OVER THE ROAD

The $1.3 billion Eurasia Tunnel in Istanbul, Turkey, was completed in 2016.

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Tunnel Vision

Forget flying cars: Chances are tomorrow's transportation won't be overhead, but underground

By Matt Alderton

HUMANS HAVE ALWAYS BEEN obsessed with flying. The ancient Greeks, for instance, told mythical stories about Pegasus, a winged horse, and Icarus, who flew too close to the sun using wings fashioned from feathers and wax. In the 15th century, Leonardo da Vinci drew detailed plans to build a human-powered ornithopter, or flying machine. Even Henry Ford was preoccupied with flight. In 1926, he unveiled a

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The Eurasian Tunnel emerges on the Asian side of the Bosporus Strait in Istanbul.

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single-seat civilian aircraft that was supposed to be "the Model T of the air," and in 1940 he declared, "Mark my words: A combination airplane and motorcar is coming."

As the next era of transit comes into focus, however, there are signs that the future of transportation won't be in the air. Instead, it might be underground.

TUNNELING TOWARD TOMORROW

Consider the buzz around the hyperloop concept, a proposed mode of transit wherein passengers board pods that use magnetic levitation to travel long distances at airline speeds. Pioneers include The Boring Company, Elon Musk's venture that has nascent hyperloop projects underway in Los Angeles, Las Vegas, Chicago and Washington, D.C. With speeds of more than 600 miles per hour, hyperloop could reduce the travel time between Los Angeles and San Francisco from six hours by car to just 35 minutes.

Key to the concept are low-pressure tubes inside which hyperloop pods travel, similar in principle to the pneumatic tubes banks use to transport checks and cash from drive-thru customers to bank tellers. Although the tubes can rest above ground on pylons, many proponents — including Musk — would prefer to put them underground.

"The subterranean option allows hyperloop to realize its full potential in terms of speed," said David Pring-Mill, a tech-startup consultant and communications director for the nonprofit Hyperloop Advanced Research Partnership. "A system elevated on pylons would invariably have to deal with existing obstacles. The tube would have a curvature, and the pods would slow down. If the whole system goes underground, companies could design routes with straight lines and maximize speeds."

Urban planners are applying the same logic to conventional rail projects. London's Crossrail will encompass more than 73 miles of new underground railway, including five tunnels beneath central London. A project of similar scale, the $25 billion Grand Paris Express, will nearly double the length of the Paris Métro subway system by 2030.

Even roads are getting the subterranean treatment. In 2016, Turkey opened the first road tunnel between Europe and Asia, the 3.3-mile, $1.3 billion Eurasia Tunnel that traverses the Bosporus Strait between east and west Istanbul. In Australia, Samsung C&T Corporation, a global provider of construction and engineering services, is building WestConnex, a 21-mile roadway consisting mostly of underground tunnels designed to ease congestion in Sydney. And a proposed undersea tunnel linking Japan to the Korean Peninsula would make it possible to drive from Tokyo to Moscow.

"The future of transportation ... lies on linking people closer and letting them

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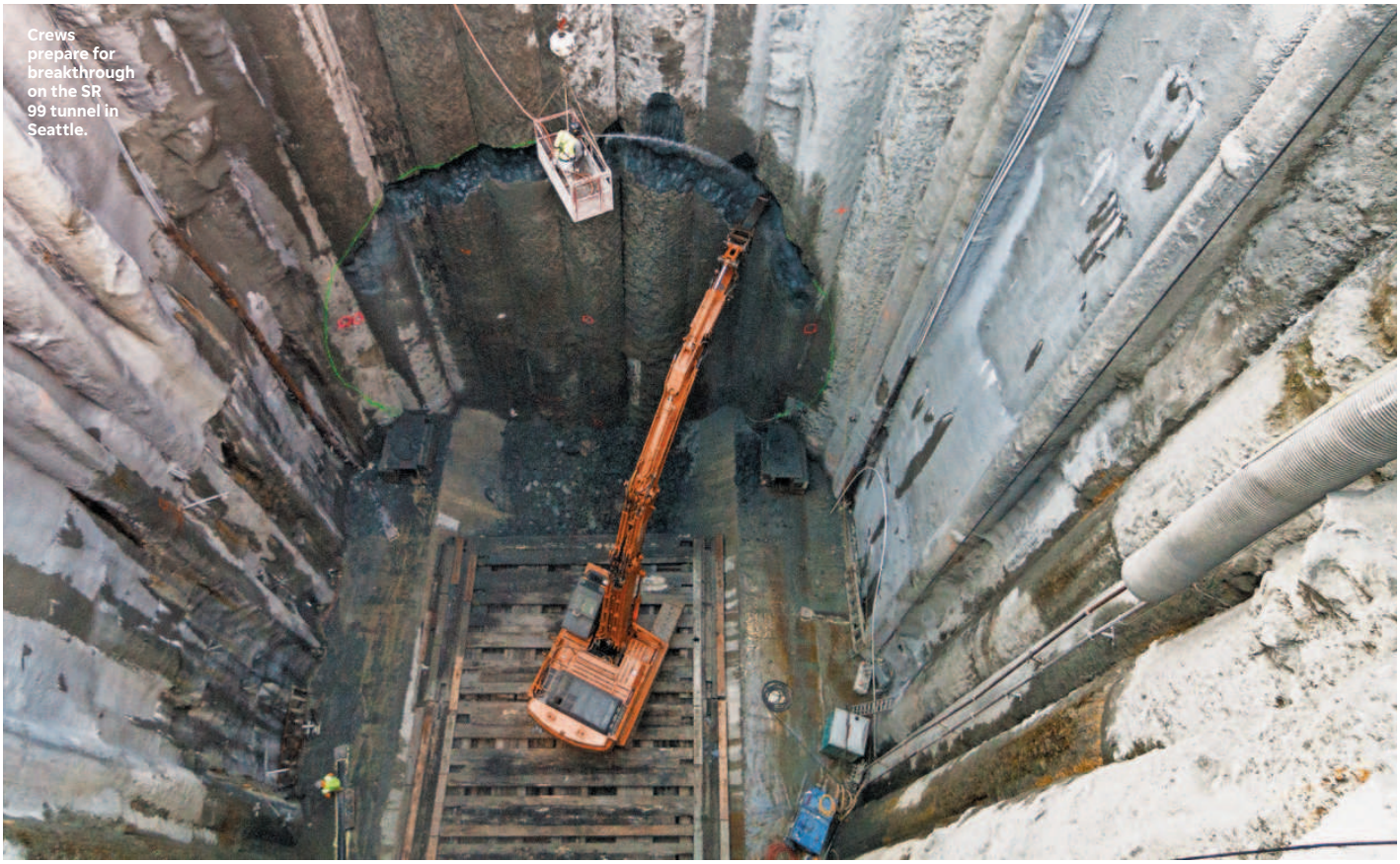

Crews prepare for breakthrough on the SR 99 tunnel in Seattle.

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

AMERICANS SPEND

97

HOURS PER YEAR SITTING IN TRAFFIC

SOURCE: INRIX

commute with ease," said Hyungrae Cho, manager of the infrastructure engineering team at Samsung C&T. "I think the tool to translate this into reality could be underground roads."

UNDERGROUND ADVANTAGES

Underground is dark, dank and dirty. As a transportation medium, however, it's advantageous for myriad reasons. For one, real estate in densely populated cities is at a premium. But where there is little space to develop on the surface, there can be unlimited space to develop beneath it.

"Subterranean transportation increases the available, traversable space by an extraordinary factor," Pring-Mill said. "Obviously, surface-level transportation operates within the limitations of existing developments, networks, natural barriers and right-of-way issues. That subterranean layer may have some pipes and cables down there, but for the most part, it can be whatever we make it."

More traversable space could mean less traffic — a significant upside, given that Americans lose an average of 97 hours and $1,348 per year to congestion, according to traffic analytics company INRIX.

Quality of life also could improve, because when transportation goes underground, surface space can be reclaimed for environmental and recreational purposes.

"If you're in an inner city that's overdeveloped, above-ground space is very valuable. There's a tendency to want to put transportation infrastructure underground to make better use of that space," said Werner Burger, chief engineer at Herrenknecht, a German manufacturer of tunnel-boring equipment whose portfolio includes the Eurasia, Crossrail and Grand Paris Express projects. "That's what they did some years ago in Madrid, when they moved a big road underground to have more open space on top in the inner city."

Completed in 2015, the decade-long Madrid Rio project buried 25 miles of urban roadway that for more than 30 years had separated Madrid from the Manzanares River. Where the surface road once stood, the city installed 370 acres of green space and 17 acres of public facilities, including cafés, urban beaches, athletic fields, art centers and playgrounds.

A similar vision exists in Seattle. There, an elevated freeway is currently being dismantled following construc-

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When completed, London's Crossrail project will add 73 miles of underground railway.

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tion of the SR 99 tunnel, a two-mile, double-decker tunnel completed this year to replace the 66-year-old Alaskan Way Viaduct, which acted like a concrete curtain between downtown Seattle and picturesque Elliott Bay.

"We had a small earthquake that damaged the highway in 2001, and we had to figure out what to do with it — rebuild it, repair it or replace it," said Tyler Sandell, director of business development at The Robbins Company, a Seattle-based manufacturer of tunnel boring equipment. "Politicians and voters ... decided it would be best to tear that structure down and replace it with a subsurface tunnel so we could develop the waterfront."

Above the tunnel, plans call for a new surface-level Alaskan Way with public transit, a bike trail and a landscaped promenade for pedestrians.

BETTER BORING

Underground transportation isn't just becoming more attractive. Thanks to next-generation tunnel boring machines (TBMs), it's also becoming more feasible.

"Nowadays, tunnels can be built that would not have been possible 20 years ago," Burger said, thanks, in part, to the fact that TBMs have gotten larger. "In the last 10 to 20 years, diameters on tunnels have grown significantly," said Mike Mooney, professor and Grewcock chair of underground construction and tunneling at the Colorado School of Mines in Golden, Colo. "We've gone from subway-sized tunnels, which are roughly 20 feet, to a roadway tunnel like (Seattle's SR 99), which is 58 feet."

TBM manufacturers and tunneling contractors have also refined their skills so they can now excavate tunnels without disturbing surface structures. "That's huge, because it allays the concerns of decision-makers in urban environments and brings down costs, since you don't have to fortify buildings or pretreat the ground, both of which cost a lot of money," Mooney said.

Yet a third development is the advent of "crossover" TBMs. "In the last decade we've been very successful at combining hard-rock with soft-rock machines so we can tunnel in a variety of conditions," Sandell said. "In the past, you had to have two different machines, which limited where you could do tunneling because it was cost-prohibitive. Now that we have machines that can cross between different geologies, you can do more tunnels in more areas."

The possibilities are as big as the ground is deep. Unfortunately, money is still an obstacle, even if technology isn't.

Musk says his hyperloops will cost $10 million per mile to build, but present-day tunnels are far more expensive. A 2018 analysis of recent subway projects by CityLab, for example, found that some cost nearly $1 billion per mile. A new four-lane highway, by contrast, costs $8 million per mile in an urban location and as little as $4 million in rural and suburban locations, according to the American Road & Transportation Builders Association.

"Most of this is contingent on the idea that the costs associated with tunnel boring can be dramatically reduced. Engineers have suggested this is possible ... but there's the big question of when," Pring-Mill said. "The Earth itself is not the only obstacle that innovators will need to cut through."