How The Uncommon Became The Commonplace

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How The Uncommon Became The Commonplace

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Highway innovations that seemed impossible at one time are now like any other technological marvels, where we wonder, "How did we ever get along without them?"

Innovation often seems inevitable to later generations, as California Governor Culbert L. Olson pointed out during the opening ceremony for the Arroyo Seco Parkway. (L-R): Highway Commissioner Amerigo Bozzani, Director of Public Works Frank W. Clark, Queen of the Rose Festival Sally Stanton, Governor Olson, Highway Commission Chairman Larry Barrett, and Chief Ray Cato of the State Highway Patrol.

In the late 19th century, when interest in good roads was growing after years of railroad dominance, the guiding principle was "we've always done it this way." The standard design guide was the "rule of thumb." And financing was often garnered by "working out the road tax"--the levy that farmers paid by donating a day or two each year to working on the roads in their community. The result, Professor Nathaniel S. Shaler of Harvard University pointed out in 1889, was that

"the common roads are built and maintained in the most ignorant and inefficient manner."

To use a late 20th century cliché, a lot of people had to think outside the box to create the modern transportation network that today's road users take for granted. Governor Culbert Olson of California had this problem in mind on December 30, 1940, during the opening ceremony for the Arroyo Seco Parkway (now part of the Pasadena Freeway) in Los Angeles, CA. He wanted to memorialize the first freeway in the West "before it fades from memory" because, "Now that we have it, and it all looks so rather simple, so obviously necessary, so wholly practical, some will ask, 'What is there so wonderful, or so bold about it?'"

Many wonderful bold ideas of the road revolution have indeed faded from memory, or more correctly, were never lodged in the Nation's collective memory. They blurred into the background, as if these innovations were always there, like mountains and rivers. Perhaps some of the ideas can be attributed to lightbulbs going off, as in cartoon depictions of inventors, but most evolved from the hard work of individuals working alone, collectively, serially, or as gears in a bureaucracy, often anonymously, to create the world of tomorrow that Americans today are lucky enough to inhabit.

Predictions Are Easy

Not long after Shaler's description of common roads, the American Press Association asked the leading men and a few women of the late 19th century to predict what life would be like 100 years hence--in about 1992 (for today, that would be about 25 years ago). In the field of transportation, the experts predicted that the government would own the railroads and telegraph lines. High-speed rail, with speeds up to 100 miles (161 kilometers) an hour, would enable passengers to eat breakfast in New York City and supper in Chicago. Goods would be transported by pneumatic tubes. Citizens would be as likely to call for their blimp as for their buggy. And, according to Chicago Mayor Hempstead Washburne, transportation

problems in great cities would be solved by some new genius who was as yet unborn.

In 1893, Chicago Mayor Hempstead Washburne predicted that congestion in cities would be solved by some genius who was as yet unborn. The genius was apparently still unborn in 1944 when this photograph of traffic on Second Avenue in Detroit, MI, was taken from West Grand Boulevard. Today, the country still awaits the genius.

A few of the leaders queried by the American Press Association did mention roads, including one very bold individual, U.S. Senator William A. Peffer of Kansas, who went so far as to predict that roads would be improved. But none of the seers predicted, even remotely, the future of the automobile and the highway. As for that unborn genius who would solve the transportation problems in cities, the wait continues.

All of which proves that making a prediction is easy, especially if the prognosticator expects to be dead when the prediction proves false. Shaping the future is much harder.

The Innovation That Started the Modern Era

If you are a motorist who curses every passing

bicyclist, you might be surprised to learn that the Nation's modern road network began as a product of the bicycle craze of the 1880s and 1890s.

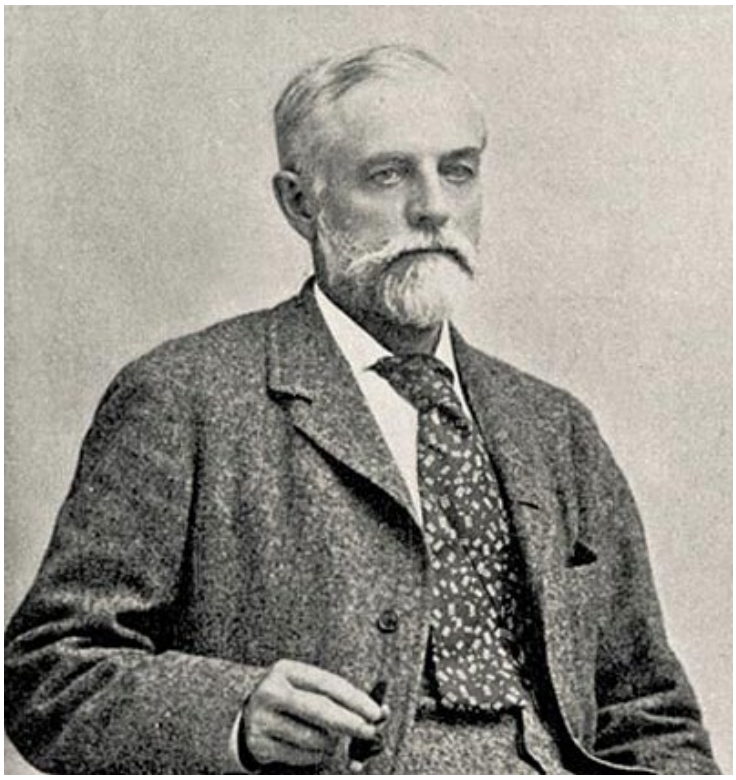
The "ordinary" (the bicycle with the big front wheel) may seem primitive to 21st-century eyes, but it created a craze that swept the Nation and the world. When the "safety" became available with equal-size wheels, the revolution seemed to contemporary observers to be permanent.

Unfortunately, the country roads that bicyclists wanted to ride on had not seen an innovation in decades. The League of American Wheelmen, bicycle makers such as Colonel Albert Pope, and league advocate General Roy Stone urged Congress to help improve rural roads, which were "hardly jackassable," to employ a cliché of the times.

In 1893, as the prognosticators longed for a genius, Congress was willing to invest only $10,000 in the Nation's roads. The appropriation was not for construction, but for a Department of Agriculture inquiry into systems of road management, the best methods of roadmaking, and the dissemination of information.

Secretary of Agriculture J. Sterling Morton selected General Stone to head the Office of Road Inquiry. With the congressional pittance in hand for anything but roadbuilding, he described the little agency's role: "It simply furnishes a rallying point for the friends of the reform and a signal tower from which its progress can be watched and reported day by day."

The bicycle is so much a part of the world today that it is easy to forget that it was once innovative. Bicyclists, such as this group of Missourians, launched the Good Roads movement. Most of these riders were still using the "ordinary" (big front wheel), but the riders on the left are perched on "safety" bicycles (equal-size wheels).



General Roy Stone, a Civil War hero, worked with the League of American Wheelmen to urge Congress to fund better roads. In 1893, Congress appropriated $10,000 per year to study the subject and disseminate information. General Stone was selected to head the Office of Road Inquiry, part of the Department of Agriculture.

The Blank Slate

As has been true throughout history, people tend to adjust their lives to the pace of transportation. Over time, each innovation that the United States experienced--stagecoaches and Conestoga wagons, steamships, canals, telegraphs, the Pony Express, streetcars, and especially railroads--was hailed for its ability to shorten distances and bring a diverse country together in a union of common interest. In the 19th century, railroads were the ultimate mode of surface transportation, able to shrink the continent from months of weary travel at the speed of an ox to a mere 5 or 6 days by steam power.

As Stone began what he called a "peaceful campaign of progress and reform," rural roads were virtually a blank slate. Since the coming of the railroad, rural and interstate roads had been left mainly to the stewardship of counties and townships that cared little about them. Shaped more by happenstance and weather than plan, these roads slowed farmers trying to move produce to market, trapping them in mud, or enveloping them in dust. Moreover, the roads lacked the infrastructure that made long-distance travel possible: no direction signs, hotels, campsites, or blacksmiths for repairs.

To fill in that blank slate, Stone began what, so far, has been more than 120 years of innovation to improve roads, starting with their surfaces, and to expand the State, local, and Federal commitment to the Nation's roads. Over that span, the process of innovation included observing needs, finding ways to meet them, convincing the highway community to adopt the innovations, and, as needs changed, improving those means through an evolutionary process.

Building a Foundation For Innovation

In the months before Stone opened the Office of Road

Inquiry on October 3, 1893, the country plunged into a devastating recession, the worst until the Great Depression of the 1930s. With the Office of Road Inquiry's annual $10,000 budget--only $8,000 some years in the tightened economy--Stone needed innovation just to pay for his efforts.

In today's terms, Stone relied on public-private partnerships with the League of American Wheelmen, roadbuilders, railroads, and farm groups to promote his agency's ideas. He employed innovative financing to encourage stakeholders to contribute equipment and supplies. He undertook outreach by using the government franking privilege to mail millions of brochures all over the country. And he used public involvement as he and his assistant Maurice O. Eldridge, and soon others, traveled across the country to give speeches advocating for good roads, scientific research, and the economic value of improving farm-to-market roads.

In the mid-1890s, Stone adapted a Massachusetts innovation to develop one of the agency's most successful methods of dissemination: the object-lesson road. Agents visited a city, held a good roads meeting, and demonstrated best practices by building a short stretch of road using local materials and borrowed equipment. People came from throughout the area for the speeches and demonstrations. The concept was based on the idea of "seeing is believing," in the hope that residents who used the short new road would see its advantages and encourage local officials to employ the same techniques to extend the road and build others like it. (For a modern take on technology demonstrations, see "Innovations Hit the Road" on page 12.)

Stone's successor, Martin Dodge, went further by introducing Good Roads Trains, an innovation conceived by his friend, Colonel William H. Moore of the National Good Roads Association. The trains took speakers, displays, and borrowed equipment on regional tours with stops at each major city for a good

roads convention and an object-lesson road project. Railroad companies were pleased to help arrange the tours because good roads made it easier for goods to reach the railroad stations.

This photograph, from 1901, shows crowds watching a mobile crushing plant produce macadam for a road in Winston-Salem, NC, as part of an object-lesson road project.

Selling ideas, whether by object-lesson roads, speeches, articles, convention displays, or other means, has long been a part of the Federal road agency's mission. PUBLIC ROADS is a good example. From its first issue, dated May 1918, the magazine has chronicled the evolution of road science.

More recently, the agency created the Demonstration Projects Program in 1969 to promote and accelerate the widespread adoption of the practical results of highway research and their application to innovative planning, engineering, and construction practices. The program included field and hands-on demonstrations, installation of pilot demonstrations, and workshops. Although the program no longer exists, the Federal Highway Administration (FHWA) continues to promote innovative ideas through such methods as training, webinars, demonstrations, and, of course, PUBLIC ROADS.

In the fall of 1901, the Office of Road Inquiry participated in the Southern Railway Good Roads Train, one of the most elaborate of the innovative Good Roads Trains of the era. At each major city, participants held a good roads convention and used borrowed equipment to build an object-lesson road.

Stone and Dodge set a pattern of innovation, coupled with promotion, that their successors would adapt for their own times to explain and promote more than a century of advancements. FHWA's most recent agencywide initiative, Every Day Counts, as launched by then Federal Highway Administrator Victor M. Mendez (2009–2014), follows the same pattern of identifying needs, finding solutions, and promoting them among a broad range of representatives from State transportation departments as well as city and county agencies, and industry representatives.

Better Pavements

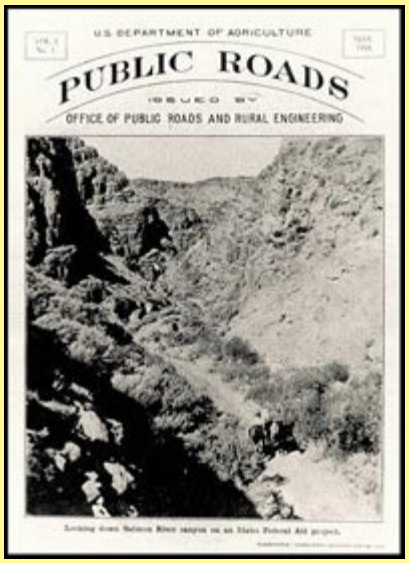
When the blank slate was at its blankest, the first issue was mud.

No one likes getting stuck in mud, but until well into the 20th century, being extracted from mud was a rite of passage. All road users paid the "mud tax," as their horses, mules, and wagons became mired following rain.

By the time of the bicycle craze, the best pavement for those who didn't like mud was macadam, which was named for John Loudon McAdam, a Scottish engineer and roadbuilder (1756–1836). The technique, first employed in 1816 on England's Bristol Turnpike, involved using layers of different sized stones, compacted and built above the water level, and raised slightly in the center for drainage to minimize the damage that water typically does to roads. Transportation historian M. G. Lay called McAdam's innovation a "quantum advance" over earlier techniques.

PUBLIC ROADS Magazine: Chronicling Innovation

From the first issue of PUBLIC ROADS, dated May 1918, the magazine has been about innovation in the field of highway engineering. In a salutatory opening in the first issue, Director Logan Waller Page of the U.S. Office of Public Roads and Rural Engineering wrote that the new magazine was "dedicated to those, both in official and private life, who are concerned [about] developing means of better rural communication, . . . facilitating the marketing of the crops of the


U.S. DEPARTMENT OF AGRICULTURE

PUBLIC ROADS

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OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING

The first issue of PUBLIC ROADS, dated May 1918, stated that the magazine grew out of "a determined and united disposition to bring to road betterment that which is best in and for this generation."

Nation, and, . . . aiding in the solution of the daily more perplexing traffic problem." The goal was to incorporate the work of those "who have in mind the ambition and at heart the desire to advance to as near perfection as possible the science of roadbuilding."

Page did not want the new magazine to be perceived as a dictator of best practices, but rather wanted his agency to use "the superior facilities at its disposition" to help the State highway agencies and others advance highway science. "It will be our earnest effort--always with the support and cooperation of the highway organizations of the States--to present matters of special interest to those directly concerned with the construction and maintenance of roads, to bring to all the progress of road improvement throughout the country, to discuss its problems and record its results."

From the start, PUBLIC ROADS has reported on innovative measures on pavements, bridges, safety, and program administration, concerns that remain today and still appear regularly as topics in the magazine. Over the years, however, the focus has broadened as the magazine, like the agency that publishes it, has focused on improving the social, environmental, and economic impacts of highways; coordinating intermodal systems; and making highways better neighbors.

As Page noted, the United States was at war in Europe in May 1918, but he hoped that PUBLIC ROADS would reflect "a determined and united disposition to bring to road betterment that which is best in and for this generation." Ninety-seven years and several generations later, PUBLIC ROADS remains a chronicle of highway innovation.

In the United States, macadam was first used in 1823 on a Maryland turnpike between Hagerstown and Boonsboro. But most rural roads remained little more

than dirt paths, known as earth roads.

As motor vehicles began to travel the few expensive macadam roads in the 20th century, the pavements deteriorated quickly. As the problem made itself evident, no one could figure out how to strengthen macadam pavement to accommodate the automobile.

In 1908, Dodge's successor, Logan W. Page, blocked off a section of Conduit Road above Cabin John Bridge in Washington, DC, to experiment with pavement used by high-speed automobiles traveling at 50 to 60 miles (80 to 97 kilometers) per hour. He used still and motion picture cameras to record the effect of the tires on the macadam.

Page concluded that the "factor of destruction," especially at higher speeds, made macadam an unsuitable pavement for the auto age. In a November 1909 presentation, he said, "With this problem before us, and a rapidly increasing motor traffic, the highway engineers throughout the world are at present investigating every known material that gives the slightest promise of meeting the conditions that confront us."

Officials around the country experimented with the materials at hand, including brick, clay, gumbo (clay soil burned into ballast), limestone, crushed oyster shells, and sand-clay. The Federal road agency studied alternatives for lower priced road surfacing, as well as ways of making dirt roads more stable and less dust-prone. The Federal researchers issued publications on their findings.

Still, earth roads ruled. When the Office of Public Road Inquiries (Dodge's renamed agency) conducted the first national inventory of rural public roads in 1904, earth roads ruled--2 million miles (3.2 million kilometers) out of 2.15 million miles (3.5 million kilometers). Only 153,662 miles (247,295 kilometers) had an added surface, such as gravel, stone, shells, or sand-clay.

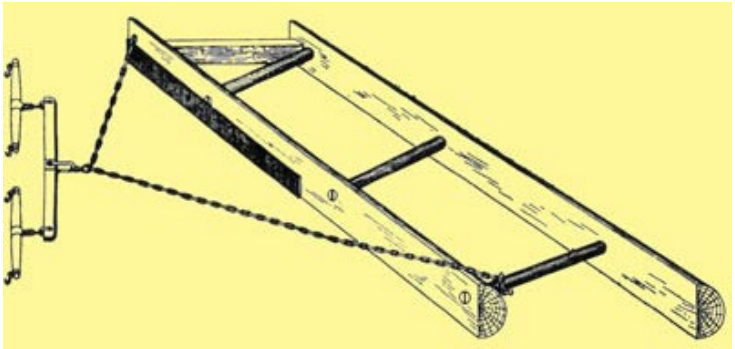
Inevitably, innovators focused on the problems of earth roads, which nearby farmers periodically

"dragged" smooth. In the early 20th century, a Missouri farmer named D. Ward King invented a simple split-log drag that could be made easily by any farmer. King would split a log lengthwise--diameter about 8 inches (20 centimeters)--and position the two halves, one ahead of the other and held about 3 feet (0.9 meters) apart by struts, to make a rigid platform. The lower edge of the front log held a 0.25-inch (0.64-centimeter) steel cutting plate. It cost about $2 (in the dollars of the day, of course) to make the King split-log drag, which was pulled by a team of mules or horses.

The King split-log drag was an inexpensive, easily made, and effective way of improving country roads for the usual light traffic. King traveled the country promoting his invention, with help from Page, who distributed a farmer's bulletin in 1906 about the King drag.

During this first decade of the 20th century, most automobiles were expensive, hand-crafted vehicles that only the well-off could afford. Henry Ford's innovation, the Model T, introduced in 1908, was an inexpensive vehicle designed for the times, with a high carriage to avoid scraping the ruts.

"America's love affair with the automobile," a widespread 20th century expression (used at times in admiration, other times in disapproval), began with the Model T. It transformed the automobile industry and the way people traveled, but exposed the inadequacy of the country's roads in a way that mattered to average folk, not just the wealthy few.



D. Ward King's design for a split-log drag was easily

built and just as easily used to level an earth road. This diagram is from the Department of Agriculture's 1908 bulletin, "The Use of the Split-Log Drag on Earth Roads," written by King.

In the wake of the Model T, Page continued experimenting to address broader problems as the automobile replaced the bicycle as the vehicle of choice for rural travelers. Dust was one of the biggest issues. If you have ever wondered why photographs of early motorists show them in goggles, hats, and long outer garments known as "dusters," now you know why they were essential.

Page conducted experiments to search for ingredients that could control dust. The agency tried oil, blast furnace slag, and mixing the earth with a binder such as bitumen. These experiments gradually shifted from "dust prevention" to "road preservation," and to the adoption of bituminous surfaces for rural roads, the forerunner of today's asphalt pavements. Ultimately, the solution to dust was to eliminate its cause by providing all-weather surfaces such as asphalt and concrete.

An Innovation Before Its Time

While traveling by train from Tennessee, Eldridge (now Dodge's assistant) and Representative Walter P. Brownlow (R-TN) began talking about the poor condition of country roads. They agreed that Eldridge would draft a bill based on a State aid concept first tried in 1891 in New Jersey. In December 1902, Brownlow introduced the bill, which would create a Bureau of Public Roads (BPR) to administer $20 million a year in Federal aid. Grants would be made to any State or county for the improvement of public highways "for the purposes of common traffic and travel, and for the rural free delivery of mail" outside cities and incorporated villages, with each State limited to a share of the funding equal to its percentage of the Nation's population. The State or county would pay 50 percent of the cost of the roads. The Federal Government would prepare the plans and

specifications, but the State or county would administer and supervise the contracts.

Logan W. Page, who headed the U.S. Office of Public Roads, conducted tests on Conduit Road (now MacArthur Boulevard, north of Cabin John Bridge in Washington, DC) to determine why automobile tires ruined macadam roads, the best paving surface of the horse-and-buggy days. Cameras recorded the effect of the tires, leading to the conclusion that the "factor of destruction" was too great; a new hard surface would be needed for the automobile era.

As Representative Brownlow told a reporter, "Once let it be understood that the desired result can be accomplished through a system of cooperation aided, fostered, and encouraged by the general government, and then let the people of the country express themselves in favor of the plan, and you will find that Congress and the Constitution will not be against but for it."

With Eldridge secretly joining with the Automobile Club of America in support of a $10,000 publicity campaign, the Brownlow bill proved popular with almost everyone except President Theodore Roosevelt, Secretary of Agriculture James Wilson, and congressional leaders. The bill died, and when Eldridge's behind-the-scenes role was revealed, he was first fired, then rehired with a demotion.

In part because of Dodge's role in the bill, he became a victim of revenge, too. In 1905, Congress made the Office of Public Roads (not yet the Bureau of Public

Roads since the Brownlow bill had failed) a permanent agency in the Agriculture Department, but specified that the director "shall be a scientist and have charge of all scientific and technical work." This language excluded Dodge, a lawyer, who was replaced by Page, a scientist who was one of the first graduates of the highway engineering program that Page's uncle, Professor Shaler, had begun at Harvard.

No one–not even these officials with the Office of Public Roads–could escape getting stuck in mud during the years before hard surfaces became common for the country's roads.

As FHWA's bicentennial history book, America's Highways 1776–1976, put it, Dodge and Eldridge had "pushed a right idea before its time."

A Series of Innovations

The Federal-aid highway program is an innovation, or more accurately, a series of innovations that started with the Federal Aid Road Act of 1916 and continued, thus far, until 2012's Moving Ahead for Progress in the 21st Century Act.

The Federal Aid Road Act of 1916 created the Federal-aid highway program along lines suggested by Representative Brownlow and Eldridge. It differed in making States, not counties, the primary partners

and giving them responsibility for selecting, designing, and constructing Federal-aid highway projects, subject to agency oversight.

Representative Walter P. Brownlow introduced a Federal-aid highway bill in Congress in 1902. He told a reporter that if people understood that the Federal Government could help build good roads, "you will find that Congress and the Constitution will not be against but for it." Like many innovations, his proposal was ahead of its time and went nowhere.

Since then, the program has required a number of innovations to survive into the 21st century. A few of those milestones include focusing funds on designated systems of roads (1921), adapting the program to job creation during the Depression, expanding into cities (1930s), designating a National System of Interstate Highways (1944), and dedicating highway user taxes to pay for the construction of the interstate system and other Federal-aid highway projects (1956). Others include requiring a continuing, cooperative, and

comprehensive planning process in metropolitan areas (1962); embracing environmental awareness (1960s); becoming part of the U.S. Department of Transportation (1967); withdrawing controversial interstate segments in return for funds for other purposes, including rail rapid transit (1973); and establishing a framework for a post-interstate program (1991).

Filling in the Blanks

In the 21st century, motorists travel the country in air-conditioned cars with state-of-the-art sound systems, DVD players to amuse the kids in the back, USB ports to power the ubiquitous devices, safety rest areas for travelers' comfort, and service stations just beyond almost every interchange ramp.

One hundred years ago, long-distance travel did not involve fighting over what music would provide the soundtrack for the journey. And the roadside infrastructure to support long-distance travel appeared only gradually.

The extent of the blankness of the country's roads is reflected in how road guides of the day advised motorists to prepare for their trips. In the 1910s and 1920s, the guides advised motorists to take food, a tent, extra gallons of gasoline, spare tires and tire-patching materials, a gun or rifle, and a block-and-tackle to extricate trapped vehicles from the inevitable mud. Guides advised motorists not to wear new shoes and to consider their interstate travels "something of a sporting proposition." Motorists, in short, were on their own.

Necessity may be the mother of invention, but as any parent knows, aggravation can inspire desperate solutions. Interstate motorists camped on the roadside since they had no choice between towns. The roadside was, to put it politely, their restroom--over there behind that tree, bush, rock, or hill. When enough farmers objected to these intrusions, communities created motorist campsites. Gradually, communities began competing for motorists by introducing amenities such as water, showers,

restrooms, and food.

As traffic increased, entrepreneurs installed cabins by the road. Owners competed for business by building better cabins with more facilities. The cabins became motels, a term coined in 1925 as an abbreviation for motor hotel. The individually owned motels, well known to motorists of the 1920s through the 1950s, were replaced in the interstate era by chain motels providing identical facilities from sea to shining sea and border to border.

Maurice O. Eldridge, assistant director of the Office of Road Inquiry in 1903, advocated for the innovative idea of a Federal–aid highway program before its time.

Barriers

The idea of gradual or continuous innovation applies

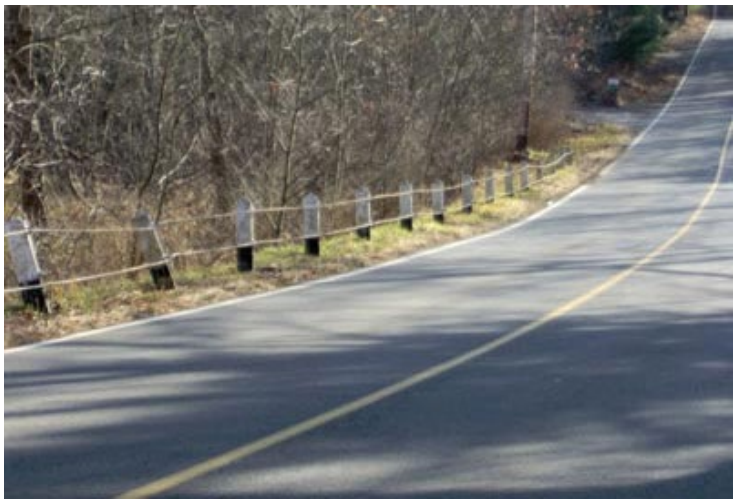
to many features of U.S. roadways.

At slow speeds, for example, going over a cliff or running into a tree or rock embankment takes extraordinary if not alcohol-induced inattention, uncommon lack of skill, and/or amazingly bad luck. High-speed vehicles made it much easier to run off the road.

Officials searching for ways to keep vehicles on the pavement tried alternatives that early on included wire rope cables linking wood or concrete posts. The number of cables increased, and the cable became stronger, but in 1925, a tension plate replaced the cables. Many innovations later, guardrails had become enabling a common feature of the roadside.

Several States began experimenting with concrete barriers in the 1940s to handle out-of-control trucks that plunged through guardrails and to reduce the cost of replacing guardrails in high-crash locations. In the 1950s, the New Jersey State Highway Department began using a concrete barrier developed by the Stevens Institute of Technology that functioned as more than a simple barrier. The sloped lower part of the barrier reduced damage by enabling vehicle tires to ride up on the sloped part to dissipate momentum and friction. The driver could regain control of the vehicle more easily and with less damage than might have been the case otherwise.

Although the New Jersey safety-shaped concrete barrier was invented for permanent use in narrow medians, "Jersey barrier" segments are also portable. They are used widely on either side of roads, in work zones, and around any type of construction, including many nontransportation settings such as around building sites and as security barriers.



Innovations often consist of a series of moves that improve upon past innovations. For example, this wire rope cable barrier on precast reinforced concrete posts was a common sight on many New England roads in the 1930s and 1940s. They were effective only up to a point. According to a U.S. Bureau of Public Roads report from 1936, "precast reinforced concrete posts are brittle and likely to crack under heavy impacts."

You probably have noticed yellow barrels arranged bowling-pin style between a highway lane and an exit. They are impact attenuators filled with sand to disperse the energy of impacts in an explosion of sand to reduce damage to vehicles and occupants. The most common type, which was invented by race car driver John Fitch, began appearing on the Nation's roads in the 1960s. Aside from their value in saving lives and reducing injuries, the barrels have proven themselves to be a dramatic special effect, when filled with water, for crashes in movies and television shows.

The Computer Revolution

Innovation sometimes involves adapting ideas from another field for the work at hand. The computer is an example.

Data are at the heart of highway construction. Highway engineers such as Logan Page and Thomas H. MacDonald (who together headed the Federal road

agency from 1905 to 1953), believed that data would enable them to make nonpartisan, scientific judgments, but processing the data was a complex challenge. For example, as mentioned earlier, the U.S. Office of Public Road Inquiry conducted the first national road inventory in 1904. The agency had to tabulate information from more than 60,000 communications with State, county, and township officials, a task that delayed publication until 1907.

The development of high-speed computers during World War II resulted in a breakthrough in data processing. By 1957, BPR's annual report began chronicling computer use: "An important activity in the past few years has been the development of applications for electronic computers as a means of expediting highway engineering operations and increasing highway engineering productivity."

Highway officials quickly adopted the card–sorter machine (as shown in this 1961 image from BPR's Data Processing Branch) to meet transportation needs.

The agency was working with the State highway agencies to compile "a library of electronic computer 'programs' for the solution of highway engineering problems." The concept was so new that the agency felt it needed to explain what a "program" was, namely "a detailed set of instructions regarding the feeding of data into the computer, and the sequences of

operations to be performed by the machine, in order to obtain the desired solution to a specific problem."

The library of programs was to be shared with any State highway department or other cooperating agency. Already, 35 State highway agencies had decided to use electronic computers.

E. H. "Ted" Holmes, BPR's top urban planner until his retirement in 1971, recalled the computer breakthrough in the 1940s and early 1950s as BPR worked with State and local officials to determine where urban interstate highways should be built. The bureau had extensive data based on innovative polling techniques developed on a sampling basis with the Bureau of the Census. However, BPR had little ability to understand the relationship among travel desires, land use, and other social and economic factors.

Holmes wrote: "It was not until the high speed computer became available, and perhaps the almost simultaneous introduction into the field of highway planning of the sociologist, the geographer, the economist, and the city planner, that a real breakthrough in establishing these relations was achieved."

Initially, BPR used computers owned by others, including the Univac I at the Bureau of the Census and the IBM 705 owned by the DuPont Company in Wilmington, DE. But BPR soon began purchasing its own computers. In March 1961, for example, BPR installed a medium-scale computer with four magnetic tape units and 8,000 characters of memory in its headquarters, replacing a medium-size digital computer, compatible with punch cards, installed in 1958.

In June 1968, FHWA installed a Calcomp line plotter that could read a magnetic tape produced on a computer, interpret the data and its format, and draw the desired plan with up to four colored inks or ballpoint pens on regular drawing paper. The plotter tabletop was so large that it did not fit in the building's freight elevator or stairwell and had to be hoisted by crane through a window removed on the 7th floor.

Gradually, computers transformed how highway officials did business. A personal computer (PC) could be found on virtually every employee's desk. Slide rules, which once hung from the belt of every highway engineer, disappeared. Computer-aided designs for highways and bridges replaced drafting boards. Modeling became easier for traffic projections, noise impacts, conformity with clean air requirements, and many other purposes. Emails allowed instant communication. Management systems, initially for pavements and then bridges, enabled officials to synthesize large amounts of data before setting priorities for project selection. Electronic toll collection gave renewed importance to innovative financing techniques such as tolling and value pricing. Gradually, the computer combined with satellite tracking for such innovations as intelligent transportation systems and geographic information systems that have altered many aspects of transportation, including highway safety and trucking.

Meanwhile, secretaries, stenographers, and the "typing pool," innovations from a distant past that a few oldtimers remember, were disappearing. The computer shifted some clerical functions to the professional staff, many of whom miraculously discovered that they could type as soon as a keyboard with a PC attached to it arrived on their desks. Steno pads and shorthand, Dictaphones, and carbon paper disappeared along with the slide rules.

(To young people reading this article, if you don't know what a slide rule, carbon paper, or type-writer is, don't panic. You'll never need to know.)

From Innovation To Humdrum

On any street, the most commonplace objects were once innovative. Signs, traffic lights, medians, street lighting, overhead wires, pavement markings, the pavements themselves, WALK and DON'T WALK signs, street parking regulations, parking meters, and parking tickets. Someone at some time had each of these ideas and helped make them so universal that

their creators' names are mostly forgotten. Even the fact they didn't exist at one time has been lost to time.

Innovations Gone Awry

The experimental steel track shown here was installed at the Trans-Mississippi and International Exposition in Omaha, NE, in 1898, to test its effectiveness as a solution to the alternatively muddy or dusty earth roads of those days. Here, Martin Dodge of the Office of Road Inquiry was seated in an electric car (left in the front seat in top hat). The cost of steel was one of the main reasons this idea did not catch on. Note that the steering wheel–an innovation itself–was not yet in common use.

It is likely that no one has ever calculated the ratio of good to bad innovations, but the U.S. road network has experienced its fair share of the latter. Here are a few that most engineers would rather forget:

Steel track roads. General Roy Stone and Martin Dodge promoted the idea of placing two narrow steel tracks in the road to provide solid support for vehicles. The agency built several experimental sections of steel track roads, but they proved impractical, in part because of the cost of the steel.

Three-lane highways. With a center lane for passing, this 1930s design concept was intended to enable motorists to pass on the narrow roads of the day. As impatient motorists

passed slower moving vehicles in both directions at the same time, this innovation became known as “suicide” lanes.

Transcontinental superhighways. During the 1920s and 1930s, many visionaries imagined a single toll superhighway across the continent, with multiple lanes for different types of traffic, access control, grade-separated intersections, concession areas, and room for airports and utilities. T. E. Steiner, a businessman from Wooster, OH, was one of the many well-known advocates of this idea. He formed the Transcontinental Streamlined Super-Highway Corporation and promoted his plan throughout the country, including in testimony to Congress, promising that the network could be built from tolls and fees without Federal funds. These ideas generated public interest but went nowhere as the Bureau of Public Roads began promoting an interregional highway system in the late 1930s, forerunner to the interstate system.

Building through parks. To minimize disruption to homes and businesses, why not build freeways through urban parks? Just one problem: people loved their parks. Battles in Baltimore, MD; Memphis, TN; San Antonio, TX; and everywhere else roadbuilders tried this innovative solution, resulted in frustration and, mostly, parks without freeways in them.

At the start of the 18th century, no one knew the steamship would be invented and dominate long-distance transportation by water. At the start of the 19th century, no one knew the railroad would be invented and do the same for surface transportation. At the start of the 20th century, no one knew that motor vehicles and the airplane would become the dominant modes.

And today, fairly early in the 21st century, no one knows whether some other transportation innovation is just around the corner to dominate the rest of the century--perhaps teleportation (preferably as in "Star Trek's" "Beam me up, Scotty," rather than as in "The Fly" movies where people emerge with fly parts). Or

driverless cars, drones for small shipments, pavements made of solar panels that generate energy while carrying traffic, magnetic levitation trains (all safe predictions since they exist in varying degrees of development) or, a personal favorite, jet packs. Maybe everyone will have interactive earbuds that enable us to go to work, sightsee, visit friends and family, shop, go to school, and communicate with anyone--all without leaving the comfort of home. Perhaps Elon Musk's well-publicized high-speed "Hyperloop" network of pneumatic tubes (an innovation that people have been trying to adapt for transportation for a century and a half) will surprise everyone by actually working.

Who knows?

It is safe to say that transportation is an ever-evolving means of satisfying the age-old need for rapid movement of people, goods, and ideas. Each era builds the most innovative transportation network it is able to create with the brainpower and tools at hand--be it foot power; chariots on the ancient Roman road network; sailing ships with men pulling oars; horses, mules, camels, and elephants; covered wagon trains; railroads, bicycles, and motor vehicles; even the World Wide Web--and in each case, future generations wondered how the people of earlier times survived with such primitive means. In the same way, today's population wonders how people survived crossing the continent in prairie schooners pulled by ox teams or crank-started their Model Ts.

The current transportation network is the product of thousands of innovative steps, leaps, and tiptoes forward. Many think of it as the best transportation system in the world, the peak of transportation progress through the millenia, or at least a serviceable system if you aren't a member of the American Society of Civil Engineers (whose annual infrastructure report card in 2013 gave a C+ for bridges and a D for roads). Regardless, when that as-yet-unborn genius shows up to solve all of the Nation's transportation problems, his or her innovations eventually will seem as primitive to observers in the 22nd century as does the chariot to

us.

Someday, surely, the little girl of the future will shyly ask, "Nana, did you ever ride in a car?"

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For more information on the history of FHWA and transpor-tation,
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