Highways: Standards and Historical Integrity

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You should be aware that I am an academic historian, not a highway planner or preservation expert. But through recent conversations with people across the spectrum of the highway community, I have become intrigued by the issues connected with assessing the historical significance and integrity of American highways. The Interstate system, with which you are most concerned, is easily the largest and most expensive public works project in history, comprising more than 44,000 miles of express highways in every state of the union. Several recent documentaries have celebrated the accomplishments of its builders and its importance to the American economy and the daily life of us all. Yet the very scale and ubiquity of these roads poses daunting questions when trying to sort out historical significance. Does one focus upon a section of a particular Interstate highway, seeing it as a physical artifact, or is the real significance found in the system of which these individual elements are a part? Is significance attributed to that ribbon of pavement, or to the complex social activities that are enabled by the linked network of pavements sections?

These dichotomies are not the only ways to pose the question, of course. But every approach to understanding the significance of these highways raises questions. Even the age of the system is problematic. The National System of Interstate and Defense Highways is 45 years old this summer. But several sections now part of the system were built before that, including the Pennsylvania and Maine Turnpikes, the New York Thruway, and the New Jersey Turnpike. In fact, the first map of Interstate routes was issued 1947 pursuant to 1944 legislation creating a system of Interregional Highways. This bill, in turn, can be traced to a 1941 advisory committee appointed by President Roosevelt, which was itself a response to the seminal report issued in 1939 by the

Bureau of Public Roads, *Toll Roads and Free Roads*. In other words, there is a lot of complex history involved. Even basic facts can be confused. For example, FHWA notes that three states all claim to have opened the first section of Interstate highway![1] I make no claim to having easy answers for the very difficult dilemmas confronting those interested in assessing the historical significance of the Intestate system and its components. I should tell you that I believe you have to start assessments of significance with the physical artifact, with the road itself. And from that perspective, I propose to offer some background information related to two aspects of the development of Interstate highways -- technical standards and highways as technological systems -- that demonstrate why it is especially difficult to build cases for significance using approaches that have worked in the past for discrete structures, like buildings and bridges.

The Nature of Highway Standards and Specifications

Knowledge of technical standards and construction specifications can prove very important in many efforts to determine historical significance -- especially for places and things that are engineering in nature. Some significance criteria focus, for example, on whether a project broke new technical ground. Was it the first, the largest, the most challenging, most innovative? It is also possible to build a case for significance that rests upon a particular place or structure being typical of contemporary practice, rather than unique. But assessing significance in terms of these criteria requires knowing the technical norms that applied -- the state of the art. Standards are at the core of the issues. In embarking upon such assessments of highways, it seems to me important to bear in mind a couple of basic points.

1. American road building -- and the setting of standards for them -- has been an exercise in federalism. Every facet of highway construction is cooperative in nature, as the Bureau of Public Roads (now the FHWA) and the state highway department shared the cost and responsibility for developing the nation's road system. But in the realm of standards, federal engineers were the central actors, drawing upon a

superior base of expertise and facilities, to shape the standards and specifications of American highways.

2. In the spirit of cooperation, the BPR worked closely with AASHO to promulgate and disseminate the standards that grew out of its research programs and its base of technical expertise without dictating things to the states. Thomas MacDonald, chief of the BPR from 1919-1953, was the primary architect of this state/federal partnership. And it was a very long-lasting exercise. For example, Joseph Barnett was with the BPR from about 1930 until 1967, during which time he worked on the George Washington Parkway, designed and oversaw construction of the Pentagon road system, and helped advise almost every city on urban expressway plans from 1940 onward. He devised a means of designing spiral or transition curves in the late 1930s. But most importantly, from 1937 through 1966, he served as secretary of the AASHO Committee on Planning and Design Policies, the body that issued the basic standards for highway geometry and construction for rural, urban, and Interstate roads. Variations of the committee's work appeared in AASHO publications in 1950 as *Policies on Geometric Highway Design*, in 1954 and 1965 as *A Policy on Geometric Design of Rural Highways* (the Blue Book), and in 1957 and thereafter in a companion volume, *A Policy on Arterial Highways in Urban Areas* (the Red Book).

3. Barnett's committee encouraged greater technical uniformity in state road building practice than was true of the period from 1920-1940. But even this work could not produce anything like a uniform set of national construction standards for American highways -- even the Interstate superhighways. Even if local conditions (economic, geological, and otherwise) had not varied so widely as to require the existence of widely divergent specifications, the political structure guaranteed it. Each state has had the authority to determine its own standards, with the federal bureaucracy charged with insuring that those standards were sufficient to protect the federal investment.

4. Taken together, these factors highlight a couple of characteristics about all systems of standards. While they deal with technical matters, they are the product of a political process. This means they reflect all kinds of compromises. They are never reflective of the highest state of the art, but instead mirror the best that can be achieved.

For a long time, for example, the BPR accepted lower standards in states that were just developing highway agencies, assuming that as it helped to develop professional highway departments, standards would eventually improve over time. Indeed, especially before 1950, the variation in standards among the states was often quite dramatic. But the BPR under MacDonald and the BPR recognized that imposing total uniformity would have required a political battle that was not worth the cost, even as local physical conditions would have required much variation anyway. This situation resulted in 48 --later 50 -- different state highway specification books, an outcome that greatly complicates the life of those seeking to assess the significance of any given road. Best practice in one state may have been old-hat in another. This situation requires special sensitivity in assessing significance FROM A TECHNICAL PERSPECTIVE.

Highways as Dynamic Technological Systems

If the nature of highway standards makes it difficult to know in absolute terms whether a project represented the state of the art - of better yet, which state of the art it represented -- there is an even more difficult technical element to consider in determining historical significance. The point is rather obvious -- roads are not an unchanging or static structure. Rather, they are complex combinations of technological elements that go well beyond the pavement and traffic-carrying structures. Most importantly, the entire technological system of the modern highway is constantly changing. This dynamic aspect poses a real problem when thinking about a central significance criteria - integrity. The problem is not unique to roads -- many long-lived structures are altered substantially over time. But the technical adjustments to highways are both subtle and extensive. The roads continue to serve the same purpose, but the question can appear -- is it the same road? Among the changes that have appeared have been many adjustments in the structure and in the technical arena. But many others have occurred in the ancillary features that are integral to a road's performance, but might as easily be thought of as part of the roadside. It is helpful to incorporate them into our thinking by considering the road and all of these various features as a technical, or even a socio-technical system.

Let's look at a couple of elements of the highway system that complicate the issue of significance and integrity.

GEOMETRIC STANDARDS

The most obvious changes in this area have been to deal with the such changes as more vehicles, larger trucks, etc. And these adjustments have resulted in substantially better and more seriously engineered roads. The basic trend is obvious to most observers -- thicker pavements, better prepared foundations, sophisticated treatment of soil conditions, and so forth. Studies of airport runways during World War II helped advance knowledge here that began to be developed slowly during the 1920s and 1930s.[2] In the postwar period, highway engineers continued to use test roads to find better solutions for various soil and subgrade deficiencies. Ever more massive pavements emerged -- slabs had been seven inches thick in the 1930s, but by the mid-1970s Interstate roads had eight or more inches of reinforced concrete laid on top of a foot of asphalt foundation and several inches of specially prepared foundation.

SAFETY

Safety factors have resulted in many changes to American roads over time. Even in the 1920s, the annual death toll on American roads exceeded 25,000; by 1937, fatalities had climbed to 37,000 a year, and in the 1990s the annual casualty list stands at about 41,000. For a long time the attitude of public officials and engineers alike was that drivers were the main problem in highway safety. Thomas MacDonald summarized this view in a 1937 article entitled "Highways Will be Safer; Driver Remains a Problem."[13] Over time, more attention was given to driving environments, resulting in recessed knobs and padded dash boards and seat belts in cars. But it also led to safer engineering designs of roads, and many changes in the highway itself.

Highway signs are one example of these changes. A century ago, motorists faced real challenges trying to find their way, and confusion led to accidents. At first directional signs were placed by highway supporters like the Lincoln Highway Association or the American Automobile Association, and they were hard to read. In 1918, Wisconsin's highway department made the pioneering effort to mark a system of 500 miles of state roads using a uniform numbering system. Other states followed suit, with Minnesota introducing the first state shield in 1921. BPR and state engineers implemented a national road numbering system for the federal-aid network and by 1925 the familiar shield and numbers were found on all U.S.- numbered roads. A manual for traffic signs was issued in 1927 that established the basic principles still used today - yellow for warning signs, white for directional signs. (Red for stop signs came later, durable red paint was developed.) Round signs were used at railroad crossing, stop signs were octagonal, warning signs were diamonds, and information was on rectangles. The goal was to allow drivers to recognize hazards quickly by both shape and color.[4]

Reflectors on the signs were in use in the late 1920s, with the first being "cat's eyes," a glass lens that focused light onto a mirror. The largest were only an inch across, and were installed as buttons outlining symbols. Occasionally they distracted drivers and could even obscure the letters. An inventor named Stimson, introduced a plastic device he called the "cube-corner" reflector in the late 1920s. Stimsonite-brand reflectors used lucite plastic, not silvered mirrors, and so were much cheaper and larger. Another inventor named Ernest Gill developed reflecting signs by placing tiny glass spheres into paint or sign material. Not long after, 3M introduced "Scotchlite" - plastic reflective sheeting containing glass spheres with better optical efficiency, allowing the whole sign to be reflective. Improved material in the 1940s remained reflective even in the rain.

With the development of high-speed freeways, and later the introduction of Interstate highways, it became imperative to know how to make a sign that drivers could comprehend at 60 miles per hour. Overhead signs of increasing size were appearing in the late 1950s, as they seemed less distracting and also could marked appropriate lanes. The BPR investigated sign colors in the mid 1950s, testing green, blue, and black signs. All were visibly acceptable, but drivers subjectively favored green, so that became the standard Interstate sign color. The BPR also required reflectorized backgrounds on all overhead signs, and strongly recommended this treatment on all others as well. Since the 1960s, self-luminescent signs have found on freeways, while human factors engineering carefully examines sign designs and placement.[5]

There are a number of other features that have a similar importance to highways, but which have changed over time.

PAVEMENT MARKINGS made their initial appearance in cities after 1900, as they started marking safety zones and the first cross walks. But markings on highways did not appear until a number of states started the first efforts at striping roads in about 1920. By the mid 1920s, center lines were commonly found on most state highways. Then in the late 1920s, Stimsonite buttons -- a trade name for reflectors -- were introduced to mark the outside line of roads. Unfortunately, snow plows ripped these off, so their widespread use was delayed for a number of years. But in the 1960s, the application of neoprene snow plow blades edges allowed the use of these devices. Shortly thereafter, recessed markers came into wide usage for marking center lines as well as the outside edge of traffic lanes.

The use of reflectors enabled highways to be much safer after dark. In 1938, Michigan created the first "reflectorized highway" on the route from Lansing to Detroit by placing 6,900 plastic reflectors on 3-foot poles at 100-foot intervals along the outer edge of the shoulder. The experiment covered seventy miles of highway, and its success has since been widely imitated. Michigan also was one of the first states to experiment with tiny glass beads (0.015 inches in diameter) mixed with paint. This allowed pavement markings to be much more visible. By 1965, 21.5 million gallons of traffic paint and 107 million pounds of reflector beads were used for this purpose in the United States.[6]

LIGHTING has been one of the most important additions to the highway system. A wide variety for lighting was used in cities the late 19th and early 20th century, but their efficacy varied enormously. Regular highway lighting was much improved with the introduction in 1934 of mercury vapor lamps and sodium vapor lights. Both were much brighter than regular filament bulbs, and nowhere near as harsh as arc lights. These new bulbs could be mounted twice as high off the ground (25-30 feet), so that fewer units were required. After WW II, newer and larger bulbs packed more power, and mercury vapor bulbs with red coatings eliminated the characteristic blue-green tint of earlier lamps. Also after the war, fluorescent lights were adopted in many urban installations, especially for tunnels, after the initial experiment in Oakwood, Ohio in 1952.

The breakthrough in highway lighting came with the adoption of "high mast" lights in the late 1960s. These installations, at first 100-150 feet high, now more typically 200 feet high in the air, were pioneered by the Texas Transportation Institute. The first trials took place in San Antonio and Texarkana; other experiments followed in Seattle, Nebraska, and North Dakota. The installation in Washington came at a freeway interchange, and 23 masts poles were required to provide adequate, light for the entire interchange, instead of 240 traditional light poles.[7]

One benefit of this development was the elimination of most of the light poles, which were traffic hazards in their own right. Rhode Island had introduced a collapsible post in the mid 1960s, but the form most commonly used in the U.S. also came from the Texas Transportation Institute (TTI), which began its study in 1963. The safety danger of collisions with light poles was the sudden deceleration, so TTI engineers designed a "slip joint" base that broke clean when hit hard, yet stood up to wind loads. By 1968, this device was mandated for all new Interstate poles and highway signs, and retrofitting was urged on the state highway departments. But change is constant, and the FHWA had to develop a new standards for light poles in the mid 1970s because of the smaller cars that began appearing in numbers on highways, with the energy crisis.[8]

HIGHWAY SAFETY BARRIERS were another safety-related development that added new design features to the highway environment. From simple posts on the roadside to posts carrying cables or cross bars, safety barriers have changed enormously from the first incarnations in the 1920s. The typical metal guard rail was strongly promoted by the steel industry in the early years of the Depression. Yet all of these early devices were dangerous to drivers if hit hear-on. Quite late in the game, rails were turned away from traffic or buried to prevent cars from being impaled on the rails. Today, impact absorption devices are often mounted in the end of guard rails.

"Impact attenuators," are the most recent development in this area, and they have taken a number of forms. These include simply binding togther 30-40 steel drums, and allowing them to crumple under impact, absorbing the speed and energy of a car. Other designs use water-filled vinyl cells held in place by panels (the Hi-Dro Cushion), or cylindrical tubes that act the same way (Tor-Shok system). Sand- or water-filled plastic drums are widely used today, and can stop cars traveling 65 mph in 18-30 feet, as moviegoers learned in "*Speed*." Yet other devices include vermiculite-filled concrete barrier that stop cars moving 60 mph in about 9 feet. And the old idea of a runaway truck ramps still can be found on many steep hills.[9]

For many highway engineers, the major safety hazard long remained head-on collisions between opposing traffic lanes. By the 1960s, 616,500 head-on accidents of all types occurred annually, producing 8,760 fatalities. This despite various forms of median strips and barriers. The solution in most cases has been the adoption of the so-called "Jersey barrier," developed after 1955 by the New Jersey Turnpike. Similar research was taking place at the same time under the auspices of General Motors. The key to the cast concrete barriers they designed is the taper, which forces a vehicle's wheels to hit the sloping base before the body touches the barrier itself. The wheels are turned, moving the car away from the barrier before full impact. Only 200 miles of barriers were in use by 1967, but the device is now ubiquitous.[10]

There have been a number of other additions to the highway system in recent years. **Noise barriers**, for example, are a product of 1960s-era concerns about the environment. After California and New Jersey began to set noise limits about 1970, these barriers began to appear along roadside in densely populated areas, especially as expensive subdivisions pushed to the very edges of interstate roads.[11] They now line virtually every interstate in urban settings. **Landscaping**, which had been much talked about since the 1930s and seriously adopted on a few parkways like the Blue Ridge and Arroyo Seco parkways. Attention to landscaping had diminished by the 1950s when the interstates were first built, but it is now a major part of almost all Interstate highways, thanks in part to the famous campaign of roadside beautification strategy spearheaded by Lady Bird Johnson in the 1960s.[12]

SUMMARY

Well, what does this all add up to? My primary points are that even Interstate Highways -- the most recent additions to the nation's road network that are approaching that magic 50 years of age -- are much more than just the pavement and have undergone substantial changes in form and appearance. And there have been a great many elements added to the road as a system, each of which has to be considered in considering the significance of the road as a transportation system. Since these roads are still in use, it is not at all clear how these changes have affected their significance and National Register eligibility. The irony is that we can have a driver going over a road that was built in 1957, but that it has no historical integrity. The pavement may be new and different than the original, lanes may have been added, and exits too may have been added. In many cases, the roads have been completely rebuilt so that the only original element remaining is the location itself -- the road, including the foundation and subgrade treatment, bridges, pavement, and all of the other elements of this technological system have been replaced or altered. This dynamic situation is a nightmare, I imagine, for anyone assessing the significance of these highways. It is instructive that several sections of abandoned Route 66 in far western states are deemed instructive precisely because this is about the only way to find roads with integrity intact. The irony is that they have listed in the National Register because, in part, they have integrity. And the only way to get there is to abandon the road. And because of that, I am not sure that most of the interstate highways that we are going to see can be evaluated to have integrity.

Thank you.

[1] See Richard Weingroff, "Three States Claim First Interstate Highway," *Public Roads* (Summer 1996): http://www.tfhrc.gov/pubrds/summer96/p96su18.htm

[2] See my article, "The Scientific Mystique in Engineering: Highway Research in the Bureau of Public Roads, 1918-1940," *Technology and Culture 25* (October 1984): 798-831.

[3] Thomas H. MacDonald, "Highways Will be Safer; Driver Remains a Problem," *Scientific American* 156 (March 1937): 213.

[4] For basic information, see A.E. Johnson, "A Story of Signing," in *AASHO: The First Fifty Years* (Washington, DC, 1976), pp. 129-46; Institution of Traffic Engineers, *Traffic Devices: Historical Aspects Thereof* (Washington, DC: 1971), pp.79-81; and "Historical Note: Signs of Fifty Years Ago," *Traffic Engineering* 38 (October 1967): 10-11.

[5] A.E. Johnson," Highway Signs for the Interstate System," *Civil Engineering* 27 (April 1957): 251-255;

[6] See ITE, "Traffic Devices," 101-105; see also "Saga of Highway Striping in Black and White," *Public Works 102* (August 1971): 72-73; "First Reflectorized Highway," *Engineering News-Record* 120: (April 14, 1938): 541-42; Making Night Driving Safe," *Mechanical Engineering* 60 (July 1938): 568-69; and Bernard Chaiken, "Traffic Marking Materials - Summary of Research and Development," Public Roads 35 (December 1969): 251-56.

[7] "Street Lighting Then and Now," *Illuminating Engineering* 51 (January 1956): 86-96; "Demonstration of High Intensity Mercury Vapor Street Lighting," *Roads and Streets* 78 (June 1935): 195; "Sodium Vapor-The Modern Highway Light," *Electrical Journal* 32

(July 1935): 289; and Edward M. Rice, "Lighting and the Modern Highway," *Roads and Streets* 81 (March 1938): 45-46; .Louis J. Horn, "Making Highway Safety Practical,"*Public Works* 99 (December 1968): 64; "Cloverleafs Get High Lights,"*Electrical World* (173 (January 5, 1970): 74-76; "High Level Lighting System Tested at Cloverleaf Interchange,"*Public Works* 100 (January 1969): 80-82.

[8] H.R. Cooke, "Safety Hardware on Freeways,"*Civil Engineering* 38 (September 1968): 56-60; N.J. Rowan and R.M. Olson, "The Development of Safer Highway Sign Supports,"*Traffic Engineering* 38 (November 11, 1967): 46-51; "Safety Effects of Breakaway Signs," *Traffic Engineering* 38 (August 1968): 12; "Breakaway Luminaires Pay Dividends," *Public Works* 100 (September 1969): 128-29; "Breakaway Poles Changed to Fit Smaller Cars,"*Highway and Heavy Construction* 123 (April 1980): 28-30.

[9] F.J. Taminini and John G. Viner, "Energy Absorbing Roadside Crash Barriers," *Civil Engineering* 40 (January 1970): 63-67; John G. Viner, "Experience to Date with Impact Attenuators," Public Roads 36 (October 1971): 209-18; James R. Kircher, "Impact Attenuators: A National Survey,"*Public Works* 117 (January 1986): 73-76; "Roadside Bunkers to Trap Runaway Trucks," *Public Works* 103 (July 1972): 55.

[10] "Making a Safe Highway Safer?"*Engineering News-Record* 163 (November 12, 1959): 28; H.R. Cooke, "Safety Hardware on Freeways," *Civil Engineering* 38 (September 1968): 56-60; "Concrete Safety Barriers Win Wider Acceptance,"*Roads and Streets* 112 (July 1969): 70, 95; also http://www.richmond.infi.net/*kozelsm/JerseyBarrier.html

[11] “California Tackles Highway Noise," Civil Engineering 43 (July

1973): 82-83; "Highway Noise Control," *Traffic Engineering* 43 (September 1973): 47-53; and "Noise Reduction by Barriers," *Acoustical Society of America Journal* 55 (March 1974): 504-18.

[12] E. McCaffey, "Uglification of America's Highways", *Professional Engineer* 14 (March 1929): 5-6; "Highway Beautification," *Proceedings of the American Society of Civil Engineers* 55 (December 1929): 2580-87; W.E. Burton, "Beautiful Roadsides," Scientific American 59 (September 23, 1930): 18-19; "Landscaping Made Integral Part of Planning," Roads and Streets 89 (January 1946): 97; and "Beautification as Well as Building is Highway Department Goal," Public Works 101 (November 1970): 77-78.