Going Digital

The New Normal in Oil & Gas

Schnitger
Corporation

The oil and gas world came crashing down in 2014, when the price per barrel of oil dropped from around $100 to $50 by year's end. Oil and gas majors canceled projects and slashed their capital budgets. In turn, these cuts rippled through the industry, leading to consolidation and restructuring.

In such difficult market conditions, companies either retrench and hope the downturn ends soon, or retool and look for new opportunities. In this paper, we'll look at how three companies took control by growing their skills, shifting to new types of projects, and using technology to become even more productive.

EPCs and owners benefit from data environments that connect design, engineering and asset information to build a complete view of an oil and gas asset. Data from many internal and external sources combine to create a digital twin of the physical asset. At a more granular level, structural engineers can take advantage of new scalable, simultaneous, cloud-based analysis tools and Web-based visualization capabilities to better understand, compare and communicate design scenarios. These technologies allow engineers to leverage their design expertise to perform parametric studies and investigate many design alternatives in roughly the time it takes to consider a single design.

In offshore, Bentley Systems' SACS enables engineers to predict structural performance. Engineering teams can automate workflows for routine and specialized analyses — essential when bringing new engineers up to speed and looking for consistency across projects. SACS includes nonlinear structural analysis and dynamic response analysis due to environmental loads, impact effects, and severe accidental loading, among other types of failure prediction.

Much of the activity in offshore today is platform life extension, decommissioning and removal. Since the majority of the world's offshore platforms are initially designed using SACS, and SACS is then typically used every 5 years to recertify platforms, it is natural to use SACS in planning and simulating these activities late in a platform's life. SACS has been enhanced to allow engineering teams to plan how the jacket and topsides structures will be subdivided into pieces for removal since, in general, it is not possible to remove them in a single lift. Planning progressive cutting and lifting of a platform's constituent parts is a complex and safety-critical process. The latest release of SACS includes specific functions for automatically dividing the structure into zones, with dynamic feedback on the weight and lifting requirements for each zone.

Whether you're working on new builds or end-of-life projects, it's no longer enough to be the best at the analysis itself. Owners and EPCs realize the benefits of a digital strategy where they unify data and processes during design, engineering, handover, operations and decommissioning, retaining that intellectual property and using it to make the next project more successful. Interrogating that data store leads to a deep understanding of what worked and what didn't. Going Digital is about harnessing that data and creating a learning organization that can thrive in any business climate.

Applying Deep Expertise to a New Niche

Sometimes you need to look outside your traditional niche to find new opportunities. Keystone Engineering did just that when project work dried up in its traditional oil and gas client base, and created a vibrant new business. Their offshore oil and gas expertise led them to bring jacket structures to the US offshore wind farm market.

Look out the window as you land in Brussels, Copenhagen, Amsterdam or many other coastal European cities, and you'll see offshore wind turbines marching into the distance. In 2015 alone, more than 400 new turbines added over 3000 megawatts of new offshore wind power capacity to the region's power grid. Why? Because Europe has come to see wind energy as a reliable and affordable energy source that also contributes to the region's energy security.

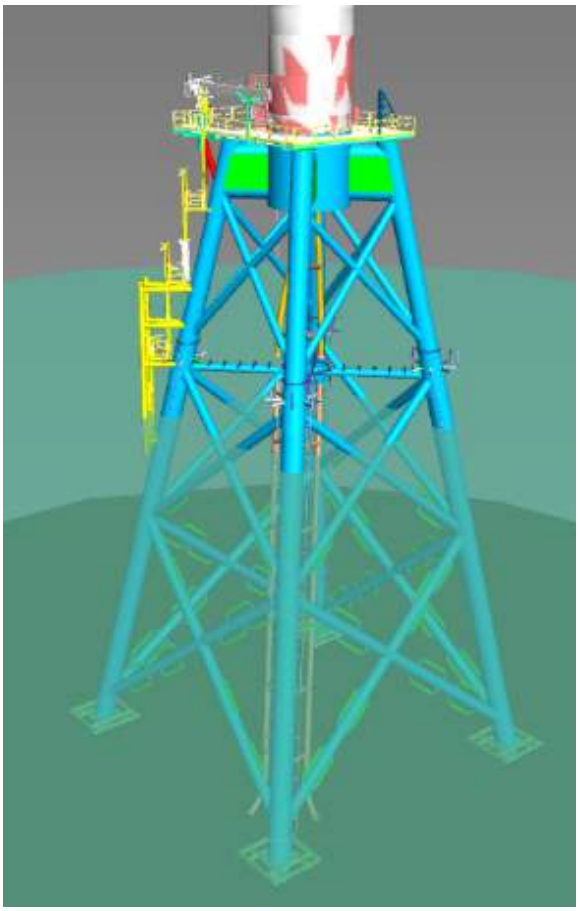
Offshore wind hasn't caught on in the US because, in general, the relatively low price of electricity doesn't warrant its cost, and because of community opposition. But that's slowly changing. Block Island, off the coast of the New England, pays a 400% premium for its power, which historically came from conventional sources on the mainland. Deepwater Wind, an offshore wind developer, secured permits to place a wind farm near Block Island to supply more cost-effective power to the island's residences and businesses—and is changing the perception of offshore wind in the US.

Deepwater Wind selected Alstom (now General Electric, GE) to supply the turbines and Keystone Engineering to design the platforms. Zachary Finucane, Keystone Project Manager, says that the project consists of five, GE Haliade 150 six-megawatt offshore wind turbines, atop towers that are 600 feet tall when the rotating blade is vertical. Each blade is 240 feet long and will hit rotating speeds of 200 miles per hour.

Mr. Finucane explains that wind turbines are dynamic systems that impart complex loads onto their support structures. The wind and blades create aerodynamic loads while the wind and waves create hydrodynamic loads on the sup-

porting jacket structure. Gathering, managing and balancing the loads was difficult. Keystone worked with GE to model the interfaces between their respective structures, combining DNV GL's Bladed (a wind turbine modeling tool) for the turbine-related loads with SACS for the foundation and sub-structure.

Using a jacket foundation rather than the more typical European monopile enabled Keystone to create a jacket that's 15% lighter, reducing the cost of steel required for the wind farm. This jacket can also be installed in deeper water, such as those off the coast of New England, and can operate in a larger weather window.



The wind farm's offshore placement poses design challenges that aren't seen in onshore installations. Onshore turbines must be safe during control faults and storm winds. Offshore platforms face significant fatigue due to wave loading and risk of vessel strikes. To address these challenges, Keystone used SACS to perform fully coupled hydrodynamic/aerodynamic analyses, and produced an innovative design based on proven offshore oil platform concepts that is hurricane- and vessel-proof.

Mr. Finucane's team modeled 25 load cases, including normal operating, storm, start-up, shut down, fault, maintenance and installation; with 8 wind directions at speeds ranging from 2 meters per second to 58 meters per second; and waves up to 19 meters high. The team performed 2,334 simulations at 30,000,000 time steps. This took Keystone's five, 24-core computers a total of 10 days, running 24 hours per day.

In addition to analyzing the viability of the design, the SACS/BLADED combo was also used to tune the frequency of the structure so that it can operate under a wide band of wind, weather and water conditions to maximize revenue from each turbine.

Mr. Finucane is already working on his next offshore wind project and has this advice for SACS users and those looking to expand into new types of projects:

- "Include the appropriate amount of detail in your model. More detail means longer runtime. Less detail, shorter runtime — but this perhaps will not answer all relevant questions. Optimize the model for both results and runtime.
- "SACS is proven oil and gas technology and methodologies. We were easily able to translate our experience with SACS from the offshore oil and gas world into offshore wind. Look for opportunities to leverage what you know

in new markets."

The Keystone team took their deep expertise in oil and gas jacket structures and applied it in a totally new industry—new to them, new to the US—and created a structure that is lighter and more cost-effective.

Keystone Engineering is already starting to be known as the go-to experts for offshore wind jacket foundations.

(The image above is an artist's rendering of the Block Island Wind Farm. It and the other images in this case are courtesy of Keystone Engineering.)

Individual Initiative *and* Standard Procedures During Simulation

Most project teams are made up of subject matter experts, whose deep experience is essential to the project's success. Effective and efficient collaboration between these experts can streamline processes, improve outcomes, compress schedules and lower costs. In the case of Saipem, having engineering capabilities and fabrication yards in the same corporate family means it can fully integrate and optimize every single stage of an offshore EPC(I) project. With yards and logistics bases on four continents, Saipem prides itself on this wide geographic reach, which gives it a strong "local" presence almost anywhere in the world.

Saipem's engineering offices in Italy are supported by 5 main design centers across Europe and Asia. Over 250 offshore structural engineers and designers work on large and complex EPC(I) projects.

Work is assigned to the engineering offices based on expertise and available manpower. FPSO projects, for example, are usually so large and complex that, when primary structures are frozen, first stage engineering is normally carried out in Europe and then transferred to a regional office, where the secondary and

tertiary steel is designed.

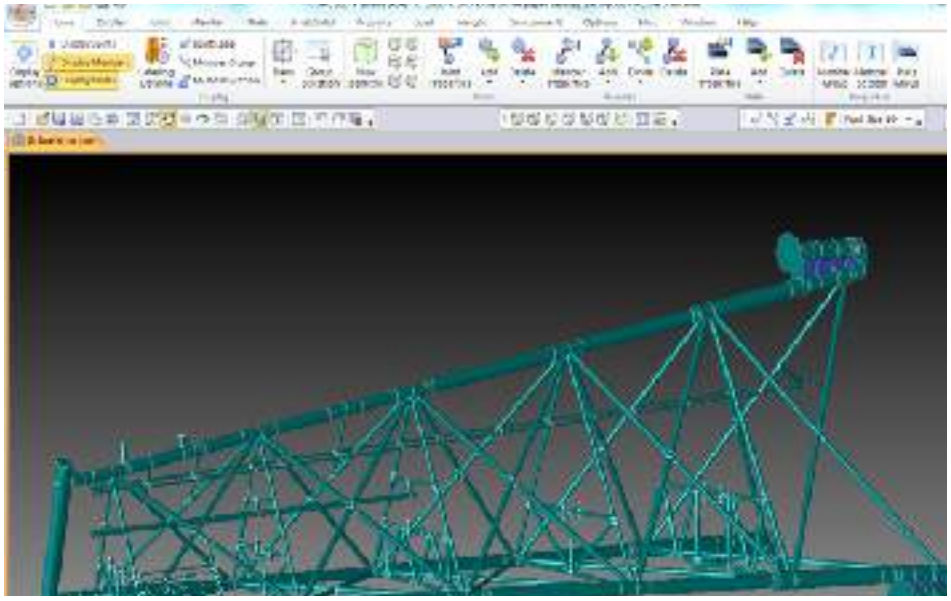
When asked how his offices collaborate on these projects, Luca Piazzi, Saipem Structural Engineering Department Manager, Engineering Technologies and Commissioning, said that they tend to divide responsibilities, in part to ensure ownership but also because each office has its own style or unique methods:

"We split according to structural subject matter, first and foremost to have a clear definition of responsibilities. Contrarily, if we shared responsibilities on the same subject matter, we would need to transfer both 3D CAD and SACS calculation models between offices.

"In our experience, the set-up of calculation models, such as the way load cases are named, the way load combinations are defined, and the way the member and joint numbers are generated, is something each engineering center has customized. Our preference is to have the same resource work on a SACS model from beginning to end. Our engineers are spread around the world and each office has its own methods. Getting them all to comply with corporate methods is not easy and takes time."

Mr. Piazzi remembers when Saipem created corporate standards for its 3D CAD models. These models are the key tool used to transfer information from the design to the fabrication yards. Because the yards expect to receive a consistent 3D CAD model, without regard for which engineering center created it, the design centers must follow standards when they create the models. This being the case, the effort to define and institutionalize corporate standards was certainly warranted. However, this can be difficult to implement.

When it comes to SACS models, Mr. Piazzi says such an approach is not always necessary:



"We can be more flexible when calculating SACS models and accept some customizations. For example, we typically tend not to model secondary beams in European centers; rather, we just add a dead load to simulate the weight of the beams in SACS so that they do not contribute to the overall stiffness of the structure. In Middle and Far East centers, our colleagues prefer to put the secondary beams into SACS to perform an automatic code check and to ensure the proper application of beam weight. The drawback of this approach is the increased number of man-hours spent on SACS model preparation."

Recognizing and leveraging these distinct work methods enables Saipem to respond quickly to the needs of each project. When discussing the need to standardize SACS models, Mr. Piazzi tells each team member:

"You are an engineer, you have your own mind, you have a SACS manual and you have the codes. We leave it to you to model and perform the analysis to ensure the best simulation of the structural behavior of this design. It is not just a matter of following a procedure, however important this is: you also need to understand how structures behave in the real world and build a SACS simulation that reflects this understanding."

Times may be tough in the oil and gas industry, but Saipem has discovered that, while corporate procedures are a vital element for ensuring consistency and uniformity across different projects, lessons learned from past projects and insights from fabrication and construction units are also essential in producing innovative designs, lowering weight and improving constructability.

(Images in this case courtesy of Saipem.)

ONGC's Ultimate Life Extension Project

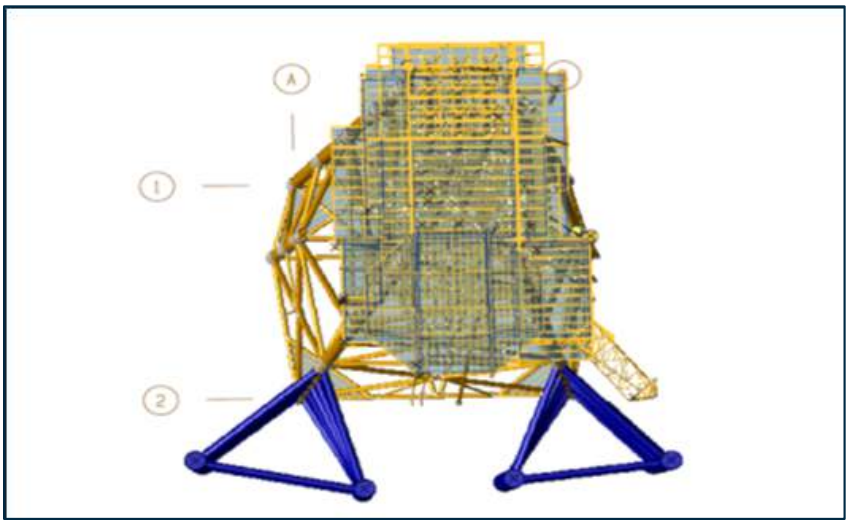
The dilemma: the price of oil is low, which limits the opportunity to build new platforms. But the fleet of existing assets is nearing the end of its life. Do you investigate new opportunities or try to extend the life of the current fleet? And what if you knew that each new platform would cost $40 million to $50 million?

India's Oil and Natural Gas Corporation (ONGC) operates 265 platforms off the coast of Mumbai, most of which were designed in the late 1970s and 1980s and are nearing the end of their planned 25-year operational life. ONGC needed to either decommission, dismantle and build anew, or re-qualify these structures to ensure continued future production. ONGC did the math and decided to assess each of its jacketed platforms, to see what would be needed to take them beyond their original design life.

Many of the platforms had been modified and revamped over the years, adding new facilities and making the repairs required by normal wear. ONGC began by assembling data on each platform, created a strategy and a set of criteria for in-service inspection, and then went to work, evaluating the structural integrity and fitness-for-purpose of each platform and recommending remedial actions.

During this process, ONGC discovered that many of the platforms in question generally did not meet current design standards, but may still be structurally adequate to serve their intended purpose when evaluated against risk-based assessment criteria.

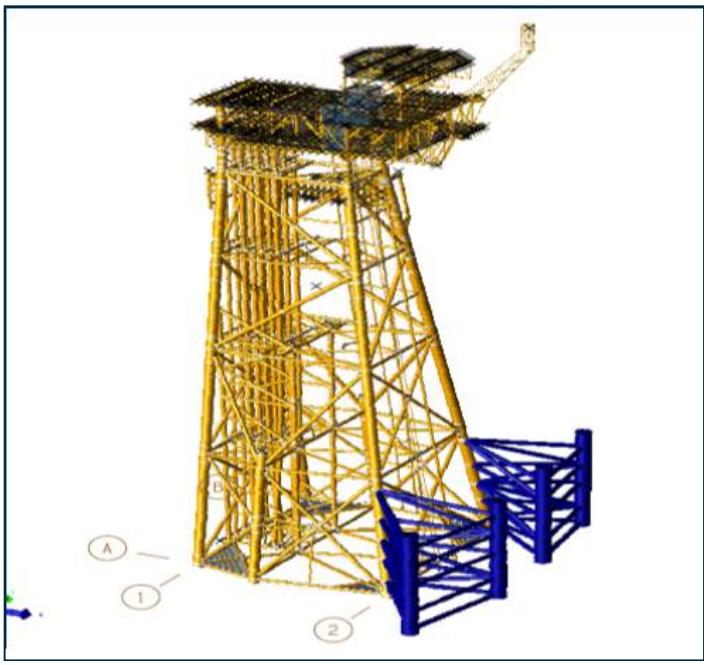
Praveen Bhat, an ONGC structural engineer, explained that his team used SACS to perform design level, ultimate strength, metocean fatigue, non-linear plastic collapse and other analyses to build their recommendations.



Mr. Bhat says that the collapse analysis "helped us understand the failure mechanisms of these structures. We looked at different combinations of load reductions, removing redundant facilities, removing marine growth and, where needed, structural strengthening. This also helped us anticipate future needs, such as for enhanced oil recovery—will we need to strengthen in advance of new equipment?"

The end-result: ONGC spent $150 million on the life extension project and is returning 25 platforms to regulatory compliance, a far more economical alternative than building new platforms. All platforms are safe for human operators and the marine environment, and will continue to provide hydrocarbons to support India's economy for another 15 years.

That's important, of course, but perhaps even more so is that ONGC created a repeatable process that it will apply to the 10 to 15 platforms per year that will reach end-of-life over the next decade. ONGC's method of creating, analyzing and evaluating digital models of their structures using SACS is an industry-leading concept that likely will be imitated by many other asset owners facing similar end-of-life decisions.



(Images of ONGC's Additional Pile Requirement analysis, courtesy of ONGC)

As we've seen, leading owners and EPCs realize the benefit of a digital strategy that unifies data and processes during design, engineering and handover, and from operations into deconstruction. They rely on their digital assets to inform a deeper understanding of the physical asset. They are Going Digital to create learning organizations that thrive in any business climate.

One last example of companies thinking outside the design-build box: decommissioning. Many oil and gas facilities in the North Sea and elsewhere are nearing the end of their operating life and an extension project, as ONGC did, is impractical. Safely decommissioning these platforms involves understanding every aspect of their structure and operations. Special consideration must be applied to the safety, environmental and economic aspects of these projects.

Bentley's SACS now includes an integrated analysis and design solution for the complete lifecycle of offshore structures, including decommissioning, with capabilities that enable engineers to decompose heavy offshore structures into manageable pieces that can be safely removed from complex working environments. SACS' decommissioning capabilities enable engineers to determine optimal cutting planes to meet decommissioning project requirements, such as structure weight for lift and transport. SACS users fully control the structural weight and can apply automatic cutting of the structure at user-defined elevations.

Several long-standing SACS users are finding new business opportunities in the growing market for decommissioning projects. With their input, Bentley continues to adapt its design tools for this new purpose and to further automate work processes.

Given the industry's uncertainty, smaller projects, revamps, life extension projects and decommissioning will continue to fill EPC order books. Successful industry players will also seek out new ways to leverage their expertise, whether in adjacent industries like wind power or with new and innovative solutions for current customers. They'll take advantage of technology—such as analysis, cloud-based services, collaboration technologies and mobile access to relevant information—to become even more productive.

How will you take your organization to the next level, Going Digital to connect people, data and processes around the world to improve project execution?

This paper was created by Schnitger Corporation at the request of Bentley Systems, Incorporated. The analysis and opinions presented here are those of Schnitger Corp. For more information, please visit www.schnitgercorp.com.