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技術主導のグローバルサービスカンパニーとしての日本における技術戦略

R&D Strategy in Japan as a technology-oriented global service company

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シュルンベルジェは石油･天然ガスの開発･生産に関する技術的なサービスを提供するグローバルサービスカンパニーである。テクノロジーは常にその経営の重要な柱の一つであり、世界のエネルギー概況を見据えた長期的なビジョンを持って研究開発が進められている。社内での研究開発に加え、最近は大学との共同研究、他の企業との共同開発、ベンチャー企業への投資など、国際的、かつ多角的な技術戦略を進めている。日本においても大学の共同研究や、他の企業との共同開発などが数多く行われているが、日本発の技術を発掘し、また日本の産業の特質を生かした効果的な開発を行うべく、さらなる試みが行われている。ここではシュルンベルジェのグローバルな技術開発の手法を述べ、最近の日本における外部との技術開発の現状と今後の課題について述べる。

Schlumberger is a global service company providing technical services for the exploration and production of oil and gas. Technology has been always one of the important pillars of its management, and the research and development are executed with the long-term vision based on the world energy outlook. Recently, global and diversified technology development is propelled not only through the internal R&D but also by joint researches with universities, collaborations with other enterprise, or through mergers & acquisitions. Many joint projects with universities or other firms are happening also in Japan, but recently further trials started for identifying hidden technology seeds from Japan and starting an effective realization in riding on the strength of Japanese industry. Through this paper, we will explain about the global R&D strategy of Schlumberger, and talk about the recent status and future challenges of technology investment in Japan.

Introduction

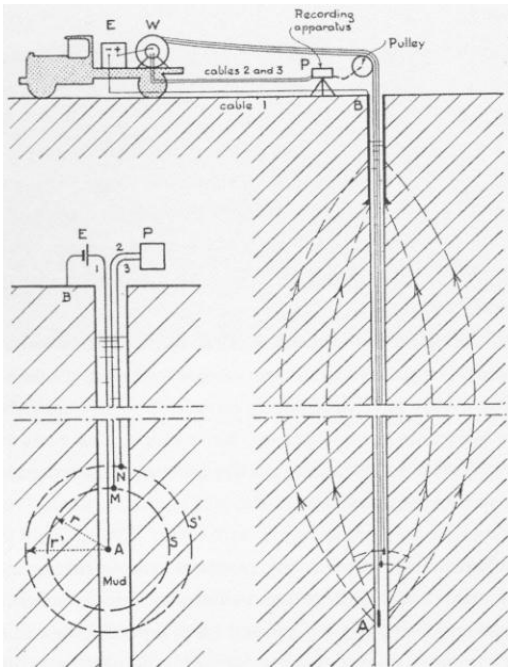
Schlumberger limited (NYSE:SLB) is the world's leading supplier of technology, integrated project management and information solutions to customers working in the oil and gas industry worldwide. Knowledge, technical innovation and teamwork are at the center of who Schlumberger is. For more than 80 years, Schlumberger has focused on leveraging these assets to deliver solutions that improve customer performance.

Today, their real-time technology services and solutions enable customers to translate acquired data into useful information, then transform this information into knowledge for improved decision making-anytime, anywhere. Harnessing information technology in this way offers enormous opportunities to enhance efficiency and productivity. This is a quantum leap from providing traditional 'just-in-case' information to delivering 'just-in-time' knowledge that meets the changing needs of our customers.

Reflecting our belief that diversity spurs creativity, collaboration, and understanding of customers' needs, Schlumberger employs approximately 120,000 people representing over 140 nationalities and working in more than 85 countries. Their employees are committed to working with our customers to create the highest level of added value. Knowledge communities and special interest groups with their organization enable teamwork and knowledge sharing unencumbered by geographic boundaries.

With 25 research and engineering facilities worldwide, Schlumberger places strong emphasis on developing innovative technology that adds value for their customers. In 2012, Schlumberger invested $1.2 billion in R&D, which shows their dedication to technology and innovation.

Foundation of the history of technology and innovation



Schlumberger's history started from the innovation of the electric measurement applied to downhole. Schlumberger brothers, Conrad and Marcel, founded the company in 1926 called Société de Prospection Électrique (Pros) in 1926 for conducting electrical prospecting. In 1927 the first attempt of electrical resistivity well logging was made by a team led by experimental physicist Henri Doll from an electrical sonde at various discrete depths in a 500-meter-deep well in Pechelbronn in the Alsace region of France.

Since then, logging technique was evolved quickly by the introduction of the continuous-recording hand recorder, and Spontaneous Potential (SP) log in1931.

Schlumberger Well Surveying Corporation (now Schlumberger Well Services) in 1935 as the first "service" company providing oilfield services worldwide. In 1940, , the company moved its headquarters to Houston to take advantage of the USA's position as a global technology leader, especially in electronics. As the decade progressed, logging applications began to expand beyond formation evaluation. In 1946, the casing collar locator was first deployed to measure changes in magnetic flux at the collar's location. This breakthrough made it much easier to correlate open hole

and cased hole logs taken from the same wellbore. The following year, the first induction log was recorded Texas, helping to distinguish oil- from water-bearing rock layers when the borehole contains fluid that does not conduct electricity.

Schlumberger acquired the first logging data in Kashiwazaki in Japan in 1936. The logging truck was substantially modernized, equipped with a winch and an electrical cable capable of operating a wide range of services in deeper and deeper boreholes. The first base of Schlumberger Japan was opened in Sakata in 1956, then moved to Nagaoka in 1957. The oilfield base of Japan is still located in Nagaoka for providing services throughout locations in Japan and Korea.

Meanwhile, progress in the company's core businesses continued apace. Throughout the 1960s, Schlumberger engineers developed density logs to improve understanding of lithology and porosity, saturation measurements through casing, computer-processed dipmeter logs, digital tape processing in a logging truck, and sonic logging.

History of new technology evolution

Schlumberger continued to expand its discipline throughout 20th century. In 1951, Schlumberger began to experiment with a microneutron device, which could measure formation porosity by sensing the amount of hydrogen present. Work also got under way on another technique for quantifying formation porosity, based on attenuation of gamma rays. Sonic measurements, introduced in 1952, provided better depth control for perforations and for placing well-completion equipment; their use quickly spread into other areas, such as rock property evaluation, porosity and fracture analysis, cement evaluation and the correlation of well logs and seismic data. The precursors to today's modular fluid sampling and pressure testing tools also emerged, when, in 1956, Henri Doll patented methods of determining hydraulic characteristics of formations traversed by a borehole.

As computing power and expertise grew, Schlumberger was able to launch several revolutionary products. The FMI Fullbore Formation MicroImager now enabled seemingly photographic images of the borehole to be made. In 1990, the MDT Modular Formation Dynamics Tester (MDT) provided improved methods of measuring reservoir pressure and collecting fluid samples. The new Platform Express wireline service introduced in 1995, a much faster and more cost-effective way of achieving the same results as the triple-combo logging system, speeding up rig-up, logging, calibration and processing.

The launch of the third-generation nuclear magnetic resonance (NMR) tool in 1995 refined

reservoir evaluation still further, facilitating the identification of thin, permeable or water-free productive zones. Sonic imaging also developed to the extent that Schlumberger completed its first commercial job using the technology in 1996. At the start of the decade, geosteering was used for the first time in horizontal wells, using logging data acquired while drilling a borehole to adjust the path of the drill to keep it within the producible hydrocarbon deposit.

History of Strategic Acquisition

Schlumberger also strengthened its operations through restructuring and strategic acquisitions. The company bought 50% of the Forex drilling rig company in 1952 and, four years later, it acquired Johnson Testers, the first of many acquisitions enabling Schlumberger to supply a more complete spectrum of formation evaluation measurements. In 1960, it formed Dowell Schlumberger, a 50/50 joint venture with Dow Chemical, which specialized in pumping services for the oil industry. In 1961, Solartron, a UK electrical instrumentation company was acquired, and in the same year, Société d'Instrumentation Schlumberger was founded to coordinate expansion into electronics and measurement systems. In 1962, the company acquired the cable operations of Vector Cable and Daystrom measurement instruments. In 1964, Schlumberger created the Neptune drilling company by merging parts of its Languedocienne operation with Forex, of which it owned 50% at the time. Strategic acquisitions included that of Flopetrol, a specialist in testing oil well production, in 1971. Schlumberger bought the 50% of Forex it did not already own and created the Forex Neptune Drilling Company in the same year. The Analysts, a directional drilling and mud logging services provider, was acquired in 1977, paving the way for success in the fast-expanding measurements-while-drilling sector.

The purchase of the SEDCO drilling rig company and 50% of Dowell of North America in 1984 led to the creation of Anadrill (a combination of Dowell and The Analysts' drilling segments) and the SEDCO Forex Drilling Company (a merger of SEDCO with Forex Neptune). Meanwhile, the acquisition of 50% of GECO in 1985 signaled the start of a long-term commitment to the seismic measuring sector. Schlumberger bought the remaining 50% of GECO in 1988.

A spate of acquisitions helped the company grow and diversify its activities. PRAKLA-SEISMOS, GeoQuest Systems, Oilphase and Camco International were some of the companies that became part of Schlumberger. Strategic collaborations were also forged, such as the Omnes communications and info tech joint venture with Cable and Wireless, and the M-I L.L.C drilling fluids company in a venture with Smith International. Schlumberger also reinforced its seismic offering. Geco-Prakla was combined with Western Geophysical in 2000 to create WesternGeco, 70%-owned by Schlumberger and 30% by Baker Hughes. Six years later Schlumberger bought Baker Hughes' stake to take full ownership.

The merger with Smith International in 2010 widened Schlumberger's lead as the world's largest oilfield services company in terms of revenue and market capitalization. Smith and M-I SWACO technologies and expertise complement Schlumberger's offerings, while benefitting from Schlumberger's large geographical footprint. The acquisition of Geoservices, also in 2010, expanded Schlumberger's products and services in mud logging, slickline and production surveillance operations.

Global expansion of Research and Development

Keeping ahead of competitors required substantial investment in cutting-edge research. In 1948, Doll was charged with establishing a new research center in Ridgefield, Connecticut - the Schlumberger-Doll Research Center. This provided the springboard for the technological breakthroughs that would define Schlumberger success in the second half of the 20th century. The Center, which still plays a significant role in the company's R&D activities, is now located in Cambridge, Massachusetts.

Schlumberger engineering center in Clamart, France was founded in 1965. The company's commitment to developing a global research network led to the opening of its Cambridge Research Center in England in 1983, focusing on drilling technology, fluids, seismic techniques, production logging and rock mechanics. The Fuchinobe engineering center in Japan was opened in 1985. In 1999 opened Schlumberger Stavanger Research Center in Norway, focusing on seismic image analysis and interpretation research. The opening of the Schlumberger Russia Technology Hub within campus of Gubkin Russian State University of Oil and Gas in 2004 reflected the growing importance of the Russian energy sector. In 2006, Schlumberger Dhahran Center for Carbonate Research in Saudi Arabia in focusing for the researches on carbonate reservoirs.

Schlumberger continues to build on its reputation for outstanding research through the geographical expansion of its R&D network. The 2010 opening of the new Brazil Research and Geoengineering Center in Rio de Janeiro reflected its desire to establish R&D facilities close to new hydrocarbons development areas, enabling the company to tap into new talent and tailor new products to specialized local conditions.

Schlumberger's efforts in transformation

Schlumberger today operates in over 85 countries. Since its foundation, Schlumberger have invested continuously in infrastructure and resources, creating a global deployment platform that is unmatched in the oil & gas industry. Schlumberger has maintained a strong commitment to recruiting and developing local talent everywhere it operates, creating both extensive local knowledge as well as deep and long-standing customer relationships. In addition, it has established Research, Engineering, and Manufacturing centers throughout the world, making sure they touch all operating environments and that they remain close to the regional challenges of its customers.

But new technology also demands many different inputs. Fundamental research, intrinsic development, adaptation of solutions from other industries, protection of intellectual property, and commercial timing all combine to lengthen the cycle and potentially retard the benefit. None of these are specific to the exploration and production industry.

In order to improve performance through improving technology development, deployment and delivery, Schlumberger implemented a new initiative since 2007. First, Schlumberger created an Engineering, Manufacturing and Sustaining organization to establish systems, processes and standards across its product development and manufacturing centers worldwide. This enables a stronger focus on design for reliability, manufacturability and maintenance, while manufacturing for zero defect. The method is centered on a system of Concurrent Lifecycle Management that represents a major evolution in the way Schlumberger works. The objectives of the method include faster commercialization of more reliable products, more efficient industrialization of innovative ideas, better coordinated development of enabling technologies and stronger operational support.

Today, Schlumberger has largely completed the transformation of the R&E organization by creating a unified global structure where engineering, manufacturing and field support work together closely, spanning centers and product lines, and re-defined and fully implemented a new product development operating system.

This new system, based on best practices from the leading engineering and manufacturing companies in the world, covers all aspects of the product development efforts including design methodologies, test and qualification principles, manufacturing techniques, as well as the capture and use of data from the field operations. These practices include a combination of LEAN and Six Sigma principles that have driven reliability and performance in high-technology industries such as automotive andaerospace. Its new product development system is focused on driving performance in three principal directions: shorten product development time; improve product reliability; and reduce the total cost of ownership for all of its products.

Since 2010, Schlumberger has been tracking the performance of 28 key technologies that have benefited from some of these new practices, with the average reliability among this group of technologies increasing by more than 250%. Still, the real impact on performance and results will be seeing in the coming years.

Recent initiative of open innovation and strategy in Japan

To sustain the position and the technology leader in coming decades, Schlumberger has been continuing the efforts in looking for new technology. As one of the efforts, Schlumberger supports external research in early-phase technologies and innovations that may produce breakthroughs to help sustain the world's oil supply for the coming decades. Some key challenges are:

¤ Finding new oil and gas reserves. Adding reserves is the top objective of the oil and gas industry.
¤ Increasing recovery from existing reservoirs. Many of the world's reservoirs produce less than one-third of the original oil in place. The rest is stuck in the pores of reservoir rocks or in regions of mobile oil that are bypassed by traditional methods of drilling and pumping. Doubling the oil

recovery factor of existing reservoirs at reasonable cost would dramatically alter the world's energy economy.

¤ Recovering hydrocarbons from unconventional resources. The hydrocarbon content of unconventional resources such as tar sands, oil shale, and methane hydrates is enormous, but difficult to exploit. New technologies and processes are needed to tap these resources on a large scale with an acceptable environmental footprint.

Schlumberger K.K. Center (SKK) was founded in 1985 to leverage the high technology from Japan and Far East. Since its creation, SKK has established its position in utilizing the advanced technology of Japanese industry in developing and providing reliable products, focusing on borehole acoustic measurements, optics and sensor products, and enabling technology. A series of measurement equipment such as Versatile Seismic Imager (VSI), Sonic Scanner, InSitu Fluid Analyzer (IFA), and SonicScope is manufactured in Japan, and shipped to Schlumberger locations worldwide, where the measurement service is provided to oil companies using this equipment.

Schlumberger has been seeking the opportunity to identify and acquire the technology seeds in early phase, so Schlumberger can commercialize a novel measurement service earlier than anybody else for helping oilfield industry and at the same time strengthen its market position as an oilfield service company. And Schlumberger believes the existence of a technology hub in Japan can bring the opportunity to identify a new technology early enough.

One of the successful developments of SKK collaborating with external parties was found in nanotechnology field. The technology seed with carbon nanotube (CNT) coming from Shinshu University was applied to the development of seal materials together with technology partners. One of the partners, Nissin Kogyo, had been working with Shinshu University on metal composite with CNT since 2003 to produce a new light but strong material. Through this collaboration, Nissin came up with a unique technology of dispersing CNT uniformly within metal and filed several patents on the methodology. Based on this base technology seed, Shinshu University and Nissin Kogyo decided to pursue the potential of CNT rubber composite technology, and formed a new combination of universities and firms to accelerate their project of CNT composite material development toward the commercialization of final products. Several manufacturing firms (e.g., Fukoku and Kowa Rubber contributed as molders in producing the rubber products). In this collaboration, several application firms participated in producing the final products using the rubber products (e.g., seal products such as O-rings) to take advantage of its superior performance, and SKK joined this efforts in 2005 for aiming to develop high temperature sealing products for oilfield application. This collaboration showed a good example of direct R&D networking with university, technology firm manufacturing firm and application firm to realize the faster commercialization of the product from technology seed from the university. This newly developed product was commercialized in 2011 and

is now being used in oilfield worldwide.

SKK decided to accelerate this efforts in 2013, and is now seeking further opportunities of collaborating with Japanese universities and industry.

Conclusion

The history of Schlumberger shows a continuous series of innovation, technology acquisition, and steady technology development. Collaboration with universities and various firms have different discipline is also being executed. This effort is also being carried out in Japan in leveraging the advanced technology and high quality.

On the other hand, there are many other cases where the new development, acquisition, or external collaboration did not work effectively. Through the recent effort in Japan, we would like to seek and establish the improved process of the technology development in coming years.

References

Oristaglio, Micheal, and A. Dorozynski (2009), “A Sixth Sense, The Life and Science of Henri-Georges Doll, Oilfield Pioneer and Inventor”, Overlook Duckworth, peter Mayer publishers, Inc.

Schlumberger Home Page (2013), “Our History”, www.slb.com/about/history.aspx

Gould, Andrew (2010), “Opportunities and Challenges in a Volatile Environment”, Schlumberger Executive Presentation, http://www.slb.com/news/presentations/2010/2010_0704_agould_iogcec.aspx

Kibsgaard, Paal (2013), “Kibsgaard Speaks at Barclays CEO Energy-Power Conference”, Schlumberger Executive presentation, http://www.slb.com/news/presentations/2013/2013_0912_pkibsgaard_barclays.aspx

Wang, Joyce (2012), “Schlumberger Innovation Partnering”, Ceantech Conference & Showcase 2012, http://www.techconnectworld.com/Cleantech2012/sym/cleantech_industry_applications.html

Yamate, Tsutomu (2013), “Current situation of oil and gas development technologies and expectations for cutting-edge Japanese technologies”, 2013 JOGMEC Techno Forum, http://techno-forum.jogmec.go.jp/program.html

Ito, M., Madhavan, R., Osawa, O., Noguchi, T., Ueki, H., Takeuchi, K., and Endo, M. (2012), Game changing technology with MWNT nanocomposites for HTHP and hostile environment sealing in enhancing oil recovery, SPE 156374 presented at the SPE International Oilfield Nanotechnology Conference, 12–14 June.

Endo, M., T.Noguchi, M.Ito, K.Takeuchi, T.Hayashi, Y.A.Kim, T.Wanibuchi, H.Jinnai, M.Terrones, and M.S.Dresselhaus (2008), “Extreme-Performance Rubber Nanocomposites for probing and Excavating Deep Oil Resources Using Multi-Walled Carbon Nanotubes”, Advanced Functional Materials 18, 3403

Endo, M., K. Takeuchi, T. Noguchi, Y. Asano, Y. A. Kim, T. Hayashi, H. Ueki, and S. Iinou (2010). "High Performance Rubber Sealant for Preventing Water Leaks" ACS, Ind. Eng. Chem. Res., 49 (20), 9798.

Osawa, O. (2012), “Study on the network at university-industry collaboration”, Japan Society for Science Policy and Research Management (JSSPRM), 2012 Annual Meeting, 2G15