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Burrowing a tunnel under the Hudson River and into the future

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NEW YORK — Sometime next month, the nation's biggest mass transit construction project in generations will begin, modestly, in North Bergen, where earth-moving machines will carve out an underpass beneath busy Routes 1&9.

The work will mark the start of an eight-year, $8.7 billion effort to build the first rail tunnels under the Hudson River in a century and the first link of any kind between New Jersey and Manhattan since the lower deck of the George Washington Bridge opened in 1962.

Known as Access to the Region's Core, or ARC, it is an undertaking nearly as immense as the construction of the two Gilded Age tunnels the new tubes will augment. It will employ thousands of people, many working deep underground in round-the-clock shifts.

Tunnel-boring machines longer than football fields will chew through the hard rock of the New Jersey Palisades and slog through toothpaste-like silt 100 feet beneath the Hudson's surface.

In Manhattan, the tunnels will end deep below 34th Street in a new two-tiered station stretching more than four-tenths of a mile, from Sixth to Eighth avenue, giving passengers access to 14 subway lines, PATH trains and the Long Island Rail Road.

When it is completed in 2017, its planners and backers say, the project will ease the commute for hundreds of thousands of New Jerseyans, speeding service, creating more transfer-free trips and encouraging drivers to abandon jammed roads in favor of trains.

"It can't be overemphasized how important this project is," said Jeffrey M. Zupan, a senior fellow at the Regional Plan Association, a nonprofit advocacy group that focuses on open space, economic policy, transportation and housing. "It creates another leap forward in increasing rail service. It's a project that must be built."

Beyond the immediate economic benefit of putting people to work, planners say, the tunnels will spur investment in Manhattan, creating an estimated 44,000 jobs. Many of those employees will come from New Jersey, Zupan says, citing studies that show 89 percent of new growth in the city draws workers from the west.

"People in New Jersey get access to higher-paying jobs in New York, and New York can tap into a highly skilled work force in New Jersey," Zupan said. "For each of the two states, it's a real synergy."

The project is also, in the view of transportation officials, a real necessity.

The existing tunnels, which enter the Palisades just a quarter mile north of the new tubes' route, reached capacity earlier this decade, creating a bottleneck for the NJ Transit and Amtrak trains that travel to and from Penn Station along the Northeast Corridor, the most congested stretch of track in the nation.

That translates into slower service and frequent delays. During peak travel periods, 23 trains pass through the old tunnels each hour, hardly enough at a time when NJ Transit sets ridership records each year.

"It's basically a capacity issue," said Zoe Baldwin, the New Jersey advocate for the Tri-State Transportation Campaign, another advocacy group. "We're just unable to run more trains."

When the new tunnels are completed, NJ Transit and Amtrak will increase the number of trains crossing the river to 34 per hour during peak periods. That number will gradually rise to a maximum 48 per hour by 2030, when ridership is projected to be nearly 60 percent higher than it is today.

HURDLES GALORE

Like the plan to build the tunnels a century ago -- a wildly ambitious endeavor that included construction of the original Penn Station and four tubes beneath the East River to Long Island -- the ARC project has had to overcome myriad bureaucratic, financial and engineering hurdles.

Talks among various agencies began in earnest in 1990. By 1995, NJ Transit and the Port Authority of New York and New Jersey emerged as partners, embarking on a laborious process that would ultimately winnow 137 scenarios to one.

Along the way, a bold vision was scaled back significantly.

A connection to Grand Central Terminal was scrapped after New York City refused to allow digging near a 92-year-old water tunnel that serves much of Manhattan. The higher price of a Grand Central connection also was a concern. (Planners say the link can be revisited when New York City decommissions the water tunnel, a move expected in the next decade.)

Even more troubling to some, NJ Transit and the Port Authority eliminated a connection to the existing Penn Station. Passengers can walk along the sprawling underground concourse to get there, but trains using the new tunnels won't be able to pull alongside the station's platforms or continue on to Connecticut and Boston.

As a result, Amtrak will be relegated to the old tubes, and NJ Transit will continue to use them even when the new tunnels are open. In a testy letter to the ARC project director last April, former Amtrak president Alex Kummant complained the expensive initiative was now for the "sole benefit" of NJ Transit.

What's more, he said, the decision to drop the Penn Station connection could require the construction of yet another rail tunnel to help Amtrak meet its expected growth in ridership.

Amtrak's current president, Joseph H. Boardman, declined to comment for this story, but as chief of the Federal Railroad Administration last year, he echoed Kummant's concerns in a letter to the head of the Federal Transit Administration, which had final say on the ARC project.

"Given the complexity and cost of such an undertaking, we must make sure that the project delivers every ounce of capacity and flexibility that is reasonably possible," Boardman wrote. "Unfortunately, I do not believe NJT's plans achieve this goal."

A coalition of passenger groups continues to complain bitterly about the project, calling the new dead-end station a waste of money.

"It's one of the greatest bamboozle schemes ever put out by a mass transit agency," said Albert L. Papp Jr., vice chair of the National Association of Railroad Passengers. "What NJ Transit has done is propose to build a brand new railroad for its exclusive use. This is unconscionable. There's only one chance to get this right in our lifetime."

NJ Transit, the lead design agency, said it dropped the Penn Station connection only out of necessity, after test drilling showed unstable rock above the new station's proposed location. As a result, engineers were forced to lower the cavern depth by more than 30 feet. The mezzanine of the new station, known as the Penn Station Expansion, will now lie 150 feet below ground.

Because of the change, any link to the existing Penn Station would be too steep to safely operate trains, the agency said.

The project's proponents say that they, too, would have preferred connections to both Penn Station and Grand Central but that the plan, even in a scaled-back form, is too important to delay.

"The transportation and economic benefits of this project are going to far surpass any of NARP's concerns," said Baldwin, the New Jersey advocate for the Tri-State Transportation Campaign. "We can't let the perfect be the enemy of the good."

CASSATT'S LEGACY

At the dawn of the 20th century, the Hudson River was a crowded place. Ferries provided the only means of transport to Manhattan, subjecting travelers to the vagaries of weather and currents.

Alexander Cassatt, president of the Pennsylvania Railroad, perceived a better way, one he believed would ultimately provide great benefit to his bottom line. He proposed a set of tunnels though the Palisades, descending below the river in Hoboken, and continuing to the world's grandest station, where a second set of tunnels would push out east to Long Island.

Editorial writers compared the project to the construction of the Panama Canal, which at the time was still years from completion. Cassatt's investors despised the idea.

"The shareholders thought it was a colossal waste of money," said Jill Jones, author of "Conquering Gotham," a book that chronicles the work. "Many people believed the whole project would fail because the tunnels would fail."

Indeed, previous efforts showed tunnel-boring was dangerous, uncertain work. Laborers known as sandhogs toiled deep underground, breathing compressed air in pressurized chambers that made them susceptible to the bends. Men sometimes died in cave-ins. They drowned when river water exploited cracks and rushed in. They were killed while handling dynamite.

An ambitious campaign to dig the first Hudson River tunnels -- now the PATH tubes -- proved particularly deadly. On one day alone -- July 21, 1880 -- 20 men drowned when the river breached one of the tunnels, which were financed by the Hudson & Manhattan Railroad.

Work was abandoned, only to be started again years later. The tunnels finally opened for service in 1908, two years ahead of the Pennsylvania Railroad tubes.

Given the many perils, Cassatt's tunnels had a remarkable safety record, Jones said, with just two lives lost.

Not that it was easy or quick.

Under the river, sandhogs pushed heavy shields through the muck, opening doors that allowed silt to flow through. Donkeys hauled the material away in carts. At the river's edges, the workers used axes to hack away at pier pilings and other debris, Jones said.

Because separate teams began tunneling on each side of the river, with plans to meet in the middle, alignment meant everything. The workers triangulated their positions several times a day, using piano wire that stretched out of the tunnels and up to towers on shore.

With every 2 feet, 10 inches gained, the sandhogs assembled large iron rings, forming the tubes' skeletons.

Progress could be painstaking.

Some days, Jones said, the workers made just 3 feet or less. Others, they advanced 30 feet. Through the life of the project, workers averaged about 14 feet a day, she said.

The first two teams met beneath the Hudson in 1906, three years after the start of construction. The two tunnels would open to the public four years later. Even then, Jones said, railroad officials worried the tubes wouldn't be safe because they shifted ever so slightly with the current. They still do so today.

"Having 750-ton trains going back and forth all day, they watched this with a fair amount of trepidation," Jones said. "But in the end, all was well."

CLAWING THROUGH THE ROCK

A century later, the philosophy of digging a tunnel remains largely the same, but the methods and technology have vastly improved.

Instead of piano wire to gauge position, today's workers use lasers and satellites. Custom-built tunnel-boring machines powered by electricity and controlled by computers claw through rock at a rate of 30 to 40 feet per day, reducing the need for blasting.

The leading edge of each machine, a disc more than 24 feet in diameter, is outfitted with some 50 wheels made of special steel alloys. When the machine advances, the wheels form concentric rings, splitting the rock ahead, said Dick Flanagan, the project's chief tunnel engineer.

The excavated pieces, generally smaller than a fist, then pass behind the machine on conveyor belts. The entire assembly stretches more than 300 feet, Flanagan said.

Beneath the Hudson, a similar boring mechanism known as an earth pressure balance machine is expected to advance up to 30 feet per day, using soil rippers to push through the silt. The machines operate without the need for compressed air, sparing modern sandhogs from the risk of the bends.

Some challenges are expected near the New Jersey shoreline, where the tough diabase -- igneous rock -- of the Palisades gives way to softer shale, siltstone and clay.

Dave Donatelli, project manager for the consortium of engineering and design firms working on ARC, said such mixed-base conditions can be dealt with by literally freezing patches of soft earth ahead with liquid nitrogen.

That allows the rock cutters to grind away without encountering a flood of runny material. A cementlike grout could achieve the same purpose, Donatelli said.

"It's extremely complex, but it's not something that we as engineers haven't done before," he said.

The tunnels will be lined with concrete, which can be poured on-site or delivered in sections.

In Manhattan, where the new station will sit in bedrock 450 million years old, workers will do more blasting. They also will use drilling jumbles, hydraulically powered machines with multiple arms.

Work on many of the project's various segments will take place at the same time, with construction expected to reach its busiest phase in 2012.

It is certain to be a test of organization and choreography.

"You'll have materials coming out of shafts and materials going into shafts, so you've got to take a systems approach," Flanagan said. "There's 100 things going on at once."

By the time the digging is done, workers will have cut through more than 8 miles of the underground, excavating an estimated 2 million cubic yards of rock, soil and silt -- enough material, Donatelli says, to fill Giants Stadium.

Some of that material will form the base of a new 82-acre rail yard in Kearny. More will be used to line embankments for new tracks that will run alongside the Northeast Corridor from Secaucus to the tunnels in North Bergen. Leftovers will be sent to approved dump sites.

All of it will be hauled by trucks. Day in and day out, dump trucks will head to and from Kearny and Secaucus. In Manhattan, where the most rock and soil will be excavated, an estimated 255 trucks per day -- 10 to 11 per hour -- will head to New Jersey and back through the Lincoln Tunnel.

ADDING UP THE COSTS

Taken in its entirety, it is expensive work, and it could grow even more expensive as construction moves ahead. Even the plan's backers say they won't be surprised if the final price tag -- financed entirely with public dollars -- runs $1 billion or more above projections.

As late as October of last year, planners said the work would cost $7.6 billion, or $1.1 billion below the current estimate. ARC spokesman Paul Wyckoff said the projection was raised because the Federal Transit Administration required that project managers factor in inflation at a higher rate and budget at least $500 million more for contingencies.

As it stands now, the Port Authority has committed $3 billion. NJ Transit has secured $1.5 billion, and an additional $1.25 billion will come from New Jersey toll revenues. The federal government is expected to fund the remaining $3 billion.

Zupan of the Regional Plan Association said the possibility of additional costs in the years ahead might seem hard to swallow, but he argued the expense should be measured in terms of the tunnels' life span.

"Once you build it, you'll probably have it not for 100 years but 200 years," Zupan said. "After all, the existing tunnels are 100 years old, and there's no sign we're going to shut them down. So the fact that it cost $1 billion or $2 billion more in 2009 is going to be pretty inconsequential when someone looks at it in 2109."