



Spatial reorganisation and time-space convergence

Donald G Janelle

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Donald G Janelle. Spatial reorganisation and time-space convergence. Geography. Michigan State University, 1966. English. NNT: . tel-02293067

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SPATIAL REORGANIZATION AND TIME-SPACE CONVERGENCE

By

Donald G. Janelle

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Geography

1966

PhD defense examination: 5 May 1966

Examining committee:

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ABSTRACT

SPATIAL REORGANIZATION AND TIME-SPACE CONVERGENCE

by Donald G. Janelle

Most scholars in geography and related social sciences have recognized that the locational structure of man's economic, political and cultural activities is not in a static state. Yet, very little attempt has been made to conceptualize the manner by which the spatial arrangement of man's establishments change over time. Many empirical studies have noted the increasing trends towards urbanization and industrialization, the growing significance of tertiary economic activities in developing countries and the functional decline of rural villages. In this study it is maintained that these and other forms of areal reformation are products of a clearly defined process of spatial reorganization. The author's purpose is to identify this process and to investigate the mathematical and conceptual properties of certain "steps" involved. Although the intent of this study is to provide a conceptual foundation and to formulate models for considering the areal development of man's activities, empirical evidence and historical examples are provided to support some of the ideas proposed.

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The author maintains that the spacing and arrangement of man's functional establishments are products of their travel-time separation; man adapts his areal patterns of occupance to changes in travel-time connectivity. Travel-speed is accepted as the surrogate of transport efficiency. As man increases the speed of his transport, it becomes possible for him to market his goods and services over a larger area and to attain access to more distant resources.

As a consequence of increasing accessibility, it is possible to derive certain benefits of spatial reorganization which may be broadly described as products of centralization (the concentration of activities at a particular place) and specialization (the concentration of effort on a particular activity in a given place or area). The less the expenditure of time (cost or effort) required to obtain man's survival and amenity needs from a given place, the greater is the opportunity for these scale economies to develop at that place. In this context, centralization and specialization are viewed (in part) as forms of spatial adaptations to the changing time-space framework of man's activities.

To characterize and to measure the changing time-space arrangement of these activities, the author has developed a concept of time-space convergence. Convergence is expressed as the rate at which the travel-time

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between places has been declining in response to increasing transport efficiency. In a basic model indicating the "steps" in the process of spatial reorganization, convergence plays a significant role--it is a measure of the impact of transport innovation on the time-space connectivity of places and it is an expression of the increased accessibility of given places to other places and to surrounding areas. In that man adapts the locational structure of his activities to changes in the time required to travel between them, convergence is also a surrogate of the potential scale economies (centralization and specialization) possible at given places. An expanded model is also proposed--it accounts for forms of areal adaptation not accounted for by the basic model (i.e., decentralization and decentralized centralization).

Spatial reorganization is not operative everywhere to the same degree and it does not occur simultaneously at all places on the earth. Therefore, a complementary concept of relative advantage has been proposed. Essentially, this concept, based on the assumption of rationality and its defined implications (man has complete knowledge, perfect predictability and a desire to maximize his utility of time), implies that man introduces transport innovations between those places which will benefit most from reduced travel-time.

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Because convergence is operative in the process of spatial reorganization, it is logical that its individual properties must also be expressed in this reformation. For this reason, the author has given considerable attention to the mathematical and conceptual properties of convergence and convergence rates. The mathematical properties account for the manner by which places approach each other in time-space, and the conceptual properties characterize how convergence varies for different times of the day or year, for different economic, political and cultural realms, for different income groups, for commodity as opposed to passenger transport and so forth. Examples are used to clarify these considerations.

By combining the convergence concept and its manifold mathematical and conceptual properties with the concept of relative advantage, insight into the mechanics of spatial reorganization is provided. The role of convergence is indicated and a means of ascertaining the degree of centralization and specialization likely to develop at a given place is made possible. In this manner, the spatial structure of man's functional establishments is viewed as a phenomenon changing in accordance with a clearly defined process of reorganization.

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ACKNOWLEDGMENTS

Whatever merit this study may have is, in part, attributable to my associations with many individuals at Michigan State University and elsewhere. Of these individuals, two deserve particular recognition--Dr. Allen K. Philbrick and my dissertation advisor Dr. Julian Wolpert. Dr. Philbrick, in many formal courses and informal discussions, has inspired my interest in theoretical geography, schooled me in the philosophy of science and offered numerous suggestions that have proven helpful in this study. Dr. Wolpert patiently directed my efforts on this study and introduced me to the world outside of geography--to work by scholars in other disciplines. His willingness to help, encouragement, original ideas and abiding interest in this study have made my work both enjoyable and profitable.

The assistance of other individuals is also gratefully acknowledged. I thank Dr. Lawrence M. Sommers for making available to me the facilities of the Department of Geography at Michigan State University and for gathering here a staff that makes geography challenging. Dr. Donald Blome has clarified for me many questions on central place theory and has offered helpful suggestions on improving the original draft of this paper; Mr. Stewart Marquis of the

Department of Urban Planning at Michigan State University offered useful ideas on the formulation of conceptual models developed in the early portions of the study; Dr. Waldo Tobler of the University of Michigan reviewed the mathematical properties and map transformations discussed herein; and Dr. James H. Stine of Oklahoma State University provided many original ideas that have been incorporated and developed in this study.

Finally, for their willingness to listen and to offer constructive criticism, I thank Dr. Ian Matley and Dr. Milton H. Steinmueller. I also thank David Jones, Samuel Reisman, Roger Smith, Clifford Tiedemann, Barbara Whitaker and the other members of the student community at Michigan State University for their encouragement and comments. While this dissertation climaxes my graduate training, it has, through the assistance of all these and other individuals, opened to me new horizons of geographical inquiry. Though this is a satisfying feeling, it is also disquieting--the job is not completed; much remains to be accomplished.

This investigation was supported (in part) by a Public Health Service fellowship (number 1-F1-CH-31, 220) from the Division of Community Health Services.

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INTRODUCTION

This study is dedicated to furthering the understanding of the temporal-spatial formation of man's economic, political, social and other activities. The author's objective is to consider the theories of central places¹ and areal functional organization² in a combined temporal and spatial framework. As such, the concept to be proposed in this study is, in many respects, an extension of existing theory. However, instead of focusing upon spatial "organization," this study will be more concerned with the concept and process of spatial "reorganization." In other words, it will consider areal "developmental" rather than areal "functional" organization.

In investigating the interrelations of man's activities it is maintained that time-space provides a more fitting framework than does a purely spatial one. This

¹For statements on the central place theory, the reader should consult Carlisle W. Baskin, Translation of Walter Christaller's "Die zentralen Orte in Süddeutschland" (unpublished Ph.D. thesis, Dept. of Geog., Univ. of Virginia, 1955). Also, see August Lösch, The Economics of Location, trans. William H. Woglom and Wolfgang F. Stolper (New Haven: Yale University Press, 1954).

²Statements of this theory are provided by Allen K. Philbrick, "Principles of Areal Functional Organization in Regional Human Geography," Economic Geography, 33 (1957), pp. 299-336; "Areal Functional Organization in Regional Geography," Papers and Proceedings of the Regional Science Association, 3 (1957), pp. 87-98.

contention is based on the assumption that the arrangement, concentration and spacing of man's functional enterprises are more a product of their time-space separation (the time it takes to travel between desired origins and destinations) than of their distance separation. For purposes of this study a functional enterprise is a basic unit in which human activities take place. These include the home, the farm, the church, the business, the factory, the mine and so forth. They may alternatively be referred to as establishments or facilities.

Admittedly, the assumption that the locational structure of man's activities is a product of their time-space separation would have little meaning were it not for the distinctive differences in the speeds at which man can travel via his various means of transportation and were it not for the increased speeds that improved transport technologies have made possible. These differences take on time-spatial implications of theoretical and practical importance only because man has not introduced his new and faster means of movement simultaneously in all directions from all points on the earth. As a consequence of this, it is possible to consider the distances which separate man's settlement centers and establishments as being relative to the time required to travel between them.

In a time-space framework it is easily seen how historical changes in the means of travel will alter the

significance of the distances separating given places. Thus, whereas the 85 miles separating Lansing and Detroit, Michigan could be traveled in approximately 1,266 minutes via stage coach in 1840, the same trip can be made today via automobile in an average of 78 minutes. But, these differences are not only developmental in nature--Lansing is also 85 miles from the small city of Big Rapids (northwest of Lansing). Yet, this trip would take about 140 minutes today. Why do such differences in the significance of distance exist and what, if any, are the areal manifestations of these differences on the cultural landscape--in the spacing of man's establishments and settlements? Which class of man's settlements will stand to gain or lose most by further improvements in transport speeds? How has man adapted the spatial arrangements of his activities to changes in transport technology? Although answers to these questions are suggested in this study, they are not intended as definitive. For the moment, the author is more concerned with outlining a conceptual foundation for future investigations.

The study is divided into two parts. The objective in Part I is to outline the nature of the problem under consideration, to outline the "steps" in the process of spatial reorganization, and to provide empirical evidence on the locational adaptation of man's functional activities to changes in the significance of distance--changes which

are engendered through advances in transportation technology. Where possible, this notion will be related to existing theory. In Part II a descriptive model will be proposed for characterizing the changes in the time-space formation of man's functional enterprises. This model provides a means of measuring what the author describes as "time-space convergence" or the rate at which the travel-times between places have been declining in response to new or improved means of transportation. A concept of "converging settlements" is proposed and is combined with a concept which is believed to account for the differences in the rates at which places converge upon one another. This study is concluded with a discussion on its implications for location theory and upon its conceptual limitations. Problems requiring further research are also outlined.

PART I

TRANSPORT INNOVATIONS, RELATIVE LOCATIONS
AND SPATIAL REORGANIZATION

CHAPTER I

A MODEL AND CONCEPT OF SPATIAL REORGANIZATION

The role of transportation technology in changing the areal form of man's activities has not gone completely unnoticed by geographers and others interested in spatial theory. Ullman's studies on interaction have focused upon the importance of transportation in changing the spatial organization of man's economic endeavors.¹ Morrill, noting how ". . . our evaluation of space changes with technological improvement . . . ," has recognized that the locational concepts of central place theory must be made ". . . to operate in an historical context."² Likewise, Isard asks "how does progress in the state of transport technology . . . impel change and rearrangement of centers and population nuclei?"³ Yet, in spite of this recognition, theorists have not, to date, considered transportation technology in

¹Edward L. Ullman, "The Role of Transportation and the Bases of Interaction," Man's Role in Changing the Face of the Earth, ed. William L. Thomas, Jr. (Chicago: Univ. of Chicago Press, 1956), pp. 862-80.

²Richard L. Morrill, "The Development of Spatial Distributions of Towns in Sweden: A Historical-Predictive Approach," Annals of the Association of American Geographers, 53 (March, 1963), pp. 2-3.

³Walter Isard, Location and Space-Economy (Cambridge, Mass.: The Massachusetts Institute of Technology Press, 1956), p. 11.

a context that explains its role in changing both the spatial and time-spatial relationships of man's activities. In this chapter the author assumes that there is a need for such a theoretical formulation; and, proposes a model and a concept which may, at least, point the way to fulfilling this need.

Viewing the Developmental Processes of Spatial Change

In general, it is possible to distinguish two broad classes of processes expressing themselves, through change in the central place structure, on the geographical landscape. These are: (1) functional processes, and (2) developmental processes. Whereas functional processes refer to the day-to-day cultural, economic and political interactions of different establishments and different places at all levels of the hierarchy, the developmental processes refer to the maturing or to the resulting areal organization that has evolved and is evolving as a consequence of the functional processes.

For the most part, this study is concerned with the developmental aspects of the formal spatial and time-spatial structures of central place organization--how settlements are rearranged by man and the patterns that result. It will be shown how changes in the time-space structure of man's functional establishments are engendered by advancements in transport technology and how locational

changes in this organization are often attributable to changes in the time-space connectivity of these establishments.

The use of a time-space framework is essential in a study of the process of spatial development. As Blaut notes, structure (the areal arrangement of earth-space phenomena) and process (the rearrangement of these phenomena over time) are one and the same thing--that is, ". . . structures of the real world are simply slow processes of long duration."¹ Inherent in Blaut's view is the implicit existence of a temporal pattern in each and every spatial pattern.² Thus, in the following development of a model of the process of spatial reorganization,

¹J. M. Blaut, "Space and Process," The Professional Geographer, 13 (July, 1961), p. 4.

²This notion, first recognized by the physicists and physical philosophers (See Henry Margenau, The Nature of Physical Reality [New York: McGraw Book Co., Inc., 1950], pp. 123-66; and, see P. W. Bridgman, A Sophisticated Primer of Relativity [London: Routledge and Kegan Paul, 1963].), has been acknowledged by many geographers and other social scientists. These include: Donald A. Blome, A Map Transformation of the Time-Distance Relationships in the Lansing Tri-County Area (East Lansing, Mich.: Institute for Community Development and Services, Michigan State University, 1963); Werner J. Cahnman, "Outline of a Theory of Area Studies," Annals of the Assoc. of Amer. Geog., 38 (December, 1948), pp. 233-43; Amos H. Hawley, Human Ecology: A Theory of Community Structure (New York: The Ronald Press, 1950), p. 288; Isard, op. cit., pp. 77-78; Fred Lukermann, "The Role of Theory in Geographical Inquiry," The Professional Geographer, 13 (March, 1961), p. 1; Morrill, op. cit., p. 2. Allen K. Philbrick is presently using a time-space framework in studying the areal functional organization of man's activities.

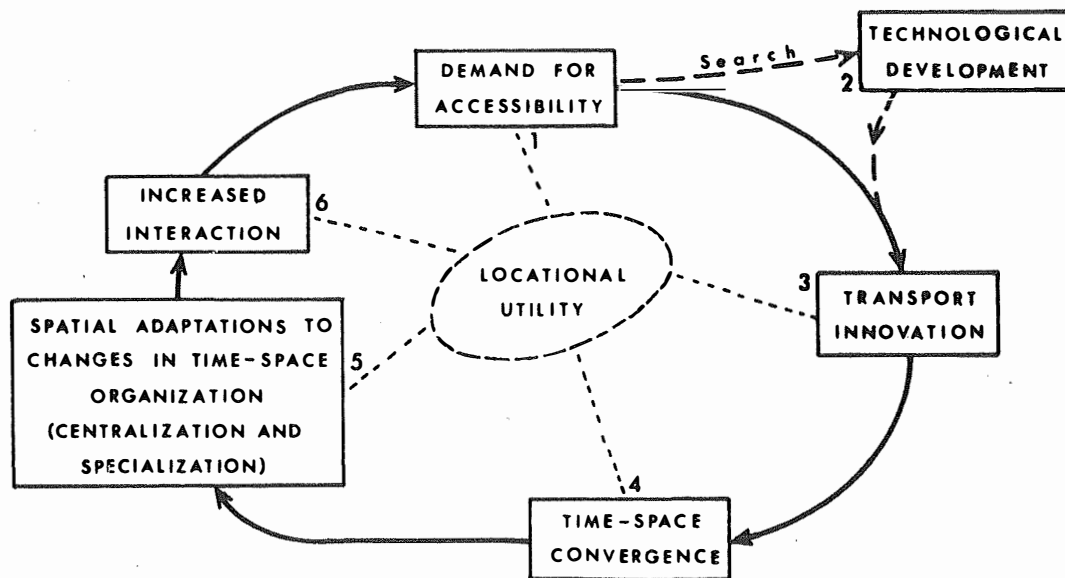
it will be noted that the time-space framework is a necessary prerequisite.

A Model of the Process of Spatial Reorganization

As used in this study, the concept of spatial reorganization identifies a process by which man adapts the locational structure of his activities to changes in their time-space connectivity (the time required to travel between them). In Figure 1, a model has been designed to depict a normative process of spatial development. Later this model (the basic model) will be expanded so as to present a more comprehensive view of areal reorganization. These models are designed to be applicable to urban-exchange economies typical of the United States and Western Europe.

Both the basic model and the expanded model (see Figure 5) are based on the premise that changes in the time-space connectivity of places are engendered through introductions of improved transport technologies. What, however, is the motivation for man to increase the speed or efficiency of travel between given places? From what are these motivations derived? These questions, along with the process of spatial reorganization, will be clarified as the concepts integrated into the model are defined. These concepts include: (1) accessibility, (2) transport innovations, (3) time-space convergence, (4) spatial

A PROCESS OF SPATIAL REORGANIZATION

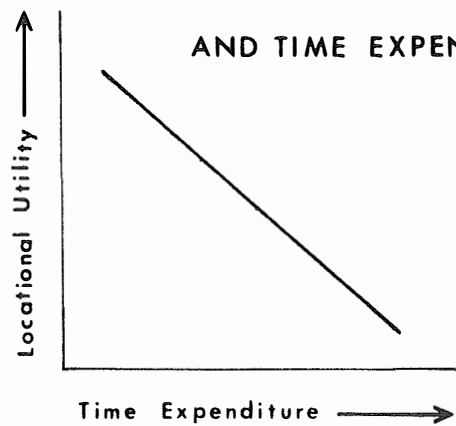


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FIGURE 1

LOCALATIONAL UTILITY AND TIME EXPENDITURE



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FIGURE 2

adaptations--centralization and specialization, and (5) spatial interaction. Before defining these five concepts, however, an additional concept which is central to the over-all process of reorganization needs to be considered--this is the concept of locational utility.

Locational utility.--Of itself, utility is a measure of value. Thus, locational utility is a measure of the value of specific places or areas. For purposes of this study, the amount of utility of a given place will be determined by how much time expenditure is required to obtain all of one's essential needs and desires at this place. (Effort or cost could be substituted for time.) As indicated in Figure 2, the locational utility or value of a place increases as time expenditure decreases. While a first degree linear function is used to express this relationship, it is possible that a second, third or higher degree function would be more appropriate.

Accessibility.--The amount of time expenditure needed to assure a given degree of locational utility at a particular place may be referred to as the accessibility of that place. Thus, accessibility is a relative measure of the ease (in terms of time or effort) by which man can attain what he wants or needs.

Transport innovations.--If it is assumed that man demands or seeks an increase in the degree of accessibility in order to augment the locational utility of places, it

is plausible that he would attempt to improve his means of attaining this end. This could be accomplished by his introduction of innovations which lessen the travel-time between desired origins and destinations (see steps 1-3 of the model). For a given place, the increase in locational utility from time t_1 to time t_2 that is derived from a transport innovation at time t_2 is indicated in Figure 3.

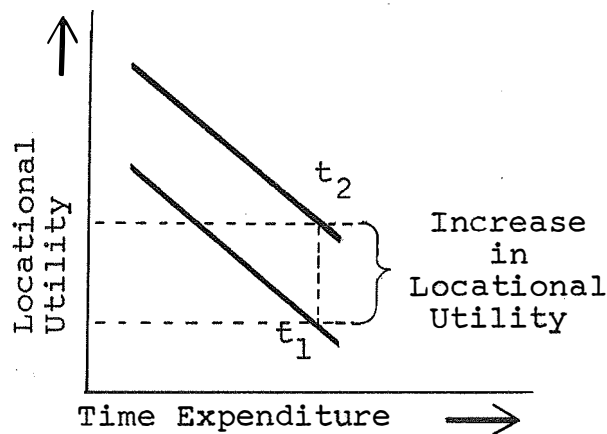


Fig. 3.--Transport Innovations and Changes in Locational Utility

In this study, transport innovations are any technologies or methods which serve to reduce the time required to travel between places or which permit an increase in the quantity of goods or the number of passengers that can be moved between these places in an allotted time period. Thus, a transport innovation may be a new and faster type of carrier, improved traffic routing procedures, better gasoline, improved lighting for night travel, the straightening of angular routes, and so forth. All such

introductions are likely to result in what the author describes as time-space convergence (step 4 of the model).

Time-space convergence.--By time-space convergence, the author is implying that, as a result of transport innovations, places approach each other in time-space; that is, the travel-time between these places decreases and distance declines in significance. As a consequence of this convergence, man has found that it is possible and practical to adapt the spatial organization of his activities to their evolving time-space framework (step 5 of the model). Empirical evidence for this assertion will be provided in Chapter III.

Spatial adaptations to changes in time-space organization.--In the basic model under consideration, the spatial adaptations of man's activities to their changing time-space framework will lead to the centralization and specialization of tertiary and secondary economic activities in specific places and to the specialization of primary economic activities¹ in the resource-oriented hinterlands of these places. (Other forms of spatial reformation

¹Tertiary activities include retail trade, wholesale trade, banking, professional services, governmental services and administration and other such activities. Secondary activities are any type of manufacturing which increases the value of a resource or item by changing its form (i.e., bakeries, steel mills, etc.). Primary activities include agriculture, mining, hunting, fishing and forestry. Primary activities such as mining are frequently centralized at specific locations.

will be considered in the expanded model.) Centralization (of which urbanization is a form) refers to the increasing focus of human activity upon a particular place; it results in the growth of an economically, culturally and often politically integrated area over which this particular place is dominant (its hinterland). Specialization (of which industrialization is a form) develops when places or areas concentrate their efforts on particular activities at the expense of others.¹ Examples of specialization include the motion picture industry in Hollywood, California, the chemical industry in Wilmington, Delaware, and citrus fruit production in Florida.

The greater the centralization and specialization of man's activities, the greater is the need for efficient transport and increased locational utility (steps 1-4 of basic model). As man speeds up his means of movement, it becomes possible for him to travel further in a given time, to increase his access to a larger surrounding area and, possibly, to more and better resources. Likewise, his tertiary and secondary functions can serve more people; and the perishable agricultural products and other primary products can be profitably marketed over a larger area. In

¹According to the economists, a place or area should specialize in those activities for which it has a comparative advantage (or least comparative disadvantage) relative to other places or areas. See Paul A. Samuelson, "The Gains from International Trade," Canadian Journal of Economics and Political Science, 5 (May, 1939).

essence these changes are manifestations of an increasing degree of locational utility (greater use of time can be derived from a given place) that permits the increasing centralization and specialization of man's endeavors. Thus, these scale economies¹ are both forms of spatial adaptation to an evolving time-space framework. This concept of areal adaptation and the concept of interaction will be developed more completely in Chapter III.

Interaction.--Step 6 of the basic model indicates that an increase in interaction results between places and areas that experience increasing centralization and specialization.² Because, as a rule, only tertiary and secondary activities centralize within given places, it is necessary for these places to interact in the forms of product, service and information exchange with their resource-oriented hinterlands. These hinterlands provide the necessities of primary production, and they demand the products and services of secondary and tertiary establishments. Similarly, if central places concentrate on a given type of secondary or tertiary activity or, if resource-oriented areas specialize in a specific form of primary activity

¹The economies that result when the scale of an endeavor (tertiary, secondary, and primary economic activities as well as cultural and political activities, etc.) is increased at a particular place or in a particular area. Generally, increased scale permits lower per unit production or operation costs--unless diminishing returns set in.

²This notion is developed by Ullman, op. cit.

(i.e., wheat, iron ore, etc.), it is necessary for them to trade and exchange with one another so that they can attain those needs or desirable items that they themselves do not produce. The greater the degree of centralization and specialization, the greater is the interaction between places and areas.

The increasing intercourse that results from the concentration of man's activities at particular places is likely to lead to an over-extension of man's transport facilities and result in their deterioration from over-use and in the development of traffic congestion. Consequently, the increasing interaction that results from centralization and specialization leads to further demands for increased accessibility, greater degrees of locational utility and transport innovations (steps 6, 1-3 in basic model). Thus, the spatial reorganization of man's activities is perpetuated in what, theoretically, is a never ending and accelerating cycle. The flow arrows of the model indicate the cyclical nature of this process. In Chapter VI the cyclical and acceleration properties will be investigated more fully.

An Evaluation of the Model-- Its Assumptions, Limitations and Omissions

Changes in the time-spatial and spatial organization of man's endeavors present him with possibilities for greater scale economies and with problems of developing

more efficient means of transport. It is man's awareness or perception of these possibilities and problems that enables him to take advantage of the changes in the time-space structure of his activities. In reality, however, the process that has been described is not so simple--not all men will perceive the changes described in the model and the implications of these changes in the same way.

Utility--an individualistic concept.--Locational utility, a fundamental concept operative in the process of spatial reorganization, is inherently individualistic; that is, "utility" is perceived according to one's values, goals and technical and institutional means of living. For example, a banker may place more value on a unit of time than would a farmer waiting through the winter so that he can plant his next crop, and warring American Indians of the eighteenth century probably attached less significance to an hour than do military leaders today. In other words, for various reasons, individuals or individual groups of people (i.e., nations, businessmen, soldiers, urbanites, farmers, etc.) may set criteria for utility that are peculiar to them.

Man's changing conception of time.--It is likely that the value that man places on time changes with time; that is, the economic or amenity value of a minute may be more today than it was in the year 1700 or 1900 (Figure 4). It is possible that an innovation that decreases the travel-

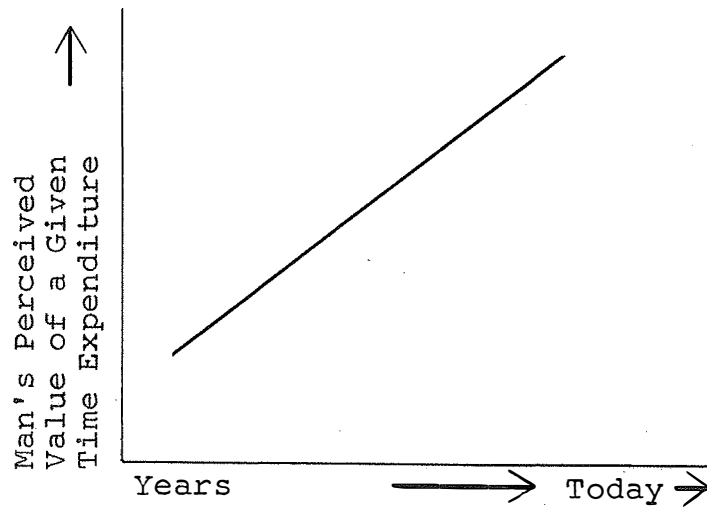


Fig. 4.--Man's Changing Perception of the Utility Value of Time

time between two places by 10 minutes today may be relatively more significant than one which reduced the travel-time between them by one hour a hundred years ago. From readings on the history of transportation,¹ the author has inferred and believes that man's perceived value of a given unit of time has increased as the tempo of his activities has increased. By sole reason of the tremendously greater commodity, passenger and information flows today as compared with past periods, man is motivated to seek greater utility for his expenditure of time. Imagine the magnitude of storage that would be necessary if New York City had to store food for its population to meet their

¹See Maurice Fabre, A History of Land Transportation (New York: Hawthorn Books, Inc., 1963); George R. Taylor, The Transportation Revolution, 1815-1860 (New York: Rinehart and Company, Inc., 1951).

needs over the winter months. With faster transport, the city can rely on more distant sources. Food can be moved to New York when it is needed, thus eliminating storage costs.

There is the additional likelihood that a person's perception of the utility of time will differ for various travel purposes. For example, a person may be willing to spend an hour's time in travel to receive the medicinal services of an eye specialist; but, he may only grudgingly spend ten minutes to purchase a loaf of bread. No model of the process of spatial reorganization could account for all of the multitudinous goals and criteria of all individuals and the changing value of time for each. Therefore, in the development of the model a standard pattern of human behavior has been assumed.

A basic assumption: the rationality of man.—The principal assumption upon which the spatial process model is based is that man is rational. This concept of a rational man or the "economic man" has been well developed elsewhere¹ and only the implications relevant to this

¹See Richard M. Cyert and James G. March, A Behavioral Theory of the Firm (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963); James M. Henderson and Richard E. Quandt, Micro-Economic Theory, A Mathematical Approach (New York: McGraw Book Company, Inc., 1958); Herbert A. Simon, "Some Strategic Considerations in the Construction of Social Science Models," Mathematical Thinking in the Social Sciences, ed., Paul F. Lazarsfeld (Glencoe, Ill.: The Free Press, 1954), pp. 388-415.

discussion need be presented. The relevant implications of this concept as related to the model include the following:

1. Man has perfect knowledge. Thus, man is completely aware of all factors operative in the areal reformation of his activities; he is aware of all of his needs and of all the possibilities open to him in fulfilling these needs.
2. Man has no uncertainty--he has perfect predictability. Thus, man can foresee the time-space convergence that will result from any transport innovation; he can foresee the degree of increased interaction that will be derived from greater centralization and specialization of his activities.
3. Man is interested solely in maximizing the utility of time at a given place. Thus, the motivational force which helps to propagate the spatial reorganization of man's activities is the quest to maximize some goal. For purposes of this study, it is assumed that man seeks to maximize the net social benefits attainable from any form of spatial organization. (Any other goal could be substituted.) Net social benefits are inclusive of all possible benefits--whether economic, political or cultural.

Limitations and omissions of the model.--While the inclusion of the rational man concept may limit the correspondence of the basic model with reality, it does permit one to consider the process of reorganization under controlled circumstances with a minimum of conflicting factors (i.e., changing criteria and varying degrees of rationality that have to be accounted for. Other factors which are, in part, attributable to a lack of perfect rationality may be summed up as perceptive, responsive and technological lags. Spatial change is not necessarily characterized by a smooth flow through the six-step process identified in the basic model.

There may be lags or delays in the process resulting from man's slowness in adapting his spatial organization to its changing time-space framework or in introducing more efficient forms of transportation. It is also possible that improvements in transfer technology will lag behind the need for such development. It will be noted from Figure 1 that the development of technology, although intimately related, is considered exogenous to the process of spatial change. Such development may take place independently of any need present within the system--innovations developed for an entirely different purpose may be readily applicable to transportation. Notions on invention theory that are related to the process of areal reorganization will be considered in Chapter VI.

An Expanded Model of Spatial Reorganization

As previously noted, the basic model of the process of spatial reorganization is based on the assumption that man is rational--that he has complete knowledge of what is happening, that he is a perfect predictor and that he is interested in maximizing his locational utility. The model also assumes that there is no delay in the development of technology to meet demands for accessibility. Now, the question is, what will happen if these assumptions are relaxed. For example, if man does not demand increased accessibility in response to his increasing interaction or

if he does not have the technology available for meeting his demands for greater accessibility, then, it is likely that either traffic congestion, route deterioration or both will occur. This, in turn, will lead to time-space divergence (places getting further apart in time-space). This is indicated by steps 7 and 8 of the expanded model depicted in Figure 5.

Spatial adaptations to time-space divergence.--It is likely that time-space divergence will lead to a completely different form of areal adaptation than was the case with convergence. On the whole, man's adaptation to divergence (step 9) has led to the decentralization of certain activities. As opposed to centralization, decentralization (of which suburbanization is a form) leads to the occupance and demand for land (step 16) away from the focal core of human activity (i.e., the central business district). In the urban areas decentralization is represented by the transfer of man's activities from the central area of the city to the outlying areas of the urban fringe. Frequently these activities are merely branches of firms having their principal headquarters in the central city (i.e., branch banks, department stores, and so forth).

Centralization within the decentralized structure of man's spatial organization also generally takes place. It is represented by the nucleation of functions in the

An Expanded Model of the Process of Spatial Reorganization

The diagram illustrates the process of spatial reorganization through 18 interconnected components:

- DEVELOPMENT OF TECHNOLOGY** (2) leads to **DEMAND FOR ACCESSIBILITY** (1) via a dashed arrow labeled "Search".
- DEMAND FOR ACCESSIBILITY** (1) leads to **TRAFFIC CONGESTION AND ROUTE DETERIORATION** (7) and **DEMAND TO REDUCE TRAVEL** (10).
- TRAFFIC CONGESTION AND ROUTE DETERIORATION** (7) leads to **DEMAND TO REDUCE TRAVEL** (10) and **INCREASED INTERACTION** (6).
- DEMAND TO REDUCE TRAVEL** (10) leads to **INCREASED INTERACTION** (6) and **DEMAND FOR SPACE: (EITHER LAND PERIPHERAL FROM THE CBD, OR VERTICAL SPACE IN CBD)** (16).
- INCREASED INTERACTION** (6) leads to **DEMAND FOR SPACE** (16) and **SPATIAL ADAPTATION: CENTRALIZATION AND SPECIALIZATION** (5).
- DEMAND FOR SPACE** (16) leads to **SPATIAL ADAPTATION: SKYSCRAPERS** (18) and **POPULATION HOLDING POWER** (14).
- POPULATION HOLDING POWER** (14) leads to **DEMAND FOR SPACE** (16).
- AMENITY DESIRES FOR "ELBOW ROOM"** (15) leads to **DEMAND FOR SPACE** (16).
- DEMAND FOR SPACE** (16) leads to **INCREASING TIME-DISTANCE FROM THE CORE OF MOST TERTIARY AND SECONDARY FUNCTIONS (FURTHER FROM CBD)** (17).
- INCREASING TIME-DISTANCE** (17) leads to **SPATIAL ADAPTATION: DECENTRALIZATION OF LOW-THRESHOLD FUNCTIONS** (9).
- SPATIAL ADAPTATION: DECENTRALIZATION** (9) leads to **TIME-SPACE DIVERGENCE** (8).
- TIME-SPACE DIVERGENCE** (8) leads to **DEMAND FOR ACCESSIBILITY** (1).
- DEMAND FOR ACCESSIBILITY** (1) leads to **TRANSPORT INNOVATION** (3) via a dashed arrow labeled "Search".
- TRANSPORT INNOVATION** (3) leads to **TIME-SPACE CONVERGENCE** (4).
- TIME-SPACE CONVERGENCE** (4) leads to **SPATIAL ADAPTATION: CENTRALIZATION AND SPECIALIZATION** (5).
- SPATIAL ADAPTATION: CENTRALIZATION AND SPECIALIZATION** (5) leads to **POPULATION ATTRACTING POWER (MIGRATION)** (13) and **INCREASED GROWTH OF FUNCTIONAL ESTABLISHMENTS** (12).
- POPULATION ATTRACTING POWER (MIGRATION)** (13) leads to **DEMAND FOR SPACE** (16).
- INCREASED GROWTH OF FUNCTIONAL ESTABLISHMENTS** (12) leads to **DEMAND FOR SPACE** (16).
- DEMAND FOR SPACE** (16) leads to **INCREASING TIME-DISTANCE** (17).
- INCREASING TIME-DISTANCE** (17) leads to **SPATIAL ADAPTATION: DECENTRALIZATION** (9).
- SPATIAL ADAPTATION: DECENTRALIZATION** (9) leads to **TIME-SPACE DIVERGENCE** (8).
- TIME-SPACE DIVERGENCE** (8) leads to **DEMAND FOR ACCESSIBILITY** (1).
- DEMAND FOR ACCESSIBILITY** (1) leads to **TRANSPORT INNOVATION** (3) via a dashed arrow labeled "Search".
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- TRANSPORT INNOVATION** (3) leads to **TIME-SPACE CONVERGENCE** (4).
- TIME-SPACE CONVERGENCE** (4) leads to **SPATIAL ADAPTATION: CENTRALIZATION AND SPECIALIZATION** (5).
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- TIME-SPACE DIVERGENCE** (8) leads to **DEMAND FOR ACCESSIBILITY** (1).
- DEMAND FOR ACCESSIBILITY** (1) leads to **TRANSPORT INNOVATION** (

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outlying regions of the central city.¹ This process is typified by the development of shopping centers carrying on many retail and service functions for the residential population and by the nucleation of secondary activities in planned industrial parks (step 11). These two forms of decentralized centralization are generally located peripherally from the main city.

Decentralized centralization and the expansion of the city.--The decentralized nucleation of man's activities may be due to the desire to reduce the number of trips or the distance of movement needed to attain a given quantity of goods and services. This is made possible by grouping many functions at one center (steps 10-11). Such nucleation of activities within given sub-regions (of which the nucleated service centers may form the cores) of the urban region may lead to increased interaction within the sub-region (step 6) and, eventually, to a demand for greater accessibility (step 1). Thus, in this manner, the sub-region finds itself in a new stage of areal rearrangement--it is operative within the basic model of spatial reorganization and will develop greater centralization and specialization (steps 1-5).

¹For discussions on the multiple nuclei concept of urban growth, see Chauncy D. Harris and Edward L. Ullman, "The Nature of Cities," Annals of the American Academy of Political and Social Science, 242 (November, 1945), pp. 7-17; Edward L. Ullman, "The Nature of Cities Reconsidered," Papers and Proceedings of the Regional Science Association, 9 (1962), pp. 7-23.

With the continuance of this process, it is easily seen how sub-nucleated tertiary and secondary activities can eventually become a part of the very core of the urban area--the increasing concentration of activities within the urban core and within the sub-nucleated tertiary and secondary centers leads to further demands for land (steps 11, 6, 1-5, 12, 16). It is possible that they will engulf each other in their expansion and become fused into one highly integrated unit. Thus, it is evident that decentralization is merely an intermediate or lag stage in the general process (described by the basic model) towards centralization and specialization.

The demand for land.--It would be naive to assume that decentralization and centralization within the area of decentralized occupance were due solely to time-space divergence. Other significant factors include the demand for land (step 16) that results from the increasing size of establishments (step 12) within the urban area (i.e., factories, warehouses and so forth which seek to augment scale economies) and the increasing numbers of people who migrate to dominant central places. This in-migration may be referred to as the place's population attracting power (step 13). Because these two factors result from centralization and specialization (step 5), it is evident that time-space convergence can indirectly lead to a different form of spatial structure than that mentioned in the

discussion of the basic model (see steps 9 and 18). Additional factors accounting for a demand for land peripheral from the central city (steps 14 and 15) include its population holding power and the amenity goal to gain more "elbow room"--to get out of the noisy, crowded city. This demand to leave the central city may result as interaction accelerates beyond a tolerable threshold.

Because the land available for expansion is generally peripheral to that portion of the city area which is already developed, the relocated establishments (residents, retail and service firms, and so forth) find themselves at a time disadvantage in attaining goods and services that are only offered in the central core of the city (step 17). To obviate this problem, these functions can take one of two actions--they can demand greater transport-access (steps 1-3), or they can encourage the location of new establishments in the city's peripheral area to serve them--shopping centers, churches, schools and the like (steps 9-11). By seeking greater accessibility, these areas may be placing themselves in line for the potential spatial adaptations that result from time-space convergence--greater centralization and specialization. Also, if they choose to attract retail centers and certain secondary activities to the periphery, they may be in for the same end-result--an increase in interaction could lead to demands for accessibility which, through transport

improvements and the consequent time-space convergence, may encourage a greater concentration of activity. Thus, conceivably, without some form of control, this process could lead to one vast urban society--a megalopolis.¹

Step 18 in the model indicates an alternative choice in attaining more space while still retaining locational utility--the skyscraper enables certain activities to have a degree of both. The skyscraper, however, is a form of centralization which fosters greater interaction and demand for accessibility. Thus, this spatial adaptation also helps to perpetuate the trend towards greater centralization.

An Evaluation of the Expanded
Model of the Process of
Spatial Reorganization

Unlike the basic model of the process of spatial reorganization, the expanded model (of which the basic model is a part) accounts for what happens when the degree of rationality is lessened or when the criteria of rationality change (if man deliberately seeks to decentralize his activities or chooses not to introduce transport improvements). This model also permits consideration of what happens when given the alternative demands of either

¹See Jean Gottmann, "Megalopolis, Or the Urbanization of the Northeastern Seaboard," Economic Geography, 33 (July, 1957), pp. 189-200.

accessibility or space (land and air). As previously noted, the skyscraper permits satisfaction of both goals.

As in the basic model, this model has a built-in property of acceleration. This property of the process will be investigated in Chapter VI. Lags in the perception or response of man to changes in the system along with technological lag are to be expected.

In concluding the discussion on the development and evaluation of the model, one further observation is necessary. Spatial reorganization is not operative everywhere to the same degree and it does not occur simultaneously at all points in earth-space. Therefore, it is essential to determine why this process is so selective and why some places undergo a more rapid areal reorganization than others.

The Process of Spatial Reorganization and the Concept of Relative Advantage

The concept of relative advantage states that the process of spatial reorganization in the form of centralization and specialization will accelerate most rapidly at those places which stand to benefit most from increasing accessibility.¹ In other words, transport innovations are

¹Interesting statements of a concept of relative advantage similar to that proposed here are provided by Zvi Griliches. See "Hybrid Corn and the Economics of Innovation," Science, 132 (July 29, 1960), pp. 275-80; and, "Hybrid Corn: An Exploration in the Economics of Technological Change," Econometrica, 25 (October, 1957), pp. 501-22.

most likely between those places which will benefit most from a lessening in the expenditure of time (cost or effort) to attain needed and desirable goods and services. Relative advantage is defined in terms of benefits that can be derived from a particular place with a given expenditure of time. As in the development of the process models, it is assumed that the benefits man seeks to maximize per given expenditure of time are net social benefits (economic, political and social). The concept is based on the same basic assumption as were the process models--the rationality of man. As the implications of this assumption have already been noted, they will not be restated here.

A study of the expanded model (Figure 5) indicates that the growth in population and the increase in the size of man's functional enterprises will eventually lead to demands for space (steps 12-14, 16). Though these factors are not stated, they are indirectly included in the relative advantage concept through their resulting demands for accessibility (steps 5, 12-17, 1). The spatial decentralization of man's activities will also eventually lead to a need for greater accessibility--either as a result of demands upon land (steps 9, 16-17, 1) or as a result of a desire for the nucleation of the decentralized functions (i.e., shopping centers, etc., steps 9-11, 6, 1). Thus, as indicated previously, decentralization is simply an intermediate or lag stage in the over-all trend towards

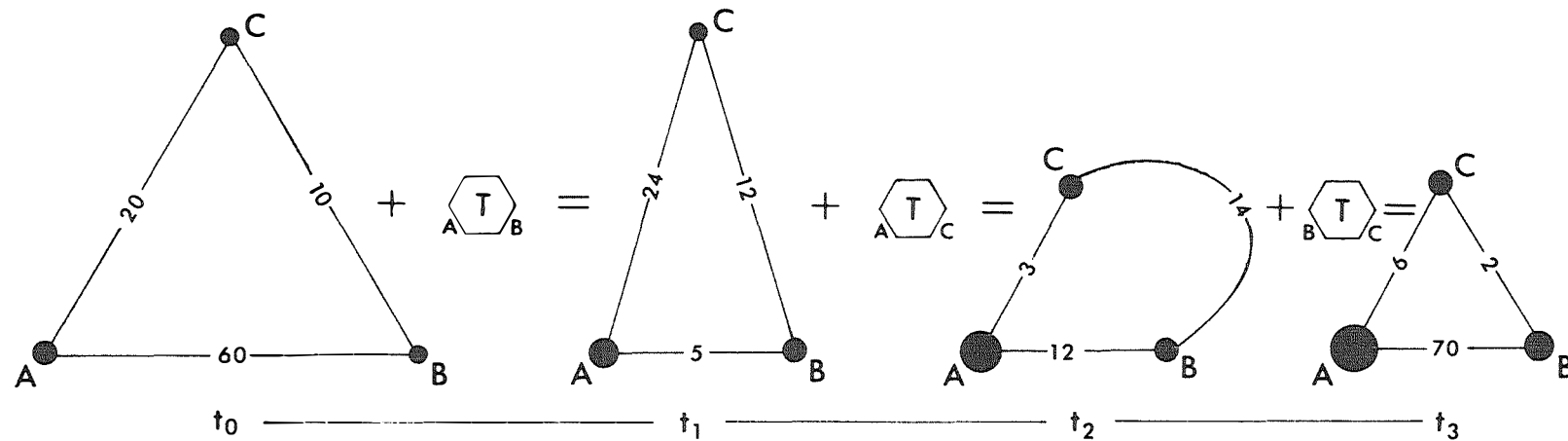
eventual centralization of all activities about certain dominant centers.¹

Since locational decentralization is a development which, over time, may eventually lead to centralization (given the continuance of the process), it is possible to confine the remainder of this discussion to the basic model of spatial reorganization. The question is, where will this process be likely to accelerate most rapidly? Or, where is man most likely to introduce a transport improvement? In seeking an answer to these questions, the concept of relative advantage will be applied to a hypothetical example of the three settlements A, B and C shown in Figure 6.

In this example it is assumed for the initial year (t_0) that these three settlements are equally distant in time-space--one hour apart. They are also equally distant from one another---20 miles. At time t_0 a new technology is developed that permits travel at 40 miles per hour. A decision is made at time t_1 to introduce this innovation

¹This trend towards centralization is not always expressed in an obvious manner upon the landscape--with rapid communications via telephone, telegraph and so forth, it is now possible for a given firm to have effective administrative control over a number of decentralized production units. Thus, in a time-space framework, it is possible to consider a firm such as Ford Motor Company (with plants all over the world) as being time-spatially centralized. Although this form of centralization could be included in the model, it will not be considered to any great extent in this paper.

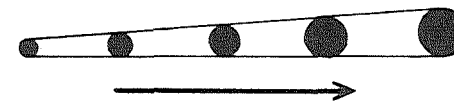
DIFFERENTIAL RATES OF SPATIAL ADAPTATIONS TO CHANGES IN TIME-SPACE ORGANIZATION



Numbers Refer to Demands for
Accessibility Between Places



 Transport Innovation
Between A and B



Increasing Degree of
Centralization and
Specialization

D. G. Janelle
1966

FIGURE 6

between those places which will benefit most from increased accessibility. In Figure 6 the advantage of connecting any two of the three settlements is indicated by arbitrary values representing the demand for accessibility between them. Since this demand is greatest for A and B, the initial introduction of the innovation will most likely occur between these places. In accordance with the basic model, the resulting time-space convergence of places A and B would lead to adaptations to their changing time-spatial relationships--to centralization and specialization. In Figure 6 the degree of this centralization and specialization is indicated by the sizes of the circles representing the settlements.

Similarly, at times t_2 and t_3 , it is decided to introduce this new means of transport between those places which will derive the greatest benefit. At time t_2 it is introduced between A and C and at time t_3 it is introduced between B and C. Thus, within this system, all three places are converging upon each other in time-space; and, therefore, in accordance with the reorganizational process, they are each adapting their spatial structures towards greater centralization and specialization. However, because the transport innovation was introduced between A and B before A and C and between A and C before B and C, it is likely that the degree of areal reorganization will differ at each place.

Estimating Relative Degrees of Spatial Reorganization

The differing rates of spatial reorganization at given places may be expressed by the average rate of time-space convergence of a place with all other places.

Because convergence is considered a causal element that leads to spatial adaptation, it is believed that this relative measure may provide a surrogate of the degree of spatial reorganization possible at given places. For the example in Figure 6, this measure can be calculated in the following manner:

1. Calculate a rate of convergence between each set of settlements in the system. To accomplish this, subtract the time required to travel between two places by means of the new transport innovation from the time required to travel between them before the innovation was introduced. Then, divide by the number of years separating time t_0 from the introduction of the innovation. The convergence rates for each set of places in the example of Figure 6 are as follows:

$$\text{A to B: } \frac{60 \text{ minutes} - 30 \text{ minutes}}{1 \text{ year}} = 30 \text{ minutes per year.}$$

$$\text{A to C: } \frac{30}{2} = 15 \text{ minutes per year.}$$

$$\text{B to C: } \frac{30}{3} = 10 \text{ minutes per year.}$$

(The mathematical and conceptual properties of convergence rates and their use in understanding the time-spatial relationships of places will be the principal topic considered in Part II of this study).

2. Calculate the average convergence of each place to all other places in the system. In other words, sum the convergence rates (CR) for each place to all of the other places and divide by the number of

such places--in this case 2. Thus, the average convergence of place A with B and C is determined as follows:

$$\frac{CR(A \text{ to } B) + CR(A \text{ to } C)}{2} = \frac{30 + 15}{2} = 22.5 \text{ minutes per year.}$$

Similar calculations for B and C give the following results:

$$B: \frac{30 + 10}{2} = 20 \text{ minutes per year.}$$

$$C: \frac{15 + 10}{2} = 12.5 \text{ minutes per year.}$$

As previously indicated, these differential rates may provide a surrogate of the degree of centralization and specialization possible at given places. Thus, in the example of Figure 6, it is evident that the spatial reorganization process is accelerating most rapidly at settlement A.

An Evaluation of the Relative Advantage Concept

Given the assumption of rationality as developed earlier in this chapter, the original thesis that "spatial reorganization will accelerate most rapidly at those places which stand to benefit most from increasing accessibility" seems tenable. On the whole, the same restrictive qualifications that applied to the models of areal reorganization apply to the use of these models in the context of the concept of relative advantage. As these qualifications (all based on the assumption of the rationality of man) have already been discussed, they need not be

elaborated upon here. It is sufficient to indicate the limitations of this assumption with an example.

The differential operation of the process of spatial reorganization, as outlined in the previous hypothetical example, may vary with changes in the criteria of relative advantage or with the changing criteria for rationality. What benefits are sought from spatial reorganization, and for whom? For instance, even though places A and B may stand to benefit most from a transport improvement, man may choose to apply the new innovation between B and C. Possibly place C is in a state of economic depression; and, it is believed that by increasing its accessibility, a degree of centralization and specialization will occur there. Thus, not only will new jobs be provided, but there is also the possibility that the process of spatial reorganization will continue. It is evident that in deciding upon where a transport innovation should be applied, there may, at times, be economic, social and other reasons which over-shadow the significance of gaining the greatest relative advantage from a given investment.

It should be noted that the concept of relative advantage does not enable one to predict all of the possible lags (technological, responsive and so forth) that can take place within the process of spatial reorganization. In many instances (on the basis of different

criteria for rationality), it is likely that a lag may be deliberately enforced. For example, because of automobile parking problems within the central city, a city government may impose zoning ordinances or restrictions on the heights of buildings so as to encourage further expansion to places peripherally located from the central business area.

As a deductive formulation the concept of relative advantage seems to be perfectly consistent with the process of areal adaptation as outlined in this chapter. However, in light of the limitations posed by the assumption of rationality, it is evident that the concept of relative advantage, as applied to this process, is not in complete accord with reality. The relative advantage concept seeks to explain man's decisions on the basis of motivation (i.e., desire for net social benefits and the like). The decisions of man, however, are often conditioned by his lack of information, or non-maxima goals.

In that much of man's spatial reorganization is presently directed by various government agencies (at the city, region, state and national levels) rather than by the demand for "locational utility," it seems that the understanding of the process of spatial reorganization may rest upon one's knowledge of the decision making process

of these agencies.¹ Upon what information are their decisions made? What are the financial and other limitations that guide their decisions? By what goals are they motivated? Answers to these questions are beyond the scope of this paper. Nonetheless, until answers to such questions as these are found, the understanding of spatial reorganization will be limited to such mechanistic conceptual frameworks as outlined in this chapter.

Conclusion

The objective in this chapter has been threefold: (1) to conceptualize the role of transport technology as a key factor in the spatial reorganization of man's activities, (2) to outline the "steps" in the process of spatial reorganization, and (3) to propose a conceptual framework that accounts for the differential operation of this process at various places. The premise upon which the study is based is that man adapts the areal structure of his activities in response to changes in transport technology which enable him to travel faster and to have access to larger areas and more resources.

It is maintained that, on the whole, transport changes have permitted greater degrees of specialization

¹For an excellent review of the notions on decision theory and their applicability in planning, see John W. Dyckman, "Planning and Decision Theory," Journal of the American Institute of Planners, 27 (November, 1961), pp. 335-45.

and centralization of man's activities. Fundamental to this notion is the assumption that man responds rationally, that he is motivated by desire and need to maximize the benefits derivable from a given form of spatial organization, and that these benefits are most easily attained in a spatially centralized framework of specialized functional units.

In developing a model and concept to explain the locational reorganization of man's functional enterprises a completely mechanistic approach has been employed. That is, it has been assumed that a demand for interaction between places would lead directly to a transport innovation which would result in the time-space convergence of these places and, consequently, in spatial adaptations in the form of greater centralization and specialization. An effort has been made to point out the pitfalls of this approach, to account for possible lags in this mechanistic system, to make allowances for departures from the basic process (i.e., the decentralization of man's activities) and to discuss the implications of changing criteria for rationality, changing goals and so forth. On the whole the author believes that the approach used here has exposed the basic elements operative in spatial reorganization. While more refined models may be made possible by employing notions being developed by decision theorists

and others, the elements identified here as being basic to the process should remain the same.

While discussion in this chapter has been primarily conceptual, empirical information on the notions developed here will be presented in the next two chapters. Later, in Part II of this study, emphasis will again be conceptually-oriented. In Part II the concept of time-space convergence will be singled out for detailed investigation. The goal will be to understand its role in spatial reorganization and to determine its mathematical and conceptual properties and their implications.

CHAPTER II

SPEED: A MEASURE FOR TRANSPORTATION EFFICIENCY

If the thesis that improvements in transportation technology constitute or stimulate a reorganization of the spatial pattern of man's functional establishments is to be explored, it is first necessary to define a means of measuring improvements in transportation efficiency.

Transportation Efficiency

The essentials of a system for the efficient transportation of goods were outlined by Leslie A. Schumer¹ as speed, cheapness, adequacy, safety, frequency and regularity of service, comprehensiveness and responsibility. For the movement of people there is the additional need for comfort. Although one can foresee situations where the significance of any one or any given combination of these requirements would be most critical, it is difficult to disassociate a given requirement from the others. Nonetheless, for purposes of this study, speed will be considered as the sole relevant measure of transportation efficiency and the surrogate for advancement in transportation technology. Since it is unlikely that a

¹Leslie A. Schumer, The Elements of Transport (London: Butterworth and Co., Ltd., 1955), p. 19.

transportation system would become operational if it did not conform to some minimum standards of safety, reliability, cost and so forth, it is believed that this assumption is a valid one. As used in this study, speed refers to the total transit-time required for passengers or goods to move between their desired origins and destinations. This includes loading and unloading times at terminals, transport transfers, stopping for fuel, lodging, toll gates and so forth.

An outline of this chapter is shown in Figure 7. As implied in this diagram, speed (the measure of transport efficiency) and the alternative substitutes for speed (to be considered in this chapter) are factors which change the time-spatial organization of man's activities. Man's perception of these changes often leads to the locational rearrangement of his establishments to conform to the time-space changes engendered by transport innovation. This notion was developed in the last chapter and will be expanded in the next chapter. For the moment, however, it is essential to mention a few of the economic and other advantages that may serve as motivation for increasing the tempo of human interaction. Later, alternative ways (other than by increasing speed) by which man has changed his time-space framework will be considered.

Transport Efficiency: The Reduction of Transit-Time

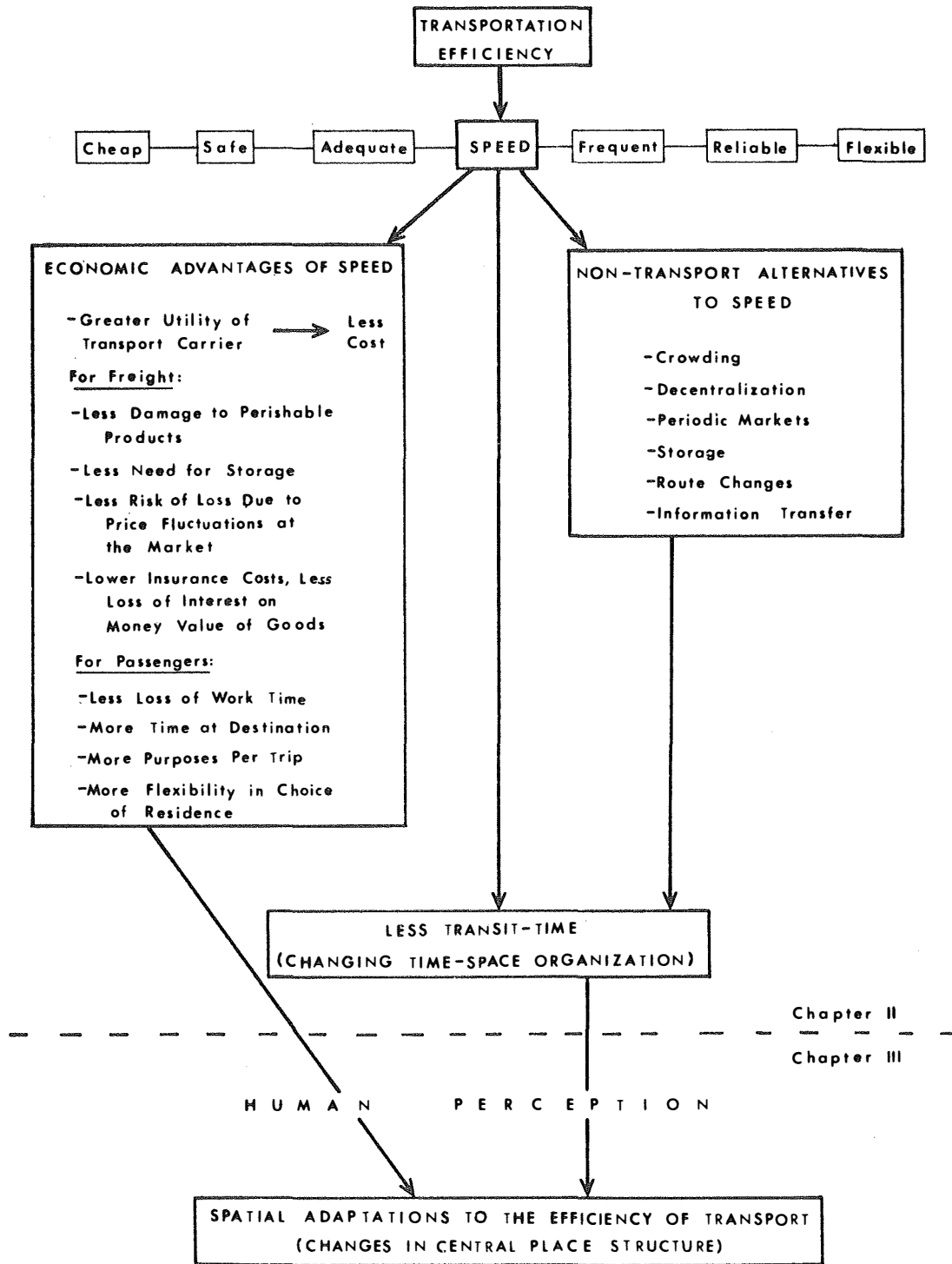


FIGURE 7

The Advantages (Utility)
of Speed

If man has some strong economic or other justifications for increasing the tempo of his transport, then it seems logical that speed should be the surrogate for the advancement in transportation technology. One such justification is that, by increasing its speed or reducing its transit-time, a transport carrier can make more trips in an allotted time and, thus, spread the cost of movement over a greater quantity of goods or more passengers.¹ Yet, in spite of the close association of increased speed in commercial land-transport with the reduction in transport cost (indicated in Table 1), it should not be inferred that speed is the sole parameter of transport efficiency. Other likely significant parameters include the load-capacities of the carriers, their fuel and locomotive systems and the physical mediums over or through which they move. Although the cost per ton-mile of freight transfer has declined as the speeds of land-transport carriers have increased, other advantages more closely allied and directly attributable to speed should be noted.

¹A study on the economic gain derived from speed is provided in Chicago Area Transportation Study, Vol. III, Transportation Plan (Chicago: The State of Illinois, the County of Cook, the City of Chicago and the U.S. Bureau of Public Roads, April, 1962), pp. 8-10.

TABLE 1

SPEED, AVERAGE LOAD AND COST PER TON MILE FOR DIFFERENT
TYPES OF LAND AND WATER TRANSPORTATION*

Type of Transportation	Speed: Miles per Day	Average Load: Tons	Cost:** Per Ton Mile
Human Porter	15-20	.03	\$0.10 - \$1.00
Horse Team	15-20	1.40	0.07 - 0.25
Pack Animal	15-25	.14	0.10 - 1.00
Liberty Ship (10,000 tons)	250	12,000.00	0.001- 0.005
Motor Truck (12 tons)	250-600	. .	0.02 - 0.08
Railroad (Steam and Diesel)	400-1,000	2,500.00	0.007- 0.05

*Source: Atlas of World Maps, Army Service Forces Manual, M-101 (Washington, D.C., 1943), p. 23; data put in table format by Hawley, op. cit., p. 352.

**Costs approximated in U.S. currency for 1943.

Through increases in speed, advantages have been derived in the transit of freight and passengers. For freight traffic, the advantages of increased speed include:

1. The transit-time for perishable goods (i.e., food stuffs, style goods and emergency goods) that are liable to deteriorate between production and manufacture or between production and consumption has been reduced.¹
2. The financial cost associated with goods in transit (i.e., the loss of interest on the money value of

¹Schumer, op. cit., p. 20.

goods idle in transit, insurance costs and so forth) has declined.¹

3. The risk of loss due to price fluctuations at the market while goods are in transit has been reduced.
4. Businessmen or manufacturing concerns can operate on smaller inventories and, thus, enjoy the benefits of fresher stocks without the danger of exhausting supplies and without the burden of storage charges.²

For passenger traffic, the economic, time and amenity advantages of increased speed include:

1. A lessening in the loss of working time for business passengers.
2. An opportunity for tourists to see more sights or to spend more time at their destination.

¹The interested reader is referred to the following sources: Fred W. Cottrell, The Railroader (Palo Alto, Calif.: Stanford University Press, 1940), p. 64; Schumer, op. cit.; Grossman, op. cit., pp. 254-55.

²See Hugh S. Norton, Modern Transportation Economics (Columbus, Ohio: Charles E. Merrill Books, Inc., 1963), p. 10; and A. M. Milne, The Economics of Land Transport (London: Sir Isaac Pitman and Sons, Ltd., 1955), p. 41.

In spite of these advantages to the reduction of transit-times for freight deliveries, there are instances where a slower mode of transport will give greater utility of time. If goods arrive at their destination before they are needed, costly storage may be necessary. Furthermore, many establishments have what Milne (op. cit.) describes as ". . . a discontinuity in the value of time over the twenty-four hour period." They may remain open only for eight or sixteen hours per day. In contrast, transportation agencies operate practically all the time and, from their point of view, the movement of goods during time which is unproductive to the transport user is practically costless in terms of time. Consequently, ". . . a slow movement during this unproductive time may represent a greater economy of time than a faster movement during the productive period of the day" (ibid.).

3. The attainment of more services or more products in the allotted time of a given shopping trip.¹
4. The possibility for people to live further from their places of work or beyond the congested residential areas without spending more time in traveling.

Aside from these many direct advantages of the quickening tempo of freight and passenger movement, other more tributary benefits or changes are also derived. These may be summarized as benefits of spatial reorganization that have had wide impact on the changing spatial structure of central places. These include: (1) the extension of the hinterlands of marketing places, (2) the broadening of markets for perishable products, (3) the large-scale geographic specialization of labor, (4) the centralization of managerial control over more geographically dispersed productive units, and (5) the opportunity to substitute superior sites and resources for closer, inferior ones. These changes in the spatial organization of economic, social and other functions were noted in the last chapter and will be discussed more fully in the next chapter. For the moment, it should be recognized that speed--enshrined with blessings though it is--is not the answer to all of man's space-organization problems.

¹Duane F. Marble, "Highway and Urban Residential Land Use," in Studies of Highway Development and Geographic Change, by William L. Garrison and associates (Seattle: Univ. of Wash., 1959), p. 159.

Indeed, man has devised many alternatives, not only to speed but also to movement.

Non-transport Alternatives to Speed and Movement

Of the many substitutes for increasing the speed of transport carriers, most involve a reduction in the amount of movement necessary to carry on a required interaction. Examples include the crowding of interrelated functional establishments, decentralization, the institution of periodic markets, storage, the straightening of angular routes and the introduction of means for transferring information that preclude the need for bodily movement or the need for face-to-face contacts. Each of these methods has had a role in shaping the time-spatial arrangement of man's activities. They will be considered separately.

Crowding.--The characteristic crowding of interrelated functional establishments is a form of centralization and stems, in part, from the desire to maximize locational utility. Crowding is most evident within the central areas of cities. The need of many business firms for rapid communications and for face-to-face contact with buyers, sellers and so forth has placed a premium on quickly accessible locations.¹ In days of the horse-and-buggy, travel-time between establishments could be

¹See Edgar M. Hoover and Raymond Vernon, Anatomy of a Metropolis (Cambridge: Harvard Univ. Press, 1959), pp. 78-83.

minimized by constructing narrow, closely spaced buildings. Prior to Elisha Otis' invention of the first safe elevator in 1852, few buildings rose above five stories. Travel was primarily horizontal.¹ Even the residential areas were tightly packed in what may have been an effort to avoid city-spread. The typical, narrow three to five storied houses of Baltimore, Boston and many European cities are examples of residential crowding.²

The introduction of the elevator facilitated an even greater degree of crowding and helped to maximize locational utility within urban areas. According to Hoover and Vernon, the introduction of the elevator in New York

made it possible to cram several hundred thousand people in a square mile or so of land space, each able to reach any other within ten or fifteen minutes. . . . [thus] . . . the communications requirements of brokers and bankers [in Manhattan] . . . were better met than anywhere else on the face of the earth. Accordingly, though the financial community grew enormously, it was slow to spread its facilities.³

In contrast to those activities which benefit from their close association within the central business area, other activities find it advantageous to decentralize.

Decentralization.--The decentralization of low-threshold activities (activities which require a relatively

¹See F. Stuart Chapin, Cultural Change (New York: The Century Co., 1928), p. 274.

²Harlan W. Gilmore, Transportation and the Growth of Cities (Glencoe, Ill.: The Free Press, 1953), pp. 112-113.

³Hoover and Vernon, op. cit., p. 92.

small population or income base for their support) is another way of minimizing the movement between the producer and consumer of frequently sought goods, services or other amenities. Thus, within walking distance of urban residential areas one often finds grocery and other staple products establishments, schools, churches and neighborhood parks.¹ Recognized shopping districts (apart from the central business district) also frequently develop as the nuclei for serving multi-purpose convenience-needs.² In the last chapter this development was characterized as a form of decentralized centralization. These highway oriented centers have become especially popular since the advent of the automobile. In line with this author's deductive conclusion from the process model developed in the last chapter, Garrison and Berry hold that these nucleated systems of shopping centers are in the process of greater centralization.³ This development would make it possible for customers to achieve more purposes from a

¹Gilmore, op. cit.

²Chauncy D. Harris and Edward L. Ullman, "The Nature of Cities," Reprinted from Annals of the American Academy of Political and Social Science, 242 (November, 1945), pp. 7-17, in Readings in Urban Geography, eds. Harold M. Mayer and Clyde F. Kohn (Chicago: The Univ. of Chicago Press, 1959), pp. 277-86.

³William L. Garrison and Brian J. L. Berry, "The Relations of Highway Impact, Spatial Structure and Urban Planning," in Studies of Highway Development and Geographic Change, by William L. Garrison, Brian J. L. Berry, Duane F. Marble, John D. Nystuen and Richard L. Morrill (Seattle: Univ. of Washington Press, 1959), p. 137.

given trip without the necessity of venturing into the central business area for convenience items.

In earlier days, given a population-threshold for its support, the rural "general store" made multi-purpose trips possible by providing a variety of food, drug, hardware, clothes and miscellaneous items. This helped the rural residents to reduce their expenses of time and money for daily travel to the nearest marketing center.¹ Frequently, however, an area will not have the necessary population-threshold to support a permanent general store; and, because of poor roads or excessive distances, travel to marketing places for daily needs may be difficult. In 1815 few American farmers visited even places of 2,000 people many times in the year.² Thus, there arose the need for periodic, mobile markets.

Periodic markets.—Periodic markets are provided when mobile establishments gather at a specific time and place to carry on marketing or other functions. In these instances, the central place structure lacks permanency. In nineteenth century America the "Yankee Peddler" assembled easily transported and marketable wares in his wagon or on a storeboat and carried them to rural villages and isolated farmsteads.³ Thus, the peddler assumed the

¹C. R. Hoffer, "Services of Rural Trade Centers," Social Forces, 10 (October, 1931), p. 67.

²Taylor, op. cit., p. 13.

³Ibid.

burdens of transport. This permitted the rural and frontier residents to maximize their utility of time in productive pursuits, while enjoying periodic place utility in obtaining necessary supplies. Even today, a similar service is rendered by newspaper boys, bookmobiles, mobile x-ray laboratories, traveling science exhibits and traveling entertainment groups.¹ In areas of traditional agrarian societies such as in parts of China and Korea, the rural markets are generally periodic rather than continuous. The nature of these periodic markets have been investigated by Skinner and Stine.²

Storage.--Where the frequency of marketing days at periodic centers is low, or when travel to a permanent center is aggravated by excessive time and money costs, there arises the need for storing essential goods. Storage, thus, helps to obviate the need for frequent and quick trips to the market and is a means of adjusting to the irregularities of the marketing or transportation systems. By permitting goods to remain in existence until

¹James H. Stine, "Temporal Aspects of Tertiary Production Elements in Korea," Urban Systems and Economic Development, ed. Forest R. Pitts (Eugene, Ore.: The School of Business Admin., Univ. of Oregon, June, 1962), p. 72.

²G. William Skinner, "Marketing and Social Structure in Rural China," The Journal of Asian Studies, 24, Nos. 1-3, (November, 1964, February, 1965, May, 1965), pp. 3-43, 195-228, 363-99. Stine, op. cit., pp. 68-88.

needed, storage is a means of creating locational utility.¹ However, with improvements in the load-capacity, speed and flexibility of transport carriers, the need for storage has steadily declined.²

Route changes.--One of the more obvious ways of decreasing time and movement in interactions between places is to straighten out the angular and curved routes that separate them. Thus, the travel-distance between New York and Kuwait--12,000 miles around the Cape of Good Hope--was cut to less than 8,500 miles with the completion of the Suez Canal in 1869. The increased directness of such journeys has, in many respects, outweighed the significance of increases in the locomotive speeds of the vehicles which use the new routes. For example, Taylor holds that the directness of the rail routes as opposed to those of the steamboat routes was more important than the differences in the locomotive speeds of the two carriers. Whereas the boat distance from Pittsburgh to St. Louis following the Civil War was 1,164 miles, the rail distance was only 612 miles.³

Figure 8 shows the route changes that have lessened the time-space separation between Flint and Lansing,

¹See William L. Grossman, Fundamentals of Transportation (New York: Simmons-Broadman Publishing Corp., 1959), p. 2.

²Hawley, op. cit., p. 295.

³Taylor, op. cit., p. 71.

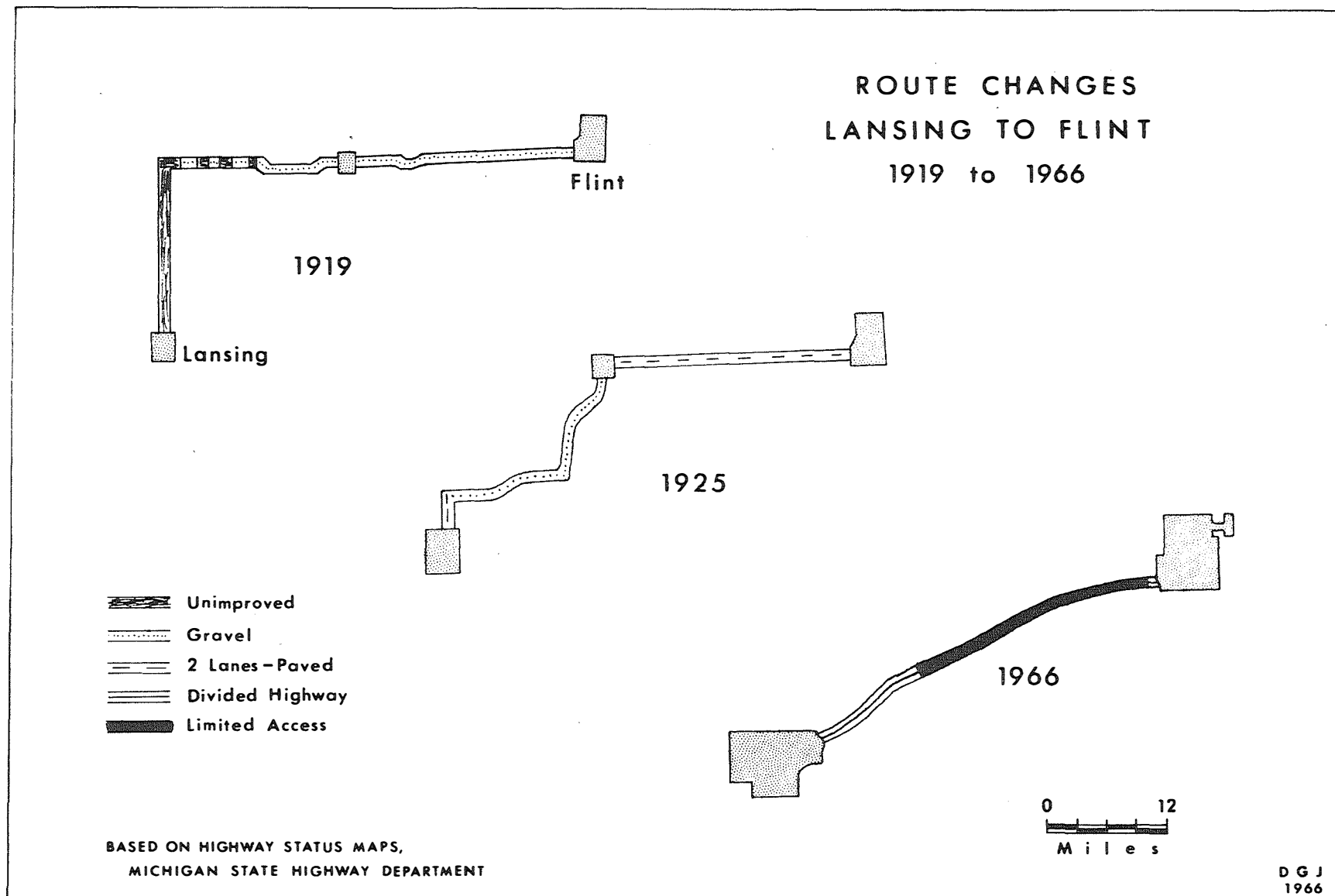


FIGURE 8

Michigan between 1919 and 1966. Over this span of 47 years there has been a gradual straightening and improving of the path between these two cities. This lends creditability to Field's¹ hypothesis that the artificially established rectangular road system of Michigan would, in time, give way to straight routes between places located diagonally with respect to one another (i.e., Lansing and Flint, Lansing and Kalamazoo and so forth). One might conjecture further that this process is dependent upon the strength of the interacting forces that join the settlements. Interestingly, the "Thumb" area of Michigan--off the major interconnecting links of the state's urban centers--has retained its rectangular road pattern with no notable changes since 1919.

Information transfer.--One of man's more significant achievements in transport has been his ability to exchange messages with distant points. It is within the area of communications that he has minimized his own bodily movement and speeded up his interactions with others most completely. Although human messenger-runners were popular in the Roman Empire, in early Greece under Alexander the Great, in the Inca Empire and in sixteenth century India

¹Arthur Field, "Road Patterns of Southern Michigan," The Papers of the Michigan Academy of Science, Arts, and Letters, 14 (1930), pp. 324-25.

under Akbar,¹ other methods such as the use of drums, smoke clouds and voice relays are most akin to modern telegraphy and telephony. In these instances, communications is substituted for the movement of physical entities.

An optical telegraph, invented by the French engineer Claude Chappe in 1794, made it possible by 1844 to send news 500 miles between Paris and Toulon in 20 minutes--weather permitting.² Astonishing as this feat seems, it was soon eclipsed by the telegraph. Today, via teletype, an important news story can be transmitted from Paris to Tokyo within a minute or two. Such phenomenal advances in the transfer of information have greatly assisted man in his efforts to coordinate the often widely dispersed functional structures of his spatial domain. Meier has made significant contributions in his investigations on the economic significance of communications. His studies have underscored the monetary, social and other values of time saved through efficient communications.³

¹Laurin Zilliacus, Mail for the World (New York: John Day Co., 1953), p. 26.

²Maurice Fabre, A History of Communications (New York: Hawthorn Books, Inc., 1963), p. 65.

³See Richard L. Meier, "Information, Resource Use, and Economic Growth," Natural Resources and Economic Growth, ed., Joseph J. Spengler (Washington: Resources for the Future, Inc., 1961), pp. 98-119.

Conclusion

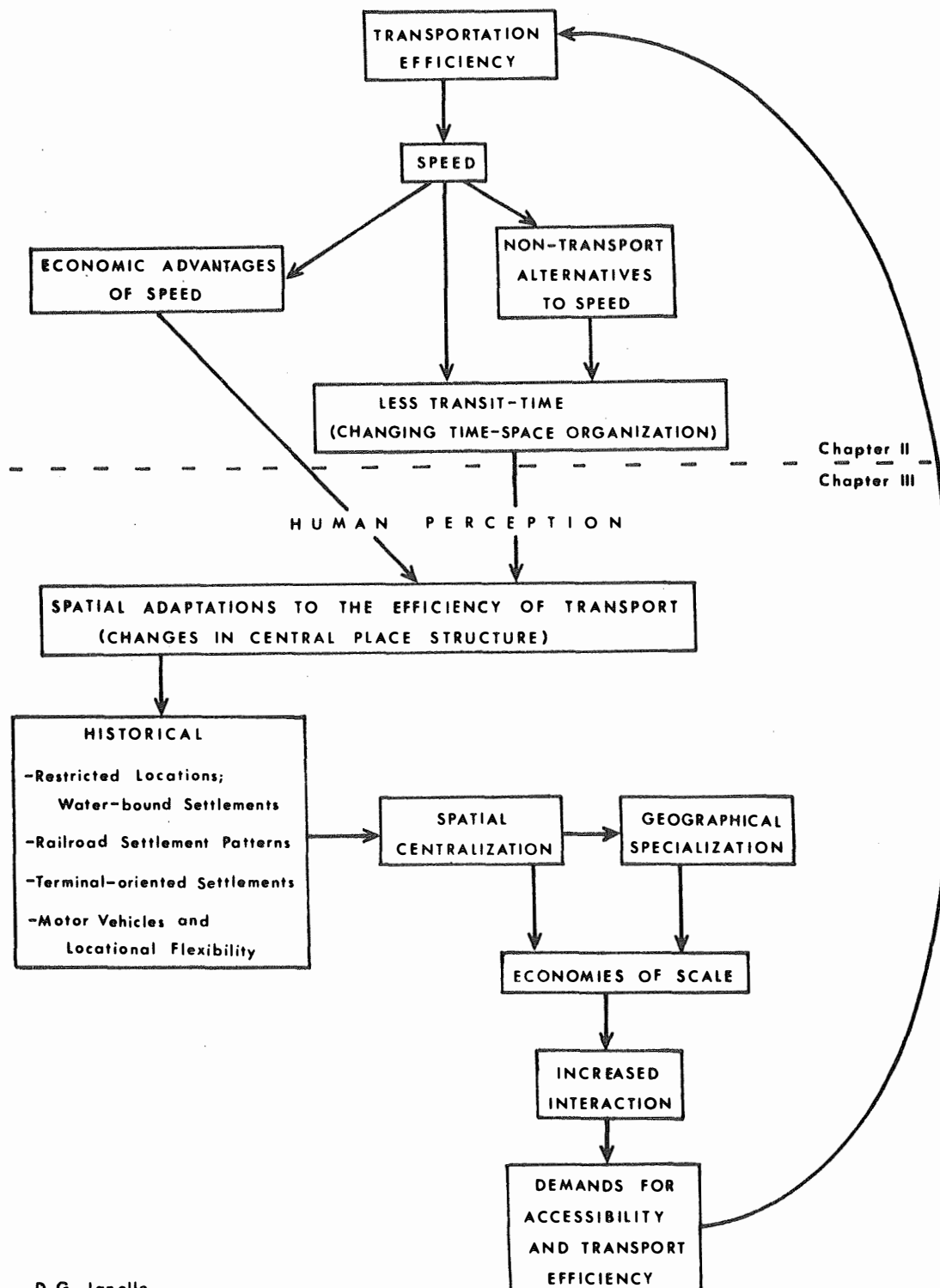
On the assumption that speed is the relevant measure of the advancement in transport technology, the utility of rapid transport and the alternatives that man has employed as substitutes for speed have been subjects for considerations in this chapter. By defining speed as the time-in-transit required to move from an origin to a desired destination, a measure for characterizing the time-space organization of man's activities is provided. This definition has the advantage of combining into one measure both the locomotive speed of the transport vehicle and the previously discussed substitutes for speed. Thus, the tempo of human interaction is also a function of man's ability to reduce the necessity of movement by crowding together his functionally related and specialized establishments, by decentralizing his convenience establishments, by shortening and improving his transport routes, by speeding up his communications and so forth. Likewise, it is a combination of all of these factors that has contributed to the economic and other advantages derived from the reductions in the required transit-times. In the next chapter it will be observed how man's quest to speed up movement and to reduce the need for movement in his interactions has been instrumental in shaping both the time-spatial and spatial organization of his functional activities.

CHAPTER III

SPATIAL ADAPTATIONS TO THE EFFICIENCY OF TRANSPORT

Having outlined a choice for a measure of transportation efficiency, and having explored the manifold ramifications of the utility of speed, it is now possible to consider the contention that "the geographic specialization of areas, the centralization of functions into higher-ordered centers and other economies of scale are greatly dependent upon the efficiency of transportation." With reference to the flow diagram in Figure 9, it will be noted that the spatial processes of centralization and specialization are characterized as spatial adaptations of man's activities to the efficiency of transport. These scale economies are considered to be the results of human perception of the potential benefits that can be derived from adapting the locational organization to the evolving time-spatial arrangement of man's activities. The process, of course, is much more complex--the interregional exchange itself (necessitated by centralization and specialization) leads to demands for greater transport efficiency (accessibility). Therefore, in Figure 9 this process is depicted as cyclical in nature; that is, the system is self-adjusting. This notion was developed

Process of Spatial Adaptation to Transport Efficiency



D. G. Janelle
1966

FIGURE 9

in Chapter I and will be expanded upon in a later chapter.

An Historical Classification of
The Locational Adaptations of
Man's Activities¹ to the Effi-
ciency of Transportation

Centralization and specialization take place over time. On this basis, and on the assumption that these scale economies are related to transport efficiency, it should prove helpful to develop an historical classification relating man's spatial organization to his changes in transportation.² This classification is as follows:

1. Restricted locations--water-bound settlements
2. Railroad settlement patterns
3. Terminal-oriented settlements
4. The motor vehicle and locational flexibility.

Restricted locations--water-bound settlements.--

Much acclaim has been given to the Roman road systems. Yet, the early empire was more economically tied to transport and settlement along water routes rather than land

¹The term "adaptation" is deemed preferable to "adjustment" because it denotes a gradual rather than an abrupt change in the geometric patterns of human occupancy.

²Stewart Marquis has used a systems analysis approach in describing spatial-organizational adaptations to improved transportation in the historical development of a hierarchy of community systems in southern Michigan. See Development of Community Centers, 1830-1960: An Analysis of the Evolution of Human Community Systems in the Lansing Tri-County Region, Paper No. 7 (East Lansing, Mich.: Institute for Community Development, Continuing Education Service, Michigan State Univ., May, 1963).

routes. Her food supplies were, for the most part, grown in the delta areas of rivers--the Nile Delta alone provided over one-third of her grain supply.¹ Wood for fuel was gathered in the forests along the rivers of Italy. In the inland areas, a scattered livestock economy predominated. Prior to the development of the railway the costs and difficulties of land-transport precluded extensive development or exploitation of resources far beyond the water routes. Most of the large cities had access to sea-going ships--usually at the mouths of rivers where they could tap resources through downriver transportation.²

As long as land-transportation was measured by the strength and endurance of animals it was limited to short distances and could not compare with the carrying capacity of ships in water-transport. A pack horse can carry approximately 270 pounds and a camel 400 pounds for only 18 to 20 miles per day.³ Although one horse with a wagon can pull 1,500 pounds over the same distance,⁴ additional horses do not increase the tractive power to the same degree. Eight horses working together can haul only about four times the load of a single horse.⁵ Under these restraints to land-transport it still cost 125 dollars in

¹Gilmore, op. cit., p. 17.

²Ibid., p. 10.

³Grossman, op. cit., p. 14.

⁴Ibid., p. 18.

⁵Joachim Leithäuser, Inventor's Progress (Cleveland: The World Publishing Co., 1959), p. 77.

the 1820's to move a ton of freight from Philadelphia to Pittsburgh.¹ Even with the completion of the Cumberland Road from Baltimore to Wheeling in 1830, freight wagons averaged less than 20 miles per day and charged approximately 15 cents per ton mile.² It is with little wonder then, that, until the introduction of the railroad, villages and towns were primarily located on river, canal or coastal sites. Inland from the water routes, travel was expensive and population was sparse. In effect, settlement was "channelized" along the water routes.³

Railroad settlement patterns.--The introduction of the railroad resulted in a rapid increase in overland freight and passenger hauls. Yet it too operated within relatively narrow limits--the railways often paralleled the already accessible areas along the water courses and valley bottoms. Therefore, the railroad was also a "channelized" carrier facilitating narrow bands of settlement along its inflexible paths of iron and steel.⁴

¹Martin A. Knapp, "Social Effects of Transportation," The Annals of the American Academy of Political and Social Science, 20 (July-December, 1902), p. 10.

²Truman C. Bigham and Robert J. Merrill, Transportation: Principles and Problems (New York: McGraw Hill Book Co., Inc., 1952), p. 53; and Taylor, op. cit., p. 442.

³Many early settlements were exceptions to this "rule"--notably Samarkand and Timbuktu.

⁴See Lewis Mumford, Technics and Civilization (New York: Harcourt Brace and Co., 1934), p. 62.

In spite of this channelization, railroads did offer more flexibility in the choice of a settlement site than did the rivers or canals. Cities such as Atlanta, Denver and Scranton are frequently referred to as products of the railroad--they could not easily be supported by water transport.¹ Also, a large area such as the Great Plains--not readily accessible by river or canal--was scarcely settled prior to the introduction of the railroad.²

The principal advantage of the railroad was its comparatively cheap and rapid service. In contrast to the high freight rates via horse-powered wagons, by 1853 railway freight rates varied from 2.4 cents per ton mile on the Erie Railroad to 3.5 cents per ton mile on the Pennsylvania Railroad. By 1860 these rates were down to 1.84 and 1.96 cents per ton mile respectively.³ Although these rates were two to three times those for canal and river transport, the railroads' faster speeds and more direct routes helped to establish them as the preferred freight and passenger carriers. Whereas steamboat shipments averaged three days and six hours between Cincinnati and Pittsburgh in the 1850's, the same trip by rail took only one day and twelve hours.⁴ Thus, because of this

¹Gilmore, op. cit., p. 64.

²Ibid., p. 65.

³Taylor, op. cit., p. 442.

⁴Ibid., p. 139.

relatively cheap and rapid service, railways soon dominated interregional movements in this country.

Terminal-oriented settlements.--Most new railroad routes in this country were established to serve an existing settlement pattern. Nonetheless, they played a significant role in changing the hierarchical ordering of places and in altering established land-use patterns. In order to increase the speed and profitability of transport and to operate on regular time schedules, the railroads designated terminals where passengers or goods could be picked up and discharged.

With the growing importance of rail transport, certain commercial establishments closest to the terminals profited by more direct contact with markets than did those more distant from the terminal.¹ For example, by the 1850's pierside locations in New York City were being abandoned by wholesalers for those closer to the rail depots. An increasing proportion of incoming and outgoing traffic was being shipped overland rather than by sea or river.² Railways helped to render distances less significant than did the steamships or barges; they could serve areas not approachable by water and could extend the inland range for marketing goods. Mumford makes note of the movement of population from the countryside into the

¹Hawley, op. cit., p. 357.

²Hoover and Vernon, op. cit., p. 80.

great terminal cities, the railway junctions and the port towns.¹ Fast express service between principal centers, he believes, served to further this concentration and thus tended to augment the hierarchical ordering of the terminal centers.

Although the early railroads enabled man to increase the size of his settlements by providing him access to more distant resources and by extending the range of his marketable products to areas not accessible by other modes of travel, their flexibility was limited to a fixed rail, established timetables and chosen terminals. With the great differences in cost and speed between overland, horse-drawn transportation and rail transportation, location with respect to the rail network and the train depots made a considerable difference in the economic viability of a business or industry.² By 1860 stage coach and wagon transportation in the United States was, for the most part, limited to localized movements. Anyone interested in regional exchange of products had to be located within economic range of a railroad depot--preferably one offering frequent service.

¹Mumford, Technics and Civilization, op. cit., pp. 162-63.

²Philip B. Herr, The Regional Impact of Highways (Cambridge: Mass. Institute of Technology Press, 1959), p. 17.

The motor vehicle and location flexibility.--True flexibility and freedom in the choice of business or industrial location was not approximated until a relatively rapid and individualized mode of travel--the automobile and more recently the truck--became popular. By 1925 automobile travel had come into its own in the United States, and the location choice had become as flexible as the conditions and densities of the street and road patterns allowed. Today, many economic activities, not requiring goods or resources of great bulk or weight, can locate without the necessity of direct rail or water transport. The movement of products by trucks over modern highways, although usually somewhat more costly than by rail or water transport, permits door-to-door conveyance, obviates the need for transshipment from terminals and, because trucks are not necessarily on fixed time-schedules, can provide almost immediate service. For hauls of less than 300 to 500 miles the truck generally provides quicker door-to-door service than rail carriers.¹

Residential locations have also been freed from their previous channelized development along the street car and interurban lines of the late nineteenth and early twentieth centuries. With fast, personal transport, families could move into unsettled areas between the main

¹Norton, op. cit., p. 41.

transport lines and still be within a minimum time-threshold from their jobs in the central business areas.

Transport Innovations and Benefits of Spatial Reorganization

Thus far it has been seen how, in varying degrees, the railroads, the trucks and the automobiles have facilitated flexibility in the choice of locations for commercial and residential purposes¹ and have increased the tempo and reduced the costs of functional interactions. These changes, in turn, have helped man to derive certain benefits of spatial reorganization which may be broadly described as benefits of centralization and specialization. Though it is difficult to consider centralization apart from specialization (and vice versa), they shall, for convenience, be considered separately, beginning with centralization.

The Spatial Centralization of Functions

Spatial centralization represents the progressive increase in dominance of a particular center over an economically, culturally and often politically integrated area. This dominance is frequently characterized by a transfer of functions from the smaller places to the dominant place, the more rapid growth of the larger place over

¹See Edward L. Ullman, "The Nature of Cities Reconsidered," Papers and Proceedings of the Regional Science Association, 9 (1962), p. 16.

the smaller ones and the spatial extension of the major center's hinterland or area of dominance.¹ The association of these changes with improvements in transportation--notably the automobile--has been identified by many scholars.² Such changes represent a spatial adaptation of man's activities to their changing time-space framework.

The decline of small service centers.--With the transfer from the horse-and-buggy to the automobile, the relative significance of distance declined--people could travel further in a given time and could bypass local facilities to frequent larger markets which offered a wider variety of goods and other amenities. Consequently, as noted by Hoover, the functions of the smallest centers have disappeared and the distances separating market towns have increased.³ This is substantiated in part by Hoffer.⁴ He notes that, between 1905 and 1929, 320 trade centers in

¹James A. Quinn, Human Ecology (New York: Prentice-Hall, Inc., 1950), p. 305.

²See the following: C. J. Galpin, Rural Life (New York: The Century Co., 1923); J. H. Kolb and R. A. Polson, "Trends in Town-Country Relations," University of Wisconsin Agricultural Experiment Station Research Bulletin, 117 (1933); P. D. Converse, "The Automobile and the Village Merchant," University of Illinois Bureau of Business Research Bulletin, 19 (1928). For a more complete bibliography, see Brian J. L. Berry and Allen Pred, Central Place Studies: A Bibliography of Theory and Applications (Philadelphia: Regional Science Research Institute, 1961).

³Edgar M. Hoover, The Location of Economic Activity (New York: McGraw-Hill Book Co., Inc., 1948), p. 125.

⁴Hoffer, op. cit., p. 67.

Minnesota were completely abandoned. The 356 trade centers that were added during this period were, for the most part, located in areas of population growth about the urban centers.

Using retail food markets as an example, Fox notes that "as the minimum efficient size of a certain type of firm increases, its function tends to migrate from smaller to larger places."¹ Hawley, generalizing from numerous studies on the topic, indicates that this migration has been particularly prevalent among "establishments that retail furniture, clothing, millinery, jewelry and other specialty goods. . . ."² The same holds true for professional services. Both Hawley and Fox attribute these changes to advancements in transportation. While the spacing, the size and the number of these establishments were originally determined ". . . against the background of travel by wagon over poor roads,"³ the use of the automobile has opened greater opportunities for augmenting the economies of size and specialization; and, on the whole, man's spatial adaptations to advances in transportation have tended towards fewer, larger and more distantly spaced functional establishments. This is particularly

¹Karl A. Fox, "The Study of Interactions Between Agriculture and the Nonfarm Economy: Local, Regional and National," Journal of Farm Economics, 44 (February, 1962), p. 16.

²Hawley, op. cit., p. 415.

³Fox, op. cit.

evident in food retailing. Fox observes that "in the process of making itself secure in a third-order central place, a supermarket tends to squeeze out entirely the small grocery stores previously existing in the second-order central places nearby."¹ Similar observation of such centralization could be made for other types of establishments in many of the developed areas of the exchange world--an area in southern Michigan is considered here.

Centralization in southern Michigan.--In a 1963 sample study of 15 hamlets of less than 200 population in Barry County, Michigan, this author noted the numerous functional changes that occurred in these places since 1900.² The grist mills, grain elevators, hotels, blacksmiths, train depots, brick factories and cider mills have all been abandoned. By 1963 only three of the fifteen hamlets still had post offices and schools. What remains of their economic life is geared either to the highway in catering to transient customers or to providing convenience items and neighborhood services to the resident population. Ten of these hamlets still have general

¹Ibid., p. 20. (Fox is using Philbrick's hierarchical classification of functional places in accordance with the principles of areal functional organization, op. cit.)

²Donald G. Janelle, Hamlet Analysis and Classification (Unpublished paper, Department of Geography, Michigan State University, August 5, 1963).

stores, five sell gasoline and seven still support churches. However, nearly 70 per cent of the hamlets' residents now earn their livelihood in the larger, nearby urban centers. (This varies from 62 to 87 per cent for individual hamlets.)

It appears that, with the introduction of the automobile and with the resulting decline in the relative significance of the time-space barrier, the hamlets of Barry County have out-lived their original functional significance and have been drawn into the daily lives of the larger cities. Direct motor transport has extended the trading areas of Kalamazoo, Battle Creek, Grand Rapids and Hastings (the county seat) over the county. In the process the intermediate hamlets have become redundant features in the functional framework of the central place structure.

Unlike the hamlets studied, Grand Rapids, Kalamazoo, and Battle Creek have direct railroad and airplane services, and have interchange approaches to limited access freeways connecting them with other major cities. As a consequence, it seems safe to predict that the dominance of these cities over the hamlets and other small towns in the area will be strengthened. This conclusion is supported by Morrill. He notes that, with the introduction of interstate highways ". . . we might expect . . . [the larger centers] to increase the domination they enjoy

and . . . [thus] magnify economic differences between the large and small centers."¹

Just as the hamlets of Barry County were drawn into the daily lives of such cities as Kalamazoo, it is possible that the centralization process may be accelerated by further advancements in land-transportation that could draw even places such as Kalamazoo or Lansing into the daily lives of Chicago and Detroit. Many auto-parts factories scattered throughout the United States are already closely integrated with automobile manufacturing plants in the Detroit area.² This centralized control of geographically dispersed productive units would not have been possible only fifty years ago.³ The increasing transit-speeds that have helped make such economic integrations possible are most likely to continue increasing; the 87 mile trip between Detroit and Lansing may some day be within a time-threshold for breadwinners in Lansing to commute to their jobs in the "motor city."

New modes of travel and expected changes in the central place structure.--Impetus for the continued increase in land-transport speeds was recently provided by

¹Richard L. Morrill, "Highways and Services: The Case of Physician Care," Studies of Highway Development and Geographic Change, by William L. Garrison, Brian J. L. Berry, Duane F. Marble, John D. Nystuen and Richard L. Morrill, op. cit., p. 232.

²Hawley, op. cit., p. 414.

³See Milne, op. cit., p. 85.

the Federal enactment of the High-speed Ground Transport Act.¹ Already, plans for ground-travel speeds in excess of 500 miles per hour are on the drawing boards.² For purposes of this discussion, however, only the more modest proposals will be considered. Speculation on the impact of greater travel-speeds on the spatial organization of man's activities will also be considered.

Under the Levacar concept being developed by Ford Motor Company ". . . rail guided ground travel at speeds of several hundred miles an hour already is technically possible."³ Such a system is now under development between New York and Philadelphia. Between New York and Washington D.C., regular passenger trains are scheduled to make 125-160 mile per hour test runs sometimes in 1966.⁴ Quimby envisions a similar system extending along the Eastern Seaboard from Portland to Norfolk.⁵ In contrast to these rail-guided transport systems, General Motors

¹U.S. Congress, An Act to Authorize the Secretary of Commerce to Undertake Research and Development in High-speed Ground Transportation, and For Other Purposes, Public Law 220, 89th Congress, September 30, 1965.

²See James C. G. Conniff, "You Will Go 500 mph--On the Ground!" Family Weekly (February 20, 1966), pp. 4-5.

³Curtis D. Buford, "New Concepts in Railroading," Transportation Frontiers, ed., Karl M. Ruppenthal, op. cit., p. 95.

⁴Warren R. Young, "What's to Come," Life, 59 (December 24, 1965), p. 146.

⁵Henry D. Quimby, "Transportation for Super Regions," Traffic Quarterly, 17 (July, 1963), p. 337.

Corporation has proposed the adoption of a more personal and flexible vehicle. Its Autoline is envisioned as two to three times as fast as present freeway driving--everything is automatically controlled to assure maximum safety and utility. A two-lane Autoline system, they say, will be equivalent to a 20-lane expressway--it could handle 20,000 vehicles per hour and would cut the travel-time from Detroit to Chicago to 3 hours and 23 minutes.¹

The impact of these and possibly greater transport advances upon man's organization of space could be considerable. For instance, Quimby notes that a rail-guided transport carrier operating at a modest speed of 100 miles per hour would require terminals spaced at least fifty miles apart.² The terminal centers, having a greater time advantage over intermediate points, would seem likely to increase their potential attraction for certain economic and social functions which place a high value on time. Other functions, whose present spatial organization is in accord with today's means of land-travel, may have to adjust to a new time-space structure.

Quimby says that land-travel will soon become faster and cheaper than air service for distances up to

¹Albert A. Atwell and Robert F. McLean, The Autoline: A Missing Link in City to City Transportation (A paper given before the International Congress of the Society of Automotive Engineers in Detroit, January 9-13, 1961).

²Quimby, op. cit.

300 miles.¹ If this prediction is correct, then it is possible, for example, that many small local-service airports could become redundant and inefficient functional establishments. Even with today's standards of highway travel, Taaffe indicates that cities less than 120 miles apart are too close to each other for effective air services.² It may be necessary to abandon many of the smaller airports in favor of larger, regional air-terminals. If the potential for traveling greater distances in equal or less time via land-transport than by air-transport increases, a larger traffic threshold will be necessary to maintain the profitability of regular flights. This centralization of air-terminals may even be augmented further by changes in air-travel technology. Taaffe notes that the ". . . increased emphasis on speed in the form of domestic jet or turbo-prop service . . . would tend to increase the primacy of the large

¹Quimby, op. cit., p. 333. This prediction could be proven false by advancements in air-travel--particularly the VTOLs--Vertical Take-off and Landing aircraft (a combination helicopter and airplane). See "The Many Choices Begin to Form Up," Life, 59 (December 24, 1965), pp. 158-67. Also, see Najeeb E. Halaby, "Aviation Horizons," Transportation Frontiers, ed., Karl M. Ruppenthal (Palo Alto: Stanford University Press, 1962), pp. 34-42.

²Edward J. Taaffe, "The Urban Hierarchy: An Air Passenger Definition," Economic Geography, 38 (January, 1962), p. 5.

centers."¹ With the commercial development of supersonic aircraft (now in process)² capable of speeds greater than 2,000 miles per hour, it is likely that the primacy of the larger centers will be augmented further. Dyckman believes that such an aircraft would require ". . . 300 mile per hour ground connections to make any economic sense."³ With land-transportation capable of such speeds, it would seem that only a few widely spaced cities could profitably support terminals for supersonic aircraft.

Centralization--conclusion.--In this discussion one may note that the process of spatial centralization has focus--it is directed to a particular place. On the other hand, the degree of centralization or the centrality of a particular place is dependent upon the ability of that place to spread its influence outward over a surrounding area which may be referred to as its trade area or hinterland. Berry and Barnum⁴ indicate that the trade area served by a place is dependent upon the maximum distance

¹Edward J. Taaffe, "Air Transportation and United States Urban Distribution," Readings in Urban Geography, eds., Harold M. Mayer and Clyde F. Kohn (Chicago: The Univ. of Chicago Press, 1959), p. 361, Reprinted from Geographical Review, 46 (April, 1956), pp. 219-38.

²Halaby, op. cit., p. 38.

³John W. Dyckman, "Transportation in Cities," Scientific American, 213 (September, 1965), p. 174.

⁴Brian J. L. Berry and H. Gardiner Barnum, "Aggregate Relations and Elemental Components of Central Place Systems," Journal of Regional Science, 4 (1962), p. 39.

that customers will travel to trade there. Thus, the outer-zone of this area will define the aggregate, maximum range of the place for all the goods and services that it offers. The goods and services or central functions provided by the place will depend upon the population and income thresholds of the area it serves.

If it is assumed that people have a limit to the time they are willing to spend in attaining a certain good or service, then it is evident that the sizes of the manifold and aggregate trade areas of a central place are dependent upon man's capacity to overcome distance by increasing the speed of travel and communications. As man improves the efficiency of transport, he is potentially extending the range of influence of an area's dominant center--giving it access to more resources and to a larger market. Therefore, faster transport not only facilitates the centralization of additional functions within the dominant center, but also increases the opportunities for specialization in both the dominant center and in its hinterland.

Specialization

The role of transportation in augmenting the degree of specialization of given functions within a central place or area may be indicated by an example. In 1800 Gloucester, Massachusetts had all the requirements for a profitable fishing industry except quick access to a

market. With the coming of the railroad in the 1830's, Gloucester attained overnight transport to Boston and ". . . a necessary minimum threshold of service . . ." ¹ to profitably exploit her resources. Thus, Gloucester citizens could concentrate on the production of fish to exchange for whatever other products or services they required. Similarly, the Maine lobster industry was highly localized until the airplane and advances in refrigeration allowed it to expand operations to supply a nation-wide market.

As in the previous discussion on centralization, it is observed that the degree of specialization is limited by the size of the market. Furthermore, improvements in transport which reduce the time-space gap separating the producer and the consumer are a means of enlarging these markets. ² This is particularly evident in many recreation-oriented industries. For instance, ski resorts in sparsely settled northern New England and northern Michigan would be economic misfits were it not for the automobile and the good highways that accommodate the thousands of skiers--many traveling 200 to 400 miles for a weekend on the slopes. Thus, these areas have, in a limited sense, attained a degree of specialization not unlike that found in many productive agricultural areas.

¹Herr, op. cit., p. 38.

²Milne, op. cit., p. 23.

Geographical specialization of areas.--Both Ullman and Chisholm¹ have noted how improvements in transportation have helped in the development of specialized agricultural production in areas which, by virtue of their climate, soils and so forth, are best endowed for particular crops. The commercial production of corn and pork in the North Central States, wheat in the Midwest and beef, mutton and wool in the Southwest would not be possible if these areas could not exchange their surplus for essential goods produced by other specialized regions or industrial centers. Because of the perishable nature of many food products, increases in the speed of transport along with other technical advances in refrigeration and dehydration have been instrumental in the development of specialized agricultural areas. In fact, Hawley notes that, on the whole ". . . trade in foods and other such necessities remained local in nature until the advent of steam transportation."²

Although advances in refrigeration and other technical developments may contribute to making specialization possible, it should not be inferred that they reduce the

¹Ullman, "The Role of Transportation and the Bases of Interaction," op. cit., p. 867. Michael Chisholm, "Tendencies in Agricultural Specialization and Regional Concentration of Industry," Papers and Proceedings of the Regional Science Association, 10 (1963), p. 157.

²Hawley, op. cit., p. 294. Hawley notes that the Romans traded many non-perishable products over considerable distances.

need for speed in transport. Cottrell mentions that "even though beef can be refrigerated and kept indefinitely, its delivery to meet a certain day's market, or to keep the production line of a packing house going, means that cattle trains have to be put on a penalty schedule if a competing road is not to get the business."¹ Therefore, it may be added that specialization and the resulting need for broad interregional exchanges have placed a premium on the proper time and place combination of resources. The utility of resources in an interrelated economy of specialized production areas and specialized industrial and commercial centers is highly dependent upon a reliable and efficient transport system.

Conclusion: Centralization-
Specialization and the Increasing Demand for Interaction

As indicated in the flow diagram of Figure 9, the spatial processes of centralization and specialization lead to and depend upon interregional exchange of goods and resources. Indeed, these scale economies generally tend to augment the necessity for intercommunity contact. While acknowledging that "improvements in transportation . . . were not . . . responsible for the whole of increased interaction between places,"² Ullman develops this notion using

¹Cottrell, op. cit., p. 64.

²Ullman, Man's Role in Changing the Face of the Earth, op. cit., p. 867.

the railway expansion in the United States as an example of a transport improvement that has led to an increase in the areal differentiation and to the development of specialized production areas tied to distant markets. According to Bigham and Merrill, as this specialization develops and the resulting need for interregional exchange increases, the role of transportation increases in significance.¹

A good example of this is the automobile industry in Detroit. This industry relies on manufacturing plants scattered all over the country and, as Hawley indicates, each of these plants is part of an assembly line. ". . . The intake [of parts] from the trucks and railways is about as sensitively adjusted to the time factor in production as is the speed of the belt within the plant itself."² In this and in other examples, the specialization exchange economy seems to perpetuate itself in an accelerating manner; and, as goods and resources are distributed in larger quantities over longer distances to places of centralized specialization, the demand for locational utility becomes more acute. Thus, further demands for transport efficiency develop and the whole cycle depicted in Figure 9 begins again; improved transport efficiency (accessibility) leads to the desired reduction

¹Bigham and Merrill, op. cit., p. 7.

²Hawley, op. cit., p. 414.

in transit-time or time-space convergence. This, in turn, through human perception of the potential benefits of adapting the spatial organization to the evolving time-spatial structure, leads to the centralization and specialization of man's activities and to the resulting needs for increased interregional exchange, improved transport efficiency and on and on. This cyclical process, which was described by the models of the process of spatial reorganization (Chapter I), ties the discussions of this and previous chapters into one dynamic whole. It will be explored more fully in a later chapter.

CONCLUSION: PART I

An understanding of man's historical and present-day choices in laying the geometric framework for his cultural landscape is complicated by many interrelated factors. Nonetheless, in this study the state of his efficiency in transportation has been singled out as the indicator of the degree to which spatially separated places and areas can interact to provide man with those things he needs and desires. Thus, it is observed how, through advancements in transportation, man has given himself increasing access to widely distributed resources and to productive potentials of specialized economies which are centralized in his industrial and commercial centers or in their monolithic agricultural and resource hinterlands. Indeed, the degree to which much of the world has specialized its productive units and centralized its settlement into urban agglomerations would have been impossible without transportation advancements. A reflection upon the historical development of transportation and upon man's corresponding economic and settlement patterns reveals that today's cultural landscape has evolved from a highly localized state where each man was his own producer and consumer.

In Part I it is noted how the evolving spatial organization of this landscape has been closely associated with the flexibility, speed and cost of transport. At times it has even benefited man to adapt the spatial organization of his functional establishments to the changes that he has engendered by increasing the speed of freight and passenger movement. By increasing the locomotive speeds of transport carriers and by reducing the cost of their movement, man has altered the relative significance of distance. But, since these changes have not occurred simultaneously or uniformly in all directions, the relative time-spatial relationships of man's functional establishments have also changed.

Though speed has been defined as the measure of transportation efficiency, it should be recognized that speed is not the sole means by which man has altered the time-spatial framework of his functional units--he has crowded functionally associated establishments into closely spaced multi-storied buildings, decentralized many activities that cater to man's everyday needs, shortened and improved transport routes between interrelated places, and he has devised means for instantaneous communications that eliminate the need for bodily movement. Other non-transport alternatives to speed and freedom of movement include the storage of frequently required supplies which, for various reasons, could not be

transported on demand, and the institution of periodic-mobile markets for areas that lack either the buying power, the means of transport or the desire to support a permanent market.

In short, by reducing the need for movement and by speeding up what movement is required, man has sought to optimize the time-spatial relationships of his establishments so as to increase his utility of time at given places. Thus, by combining his multitudinous needs in the right place and at the right time, man minimizes movement and the time and expense of movement. On the assumption of such optimal conditions, Christaller and Lösch have developed normative models of the areal arrangement of man's activities. However, these ideal patterns of human organization would seem to be even more difficult to verify in a time-space framework than they have been in the spatial framework. These models do not account for the spatial adaptations to the changing time-space framework--they are not responsive to changes in transportation technology. The Christaller-Lösch models are based on the assumption of a homogeneous transport system; that is, the speed and cost of transport is assumed to be the same on all routes directed radially from a given central place. Yet, the optimal distribution of service centers in the horse-and-buggy era is not necessarily the same as that of the automobile era. Furthermore, transportation efficiency,

transported on demand, and the institution of periodic-mobile markets for areas that lack either the buying power, the means of transport or the desire to support a permanent market.

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in general, has not progressed uniformly and symmetrically along all the routes which radiate from central places. Consequently, since distance is relative to the time it takes to traverse space and since man has tended to organize the locational arrangements of his activities on the basis of changes in transport efficiency, it seems that time-space would be a more valid framework for describing the central place structure than would distance-space.

In Part II of this study it will be seen that the time-space framework enables one to view a system of central places as an evolving structure which is intimately allied to changes in transportation technology. A descriptive-predictive model will be proposed for characterizing this evolving structure. The reasons for such changes, and the problems that future transport advances might pose to the efficient organization of earth-space, will also be considered.

PART II

SPATIAL REORGANIZATION AND THE CONCEPT
OF EVOLVING SETTLEMENT PATTERNS

CHAPTER IV

SETTLEMENT CONVERGENCE IN TIME-SPACE: A MODEL

An Evolving Settlement Structure

The geometric patterns of human settlement are linked by a framework of transport lines which, through time, have varied greatly in their capacities for volume and speed of traffic. If the speed of man's transport carriers were uniform throughout the world, if he could travel in any direction and over any type of terrain at a given speed--no faster or no slower--then it is possible that man's settlement patterns would exhibit some geometric regularity. But, the adoptions of transport innovations have not occurred simultaneously in all directions from all points on the earth.

The distances which separate man's settlement agglomerations may be viewed as relative to the time or cost required to traverse the distances between them. Furthermore, as noted in Part I, man has altered the time and cost distances which separate his functional establishments; but, again, this has not been done uniformly throughout the world. Such considerations shed doubt upon suggestions for static and formal patterns of spatial organization. Therefore, the descriptive model to be

proposed for characterizing the dynamics of this settlement-transport complex will consider spatial patterns as a phenomenon evolving in a realm of time-space.

Relationships of Points in Time-space

In outlining a model for characterizing the dynamic state of settlements in time-space, an approach traditional to the physicist but, in many respects, new to geography will be utilized. In modern physics and philosophy, distance is no longer considered a universally valid parameter for describing the relationships between points, events or particles in space. For the physicist to describe such relationships, it is necessary that he view them in time-space and know their positions, their velocities and the directions in which they are moving. By velocity, he means the time-rate at which the distance of separation between points, events or particles changes.¹

Geographers, as the physicists, have traditionally been concerned with the positions of points (settlements) in space and with the directions of movements between them. However, geographers have not employed the concept of "velocity" in studying spatial relationships. Yet, it might be of value and not too far-fetched for the geographer to ask--"at what 'velocities' are settlements approaching one another in time-space." This study seeks

¹Bridgman, op. cit., pp. 28, 70.

to provide at least a partial answer to this question. In doing so, it is hoped that the information gained will shed light on a developmental process of spatial change--a process of settlement rearrangement in time-space.

A Dynamic Model of the Settlement Structure

The manner in which "velocity" through time-space is to be considered in a study of evolving settlement patterns demands clarification. Acknowledging the word of the physicist, that time-space is the most valid parameter for measuring the relationships between two points, the changes in travel-time required for the trip between Edinburgh and London, England will be considered. These changes and the corresponding transportation innovations and improvements are indicated in Table 2 and illustrated in Figure 10.

The trip from Edinburgh to London that took approximately four days or 5,760 minutes by stage coach in 1776 can be made by a turbo-prop airplane in 180 minutes today (including land-travel from airport to center of town). Expressed in a form analogous to velocity, by subtracting the required travel-time today from that of 1776 and dividing by the time-interval in years, it is found that Edinburgh and London have been approaching each other in time-space at the average rate of 29.3 minutes per year for the past 190 years. Thus:

TABLE 2

TRAVEL-TIME: EDINBURGH TO LONDON* 1658-1966

Year	Means of Travel	Travel-time (Minutes)
1658	Stage coach	18,720 (13 days)
1776	Stage coach (Improved roads and coaches)	5,760 (4 days)
1830's	Stage coach (Improved roads and coaches)	2,550 (42-1/2 hours)
1850's	Railroad--via Rugby, Darby and York	750 (12-1/2 hours)
1870's	Railroad--shorter route	600 (10 hours)
c. 1900	Railroad	510 (8-1/2 hours)
1932	Railroad	465 (7-3/4 hours)
1937	Railroad	360 (6 hours)
1928	First motor coach (bus)	900 (15 hours)
1938	Aircraft (2-1/2 hours flying time; 2 hours for travel between airport and center of cities)	255 (4-1/4 hours)
1950	Aircraft (1-1/2 hours in the air)	210 (3-1/2 hours)
1966	Aircraft (1 hour in the air--turbo-prop)	180 (3 hours)**
1966	Railroad	360 (6 hours)**

*Source: A. C. O'Dell, Railways and Geography (London: Hutchinson's Univ. Library, 1956), pp. 179-83.

**Estimated by author.

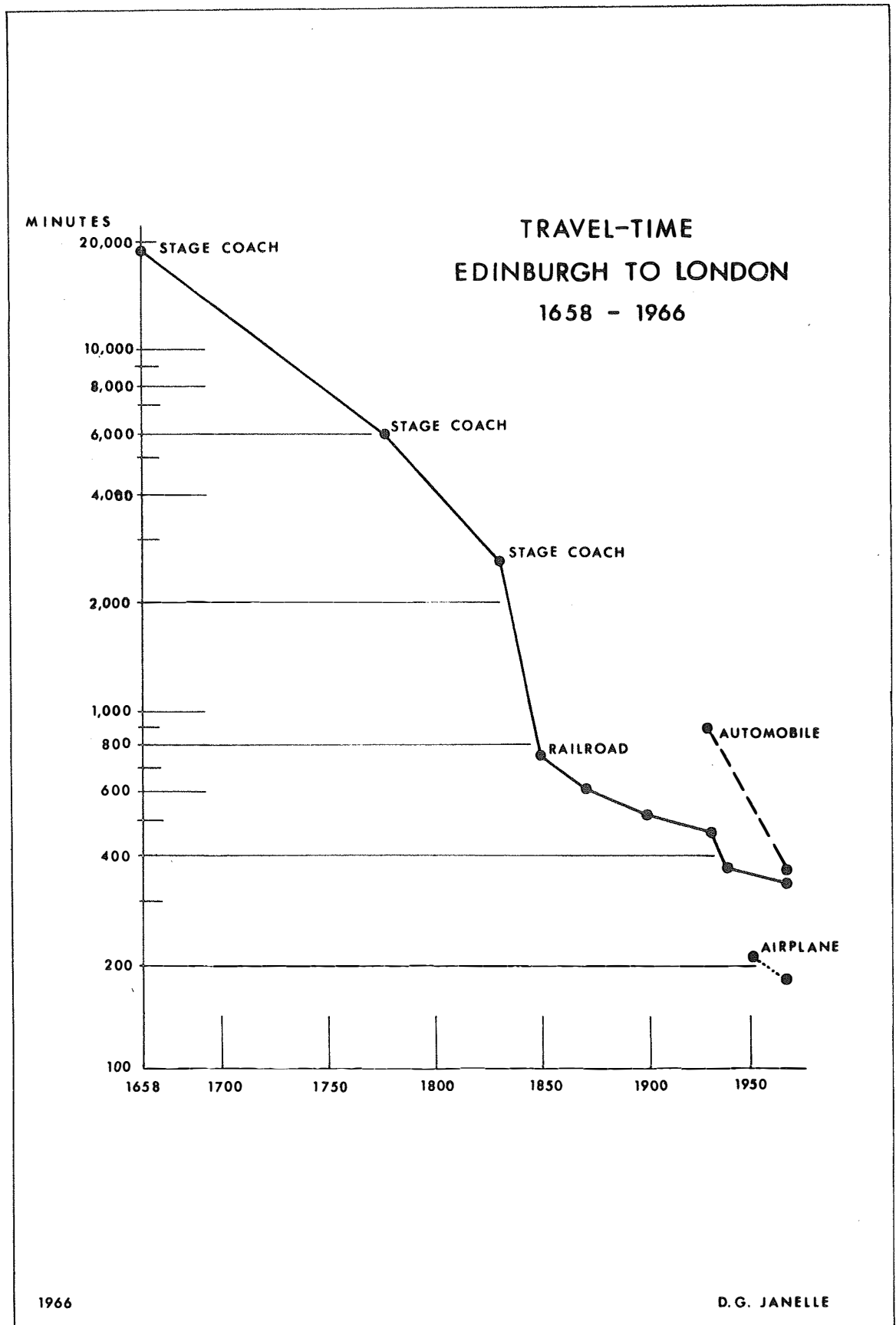


FIGURE 10

$$\frac{\text{Travel-time (1776)} \text{ minus } \text{Travel-time (1966)}}{\text{Interval in years}} = \text{Average rate of time-space convergence}$$

$$\frac{5,760 \text{ min.} - 180 \text{ min.}}{190 \text{ years}} = 29.3 \text{ minutes per year.}$$

If only railroad travel from about 1850 to the present is considered, then Edinburgh and London have been approaching each other at the average rate of 3.4 minutes per year for the past 116 years.

$$\frac{750 \text{ min.} - 360 \text{ min.}}{116 \text{ years}} = 3.4 \text{ minutes per year.}$$

A comparison of this convergence rate (as "velocity" will be defined) with the one for the 1776-1966 period reveals the responsiveness of this measure to the introduction of transportation innovations. Furthermore, this measure reduces distance to a concept that is relative to man's means of traversing space. Reference to this measure as a "time-space convergence rate" rather than as a "velocity" is preferred. Conceptually, the convergence rate is not a velocity--it is a time-rate change of time. It is, however, mathematically analogous to velocity as defined by the physicist, and it provides a tool for describing the changes in time-space relationships between settlements.

Social Physics

Models in social science which bear close resemblance to models and laws in physical science (i.e.,

Zipf's gravity model¹ or the "velocity" model developed in this paper) are frequently referred to as products of social physics. It is generally conceded that congruence of social science models with those of physical science should not be a goal of objective research. Both Lukermann² and Berry³ have acknowledged the pitfalls of such undertakings. Nonetheless, as Berry observes, the mere congruence of a social science model with one in the physical sciences should not discredit its value. Fortunately, the time-space convergence model proposed here is easily verifiable without reference to physics. This model provides a means of measuring a purely cultural conception--man's frequently-referred-to "shrinking world."

¹George Kingsley Zipf, Human Behavior and the Principle of Least Effort (Cambridge, Mass.: Addison-Wesley Press, Inc., 1949).

²Fred E. Lukermann, "The Role of Theory in Geographical Inquiry," The Professional Geographer, 13 (March, 1961), pp. 1-6.

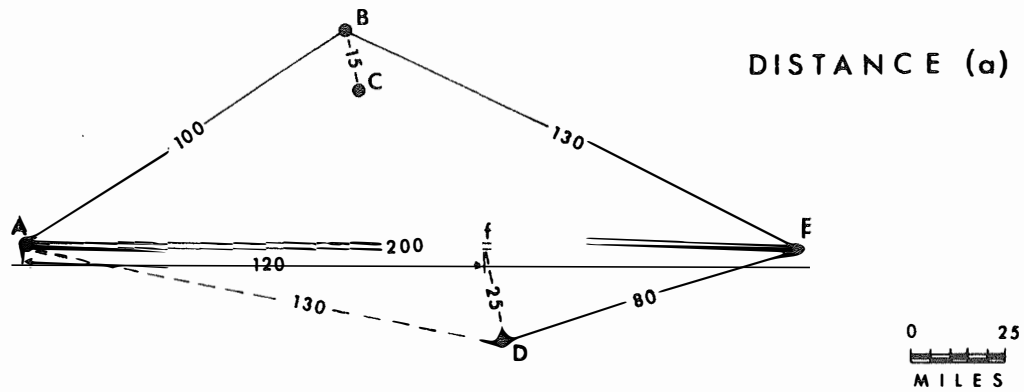
³Brian J. L. Berry, "Further Comments Concerning 'Geographic' and 'Economic' Economic Geography," The Professional Geographer, 11 (January, 1959), pp. 11-12. For further discussions on the concept of social physics in geography see: Leslie J. King, "A Note on Theory and Reality," The Professional Geographer, 12 (May, 1960), pp. 4-6; William Warntz, "Transportation, Social Physics, and the Law of Refraction," The Professional Geographer, 9 (July, 1957), pp. 2-7; John Q. Stewart, "The Development of Social Physics," American Journal of Physics, 18 (1950), pp. 239-53.

Settlements in Time-space and Differential Transport Innovations

Before suggesting an explanation for the convergence of settlements in time-space and before examining thoroughly the mathematical and conceptual nature of the convergence rate, it may be helpful to apply the convergence concept to a system of several settlements. In so doing, the model becomes more complex. This may be attributable to differential transportation developments which induce variations in the relative rates with which places approach one another.

This analysis is begun by introducing a hypothetical set of settlements A through E organized in distance-space as shown in Figure 11a. By introducing changes in the state of transportation technology at various points in time, it is observed how the spatial pattern of this settlement structure evolves in time-space. For instance, if it is assumed that in 1800 places A and E were connected by a stage coach capable of traveling 30 miles per day (based on a ten hour travel-day), that places E and D were served by a stage coach that averaged 20 miles per day and that all other interconnections were possible only over trails on which one could travel about 10 miles per day, then a transformation of the distance map in Figure 11a into a time-distance map would result in the time-space settlement pattern depicted in Figure 11b. It should be

DISTANCE AND TIME-SPACE RELATIONSHIPS SETTLEMENTS A — E



Stage Coach:

==== 30 Miles Per Day

—— 20 Miles Per Day

Trail:

----- 10 Miles Per Day

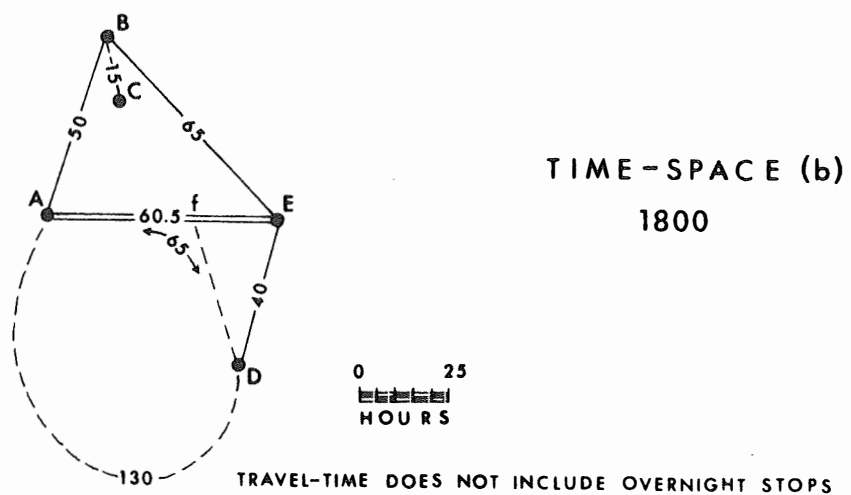


FIGURE 11

pointed out that this cartogram does not show true spatial relationships--only the lengths of lines between settlements are significant. Thus, the trail A-D and the coach road A-E represent a time-space inversion. Time-space inversions result when places such as A and E are favored by a transportation superiority which places them closer to each other in time-space than less distantly spaced settlements such as A and D which do not share the same transport advantage.¹ In constructing this cartogram and those that follow it is assumed that travel-times between two places are the same in both directions; that is, it takes the same time to travel from A to E as it does from E to A.

If new innovations in transportation were introduced into this system, it is likely that the time-space pattern would change. For example, if in 1850 a railroad line was constructed between A and E--permitting travel at 20 miles per hour, that the trail had been replaced by roads with stage coaches traveling them at 25 miles per day, and the previous stage coach lines had been replaced by more modern coaches and served by better roads that

¹Tobler (op. cit., p. 70) says that inversions imply ". . . that order relations are disrupted in such a way that places which are at greater distances on the ground are closer on the map." For further discussion on time-space inversions, see William Bunge, Theoretical Geography (Lund, Sweden: The Royal Univ. of Lund, Dept. of Geography, C. W. K. Gleerup, Publishers, 1962), p. 168.

enabled them to travel 50 miles per day; then, the new and evolving time-space settlement pattern would be as shown in Figure 12.

By carrying this evolutionary pattern up to 1960, and considering only land-travel, additional changes in the time-space relationships may be noted. Because of the profound convergence that has taken place between these settlements since 1850, it is practical to change the scale of the cartograms from hours to minutes for 1960. The travel assumptions for land-travel in 1960 are stated in the legend of Figure 13a. Now, by including air-travel into the graphic model for 1960 (Figure 13b)--assuming jet-plane service between A and E at 500 miles per hour and conventional air service between A and D at 200 miles per hour--a time-space settlement pattern that is indeed a far cry from those based solely on land-travel is obtained. It is believed that these time-space cartograms

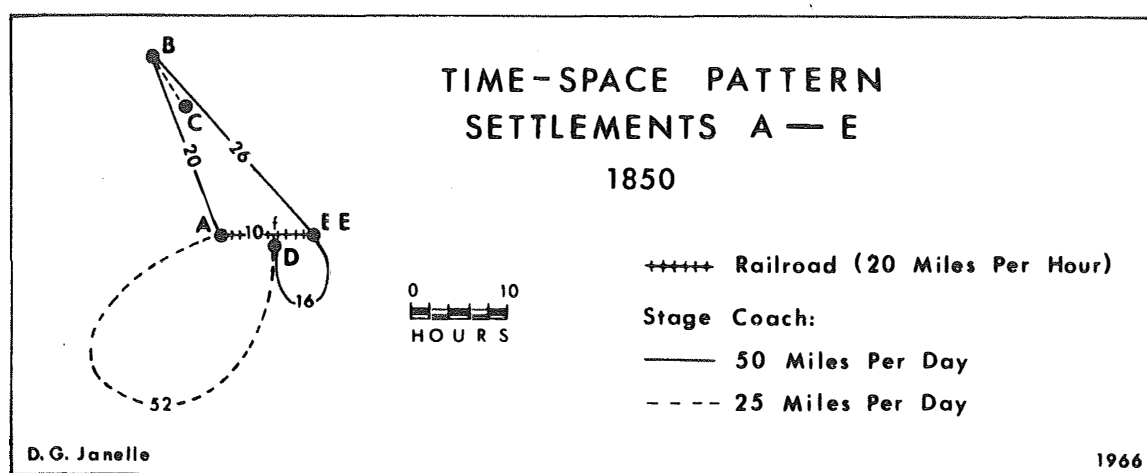
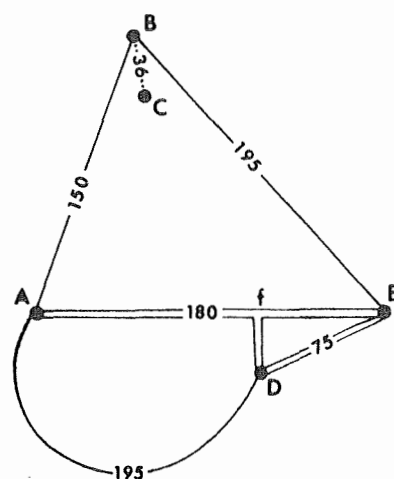


FIGURE 12

TIME-SPACE RELATIONSHIPS

SETTLEMENTS A—E

1960



LAND-TRAVEL (a)

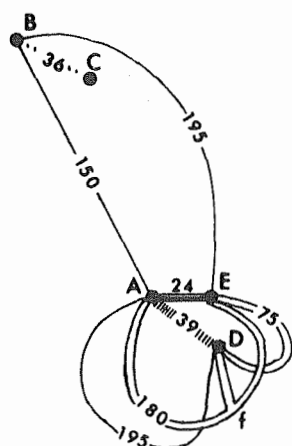
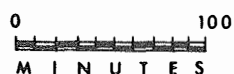
..... Gravel Road, 25 Miles
Per Hour

Paved Highway:

—— 2 Lane, 40 Miles Per Hour
==== 4 Lane, 65 Miles Per Hour

Air-Travel:

||||| Conventional, 200 Miles
Per Hour
===== Jet, 500 Miles Per Hour



LAND AND AIR TRAVEL (b)

1966

D. G. JANELLE

FIGURE 13

give a more realistic picture of the interconnectivity relationships existing within a system of places than do distance maps. Tobler notes that time, cost or convenience provide more relevant measures of distance than miles or kilometers.¹

Time-space Convergence in
a System of Settlements

In describing the changing time-space relationships between the settlements of the preceding hypothetical example, the time-space convergence model will prove helpful. With this model it is possible to determine the time-rates at which the functionally related settlements have been coming closer together over the past 160 years. Functionally related settlements are defined as those which are directly connected with each other. Thus, in the preceding example, C is functionally related with B, but not with A, E or D. For the time-intervals 1800-1960 and 1850-1960 the rates per year at which these places have been moving closer together in time are shown in Table 3.

A comparison of the convergence rates for the 1800-1960 and the 1850-1960 periods could lead to interesting speculation. For instance, it may be concluded that convergence in time-space is greatest for those settlements between which transportation innovations have

¹Tobler, op. cit., p. 115.

TABLE 3

COMPARATIVE RATES OF TIME-SPACE CONVERGENCE
SETTLEMENTS A - E: 1800-1960 AND 1850-1960

Cities	Distance (miles)	Travel-time (minutes)			Time Convergence (minutes)		Rate of T-S Converg. (minutes per year)	
		1800	1850	1960	1800- 1960	1850- 1960	1800- 1960	1850- 1960
A - E	200	3,630	600	24	3,606	576	23	5
A - B	100	3,000	1,200	150	2,850	1,050	18	10
A - D	130	3,900 (thru f)	720 (thru f)	39	3,861	681	24	6
B - C	15	900	432	36	864	396	5	4
B - E	130	3,900	1,560	195	3,705	1,365	23	16
D - E	80	2,400	960	75	2,325	885	15	8

been greatest. By comparing the rates between A and E and A and B for the two periods, one may suspect that as the means of transportation between points continue to improve, the time-space convergence will also continue; but, possibly at a decreasing rate according to some asymptote. This could be based on some practical limit to the reduction of time-separation between places--they cannot be any closer than what the imposed frictions of traffic congestion, transfer-time and so forth will allow. Thus, each successive transportation improvement decreases the maximum gain possible for any subsequent improvement. Aside from such speculation, one may also wonder how the convergence rate will vary for different modes of travel and for different types of commodity or passenger flows. Furthermore, it may be interesting to know if settlements can get further apart in time-space or if places linked by the same transport system will have the same convergence rates for similar time-intervals. These and other questions will be considered in the next chapter.

CHAPTER V

THE NATURE OF THE CONVERGENCE RATES

In Chapter IV ideas about the nature of time-space convergence were introduced. What do convergence rates actually suggest about the dynamics of the central place structure? Do places approach each other in an asymptotic manner, and how will convergence vary for different methods of transport, in different cultures, for different income groups and so forth? Are convergence rates likely to remain the same between all settlements strung out along a given transport line? And, what are the chances of places diverging or moving further apart in time-space? These and other questions merit consideration--their answers will enable one to specify some generalizations and some mathematical and conceptual properties about the convergence model.

In this chapter the step-like and the asymptotic nature of time-space convergence will be considered, the latent significance of distance in this measure will be exposed, and the implications of time-space divergence and the temporal and seasonal variance in the time-space organization of man's activities will be investigated. A

categorical classification of convergence structures will also be proposed.

The Step-like Nature of Time-space Convergence

As noted previously, the convergence model provides a measure which is defined as a rate of time-space convergence. Thus, if it took 74 hours to travel between Boston and New York City by stage coach in 1800¹ and only 5 hours by automobile in 1960, we could say that these two cities have been approaching each other in time-space at the average rate of 25.9 minutes per year for the 160 year interval.

$$\frac{4,440 \text{ min.} - 300 \text{ min.}}{160 \text{ years}} = 25.9 \text{ minutes per year.}$$

As shown by line A in Figure 14 this rate represents convergence as a linear function of time. Obviously, Boston and New York could not continue to approach each other at 25.9 minutes per year. Thus, whereas this straight line function may be a valid generalization of the time-space changes between the two cities for the 160 years, it certainly gives no indication of all the transport innovations or changes in the time-space relations that have occurred during this period. Line B in Figure 14 also represents convergence as a continuous function of time; but, in this case, the relationship is non-linear.

¹Taylor, op. cit., p. 142.

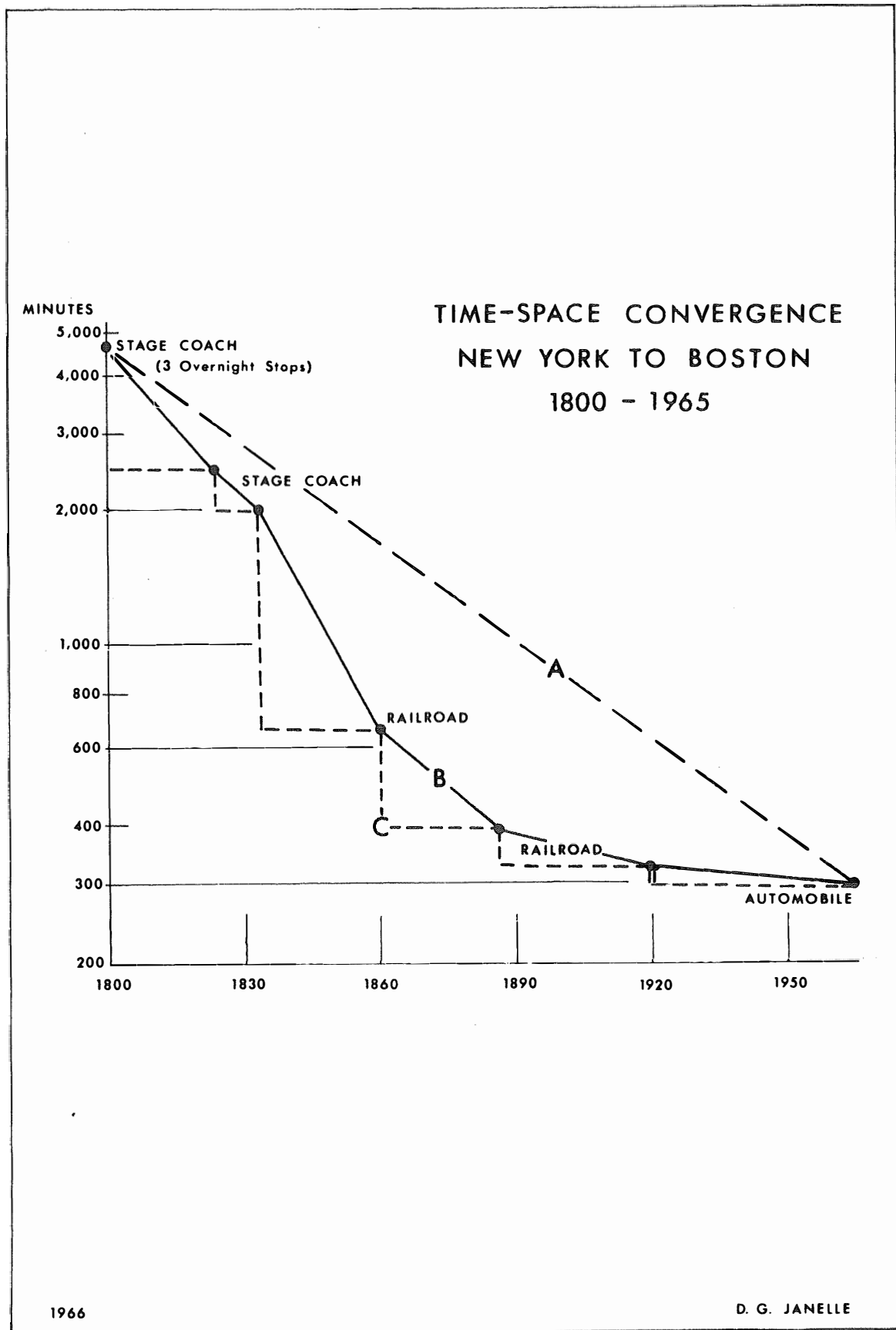


FIGURE 14

Therefore, it is observed that the rates are constantly changing and are marked by a series of recurrent accelerations and decelerations in the rates at which places are coming together over time.

Now, in contrast to these two highly generalized lines, line C shows convergence as a non-continuous, step-like function of time. These steps seem to be more representative of reality than are lines A and B. For example, the opening of a new limited access highway between two settlements is likely to result in a very abrupt change in their time-space relationship. The steps shown in Figure 14, however, do not represent all of the many minor beneficial transport innovations that have been introduced between Boston and New York.

Development of better brake systems, better lighting for night driving, improvements in tires, gasoline and windshield wipers, better road maintenance, improved traffic routing and many other advances have helped to bring these settlements closer in time-space. If these and other numerous innovations were accounted for, and if more data were available for this example, it is likely that the many step-like accelerations would approach the non-linear curve (B) shown in Figure 14. Then, it would be possible to characterize the different segments of the curved line by a series of straight-line functions or a changing series of time-space convergence rates. This

will be illustrated in a discussion on the asymptotic nature of convergence rates.

Asymptotic Nature of Convergence Rates

There is likely to be a practical limit to the reduction of time-space separation between places that is somewhat greater than zero minutes. It seems safe to assume that there will always remain some friction in the forms of traffic congestion, transfer-time and technical limitations that will prevent the instantaneous or nearly instantaneous transfer of goods and passengers. As a consequence of these practical limits, any advance in transport-speed between two points minimizes the maximum possible time-space gain that can be attributed to any future increase in travel-speed. This leads one to suspect that, although convergence should continue with introduction of new transport innovations, it will most likely do so at an ever decreasing rate. This notion has at least intuitive appeal.

An asymptotic relationship does appear to exist in the convergence of Lansing and Detroit, Michigan for the 1840-1965 period (Figure 15). Convergence rates for successively shorter periods--all ending with 1965, for successively longer periods--all beginning with 1840, and for consecutive periods from 1840 to 1965 have been determined (Table 4). In only two instances are there

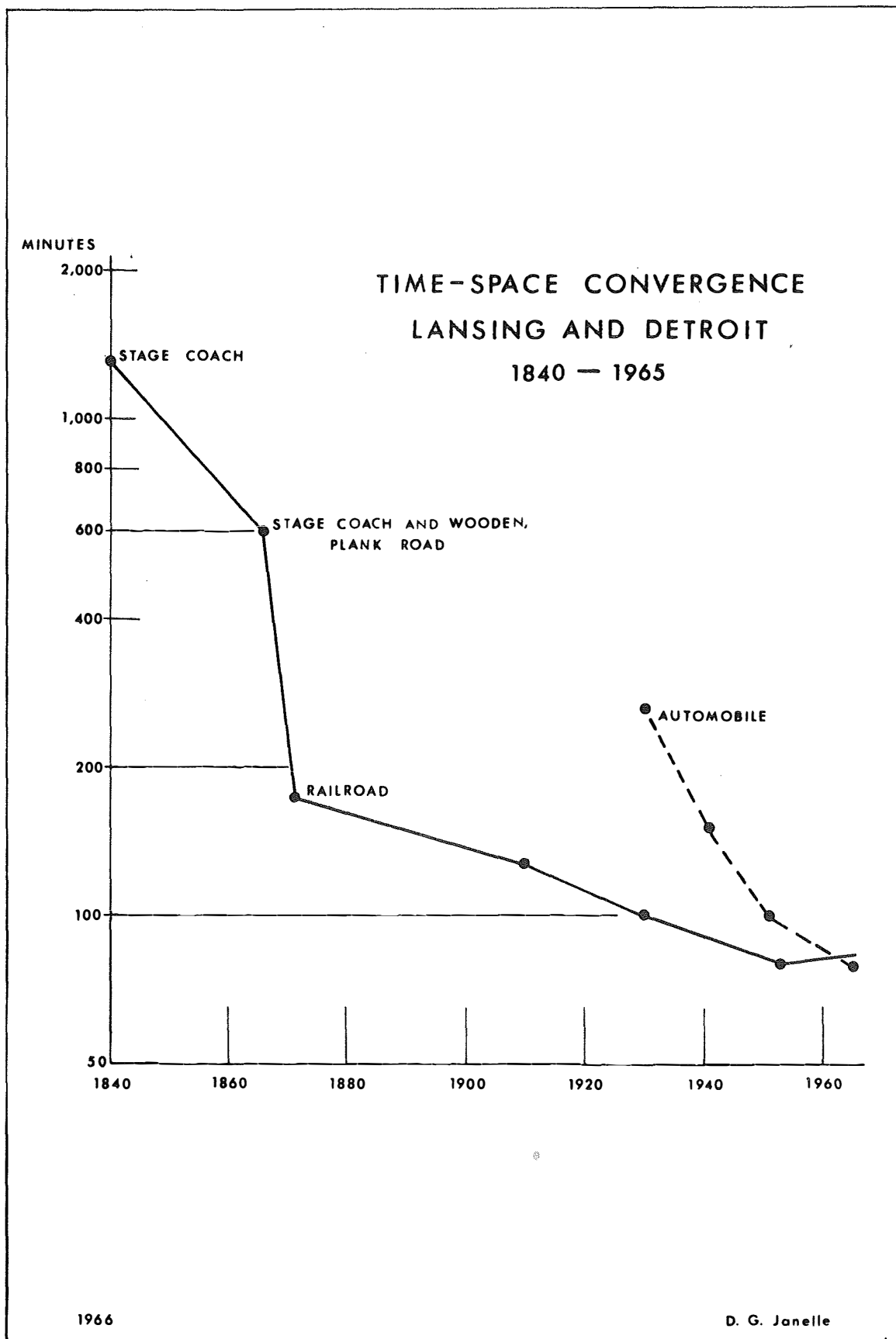


FIGURE 15

TABLE 4

CONVERGENCE RATES: LANSING AND DETROIT* 1840-1965

Period of Convergence	No. Years	Decrease in Time-distance (minutes)	Converg. Rate (min. per year)	Range of Transport Innovations
For Successively Shorter Periods--Ending with 1965				
1840-1965	125	1,188	9.5	Trail--Auto and Freeway
1866- "	99	522	5.3	Stage C.-- "
1871- "	94	92	.98	Railroad-- "
1910- "	55	47	.85	" "
1930- "	35	22	.63	" "
1950- "	15 } ³⁵	22 } ²²	1.5 } ^{.63}	Auto-- "
For Successively Longer Periods--Beginning with 1840				
1840-1866	26	666	25.5	Stage C.--Stage and Plank Rd.
" -1871	31 } ³¹	1,096 } ^{1,096}	35.4 } ^{35.4}	" --Railroad
" -1910	70	1,141	16.3	" --Improved Railroad
" -1930	90	1,166	12.9	" -- "
" -1950	110	1,166	10.6	" --Auto
" -1965	125	1,188	9.5	" --Auto and Freeway
For Consecutive Periods--1840-1965				
1840-1866	26	666	25.5	Stage C.--Stage and Plank Rd.
1866-1871	5 } ³¹	430 } ^{1,096}	86.0 } ^{35.4}	Stage and Plank Rd.--Rail
1871-1910	39	45	1.5	Improved Rail
1910-1930	20	25	1.3	" "
1930-1950	20	0	0.0	Railroad--Auto
1950-1965	15 } ³⁵	22 } ²²	1.5 } ^{.63}	Auto--Auto and Freeway

*Based on the most common means of intercity travel for indicated periods. In 1840 it took approximately 1,266 minutes to travel from Detroit to Lansing by stage coach. This trip was made in approximately 78 minutes by automobile in 1965.

departures from the otherwise continually declining convergence rates. One of these corresponds with the introduction of the railway between these two cities in 1871, and the other with the introduction of the interstate expressway in the 1960-1965 period. These two transport innovations appear to have had the greatest relative significance in reducing intercity travel-times.

It was not until the opening of the expressway that the automobile could surpass the intercity speeds of the railway. Nonetheless, by the 1930's, the automobile was the preferred means of intercity travel. Its great advantage was its flexibility--it eliminated the need for transport transfers, it did not operate on fixed schedules and it could serve residents of rural areas and settlements not having railway depots.

With Lansing and Detroit only about 78 minutes apart by automobile today, as great an absolute shrinking in the time-space gap as accompanied the railroad can no longer be expected. Even if land-transport speeds of 150 miles per hour were possible by 1985, the absolute decline in the time-distance between Detroit and Lansing would be but 44 minutes. The cities would then be 34 minutes apart and, for the 1965-1985 interval, they would be approaching each other in time-space at 2.2 minutes per year. For the 1840-1985 period the convergence would be 8.5 minutes per year. When it is realized that normal land-transport

speeds of 150 miles per hour would require technological and innovational break-throughs far greater than that of the freeway, it is evident that the anticipated rates for 1965-1985 and 1840-1985 are in close accord with the asymptote of time-space convergence.

Time-space Convergence and the
Latent Factor of Distance

Another peculiarity of the convergence rate concerns the manner in which it is related to distance. Given a homogeneous transportation line (one on which it is possible to travel at a given speed over its entire length), the convergence rates between a settlement and each successive settlement along this line will change with distance. For example, in 1840, Flint and Saginaw were both connected with Detroit by a stage coach line capable of traveling an estimated 4.5 miles per hour.¹ Today these same cities are joined by a limited access highway over which automobiles can legally travel up to 70 miles per hour. Yet, because this improvement is stretched over a greater distance between Saginaw and Detroit (93 miles) than between Flint and Detroit (59 miles), Saginaw and Detroit have been approaching one another in time-space at the average rate of 9.9 minutes per year for the past 125 years as compared with only 6.4 minutes per year for Detroit and Flint. This property of

¹Based on Bigham and Merrill, op. cit., p. 53.

convergence is not intuitively obvious--the following hypothetical example should help to clarify it.

In Figure 16 a hypothetical example is used to help illustrate this phenomenon. This example assumes that a homogeneous transport system existed between settlements A through F in the year 1950 and that transport innovations by 1970 will also result in a homogeneous transport system.

THE INCREASE IN CONVERGENCE RATES WITH INCREASING DISTANCE						
	0	10	20	30	40	50 MILES
	(A)	(B)	(C)	(D)	(E)	(F)
Travel-time from A at 25 mph in 1950 (minutes)		24	48	72	96	120
Travel-time from A at 50 mph in 1970		12	24	36	48	60
Decrease in travel- time, 1950-1970		12	24	36	48	60
CONVERGENCE RATES 1950-1970 (minutes per year)		.6	1.2	1.8	2.4	3.0

D.G.J.

D.G.J.

Figure 16

The average speed between these settlements was 25 miles per hour in 1950 and will be 50 miles per hour in 1970. Thus, the absolute times for travel between any two of these settlements have in all cases been cut in half. Yet, in spite of this, and in spite of the homogeneity of the transport routes, the convergence rate for place A with

each successive place is not the same--it increases with distance. Thus, in this example, settlements 50 miles apart are approaching each other five times as fast as those 10 miles apart. If the data in Figure 16 were plotted on a scatter diagram, it would be noted that the convergence rates are a linear function directly related to distance.

In reality, however, transport innovations are not always homogeneous and are seldom simultaneously introduced between all cities on a given route. Nevertheless, in the following example of the railway line connecting London, Exeter and Plymouth, England, the relationship between convergence and distance is close to what would be expected had developments along this route been homogeneous and simultaneous. In Table 5 the changing railway travel-times between London and Exeter and London and Plymouth for the 1830-1960 period have been indicated. By comparing the rates at which these settlements have been approaching each other in time-space for consecutive intervals, their marginal convergence rates may be determined. Thus, whereas London and Exeter (193 rail miles) converged at 6.9 minutes per year from 1830 to 1960, the corresponding convergence for London and Plymouth (248 rail miles) was 8.7 minutes per year. The marginal difference in their convergence--1.8 minutes per year--is (assuming a homogeneous transport line) due to the greater

distance that the rail improvements have to express themselves between London and Plymouth than between London and Exeter.

TABLE 5
MARGINAL CONVERGENCE: LONDON TO EXETER
AND LONDON TO PLYMOUTH*

London to: Exeter			Plymouth		Margin Due to Distance
Year	Travel- time (min.)	Converg. Rate (min.)	Travel- time (min.)	Converg. Rate (min.)	
1830	1,080		1,380		
		24.2		31.1	6.9
1862	285		385		
		3.3		1.1	-2.2
1871	255		375		
		.53		2.1	1.6
1890	245		335		
		2.69		5.2	2.5
1903	210		267		
		.44		.47	.03
1960	185		240		

*Sources: (Refer to Bibliography for complete references) W. H. Johnson, pp. 230-54; Reginald B. Fellows; E. T. MacDermot; Christopher I. Savage; Jack Simmons and David St. John Thomas.

It was only in the 1862-1871 period that Plymouth's convergence with London lagged behind that of Exeter's. In the 1871-1903 period, rail improvements were extended from Exeter to Plymouth and this lag was compensated for. Thus, on the whole, it appears that this example corresponds quite well with the theoretical relationship of convergence with distance. In reality the correspondence

will depend on the degree of homogeneity in transport development linking the places considered.

Declining Significance of
Intervening Opportunities

Usually, an increase in transport-speed on a route connecting successive places will result in greater convergence rates for the more distant places than for the closer or intervening ones. This finding, based on the study of the relationship between distance and the convergence rates, may have important implications for central place theory. With every increase in the speed of transport, the significance of distance decreases most rapidly for the more distant points. For instance, with continued improvements in travel-speeds, people living relatively near Flint, Michigan may find that, with an additional small increment of time, they can continue on to Detroit where the choice of commodities and the range of services are considerably more varied.

It is possible that, for certain functions, Flint will no longer represent an intervening opportunity¹

¹For discussions on the concept of intervening opportunities see: Samuel A. Stouffer, "Intervening Opportunities: A Theory Relating Mobility and Distance," American Sociological Review, 5 (December, 1940), pp. 845-67. Edward Ullman, "The Role of Transportation and the Bases of Interaction," op. cit. Also, see Herman Porter, Application of Intercity Intervening Opportunity Models to Telephone, Migration and Highway Traffic Data (Unpublished Ph.D. Thesis, Dept. of Geography, Northwestern University, 1964).

between Saginaw and Detroit. If land-travel speeds were increased to 150 miles per hour, Saginaw would be only 37 minutes from Detroit--close enough for Saginaw residents to work or shop in Detroit on a daily basis.¹ The same would apply for Flint--only 24 minutes from Detroit. In general, it is believed that any transport improvement will tend to be of greatest advantage to the highest-ordered center that it connects. And, the greater the difference in the hierarchical or functional order of centers joined by the transport improvement, the greater the likelihood that the highest-ordered center will continue its growth in dominance over an expanding tributary area. Thus, it appears that the relationship of time-space convergence with distance for any given transport improvement is a factor which helps to augment the dominance of the higher-ordered centers in the central place structure. This notion is based on the assumption that higher-ordered places are generally more distant from one another than are lower-ordered places.²

¹Harold S. Lapin notes that people in Philadelphia spend from 17 to 47 minutes in traveling to work--the median figure was 27 minutes. See Structuring the Journey to Work (Philadelphia: Univ. of Pennsylvania Press, 1964), p. 48. In most American metropolitan areas, travel-time to work averages about 30 minutes--see Hans Blumenfeld, "The Modern Metropolis," Scientific American, 213 (September, 1965), p. 67.

²See Berry and Pred (op. cit.), p. 1.

Aside from the change in convergence rates with distance, the step-like and the asymptotic nature of the convergence rates have now been considered. These may be referred to as the mathematical properties. There are, however, other properties of time-space convergence that remain to be investigated. These include the concept of divergence, the temporal and seasonal aspects of convergence, and the differing structures of convergence. Each of these properties will be briefly considered.

Time-space Divergence

Just as it is possible for settlements to come closer together in time-space, it is also possible for them to get further apart. This phenomenon will be referred to as time-space divergence. Divergence may occur when transport routes deteriorate or become overused. If route deterioration is allowed to persist without improvements or new transport innovations, it may reflect a decline in the demand for interaction between places. On the other hand, traffic congestion may indicate a need for new or improved means of meeting the demands for interaction. Thus, the decrease in transport speeds resulting from traffic congestion may eventually encourage transport improvements that will lead to time-space convergence as opposed to divergence. (See the models of spatial reorganization developed in Chapter I.) Automobile congestion is particularly relevant in this

consideration. In the post World War II period, demands in the United States for interregional travel resulted in traffic congestion which, along with other factors, prompted the Federal government in 1956 to undertake construction of a system of limited-access, interstate highways connecting the nation's major metropolitan centers.

A similar process is going on in many large cities today--traffic congestion has resulted in declining speeds within the central business areas¹ and along routes connecting the city's central business core with its residential suburbs.² In response to these problems, there have been many proposals to reverse the decline in intra-metropolitan traffic speeds.³ Detroit has approved proposals for an experimental transit system based on electrically propelled individually operated vehicles that will be guided by a computer through suspended tubes at 45 miles per hour.⁴ This system (Teletram) could accommodate up to 17,000 vehicles per hour. In comparison, one

¹P. H. Bendtsen, Town and Traffic in the Motor Age (Copenhagen: Danish Technical Press, 1961), pp. 12-13.

²Harmer E. Davis, Some Aspects of Metropolitan Area Transportation Problems (Paper presented before the Syracuse Transportation Conference, Syracuse University, April 29, 1953), p. 4.

³The problems and prospects of transportation within metropolitan areas are discussed by Dyckman, op. cit.

⁴"Experimental Transit System, Individual Cars, Near Reality," The State Journal (Lansing, Michigan: January 11, 1966), p. C-7.

expressway lane can handle only 1,500 vehicles per hour. Other plans envision the use of vertical take-off and landing aircraft (VTOL), fast urban-transit trains such as those under construction in San Francisco, monorails capable of speeds up to 100 miles per hour and many others.

Presently, it appears that transportation innovations in metropolitan areas throughout the world lag behind the demands for rapid means of movement. According to Davis¹ this has contributed to the transfer of businesses, warehouses and factories from the city's central area to its outskirts. Thus, the time-space divergence resulting from traffic congestion may be leading to the changes in the arrangement of man's functional activities noted in the process model developed in Chapter I--decentralization. But, as the crisis of traffic congestion gets worse, radical changes in intra-metropolitan transit can be expected or at least hoped for.² In reality, convergence and divergence may take place in succession of one another in response to the changing traffic demands and technological innovations; this succession may even vary with the time of day or the season of the year.

¹Davis, op. cit.

²For a discussion on metropolitan traffic problems and prospects in Canada, see J. C. Lessard, Transportation in Canada (Montreal: Royal Commission on Canada's Economic Prospects, 1956), pp. 116-17.

Temporal and Seasonal Variance
In Time-space Organization

The time-space organization of places may vary depending upon the time of day or the season of the year. Fluctuations in time-space convergence and divergence occur almost continually. For example, a 1949 study in St. Paul, Minnesota showed that a motorist could expect to travel 45 per cent further in the first 15 minutes from the business area in off-peak as he could during the peak periods¹ (times when traffic is heaviest--usually between 7:30 and 9:30 a.m. and between 4:30 and 6:30 p.m.).²

Seasonal variations in travel-speeds are also evident. In 1915, train-times between London and Cromer, England averaged 2 hours 57 minutes in summer; but, they averaged 3 hours 25 minutes in winter.³ In contrast, the crossing of a river at a point lacking a bridge may require considerably less time in winter than in summer--depending upon the degree to which the river lies north or south of the equator. In the summer this same river may be traversed by a ferry offering crossings every two hours. In this instance a traveler, wishing to cross the river and desiring to minimize travel-time, would have to plan

¹Lapin, op. cit., p. 60.

²Hawley, op. cit., pp. 302-303.

³Cecil J. Allen and H. C. Johnson, The Great Eastern Railway (London: Ian Allan Ltd., 1961).

his trip within the time-constraints of the ferry departures. Thus, the convergence or divergence of points in time-space may vary with the time of day, the season of the year or with the scheduling of transport departures. Convergence (or divergence) is also likely to vary with several other factors which will be referred to as structures of time-space convergence.

Structures of Time-space Convergence

The structures of time-space convergence are the many categorical frameworks in which the convergence concept may be considered. The categories to be briefly considered include: (1) within-city or between-city convergence; (2) freight, passenger or information transfers; (3) different income groupings; and (4) different cultural and economic realms.

Within-city and between-city convergence.--The degree of increase in travel-speeds between cities has been considerably greater than that within cities. For example, speeds of horse-drawn vehicles of 4 to 10 miles per hour were possible within cities in the 1840's and earlier. Yet, the average peak hour speeds of automobiles in the central business districts of San Diego in 1959 and Boston in 1952 were only 9.7 and 7 to 12 miles

per hour, respectively.¹ As one leaves the central business districts these speeds generally increase. In Nashville, Tennessee, automobile speeds in the central business area averaged 14 miles per hour and, from 4 to 5 miles from the CBD, they averaged better than 25 miles per hour.² In many places these speeds have been declining rather than increasing--in Munich, Germany the lowest speeds in the central business district declined from 11 to 8 kilometers per hour between 1955 and 1957.³ In other instances, however, improvements have been made--urban freeway traffic in Hollywood averages 33 miles per hour, and speeds of 50 miles per hour are often possible on other urban freeways in such places as Cleveland and Pittsburgh.⁴ Public transit systems planned for Atlanta, Los Angeles and San Francisco envision speeds of 35 to 50 miles per hour.⁵

In spite of the gains and the many promising prospects, increases in urban travel-speeds have not

¹Donald S. Berry, George W. Blomme, Paul W. Shuldiner and John Hugh Jones, The Technology of Urban Transportation (Evanston, Ill.: The Transportation Center at Northwestern University, Northwestern Univ. Press, 1963), p. 15.

²Ibid.

³Bendtsen, op. cit., pp. 12-13.

⁴American Automobile Association, Metro: Toward a Brighter Traffic Future for Cities and Suburbs (Washington D.C.: American Automobile Association, 1960).

⁵See Donald S. Berry, Blomme, Shuldiner and Jones, op. cit., p. 33.

matched the gains for interurban movements. For instance, transit-speeds between Detroit and Chicago increased from about 10 miles per hour in the early 1840's to better than 60 miles per hour by land and to well over 200 miles per hour by airplane today. Thus, convergence rates for points within urban areas are not likely to be as great as those between cities. This is even less likely when it is realized that distance has great significance in determining the rates of time-space convergence.

Freight, passenger and information transfers.¹--In using the basic time-space convergence model, it is necessary to specify whether one is concerned with flows of passengers, freight or information. The advances in speed for each of these flows vary considerably. Milne notes that the economy of time is generally more significant in passenger transport than in goods transfer.² In goods transfer neither the producer nor the consumer is actually involved in the transfer and the goods can often be shipped during times that are unproductive for the consumer (non-work hours). This does not mean, however, that freight movement is insensitive to the time element. Yet,

¹It is also possible to consider progress in the means of transferring energy (i.e., fuels such as oil and natural gas through pipelines, or mechanically generated energy such as water power and electricity).

²Milne, op. cit., p. 101. Also, see Walter E. Weyl, Passenger Traffic of Railways (Philadelphia: Ginn and Co., 1901), p. 41.

on the whole, the movement of freight is slower than passenger movement. Speed limits on highways generally favor the automobile over the truck and commercial airline freight revenues in this country are generally five to six times less than airline passenger revenues.¹ Furthermore, freight transit by rail, air, ship or barge often requires time consuming loadings and unloadings at origins, destinations and transfer points--increasing the total transit-times far in excess of those for passengers.

The speed gains in information transfer are even greater than those for freight and passenger movements. In earlier centuries, information transfer was essentially transportation--most messages were carried from place to place by special messenger-runners, stage coaches and so forth. Today, however, communications no longer require bodily movement, and distances of thousands of miles are only seconds or minutes apart.

Within 30 minutes after the 1953 death of Senator Robert Taft in New York, six major Seattle, Washington radio stations had broadcast the news.² This was repeated throughout the United States and is indicative of our present capacity to disseminate news rapidly to millions

¹Harry Hansen (ed.), The World Almanac and Book of Facts, 1963 (New York: New York World-Telegram, 1963), p. 761. Based on information from the Air Transport Association of America.

²Charles R. Wright, Mass Communications (New York: Random House, 1959), p. 66.

of people. Even by present standards, this feat could not be duplicated through transportation. Thus, the inherent differences in speeds of transportation (passenger and freight) and communications warrant the determination of separate time-space convergence rates for passenger, freight and information flows. Such an ensemble of convergence rates would give a more complete description of the evolving time-space organization of the central place structure.

Income groups.--The use of separate convergence rates may also be necessary to characterize the time-space organization of society for people in different income levels. As Stine notes, "the [time-space] separation between Los Angeles and New York depends in part on whether one is a member of the jet set or the car clan."¹ A study by the Institute of Social Science Research revealed that the 16 per cent of the adult population with annual incomes of \$10,000 and over took more than 66 per cent of all air trips in 1959-1960.² In contrast, the study notes that bus travelers are generally lower income people on trips of less than 300 miles.³ Stine indicates that the

¹Personal communication from James H. Stine, Oklahoma State University, Stillwater, Oklahoma, November 29, 1965.

²Eva Mueller, John Lansing and Thomas Lorimer, The Travel Market, 1959-1960 (Ann Arbor: Institute of Social Science Research, University of Michigan, 1961), p. 29.

³Ibid., pp. 25-26.

use of separate time-space convergence rates for different income groups may be ". . . especially important in studying . . . underdeveloped regions where primitive and modern transfer media exist side by side, where median incomes are low and where the distribution of incomes is highly skewed."¹ This leads into the final discussion on convergence structures--how will time-space convergence vary in different political, cultural and economic realms.

Different political, cultural and economic realms.--

A comparison of convergence rates may provide a measure of relative transportation efficiencies and may indicate corresponding differences in the central place structure prevalent under different political, economic and cultural systems. For example, about 90 per cent of all long-distance passenger movement in the Soviet Union is via railway.² Yet, on the whole, the speed and frequency of passenger trains are unsatisfactory. Between 1928 and 1960, freight services took priority over passenger travel.³ Passenger train-speeds in 1949 showed little, if any, improvement over those in 1934. (Average speeds between Moscow and

¹Stine, op. cit.

²Holland Hunter, Soviet Transportation Policy (Cambridge, Mass.: Harvard Univ. Press, 1957), p. 194.

³See J. N. Westwood, Soviet Railways Today (London: Ian Allan, Ltd., 1963), p. 266. Also, see Ernest W. Williams, Freight Transportation in the Soviet Union (Princeton, N.J.: Princeton Univ. Press, 1962), p. 60.

Kiev were 23.6 miles per hour in 1934 and 24.4 miles per hour in 1949).¹ In the late fifties and early sixties, the Soviets greatly increased the speed and frequency of service on certain "show case" lines. Trains on the Moscow to Leningrad line averaged only 34 miles per hour in 1950; but, by 1960 they averaged 64 miles per hour. In 1963 the line was electrified and the fastest day train was accelerated up to 74 miles per hour. Elsewhere, however, speeds on electrified lines averaged only 44 miles per hour in 1962, and steam engines averaged only 28 miles per hour.² These speeds are more typical of passenger speeds throughout the Soviet Union. The Leningrad-Moscow line is a high-priority "show case" route--much the same as our New York to Washington line which is scheduled to begin experimental passenger runs of 125 miles per hour in late 1966.

In contrast to the Soviet Union, railway traffic represents only a small proportion of intercity passenger movement in the United States--nearly 90 per cent of all intercity passenger miles traveled in this country are by private automobile.³ Thus, the average American traveler is less restrained by fixed transport schedules, he can go

¹Hunter, op. cit., p. 193.

²Westwood, op. cit., p. 267.

³Tri-County Regional Planning Commission, Transportation; An Inventory (Lansing, Mich.: Tri-County Regional Planning Commission, 1962), pp. 48-50.

from origin to destination without need for depot transfers, and he can more easily plan for multi-purpose trips than can his Soviet counterpart. In light of developments in previous chapters, it would appear that such over-all differences in transportation would be associated with distinct peculiarities in the time-space organization of these two countries. Unfortunately, the author is not in a position to explore this possibility. In other parts of the world that still rely upon human-energy-transport, it is likely that differences in central place organization would be even more pronounced.¹ In certain subsistence areas the wholesale, transshipment, exchange, leadership and control functions of man's areal organization may even be totally lacking or only loosely developed.

Conclusion

A few of the many possible structures by which it is possible to categorize time-space convergence have been considered in this chapter. It has been observed how transportation technology and the corresponding convergence of places may vary according to differences in the prevalent cultural, economic or political systems and

¹R. D. McKenzie, "Spatial Distance and Community Organization Pattern," Social Forces, 5 (June, 1927), pp. 623-24; Skinner provides an interesting analysis of the central place structure of marketing in rural China, op. cit.

according to different income groups. The degree of convergence may also depend upon whether one is considering transfers of freight, passengers or information, or whether one is concerned with intercity or intracity movements. Furthermore, the changing state of transportation efficiency and, consequently, the time-space organization of man's functional activities may vary with the time of the day or the season of the year and, in many instances, may result in time-space divergence instead of convergence.

Through the calculation of convergence rates, it is possible to characterize certain peculiarities of the time-space organization for these different convergence structures. But, in interpreting these rates, it is important to have an understanding of their mathematical properties. For example, given a similar sequence of transport innovations between different settlements, convergence rates increase with increasing distance. Also, the rates at which places approach each other in time-space are most likely to increase at a decreasing rate in an asymptotic manner. Finally, it should be recognized that the convergence model provides a highly generalized measure of the actual process of time-space convergence--it may not always permit one to single out the convergence accounted for by a specific transportation innovation. Instead, it shows the cumulative convergence of all

transport innovations introduced during the time-interval considered in the model. With an understanding of these mathematical and conceptual properties of the model, it is possible to formalize more objectively the concept of settlement convergence. This will be accomplished in the next chapter.

CHAPTER VI

THE LOGIC AND DYNAMICS OF SETTLEMENT CONVERGENCE

The Logic of Convergence-- The Model and Reality

The time-space convergence model, or any model for that matter, is intended as an aid to describing and understanding reality--it is not of itself reality. The convergence concept may give insights on the way settlement structures change with transportation innovation; but, this does not indicate why such convergence or new technologies take place. Although the model helps one to explain and measure the changing relationships of settlements in time-space, it cannot identify the "cause" or basis of this phenomenon. According to Lukermann ". . . the word explain . . . does not necessarily imply or identify cause nor answer the question why."¹ Thus, one has no clear-cut reason for time-space convergence. At best, one can only hypothesize what the cause is; and, the congruence of this hypothesis with reality will remain to be tested. This hypothesis, combined with the model, will hopefully provide a useful schemata or theory for viewing and measuring the reality of time-space relationships.

¹Lukermann, op. cit., p. 2.

The Role of Time-space Conver-
gence in the Spatial Reorgani-
zation of Man's Activities

In Chapter I an attempt was made to identify the process of spatial reorganization. This attempt resulted in the design of causal models (Figures 1 and 5). But, as noted in the evaluations of these models, it is not easily possible to determine the motivational forces that prompt man to seek faster transport, greater centralization of his activities and so forth. Nonetheless, on the basis of empirical evidence provided in Chapters II and III, it seems that these models bear close correspondence with what we find in reality.

The role of the time-space convergence concept, as a causal element in the process of spatial reorganization, is best considered within the framework of the concept of relative advantage (see Chapter I). As previously noted, this concept states that areal development in the form of centralization and specialization would accelerate most rapidly at those places which stand to benefit most from increasing accessibility. As with the process models, this concept is also based on the assumption of rationality--man introduces transport innovations between those places which will benefit most from time-space convergence. If the convergence rates are accepted as a logical surrogate of the impact of transport improvements on the changing time-space relationships between places, and if it is

assumed that man rationally introduces his transportation advances where they will be most beneficial; then, the convergence rates are time-spatial manifestations (or surrogates) of man's rational behavior.

In accordance with the concept of relative advantage, it seems intuitively obvious that a transport innovation between Detroit and Chicago (268 miles) would be more beneficial than one between Alpena and Muskegon, Michigan (257 miles). Thus, it would be expected that Chicago and Detroit would be converging upon each other in time-space more rapidly than would Alpena and Muskegon. This expectation seems quite realistic and is borne out. Since 1940, Detroit and Chicago have been approaching each other in time-space at an average of 5.4 minutes per year via highway transport. In contrast, the convergence rate for Alpena and Muskegon is only 1.7 minutes per year.¹

The Concept of Relative Advantage and the Mechanistic Framework

Admittedly, as noted in Chapter I, the concept of relative advantage may not be completely valid for all situations. For example, man may not possess the technical

¹These convergence rates (1940-1965) were calculated as follows:

Detroit and Chicago (268 miles)	$\frac{402 \text{ min.} - 268 \text{ min.}}{25 \text{ years}}$	= 5.36 min. per year
Alpena and Muskegon (257 miles)	$\frac{385 \text{ min.} - 343 \text{ min.}}{25 \text{ years}}$	= 1.68 min. per year.

know-how or facilities to meet the demands for interaction between places, or he may set barriers (i.e., trade tariffs, political friction, and etc.) to interaction. Such barriers, according to Gilfillan,¹ may lead to less transport innovation than is warranted by the demand for interaction. For these and other reasons, a strictly mechanistic framework such as that developed in the model of the process of spatial reorganization in Chapter I (i.e., demand leads directly to transport innovation to meet demand) seems untenable. Nonetheless, for the sake of theoretical purity, such a framework has been adopted for use in parts of this study.

The Dynamics of Convergence:
Feedback and the Acceleration
of Transport Innovations

As indicated in Chapters I and III, the introduction of transportation improvements between centers will encourage an increase in the interaction between these centers and, thus, lead to demands for additional innovations. This notion of a multiplier effect or positive feedback² implies that the state of a system (that is, the degree of convergence between interacting settlements, their demands for accessibility and so forth) at a given

¹S. C. Gilfillan, The Sociology of Invention (Chicago: Follett Publishing Co., 1935), pp. 50-51.

²This notion of a multiplier effect or one of positive feedback was suggested to the author by Stine, op. cit.

time is determined completely from within the system and by the previous state of the system.¹ Thus, a positive feedback system is self-perpetuating. This may be illustrated for a system of converging settlements by the diagram in Figure 17. This diagram is an abstraction from the basic model of the process of spatial reorganization discussed in Chapter I. In reality, the demands for interaction between cities such as Boston and New York may have led to the paving of the previous gravel roads that connected them. But, this improvement and the resulting convergence of these two cities in time-space made travel between them so much easier that interaction over and

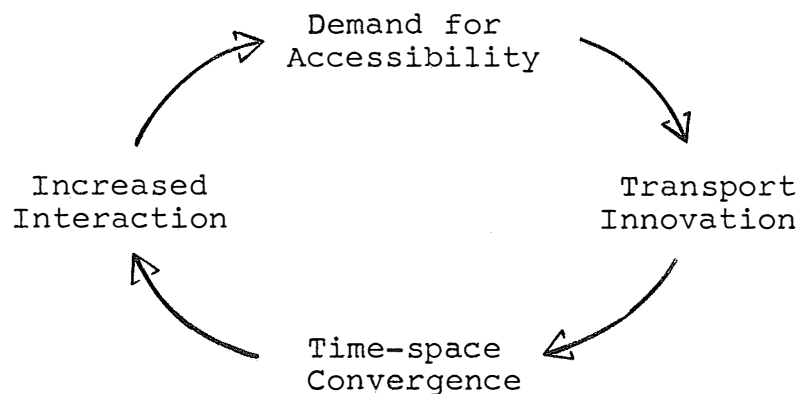


Fig. 17.--The Feedback System in the Convergence Process

¹An excellent discussion on both positive and negative feedback systems is provided by Magoroh Maruyama, "The Second Cybernetics: Deviation-Amplifying Mutual Causal Processes," American Scientist, 51 (June, 1963), pp. 164-79. Also, see Ludwig von Bertalanffy, "General System Theory," General Systems, 1 (1956), pp. 1-10.

above the previous levels was made possible. This increased interaction possibly resulted in an additional demand for intercourse which, in turn, led to further transport innovations such as wider roads, limited access highways and so forth and on and on.

For the most part, the same limitations that applied to the model of the process of spatial reorganization apply to this notion of feedback. Thus, a lack of technical knowledge may prevent or delay man from meeting additional demands for interaction, or political and economic barriers may prevent the interaction made possible by transport innovations. As was noted in Chapter I and, as will be emphasized later in this chapter, there are also lags in man's spatial adaptations to changes in his time-space framework.

Support for the notion that a transport improvement encourages increased interaction is available. Studies by Coverdale and Colpitts¹ show that improvements in highway traffic facilities result in traffic volumes greater than the number accounted for by the diverted traffic. That is, many new facilities (i.e., bridges and freeways) will attract considerably more traffic than would be expected had the previous facilities continued to

¹Coverdale and Colpitts, Consulting Engineers, Report on Traffic and Revenues, Proposed Mackinac Straits Bridge (New York: Coverdale and Colpitts, January 22, 1952), p. 18.

operate alone. This increase is frequently termed "induced traffic." The volumes of induced traffic encouraged by bridges replacing ferries have ranged, in many instances, from 65 per cent to 75 per cent of that before the improvement. For the Philadelphia-Camden bridge it was 78 per cent and for the San Francisco-Oakland Bay Bridge it was about 64 per cent.¹

Feedback: Acceleration in
Transport Innovations and
the Hierarchy of Central
Places

The existence of feedback in a system of converging places appears to be relevant to considerations on the hierarchical ordering of settlements in the central place structure. For example, the demand for economic, political and social exchange between dominant centers is likely to be greater than for lower-ordered places. Consequently, according to the concept of relative advantage as applied to the process of spatial reorganization, the superior transport systems would be introduced between the highest-ordered places--thus, in effect, accelerating their increase in dominance over the lower-ordered places and propagating their convergence in time-space. In Britain and in Western Europe, according to Smailes,² the railways

¹Ibid.

²Arthur E. Smailes, The Geography of Towns (London: Hutchinson and Co., Ltd., 1957), p. 59.

tended to follow the existing transport routes and thus helped to confirm the dominance of the established towns. In a recent study on the metropolitan growth of American industrial centers, Pred notes how transportation improvements ultimately resulted in greater economies of scale, ". . . some multiplier effect, and additional growth of the favored city . . ." ¹--all of which helped to perpetuate and augment its initial advantages. The gains of the dominant centers, in the forms of increased centralization and specialization, are in part attributable to transport improvements which help them to increase the range of their daily influence.

As noted in Chapters I and III, travel improvements frequently permit the more dominant settlements to take on functions which have higher threshold values (demand a higher population and income base). Places adopting these functions will experience increased interaction with other places. This could result in demands for further transport improvements and, eventually, in the adoption of functions having still higher thresholds. Theoretically, this cyclical and accelerating process (depicted in the model of spatial reorganization in Chapter I) could continue indefinitely. However, this process is likely to be impeded by a number of restraints--political or natural

¹Allan Pred, "Industrialization, Initial Advantage, and American Metropolitan Growth," Geographical Review, 55 (April, 1965), p. 176.

boundaries which set limits to the hinterlands of a settlement's functions, competition with other dominant centers, lags in the improvement of transportation technologies, planned economies and planned distribution of functions (i.e., land-use zoning) and so forth.

Feedback and Notions on Invention Theory

A basic assumption of the feedback concept as applied to the process of spatial reorganization is that transportation inventions are developed in response to man's needs for accessibility. Alternatives to this view are that inventions result from individual genius, accident or from a combination of need, genius and accident. The invention of the telegraph and the introduction of the telephone are often cited as examples of communications inventions for which little utility was originally foreseen. At first, so little use was found for the telegraph that chess games were promoted over the original line from Baltimore to Washington.¹ Nevertheless, in his noteworthy study on The Sociology of Invention, Gilfillan lends support to the view advocated in this study--that ". . . inventions are led by perception of need and easy possibility, accidental invention being rare."² Furthermore, he notes how the role of individual genius in

¹Taylor, op. cit., p. 152.

²Gilfillan, op. cit., p. 150.

invention history is rapidly being usurped by the organized inventing groups of government and industry. As a rule, these groups of professionals work deliberately and surely towards specific goals in both applied and basic science. As a consequence of these trends, Gilfillan reports that there has been ". . . a prodigious increase in the efficiency and rate of invention."¹

Gilfillan also recognizes the cyclical nature of the feedback acceleration of major transport innovations. He observes how ". . . inventions, the result of social and other forces, become themselves the cause of further inventions or of obstruction to invention. [Thus,] cause and effect alternate endlessly . . . , and each invention is both."² Empirical support for the historical acceleration of major transportation advances is provided by Hart. Though acknowledging the difficulties of isolating major transport eras, he generalizes that:

. . . the Horse Transportation Age lasted thirty-five hundred years, the Deep Sea Sailing Age about three hundred years, the Steam Transportation Age (throwing in the electric railway phase) about seventy-five years, and the Gasoline Engine Age about thirty, with Diesels, jets and . . . atomic-propulsion succeeding each other too rapidly to justify assigning any time periods as their ages.³

On the whole, each of these transport eras has witnessed

¹Ibid., p. 11.

²Ibid., p. 131.

³Hornell Hart, "Technology and Growth of Political Areas," in Technology and International Relations, ed., William F. Ogburn (Chicago: Univ. of Chicago Press, 1949), pp. 49-50.

the introduction of increased potentials for speed and, as a result, an increase in the time-space convergence of interconnected points in earth-space. These eras, however, do not give one any idea of the many innovations that have helped to speed up transportation--improved sails, the development of steel rails, better highways and so forth. It is likely that there has also been an acceleration in these more minor transport improvements.

Transportation Introductions
and Cultural Lag--A Case
for Feed-forward

As a rule, new transport innovations, such as the automobile or the railway train, have been introduced onto cultural and economic patterns organized in days of slower modes of travel. To attain their potential efficiency, these innovations require their own patterns of economic and technical support. Yet, according to Mumford,¹ the automobile (capable of safe speeds of 60 miles per hour after the invention of the cord tire) was imposed on an existing pattern of dirt or macadam roads designed for the horse and wagon. Until only recently, interregional automobile traffic in the United States was channeled through practically every city or town possible--a practice which seems to be a hangover from the horse-and-buggy days when frequent service needs were necessary. Likewise, the

¹Mumford, Technics and Civilization, op. cit., p. 237.

railways made their ways into the center of cities and, along with the automobile, contributed to the problems of congestion, noise and danger. Ogburn¹ noted a considerable delay in the straightening of many of the early highway and rail routes--a necessity if they were to accommodate the potential speeds of the newer transport carriers.

A possible tributary to these lags in the development of the support structure for the new modes of travel is the delay of man in reorganizing the spatial arrangement of his functional and administrative establishments. As noted in Chapters I and III, speedier means of transport helps permit the numerous economies of scale which were defined as benefits of centralization and specialization. Yet, until recently, there has been strong social inertia against the consolidation of the American rural schools into larger, more efficient units.² The organization of small government units on the township and county levels (laid out for efficiency in the days of horse-and-buggy transportation) are considered inefficient by modern transport standards. But, unfortunately, vested political

¹William Fielding Ogburn, "The Process of Adjustment to New Inventions" in Technology and International Relations, ed., William Fielding Ogburn (Chicago: Univ. of Chicago Press, 1949), p. 24.

²Donald G. Marquis, "Psychology of Social Change," The Annals of the American Academy of Political and Social Science, 249 (January, 1947), p. 75.

and economic interests have frequently thwarted efforts to reorganize them into more efficient functional units.¹ As previously noted, the increased speeds of land and air travel may necessitate a spatial reorganization of other activities--for instance, many small airports may have to be abandoned (Chapter III).

In contrast to these examples, there are instances where man has more successfully altered the spatial arrangement of his establishments with respect to the changing efficiencies of transport. Vaile and Nordstrom note that as carload shipments between Chicago and Minneapolis were reduced from 3 or 4 days to 36 hours by rail transport, it became feasible for manufacturers to consolidate their warehouse stocks in one of these cities instead of maintaining stocks in both of them.² Sears, Roebuck and Company provides a classic example of a firm that has concentrated its warehouse facilities in a few selected cities from which it serves stores throughout the United States. Without nearly instantaneous communications and rapid truck-transit over modern highways, such centralized activities would be somewhat impractical. Serving the United States on an overnight basis from centralized

¹Ogburn, op. cit., pp. 24-25.

²R. S. Vaile and A. L. Nordstrom, "Public Merchandise Warehousing in the Twin Cities," Bulletin 3 (Minneapolis: Univ. of Minnesota Studies in Economics and Business, 1932), p. 40. Cited from Hoover, op. cit., p. 167.

warehouse facilities results in time, labor and other overhead savings.

It seems that increasing transport-speeds along with improved communications may augment the realization of further benefits from the spatial reorganization of certain administrative and distributive functions. But, if man is to have any control over the rearrangement of his activities, he must understand the spatial reorganization process and the implications of time-space convergence resulting from transport innovations. With this knowledge it may be possible for man to allocate his new technologies so as to achieve desired spatial consequences. By careful allocation of new transport improvements, centralization and specialization at specific places may possibly be encouraged or discouraged.

CHAPTER VII

A SUMMARY OF CONCLUSIONS AND LIMITATIONS

In Part II of this study the role of time-space convergence in the over-all process of areal development has been investigated. It was possible to consider this concept as operative at each of the "steps" in the basic model of spatial reorganization. For example, it was observed that convergence provides a measure of the impact of transport innovations on the time-space connectivity of places and that it is also an indicator of the increasing accessibility of given places to other places and to surrounding areas. Furthermore, it was noted that convergence is a likely surrogate of the degree of locational adaptation (centralization and specialization) possible at given places.

Because of the significance of convergence in the spatial reorganization process (as indicated in the models developed in Part I), because of its importance in understanding the concepts included within the process models, and because of its stated role in the concept of relative advantage, an attempt has been made to expose its individual mathematical and conceptual properties. These properties seem to have implications relative to the

occurrence of areal change. Of the properties discussed, the distance and the asymptotic properties of convergence are most relevant to understanding the basic model of spatial reorganization.

As noted in Chapter V, the degree of convergence resulting from a transport innovation is directly related to distance. Partially on this basis, it was conjectured that the more distantly-spaced higher-ordered centers stand to profit most from a transport improvement. Thus, if convergence is a surrogate of the degree of spatial change possible at given places, then, it is likely that the centralization and specialization of man's activities should develop most rapidly at these more distantly-spaced higher-ordered centers. The distance property of convergence may also suggest that the spatial inter-relations of man's functional activities are likely to become more highly integrated over an expanding geographical base and that these more highly integrated activities will be managed from fewer and fewer nodes or centers of human occupancy.

The implications of the asymptotic property of convergence are somewhat related with those of the distance property; but, they are more difficult and risky to speculate about. One may hold that the convergence asymptote indicates that the significance of future transport innovations is likely to be less than that of previous

improvements. As noted in Chapter I, however, there is reason to believe that man (in the economically developed areas of the world) places more value on a unit of time (i.e., minute) today than he did in past periods. Thus, it may be that, as absolute time-space convergence decreases, the relative value of a reduction in travel-time is increasing. Much more empirical work is needed to validate this claim. By combining the asymptotic and distance properties of convergence, it is evident that the potential for convergence is likely to be greater for those places which are most distant relative to other places. Thus, in this respect, the asymptotic property also lends support for the argument that man's activities will become more highly integrated over a larger and larger area and will be directed from fewer and fewer places than is now the case.

The implications of the other properties of convergence are not quite so sweeping as are those of the distance and asymptotic properties; but, they are, nonetheless, significant. They help to account for departures from the expected occurrences outlined in the basic model of spatial reorganization. For example, the step-like property of convergence may account for some of the lag in the process of centralization and specialization. Although man may anticipate the significance of a proposed transport innovation, he may be reluctant to invest in

expansion of his activities until it is definite that an increased degree of interaction is made possible so as to profitably support his expanded operations.

The different structures of time-space convergence were outlined in Chapter IV. These included within-city as opposed to between-city convergence, the differing convergence for freight, passenger and information flows, and the convergence variance evident for different income groups and for different economic, political and cultural realms. These convergence structures, along with time-space divergence and the temporal and seasonal variance in man's time-space organization all help to account for the departures from the expected forms of areal organization outlined in the basic model. In part, these factors reflect either a lack of perfect rationality (as defined in Chapter I) or criteria of rationality differing from that assumed in the model of spatial reorganization. Thus, these factors may tend to foster either lags in the trends towards the centralization and specialization of man's activities, or they may encourage other forms of central place development--some of which were accounted for in the expanded model (Figure 5).

Though the author has attempted to outline the properties of time-space convergence and to speculate on the implications of these properties in spatial reorganization, it is evident that many questions remain unanswered

and that further understanding is needed. The author has sought to indicate the limitations of this study throughout the text. Nonetheless, since they are indicative of problems requiring further research, it may be of value to briefly restate these limitations.

It has been noted how the spatial structure of man's activities may depart from what would be expected under the circumstances of perfect rationality and under the criteria of rationality proposed herein. Manifestations of departure from perfect rationality were noted. They included the technologic, perceptive and responsive lags in the process of spatial reorganization and the introduction of transport technology between places which do not derive the greatest benefits relative to the benefits that other places would receive were the innovation introduced to serve them.

These departures from the expected occurrences predicted by the models and concepts proposed in this study may suggest means of improving upon the understanding of the areal development of man's functional activities. For example, it is known that culturally imposed restrictions in the forms of laws, zoning ordinances, tariffs, jurisdictional boundaries and so forth are factors operative in the process of locational change. While these factors are indirectly included in the expanded model of spatial reorganization, it is difficult to understand or

to assess the relative significance of any individual factor. Yet, such an understanding is required--these cultural restrictions are often introduced for the specific intent of directing the spatial development of man's occupancy of the earth.

It is possible that work in decision theory and in simulation techniques may provide means for improving the scientist's understanding of the underlying motivation that prompts man to seek one form of areal organization as opposed to others. Hopefully, the findings may be incorporated in more sophisticated models than those proposed in this study. Such models may expose the reorganizational processes associated with varying degrees of rationality or with varying criteria of rationality.

The primary goal of this study was to establish a conceptual foundation for understanding the process of spatial reorganization. While the author believes that progress towards this goal has been made, he foresees the need for more sophisticated conceptual constructs and for more empirical study than was possible to provide in this effort. Only one of the components in the process model--time-space convergence--was singled out for detailed investigation. Yet, the implications of this concept remain vague and ill-defined. For instance, this study has only hinted at the locational and social implications of differing convergence rates for various cultural,

economic and political groups. Could a more thorough understanding of this concept lead to greater awareness of local, national and international problems? While this study has emphasized the significance of time-space convergence, it may be more important to think in terms of cost-space convergence. This, and many of the other assumptions upon which this study is based are open for dispute. Indeed, many of the ideas presented in this paper are in need of conceptual refinement. Much work is required before the process of man's spatial reorganization can be "understood."

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