	124,000,000
2007	121,000,000	102,000,000
2006	83,000,000	96,000,000
2005	31,000,000	56,000,000
2004	12,000,000	44,000,000
2003	9,000,000	41,000,000
2002	(9,000,000)	22,000,000

2 Maximize Return on Invested Capital

Core's Board of Supervisory Directors has maintained an incentive compensation program for the executive and senior management teams based on the Company achieving a leading Return on Invested Capital ("ROIC") performance when compared with the oilfield service companies listed as Core Lab's Comp Group by Bloomberg Financial. Core Lab's Board believes that stock price performance over time is directly related to ROIC. Table 4 lists the ROIC for major oilfield service companies as calculated by Bloomberg Financial. Core Lab has the highest ROIC of the major oilfield service companies and is one of only two companies with a return above its Weighted Average Cost of Capital ("WACC").

Table 4 **- Return on Invested Capital, %**

Company	Return on Invested Capital	WACC	Returns Above WACC
Core Laboratories	**20.1%**	**10.4%**	**9.7%**
Halliburton	10.5%	8.4%	2.1%
Schlumberger	4.2%	8.5%	-4.3%
John Wood Group	1.5%	9.0%	-7.5%
Helix Energy Solutions	-0.1%	9.3%	-9.4%
Oil States International	-0.2%	10.2%	-10.4%
Baker Hughes	-0.8%	7.8%	-8.6%
Fugro	-1.0%	6.9%	-7.9%
Nabors Industries	-2.8%	5.5%	-8.3%
Average	**-6.6%**	**8.7%**	**-15.3%**
Oceaneering International	-7.7%	9.6%	-17.3%
TechnipFMC	-8.8%	9.1%	-17.9%
Frank's International	-10.2%	12.8%	-23.0%
CARBO Ceramics	-15.8%	7.6%	-23.4%
Forum Energy Technologies	-25.2%	9.4%	-34.6%
Weatherford International	-45.4%	5.7%	-51.1%
Superior Energy Services	-51.5%	7.5%	-59.0%

Source: Bloomberg and company filings, Return on Invested Capital and Weighted Average Cost of Capital reported through 14 March 2019

3 Return Excess Capital to Shareholders

Since October 2002, Core Laboratories has returned excess capital to its shareholders in the form of reductions in diluted share count (Table 5) and through dividends and share repurchases. As indicated in Table 6 and shown in Figure 4, Core Lab has returned $2.6 billion, or over $58.26 per diluted share, to its shareholders.

The Company will continue to return excess capital to its shareholders via dividends as well as through additional opportunistic share repurchases.

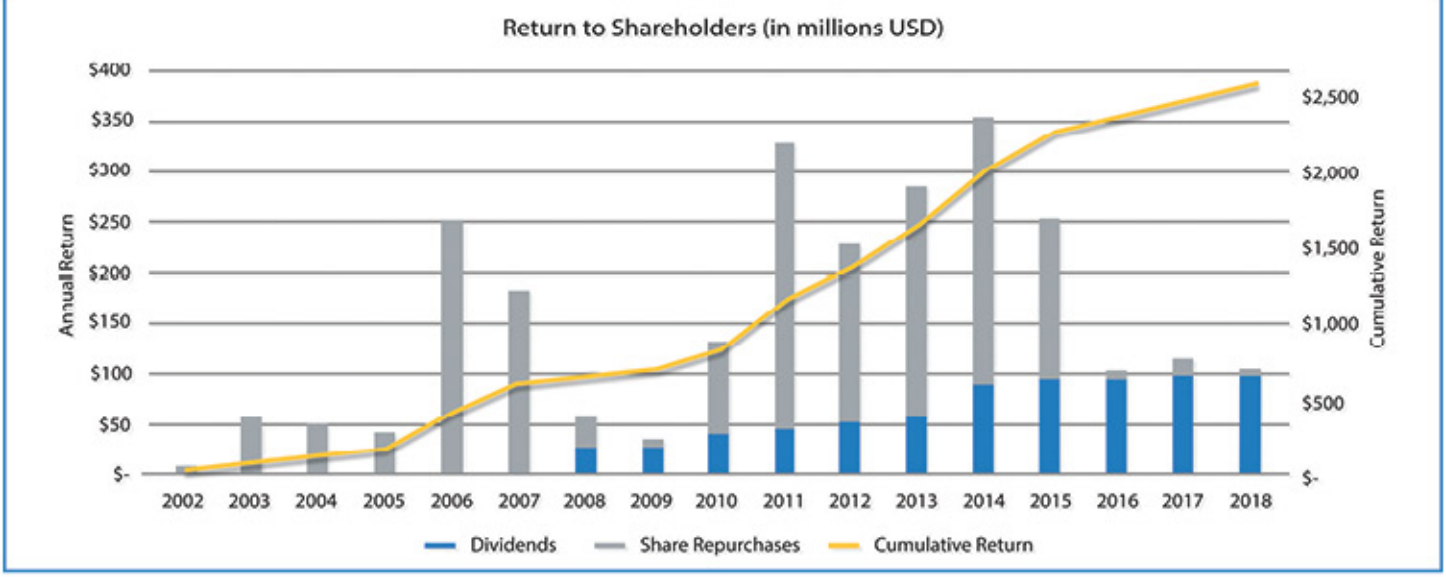
Table 6 - Capital Returned to Core Lab Shareholders

Total Capital Returned	$2.6 billion
Share Repurchases, Warrant Settlements	$1.9 billion
Quarterly Dividends	$724 million
Per Share Capital Return	$58.26

Table 5 - Annual Diluted Share Count

Year	Outstanding Share Count
2018	**44,400,825**
2017	**44,275,735**
2016	44,325,888
2015	**42,517,685**
2014	43,927,036
2013	**45,516,702**
2012	46,857,328
2011	**47,676,588**
2010	49,256,611
2009	**47,353,640**
2008	46,577,983
2007	**49,059,559**
2006	51,306,408
2005	**56,088,454**
2004	56,644,130
2003	**59,018,048**
2002	66,249,908
2001	**67,851,938**

Figure 4 - Cash Returned to Shareholders ($ in millions)



Message from the Executive Team

Core Lab honors Richard Bergmark, EVP and CFO and Monty Davis, SVP and COO as these two senior executives retire from the Company

Front Row: Mark F. Elvig, David M. Demshur, Lawrence V. Bruno
Back Row: Gwendolyn Y. Schreffler, Christopher S. Hill

Richard L. Bergmark,

Core Lab's Executive Vice President and Chief Financial Officer, retired from the Company after 30 years of service. Richard also served on Core Lab's Supervisory Board of Directors and retired from the Board in early 2018. Mr. Demshur and Mr. Bergmark were part of the management-led buyout of Core Laboratories in 1994, the Company's IPO in 1995 and were the longest standing CEO/CFO Team in the energy space. Richard was the architect and led the execution of the Company's three financial tenets:

1. Maximize Free Cash Flow through Fiscal Discipline
2. Maximize Return on Invested Capital
3. Return Excess Capital to Shareholders

and three growth strategies:

1. Develop New Innovative Reservoir-optimizing Technologies
2. Leverage Core's International Network
3. Acquire Complementary and Strategically-positioned Technologies

Monty L. Davis,

Core Lab's Senior Vice President and Chief Operating Officer, retired from the Company after 36 years of service. Monty was promoted to COO in 1998 and, since that time, led the operational performance of Core's two business segments, Reservoir Description and Production Enhancement, in addition to Business Development.

During his time as COO, Monty created an operational structure which focused on innovative and differentiated technological solutions to meet Core's clients' needs. By doing so, Monty and his operational team produced industry-leading operating margins and free cash flow.

Over the last 20 years, Mr. Bergmark and Mr. Davis have been part of a senior management team that generated total shareholder return for Core Lab's owners which has outperformed every member of the Philadelphia Stock Exchange Oil Service Sector Index ("OSX"). This exceptional performance has been achieved through their strategic and strict adherence to the Company's three financial tenets and three growth strategies initiated when Core Lab became a public company.

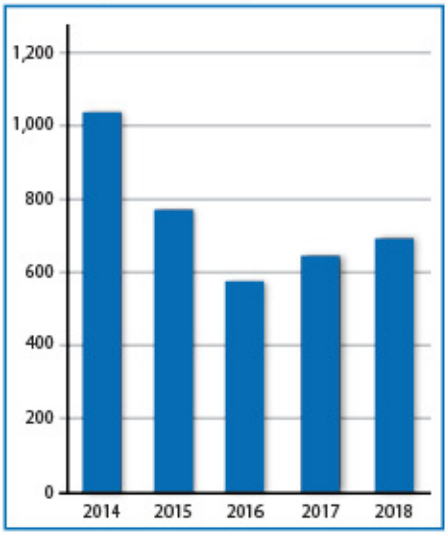
Consolidated Company Results from Continuing Operations

For 2018, Core Laboratories posted revenue and operating profit of $701,000,000 and $119,000,000, respectively. Operating margins remained at an oilfield industry high of 17%, several hundred basis points higher than those of other major oilfield service companies. Net income for 2018 was $80,000,000 and earnings per diluted share were $1.79.

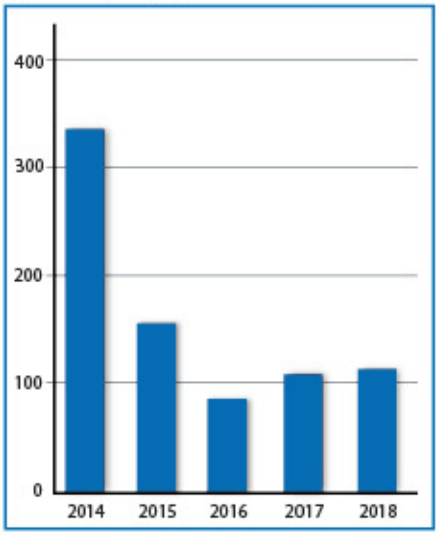
Core Lab's continued focus on maximizing FCF, the Company's first financial tenet, resulted in the highest revenue to FCF conversion ratio among comparable oilfield service companies. By selecting projects that generate high ROIC, Core Lab's second financial tenet, the Company has achieved the highest ROIC among all major oilfield service companies.

In keeping with Core Lab's third financial tenet, the Company continued to return excess capital to its shareholders in 2018 via regular dividends and share repurchases. The cumulative capital returned to shareholders as of December 31, 2018 was approximately $2.6 billion, or approximately $58.26 per diluted share.

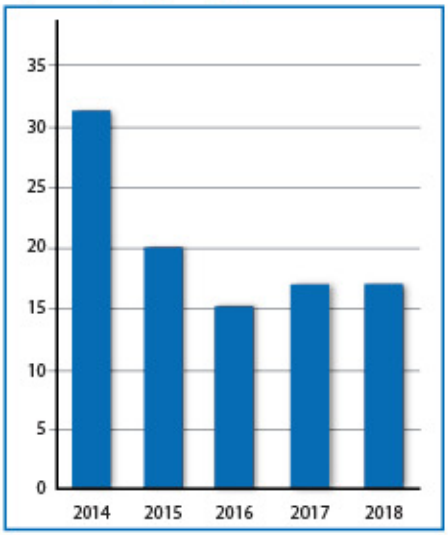
Revenue ($ in millions)



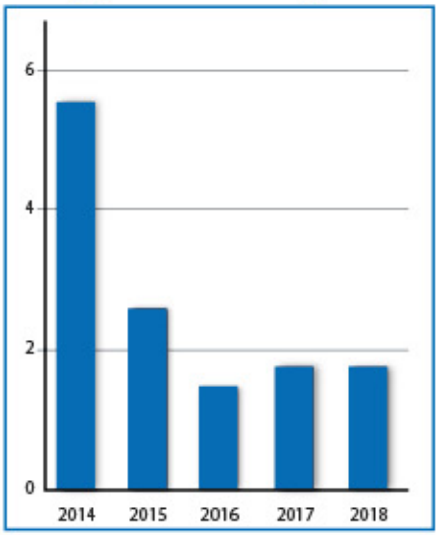
Operating Profit ($ in millions)



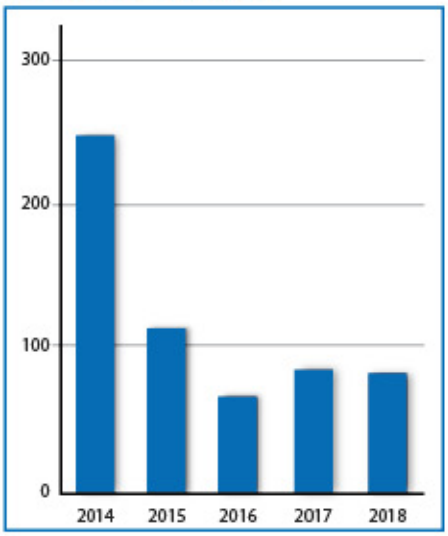
Operating Margins (%)



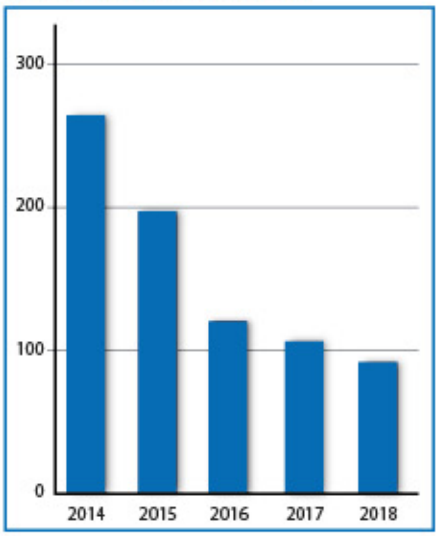
Earnings per Diluted Shares ($)



Net Income ($ in millions)



Free Cash Flow ($ in millions)



Operator capital discipline and emphasizing returns on invested capital trend benefits Core Lab

During 2018, Core was encouraged by the operating companies' focus on working within free cash and emphasizing returns on invested capital as demanded by today's investors, a trend which benefits Core Lab. Core's best clients tend to be the more technologically-sophisticated and understand how the use of technology can assist them in optimizing their production and gaining efficiencies, thus improving their return on investment.

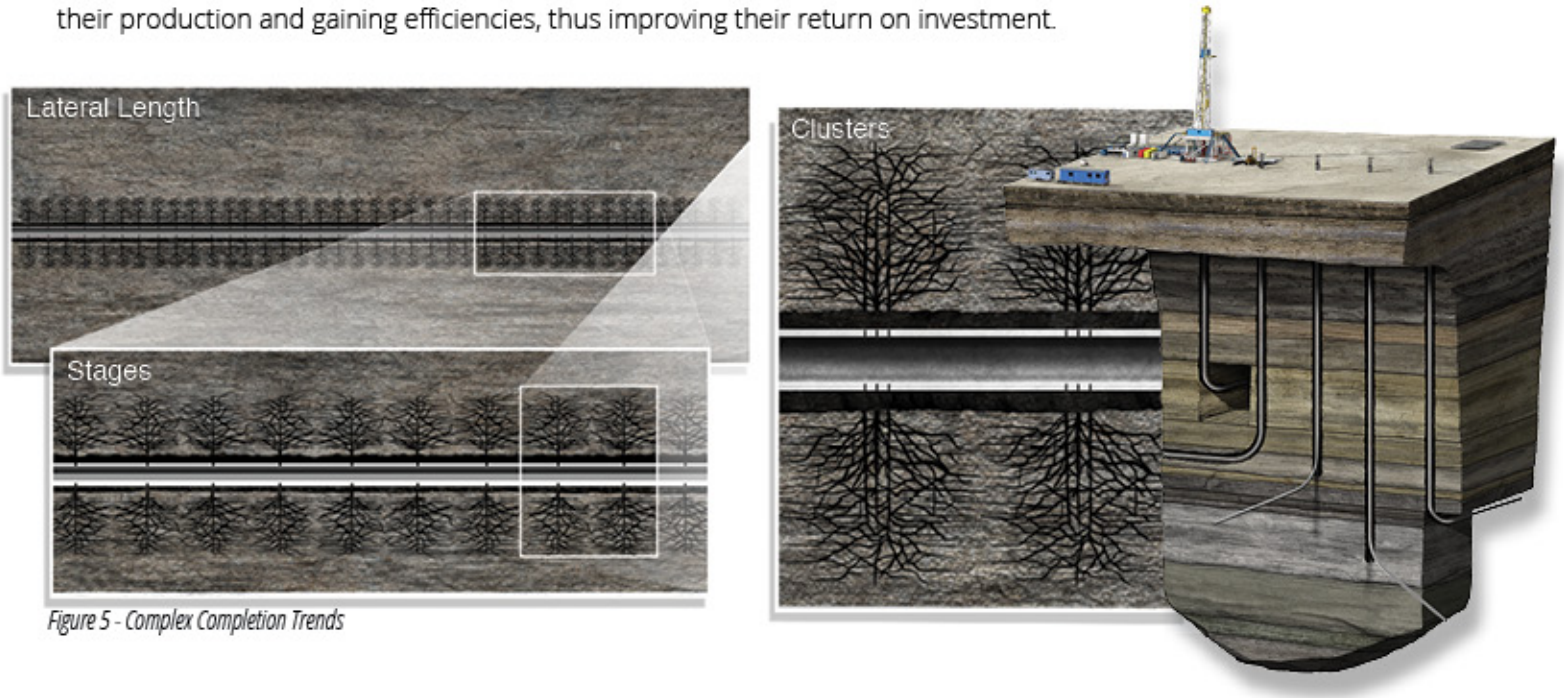


Figure 5 - Complex Completion Trends

In the U.S. onshore unconventional oil and gas fields, clients continue to use Core Lab's proprietary technology to advance the design of complex well completions in efforts to improve their internal rate of return and increase the estimated ultimate recoveries from these fields. Clients are using Core Lab's proprietary diagnostic technology to evaluate parent-child well relationships and achieve optimal well spacing, which may result in either down-spacing or up-spacing the placement of wells for a pad or development area. Core is uniquely positioned with its technologies to provide critical data sets to assist clients in determining optimal well spacing and well positioning which can eliminate the deleterious effects of well bashing and well interference.

Additionally, while frictional forces are limiting expansion of the lateral length of horizontal wells, operators continue to evaluate optimization opportunities in the completion of each well. More recent trends show operators continue to evaluate the length and total stages per well, while increasing the number of perforation clusters used per stage and total perforation clusters per well (Figure 5).

The most important trend for Core is its clients' reinvestment in international and deepwater, long-cycle projects. Discussions between Core and its clients continue for current and future projects. The 30 FID projects announced during 2018, which will be needed to replace reserves and meet future production demand, will provide further opportunities for Core. The following map (Figure 6) highlights the notable regions where these projects have been announced.

Figure 6 - International and Offshore Recovery Regions

Core Laboratories 2018 Recognition Highlights

During 2018, Core Lab celebrated several milestones whereby Core was recognized for its Corporate Responsibility efforts and financial performance. In January of 2018, Bloomberg announced that Core Lab was one of the 104 companies out of over 5,000 publicly-traded companies from ten sectors, representing 24 countries and regions, to join the inaugural 2018 Bloomberg Gender-Equality Index ("BGEI") (Figure 7). The BGEI, with the focus on gender equality in the workplace, is yet another metric by which investors can gauge a company's commitment to environment, social and governance ("ESG") factors across industries.

Figure 7 - 2018 Bloomberg Gender-Equality Index (BGEI)

We are proud to have accomplished the goal we set in 1994 of becoming the Best Oilfield Services Company. In the most recent Oilfield Services Suppliers Customer Satisfaction Rating & Analysis Report from EnergyPoint Research, Core Laboratories was rated:

- 1st in Total Satisfaction for all Oilfield Services
- 1st in Core and Fluids Analysis
- 1st in Formation and Well Evaluation
- 1st in Technology
- 1st in Job Quality
- 1st in Onshore Applications
- 1st in the U.S. & Canada, Asia & Pacific Rim, the Middle East, and Eastern Europe & Former Soviet Union

The survey rankings are based upon more than 3,300 comprehensive evaluations by qualified respondents at domestic and global E&P companies and other upstream professionals and organizations.

2018 Result Drivers

Since mid-2016 when the North American onshore activity began its recovery, Core has seen marked improvement each year. 2018 started on an upward trajectory of activity, most notably in the U.S. Permian Basin as one of the fastest growth areas for onshore production; however, the region experienced industry logistical bottlenecks. From assembling and training frac crews, acquiring and/or updating pressure pumping equipment, to crude oil take-away capacity, these bottlenecks experienced in the basin moderated the growth of well completions throughout the year. Nonetheless, 2018 served as another year of improvement since the industry's downturn which began in November 2014.

The macro fundamentals for global crude oil supply and demand continued balancing until the fourth quarter 2018, when a sharp increase in production caused crude oil inventory levels to rise, likely as a result of expectations that Iranian sanctions would limit that country's export of crude oil.

As these two industry items emerged, so did the operators' focus on financial returns to their shareholders. Core Lab clients have been, and are today, among those producing financial returns through the use of technologically advanced services and products to drive the most economical crude oil production growth over the life of their fields. The potential U.S. onshore unconventional areas such as the Wolfcamp Formation in both the Midland and Delaware Basins is great, but will require the use of technologically advanced completion techniques to maximize the return on investment. As illustrated in Figure 8, advanced completion techniques are being used as the industry transitions to multi-well pads from single well drilling.

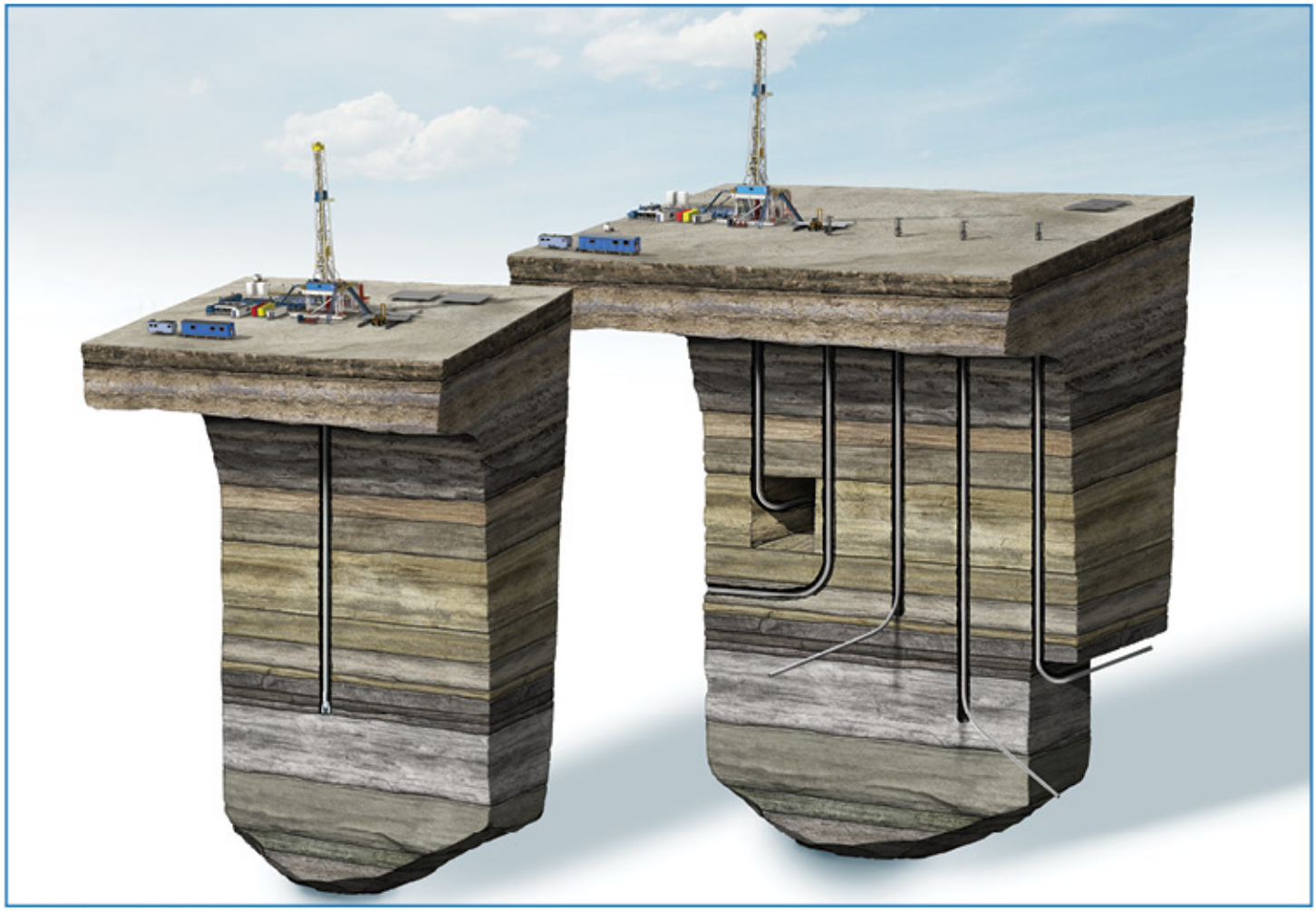


Figure 8 - Industry transitions from single well to multi-well pad drilling

International and Offshore Developments

As the international recovery unfolds, Core Laboratories continues to play a key role in helping its client's improve the return on their investments, by optimizing daily hydrocarbon production and ultimate hydrocarbon recovery from these valuable assets. Several of the FID projects announced in the last couple of years are projected to have recoverable reserves exceeding several billion barrels of hydrocarbons, and Core Lab will be providing extensive data sets and analytics to help its clients optimize hydrocarbon recovery. Core Lab's decades of knowledge, proprietary processes and instrumentation will be used to help clients analyze both the reservoir rocks and reservoir fluids. These data analytical programs will include more standard characterization of the reservoir rock properties, such as mineralogy, porosity, permeability and rock mechanics, as well as more advanced programs analyzing the reservoir rocks and fluids under reservoir pressure and temperature conditions. These data sets are used not only to describe the quality and quantity of the discovery on day one, but also to assist the operator in how to optimize the production over the life of the reservoir. These data analytical programs provided by Core Lab are critical in assisting its clients to optimize the development and production of the reservoir which improves the return on their investment.

Core Lab continues to roll out new technology across its global network

Core Lab's proprietary Dual Energy Computed Tomography ("DECT") (Figure 9) and Micro CT technologies are currently being used by clients in the Asia Pacific region to calculate net-pay in thin-bedded, highly-laminated sandstone reservoirs. Thinly-bedded reservoirs introduce several challenges to geologists and petrophysicists, often resulting in errors in net-pay determination and, consequently, reserve calculations. These types of errors are primarily due to the limitations of bed resolution from wireline logs, as well as inconsistent methodologies. Highly accurate net-pay determinations measure the cumulative thickness of productive sand in a stratigraphic zone by excluding non-productive sedimentary beds and lamina from the gross pay interval. Core's proprietary DECT scanner-based deliverables generate millimeter-scale three dimensional images and accompanying high-resolution petrophysical logs on cored intervals by calibrating DECT information to the vast library of physical measurements available in Core Lab's proprietary database. The DECT deliverables from Core are more detailed than down-hole logs and provide better bed resolution, as well as accurate information on rock properties such as lithology, porosity, density, rock strength and acoustic properties.

Figure 9 - Dual Energy Computed Tomography (DECT) Technology

Offshore Guyana Basin

A consistent and important trend throughout 2018 for Core is that client discussions have continued to increase for international and deepwater, long-cycle projects that will be needed to meet future production demand. The increase in activity has been evident in the 25 FIDs approved in 2017, with another 30 announced in 2018, and 30 more anticipated for 2019. There has been minimal investment and activity associated with these longer-cycle projects for several years, however, we expect Core's involvement on these projects through the Reservior Description segment to grow throughout 2019.

Since the initial discovery of Stabroek Block, there have been many additional discoveries announced – the majority during 2018. One notable discovery was offshore Guyana, and in 2017, the Liza Phase I project was announced. This discovery has been described by both Hess and ExxonMobil as a "world class investment opportunity with multi-billion barrels of additional exploration potential", and the monetization of this oil bearing province is underway.

The prolific, hydrocarbon-bearing, offshore Guyana Basin (Figure 10) forms the north-westerly part of the larger Guyana-Suriname Basin, in which an approximately ten kilometer-thick wedge of Mesozoic-Tertiary strata is preserved. The history of the basin can be traced back to the break-up of the Pangea "supercontinent" during the Early Jurassic Period as the North Atlantic rift system progressed southward. During the Early Cretaceous Period, ongoing continental break-up led to the opening of the Southern and Equatorial Atlantic Oceans, while a passive margin developed along the Guyana-Suriname margin. Early post-rift deposition was dominated by fluvial-deltaic sediments and associated sandy turbidite deposits in the deep basin, as well as shelf-edge carbonates. The climax of Equatorial Atlantic rifting in the Late Albian Period led to uplift and widespread erosion, creating a regional unconformity.

During the Late Cretaceous Period, the South American and African plates continued to drift apart. Although this period was tectonically quiet across the Guyana Basin, the inherited rift topography continued to influence sediment transport pathways and hydrocarbon migration. A Late Cretaceous regional marine transgression deposited the organic-rich Canje Formation mudstones, which form the prolific source rock in the basin. Late Cretaceous to Mid-Tertiary shelf-margin deltas and associated sand-rich deep sea fans overlie this source rock, forming multiple hydrocarbon reservoirs.

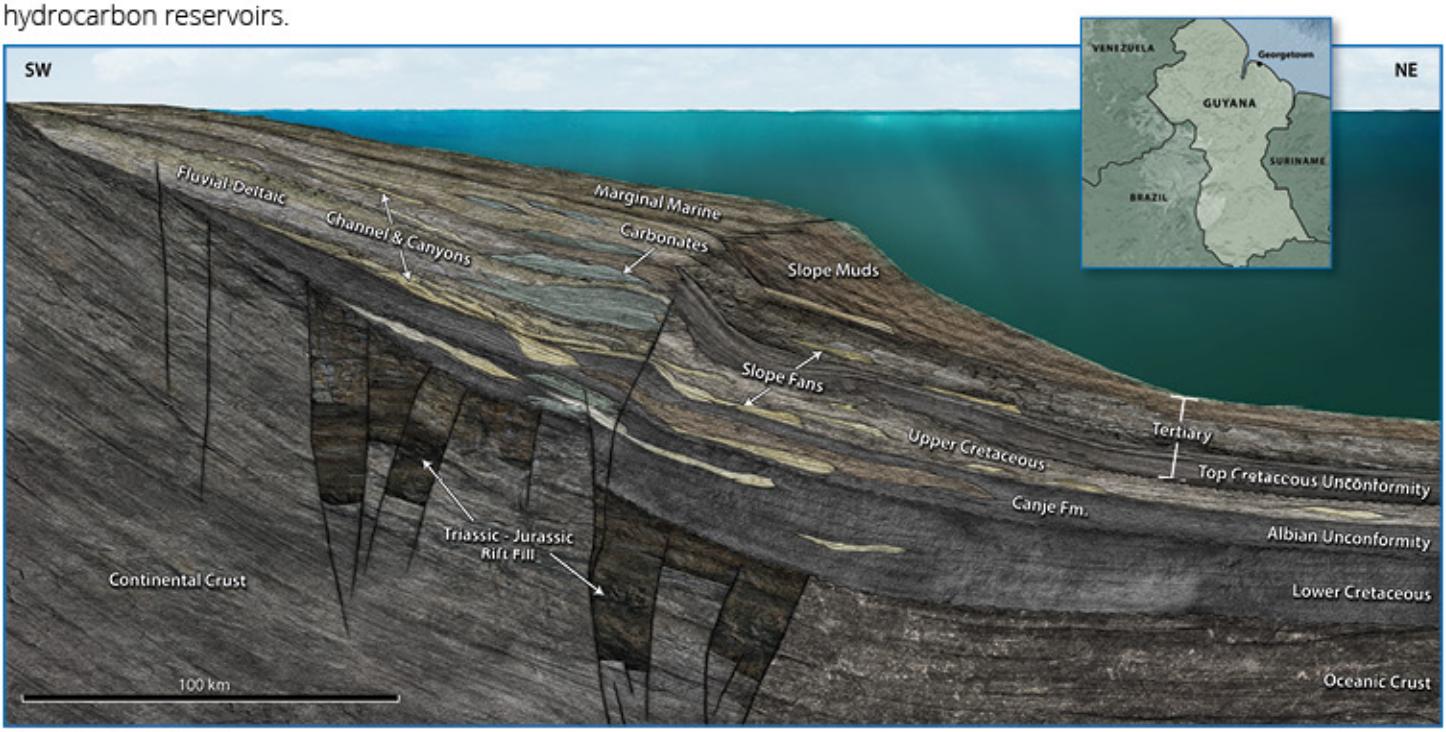


Figure 10 - Offshore Guyana Basin

Understanding the reservoir fluid and optimizing production levels

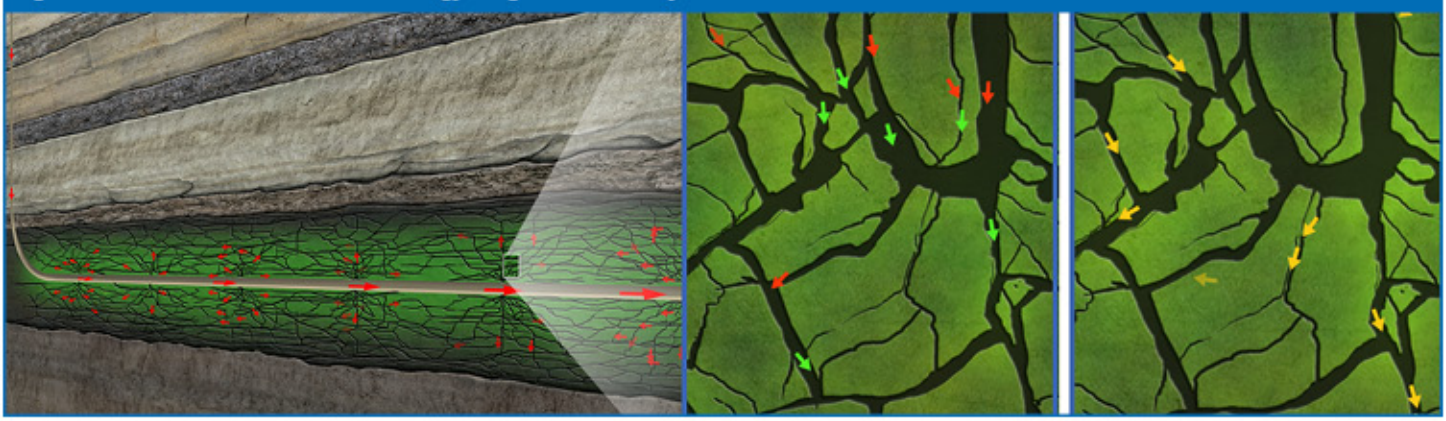
The analysis of reservoir fluids (crude oil, natural gas and water) continues to be an important driver of Reservoir Description results, representing more than 60% of total revenue for the segment. As the reservoir fluids are very dynamic over time, understanding the properties of these fluids is key to predicting hydrocarbon recovery over the life of a field. Pressure-Volume-Temperature ("PVT") laboratory tests are used to determine the phase behavior of hydrocarbons at reservoir conditions. These data sets can be employed to determine both primary production and enhanced oil recovery ("EOR") opportunities. During 2018, Core Laboratories' Middle Eastern operations were engaged by a major national oil company to conduct advanced PVT studies to determine both primary production and the potential injection options for a large-scale enhanced oil recovery program. Although these fields are naturally prolific, they are not exempt from the laws of physics, which inevitably result in declines of the reservoir's production. Utilizing Core's proprietary fully visual PVT cells, Core's scientists precisely measure pressure, volume and temperature variations as a function of injection options and compositional changes (Figure 11). The analytical program will enable the operator to implement the optimal injection strategy to sustain current production levels and maximize ultimate recovery over the life of the program.

Figure 11 - Pressure-Volume-Temperature (PVT) Laboratory

Enhanced Oil Recovery in Unconventional Reservoirs

An example of the importance and use of reservoir fluid analysis and advanced technology is the work Core Lab is doing for its clients for unconventional EOR. Liquid hydrocarbon production from unconventional reservoirs remains the trend setter in the continental United States. Core Lab developed new technologies to create methods of increasing production in these types of low permeability reservoirs through enhanced recovery mechanisms. In the laboratory, hydrocarbon and gas cycling under reservoir conditions to initiate crude oil swelling or vaporization as shown in Figure 12 is one such method that can be used to increase ultimate recovery. Core's proprietary high frequency nuclear magnetic resonance and data mapping is conducted to reveal changes occurring to the oil in place during a reservoir condition gas cycling experiment. Understanding which gases have the largest impact on incremental production during the EOR cycle requires testing using Core's proprietary, made-for-purpose core flow testing equipment.

Figure 12 - Unconventional EOR Technology - Engineered Gas Injection



Optimizing the Drilling Program

Technology and data analysis focused on parent-child well relationships in horizontal well developments has been a topic of immense interest from Core's clients involved in unconventional reservoir developments. New, cutting-edge technology offerings from Core have been utilized by clients in a number of proprietary projects to define proper spacing and well positioning. During the year, Core hosted conferences for various industry groups and financial analysts to discuss optimal well spacing, right-sizing, up-sizing, well positioning, and parent-child well relationships. Core Lab is uniquely positioned to provide technology-driven datasets to determine optimal well spacing and well positioning to eliminate the deleterious effects of horizontal well interference.

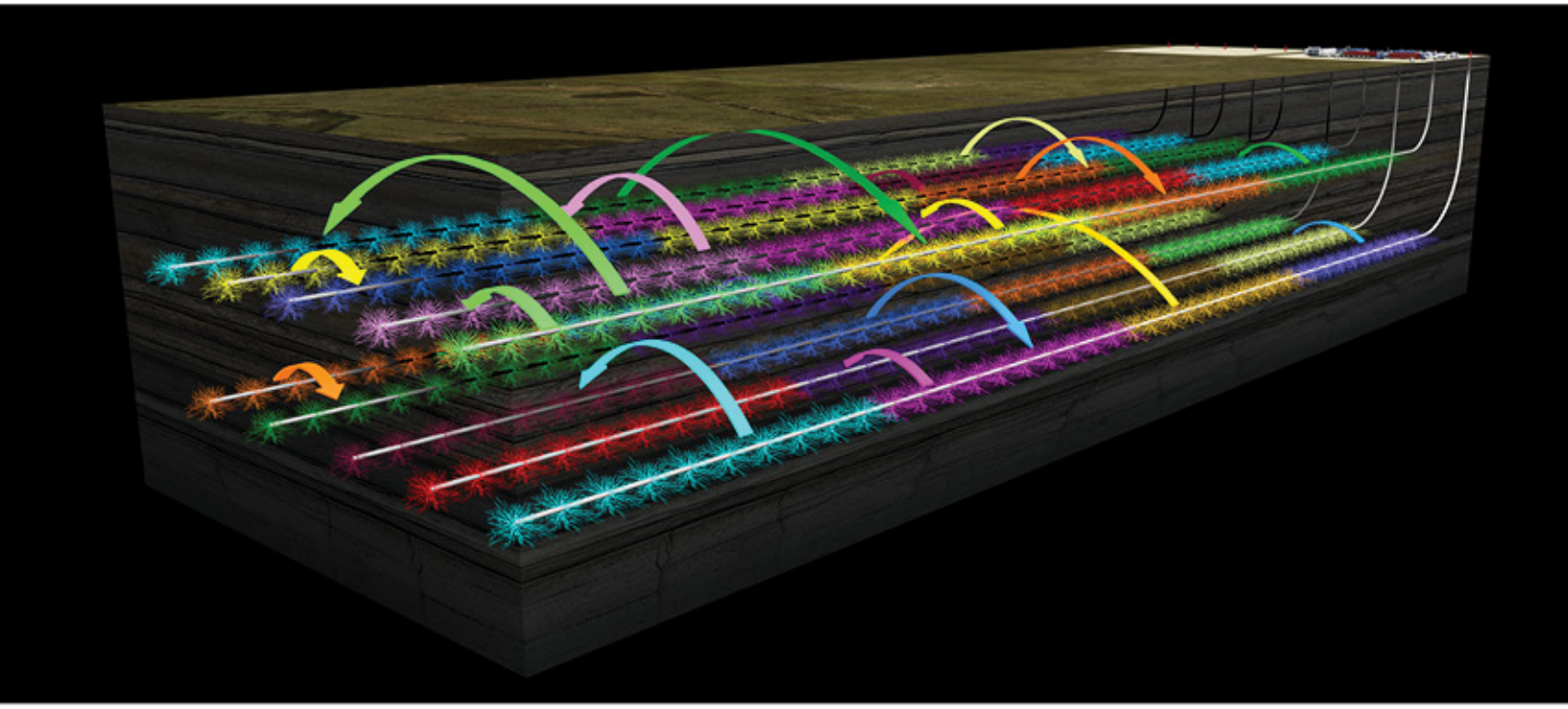


Figure 13 - SPECTRASTIM™, SPECTRASCAN® and FLOWPROFILER EDS™

To optimally determine well spacings and improve the location of wells associated with pad drilling, Core's most technologically-advanced clients are cutting cores, as well as taking multiple reservoir fluid samples, throughout the entire pay zone. Detailed analysis of these core and fluid samples provide information to the operator on microlithology, rock competence, rock mechanics and crude oil properties; all datasets necessary to determine optimal well spacing and well positioning. As horizontal wells are drilled, completed and stimulated, Core's **SPECTRASTIM™**, **SPECTRASCAN®** and **FLOWPROFILER EDS™** completion diagnostics optimal well spacing and well positioning technologies (Figure 13) can verify that wells either are, or are not, interfering with neighboring wells on the pad, reducing inefficient well spacing and optimizing producible reserves. This becomes more critical as well pads will soon see 24 or more wells drilled from a single pad location. Core sees an industry trend of upsizing well locations in 2019. The combination of Core Lab's Reservoir Description and Production Enhancement technologies will assist Core's clients in gaining those valuable incremental barrels of production and achieving greater levels of cash flow and better returns on their investments.

Optimizing the perforation clusters in well completion design

Core Lab, through its Production Enhancement segment, designs, manufactures and sells best-in-class perforating energetic products and systems, which are used by its oil and gas clients during the well completion process. Although the current lateral length of horizontal wells appears to have reached limitations due to frictional forces, the industry continues to explore optimizing and analyzing the design of how each well is completed. One aspect in the design of the well completion is associated with the number of stages or zones employed, and the amount of perforation clusters used in each stage. The more recent trends show an increase in the number of perforation clusters used in each stage (more perforation clusters across the entire well), and an increase in the length of individual stages as seen in Figure 14, which ultimately reduces the total number of stages for the well. The use of more perforation clusters within each stage has improved and increased the amount of stimulated reservoir rock near the wellbore, while lengthening and reducing the number of stages in the well has reduced the well completion cost. The use of more perforation clusters (more perforation energetics) per stage/well is a favorable trend for Core's Production Enhancement product sales and will allow operators to continue optimizing the production of their wells, while also reducing costs and some of the deleterious effects experienced in parent-child well relationships.

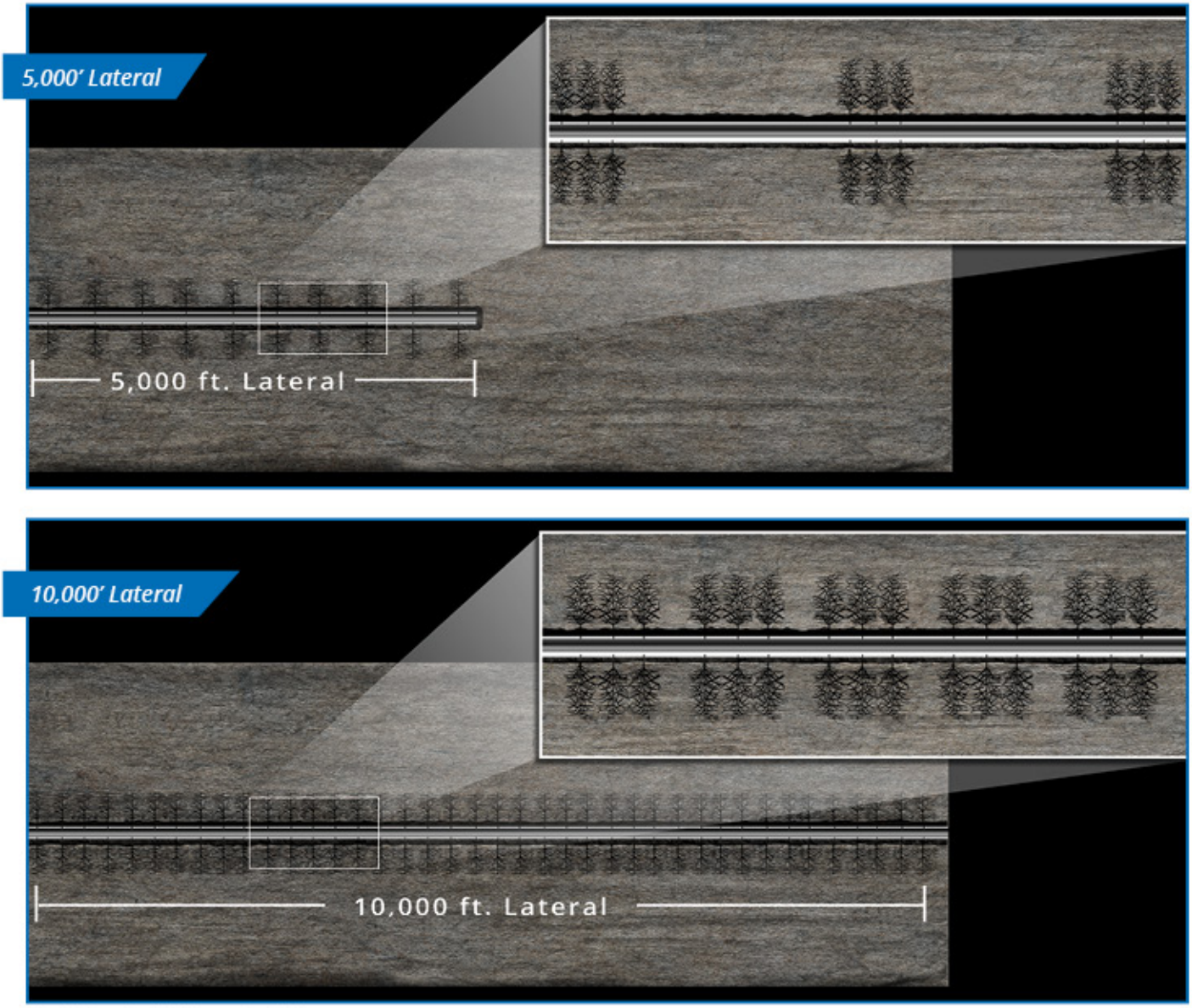
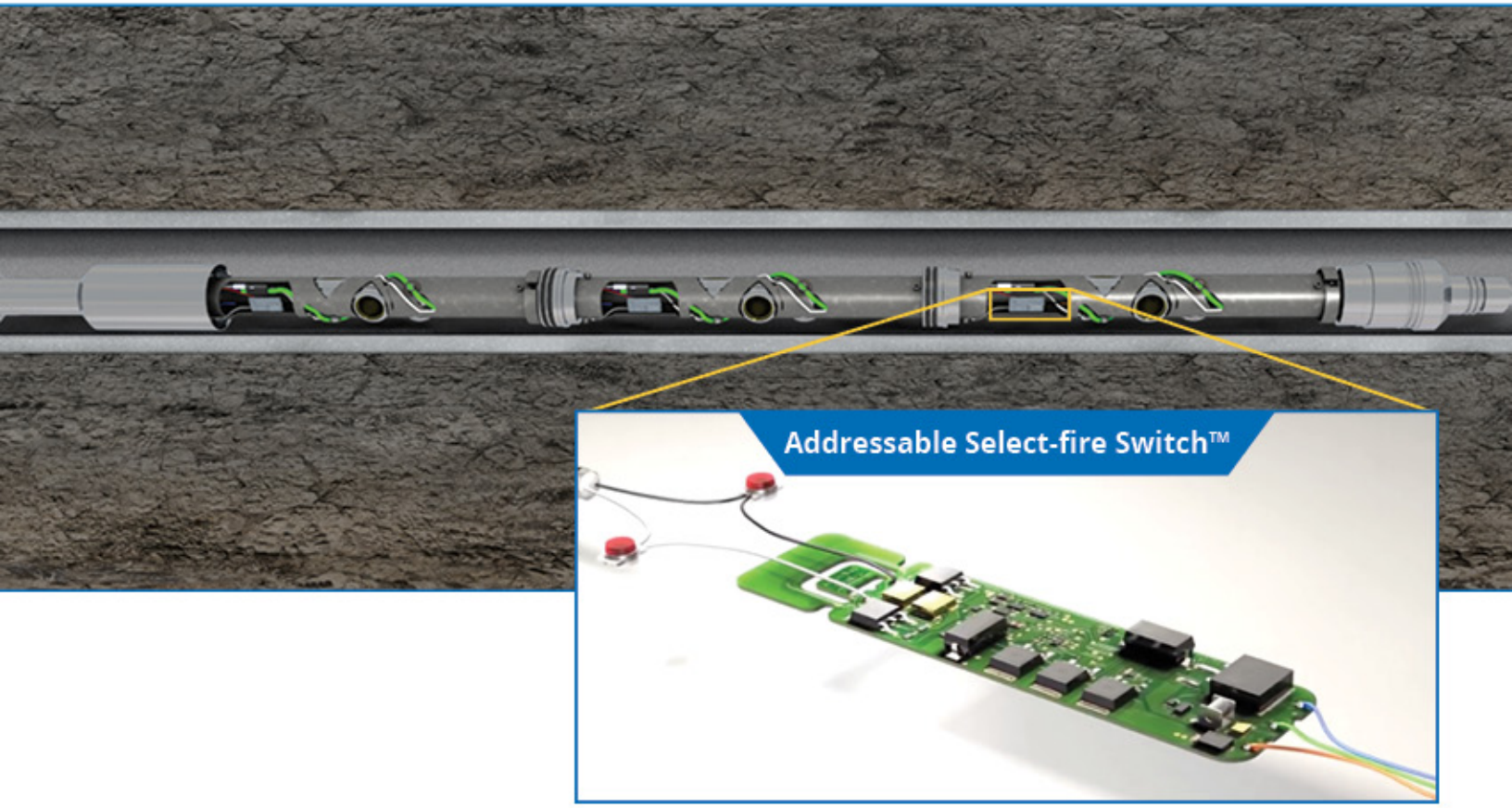


Figure 14 - Increasing stimulated reservoir rock volume

Near Term Growth Drivers

GoGun℠ Adaptive Perforating System

Following the acquisition of Guardian Global Technologies in the third quarter of 2018, the integration of Guardian's patented downhole technologies into Core's Production Enhancement business segment is well underway. The Production Enhancement team is sharply focused on proprietary downhole energetic solutions designed to systemize, simplify, automate, and de-risk the deployment of the perforating system. As part of the integration, Core began the introduction of the new pre-assembled **GoGun℠ Adaptive Perforating System**. This system combines Guardian's best-in-class **Addressable Select-fire Switch™** technology with Core's proprietary energetics into a pre-assembled, integrated perforating system. The **GoGun℠** is an "open architecture" system that gives the operator maximum flexibility in designing their perforation system for wellsite efficiency and reservoir performance.



Ballistics Delivery System (BDS)™

Core has also introduced the Guardian **Ballistics Delivery System ("BDS")™** (Figure 15), an advanced wellbore communication system driven by client demand. When combined with Core's differentiated perforating systems and energetics, Core provides the industry with the only comprehensive perforating solution. The BDS, combined with Core's variety of technologically advanced energetic products, will enable Core's clients to optimize the downhole tool-string for each perforating system operation. The client is better able to manage the outcome of their investment with faster and safer operations, while reducing the risk and potential cost of unplanned downhole incidents. The BDS intelligent communication protocols automatically detect which products are present in the tool-string and can be configured for the client's desired downhole communication.

Ballistics Delivery System (BDS)™ Cont.

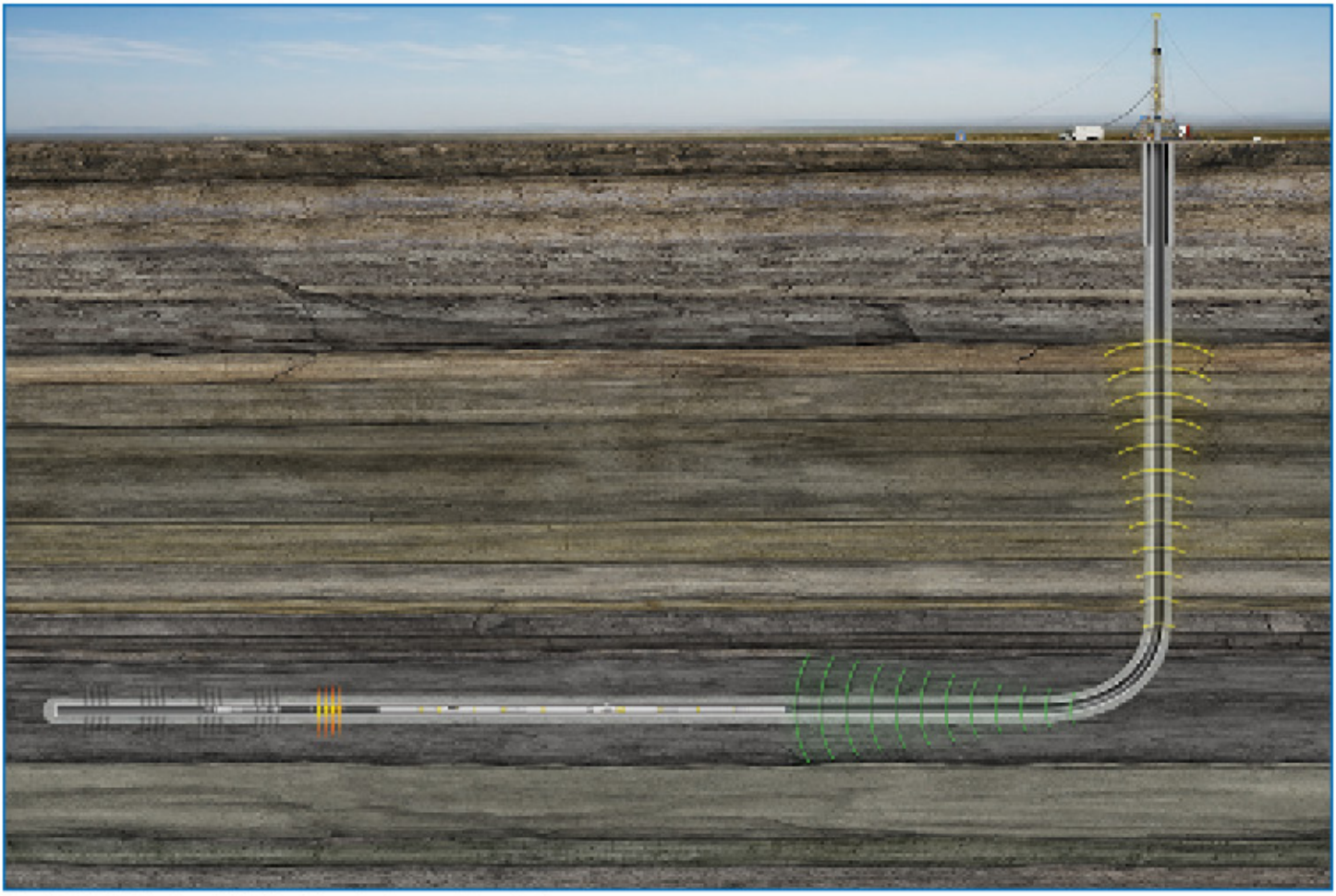


Figure 15 - Ballistics Delivery System ("BDS")™ downhole perforating communication technology

Utilizing the advanced **BDS™ System** along with the wide array of Guardian tools, the new pre-assembled **GoGun℠** and **HERO®PerFRAC** energetics, will enable the operator to optimize wellsite efficiency, perforating accuracy and reliability. Combined, these downhole technologies will significantly enrich Production Enhancement's ability to bring new and innovative product offerings to Core's clients. Core's patented and proprietary energetics and perforating systems now lead the market dynamics for ultra high-end completions in unconventional reservoirs. Together with Guardian Global Technologies, Core now provides technology across the entire completion string, from the cable head to the bridge plug, in a way offered by no other oilfield service provider.

Core Lab expects Guardian's addressable downhole capabilities, combined with Core's differentiated perforating systems and energetics, to lead to the introduction of differentiated and disruptive perforating technology in 2019 and beyond, expanding its participation in the multi-billion dollar perforating market.

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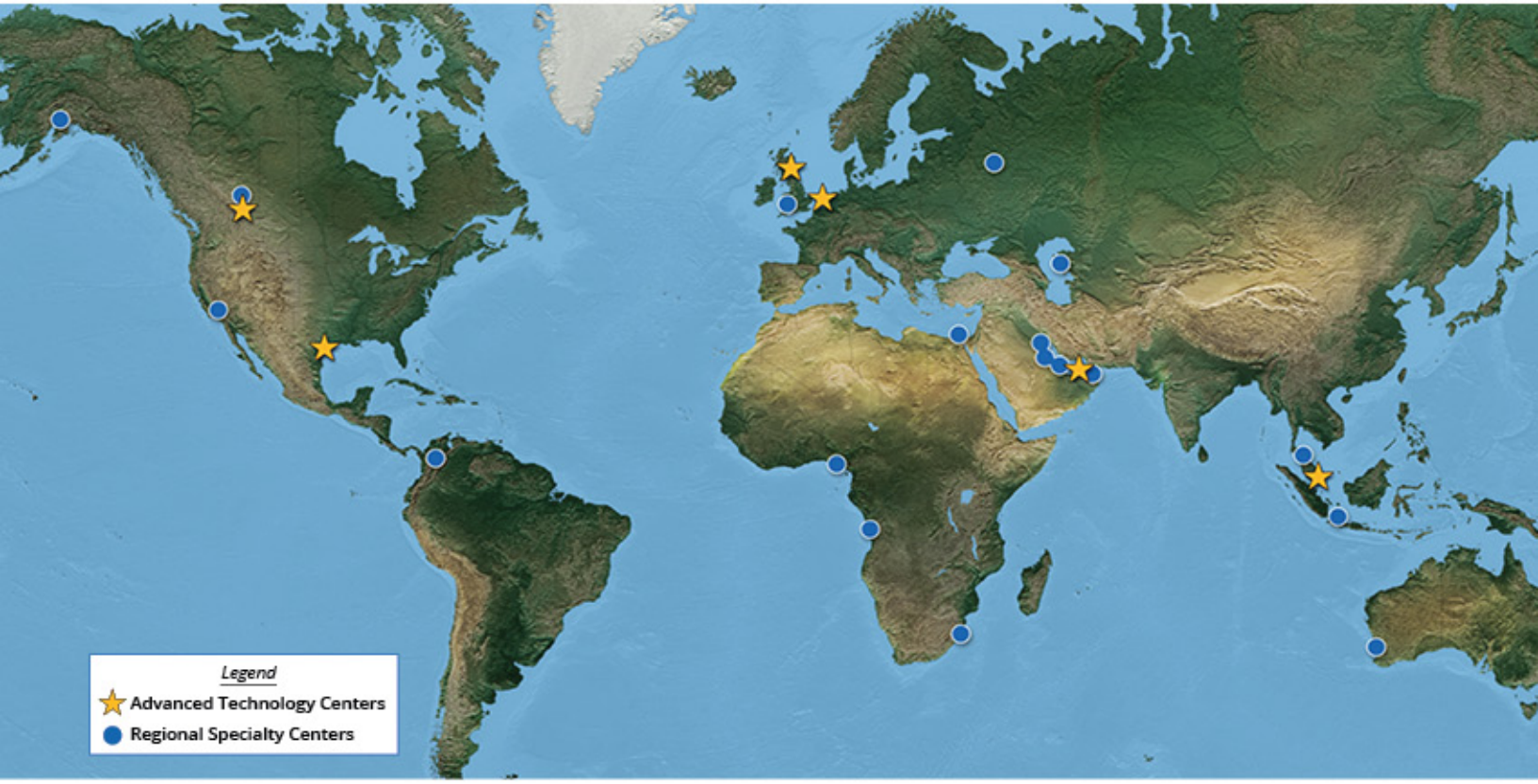

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