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How Shell is Shifting its Engineering Mindset through MIT's Architecture and Systems Engineering Online Program

The oil bust of 2014, which saw prices drop by 40%, brought more to the oil and gas industry than just lower profits. For one company, Royal Dutch Shell (Shell), it ushered in a comprehensive shift in thinking about the development approach for new capital projects and technology. Taking cues from the aerospace and automotive industries, the company put systems engineering programs in place to improve the efficiency of its global capital and research projects, not only to survive in a low oil price environment, but to enable their vision of providing more and cleaner energy to the world.

Since 2016, a part of Shell's efficiency improvement plans has been its participation in the MIT four-course program, "Architecture and Systems Engineering: Models and Methods to Manage Complex Systems." For close to 20 years, Shell has collaborated with MIT on a variety of energy research projects and in 2010 it became a founding member of the MIT Energy Initiative (MITEI), a multidisciplinary initiative dedicated to transforming global energy systems for a low-carbon future in collaboration with industry and government.

PRICE DROPS, HARSHER OPERATIONAL REALITIES, AND ENERGY TRANSITION

Beginning in mid-June 2014, crude oil prices dropped about 40 percent from $100-115 a barrel to about $70 per barrel by year-end and continued to drop in subsequent years to below $30 a barrel. As a result, lingering inefficiencies were revealed. Over the years, trends had resulted in increasing project specifications, mounting project-management costs, and a preference for the made-to-order over the tried-and-tested. These factors were in effect before the low oil price, but now the true extent of their negative impact on the competitiveness of the oil and gas industry became apparent. The same was true for Shell, which at the time was spending more than $25 billion/year on new capital expenditures, which included development of new projects and technology.

Shell's company purpose is to power progress together by providing more and cleaner energy solutions. Harry Brekelmans, Shell's global Project and Technology Director, has very publicly embraced the company's commitment to the 'energy transition', expanding the scope of Shell's Business from reliance on solely fossil fuels to including renewable sources and implement-ing gas/carbon capture and storage systems. (He has given several major speeches on the topic, including one at MIT in 2017). Innovation and namely digitalization would be key to the transition.

As these influences around capital efficiency and energy transition have come together at Shell, so has the recognition that systems engineering practices could help the company contribute to the energy transition and improve the way it operates its businesses and technology development. "In order to deliver on our company purpose we needed to be as cost competitive as possible and efficient with our capital expenditure. This would enable us to invest in

expanding our New Energies Business, as well as ensure our new projects and existing facilities provide this increased and cleaner energy. Ensuring the way we design and build our projects and upgrade our facilities through efficient systems engineering practices will be crucial in our Energy Transition journey. " says James Haug, General Manager of Systems Engineering at Shell.

In the spirit of Powering Progress Together, in 2016, Shell along with BP and several major industry contractors and suppliers formed an oil and gas working group within the International Council on Systems Engineering (INCOSE). Chevron also joined the group and is now a co-chair. The group's goal is to develop the work processes, tools, and competencies to mature systems engineering thinking and ways of working in the energy industry.

In-house, Shell's commitment to improving its project efficiency and expediting the energy transition with systems engineering includes the MIT program. The company enrolled its first cohort of engineers into the MIT program in 2016 and other groups from Amsterdam, Houston, Cambridge (USA), and Bangalore have completed the four-month program and continue to enroll each time it is offered.

FULFILLING THE NEED FOR A HIGH-CALIBER TRAINING

"We want to develop a common understanding and vocabulary and teach that commonality to others," says David Kordonowy, Systems Engineering Expert, whose job is to develop systems engineering practices to increase the value of the technology Shell is developing. Kordonowy, an MIT alum with a degree in mechanical engineering, advocated for the MIT program at Shell and is currently enrolled in the program himself.

"Shell is focused on the successful system, not just the technically correct one," he says. "That means we need to focus on the commercial aspect of making something successful, not just whether it can be done." To that end, Kordonowy and his colleagues credit the MIT program with providing a high-caliber

training program that helps all stakeholders in a project or program. Specifically, he finds the course-work has helped team members focus on the problem definition up front and discuss potential directions and alternatives. “It gets all people involved to understand the vocabulary of systems engineering in their work.”

To date, about 30 Shell employees have completed or are currently enrolled in the MIT program. This includes the Innovation Excellence group within the company’s technology organization, a team committed to enabling researchers and technologists to realize the impact from their technologies. A second group is from Shell TechWorks, which looks at problems and challenges Shell faces with new and innovative solutions from typically outside the industry. A third set that has taken the course is from the Capital Projects group, including several from James Haug’s team.

“We are trying to use and have systems thinking imbue all of our technology centers in Houston, Bangalore, Cambridge (USA), and Amsterdam to improve the development of new technologies,” Kordonowy says. Shell typically has a portfolio of projects organized thematically around a technology, asset, or business. The MIT program has helped organize the flow of projects from an integrated perspective, including outside vendors and its commercial potential. “This has helped shift our understanding of commerciality of projects, and allowed us to concentrate on the ones with the best commercial potential rather than just technically implementing them because we can.”

SHELL TECHWORKS AN EARLY ADOPTER

To expedite the introduction of systems engineering best practices into Shell’s development programs, the company is relying on its Shell TechWorks innovation

center based in Cambridge (USA), and is currently operated out of rented space on the MIT campus. As a technology development and deployment organization, Shell TechWork’s mission is to leverage knowledge from other technology industries to the oil and gas industry. “We leverage systems engineering extensively to ensure we work on the right problems and find the right solutions,” says Amedeo Conti, Head of Systems at Shell TechWorks, who manages the organization’s systems engineering groups. Conti was one of the first Shell employees to go through MIT’s “Architecture and Systems Engineering” online program.

The organization was one of the earliest parts of Shell to pursue SE practices. The MIT program was brought in to educate those charged with implementing SE. “I found that the certificate program brought us all a common vocabulary in systems engineering,” Conti says. He also came to appreciate that systems engineering and model-based system engineering can be used as a communication tool. “When a system is complex like some of those we deal with, it is very difficult to get a common level of understanding of a

system between the CEO of a company and the super-expert PhD in the mechanical engineering department," Conti explains. "The program provided that connection and the tools, so that everyone has a common understanding of the bigger picture. I think that is extremely powerful since the reason we are using these tools is to manage the complexity of incredibly large systems."

Conti credits the program with helping him and his engineers help their customers within the larger Shell technology organization visualize and understand the complexity of their own systems. "Bringing systems engineering as a way to reconcile all of that knowledge into a common vision is extremely impactful," he says. "Once everyone understands and is in agreement how the system works, it is much easier to discuss what would be even better, what could be improved." And when the project moves to a solutions phase, he finds everyone is much more in agreement about the direction. Systems engineering provides the framework to advance in the development process in an orderly fashion by rationally managing requirements, interfaces, designs and risks.

BOOSTING EFFICIENCY OF CAPITAL PROJECTS

In the energy industry, the conceptual design work for capital projects is usually completed in-house, but the detail design work is customarily handed off to an engineering and construction contractor (EPC). In addition, when building a new facility, most of the engineering is predicated on a large range of requirements from different sources, including Shell's design standards, the EPCs standards, and global and local codes and standards. "There is the whole process of mashing all those requirements with a contractor to determine what you hand-off as the actual requirements and build," Haug explains. What we saw in the last couple of decades is that process has become increasingly complex, especially as the number of requirements and stakeholders increased. "That resulted in increased project costs, as we were sorting through complex requirements that were often ambiguously written and needed significant time to sort and interpret," he says. Applying requirements management to efficiently and effectively determine the right requirements for each project will be a key differentiator.

The systems engineering environment is also seen as a key enabler for automated design capabilities. The goal is to shorten the cycle between selecting requirements and the final design configuration. For the past three years, Shell has been introducing systems engineering within the company, starting with an overhaul of Shell's requirements management system. It is now looking to lay the groundwork creating the ties between the requirements, the 3D, 4D, 5D models[1] used to design the project, and modeling how the project will be constructed."

With the requirements management aspects of Systems Engineering in place, the mission is to tie this with the rest of the Digital ecosystem to make their projects more efficient. Says Haug, "That's the journey we are on now – to be a leader in our industry and apply systems engineering to specific projects coming through our development and capital projects funnel."

[1] 5D= 3D geometry plus time (schedule constraints) and cost