The Sprint to the Final Click

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Even during the construction of the world's most powerful laser, meeting deadlines can come down to a simple click.

It was 3:17 a.m., and we were only minutes away from completing an October 23, 2001, National Ignition Facility (NIF) milestone. The deadline was 6:00 a.m. We were at the very last stage of the milestone: installing the bottom enclosure covers inside the periscope optical support structure. Steve Yakuma pushed the final cover into position as we waited, holding our breath. We all knew too well that the only way to know that the bottom cover was installed properly was if we heard the engagement click of two spring-actuated plungers. Steve pushed up. No click.

We were at the end of a surge of activity that had started back in the summer. The main objective was to complete the construction of the laser beampath for the first 6 of a total of 24 laser bundles on NIF. We were installing and connecting many large structures, including beam tubes, connecting tubes, and enclosures that provide the precision clean and highly stable environments for NIF's high-power, large-aperture laser beams. At the end of the line of several stages of construction was the task to install 85 small aluminum covers to the bottom of the periscope, one of the largest structures within the beamline that houses several key optical components of the laser. Each cover had two pins that automatically engaged when the cover had been successfully positioned. Hearing—or not hearing—those little clicks indicated success or not. Although that click may seem insignificant, it represented the completion of the job and the culmination of millions of hours of work by hundreds of people.

We're building a big laser, and some people may think "Well, you've done that before at Livermore. What are the new challenges?" But NIF is not one laser. Rather, it's 192 large-aperture lasers densely packed into a stadium-sized building. NIF would just fit inside a major-league baseball stadium. So no matter what you require, you usually need to buy 192 of them, and then carefully design them to fit into a very tightly-packed facility. What is even more challenging is that many of the parts must be precision-cleaned to prevent contamination that can cause damage when the laser beams are fired.

Our goal was to complete a 150-meter section of the laser beampath by October 23. When the beam tubes are installed, they have to fit precisely—the schedule did not permit any significant unexpected delays. Under normal circumstances, installing a beam tube seems like it wouldn't be that hard to do. But because we have been very cost conscious on this project, we made the facility as small as we could to keep the construction costs down. Thus, there is little room around installed components and tolerances are very tight. We calculated that we were going to have just enough room around the vacuum vessels, which were already in place, to move many of the large beam tubes. As we installed these components, utilities and other construction work were being completed in parallel, making the facility even more congested with people and giving us less room to maneuver each subsequent beam tube.

As we got closer to October 23, things were really getting tense, but we were beginning to get some good momentum. Time was running out, however, so we started working two shifts each day. The day shift was given a set of things to accomplish that day. At the end of that shift, they reported to the night shift team what they had accomplished, and what they thought needed to be done on the night shift. Then the night shift would do what they needed to do by morning. As time went on and the deadline approached, we developed a sense of rhythm and teamwork that helped us progress at a rate that no one thought possible.

A big portion of the work was focused on the periscope, the structure that houses the plasma electrode pockel cells, a really important part of the laser. Pockel cells are optical switches: they direct the laser light into the cavity of each of the 192 beam paths and then switch the laser pulses out after 4 passes. Inside the periscope, we had to install mounting hardware for all these optics, which had to be precision aligned. Furthermore, we had to put in utility lines and cables to activate the actuators for these mounts. There's a lot of work, and it all had to meet stringent cleanliness requirements.

We had to pull people from all over the Laboratory to handle different issues. We were having problems with a caulking material to seal panels on the roof of the periscope. This very specialized caulk is manufactured in the Lab's Plastics Shop. At the beginning, we mistakenly told them we wanted to have a long cure time because we wanted to have time to apply it. But when you're on an accelerated schedule, you really want a rapid cure to provide enough time for leak testing. So we worked with the Plastics Shop on a daily basis, saying, "No, we want a 2-hour cure time!" And they would say, "We can't give you a 2-hour cure unless we test its adherence properties first!" Time was running out. In the end, they were very responsive, considering that we were asking them to develop new materials for us.

Things were getting really hectic around the periscope. We had about 20 people under the structure crammed into a space the size of a living room. They were all in clean room "bunny suits" and working in Class 4 cleanliness protocol. Another 10 people were on top of the structure sealing gas leaks. Managers and

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A view up the NIF periscope, a most critical part of the beamline.

shift leaders surrounded the team, responding within seconds to each and every issue that arose. By this time, it did not make any difference who you were. We were one team with one objective. Everyone had a job, everyone knew what they needed to do, and there were no organizational barriers. From time to time, there were flare-ups, but our commitment to the objectives kept us together.

As the deadline neared, we were sweating over putting in the final bottom covers on the periscope. Each cover is about 2 feet by 3 feet and weighs about 30 pounds, so you had to have two people to push one into position. But to push it up, you had to apply about 1,000 pounds to compress a seal that is around the perimeter, until you heard the all-important click. But we had to install 84 of these bottom covers in a couple of days. To be successful, we had to install two or three an hour. The devices that we put together to install them weren't working well. We couldn't get the covers to click. It was extremely frustrating.

We called in the people who had designed the covers. I remember calling Steve Yakuma and saying, "I don't care what you're doing, you and Jeff Horner have to come over here! You have to help us install these covers!"

On October 23, Jeff, Steve, Mark Jackson, Gary Deis, numerous other NIF staff that we had rounded up, and all the supporting craftspeople were buzzing in and around the periscope, and we were putting in doors as fast as we could. Every time we heard a click, we knew it was one click closer toward that milestone.

But then we got to the last door. It was 3:17 a.m., and we had until the end of that night shift, which was at 6 o'clock in the morning, to finish the bottom covers and meet the deadline. As Steve pushed up on that last door, it didn't click. We'd have to battle this to the very last second. We put that door down, and got another one. At 3:44 we pushed it up—and got the final click.

Since then, "10/23" is a commonly used phrase around the NIF project. When people talk of 10/23, they talk about different aspects of what happened, but one of the most important things that happened was the breaking down of mental barriers. Together as a team, we started to gel, both within the Livermore team and working with the Jacobs Construction team. A powerful partnership emerged, and it was terrific. Best of all, we learned to say, "This is something that we will make happen—on schedule." And we did.

Workers installing bottom covers on the periscope.