TOPIC 1
TRANSPORT AND
LAND USE (SIG)

TRANSPORTATION-LAND USE INTERACTION: THE US EXPERIENCE AND FUTURE OUTLOOK

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Abstract

The authors present a brief review of the impact of transportation on urban land uses in the US. Also presented are brief discussions on the types of transportation programs (different from highways) likely to be implemented in the 1990s and their impact upon urban and regional growth patterns.

INTRODUCTION

The location, growth and shape of cities throughout history have been influenced by the complex interactions of many forces, transportation being one of them. It is generally believed that long-distance transportation has a major role in the locations of cities as human activity centers, while local travel patterns affected our urban forms and structures.

Ports and harbors became the most common determinants of urban locations prior to the locomotive era, as is evident from the distribution of some of our older cities including Istanbul, Rotterdam, Hamburg, Boston, New York, San Francisco and Los Angeles. In later years, railroad junctions became a major factor in the location of cities, as exemplified by Chicago, Atlanta, London, Amsterdam, and Calgary. In other cases, route intersections and river crossings were instrumental in the initial development of cities such as Berlin, Paris, Moscow, and Pittsburgh.

Transportation and urbanization

Transportation thus has had a major role in the initial determination of urban locations, and in most cases became a dominant factor in the subsequent development of these cities. Intra-city mobility, being a direct function of transportation supply within cities, affected greatly the development of urban land uses and population growth. Similarly, the configuration of the transportation network became a dominant factor in determining the shape of cities. For example, the patterns of grid network (eg Chicago, New York, Toronto), circumferential network (eg Cologne, Copenhagen) and combination (Paris, Washington, D.C.) appear to have a direct bearing on the geometric form of these respective cities.

It has become increasingly clear that the role of transportation is not only to provide for mobility, but also to coordinate urban development. The concept of multiple use of transportation right of way, for example, has gained prominence with the gradual realization that transportation must be considered in a context broader than the facility itself, and that transportation can be used as a vehicle for growth management.

Researchers are divided in their opinion on whether urban transportation acts as determinants/catalysts of land use or whether the opposite is true. It has been suggested that forces resulting from decreases in commuting prices, from increases in income and from consumer preference for spacious living were magnified during post-World War II era resulting in suburbanization (Kain, 1975). With this viewpoint, transportation planning becomes the process of forecasting land uses and developing a transportation system that best serves the anticipated land uses. A somewhat different view is presented by others in it that since transportation strongly affects land use, it should be used to further social objectives. The following quotation may be noted (CEQ, 1976):

> The construction of new highways, mass transit lines . . . can have a powerful effect on local land use. For example, most people are familiar with how the Interstate Highway System has speeded up suburban growth.

Despite the differences in opinions among researchers on the cause and effect relationship between transportation and land use, there is a consensus that the interaction between the two is quite significant and that such interactions have greatly affected our urban lifestyle and employment opportunities. Historically, transportation investments have been made where growth was anticipated; growth was accommodated by the resulting facility that was instrumental in most cases for additional growth calling for improved transportation.

It has been argued that transportation improvements lead to reduced travel costs and those cost savings are "capitalized into the value of the land leading to higher land values and densities." (Goldberg, 1984) Accordingly, areas advantaged by transportation improvements are likely to experience increases in property values and pressure for denser developments. By the same token, areas adversely affected through reduced accessibility, congestion and disruption can be expected

to exhibit declines in land values. In some cases, a secondary set of impact has resulted from the negative nuisance aspects of transportation on land use and land value.

Purpose of the paper

The purpose of this paper is two-fold. First, an historical review of the impact of transportation on urban land uses in the US is presented along with a discussion on the efforts by our planners and engineers to capitalize on the growth-shaping potentials of transportation investments. Next, transportation investments likely to be made during the future and the possible impact of these developments upon urban growth are examined.

URBAN DEVELOPMENTS: PRE-AUTOMOTIVE ERA

Since the early 1900s, economists and planners have attempted to formalize a theory of how transportation investments influence changes in urban land uses and land values. There exists a vast body of literature that appears to substantiate the major proposition of this theory. Yet there appears to be a lack of understanding among researchers and practitioners on the possible impact of transportation on urban land uses and land values. (Gomez-Ibanez, 1985)

The process of urbanization that resulted from a massive movement of population from rural to urban areas has been greatly influenced by the availability of transportation. These movements are a direct consequence of employment shifts from agricultural to manufacturing and government sectors during the process of industrialization.

The invention of the steam engine by James Watt around 1765 is regarded by many as symbolic of the beginning of the industrial era. Similarly, the introduction of the railroad by George Stephenson in 1825 is considered significant transportation milestone affecting the subsequent development of cities. England and a number of other European cities were more urbanized at the turn of the last century than their American counterparts, presumably because of the accessibility provided by the railroads. The following quotation on the impact of the railroad may be cited (Vuchic, 1981):

> The new mode of transportation possessed speed, capacity, comfort and reliability many times greater than that possessed by any mode previously known. The improved quality and decreased cost of the transportation it offered resulted in increased travel, intensified communications, and... by the end of the nineteenth century virtually all European and North American cities depended on the railroad services for their economic survival.

Starting from the canal era to the age of railroads, inter-regional transportation of raw materials and manufacturing goods became the prime determinant of the location and size of most US cities. The early American cities from the east-coast to the midwest, Boston, New York, Philadelphia, Pittsburgh, Cleveland, Detroit and Chicago, were initially developed around waterways. After the industrial revolution, the location of cities west of Chicago were greatly influenced by the railroads. However, highways have dominated the transport infrastructure in the US after the post World War II era (Nakicenovic, 1985).

URBAN DEVELOPMENTS: AUTOMOTIVE ERA

The impact of highway facilities on the growth, shape and form of urban areas is well documented in the literature. Past studies have attempted to show that the impact of these facilities spreads beyond the physical environment of the facility, having a far-reaching effect on the regional economy and on the industrial base. The characteristics of land development and freeway impact depend on a number of factors. These include the type of facility, the time the facility was developed, the phasing in of the facility in relation to the overall transportation plan and the land use character of the area where the facility was built.

Types of urban freeways

In the framework of the urban transportation system, urban freeways can be categorized as one or more of the following: bypass, beltway, crosstown artery, or radial, depending on their intended function (Babcock and Khasnabis, 1973).

Bypass: This type of facility is intended to separate local traffic from the vehicles that have no destination within the community. It is thus built away from the urban fringes to serve external traffic.

Beltway: A beltway is closer to the community developed in the form of a loop and is designed to improve accessibility between various parts of the urban area. Areas around beltways in moderate-sized cities have become the most attractive locations for land development.

Crosstown artery: These facilities are designed to pass through the central business district (CBD). Its functions are to reduce local traffic from the CBD and to increase the accessibility of the CBD, while at the same time expediting traffic flow between different parts of the community.

Radial: This type of facility is designed to move traffic from the outlying areas of the community to major destinations in the urban core.

Freeway impact studies

The authors have chosen to refer to two specific studies in this paper. First, a study conducted in the early 1970s, referred to here as the North Carolina study, attempted to analyze the land use changes in North Carolina following the construction of the interstate highway system with special emphasis on urban areas (Khasnabis and Babcock 1973, 1978). Secondly, a study conducted for the US Department of Transportation referred to as the Beltway Study, analyzed the beltway induced land value/land use changes for a total of 54 metropolitan areas (The Land Use, 1980).

North Carolina study

Land use changes and traffic impact along the 600-mile stretch of the interstate highway system in North Carolina were analyzed in the early 1970s at the North Carolina State University for a project sponsored jointly by the North Carolina Department of Transportation and the US Department of Transportation. Interchanges were categorized as rural, suburban, or urban, depending upon their location, adjacent land uses and their proximity to established municipalities. It was found that developments in rural areas were so scattered that there was no predictability to their locations. In suburban areas, developments were denser and locations of commercial developments and industries could be reasonably predicted. A measurable amount of traffic generation is caused by these land developments; however, the impact of such generated traffic upon the interchange operation is mostly insignificant.

In urban areas, both land-use and traffic impacts were found to be significant enough to warrant an in-depth investigation of such development patterns. Five urban areas in North Carolina (Charlotte, Durham, Greensboro, Raleigh and Winston-Salem) are served by controlled-access facilities in the form of a bypass, beltway, or crosstown artery. These facilities were developed as part of the interstate system and were incorporated into the respective transportation plans of the communities.

Analysis of these five urban freeways showed that the development of new highways had a definite influence on the land-use patterns of the community. Typical examples of these effects are: (a) accelerated residential growth near the facility; (b) denser commercial, industrial and institutional developments around the interchange areas; (c) concentration of large retail centers at junctions with major radials; and (d) a tendency to promote the decentralization of urban activities. Furthermore, in areas where a bypass or a beltway was built (Charlotte, Raleigh, Durham and Greensboro), the "attractor" characteristics of the facility played a significant role in shaping the urban structure. Even in smaller communities, a bypass that was originally located in a rural setting encouraged the community to shift and build around the bypass. This shift was followed by

the development of commercial facilities that served not only the community itself but also attracted business from other communities. In Winston-Salem, the freeway was built primarily as a crosstown artery through the edge of the CBD. The land-use impact of this facility does not seem to be quite as significant as that in other cities because the corridor was already developed when the facility was constructed (Khasnabis and Babcock, 1977).

This study also showed that the land development surrounding highway facilities had a profound effect on interchange traffic operation. This is caused by the large and unanticipated growth of traffic volume on the crossing roadways that can be directly attributed to the land-use changes. This study revealed that, although some facilities were designed to serve only one function, over a period of time they were required to serve several others. This is primarily attributable to the changing characteristics of the facility.

The Beltway study

The 1980 beltway study commissioned by the US Department of Transportation and the US Department of Housing and Urban Development attempted to assess beltways' land use and urban development impact in the US (The Land Use, 1980). The study included: a review of prior research on eight urban freeways by different authors (including one by Khasnabis and Babcock) and a comparative statistical analysis of 54 metropolitan areas (27 with beltways and 27 without).

The eight metropolitan areas studied ranged in size from a city population of 136,000 (Raleigh, NC) to one of the largest metropolitan areas, 2.5 million (Boston, MA). While each of these studies made valuable contributions to the state of the art in its own right, it was also clear that the exact relationship between the beltways and other forces shaping our cities is not well understood. Beltways have played a critical role in the movement of people and goods within our cities and have significantly affected our location and development decisions. While the interstate highway system was planned in the 1950s, beltways were designed primarily for through-traffic around central cities. While this function was served, with dramatic suburbanization and decentralization beltways became important links between suburban centers. There is a multiplicity of other factors that have greatly affected the extent and type of urban developments, including: the age and structure of the city, the compatibility (or lack thereof) between transportation and land use planning, land availability, real estate markets, local zoning and land use planning, annexation laws and environmental factors.

The comparative statistical analysis of 54 metropolitan areas shows some statistically significant differences potentially attributable to beltways. The analysis attempted to expand the previously described evaluations of beltways' effects upon urban land uses and to portray the similarities and differences between cities in relation to beltway location and age. The study used a multivariate analysis of beltway influence both as an independent variable as well as in conjunction with other explanatory variables.

The primary results of the statistical analysis are presented in Table 1 in the form of a set of null hypotheses that were tested with historical data from the 54 cities. Table 1 shows that in five out of the eleven cases, the null hypothesis of no major impact was rejected, signifying the presence of a significant impact. The study, however, does not make a strong case for association between transportation and land use (The Land Use, 1980).

The most important discovery of this statistical analysis is that beltways and beltway attributes such as length, distance from downtown, interchange spacing and age are less important than non-beltway factors shaping regional economic growth and the distribution of population, employment, housing and retail sales.

Further, in all the cases studied, the impact was found to be significant, particularly in cases where local initiatives were prevalent. However, beltways did not appear to have any major regional impact. To quote the study:

> The comparative statistical analysis reveals that beltway construction rarely has significant regional consequences... a beltway may be predicted to alter the character of urban growth, but local initiative is required to reduce or eliminate potential adverse impacts of beltway construction on development patterns...and on metropolitan environment. Local initiative can also enhance the benefits of beltways.

Table 1 Results of multivariate analysis

No.	Factor	Null Hypothesis (Ho)	Results
1.	Population Growth	Beltways do not have any effect on the overall rate of metropolitan population growth.	Reject Ho
2.	Manufacturing Activity	Beltways do not stimulate the rate of growth of the metropolitan manufacturing activity (basic employment, value added, and capital investment).	Cannot Reject Ho
3.	Employment Growth	There is no difference in the overall rate of metropolitan non-basic employment growth that can be attributed to a beltway.	Reject Ho
4.	Population Growth	Beltways do not have any effect on central city population growth.	Cannot Reject Ho
5.	Residential Development Patterns	The proportion of new SMSA housing built in the central city is not affected by the development of a beltway.	Cannot Reject Ho
6.	Manufacturing Activity	Beltways have no effect on the distribution of manufacturing activity (basic employment, value added and capital investment) within metropolitan areas.	Reject Ho
7.	Retail Sales	Beltways and their characteristics have no discernible effect on changes in central city or central business district retail sales.	Cannot Reject Ho
8.	Employment	There is no difference in central city employment growth that can be attributed to beltway existence or characteristics.	Cannot Reject Ho
9.	Commuting Patterns: Vehicle Miles Traveled	Beltways have no significant effects on vehicle miles traveled (VMT) and are unlikely to have effects on energy consumption and air quality	Reject Ho
10.	Commuting Patterns	Beltways have no effect on suburban commuting patterns.	Fail to Accept Ho
11.	Workplace: Location Intra-Metropolitan Migration and the Suburbanization of Minorities	Beltways do not affect residential suburbanization rates and the suburbanization of the minority population; nor do they affect suburbanization of employment opportunities.	No Effect

URBAN DEVELOPMENTS: TRANSIT ERA

The transportation planning profession has witnessed an increased emphasis to coordinate urban development with transportation investments during the last few years. The term "joint development" has often been used to signify an integrated planning approach by which public facilities are built in concert with other development projects through coordinated efforts of public and private agencies. This definition implies that projects are related in time (before, during and after) and space (over, adjacent or under) to public facilities and implemented in a manner consistent with community goals ("Joint Development," 1976, 1983).

The emphasis on urban rail transit in the United States in the post-1970 era has provided new opportunities for transit and land use coordination through the application of the joint development concept. A number of large cities, notably Atlanta, Baltimore, Miami, San Francisco and Washington, D.C., and Los Angeles have been forerunners in such rail transit activity. The stations on these systems, representing nodes of high accessibility were considered to be prime candidates for the application of the joint concept. Joint projects are utilized to promote multiple

use of station sites and to encourage high density land uses, as well as to provide direct access to the transit facility. Such coordinated planning is necessary to integrate new development projects into the fabric of the station environment to the mutual benefit of the community, transit agency and the private sector (Arbogast et al. 1980, Opiela et al. 1980).

Research in the area of station planning supports this joint concept. (Sharpe, 1977, Khasnabis et al. 1982) Studies conducted by the Rice Center for Community Design and Research have attempted to apply the concept of "value capture" on development projects around transit stations. The term "value capture" has been used to denote a financing technique that seeks to return to the public sector a portion of increased value of land and properties thereon resulting from the investment. It has been argued that the "value capture" approach provides an opportunity to realize public finance benefits as well as community design benefits through special forms of taxation and participation programs.

Despite the above, researchers are somewhat divided in their opinion on the exact impact of the urban rail systems, particularly those built after 1970 on urban land uses. There is a general agreement on the positive impact of the metro-rail system, Washington, D.C., on urban land values and land uses around the station areas. The BART system in San Francisco, many researchers feel, did not fully live up to the original expectation of bringing about massive land use changes in the area, although there were significant changes in the travel patterns and mode-choice behavior of the affected communities. Evaluation of the Atlanta and Baltimore system is yet to be completed, but generally, the perception among planners on their land use impact is positive. The Los Angeles system has been opened only recently and it will be many years before the exact impact of the system will be assessed. There are studies currently underway to investigate the question of transit-land use interaction.

FUTURE DIRECTIONS

During the last two decades urban travel patterns in the US have undergone dramatic changes brought about by the nation's changing demographics, continued suburbanization and decentralization. While the relative prominence of the CBD as an employment center continued, changing land use patterns were instrumental in the development of major focal points of activities in the suburbs. As a result, urban travel patterns have changed significantly.

The trend toward suburbanization, which started in the early 1960s with the interstate highway program, is still continuing. Current estimates are that suburbs contain approximately half of the US population; this figure is expected to grow to 75 percent by the turn of the century. By the same token, employment opportunities in the suburbs have increased by a factor of two during the last decade. However, few individuals live and work in the same suburb. Other important demographic changes include a reduction in household size and increases in auto ownership and in median income. The combined effect of these changes has been an overwhelming increase in urban auto traffic.

While the era of major highway construction may have come to a close with the virtual completion of the interstate highway system, the traffic and land use impact of these investments continue to mount (Johnson, 1993). Among the emerging concepts to alleviate these problems are automated highways, intelligent vehicles, transit privatization and multiple use of transportation facilities. The questions of using transportation as a vehicle for urban growth management has become more important now than any time in the past.

It is beyond the scope of this paper to discuss all of the above emerging concepts. The authors present, in brief, their thinking on two of the emerging concepts: (1) privatization and (2) intelligent vehicles/automated highways.

Privatization

Transit services in the US during the post-World War II period were provided by private industry. It was largely due to sharp increases in operating costs that the nation witnessed the quick demise of the private transit industry during the late 1960s. With the advent of the "public transportation" concept in the 1970s, most of the financially stricken and privately owned transit companies were acquired by public agencies. Unfortunately, the transition from private to public operation did not, in any way, ease the financial crisis.

Privatization of transit services, essentially an old concept, once again gained momentum with the realization that the need to provide services in a cost-effective manner. There is also a growing feeling that a more equitable allocation of the cost of transit services should be made among the users. Further, many researchers contend that in order to provide high-quality services, there must be some level of competition among the providers—a factor that has been conspicuous by its absence since the demise of the private operator.

Proponents of privatization have argued that complete privatization should start with elimination of entry barriers and should allow carriers to set fares, to develop service policies and to select networks. The expected result will be the creation of a competitive environment among many carriers. Opponents contend that this philosophy works only when there is enough demand to allow market forces to help establish price and service policies. Further, it is argued that privatization may have the reverse effect of degrading of service and increasing costs because of the possibility that only "profitable" routes will be selected by the private operator and all other routes will be neglected.

Although the benefits of transit privatization are yet to be conclusively documented, the concept has gained prominence in recent times. The Federal Transit Authority (FTA) has adopted a policy that encourages public/private partnership in the development of transportation services to improve urban and suburban mobility. A number of cities have already experimented with the concept of privatizing transit services, including Chicago, Cleveland, Dallas and Los Angeles. A recent study concluded that privatizing transit services in the Detroit area is a viable means of providing suburban transit services in selected market areas in the region (Khasnabis et al. 1992).

Intelligent vehicle highway system

Technology in autonomous navigation and Intelligent Transportation Systems (ITS) has progressed dramatically during the last few years, mainly through defense-oriented research in the US The need to develop intelligent systems for civilian purposes has become increasingly evident The quality of our urban transportation infrastructure, which is largely dominated by highways, is barely adequate to meet 21st century demands for economic growth and development. Studies to date indicate that potential capacity gains are likely to be only of the order of 10 percent at the network level, by conventional route guidance and traffic management programs. Automated vehicular control, will, on the other hand, accommodate smaller headways and higher speeds, without the loss of safety, resulting in substantially higher throughput. Traffic accidents, many caused by congestion, drain away billions of dollars each year. While the potential of ITS to alleviate our urban congestion and safety problems appears to be good, the implementation of such projects will unquestionably require substantial capital investment, the infusion of large amounts of federal dollars and public acceptance.

In recognition of these problems, the US Congress passed the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The purpose of the act, as enunciated in the statement of the policy is to ("ITS Architecture" 1994):

> ...develop a National Intermodal Transportation system that is economically efficient and environmentally sound, provides a foundation for the nation to compete in the global economy, and will move people and goods in an energy efficient manner.

While it is beyond the scope of this paper to elaborate on the evolving ITS program in the US, it should be mentioned that the US Congress has authorized a $660 m program over the next 6 years

in the ISTEA legislation, for the planning, deployment and evaluation of a nationwide ITS program.

ITS comprises a wide array of technologies including electronics, computer hardware and software, communication and control. Initially a total of five functional areas in which these technologies can be applied were identified:

- Advanced Traffic Management Systems (ATMS)
- Advanced Travel Information Systems (ATIS)
- Advanced Vehicle Control Systems (AVCS)
- Commercial Vehicle Operations (CVO)
- Advanced Public Transportation System (APTS)

A sixth functional area, Advanced Rural Transportation (ARTS) was added later and the list may be expanded further to accommodate the needs of the nation.

Currently, there are over 50 ITS projects that are in various stages of development and operational tests (Strategic Plan, 1992). Similar projects are currently underway in Europe, Japan and Australia. Clearly, the ITS is a worldwide program, which may bring about significant changes in the travel behavior, urban growth and lifestyles of many communities.

CONCLUSIONS

The purpose of this paper is to present a historical overview of the impact of transportation on urban growth in the US and the possible impact of transportation investments during the coming decade. Major transportation projects undertaken in North America have demonstrated a close relationship between land use and transportation especially when supportive policies (eg land use, zoning, etc.) have been in place. Examples include: the development of major metropolis around railroad hubs at the turn of the last century; the phenomenal growth of cities around urban freeways during the 1960s; and the clustering of activity centers around rail transit stations built in the 1960-1980 era. It has become evident that the ideal role of transportation is not only to provide for mobility, but also to assist urban development. Transportation by itself may not be the sole causal factor of a land use impact, but it works with other forces affecting travel, location and urban development patterns, and urban economy.

Planners have often looked upon transportation policies as a means of controlling broad patterns of urban land uses. Following this trend of thinking, it is sometimes argued that past transportation policies such as the federal aid highway program, energy pricing, etc., contributed to the decentralization of urban activities in major metropolitan areas. Redistribution of population and jobs between central cities and suburbs resulting from such decentralization have, in turn, contributed to congestion, traffic hazards and environmental pollution. The reverse argument is that urban land uses reflect location decisions made by individual households and employers. Transportation is just one of many factors that affect such decisions. Because of certain characteristics of urban development and the stock of residential and commercial properties that is already in place, public policies in transportation have very little opportunity to alter, in any meaningful way, future land uses. Clearly, more research is needed to fully understand the transportation-land use interaction phenomenon.

It is impossible to quantify the exact nature of the impact of future transportation investments that are likely to focus more on modernizing transportation systems to support economic growth as opposed to traditional highway building. The possible long-term impact of ITS alone on our urban environment may be at the same scale as the impact of the interstate highway program initiated in the late 1950s. There are, however, serious questions about the viability of these evolving technologies, their acceptability by the users and their sustainability under the existing legal and institutional framework.

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