AN EXPLORATORY PROFILE OF LAND USE DEVELOPMENT PATTERNS AT INTERSTATE INTERCHANGES IN ALABAMA: 1964-1970

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Optimal and efficient planning, use, and protection of interchanges in urban and nonurban areas is necessary if the Interstate Highway System is to achieve functional goals of traffic movement and serve as a catalyst to economic and social development, both in the short and long run. The initial monetary outlays for interchange construction are significant, and this reason alone partially justifies detailed socioeconomic and land use impact studies to insure proper interchange planning, development, and utilization.

The use of abuse of interchange areas directly affects the efficiency of major portions of the Interstate Highway System. As has been stated, "... uncontrolled access to service stations, restaurants, motels, shopping centers, and other traffic generating developments may quickly create the kind of congestion often encountered along the commercial strips of many highways today."[1] David Levin several years ago accurately pinpointed the nature of this problem as he stated:

In terms of a given interchange, the highway official will assume that certain land-use development will reasonably occur in the areas that will be tapped by that interchange. He designs the interchange on that basis. In a number of instances, particularly in urban and suburban areas, and where other factors encourage the location of land uses involving substantial traffic generators, almost before the pavement is dry on an interchange ramp, several huge industrial plants, a regional shopping center, a hugh housing center, a complex of motels and restaurants, and other large traffic generators will be located next to the entrance or exit terminal of the interchange, literally at the end of the ramp or in the general vicinity.[2]

An orderly and controlled process of land development and change near interchanges is necessary for the most efficient allocation of resources and to avoid congestion and early obsolescence. However, there is presently a deficiency of information that will allow the planning process for these areas to anticipate land uses and traffic demand and plan accordingly. A planning and control procedure is needed which will incorporate both recent and anticipated land use and environmental changes into alignment determination and design features. Such planning and control procedures to be effective must include, as a start, information on such developmental criteria as the land use patterns which have evolved at the interchange over time and the basic reasons for the changes which have occurred. In keeping with the above needs, the specific objectives of this research were: (1) to develop a portrait of land uses which occurred following interchange construction, (2) to seek associative relationships in terms of the interchanges which did and did not experience land use changes after the beginning of interchange construction by cross-classifying the information with selected geographic, spatial, and design variables, and (3) to develop insights into possible data relationships which could effectively be explored in terms of appropriate multivariate analyses.

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STUDY METHODOLOGY

The analysis focused on land use changes at every interstate interchange in Alabama on which construction began during the 1964-1970 period (157 interchanges). The basis for this investigation of land use changes was a series of aerial photographs taken annually by the Alabama Highway Department during the 1964-1970 period.[3] The purpose of the annual photographic survey was "to detect, by means of aerial photographs, and to evaluate, in those cases where such action is considered desirable or necessary, the cultural growth in the vicinity of the interchanges."[4] In addition to the aerial photographs, a subsequent inspection was made at each interchange site by the Highway Department to provide further details on the growth and development at these points. Via these two approaches, the Highway Department has developed a detailed record of land uses at each interchange location.

No standardized definition of the interchange area of influence exists for data collection purposes, primarily because the potential for economic growth and development varies with the characteristics of each interchange and the surrounding area. Prior studies of interchange development, based on empirical analyses, have ordinarily included an area within one mile or less of the interchange as the primary area of influence, however.[5] The Alabama Highway Department, in collecting the photographic information during each of the seven years, defined the area of influence as "a distance of one-half mile along each approach road to the interchange".[6] Based on visual observation and personal interviews by the authors, it was determined that the greatest amount of construction related to the interchange indeed occurred within these limits. The nine different categories of land use included in the analysis are as follows: unimproved, residential, commercial, industrial, institutional, agricultural, highway-oriented, highway-oriented in combination with another use, and miscellaneous.[7]

When possible, the developments at the interchanges were cross-classified with the following variables: type of intersecting road; type of interchange; distance from preceding interchange when traveling south or west distance from preceding interchange when traveling north or east; type of land use existing prior to interchange construction; whether the interchanges are located in an urban or a rural area and distance from the nearest urban area of 2,500 or more. When possible, the cross-classifications were tested for statistical significance by chi-square analysis.

Broadly based generalizations relative to the land use development process at interchanges have not yet emerged, partly because of the newness of the System and partly because of the relative sparsity of published analyses of interchange development patterns. This research endeavored to relate the analyses performed to tentative conclusions which have emerged from other studies so as to broaden the base of generalizations and offer guidelines of greater usefulness to urban and regional planners whose responsibility is to insure an orderly process of development in these areas.

As an example of the types of findings which have emerged, Floyd Thiel, in an analysis of data on 322 interchanges in 16 states reached the five following conclusions.[8]

1. Service station developers prefer to locate at interchanges of an interstate and a U.S. numbered highway as do other tourist oriented businesses (p. 243).

2. Industrial and institutional land uses are disproportionately distributed at interchanges of two interstate highways (p. 243).

3. The importance of access, either by a free access crossroad or a frontage road, must be recognized (p. 244).

4. Land uses occur more frequently after interchange construction has been completed than during or before construction (p. 244).

5. As a suggestion for further research, Thiel stated that "interchange land development may differ according to type of interchange design and type of limited access facility concerned" (p. 248).

Research has also found that developers have a strong preference for locations at diamond or partial diamond interchanges. [9]

By way of other generalizations, a recent doctoral dissertation also provided basic insights into the interchange development process. It was revealed, for example, that development varied by distance from the nearest urban area and by distance from the preceding interchange. [10] Still another study has revealed that the nature of existing land use prior to interchange development exerts an influence on development which occurs after interchange construction. (p. 561). [11] Other analyses could be offered, but these are representative of the existing literature on this topic and basically serve to acquaint the reader with the rationale for the variables chosen for inclusion in this analysis. [12]

AN AGGREGATE OVERVIEW OF LAND USE CHANGES

As an overview before focusing in detail on specific land use changes, Table 1 shows that a total of 805 land use observations were recorded for the 157 interchanges prior to the beginning of interchange construction. More than 44 per cent were household units, followed by undeveloped and unused land, 20.9 per cent; and general farms, 10.1 per cent. Service stations accounted for less than four per cent of the existing development, while restaurants totaled only one per cent. Motels accounted for two-tenths of one per cent of the total number of before land use observations. [13]

A total of 224 land use changes occurred after the beginning of interchange construction during the seven year period. Service stations accounted for 63 per cent of total development, followed by restaurants with slightly more than 11 per cent of the developments, and motels with seven per cent. In the aggregate, these three developments accounted for more than 81 per cent of the total land use changes which occurred after the beginning of interchange construction.

AN ANALYSIS OF YEARLY LAND USE DEVELOPMENT PATTERNS AFTER INTERCHANGE CONSTRUCTION

Analysis revealed that 70 per cent of the developments which occurred in the 1-12 month period following the beginning of interchange construction were highway-oriented (restaurants, service stations, or motels), while slightly less than 22 per cent were commercial. Five per cent of the developments were industrial, and 3.3 per cent were residential.

In the 13-24 month period, almost 87 per cent of the 69 land uses which occurred were highway-oriented, while commercial developments accounted for slightly more than seven per cent of the land use changes. Approximately 4 per cent of the developments were institutional, while industrial developments were 1.5 per cent of the total.

Table 1. Total Land Use Existing Before And After The Beginning Of Interchange Construction

Land Use	Land Uses Existing Before Interchange Construction		Land Use Changes Which Occurred After Interchange Construction	
	Number	Percentage	Number	Percentage
Household units	357	44.4	3	1.3
Undeveloped and unused land	168	20.9	0	-
Farms (general)	81	10.1	0	-
Service stations	29	3.6	141	63.0
General Retail trade	24	3.0	7	3.1
Religious activ.	16	1.9	1	0.5
Primary and secondary edu.	13	1.6	1	0.5
Commercial area	11	1.4	2	0.9
Restaurants	8	1.0	25	11.2
Industrial area	8	1.0	1	0.4
Railroad	6	0.7	0	-
Water areas - general	6	0.7	0	-
Warehousing & storage services	6	0.7	9	4.0
Cemeteries	4	0.5	0	-
Nonreserve forests (undeveloped)	4	0.5	0	-
Medical & health services	4	0.5	0	-
Military base	3	0.4	0	-
Mobile home parks	3	0.4	1	0.5
Farms (dairy)	3	0.4	0	-
Business area	3	0.4	0	-
Shopping centers	3	0.4	4	1.8
Sports activ.	3	0.4	0	-
Retail stores - fruits & veg.	3	0.4	3	1.3
Lakes	2	0.2	0	-
Motels, hotels	2	0.2	16	7.0
Other retail trade	2	0.2	0	-
Retirement homes	2	0.2	0	-
Pecan groves (nut tree farms)	2	0.2	0	-
Electric utility	2	0.2	0	-
Machinery mauf.	2	0.2	1	0.5
Manufacture area	2	0.2	0	-
Recreation areas - general	0	-	2	0.9

Table 1. Total Land Use Existing Before And After The Beginning Of Interchange Construction
Continued

	Land Uses Existing Before Interchange Construction		Land Use Change Which Occurred After Interchange Construction	
Land Use	Number	Percentage	Number	Percentage
Other	25	3.1	7	3.1
Totals	805	100.0	224	100.0

Source: Computations Performed by the Alabama Highway Research Group, Universi ty of Alabama, 1971.

Highway-oriented developments continued to dominate in the 25-36 month period with 83 per cent of the total developments in this category. Commercial developments accounted for 14.6 per cent, a significant increase from the seven per cent which had occurred during the 13-24 month period. The only other development which occurred within this period of time was one institutional land use.

In the 37-48 month period, highway-oriented developments accounted for approximately 87 per cent of total development. Commercial developments accounted for almost nine per cent of the total land use changes and residential land use changes totaled 4.4 per cent. Overall, 20 of the 23 total developments in the 37-48 month period were highway-oriented.

Basically, the above portrait also emerged in the 49-60 month period. Eighteen of the 22 developments, or 81.7 per cent, were highway-oriented. The remaining four developments were scattered over residential, industrial, and institutional land uses. Only nine developments occurred in the 61-72 month period. Eight of these nine land uses were highway-oriented. No new land use changes occurred in the 73-84 month period following construction.[14]

Summary

The majority of the developments which occurred in each of the seven years were highway-oriented, followed by somewhat distantly by commercial developments. The greatest number of developments occurred in the first four years after the beginning of interchange construction. For example, in the sixth year after the beginning of interchange construction, only nine land use changes occurred; while in the seventh, no new land use changes occurred.

AN ANALYSIS OF THE INTERCHANGES WHICH DID AND DID NOT EXPERIENCE LAND USE CHANGES AFTER THE BEGINNING OF INTERCHANGE CONSTRUTION, CROSS-CLASSIFIED BY SELECTED VARIABLES[15]

The preceding analyses focused on changes in land use patterns without reference to the characteristics of the interchanges themselves. This analysis focuses on the differences, if any, between interchanges which did and did not experience land use changes after the beginning of interchange construction. The analysis was performed by relating land use changes or the lack thereof to the following variables: type of intersecting road, type of interchange, distance from preceding interchange when traveling south or west, distance from preceding interchange when traveling north or east, type of land use existing prior to interchange construction, whether the interchanges were located in an urban area or a rural area and distance from the nearest urban area of 2,500 or more in population.

Type of Intersecting Road

As Table 2 indicates, the type of intersecting road had no apparent influence on whether an interchange experienced land use changes after the beginning of construction in that no significant differences were found at $P < .05$. The three types of intersecting roads examined in relation to development were U.S. highways, state highways, and county roads. As may be observed, virtually no variation in development levels occurred by type of intersecting road.

Table 2. Number and Percentage Distribution of Interchanges With and Without Land Use Changes, Cross-Classified By Type of Intersecting Roadway*

Land Use Changes	Type of Intersecting Road: U.S. Highway Number	U.S. Highway Percentage	State Highway Number	State Highway Percentage	County Road Number	County Road Percentage
Yes	23	57.5	19	57.6	24	58.5
No	17	42.5	14	42.4	17	41.5
Total	40	100.0	33	100.0	41	100.0
Aggregate Percentage	35.1		28.9		36.0	

*Not significant at $P < .05$

Type of Interchange

The interchanges which did and did not experience land use changes following the beginning of interchange construction were, however, significantly related to the type of interchange at $P < .01$, as shown in Table 3. Of the 148 interchanges included in this analysis, 110 were diamonds. Slightly more than 59 per cent of the diamond interchanges experienced one or more developments. Conversely, of the 30 partial or modified diamond interchanges, only eight experienced one or more land use changes. (Eight of the interchanges examined were full cloverleafs, and six of the eight experienced one or more developments). The relative lack of development at partial or modified diamonds gives further credence to statements in the literature that a partial or modified diamond interchange is not a highly desirable location because of the relative difficulty of returning to the interstate after exiting.[16]

Table 3. Number and Percentage Distribution of Interchanges With and Without Land Use Changes, Cross-Classified By Type of Interchange*

Land Use Changes	Type of Interchange: Full Diamond Number	Full Diamond Percentage	Cloverleaf Number	Cloverleaf Percentage	Partial or Modified Diamond Number	Partial or Modified Diamond Percentage
Yes	65	59.1	6	75.0	8	26.7
No	45	40.9	2	25.0	22	73.3
Total	110	100.0	8	100.0	30	100.0
Aggregate Percentage	74.3		5.4		20.3	

*Significant at $P < .01$

Distance From Preceding Interchange South or West

Interchanges experiencing land use developments were also statistically related to distance from the preceding interchange when traveling south or

west at $P < .02$--see Table 4. Fifty of the interchanges studies were within two or less miles of the preceding interchange when traveling south or west. However, only 17, or 34 per cent, of these interchanges experienced one or more land use changes after interchange construction. In each of the remaining mileage categories, at least 60 per cent of the interchanges experienced one or more developments. For example, 23 of the 36 interchanges located within three to four miles from the preceding interchange when traveling south or west experienced one or more land use changes. Likewise, almost 61 per cent of the interchanges in the five to six mile range experienced land use changes, and 24 of the 40 interchanges in the six to twelve mile range experienced one or more land use change.

Distance From Preceding Interchange North or East

Distance from the preceding interchange when traveling north or east did not have a significant relationship at $P < .05$ in terms of the interchanges experiencing land use developments, as shown in Table 5. In the 0-2 mile category, 39 per cent of the 46 interchanges experienced one or more developments. This is closely related to the finding for the percentage of developed interchanges in the same mileage range from the preceding interchange south or west. Slightly more than 55 per cent of the 38 interchanges located three to four miles from the preceding interchange north or east experienced one or more developments. In terms of the 25 interchanges which were located five to six miles from the preceding interchange north or east, 48 per cent experienced developments, while slightly more than 61 per cent of the 39 interchanges in the six to twelve mile range experienced one or more land use changes.

Rural or Urban Location of Interchange

Whether the interchange is located in a rural or an urban area has a statistically significant effect at $P < .01$ on whether developments will occur at a given interchange. Of the 157 interchanges studied, 107 are located in rural areas. Slightly more than 61 per cent of these interchanges experienced one or more land use developments after interchange construction. Three of the interchanges are located in isolated cities with populations of 2,500-50,000 people. Two of the three interchanges experienced one or more developments. Likewise, eight of the interchanges are located in the city limits of cities contiguous to metropolitan areas with populations of over 50,000. One-half of these interchanges experienced developments. Thirty-nine of the interchanges are located in the city limits of metropolitan areas with populations of more than 50,000 people. Slightly more than 28 per cent of these interchanges experienced one or more land use developments. A probable explanation for the relative lack of development in this instance is the presence of directional interchanges in major metropolitan areas from which ingress and egress is difficult.

Type of Land Use Prior to Construction

The type of land use existing in the vicinity of the interchange prior to the beginning of interchange construction was also found to be related to whether land use changes occurred after construction of the interchange ($P < .10$). Development occurring at a given interchange after its construction varied from a low of 40 per cent at interchanges where highway-oriented development existed prior to construction to a high of more than 58 per cent of the interchanges with agricultural land uses prior to construction. This pattern may reflect a concept of highest and best use in terms of land in that 60 per cent of the interchanges with highway-oriented uses existing prior to construction experienced no land use changes while almost 60 per cent of the

Table 4. Number and Percentage Distribution of Interchange With And Without Land Use Changes, Cross-Classified By Distance From Preceding Interchange South Or West*

Distance From Preceding Interchange South or West (in miles)

Land Use Changes	0 - 2		3 - 4		5 - 6		6 - 12	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Yes	17	34.0	23	63.9	14	60.9	24	60.0
No	33	66.0	13	36.1	9	39.1	16	40.0
Total	50	100.0	36	100.0	23	100.0	40	100.0
Aggregate Percentage	33.6		24.2		15.4		26.8	

*Significant at $P < .02$

Table 5. Number and Percentage Distribution of Interchanges With And Without Land Use Changes Cross-Classified By Distance From Preceding Interchanges North Or East*

	Distance From Preceding Interchange North or East (in miles)							
	0 - 2		3 - 4		5 - 6		6 - 12	
Land Use Changes	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Yes	18	39.1	21	55.3	12	48.0	24	61.5
No	28	60.9	17	44.7	13	52.0	15	38.5
Total	46	100.0	38	100.0	25	100.0	39	100.0
Aggregate Percentage	31.1		25.7		16.9		26.3	

*Not significant at $P < .05$

interchanges with agricultural land use in existence prior to construction experienced a change in land use following construction.

Distance From Nearest Community

Interchange development was also found to be statistically related to distance from the nearest community of 2,500 or more ($P < .01$).[17] Of the 50 interchanges located within city limits, 17, or 34 per cent, experienced one or more land use changes. However, of the interchanges located within one or less miles of the nearest incorporated area, eleven of the 14 interchanges, or 78.6 per cent, experienced one or more land use changes. Within the two to three mile range, a reasonable balance between developed and undeveloped interchanges was noted. Almost 58 per cent of these interchanges experienced one or more land use changes. In the four to five mile range, ten of 13 interchanges experienced one or more land use changes, while in the six to seven and the eight to nine mile ranges, the extent of the interchange development again decreased. For example, only two of the nine interchanges in the six to seven mile range experienced one or more land use change, while four of the nine interchanges in the eight to nine mile range experienced land use changes. Twenty-five of the 36 interchanges, or 69.4 per cent, located more than nine miles from the nearest community of 2,500 or more experienced land use changes. As a generalization, it seems that the interchanges located in or near to the communities are more likely to experience land use changes. A secondary increase in development probabilities again occurs approximately nine miles from the nearest community.[18]

CONCLUDING OBSERVATIONS

If land use controls are to be effective in assuring optimal interchange development, control procedures must be established prior to or soon after construction, because most of the development which occurs will take place in the first three years following interchange construction.

It does seem that the market control mechanism is functioning rather well at the interchanges which are in effect spatial monopolies. More than 80 per cent of all development which occurred was of a highway-oriented nature and thus ideally should have the most conveniently available access to the interchange.

Certain limited generalizations relative to the interchange development process have emerged based on this research. The diamond interchange, followed by modified or partial diamonds, is likely to experience the greatest amount of development, particularly of a highway-oriented nature. Likewise, interchanges located in minimum of three miles from the preceding interchange seem to have a higher probability of development than do more proximate interchanges. Also, interchanges located proximate to, but not in, metropolitan areas apparently have higher probabilities of development than do the interchanges within the community itself. This is at least partially a function of the design of the interchange, and observation revealed that a relatively higher percentage of directional and non-free access interchanges existed in the urban areas than in the non-urban areas. Lastly, a secondary peak in development levels apparently occurs nine to twelve miles from the nearest metropolitan area, seemingly reflecting some types of spatial market perception by the developers of facilities at these points.

The findings suggest that if land use controls are to be effective in assuring an orderly process of development at interchange areas, the planning process should begin quite early. Ideally, controls should be established prior to the construction of the interchange. The research has shown that

the greatest amount of development which is going to occur at a given interchange will take place within three years after interchange construction. Further, the developments most likely will be of a highway-oriented nature (restaurants, motels, and service stations), all of which require ease of ingress and egress from the System. Because of the nature of these types of businesses and the need for relative tranquillity, the problem of compatibility in land use becomes especially crucial at these points. It does seem however, that basic compatibility may be rather easily achieved in that the market mechanism seems to be functioning so as to allocate the greatest amount of space to the businesses which require the most ready access to interstate travelers.

Additional research will be necessary to develop a sufficiently broadened base of generalizations relative to the interchange development process. For example, research must be performed relative to each separate category of land use to determine whether unique locational patterns characterize a given type of land use. Further, the question of whether certain interchange types tend to or should specialize in a given type of land use must be answered. These types of analysis basically require a series of case studies, particularly if the analysis is to be carried to the quadrant level of the interchange. Indeed, limited research has shown that analysis of land use on a quadrant basis may be particularly fruitful. As has been said, "Several studies have indicated that the most desirable location for highway services is the first quadrant on the motorists right as he approaches the interchange."[19] Thiel has long been an advocate of the case approach to the study of the interchange development process.[20]

The number of multi-variate analyses must also be expanded to better determine key variables in the interchange development process. In terms of limited findings which have emerged, researchers at Pennsylvania State University found that average daily traffic on cross routes was the single most important factor in explaining new highway-oriented development.[21] Likewise, an analysis of Oklahoma interchanges revealed that traffic volumes and size and distance of the nearest urban area were the factors of greatest association with highway-oriented establishment.[22] Additional research of this nature is a necessity in broadening the base of generalizations relative to interchange development. However, the research reported in this article is a desirable step in the proper direction.

FOOTNOTES

[1]William Pendleton, "Land Use at Freeway Interchanges," Traffic Quarterly, Vol. 15 (October 1961), p. 538.

[2]David Levin, "The Highway Interchange Land-Use Problem," Land Use Development at Highway Interchanges, Highway Research Bulletin 288 (Washington, D.C.: Highway Research Board of the National Academy of Sciences, 1962), pp. 1-2.

[3]In this analysis, reference is often made to a six year period of analyis even though data was analyzed over a span of seven years. The reason is that for those 58 interchanges on which construction began in 1964, the first year of analysis, no land use changes occurred in 1970.

[4]Photographic Comparison of Land Use Areas Adjacent to Interchange Limits of the Interstate System (Montgomery, Alabama: Alabama Highway Department and U.S. Bureau of Public Roads, 1965), p ii.

[5]See, for example, Edward Stockwell and John P. Dixon, Social and Economic Change at Interchange Areas of the Connecticut Turnpike, 1958-1964, Research Report 16 (The University of Connecticut: Storrs Agricultural Experiment Station, 1966), p. 4; Owen Sauerlender, Robert Donaldson, Jr. and Richard Twark, Factors That Influence Economic Development at Non-Urban Interchange Locations, Research Report 9 (University Park, Pennsylvania: Institute for Research on Land and Water Resources, 1966); John D. Sears and Charles G. Smith, A Study of Land Development and Utilization in Interchange Areas Adjacent to Interstate 40 in Tennessee (University of Tennessee: Tennessee Highway Research Program and U.S. Bureau of Public Roads, 1968); and Harold Marks and Salem Spitz, A Review of Transportation Aspects of Land Use Controls, National Cooperative Highway Research Program Report 31 (Washington, D.C.: Highway Research Board of the National Academy of Sciences, 1966), pp. 30-31. For further readings, see, Joseph Barry Mason, A Selected Bibliography of Interchange Development and Land Use Controls. Exchange Bibliography 212 (Monticello: Illinois: Council of Planning Librarians, 1971).

[6]Photographic Comparisons, op. cit., p. ii.

[7]A differentiation between highway-oriented and commercial developments was felt to be necessary to allow proper sensitivity in data analysis. For example, over 80 per cent of the developments were service stations, motels, or restaurants. These were defined as highway-oriented, while the remaining retail wholesale, and service establishments were defined as commercial business. The definitions are similar, but no overlap occurred in terms of land use categorization.

[8]Floyd Thiel, "Highway Interchange Area Development: Some Recent Findings," Public Roads, Vol. 35 (December 1969).

[9]Joseph Barry Mason and Charles Thomas Moore, "A Note on Interchange Location Practices by Developers of Major Retail Centers," Land Economics (May 1972); "A Jobber Builds an 'Unplanned' Interstate Site," National Petroleum News, Vol. 55 (November 1963), p. 120.

[10]Brooks Smith, "An Explanatory Analysis of the Relationships of Selected Social, Economic, and Spatial Variables to Interchange Area Develop-

ment," (Unpublished Doctoral Dissertation, Graduate School of the University of Alabama, 1972).

[11]William R. Beaton and Thomas H. Hall, III, "Service Station Site Considerations on the Interstate Highway," Appraisal Journal, Vol. 36 (October 1968).

[12]For those interested in further detailed analyses on the topic of interchange development, see the following as examples of existing literature: Charles W. Campbell, Economic Problems Emerging as a Result of Interchange Patterns on the Interstate Highway System in Virginia (Charlottesville, Virginia: Virginia Council of Highway Investigation and Research, 1964); Thomas Eighmy and John J. Coyle, The Simulation of Land Use for Highway Interchange Communities (University Park, Pennsylvania: The Institute for Research on Land and Water Resources, Highway Impact Research Program, 1967); Robert D. Fowler, A Pilot Study of Highway-Oriented Business Development of Non-Urban Interchange Areas (University of West Virginia: West Virginia Center for Appalachian Studies and Development, 1965); William C. Pendleton, "An Empirical Study of Changes in Land Use at Freeway Interchanges," Traffic Quarterly, Vol. 19 (January 1965), pp. 89-100.

[13]The land use categories are based on a modified version of A Standard System for Identifying and Coding Land Use Activities (Washington, D. C. Superintendent of Documents, 1965).

[14]The number of interchanges included in each period of analysis was as follows: 1-12 months, 157; 13-24 months, 140; 25-36 months, 133 interchanges; 37-48 months; 123; 49-60 months, 105; 61-72 months, 87; 73-84 months, 58. The number of land use changes were: 1-12 months, 60; 13-24 months, 69; 25-36 months, 41; 37-48 months, 23; 49-60 months, 22; 61-72 months, 9; 73-84 months, 0.

[15]The base for each of the tables in this analysis does not necessarily total 157 interchanges because of the varying nature of the analysis. Of the 157 interchanges analyzed, 85 experienced one or more land use changes after the beginning of interchange construction. With a total of 224 developments, this is an average of 2.6 land use changes for each interchange at which development occurred. The detailed breakout is as follows: 24 interchanges experienced one development; 28 experienced two developments; 14 experienced three developments; six experienced four developments; five experienced seven developments; and one experienced eight developments.

[16]See, for example, "A Jobber Builds an 'Unplanned' Interstate Site," National Petroleum News, Vol. 55 (November 1963).

[17]The grouping of all urban areas of 2,500 or more together for purposes of analysis yields loss sensitivity in the data than ideally is desired. However, this was necessary to statistically test for associative relationships. Disaggregation was not possible because of the relative fewness of the interchanges experiencing land use changes and the fewness of communities in varying population categories along the System in the State.

[18]Since the basic purpose of the research reported here was to develop tentative insights, via cross classifications, into associative relationships in the data which could later be tested by appropriate multivariate analyses, a detailed discussion of such findings is not warranted here. However, a brief mention is in order to allow the reader to better determine the meaning of the yields of the cross-classification analyses. Stepwise regression techniques were applied to the data for each interchange in the State which

experienced land use developments in the seven year period following interchange construction. The analysis was further aided by normalization of the data in terms of beta coefficients. Analyses were performed for each of the categories of land use, as well as for associative relationships when all data were aggregated. Moderate levels of association were evident. The aggregate R^2 for all of the land uses was .42. The R^2 values for each of the individual categories of land use ranged from .26 to .44.

[19]Thiel, op. cit., p. 243.

[20]Floyd Thiel, "Highway Interchange Area Development," Public Roads, Vol. 33 (June 1965), p. 164.

[21]Richard Twark and Owen Sauerlender, A Predictive Model of Economic Growth at Non-Urban Interchange Sites on Pennsylvania Interstate Highways (Pennsylvania State University: Institute for Research on Land and Water Resources, 1965).

[22]Robert Lehr, Joseph L. Rogers, and William N. Willcut, Relationship of the Highway Interchange and the Use of Land in the State of Oklahoma (Oklahoma Center for Urban Studies, 1965).