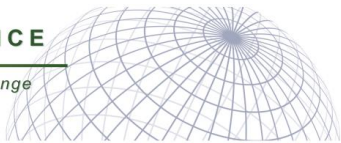
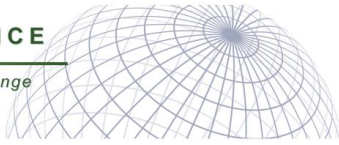


Lloyd's Register Energy Crossover Technologies



Lloyd's Register
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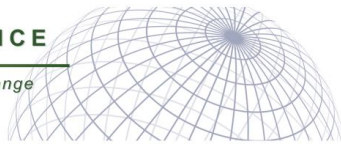


Crossover Technologies – Integrating 21st Century Silicon Valley Dynamics into the Global Hydrocarbons Industry

Roundtable Participants:

- John Wishart, President, Lloyd's Register Energy
 - Dr. Wafik B. Beydoun, Manager R&D Division E&P Directorate, ADNOC
 - Dr. William Kline, Drilling and Subsurface Manager, ExxonMobil Upstream Research Company
 - Dr. Alan Lumsden, Medical Director, Houston Methodist DeBakey Heart and Vascular Centre
 - Peter Richards, Vice President of Marketing & Communications, Lloyd's Register Energy
 - Dr. Joy Kelly, Vice President & Deputy General, Manager, General Engineering and Science Contract Group, Jacobs Technology
 - James McCallum, CEO & Chairman, LR Senergy
 - Bob Alford, Deputy Managing Director, Maersk Oil Middle East
 - Dr. Abdel Qader Abusafieh, Advisor, Mubadala – Aerospace
 - Ali Al Habshi, Senior Field Development Reservoir Manager, ZADCO
 - Nick Nooren, General Manager – Middle East, India & Africa Hub, Lloyd's Register Energy
 - Jamal Bafagih, Director, Houston Office, National U.S.-Arab Chamber of Commerce
 - George Yacoub, Acting Chief Information Officer, Abu Dhabi Health Services Company (SEHA)
 - Dr. Geoff Nesbitt, Head of Technology Strategy, Petrofac
 - Dr. Marc Durandeau, SVP Research & Development, Petroleum Institute
 - Stan Ramirez, Managing Director, Industrial Participation and Offsets, Lockheed Martin International
 - Geoffrey Akiki, Country Manager, GLOBALFOUNDRIES
 - Moderator: Sean Evers, Managing Partner, Gulf Intelligence
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Roundtable Host: John Wishart, President, Lloyd's Register Energy



John leads the Energy business of Lloyd's Register, responsible for worldwide operations as well as strategy and business development. He leads the organisation in ensuring that LR can help organisations comply with regulations and industry best practice so they can operate safely and productively.

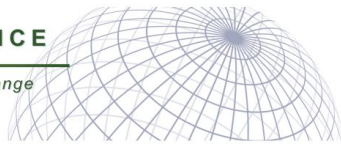
John joined the Lloyd's Register Group on December 1, 2011 from GL Noble Denton (GLND) where he held the position of group MD in 2008 and became President of GLND in January 2009 following the merger of ND with GL. In his role as

President, John was responsible for positioning and growing their oil and gas business from a broad range of heritage organisations within their Group.

In addition to his role at Lloyd's Register, John was appointed Chairman of the ITF in August 2014, a not for profit organisation, driving technology development and global collaboration within the oil and gas industry.

Throughout his career of over 30 years, John has shown great leadership and entrepreneurship in engineering and EPC (Engineering Procurement and Construction) operations. He began his career in technical, project and leadership roles in upstream and downstream sectors, first with John Brown and then with BP. He later joined Genesis Oil & Gas Consultants and moved to the US where he became responsible for the operational management of their offshore and deepwater engineering applications. His move to Technip in 1998 saw him rise to the position of President and CEO and in 2007 where he was accountable for strategy, growth, operations and financial performance of Technip's regional E&C business.

While John's career has been heavily focused in the oil and gas industry, he has had exposure to the nuclear industry and also in the power and renewable energy sectors. He has a strong industry network and is accustomed to developing business with a range of stakeholders including government, IOC's, NOC's and service companies around the world.



Crossover Technologies Whitepaper

The global oil industry should place greater efforts on changing its existing mindset and practices, and embrace the more flexible and open culture dominating Silicon Valley companies if it wants to retain its position at the cutting edge of 21st century innovation and technology, experts from the aerospace, healthcare and oil sectors said at a roundtable discussion hosted by Lloyd's Register Energy (LR Energy) in Abu Dhabi¹.

Creating a more Silicon Valley-type environment in which innovation can thrive would support the development and advancement of groundbreaking technologies in such crucial areas as sub-sea processing, remote monitoring, automation and autonomous intervention. It would also facilitate new types of collaborations with other industries to generate 'out-of-the-box' ideas and to identify crossover technologies that offer potential solutions to more than one industry.



To be sure, technology and innovation have always been at the heart of the global oil industry and there can be little doubt that it will continue to do so. But, according to experts participating in the LR Energy roundtable—aimed at stimulating a debate on how the oil industry can benefit from other industries—the sector is at a critical juncture.

On the one hand, it faces the challenge of having to cope with a generational shift and looming shortage of engineers which goes back to the 1980s oil glut that saw prices slump nearly 80-percent between 1980 and 1986, in turn causing a fall in company profits, leading the petroleum industry in the U.S. alone to slash its workforce by 60 percent, and tarnishing the sector's image as an employer of choice for decades to come.

On the other hand, the industry is under increasing pressure to innovate as it seeks to increase efficiencies and develop new hydrocarbon reservoirs in harsh environments like the Arctic, ultra-deep waters and difficult deposits such as shale oil.

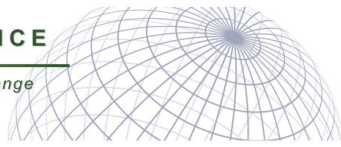
According to a survey carried out by LR Energy this year among senior industry executives and academics in 17 countries, three-quarters of respondents said that pressure to innovate has indeed intensified over the last two years, and only 25 percent of survey participants considered themselves to be early adopters of new technology².

But although the oil industry is eager to adopt change, it remains conservative due to the often large investments required, long project time frames, its operations in tight—and often severely punishing—regulatory environments, and—for listed international oil companies (IOCs)—the need to meet shareholder expectations.

While the industry's position is understandable, the resulting risk aversion in the sector, especially with regard to the deployment of new technologies, is a major brake on innovation. Indeed, most companies prefer to wait for new technology to be proven time and again before adopting it themselves, often foregoing on what may otherwise have turned out to be an early adopter advantage.

¹ Lloyd's Register Energy hosted the Breakfast Roundtable with 20 senior executives from the oil, healthcare and aerospace industries in Abu Dhabi on Nov. 11, 2014

² Source: <http://www.lr.org/en/energy/technology-and-innovation/technology-and-innovation-radar/>



This is particularly true at a time when the large, listed IOCs—unlike major Silicon Valley players—appear to receive less support from their shareholders for risky technology investments, and thus face greater constraints in their decision making, some roundtable participants said. Today, markets reward major oil companies for focus, as a result of which they are splitting their operations and selling off assets – in turn limiting their appetite for higher-risk investments into future technologies.

EXTRAORDINARY INNOVATION

The approach to innovation and technology development has been rather different among Silicon Valley companies, setting them apart from more conservative industries such as oil and gas.

“Product development cycles for many companies typically span just weeks, not months. But what really drives Silicon Valley companies is an emphasis on getting things done quickly rather than agonizing over every potential flaw,” consulting firm Accenture said in a report on what makes Silicon Valley companies tick published earlier this year³. “This story of extraordinary innovation and entrepreneurship has not been lost on other industries and the rest of the world.”



Silicon-Valley companies' attitude has been reflected in the rapid advancements in information and communication technology and big data capabilities over the past decade, which have led to the creation of tech giants such as Apple, Facebook and Google. Today, out of the world's top-5 most valuable companies, three are located in Silicon Valley, according to the latest FT Global 500 rankings⁴. Others such as electric-car maker Tesla Motors have chosen to operate out of Silicon Valley to focus on, for example, revolutionizing the automotive industry.

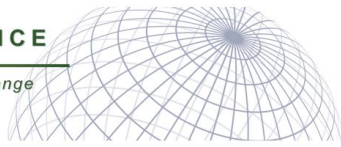
Many of the information and communication technologies originally invented in Silicon Valley have found their way into sectors such as healthcare, where new ‘smart’ and mobile solutions are being integrated into hospitals and clinics, providing patients with unprecedented levels of access to medical records and health information, supporting illness management through remote and mobile healthcare, and minimizing risk through real-time data sharing.

In the aerospace industry, the collection of large amounts of data from aircraft in real time allows for analyzing and establishing trends that help reduce plane downtimes and optimize maintenance.

In the oil sector, meanwhile, the application of new information and communication technologies has enabled the end-to-end connection of oil fields and allowed companies to harvest and analyze ever-larger amounts of data generated by people and assets along the industry's value chain in real time. Digital Oil Field (DOF) technology is being used to optimize reservoirs and production, as well as drilling and well completion among other processes. Across the board, advanced technologies and analytics tools speed up and allow for more accurate analysis and decision making, while also improving efficiencies and safety.

³ Source: <http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Outlook-California-dreaming-corporate-culture-Silicon-Valley.pdf>

⁴ Source: <http://im.ft-static.com/content/images/7097ad1a-fded-11e3-bd0e-00144feab7de.xls>



All these developments are part of a larger trend, which has seen digital technologies become essential to competitiveness in even the most traditional industrial segments. As companies are investing in digital capabilities, mobile solutions and analytics, transformative—often disruptive—technologies are emerging and fundamentally changing the way companies and individuals operate.

With digital technologies ubiquitous in today's oil industry and interconnectivity growing, there is also an increased recognition that sectors such as energy, medical, aerospace and automotive actually have a great deal in common.

In the medical space, for example, cardiovascular disciplines share the same fundamental objective of flow assurance as the oil and gas industries. Among the successful outcomes of collaboration between the two industries has been the visualization of well flow through a gravel pack resulting from a 3D model generated by an MRI machine of Houston's Methodist DeBakey Heart and Vascular Center.



Space agency NASA meanwhile is operating in frontier regions, just as the oil and gas industry, which means both have a common interest in optimizing the performance of robots in hostile environments.

In Brazil, aerospace group Embraer and energy giant Petrobras have teamed up to utilize their joint expertise in areas such as reliability and safety of critical systems. Additive manufacturing too is crossing over into oil and gas, with companies such as GE Oil & Gas and Halliburton using the technology to print fuel nozzles and parts for drilling among others.

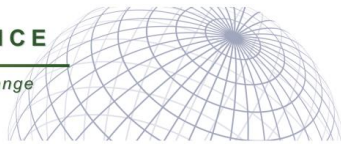
From automation to robotics, innovative technologies will without a doubt drive further change in the industry in coming years. According to LR Energy's Technology Radar report, 51 percent of all survey respondents expressed the view that automation will have the greatest impact on the sector by 2020, while 48 percent see subsea robotics, autonomous underwater vehicles, and other ultra-deep-water equipment as high-impact technologies that will go mainstream in the long term, after 2025⁵.

LOOKING AHEAD

With pressure to innovate increasing if the oil industry is to meet and overcome future targets and challenges, it will have to foster both fundamental and 'blue-sky' research to identify and develop cutting-edge technologies, and to pursue new types of collaborations with other industries to generate 'out-of-the-box' ideas and to identify crossover technologies that offer potential solutions and improvements.

This in turn will require breaking up existing, rigid corporate structures; supporting more risk-taking and entrepreneurial spirit; and providing venture capital-type funding and mentorship for startups, roundtable participants said.

At the same time, the industry will have to improve its often poor public image, which has long been viewed as an obstacle to attracting more of the brightest talent to the industry. This is of particular importance given that attracting talent from all types of backgrounds to the industry, including from



geology, mathematics, IT and analytics, will remain critical in the years to come. For these are the people who will drive innovation in future technologies.

Experts at the roundtable remained largely positive that the industry isn't necessarily constrained by a lack of talent. What's required, they argued, is to harness existing talent and provide it with space to innovate by establishing the right environment and type of platforms to collaborate between each other and with other industries, which in turn would also drive greater crossover technologies. Without greater commitment to developing more of a Silicon Valley mentality this may prove difficult, however.

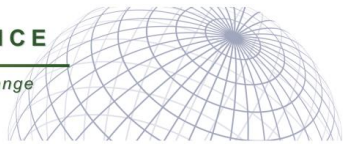
In short, the oil industry needs to create an eco-system that integrates 21st century Silicon Valley-type dynamics into a sector that operates very much along 20th century mindset, structures and processes. Failure to do so could hamper the industry's progress in the coming years and decades, limit its technological capabilities, and pave the way for non-traditional competitors to grab market share.

Those competitors may increasingly come from Silicon Valley or other non-traditional oil hubs. With big data sitting at the core of most industries going forward and Silicon Valley companies equipped with the infrastructure, capacity and expertise to handle ever larger data volumes, they are well positioned to make a foray into sectors such as energy, and potentially play a disruptive role.

In a first sign of what the future may hold, Google earlier this year spent \$3.2 billion on Nest Labs, the maker of digital thermostats and smoke detectors, giving it for the first time a foothold in the automation sector, where it will use its big data and analytics capabilities to compete with long-established players such as Honeywell, which also operates in the natural gas and refining industries.

But there are first signs that the industry's eco-system is beginning to change, at least in the U.S. Spurred by the breakthrough in drilling technology that has led to the shale boom, a new generation of young entrepreneurs is entering the sector, bringing with them different mindsets and practices, launching start-up companies, and raising funds through deals that resemble more Silicon Valley than Texas.

Dallas-based unconventional oil-focused E&P company PetroCore, for example, earlier this year raised \$100 million – having been set up only months earlier by 27-year old entrepreneur Mark Hiduke with three partners. Dozens of other start-ups have emerged in the sector as they seek to push the boundaries of unconventional hydrocarbons. This may just be the beginning of the kind of mentality change that many believe the 21st century oil industry needs.



Crossover Technologies Roundtable Discussion

Moderator:

This morning we are putting forward a fairly big idea question: "Crossover Technologies – How to Integrate 21st Century Silicon Valley Dynamics into the 20th Century Hydrocarbons Industry?". We're honored to be hosted today by Lloyd's Register Energy and it gives me great pleasure to introduce the President, John Wishart, to give us some opening comments.



John Wishart:

Lloyd's Register is a 200 year old group with deep roots in marine history. We were probably the first people to use data—our registers were a collection of data. At Lloyd's Register Energy our key role is to use deep knowledge and expertise to help our customers, whether they be operators, owners, regulators or suppliers, to make sure they're able to operate critical infrastructure to the highest levels of safety, reliability, sustainability, and most of all operational efficiency. And in setting that out, we've been looking at where we go in the future.

Technology is no longer an optional hobby - it sits at the heart of enabling business to move forward and to access challenging environments. We have only just started scratching at the surface of technology crossover - examples of our own would be our drillers working with our nuclear specialists and we've also come up with new ways of looking at BOP risk doing real-life monitoring of BOP operations; and it really wasn't as big a leap as we thought.

Mutual sharing of information, knowledge and technology is going to be a key enabler. There aren't many organizations left today who can really go it alone.

Moderator:

What's the 20-30 year outlook when we look at crossover technology?

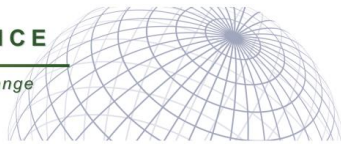
Gartner has reported that there's currently 10 billion devices connected and communicating to each other today in the world of the 'Internet of Things'. By 2020, this figure will be 50 billion. What does that mean? What does that amount of data do and who processes it? And who then owns it and is the power player? With 50% of petroleum engineers due to retire in the next decade, who's going to do all the brainpower work to bring new innovations and technologies to the industry?

I'd like to introduce Dr. William Kline, manager of ExxonMobil Upstream Research Company, in from Houston and ask where he sees that sense of time and change from a multitude of crossover and cooperation.



Dr. William Kline:

Our topic today is to ask how we can bring a Silicon Valley sensitivity and nimbleness to what we're doing in the energy industry. Let's compare results. In the last 30 years, the transformation within the whole Silicon Valley world has been staggering. When I went to college, we were putting



cards in mainframes; then we went through the whole PC revolution and now we all have 1 or 2 phones in our pockets and devices on our refrigerators. And who has done that? Mark Zuckerberg and the other 20-somethings have revolutionized the world.

What has the energy business done in that same period? I would stipulate that we have added over a trillion barrels to the world's endowment of commercially recoverable reserves; that's 25% of what has been discovered since the dawn of oil and gas in the 1850's and we've done it with staggering change as well.

I'm not the least worried that when my generation retires, that the new generation is going to carry on and be invested in discovery and the whole world of technology. And that's what gets us into outreach. When I think of the people that were worried whether we could drill at 60 degrees in Norway, what they didn't know is that we would have this galaxy of technology, directional technology, rotary steerable drilling technology- if you translate that, it is NASA rocket science turned upside down.

Here in Abu Dhabi, Exxon is drilling some of the world's longest completion intervals: long, thin tubes. How do we get out there? How do we measure the friction? That is exactly what Alan's doing as a vascular surgeon. And so when we look at being nimble and being ready for the future, nobody will ever know what the future will bring but we can be ready by embracing change across the spectrum.

Moderator:

Dr. Alan - you are Medical Director at Houston Methodist DeBakey Heart and Vascular Center. How would you judge the oil and gas industry is doing in its innovation posture, its need to change to become more Silicon Valley-like?

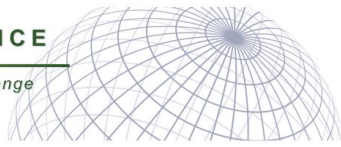


Dr. Alan Lumsden:

We worked with an oil company called Verdandi who were doing a case-based analysis of active drilling sites. They created logarithms and an interface for the driller to see whether the drill was getting in trouble. And they came to us because they wanted us to take a similar technology into our cardiovascular ICU to enable us to do real-time risk analysis. And in talking to them, one thing they said was, "We really like working with the physicians because you guys are so much more open to innovation and change". To be honest with you, I was very surprised to hear how prescriptive processes are in the oil and gas world, and how rigid and difficult it is to actually change it.

The industry needs to boast about the awesome technology that it has and what it is doing, and not be apologetic. Somehow, that message needs to get out there better, if only from the point of view of attracting the next generation of petroleum engineers.

You mentioned Silicon Valley and data - my big concern going forward is data security. In the healthcare world, we live in fear of exposing patients' data. The idea of having 50 billion devices that are connected carries massive security problems and control problems that are associated with it.

**Moderator:**

It also gives a lot of power to whoever is doing the cyber security management and the knowledge and data associated with that.

Dr. Joy Kelly - if I can bring you into the conversation. You are Vice President, Deputy General Manager at Jacobs Technology, essentially aerospace. We have seen in recent times, big cutbacks in the NASA universe and a lot of those brains have come into the oil and gas industry. Is the oil and gas industry winning in the brain battle or aeronautics?

**Dr. Joy Kelly:**

The oil and gas industry at large has a lot more money than aerospace. And from my personal experience with folks leaving our business because of the downturn and going to oil and gas, they love the new challenge. Robotics and automation is a very attractive element that's bringing people into the oil and gas industry. But the energy sector is also giving us new business and bridging that collaboration. So I think there's a lot of opportunity on both sides to be gained.

Moderator:

I'd like to bring in Dr. Wafik Beydoun who is leading ADNOC's push into R&D and innovation. From a national oil company point of view, one of the findings of the Lloyd's Register Energy report was that NOCs are becoming the dominant spenders in R&D and leading the charge there. What's at stake if the oil and gas industry doesn't take a Silicon Valley kind of risk leap forward, positioning innovation and technology at the center of the priority?

Dr. Wafik Beydoun:

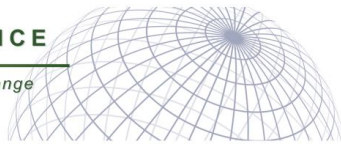
About a year and a half ago, ADNOC decided to establish an R&D organization. It has big ambitions – it is driven by ADNOC objectives to increase the capacity of production to 3.5 million barrels per day by 2017 from the current 2.8 million, and the aspiration to recover 70% of the oil in place (right now, we are at about 35%- 40%). There is no way to achieve these objectives without developing and/or implementing technological innovations adapted/customized to our fields.

Moderator:

In one sense, you could say that is fanciful thinking, but you might also say it's very Kennedy-like, putting a very big vision out there. Maybe it's something that the oil industry needs to do more of. On the news this morning, Google announced it's just taken a 60-year lease on a property in San Francisco for \$1 billion to get into the aerospace industry - big idea, but you have to commend them for that.

**Dr. Wafik Beydoun:**

Yes - so we're in that spirit now of establishing strategic partnerships for R&D over the next 5 years. One good thing about only starting now is that we've seen how other R&D organizations were set up, some of the lessons learned, so we are hopefully adapting the best type of framework and also focusing on hiring the right people to work on the relevant problems.

**Dr. William Kline:**

I think this is an excellent example of what we've been talking about. ADNOC has a very effective and innovative organization and, even without R&D, is continuing to develop the resources here. But there is a difference between development and discovery. Development is getting better every day. But those leaps we are talking about are discovery. And I think that's the reason why the business, not the academics, said, "We need R&D because we're looking for a discovery." Discovery doesn't come by doing things the same way or talking to each other. It's reaching outside, which are the partnerships that are being established.

Dr. Alan Lumsden:

Let me just jump in on what Bill's saying. I talk to surgeons, I talk to cardiologists; 99% of the way they've been trained is exactly the same as the way I've been trained. They are predetermined within the boundaries of the thought processes for this gradual evolution, these incremental changes which are going to occur.

That is one of the advantages of working with people like Bill and Joy - they're trying to place a rocket or a drill on a target, using imaging and navigation. Well, that's really what I do on a daily basis. But unlike us, they come to the challenge with no preconceived notions of what you can do inside the body. And that's where the incremental discovery-type change can be the opportunity. I suspect that if you're a petroleum engineer, most people also go through the same training processes and are not exposed to people who think just a little bit differently.

Moderator:

I suppose that's the fundamental difference between the center of the energy world such as Houston which is an evolutionary place, and Silicon Valley which is revolutionary.

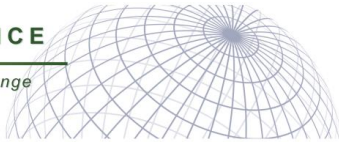
**Geoffrey Akiki:**

I've been in Silicon Valley for 32 years and every 3 years, we quadruple our density. I've gone through 4 impossible walls when we've said, "It can't be done. No way. We're gonna hit the wall." But we continue to go through them - it's this mindset of do or die and it's a worldwide industry where if you miss a beat, you're done. That's the Silicon Valley dynamic.

Electronics are everywhere now - big data. My last job at IBM was selling supercomputers to do seismic processing; data analysis of the equations you guys all need for the salt domes, as well as the visualizations of things to make it more productive. The energy industry has been using Silicon Valley tools and there are some forward-looking people, like the ExxonMobils of the world, who are leaders and others will start getting on board and mold around that.

Energy Industry Executive:

I am from a solar energy company from Silicon Valley originally and we produce solar energy for enhanced oil recovery; we inject steam into heavy oil reservoirs using solar energy instead of burning gas. Most of the technology is developed in Silicon Valley.



I've got 20 years in Schlumberger, so I come from the traditional way that the oil industry has developed technology through the service industry.

Most field developments I've worked on from discovery to first oil may be 5 years, but then the field development probably goes on for another 10 years and then produces for 30 or 40 years. The amount of capital that flows into the development in that time is huge and on a completely different scale to Silicon Valley. So you have this mismatch in time - you start the field development in one era of technology and a few years later, the technology industry has advanced and you have a whole new set of options - so all this has to be incorporated in planning at the outset.

Moderator:

It seems that the energy sector is confined by CapEx and ROI on capital over the long term. It doesn't have that sort of freedom to leap into the revolutionary space that Silicon Valley has.

Energy Industry Executive:

To really be at the cutting edge of technology, you have to start a project not knowing what the answer is but knowing that it will come from somewhere. And people aren't willing to do that generally.

Moderator:

Like Google buying up robotic firms -they've no idea where it's going to take them but they're going for it.

I'd like to bring in James McCallum, CEO and Chairman of LR Senergy - we're looking at a world of big data, sensors on everything, 50 billion devices talking to each other, the declining brainpower in the oil and gas space. So those who control the processing of data and the ability to capture it and make intelligent analysis out of it, will be the power players.

It doesn't look like that is ever going to be Houston, so is the survival of the industry in question in this context? James - can you paint a road map for us in which Google doesn't take over this industry?

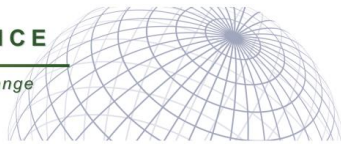


James McCallum:

I gave a demonstration of a piece of technology at LR's Global Leadership Summit the other day. A company which actually raised \$200,000 on Kickstarter two years ago and recently sold to

Microsoft for the same market capitalization value of Lloyd's Register - and there's 260 years between them. It took them 18 months to create a company with that kind of value. So is it so radically out of order to think that somebody like Elon Musk might take over ExxonMobil? I think not.

I do believe that the oil and gas industry will continue to exist and continue to occupy the principal space in the supply of energy. As a consequence of that, it will play an incredibly important role in history as the pivotal industrial sector for global economic



stability. That said, despite our industry being dominated by very, very clever people, we have allowed ourselves not to be as innovative as we would actually like to be. So why is that?

I don't think it is because we are focused simply on cost efficiency. I think the industry is too humble about its achievements. If we could simply apply the skill sets and the knowledge that we actually have now, to the digital and big data economy, we would radically influence it's development.

Instead, we continue to allow our companies to build up procurement practices that actually take us away from collaboratively engaging with our supply chains, which Silicon Valley is much more successful at. And if somebody has a great idea, by the time the actual technology is applied, it is frequently years later. We need to enact a massive change in our processes, in the way we think, the way we behave, if we are to achieve best practice.

Moderator:

What if we don't? What's at stake?

James McCallum:

I think we will see history repeat itself. In the short term, we will have redundancies across the industry and if the oil price continues to move downwards, we will see investment into R&D stall. Then, as the oil price comes back, we will go back into a cycle of increased production and recruitment again. And we will have missed an unbelievable opportunity to have learned from our mistakes of the past, and position our industry as a technology leader that sits alongside industries in Silicon Valley, known for its innovation.

The big question is, are we just old dogs who can't learn new tricks?



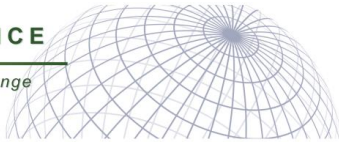
Dr. Geoff Nesbitt:

I don't believe we are old dogs. It's about risk and how we manage that. It's the smaller companies that can take these bold steps because they can manage risk better. They're not publicly listed and so not exposed to the pressures of shareholders and financial analysts. The pharma community is an example of one industry that was under siege because of the risks of lawsuits, but thankfully, for the most part, we've got over that and we're still developing medicines that are terrifically risky at the moment, but hold the promise of a new generation of drugs.

I see a similar trend in most industries - small companies, startups, the Kickstarter example that James gave us, are able to take that chance, put the money at risk, work 24/7, and attract capital. And I think if there's optimism in the industry, it will come from these small companies that will drive that growth forward.

Moderator:

Stan - I'd like to bring you in. We think of Lockheed Martin as a very traditional defense industry company, but you have made some leaps into other opportunities such as data and software technology. How has that been achieved and how would you see the oil and gas industry doing in that same regard, given your experience?

**Stan Ramirez:**

I think the fears that you're describing here in the oil and gas industry have been resonating in the aerospace industry as well. There's this looming gap of manpower that's gonna happen because of a dearth of science and engineering people available. How are we going to bridge that gap? There are a number of times when the solution comes from outside our core group of engineers and scientists. So should we harness it or let it loose? To your question about how challenges in entering new areas like IT, we are now looking at energy and a couple of other areas that differ from what we traditionally are known for. It hasn't come

without challenges; it takes some time and some effort by visionaries within the corporation to say, "Look, it's time to rethink our approach to some of these things." So while it is often a painful process, I do believe we're not alone.

Moderator:

And leveraging the skill sets inside so that as new industry or opportunities emerge, you're seeing the ability to use those.

Stan Ramirez:

I think the biggest thing that we should try to do more of is apply risk management templates to how we evaluate new technology enterprises that are coming in and say, "Look, the risk was predictable, it was understandable" Emerging companies use this more freely because it's

what they had to do to become successful. Don't dampen this risk taking, in fact, ask "How do I exploit that and employ it in what I'm trying to do?". We need to learn better how to again apply that way of thinking as I think the oil and gas industry is in the same position, in that the ability has kind of gotten lost in the fog of age (time), if you will. We've got to pull it back out and use it.

Dr. Alan Lumsden:

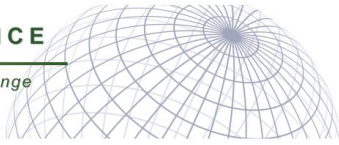
Sometimes the internal machinery of a company can't visualize the new technology that's coming in and they think it's better to leave it outside. But then what happens is that it grows into a half billion dollar business, and they end up buying it and bringing it in internally. So how we manage the new technology evolution inside big companies is the real challenge.

Dr. Joy Kelly:

And that's what a lot of companies are doing now. The Shells and the ExxonMobils and a lot of companies have a VC arm - they're funding these small startups.

Geoffrey Akiki:

I worked in the old IBM and the new IBM. The old IBM was very structured - kill the antibodies that come to try and do something new. When IBM went through its crisis, it decided to fund ideas being suggested internally; a change in mindset that all of a sudden made it more entrepreneurial and unleashed a whole new way of doing things.

**John Wishart:**

The restriction seems to be the fact that we're locked into a business model that's liable to shareholders and it's that environment that's constraining how we operate. The beauty with startups and small companies is that just do anything and everything, driven by a desire to change the world. So how do we educate shareholders that they may be inadvertently killing the business they're looking to get the long-term investment from?

**Bob Alford:**

The market right now is actually rewarding oil companies for focus and splitting it up.

I'm trying to integrate in carbon capture from the rocket industry down into EOR, and we're finding the integration challenge is one of the biggest things. If you look at our industry right now, a lot of these companies, such as Marathon and even Oxy, are splitting their company across geographical lines. And that's being rewarded in the stock market.

How do we take crossovers from different industries? How do we use that technology? It's very easy to license the technology into oil and gas - it's a win-win opportunity that we've been really overlooking.

James McCallum:

The same public markets which reward oil & gas companies for being conservative, are the ones that award Google and other tech companies innovative and groundbreaking. We have allowed ourselves to be positioned into that space by the markets because that's the way we have historically operated, so we need to break that paradigm.

**Nick Nooren:**

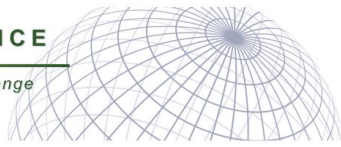
If you look at the shale industry, shale gas, it's revolutionized our drilling industry. It's no longer about thousands of hours or number of months in order to be drilling your well; it's about doing many of them and in a very short period. So this has actually completely revolutionized the whole supply chain that's required for that and changed the mentality of the drilling sector.

Energy Industry Executive:

There's another meaningful innovation that I think we haven't touched on yet. If you take the medical industry, it has a golden ticket which is IP. If you have a drug, no one else can make it for 17 years, guaranteed.

If you're in the IT industry, in Silicon Valley, you can go faster than anyone else, you're ahead and then you're fine.

In the oil industry, patents aren't as valuable because we're trying to operate in 100 different countries and often there's not a solid IP background in some of those big markets. To navigate and create value of technology in the oil and gas industry, you have to use a combination of patents which is not easy and it also means there's a lot of things under the table.



You then end up with an integrated delivery method like Schlumberger or Halliburton where you've got an office in every country and you can only really distribute your technology because of scale. This is a fundamental issue - we either need to be more rigorous with IP or we need to be getting it to go faster.

John Wishart:

We have really talented people in this industry but we don't create an environment to collaborate. There's some very interesting paradigm shifts we need to make. If we're continually driven by market conditions and our shareholders, this will kill the business. One of the problems of the human resource crisis today is not because of now; it's because of the various down cycles 10 and 20 years ago which made employees move to different industries where they felt more appreciated or secure. I think some things we can control, but the market is what worries me as I'm not entirely sure how we change that.

Moderator:

Taking the image of an industry and how it's perceived by Wall Street - if we look at aeronautics, it would appear to me that the shine's gone off that a little bit - not quite the image that it had?

What about the privatization of aerospace? NASA has lost a lot of its funding from the U.S. government and we now have people like Elon Musk and Google going into aerospace. Do you see Silicon Valley as a possible "threat" to your business model?

**Dr. Abdel Qader Abusafieh:**

We don't really see it as threat. In fact, when I look at emerging trends like analytics and data utilization, I see that as an enabler for us in the aerospace industry. As safety remains a primary driver for aircraft design in terms of risk management, this is a huge opportunity to enable tracking flight safety data to predict problems before they occur. New aircrafts are already being designed with integrated "health monitoring systems" that rely on collecting real-life data from critical components (such as engines and wing structures) during operations. This approach could not be implemented on the

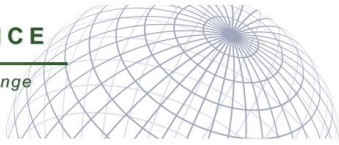
last generation of commercial aircrafts because of limitations related to magnitude of data that need to be collected, analyzed, and validated for reliable decision making.

On a different dimension, I see different industries are coming together in terms developing and utilizing new technology platforms such as data management, automation, and advanced materials. I think we are realizing more and more the value of utilizing innovations in adjacent industries to help our own even though the end applications are different.

When you boil it down to the fundamental level, we may be trying to solve the same problems for different reasons.

Dr. Joy Kelly:

I also think companies like Google and SpaceX are going to help NASA, because as soon as we get commercial space flight, we will be in a totally different league than we are today and that opens up opportunities for many of us.

**Dr. Marc Durandau:**

At the Petroleum Institute, we are already collaborating with different systems outside. We are looking at very small sensors of about 1 mm which can be injected to trace reservoirs and give back data. We are looking at how to analyze all this data. Of course, this is not our core business so we are looking for partners. The oil industry is already moving in this direction of collaboration in order to improve and enrich enhanced recovery methods. We will always need new products to improve oil recovery and we have to develop relationships with smaller specialised companies in order to innovate in this direction. This trend has already been set.

George Yacoub:

I'm the CIO for SEHA. I'm the IT guy in healthcare, the outsider. What I have learned over the years is that we need to disrupt the way we think and the way we do business and come up with new solutions - if we don't, somebody else will. This is what is going to drive all industries to collaborate and benefit from each other's mistakes. Oil and gas and aerospace are somewhat old industries. They need to be disrupted by somebody else.



I'll give you an example; in the early 1980s Kodak was the largest photo company and they invented a digital picture but they didn't know what to do with it. A few years later, they filed for bankruptcy and now look at the other companies that have gone into the digital business.

From a technology adoption point of view, oil and gas has done marvelous things over the years. We all know that we need energy and we will continue to need energy in various forms. In 10 or 15 years, some companies may cease to exist but others, who may not know it themselves yet, will have pushed to think in a disruptive way as innovators. Demand will push us to change the way we do business and ultimately give us what we're looking for.

Dr. William Kline:

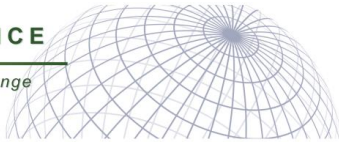
What each industry needs is a line of sight in its strategy. The energy industry has to fulfill 3% per year growth in world energy demand; in Alan's business it's that much of the world does not have healthcare and he has to get there; in Joy's business, the peak of expenditure is when we had a national line of sight to go to the moon and new ones will always form etc.

Moderator:

Dr. Alan, your closing thoughts.

Dr. Alan Lumsden:

NASA published a thing called 'Spinoffs' and it was all about what came out of the aerospace industry that helped your refrigerator, kept your garbage get cleaned, got your packages shipped with FedEx etc. And there are innumerable examples in the oil and gas business that are just like that. That would be a tremendous story to tell - getting that message out on how oil and gas can help us in the cardiovascular world, how it helps you guys sitting around the



table, that's part of the story that you need to package and help you with your image. Because you do have a great story to tell, you're just not telling it.

James McCallum:

We do have a line of sight and incredible heritage. So who is it and how is it that we convert all of that into incredible opportunity? We need leaders who can take the current situation and convert it in a way that the next person hasn't even imagined yet. I'm absolutely certain that there are individuals who will lead the energy industry in 10 years' time particularly around the liberation of data that we cannot yet imagine, and if that is Elon Musk, so be it.

Moderator:

I'd like to give the floor to John, our host, for some closing comments.

John Wishart:

We've got real talent coming into the industry so I don't think the who is really a challenge. In fact, I'm pretty sure the new generation is gonna sweep me and the rest of my team out pretty quickly.

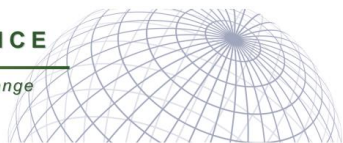
The what - I think we are an innovative industry and we've got a lot to be proud of but the story is one that's not being told too well.

The bit I struggle with is the how - this is our challenge. We talk about collaboration: it's interesting talking to our young grads about this as it's a much freer form of transfer of information than our generation employs, which is still bound by quite rigid traditions in its procurement processes, contracts or whatever. That to me is something that I think we need to change to really blast open the platform for innovation and change. And that is going to take great leadership.



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