Canberra: Toward a Scheme for Continuous Growth

IAN W. MORISON, National Capital Development Commission, Canberra, Australia, and
WALTER G. HANSEN, Alan M. Voorhees and Associates, Inc.

This is a pragmatic examination of the physical planning issues facing a city expanding rapidly toward metropolitan status under a program of comprehensive development. A number of simple procedures are developed from existing transportation study techniques to provide an array of planning tools to compare the performance of eight plans for one million population. These are all on the theme of a constellation of subregional units about a metropolitan center, but radically different in their degrees of subcentralization, urban form, distribution of activities, and transport networks. Diagnosis of the problems produced in retailing and travel patterns, along with those of congestion, limited capacity to grow, insecure demand for major facilities, leads to the identification of a set of practical planning principles. These are in terms of the urban form, degree of centeralization, structural balance, configuration of the transport system, and growth strategies, which when taken together form a general conceptual plan.

•CANBERRA, Australia's national capital, was founded in 1913, twelve years after federation. It lies in a rift in the Great Australian Alps, 200 miles from Sydney and 400 miles from Melbourne, which forms part of the 911 square miles of the Australian Capital Territory, ceded to the Commonwealth Government by New South Wales in 1911. Some 300 square miles of rural land in the northeast part of this area was acquired by the Commonwealth for the development of the capital (Fig. 1).

The bare outline of the city, designed for a population of 75,000 by Walter Burley Griffin of Chicago in an international competition, was established by the late 1920's. It grew slowly, to a population of only 22,000 by 1950. After a decade of planned transfers of federal departments from state capitals and rapid institutional and commercial growth, the population has passed 100,000 and Canberra is clearly recognizable as the national center of the Commonwealth.

Growing at its present rate, Canberra will have 590,000 people at the end of the century and could have one million early in the next. Situated in circumstances where the comprehensive control of land can be practiced through public ownership, the proper direction of national capital growth poses a special challenge to the city's developers. The advantages of comprehensive and integrated development must be understood and exploited so that the forces of growth and change can be channelized to meet the immediate needs of an affluent society, within an effective long-range framework.

This paper originates from a study conducted in 1966 by the authors for the National Capital Development Commission which is responsible for the planning and development

Paper sponsored by Department of Urban Transportation Planning and presented at the 47th Annual Meeting.

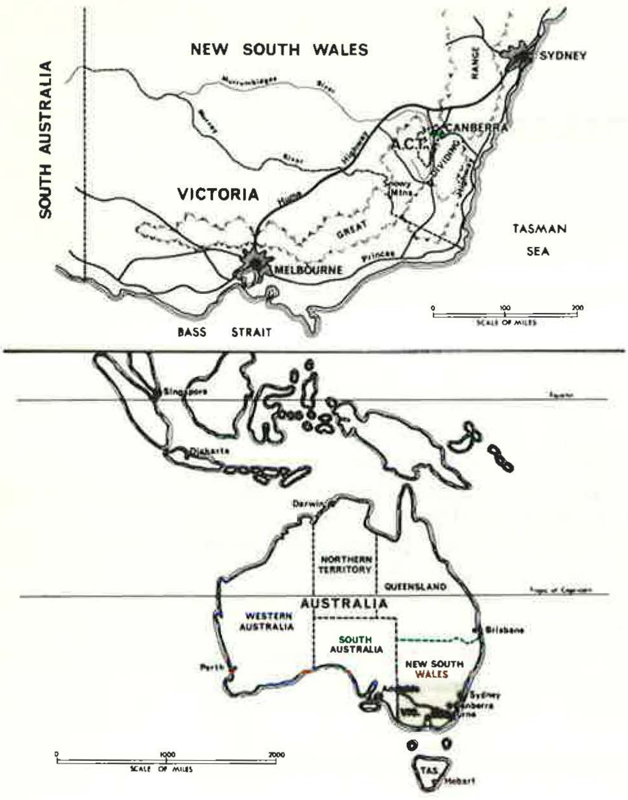


Figure 1. Location map.

of Canberra. It describes this study with the object of finding ways of directing future growth into an acceptable urban form and structure: one capable of accommodating increasing physical expansion and higher levels of activity without developing the chronic transportation bottlenecks symptomatic of large cities around the world.

However, this study was not an academic investigation of regional forms, constructed on the basis of satisfying a single transportation objective. Instead, the problems of transportation were examined within the context of several wider terms of reference. These were the growth of the national capital as a dignified setting for the seat of government; the need for an urban structure within which development can proceed on a rational basis but leave room for future social and technological change; and the need to maintain a choice of residential environments and work opportunities. Finally, the problems involved in the growth process itself had to be recognized and a practical programming strategy developed.

ESTABLISHED BASIS OF LAND DEVELOPMENT

Before this study, some important policies had already been well established as controlling factors in the growth of the city; notably the accommodation of residental expansion in suburban districts planned to have the character of self-contained complete towns. Two such towns, which will ultimately house about 100,000 people each, are being developed in areas to the south and northwest of the present city in areas having distinct topographic identities, and separated from the city by well-defined hills and ridges up to a mile or so in width, in which natural forest and open country will be retained.

The nodal points of these subregional units or towns are to be more than residential service centers. Local retail and service functions will be strengthened by commercial and government office employment and town-center activities. This will give the town centers greater scale and variety, and will also be a means of safeguarding against pressure for excessive building, leading to excessive traffic concentrations around the center of the capital.

THE TEST PLANS

The spatial arrangement of these towns and the transport networks to serve them were the prime subjects of this study. Three mean variables were considered (Fig. 2):

1. The arrangement of towns (metropolitan form),
2. The location and size of centers (activity-structure), and
3. The network of transport facilities (transport structure).

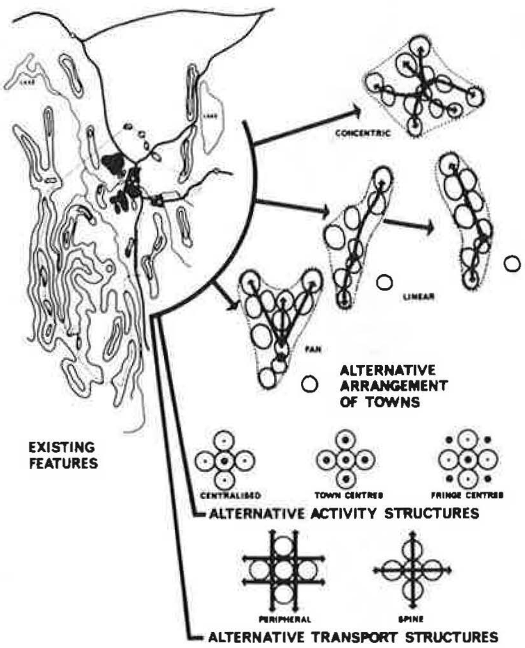


Figure 2. Major components of test plans.

Among the manifold advantages that flow from a comprehensive control of land is that of being able to formulate, as potentially practical plans, alternatives that are radically different from one another. Urban forms, as well as activity and transport structures that might be thought suitable only for theoretical study in regions without such control, were included in this project in order to explore every possibility.

Nine plans were constructed, using towns of 50 to 150,000 population as building blocks, to demonstrate, through independent variations in total urban shape (form), subcentralization, and highway structures, to uncover the physical characteristics of a conceptual plan having:

1. Efficient organization at metropolitan scale,
2. A measure of self-containment in subregions (towns),
3. Acceptable degrees of centralization at town and metropolitan levels, and
4. Efficient arterial, freeway and public transport systems.

The main characteristics of six test plans for one million people are shown in Figure 3. Plans A, A1, and A2 arranged towns concentrically around the existing city. Plans B and C each involved substantial growth along two corridors in opposite directions and Plan D assumed substantial northerly growth in a V-shape.

Plan F was built up using criteria developed from analysis of the preceding plans. It made use of more clearly defined and structured corridors in a Y-shape. Plan G was a stage development of Plan F to accommodate 500,000 people.

DETAILED PLAN ASSEMBLY

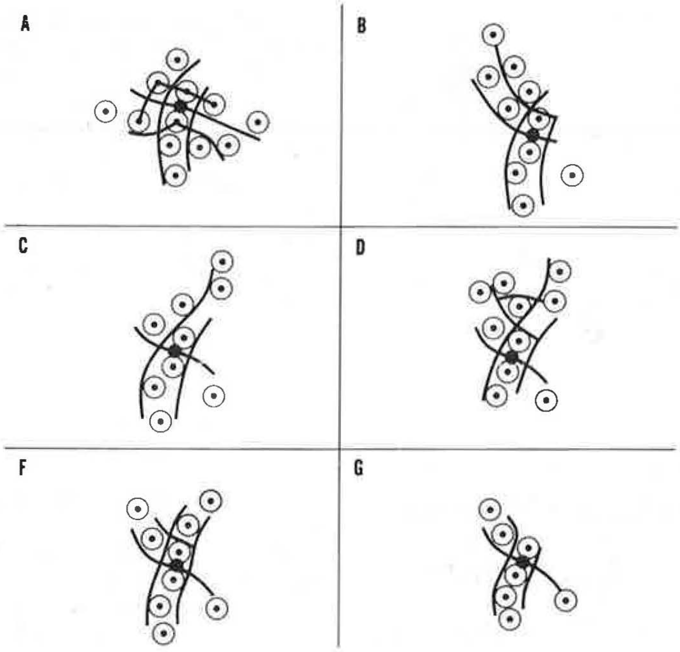
For ease of manipulation and to be consistent with the broad planning aims of the study, plans were constructed from land-use units having more or less standard dimensions and character.

For each plan the same projected requirements for one million people (Table 1) were distributed in different ways over the triangular area (measuring 50 miles north to south and up to 25 miles east to west) capable of large-scale urban development. This area was divided into 300 subareas for computer input.

The basic network of arterials designed to serve these 300 areas was common to all plans. This network recognized topographic limits and major traffic generators and was physically integrated in most cases with the pattern formed by separate land areas. Freeways were added by upgrading arterial links where necessary. Later handling of traffic feedback on a manual basis enabled two separate computer networks of freeways to analyze the nine plans effectively.

TRAFFIC MODELS

The examination of an urban structures performance in the remote future demands the formulation of models based on a few simple and, hopefully, predictable parameters: resident population, retail employment and total employment. Vehicle trip-production rates were based on 1961 data adjusted for the likely consequences of having 0.4 cars per person in the future. Public transport was assumed to maintain its present level of 15 percent of work trips but a subjective "transit factor" allowed for



% OF JOBS IN CENTRAL AREA				
A	17.5 HIGHER-DENSITY HOUSING	C	17.5	
A-1	17.5	D	17.5	
A-2	32	F	25	
B	17.5	G	30-50	HALF-MILLION

Figure 3. Main features of test plans.

possible major variations in usage in local areas. Trip production and attraction equations were developed for home-based vehicle trips to work, shop and business, social and recreation, and nonhome-based trips for an average weekday. The overall level of trip making was assumed to be over 1.9 vehicle trips per person (all ages) per day, compared with the 1961 level of 1.6.

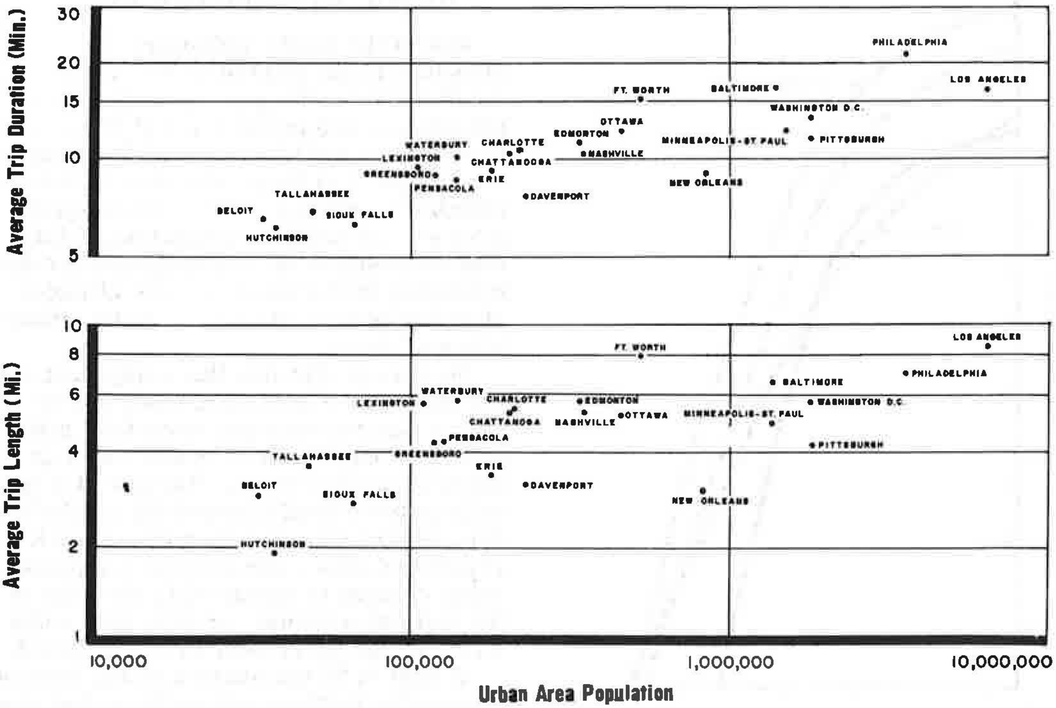
For trip distribution, the gravity model required assumptions to be made about the order of magnitude of future trip lengths for the four categories of trips produced, without having any reference points provided by the present city, except that it would be an open-textured, low-density metropolis with a high level of mobility by private transport. It was therefore necessary to

TABLE 1

LAND-USE AREAS FOR ONE MILLION PEOPLE

Dominant Character	No. of Units in Plans	Extent of Avg. Unit (acres)	Avg. Size of Unit	
			Residents	Jobs
Suburban	45	1,500	17,000	800
Higher density suburb	10	400	17,000	800
Extensive institutions	20	3,000	1,000	500
Light industrial	10	1,500	—	7,500
Government Office Centers	2-4[1]	200	—	12,000
Intensive inst.	20	200	2,000	3,000
Town Centers	8-11[1]	400	2,000	10-15,000[2]
City Center (CBD)	1	600	5,000	30-60,000[2]

[1]Range reflects change in urban forms.
[2]Range reflects degrees of centralization.



Auto driver average trip times and distance exclude terminal time effects.

Figure 4. Average auto driver work trip length, duration, and population (twenty-three cities).

refer to information on trip lengths by motor vehicle in other cities of the order of one million population.

Figure 4 shows the variation in average trip lengths from a research study conducted for the National Cooperative Highway Research Program (1). From this study, the average duration (in minutes) and length (in miles) of work trips could be estimated, given the average speed of trips, and the range of core density (high, medium, or low) for a city of given size. The expected work trip lengths for Canberra, using these relationships, were of the order of 15 to 16 minutes and 7 to 8 miles.

A trial-and-error process was used to develop a set of synthetic friction factors for work trips which achieved average trip lengths within this range for the first plan. These friction factors were then held constant for the subsequent comparative analysis with alternate plans. In real situations radical variations in the form of the city and in the allocation of work opportunities would lead to modified attitudes to travel (i.e., friction factors would change), but for the purpose of this study the introduction of this variable (whose effects would be difficult to disentangle from other factors) would have tended to blur rather than clarify differences between alternate plan characteristics.

The set of work trip friction factors finally adopted for the study are shown in Figure 5, along with sets of factors for shopping, other home-based trips and nonhome-based trips, which exhibit less variance with city character and therefore could be selected with relative ease. No assumptions were made about variations in socio-economic characteristics as these are expected to produce little differentiation in the travel characteristic of individual zones.

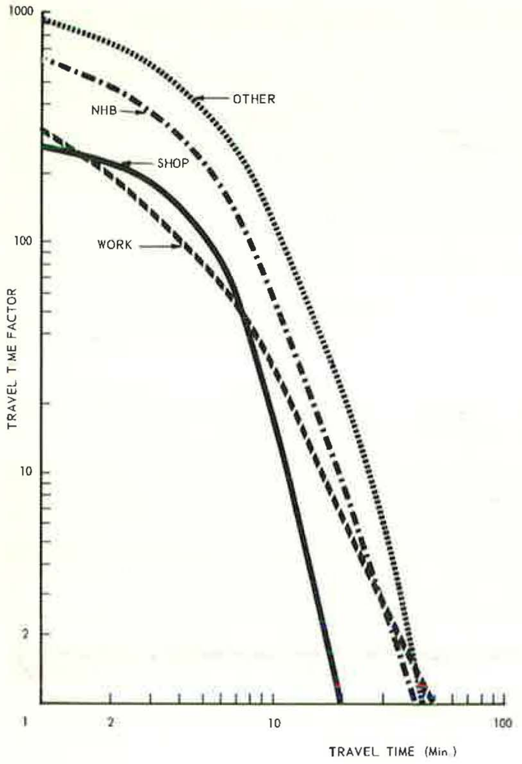


Figure 5. Final friction factors.

RETAIL EXPENDITURE MODEL

One of the major influences on city structure is the pattern formed by major retail centers. They are sensitive to market changes and pressures and form the key areas of activity in any plan. From the viewpoint of future stability in merchandising, as well as that of transport planning and traffic management, a full understanding of the requirements for determining the location and size of major shopping centers is critical to the formulation of plans.

To gain insight into this component of the plans, forecasts were made of consumer expenditures per household and average comparison of goods sales at major shopping center. The use of a retail market potential model (2) enabled the sales linkages from consumers in each residential zone, attracted by competing retail centers to operate (via the links of the highway network), and the total sales attracted by each center to be estimated.

A total of 22 subroutines in the form of alternative location-size patterns for shopping centers were tested. These enabled balanced retailing systems to be devised for each plan, where all centers attracted sufficient sales in relation to their assumed size to be profitable to the entrepreneur, without being so profitable as to suggest an unsatisfied demand for further growth.

COMPARISON OF PLAN PERFORMANCE

The output of gravity model analysis, first for annual retail expenditures, and then for daily vehicle trips, followed by traffic assignments, enabled plan performances to be compared. The objective of comparative analysis was not the selection of the most

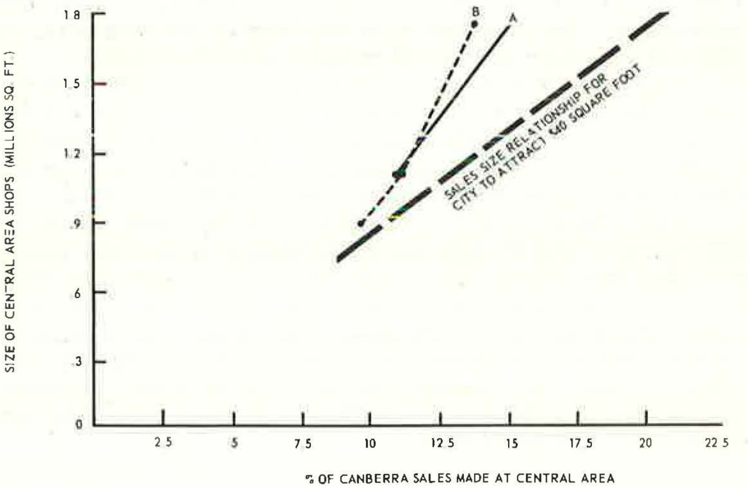


Figure 6. Influence of plan-form on proportion of local sales made in CBD.

TABLE 2

RETAIL PERFORMANCE BY LOCATION OF SITE

Plan Form	Location of Site		
	Access via Freeways	Focal Point of Town Arterial System	Elsewhere in Towns
A	$38	$57	$48
B	$33	$63	$45
C	$34	$63	$48
Average for Plans A, B, C	$35 (15 sites)	$61 (29 sites)	$47 (30 sites)
Range of individual performance	$25-$50	$43-$100	$34-$68

efficient plan in terms of transportation however, as the plans were designed to uncover the transportation implications of a full range of urban forms. In particular, the analysis set out to uncover those transportation situations and travel characteristics which suggested:

1. Limits in capacity for further urban expansion;
2. A configuration of assigned travel demands which could weaken the development of freeways and rapid transit facilities needed to support, and in turn create, metropolitan structure; and
3. Avoidable conflict between traffic concentrations attracted to freeways and those attracted to subregional centers of activity.

To find these points of weakness in alternative urban forms and structures, a number of specific questions were asked:

1. What is the most efficient system of retail centers?
2. What are the transportation implications of alternate population and employment and activity patterns?
3. Where do traffic bottlenecks occur?
4. What is the potential for freeways and rapid transit under alternate regional forms?

THE SYSTEM OF RETAIL CENTERS

Analysis of sales potential showed that the CBD would attract 10 percent to 12 percent of the local market. Tests of plans which assume a much larger attraction to the CBD showed that it might indeed attract a greater share, but average sales might drop to an unhealthy level (Fig. 6).

In none of the plans was there a definite potential for the establishment of major shopping centers on freeways running between residential towns, unless the development of centers inside the towns was placed under some restraint. In fact those shopping sites which were dependent on freeways for their accessibility generally had the least attractive power. Freeway sites, in open competition with other locations, were only able to attract an average of $35 sales per square foot, compared with $47 inside the town areas, and $61 at the focal point of the town arterial system (Table 2).

This conclusion, which is the opposite of much practical experience in the United States, may be explained by the well developed pattern of towns proposed for Canberra and the avoidance of freeways running through residential areas. The physical and spatial definition of the towns, with an internal focus, appears to more than compensate for the influence of the fast speeds on freeways in creating accessible locations.

Due to a high level of self-containment of consumer expenditures within each residential area, radical changes in the spatial arrangement of towns throughout the metropolitan area had little effect on the efficiency of town-centered shopping systems. This evidence, plus the lower average trip lengths (for consumer expenditures) produced in plans using a shopping pattern based on town centers, led to the conclusion that they produce the most efficient and stable system.

EVALUATION OF TRAVEL DEMANDS

Assessment of travel demands between alternative plans is commonly done by comparing total vehicle-miles traveled. This was not the best measure for a region made up of clearly separated residential areas having a measure of self-containment. Total vehicle-miles were therefore broken down by freeway, arterial and local roads and a

TABLE 3

SUMMARY OF TRAVEL DEMANDS—ALTERNATE PLANS

Travel Demand	Concentric Growth		Corridor Growth		
	A	A-2	B	C	F
Total vehicle-miles (000)	9750	9970	9930	9770	9570
Intertown travel (% of all vehicle-miles)	77	78	72	72	74
Intertown vehicle-miles (000)	7500	7800	7150	7000	7080

separate breakdown developed for intertown vehicle-miles, to see more precisely where any efficiences might be developed.

Intratown vehicle mileage was 22 to 28 percent of the total; this was the portion of the travel that must be carried by roads within the towns, constructed as part of the suburban development operation. Comparison of the remaining (intertown) travel, therefore, provided a better measure of the demands for major metropolitan facilities: freeways and rapid transit. On this basis corridor-type Plans B, C, and F made lesser total demands for regional facilities than Plan A which was based on concentric expansion (Table 3). The most centralized plan (A-2) made the highest demands, and corridor-type plans were generally 10 percent better in this respect.

Trip Lengths

As might be expected, the average length of trips made for the purposes that tend to be locally oriented, such as shopping and social travel, varied little from plan to plan, despite the radically different spatial arrangements of towns.

The average length of vehicle trips to work varied between 15.2 minutes for Plan A-1 to 17.6 minutes for Plan C—a difference of 15 percent. The substantially greater length of work trips in all plans and their relatively wide variation from plan to plan indicate clearly the potential economies of an urban form and a distribution of work opportunities, which minimize the total miles of vehicle travel to work.

Table 4 gives the effect on vehicle-trip length (in Plans A and A-2) of increasing metropolitan centralization of employment from 17.5 to 32.5 percent. It is recognized that increased centralization would also increase the potential for public transport usage and could result in reduced car use for longer trips. The practical result of the tendency for vehicle trips to be lengthened by centralization would therefore be dependent on related changes in public transport service.

The results for Plan A-1 illustrate the effect of increasing residential densities from 12 to 30 persons per gross acre around the town centers. The average length of locally oriented trips, as well as work trips, was reduced. Additional reductions in work trip by auto could be derived by rapid transit designed to exploit accessibility to residences, if this kind of compaction of development occurred on a large scale.

Plans B and C illustrated the effect of a significant lack of balance in employment-location in relation to the major directions of growth. Approximately 20,000 jobs were located in the southeast area of the region, whereas growth was substantially to the north. This lack of balance countered the localizing effect on work trips of a more linear form of growth. Compared to A plans, the more linear form had a lower accessibility to work, so that the resident work force of each town would tend to place more value

TABLE 4

AVERAGE TRIP LENGTH VS PLAN FORM AND CENTRALIZATION

Trip	Urban Form					
	Concentric Growth			Corridor Growth		Articulated Corridors
	A	A-1	A-2	B	C	F
Home based						
Work	15.8	15.2	16.8	17.1	17.6	16.0
Shop	8.5	8.3	8.4	8.5	8.5	8.4
Other	11.2	10.7	11.3	11.1	10.7	11.3
NHB	10.9	10.7	10.7	10.8	10.5	10.2
Centralized employment, %	17.5	17.5	32.5	17.5	17.5	24.5

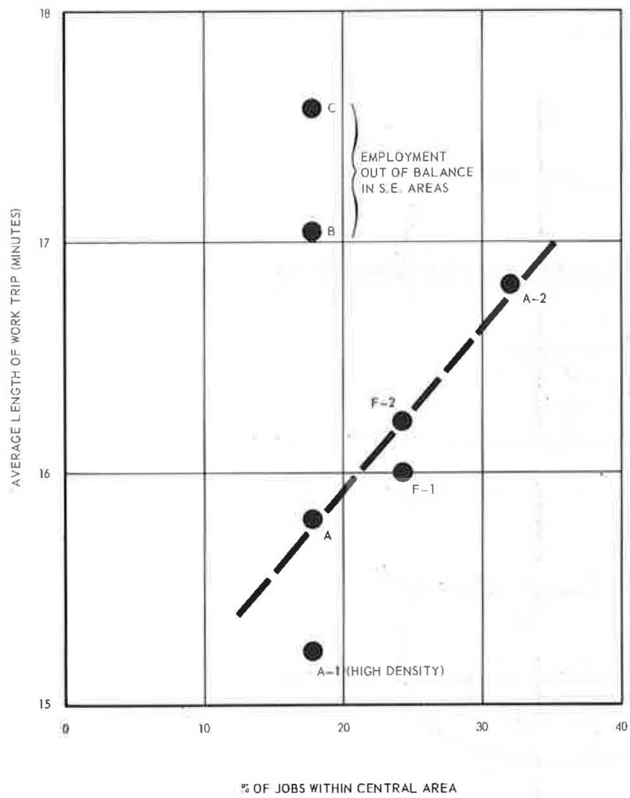


Figure 7. Variation of work trip lengths in test plans.

on local opportunities. This conclusion is supported by a 5 percent increase in intratown trips in these plans. Despite this increased tendency to self-containment, the imbalance between residences and jobs in B and C plans increased the average length of work trips, above those of the A plans.

This imbalance was corrected in linear Plan F, so that, despite its more centralized employment pattern (24.5 percent compared to the 17.5 percent of B and C) the average work trip length was lowered sufficiently to make it comparable to the average trip length for the concentric growth of A plans (Fig. 7).

Growth Strategy

Road traffic bottlenecks on a scale defying satisfactory or permanent solution are normally due to an over-concentration of activities at major urban centers. Thus an important objective was to find the general upper limit of concentration that could be tolerated in the central area (a lower limit of 17.5 percent central employment at the one million population stage was based on the national minimum required to establish a central area transport structure and to maintain an activity-node of metropolitan status and dimensions). The upper level of centralized employment tested (32 percent) appeared more likely to overload the secondary system of distribution in the central area than its approach freeways. This indicated the probability of the detailed distribution of central area activities (rather than transportation) as the prime determinant of limits to centralization. Subject to the changing role played by public transport, the centralization of 24 percent of jobs at the stage when one million people live in the metropolitan region, appeared to provide one of the many reference points needed to design for growth at the heart of the capital.

To develop similar reference points for the central area as the region expands to one million population, an analysis was made of a plan containing 500,000 persons. In test Plan G, it was first assumed that growth of employment at the central area of Canberra would maintain its present 50 percent share of total jobs. Traffic analysis showed that travel demands on numerous roads leading to the central area by the half million population stage would exceed those generated at the one million stage if the central area grew at this rate. (Traffic conditions could of course be a great deal worse in practice, because traffic corridors would be less highly developed to carry the load at this stage.)

To avoid developing higher traffic demands along certain corridors than are forecast at later stages (a condition not easily rectified once it has appeared), it is clear that a balance needs to be struck between the growth of towns with subcentralized employment, and increases in jobs in a central area that absorbs a decreasing proportion of total activity. To achieve this, the activity in the central area should be kept in

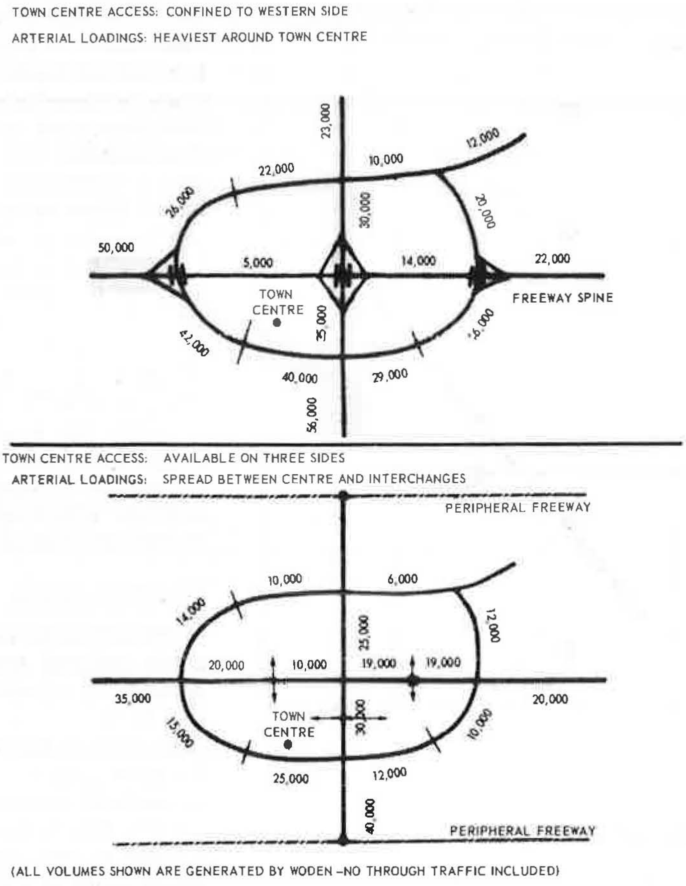


Figure 8. Impact of freeway location on town traffic conditions at the center of Woden.

approximate balance with the ultimate contribution made by the labor force of each town to central area employment. This ultimate balance between town and central area could be achieved if each town and its work center were established together and as early as possible, to promote attractive alternatives to central area work locations. On the other hand the central area would need to grow slowly as a work place, reaching at a half million population level only two-thirds of its size at the million level.

Traffic Bottlenecks

The pattern of traffic loads assigned to arterial-freeway networks provided valuable clues to the capacity of the total land use and transport network to accommodate outward growth without the development of major bottlenecks. An important finding of the tests of Plans A to D was the potential congestion around town centers when located on urban expressways penetrating the towns and functioning as major intertown routes. Figure 8 shows the effect of penetrating a town of 90,000 people with a limited-access expressway facility designed to serve both the town center and regional intertown traffic compared to a plan which separates these transportation functions by the provision of peripheral freeways.

In each case, the traffic volumes are only those associated with the town. If through traffic were also shown, the results would be even more striking. It is quite clear that a central transportation spine creates a few points through which the majority of traffic must move irrespective of its ultimate origins and destinations. In addition, the expressway facility drastically reduces the access-egress perimeter of the town center, thereby concentrating the generated traffic even further.

The resolution of these localized difficulties points to the separation of intensive local traffic generators and high-type traffic facilities. A plan that looks beyond a static horizon to the requirements of continuing growth (growth of either the nodal activity centers or of long-distance metropolitan traffic demands) must look to an articulated highway system composed of arterials inside the urban growth corridors, to give access to activity-nodes, and transport-nodes (interchanges) on peripheral freeways linking towns to one another, and to the metropolitan core.

FREEWAYS AND RAPID TRANSIT

The objective was to evaluate the geographic pattern of travel demands, particularly those long intertown movements which should be accommodated on a freeway system. Information on daily two-way vehicle trips assigned to each link of the highway system was supplemented by the assignment of intertown trips to a spider network in which each centroid represented a town. The longer trips were identified on each spider diagram link as the difference between total intertown trips and adjacent intertown trips. These trips were considered to represent the basic demand for freeway-type travel.

Intertown vehicle travel demands for Plan A exhibited a dispersed pattern compared to the more centralized Plan A-2, whose freeway demands were substantially greater. The clearly structured demands of Plan B could be served easily by an efficient system of freeways, but the development in Plan D of a heavy cross-metropolitan demand between its extensive northern towns, accompanied by reduced radial demands, produced a pattern of longer trips that would be difficult to translate into a freeway network.

Corridor Plan F developed freeway demands of 50, 000 trips or more per day in three directions from the city center, clearly enabling a radial network to be defined. (The addition of adjacent intertown trips raised the total assigned load on the network of peripheral freeways to between 30, 000 and 60, 000 trips per link.)

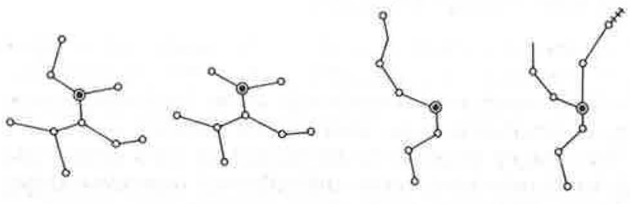
Potential for Public Transport

Of particular concern was the assessment of possibilities for providing Canberra with a high level of public transport service. This objective did not stem from notions of favoring public over private transport but from the recognition of its importance to large segments of the population in urban areas of the size being considered: Their requirements are neither more nor less important than others, and the ability to utilize fully the transport characteristics of public transport modes will increase the opportunities of opening up the range of land development intensities that can be provided in the future.

No attempt was made to forecast modal splits for alternative plans, but a basic 15 percent level of patronage was assumed to exist for work trips. However, the information available from spider diagrams in intertown travel provided a general guide to the potential for providing a regional or intertown public transport system. Intertown trips were factored to represent total person movements which might be attracted to a form of public transport providing high levels of service.

The factoring procedure involved examining the purpose-composition of vehicle trips of 12 minutes' duration or more and assuming that up to 5 percent of their person trips in the shopping, social, recreation categories and 10 percent in the work category could be attracted to a good transit system. The resulting 17 percent factor was applied to total intertown vehicle trips to produce a diagram of potential public transportation usage for each plan (Fig. 9). The trunkline demands that were produced by Plan A showed that a system requiring high capital investment (fixed track vehicle, or bus on separate right-of-way) would not be justified. This was after allowing that prior reservation of a right-of-way at no cost would require a daily patronage (including intratown) of around 25, 000 passengers to offset operational costs. Plan A-2 showed a more clearly structured potential, with three intertown links approaching the required level. However,

		Concentric Growth		Corridor Growth	
		A	A-2	B	F
Intertown links with potential as rapid transit or express bus route	Number of links	9	8	6	7
	Sum of link loads	129,000	124,000	112,000	131,000
	Number of lines & branches formed	5	5	2	3
Potential rapid transit link-loads as % total intertown link-loads		67%	67%	65%	75%
Average load per R-T link		14,400	15,500	18,600	18,800
Miles of route involved		35	30	25	30



Configuration of potential network for rapid transit

Figure 9. Comparison of public transport potentials.

as shown in Figure 9, the directional diversity of the potential in both plans and the resulting branch lines was an additional barrier to a practical design that would exploit the potential demand.

Plan B indicated clearly the value of a linear plan form as a means of providing higher levels of public transport. With carefully located employment centers and residential development at the local as well as the metropolitan level, this plan could possibly support 25 miles of a high-type public transport route.

The articulated land-use pattern and corridors of Plan F show clear support for a high level of transit service in three directions from the central area. Figure 9 shows that Plan F was able to attract 75 percent of the assumed potential intertown patronage, whereas the other plans could attract only 65 to 67 percent. The average potential patronage over the 30-mile system involved was 18,800 persons per day: intratown usage, with suitably designed towns, could provide the additional support required to justify a system on its own right-of-way. From examination of Plan G, it appeared that a high-level transit service might be begun at about the half million population stage.

In considering how operations in a separate rapid transit reservation might be commenced, it should not be assumed that justification in terms of daily load can be a guarantee in itself. The feasibility of initiating such a system could very likely lie in the ability to make a series of improvements in the service given by existing bus systems, by putting successive sections of the reserved alignment into operation over a period.

The conclusion was that public transport on separate rights-of-way is a realistic objective, providing that future land development at the regional, town, and local level is developed to exploit the full potential of this mode of travel. This involves the channeling of growth into several radial corridors to increase the density of point-to-point movements, the growth of the central area to be as large as its design and function will allow, and town centers and other out-of-town employment areas with a high level of activity (such as universities) to be sited and designed in relation to a reserved public transport spine as an integral element.

Work Trips, Urban Form and Structure

The conclusions to be drawn on the relationships of form, structure and travel confirm in the main what has been established in earlier work (4); namely, that efficient land-use distribution is the major source of reductions in travel demands and is a potential source of transport economies. Analysis of variations in work trip length under corridor-type and concentric-type plans with varying degrees of subcentralization provided further specific conclusions on this general theme.

First, as demonstrated by Plans B and C, an imbalance of seemingly minor proportions in the distribution of jobs over the whole metropolitan region can increase the mileage of travel to an extent that nullifies the effect of organizing the rest of the urban structure into self-contained areas having a high measure (60 percent) of internal work opportunities. In practice of course any significant imbalance in employment that is not a centralized one will, in addition to increasing the amount of travel, have a weakening effect on the development of efficient transport facilities through the introduction of more competing and conflicting desire lines.

Second, linear forms which are reasonably balanced in respect of work locations can have work trip lengths similar to those of the circular plan that, under superficial inspection, seems to require shorter trips because it looks more compact. Figure 7 illustrates a relationship between average work trip lengths and centralization of employment for circular and linear plan forms. For plans having some claim to structural organization, and without serious imbalance in employment distribution, the form (or shape) of urban growth alone should have little influence on average trip length. On the other hand, regional centralization in the context of the loosely knit low-density metropolis seems to have a dominant role in the production of longer trips to work.

If plan form, as a result of this conclusion, can be regarded a relatively neutral factor in the production of inefficient work trip patterns, it becomes even more important to look at the question of structural balance, particularly the capacity of different plan forms to grow in a way that retains a balance between population and employment locations.

Concentric and lineal or corridor-growth patterns may have different capacities to maintain a near optimum trip length for any given degree of imbalance in employment distribution. With limited possibilities for clearly articulated growth, a city undergoing concentric expansion will have less potential for developing efficient patterns and modes of travel. But as a part compensation for these limitations, badly distributed employment could increase trip lengths less in a circular city form than in one assuming an articulated form.

In the all to normal context of limited or nonexistent control over land development, it is obvious that a city articulated into corridors, each with a balanced employment structure, represents a higher order of organization than one based on peripheral growth around a single dominant core. Yet it is the ability to progress, in land-use terms, toward such higher order structures that appears to provide cities with the capability of sustaining continued growth in an efficient manner.

SUMMARY AND CONCLUSIONS

This examination has shown how much the performance of alternate plans, all of them genuine attempts at metropolitan organization on the common theme of subcentralization, can vary in their capacity to cope with the problems caused by growth. The necessary adoption of the multi-nucleated approach to urban development has been shown to require the strict application of many checks and balances if in the future, cities are to develop the firm and efficient structural elements to a large degree self-reinforcing, that characterized those of the past. A constellation of centers is capable of growing and generating demands in so many ways that its major hazard is the loss of this organization at the metropolitan level.

The concentration of land development into corridors in conjunction with a structured arterial freeway system will allow metropolitan growth to occur with a minimum of points or areas of congestion. This concept will also give maximum support to a good public transport system in low-density and low-patronage conditions.

Finally, and perhaps most importantly, the general concept of directional growth in the motor age appears to entail careful attention to the detailed timing, location, detailed arrangement, and growth of the important centers of activity and of the transport network, if it is to actually achieve the structural strength and stability that will avoid chronic congestion being a concomitant of continuing growth.

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