From right to left:
1. The steam generator is transported on SPMTs to the JS500 jack-up system.
2. The JS500 raises the steam generator to the height of the temporary hatch.
3. The steam generator is skidded along a track into the plant.
4. A temporary lifting device, a 900 metric ton strand jack on a gantry, raises the steam generator.
5. The generator is maneuvered by the temporary lifting device mounted on the polar crane.
6. The reinforced polar crane, with its temporary lifting device, rotates the steam generator around the plant and lowers it into place.
IN AND OUT THE HATCH

Squeezing time and space for nuclear outage in Ohio

At the southwest shore of Lake Erie, in Oak Harbor, Ohio (USA) lies the Davis-Besse Nuclear Power Plant. In 1978, it was the 50th nuclear power plant to come online in the USA. A pressurized water reactor and two steam generators are at the core of this plant and provide more than 7,000 Gigawatt-hours of electricity annually. In 2009 it was decided that the reactor vessel closure head (RVCH) and the two steam generators had to be replaced.

Three complications...
The replacement was set for 2014, and at that time there were three known complications. First, the polar crane in the plant was not strong enough to lift an entire steam generator for replacement. Second, the floor level inside the Davis-Besse nuclear power plant is around six meters higher than ground level outside. Usually, replacement projects in nuclear power plants are performed by creating a temporary hatch in the plant’s wall, big enough to skid the old steam generators out and the new ones in before they are installed. However, the floor level height inside the plant made it necessary to create a temporary hatch six meters above the outside ground. This would require Mammoet to lift the steam generators. And that is where the third and biggest complication came in: above the point where the temporary hatch had to be constructed, power lines exit the plant, delivering the generated electricity to the grid. The plant would still provide power during the steam generator replacement operation, so temporary removal of the power lines was not an option. According to safety regulations, a minimum safety distance of six meters (20 feet) has to be observed between operating equipment and the high voltage power lines. This ruled out the use of our cranes to simply lift the steam generators in and out of the plant.

“Our deadline was suddenly moved forward by three years.”

…and a comprehensive approach
Mammoet proposed a comprehensive approach that would deal with all three obstacles in the safest possible manner.
Project manager Stefan ten Hoeve explains: “The most challenging issue was to find a way to deal with the power lines. We could not lift the components from above, but we could push them up from below, positioning them at the correct height to move them through the temporary hatch. This was made possible by the JS500 jack-up system—an innovation that had just been introduced by Mammoet, and the only available equipment able to handle such an operation. This was the safest and most efficient solution.”

On the inside, Mammoet needed to reinforce the polar crane. As the girders were not strong enough for the operation, Mammoet had proposed to reinforce them using a temporary support tower. The polar crane needed to rotate during its lifting operations so the support tower was connected to the bottom of the girders with a turntable. On top of the polar crane, Mammoet installed a temporary lifting device consisting of a 900 ton strand jack on a travelling gantry system that provided the additional lifting capacity needed for the entire operation.

**Dealing with the unforeseen**

Mammoet signed an agreement in 2009, stipulating that the replacement operation take place during a power outage in 2014. We had five years to prepare and it seemed like smooth sailing, but a complication soon arose that seriously upset the timetable: the Nuclear Regulatory Commission, which is in charge of issuing and renewing operating licenses, did an inspection in 2010. It ruled that the RVCH at Davis-Besse was nearing the end of its 20 year life-span earlier than anticipated, and had to be replaced sooner in order for the license to be renewed. The Commission decided that this had to take place during a mid-cycle outage in the fall of 2011.

Stefan ten Hoeve explains the consequences of the Commission ruling: “This meant our deadline was suddenly moved forward by three years, which called for us to respond immediately. Now the work had to be divided into two parts: replacing the RVCH in 2011, and then replacing the two steam generators in 2014. It would be a tight squeeze, but we were confident we had the know-how and determination to do it.”
Replacing the RVCH
We immediately set about speeding up the engineering and test phases, without compromising quality or safety, in order to beat the accelerated deadline. By working around the clock, the technical crew managed to meet the new deadline and complete the test-loading and fit-testing by the summer of 2011. Mammoet was ready to replace the 140 ton RVCH during the planned outage, as requested. Things went safely and smoothly three years ahead of our original deadline. Immediately after the RVCH replacement we started preparations for the removal of the two steam generators.

Leaving nothing to chance
By 2013, the engineering phase for the remaining work was completed and all equipment had been prepared and tested at our yards in the US and the Netherlands. Stefan describes one of the most complicated challenges posed by the project: “We replicated the polar crane girders so that we could load-test the temporary lifting device designed for the top of the polar crane. The tests were successful and we were ready to go.”

There are 435 civil nuclear power reactors operational in the world and some 70 more under construction. Each of these plants was customized according to the technology and insight at the time of their construction. But often they were not designed with efficient outages in mind.

‘Outages’ are scheduled shutdown periods for nuclear plants during which fuel is replaced, maintenance takes place and components may be changed out. For many nuclear plants this process was not included in their design and their infrastructure does not allow for the easy and swift change-out of large key components such as steam generators and reactor vessels. As downtime is very costly, innovative approaches to the lifting and transport of these components are needed to ensure outages are executed as efficiently as possible.

Plant owners are often unaware of this when they start working on the mechanical engineering for maintenance projects. It makes a significant difference in the efficiency of these projects when engineered heavy lifting and transport activities are integrated from the beginning. They define the critical path of a maintenance operation and therefore the actual downtime.

The timing depends on many factors, particularly the internal layout and installations that define the room to maneuver, the capacity to lift and potential complications along the way. Therefore, the mechanical engineering plan should be integrated with a detailed logistics plan to encompass all lifting, transport and change-out of the large key components involved.

Current heavy lifting and transport technology offers many opportunities to minimize downtime in safe ways that were not foreseen at the time of the plant’s construction. As demonstrated by the Davis-Besse project, an integrated approach offers significant benefits: it optimizes processes and can complete outages faster while maintaining the highest safety standards.
The equipment and new steam generators had arrived on site by October 2013. Everything was pre-assembled and in position by January 2014. It all appeared to be under control and the rest of the operation seemed as if it would be a walk in the park. We were soon reminded that Mammoet can control a lot of things … except the weather.

Against the elements
When the replacement operation officially got underway in February 2014, the region was being ravaged by the worst winter in 30 years and the idyllic location had been transformed into a freezing wasteland. There were three meters of snow on the ground and temperatures had plummeted to between -10°C and -40°C. This caused all kinds of problems for Stefan and the team, who worked in two rotating shifts of twelve hours, six days a week for ten weeks. Working outside was grueling, fighting against the constant snowfall and artic winds that whipped off the lake, constantly filling the air with an ominous howling.

Real troopers
The weather was dark and grey with gun-metal skies and bad visibility because of the ceaseless wind and stinging sleet. The team had to wear bulky, double-lined protective clothing that hampered their movements, making it even more difficult to move along the icy, slippery paths. Team members could only work outside for an hour before having to go indoors to rest and thaw out. The weather also required special measures to keep the equipment running. The machines were covered in thermal blankets and kept idling at all times so that the engines wouldn’t freeze. Special industrial heaters were also mounted on the power packs against the severe cold. It was an extreme challenge, but the team worked with dogged determination to keep everything running smoothly and efficiently. “The team was amazing”, says Stefan. “Real troopers. They never grumbled; just knuckled down and completed the job!”

Steam generator extraction
Once the plant had cooled down, a temporary hatch was made in the plant’s concrete wall. This large entrance allowed us to move all our equipment and transport the steam generators in and out. The JS500 was arranged in front of the work platform and a connecting skid way on top of it provided the route inside the plant that the generators would travel—both ways. Once each steam generator was skidded out of the plant, it was quickly transferred to its final resting place in the mausoleum, a concrete bunker with walls so thick that no residual radiation can escape. Then the whole process was repeated for the second steam generator. The new steam generators were installed using the same procedure, but in reverse.

A tough job, well done
Stefan looks back on the project: “The first steam generator was extracted on 28 February 2014 and the last new steam generator was set on its foundation on 11 March 2014. It was the first time that the procedure had ever been carried out and it was specifically developed for this project. Our plan enabled us to work quickly; every day saved meant saving a million dollars for our client. We beat the revised deadline for replacement of the RVCH and delivered everything without incident. Our customer was delighted with the outcome.”