Purdue Engineering

Extrapolations

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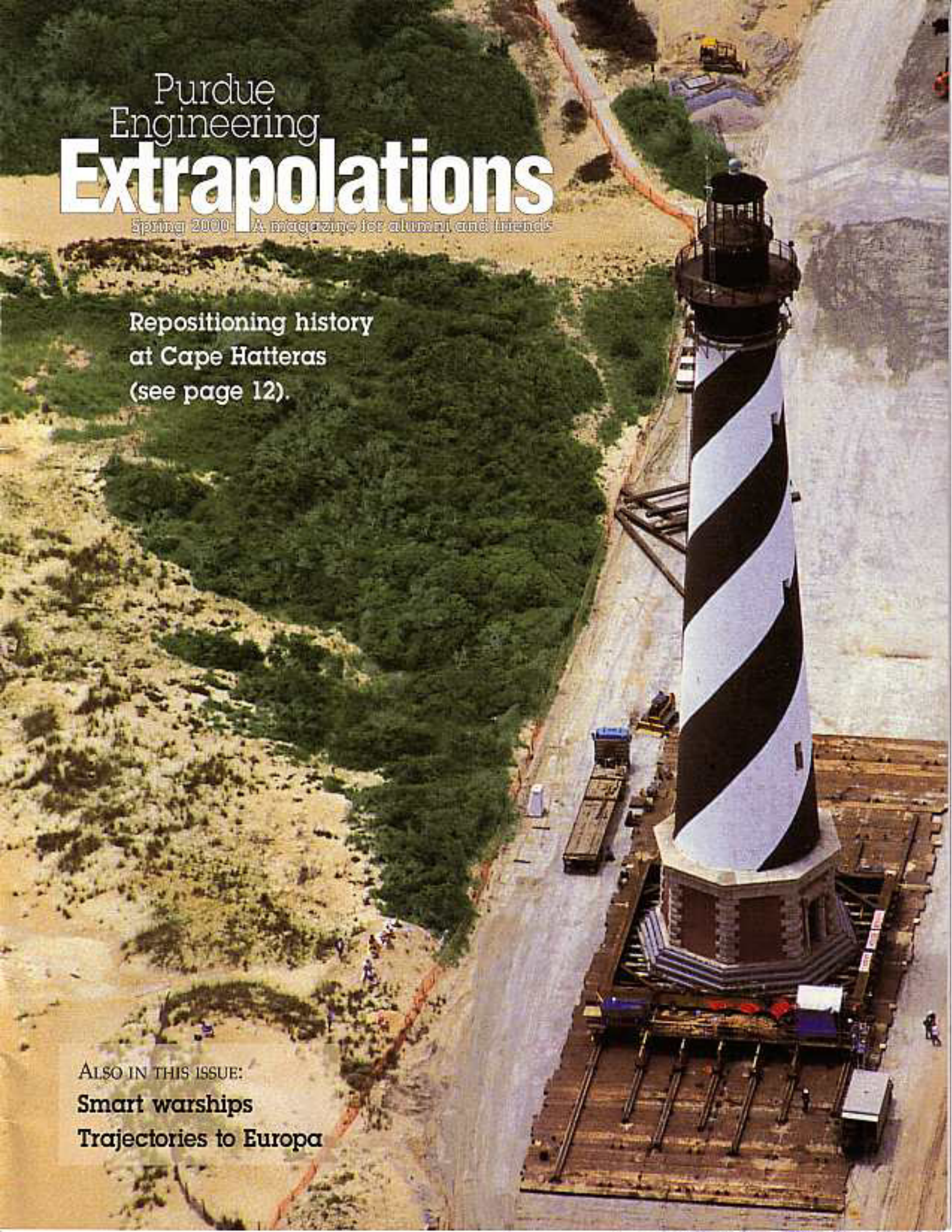

Repositioning history at Cape Hatteras **(see page 12).**

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A Purdue IDE graduate helps manage the relocation effort of the Cape Hatteras Lighthouse.

Paul Cloyd, a registered professional engineer and licensed architect, admits dodging a dynamics class in his undergraduate days at Purdue. It was a tough course perhaps more suited to engineers who design things with moving parts, and Cloyd (IDE '76) passed on it after concurring with a counselor that "buildings don't move." But when the Atlantic Ocean threatened to swallow America's oldest brick lighthouse off the coast of North Carolina's Outer Banks, and Cloyd's position as historical architect with the National Park Service (NPS) called on him in 1997 to evaluate a move and eventually help select and direct the company that would place the 200-foot structure out of nature's way, perhaps he wished he had at least audited the course.

For this move was no small task. Nor was it without controversy.

Those opposed claimed that any move would be a downright deliberate case of historical revisionism. And—perched as it is on the country's far-eastern edge—could the Cape Hatteras Lighthouse talk, what a course it could teach in American history.

Indeed, American patriot Alexander Hamilton nearly died in a 1772 shipping mishap in the dangerous Diamond Shoals, the three shifting ridges of sand traps and unruly currents off the shoreline of Hatteras. The future statesman, first secretary of the treasury, and ultimately done-in dueler, Hamilton coined the moniker "Graveyard of the Atlantic" for all the ships the shoals had taken and was instrumental in securing legislation for the building of lighthouses in the young country. At the top of his list was a warning beacon for Hatteras.

Over time this graveyard would claim thousands of ships, and the Outer Banks' narrow strip of land would seem little more hospitable to the towers that tried to warn sailors to steer clear. The first lighthouse—a sandstone structure raised in 1803—would eventually prove a little too short, weak-beaconed, and thin-skinned for the harsh island climate, despite a better Fresnel lens added along with a five-story lift in 1854. During the Civil War, Confederate troops put out the light and used the tower as a lookout, thus making an ally of the Diamond Shoals against the Union Navy. When it passed to Northern hands, however, a Georgian commander vowed to destroy the lighthouse. But its dismantling would wait for peaceful times.

After the war, once it was determined that the price of further improvements would exceed the cost of a new tower, Congress commissioned New England carpenter Dexter Stetson to build a better one. Stetson and crew battled militant mosquitoes, watched granite- and brick-delivering ships from Virginia sink in the shoals, and grappled with the quandaries of building on sand. But in 1870, the candle (oil lamp, actually) was lit on the tallest lighthouse in the country, with a brand-new principal keeper's house and double keeper's quarters alongside it. The distinctive black and white candy stripes would wind down the tower in three years' time.

Lighthouse photo by Mike Rector

BENEATH THE DOUBLE KEEPER'S QUARTERS: **Paul Cloyd (center, blue coat) and co-workers pause during a progress meeting.**

Cloyd speaks of Stetson's engineering ingeniousness in taking what the island offered him. "He discovered that he could only dig about six feet before hitting hard, compact sand," Cloyd says. "Though he had the use of pile drivers, Stetson used the naturally compacted subsurface upon which to lay three courses of yellow pine timber that would serve as the first layer of the foundation. Submerged below the freshwater table, Stetson believed, the timber would remain steel-strong." Stetson was right. Cloyd says the contractors found the timbers in "sound condition" when they were uncovered for last summer's relocation.

And, according to Cloyd, there's much significance in the brick. "The tall brick towers consisted of a double wall with a hollow space between the walls," he says. "The design lightened the load and reduced the overall cost by using fewer bricks while providing a highly durable structure." The Cape Hatteras Lighthouse became not only a National Historic Landmark but also a Historic Civil Engineering Landmark, as dedicated by the American Society of Civil Engineers in 1999.

Move it or lose it

However sound its original construction, the Cape Hatteras Lighthouse would always suffer from its precarious location. Hurricanes and nor'easters were common, and an 1886 earthquake—centered in Charleston—swayed the lighthouse like a tree, according to one keeper's account (with the unfortunate soul in the very belfry at the time). Still, thermal stresses and not the earthquake, Cloyd claims, caused the few cracks in Stetson's steady tower. The real danger was rolling in on waves.

In 1870, the lighthouse stood 1,600 feet from the shore. "By 1919," Cloyd says, "the ocean had advanced within 100 yards of the tower, and to within 30 yards by 1935."

In the 1930s, the Civilian Conservation Corps built a barrier and sand-dune system along the entire length of Hatteras Island, and for a while the Atlantic did retreat. But with so little beach left, a third tower was built and placed up in the woods in 1936. This "Buxton Light," man-made of steel, gazed out over the ocean while the brick tower went blind for the first time in 66 years. Automatic beacons were replacing manned stations, and even Stetson's tower would sit vacant for many years, playing host mainly to vandals who broke windows and walked off with pieces of the lens.

But after another big war and some public pressure, the Coast Guard, along with the NPS, decided to get the old tower back in working order. With some paint, repairs, and now an electric light, the Cape Hatteras Lighthouse was again shining in 1950. As station wagons gave way to minivans, millions of vacationers from the west would arrive to climb its spiral stairs. And millions of dollars would be invested throughout the 20th century to try to keep the sea at bay.

Efforts to harden the shoreline included beach nourishment (pumping in sand), groins (walls perpendicular to the shoreline intended to trap sand), huge sandbags, and artificial seaweed (planted to stabilize sand offshore). But just as this pointed edge of the island resembled America's elbow on a map, coastal geologists said the tower's Achilles' heel was the saltwater threat to the yellow pine timbers that rested beneath its foundation. "If saltwater were to displace the fresh water," Cloyd says, "the timbers would begin to rot and the foundation would fail."

By the end of this last century, various committees and ad hoc organizations were meeting to decide what, if anything, could be done to save the Hatteras Lighthouse. In 1988, the National Academy of Science recommended that a move was the best way to save it. For a decade, a faculty committee from North Carolina State University, the local Lighthouse Society, the Office of the Governor, and a host of other organizations all weighed in with findings and opinions. Cloyd, a true preservationist, had to be convinced that a move was best. Ultimately, he was. "But only after our backs were literally to the sea," he says.

Some local, and very vocal, opponents not only feared that the tower might tumble en route, but figured these authorities had no right to such an intrusion, that any change in the tower's longitude and latitude would compromise its historical integrity. Islanders, too, may not have been too keen on advice coming from inlanders and the spokesmen of organized acronyms. Lawsuits were filed, denied, and filed again (one with the move already underway). For three months workers went about the move, hopeful that a judge would not order them to cease and desist. Despite the threat, the transplant wouldn't be stopped.

"We do what we can to preserve historical landmarks in their original positions," Cloyd says, "but Mother Nature always has the bigger hammer."

DOWN UNDER: **A worker removes granite from under the lighthouse.**

An engineering marvel

When Congress appropriated funds in October of 1998 for the Hatteras Lighthouse relocation project, Cloyd compiled technical information to aid in contractor proposals. The NPS ran an advertisement in the *Commerce Business Daily* and estab-

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lished a panel to review the qualifications of the bidders. After narrowing the choices to two firms, Cloyd provided each with complete technical specifications and allowed them two months to come up with their own plan.

The companies had very fundamental differences, Cloyd says. International Chimney Corporation (ICC) was awarded the job (with a contract of roughly $9.5 million to design and implement a move) because its plan called for setting the lighthouse on a system of jacks (100 in all) that held it vertically through three different zones. It would travel on steel rails, or tracks, to its new site.

Cloyd explains, "The three-zone hydraulic system concept enjoys wide use in structure-relocation projects. Fundamental to this is that three points determine a plane. The structure rests on a steel grid set to maintain its horizontal and vertical axes. The crew monitors the pressures in the jacks constantly during the move, while additional instruments check on the horizontal and vertical alignment of the lighthouse.

"Any dips in the 'roadway' would be compensated for by adjusting the extension of the jacks in any of the zones as needed. All ensured the lighthouse felt nothing but a smooth level ride. The sand along the route was compacted by vibrating rollers and strengthened with a one-foot overlay of road base, then strengthened again with a steel I beam matting that the rails rested upon."

Operators made corrections in this hydraulics system to keep the structure sitting on a uniform plane even when traveling over inconsistencies in the move route. This "soft move," which mitigates transmission of stress throughout the tower, is roughly comparable to car shock absorbers, Cloyd says.

First, the two keeper's buildings were moved using roughly the same measures that would be used for the tower. Then, after digging out the foundation and installing the relocation equipment beneath the lighthouse, crews readied for the big one—with steel lift and lighthouse on top, nearly a 4,800-ton move weight.

FOR LIFT AND SUPPORT: **The roller beams (below) and the jacking beam (above) await action on a crib at the old site.**

Paul Cloyd: A Cape Crusader

Paul Cloyd never thought he would be moving a lighthouse. He started his career as a historical architect with the National Park Service (NPS) two years after his 1976 Purdue graduation. From 1982 to 1984 he took a leave of absence to serve as an architect with the United States Peace Corps in the Caribbean island nation of Antigua-Barbuda. With the country's Public Works Ministry, he renovated government buildings and school buildings, as well as making proposals for a new school. There he developed an appreciation for the beautiful wooden architecture built in adaptation to the area.

"The vernacular architecture was really well suited to the climate," he says. "Buildings with stone bases and wooden superstructures were logical in many ways— from homes armored against insect attacks, with wooden-framed upstairs for cool sleeping, and roofs designed to resist hurricane winds."

Cloyd's NPS career has taken him from projects in an 1890s gold-rush boomtown in Alaska to a historic leprosy settlement in Hawaii to a short consulting stint on centuries-old Buddhist temples carved into live rock in central India. He has studied in Rome, Italy, and York, England, completing a master's degree in the preservation of buildings in 1994. His studies focused on incorporating modern fire detection and suppression technologies in historic buildings—a popular topic in England following the Windsor Castle fire of 1992.

Had Purdue prepared him for his engineering travels? "The interdisciplinary aspect of my education has really been helpful throughout my Park Service career," Cloyd says. "It certainly hasn't been just all engineering and architecture. We deal with historians, archeologists, natural resource specialists, and more."

Cloyd admits to first being skeptical a dozen or so years ago when engineers talked about having the technology to move massive structures, like the Cape's tower. He thought, Wouldn't this money be better spent on historic buildings that did not have to be moved? But learning about the significance of the Hatteras light in the last few years, he concluded that there are times when we must take advantage of such engineering technologies.

In a paper presented at an International Preservation Conference in Mexico last fall, he assessed the Hatteras situation: "Because of the shoreline erosion, either the buildings are going to move from the site, or the site is going to move away from the buildings." In another 100 years, another decision will be made about the Cape Hatteras Lighthouse. Move again or give it up to the sea.

On June 17, 1999, the Cape Hatteras Lighthouse began its slow roll toward a new home. While daily crowds gathered in the thousands, the tower, like a massive skateboarder at a senior citizen's speed, made its way in five-foot *gentle* lurches. Its journey would end some three weeks later, on July 9th, some 2,900 feet from where it first stood. And as in 1870, the tower rests approximately 1,600 feet from shore, with dual keeper's quarters in the same relative positions.

On November 13, 1999, two days after Veterans Day, the Cape Hatteras Lighthouse lit up the early evening sky. On Memorial Day of 2000 it will once again open its historic doors to the public.❖

—William Meiners

For sights and sounds from the Cape Hatteras Lighthouse move, go to this Web site: **www.wral-tv.com/news/wral/5newsfocus/1999/0310-lighthouse-move/.** *Also, the National Park Service's Web site has an abundance of information on the Cape Hatteras project. Check out* **www.nps.gov/caha/lrp.htm**

AT THE TOWER, PLANNING: **Paul Cloyd (black shirt, hand on hip) listens to instructions from colleague Joe Jakubik.**

A SAFER HAVEN: **The Cape Hatteras Lighthouse nears the end of its long trek.**