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Route change on the American freeway system

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ABSTRACT

The first elements of the American freeway system were built in the 1920s and now comprise over 59,000 miles of roads. In addition to growth in the system at both the national and urban levels and increases in capacity, over five hundred miles of freeways have been relocated. These route changes have previously escaped attention from researchers. A database of all route changes on the Interstate system and other freeways was compiled in GIS and analyzed. Route changes are due to the need to replace old and obsolete bridges and tunnels, rebuild sharp curves or steep grades, and eliminate substandard sections. These route changes are overwhelmingly urban in nature. New relocations will appear as the American freeway system ages and continues to adapt to changing conditions. Some bypassed sections of freeways may eventually become tourist attractions.

1. Introduction

Before World War Two a number of cities had begun planning and building parkways, expressway, or freeway systems. New York initiated the largest system in 1923 with the world's first freeway, the Bronx River Parkway. This was a 20 mile multilane road with 28 overpasses as well as 35 miles of walking trails and 60,000 trees or shrubs (MacDonald, 2002). Los Angeles opened the Arroyo Seco Parkway in 1940, the first of many freeways in that city. Elsewhere isolated roads appeared, including the Merritt Parkway in Connecticut in 1938 and the Pennsylvania Turnpike between Carlisle (west of Harrisburg) and Irwin (east of Pittsburgh) in 1940.

These early freeways were incorporated into a nationwide freeway system that began construction in the postwar era. This new Interstate Highway System was actually initiated in the 1930s and formally created in 1944, but little was accomplished until it was put on a secure financial foundation in 1956. The system had its origin as a set of long-distance routes connecting the nation's largest cities. An extensive set of urban routes was added later to facilitate passage through cities and gain the required favor of urban congressmen, though at enormous cost in economic and social disruptions of established neighborhoods (Schwartz, 1976; Seely, 1987; Rose and Mohl, 2012). The system continues to have tremendous impacts (often unanticipated) on the nation's mobility, accessibility, economy, and urban geography (Garrison, 1960; Moon, 1994; Weber, 2004, 2011; DiMento and Ellis, 2013). It has been expanded from 40,000 miles in the original plans to almost 47,000 miles in 2017, along with another 12,000 miles of non-Interstate freeways to make up an American freeway system of over 59,000 miles (Weber, 2012, 2017).

But freeway routes were not always built according to plan. Over 340 miles of planned Interstate routes were altered or cancelled before construction (Weingroff, 2015a), along with a substantial mileage of other freeways, much of it attributable to various 'freeway revolts' from the 1950s into the early 1970s (for example, Baumbach and Borah, 1981; Rodriguez, 1999; Mohl, 2004, 2008; Rose and Mohl, 2012; DiMento and Ellis, 2013). These came about due to local opposition to freeways being built through established neighborhoods and the wholesale demolition of homes and businesses required. In some cases, notably in San Francisco or Memphis, these successfully prevented the construction of new freeways or forced redesigns of others.

Although one of the most substantial and expensive components of contemporary transport systems, freeways are not permanent and unchanging. In addition to continual maintenance, reconstruction, and frequent widening, freeway routes may be altered, as when sharp bends are replaced with wider sweeping curves. These represent adaptations to changing standards or traffic, in which a highway route is altered to better fit current needs. This is a common occurrence with roads (Newton Jr, 1970, 1971; Clay, 1973; Raitz, 1996; Krim and Wood, 2005), but has gone unexamined in the case of freeways. This paper examines the phenomenon of route changes on the American freeway system in order to identify to what extent this system has evolved, why it has done so, and how it will likely do so in the future. After locating and mapping freeway route changes several specific questions will be addressed. How common have route changes been on freeways? What explains these route changes? And where and why will they take place in the future?

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2. Literature review

Examining the growth of transport networks has long been a topic for geographers and others (Meinig, 1962; Thomas, 1963; Vance Jr., 1995; Xie and Levinson, 2009). One of the basic problems in network expansion is that of the location of individual routes (Vance Jr, 1961). This has usually been approached in geography as an optimization problem, typically that of minimizing travel time, construction cost, or some other variable. One of the earliest examples is that of Wellington, a railroad engineer seeking the most efficient route for trains (Wellington, 1893; Black, 1993, 2003). His approach balanced operating costs with the potential to increase revenue by adding more towns to a rail line. A related concept is the law of refraction (Warntz, 1957; Werner, 1968), in which an optimal route is found across several cost surfaces. This approach is now more likely to be expressed as cost-distance models within GIS that finds a route across a raster surface with cells coded for cost, effort, or other variables (such as Atkinson et al., 2005; Howey, 2007). Each optimal route would be based on particular factors involving terrain, vegetation, water, land ownership, or other relevant considerations. This has found application for route location problems (Atkinson et al., 2005) as well as predicting or explaining historic or prehistoric routes (Howey, 2007; Raitz et al., 2010).

Route changes can be conceptualized as being due to changes in the optimal route location due to some external event or changing conditions, or the need and ability to further reduce travel time or cost, perhaps as speeds and traffic volumes increase. The standards to which highways have been built have changed continually to the present, including preferred and maximum grades up and down hills, curve radius, sight distance, lane width and road capacity, and the design speed of the road. Preferred values for road curvature, measured as the radius of a circle that fits the road's curvature, increased from 100 ft in the 1850s (Gillespie, 1853) to 200 ft at the beginning of the automobile era (Harger and Bonney, 1912), and between 1000 and 5000 ft by the 1930s (Wiley, 1935; Bruce, 1937; Hewes, 1942). Other design features were added, such as superelevated or banked curves and a spiral transition into and out of curves. While some improvements can be incorporated within a road's right of way, changes involving curves or gradients will often require a new location to contain these improvements.

Descriptive route change models incorporating these changing features have been devised showing how roads change over time as they are improved and the roadside environment is developed (Clay, 1973; Clay and Raitz, 1996). Despite tremendous attention given to highway evolution, freeway route change has received none, perhaps because freeways are treated as the end of highway evolution. Descriptive models of American highway evolution have treated freeways as a final stage of development. As part of his historical geography of American transportation James Vance Jr. (1990) described five broad stages in the development of the American highway system, for which the fifth and last stage began in 1956 when the Interstate Highway System was fully funded and construction began in earnest, creating a national system of freeways. Similarly, Hokanson (1988) described four stages of highway construction for which the fourth and last stage is the Interstate Highway System and similar freeways. In these accounts the beginning of the Interstate system in 1956 marks the end of road development.

But 1956 was not the end of the road. Design standards for this system have evolved tremendously over time, and the American freeway system has been continually changed to keep up with new conditions. Weiss (2008) identified a number of distinct Interstate 'generations,' beginning with early freeways built before the Interstate Highway System was fully funded. 'Interstate 1.0' began in 1956 and rapidly built routes with narrow medians and the possibility of left hand exits. This system also incorporated many existing freeway routes built to lower standards than are found now. An 'Interstate 1.1' began in the 1960s with improved ramps and wider medians. 'Interstate 2.0' took place in the era of environmental impact statements and was built not just to higher standards but with environmental features in mind. Later generations differed in their funding and political justification; it is evident they also introduced improved landscaping and safety features as well as carpooling lanes and other features. Many of the features of later generations were retrofitted onto existing freeways, and along with widening to increase capacity and the need to replace worn out bridges, has meant not only that freeway construction has never ended, but never will so long as the system remains in use. There is every reason to expect that the system will continue to adjust.

This situation is however complicated by politics. The Association for State Highway and Transportation Officials (AASHTO) Committee on U.S. Route Numbering is responsible for approving all changes to U.S. numbered and Interstate routes, which encompass most freeways in the U.S., using categories of establishment, elimination, extension, and relocation (AASHTO, 2017). Elimination refers to the removal of a particular route number, as happened when the legendary U.S. 66 was decommissioned in 1985. Extension is the lengthening of a route past its original endpoint, as when an extension of I-40 from Greensboro to Wilmington, North Carolina, was approved in 1984. Truncation would be the opposite, when a route is shortened from its original endpoint, as in 2011 when the eastern end of I-370 in Maryland was shifted west by one mile. With relocation a route number is moved from one road to another, which requires a distinction between the physical road and the numbered route. A road (and the route it carries) may be shifted to a new location and the old road demolished, or a route may be transferred to a new road while the old road remains in use with a different route number.

Although all four cases can be found on the American freeway system, this paper focuses only on relocation. The goal is to examine these route changes in order to understand this important component of how the system has evolved and will likely do so in the future. Several questions will be addressed. How common have route changes been on the American freeway system? What explains these route changes? And where will they take place in the future?

3. Data and methods

There is no database of highway route changes to draw on. Federal Highway Administration statistics (FHA, 2016) show the mileage, lane miles, vehicle miles traveled (VMT), cost, pavement condition, and other variables by state and for the nation, but are not broken down by route. Instead, freeway route changes were found by examining the entire freeway system for evidence of change. First, aerial imagery of all freeway mileage in the contiguous 48 states were examined for recent location changes in Google Earth software (Google, 2017). Changes in major cities were found comparing current and older aerial imagery, allowing changes within the past 10 to 15 years to be found. A search of the entire freeway system was carried out using a United States Geological Survey 7.5 min topographic map overlay (USGS, 2017). These 1:24,000 scale maps typically date from the 1970s and 1980s and show roads with a high level of locational accuracy. When displayed in Google Earth with the software's current road overlay they will reveal any changes since the maps were made.

Recent route changes were also found by examining the meeting reports of the Association for State Highway and Transportation Officials Committee on U.S. Route Numbering (AASHTO, 2017), which has jurisdiction over numbering for the majority of freeways in the country. A list of decisions made onwards from 1989 is available on their website. Finally, histories of a few older highways, such as the Pennsylvania Turnpike, are available (for example, Cupper, 1990), and these sources provided details on some of the earliest route changes.

While not a comprehensive list of all freeway route changes, it is expected that the majority of significant changes have been found. A GIS database of these route changes was created in ArcGIS (ESRI, 2017) by mapping route changes as linear features, though in Fig. 1 these are