A SERIES OF SIX DISCUSSIONS

ON

TRANSPORTATION ENGINEERING.

BY

R.I. JACKSON B.Sc. (ENG.). M.Sc.

"THE URBAN TRANSPORTATION PROBLEM".

MAY/JUNE 1965.

FORWARD PLANNING BRANCH,
CITY ENGINEER'S DEPARTMENT.
JOHANNESBURG.

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CONTENTS.

1. TRENDS AND ISSUES.

1.1 Historical Note.

In the early 19th century, urban populations concentrated around the Central Business District (C.B.D.). Growth was limited to a 2 mile radius for travel on foot.

In the 1860's and 1870's, the horse car extended the residential boundaries a few miles. The electric street car doubled the travel speed amd growth extended further, although it remained dense and was concentrated in corridors about the street car route.

The 20th century brought the automobile, and the city has exploded!

1.2 Changing Patterns in Urban Growth.

The evolution of the modern urban area is dominated by two striking trends -

1. The strong flow from the rural areas to the urban areas.
2. The decreasing density of these growing urban areas.

Already 75% of South Africa's population lives in and around the urban areas. (1) Between 1951 and 1958 the urban population of the 12 largest cities increased by 25%!

The dramatic growth of the urban population in South Africa can be seen as a result of the change in character of the national economy from mainly agricultural in 1912 to mining by 1920 and manufacturing by 1963 as shown in the table below (2):

DISTRIBUTION OF NATIONAL INCOME.
(PERCENT).

Year	Agriculture	Mining	Manufacturing	Commerce
1912	17.4	2.7	6.7	13.5
1920	20.9	21.3	10.7	16.8
1930	13.9	17.3	15.4	14.5
1940	11.8	22.8	17.5	14.3
1950	13.1	13.6	22.1	15.1
1960	11.2	13.8	23.1	12.7

The cause for alarm at the effects of this Urbanisation trend can be seen from projections of the total population shown in the table below. Note that today's 17,000,000 will grow to 25,000,000 by 1984!

POPULATION GROWTH.

Year	Population
1891	3,000,000
1920	6,800,000
1950	12,400,000
1961	16,000,000
1984	25,000,000 (Projected

1.3 Vehicle Ownership Rises with Income Increase.

The rising prosperity which increased the national per Capita Income by 75% between 1950 and 1960 has also increased the opportunity for vehicle ownership.

Note the dramatic change in vehicle ownership from 134 persons per vehicle in 1924 to 13 persons per vehicle in 1963 (3).

SOUTH AFRICAN VEHICLE OWNERSHIP
(PERSONS PER VEHICLE).

Year	Vehicles/person
1924	134
1930	60
1950	20
1963	13
1985	?

Phenomenal increase in vehicle owenrship can be expected as the Bantu ownership rate rises due to:

1. Increased income.
2. Changes in financing techniques.
3. Changes in vehicle technology.

3/ ... ...

It is of interest to note that South Africa's 12 million Bantu already own 100,000 motor vehicles - a figure for comparison with the other African countries as shown in the table below (3):

AFRICA : VEHICLE REGISTRATIONS.

Country	Population	Vehicles
South Africa (Total)	17,000,000	1,244,570
South Africa (Bantu)	12,000,000	100,000
Nigeria	50,000,000	80,000
Ghana	7,000,000	45,000
Ethiopia	22,000,000	26,000
Egypt	26,000,000	97,000

In Johannesburg today there is one motor vehicle to every 2½ White people.

1.4 Urban Travel Increase.

At present 60% of the nation's vehicle miles are travelled on 10% of the nation's roads - the urban system of 10,000 miles!

By 1984, based on the most pessimistic projections of population and vehicle ownership, vehicle travel will have trebled itself to 27,500,000,000 vehicle miles per year.

Studies in the U.S.A. show that person trips are distributed amongst the various purposes as follows (4):

Work	34%
Social-Recreation	21%
Shopping	17%
Business	11%
Miscellaneous	10%
School	7%

Work and business account for at least 45% and in other studies 55% of urban travel.

At this point in time in Johannesburg most of these trips are orientated towards downtown or industrial areas close to downtown.

However, the effect of downtown congestion and parking difficulties has caused in United States cities a "flight to the suburbs" by shopping centres and industries so that most work trips today in the United States are not downtown orientated! This pattern can be expected to develop here as well. The result is congestion on suburban routes as well. As business decentralises it becomes necessary to provide a network of freeways.

1.5 The Decline in Public Transportation.

The private automobile has today become more than a means of transportation - it has become a way of life! The use of a personal car is more appealing to the traveller than mass transportation because of its flexibility and the independance it gives him. He can depart at any instant chosen by himself, travel by the route of his choice. He can take with him any bags, papers, children's toys, etc. In fact the car can be a mobile office.

The low population density of the modern urban sprawl has made the traditional bus-route or transit route uneconomical to operate with a high frequency of carriers. As a result the service frequency is reduced and/or fares increased. This has the immediate result of converting more bus riders to car drivers. Revenue, therefore, drops and services are further reduced, and so on.

In the U.S.A. between 1946 and 1962 urban transit ridership decreased by 66%, while in the same period, automobile travel increased by 85%!

A study was undertaken in Chicago to find what inducement could be offered by fare reduction to convert automobile drivers to transit riders. The study concluded that if fares were free, only ⅓ the drivers could be converted. To induce ½ the drivers to use the transit, they would have to pay each passenger 25 cents!!

The unpopularity of mass transportation is indeed an urgent problem and the more popular use of private cars is throwing a severe load on the highway transportation facilities, as the average car occupancy is found to be 1.7 persons per car.

A British study calculated figures to show what total area of a city has to be set aside for transportation depending on the mode of travel used. The following areas are required to move one passenger one mile in rush-hour:

By Rapid Rail Transit	- 1 sq. ft.
On Foot	- 3 sq. ft.
By Bus	- 4 - 10 sq. ft.
By Automobile	- 14 - 70 sq. ft.

2. PREDICTING FUTURE TRANSPORTATION DEMAND.

2.1 Cost of Transportation Studies.

Comprehensive transportation studies are required to predict future transportation demand for planning purposes. The problem is so urgent and the investments required to provide the necessary travel facilities, such as freeways, transit systems, etc., are so great, that the studies must be searching and thorough. It is in fact economical to spend large sums of money on these studies. As an example of the cost involved in arriving at the most economical solutions, the costs of some American studies are shown in the table below:

COST OF TRANSPORTATION STUDIES.

City	Cost (Rand)	Cost per person (Rand)
Chicago	R2,640,000	0.51
Milwauki	R1,420,000	0.90
Philadelphia	R3,200,000	0.75

In terms of these figures, Johannesburg should be thinking of spending about one million rand to develop a transportation plan! Note that Milwauki (metropolitan population 1½ million) is nearer to the scale of operations in Johannesburg.

2.2 Collecting the Facts.

A large number of surveys have to be made. The most expensive are the origin and destination surveys. In the current study in Johannesburg, 8,500 families have been interviewed in their homes, 4,500 truck owners will be interviewed at their offices and 40,000 drivers entering or leaving the Johannesburg area in vehicles registered outside of the T.J. or T.R.G. areas will be stopped on the road and interviewed.

Basically, if we know where people are trying to get to, we know where routes should be provided or improved. If we know how many people are going there, we know what size facility to supply. But even more important, if we can find the correlation between the number of people going to a place and what attracts them there, then we can predict how many people will travel on a future route if certain developments take place in some given zone.

In developing the final plan, many other studies are required. Speed and delay studies for cars and buses, sufficiency ratings of present roads, bus usage, train commuting, accident studies, fiscal studies, parking surveys and land-use studies are some of the basic studies required.

2.3 The "Gravity Model" for Forecasting Trips.

The most versatile technique for predicting future trips is the "Gravity Model". Not only can this technique predict increases in the interzonal transfers (trips between zones) due to growth, but it can also predict the increase caused by improvements such as building a freeway between the zones as well as the decrease in the number of trips between zones caused by congestion! Earlier methods, based on "growth factors", estimated the increases in trips due to growth within the zones, but could not take into account changes in the road facilities. For example the "growth factor" techniques would predict the same number of trips between a residential zone, and two equal sized shopping centres even if a future multilane freeway placed one within 5 minutes travel time and future congestion on an old road placed the other one 30 minutes travel time from the same residential zone.

The "Gravity Model" has been successfully used in Washington D.C., Baltimore, Cincinnati, Twin Cities (Minneapolis and St. Paul), Torronto and other cities.

Once the model has been constructed and calibrated and certain constants peculiar to our population are known, it can be used in future studies without the expense of origin and destination surveys.

In Cincinnati, Ohio (population $\frac{3}{4}$ million), the "Gravity Model" was tested and found to be as accurate as their Home Interview Origin-Destination Survey, interviewing one home in every 5, and very much more accurate than 1 in 20 interviews!

In Washington D.C., the model was calibrated using their 1955 origin-destination survey and was tested by projecting backwards to 1948 conditions for comparison with their 1948 origin-destination survey. Accuracy for 1948 was equal to that of the base year, 1955. (5).

2.4 <u>Theory of the "Gravity Model" (with example)</u>.

All trips starting from some origin area are distributed amongst the various possible destination zones in direct proportion to the relative "sizes of the attracters" at these destinations. For shopping trips the number of retail employees or retail floor space would be the attraction, while for "work" trips the office space or employment would be the attracter.

The distribution is also inversely proportional to some power of the travel time between the origin and the destinations.

Mathematically this can be stated (6) as:

$$T_{ij} = T_i \frac{\dfrac{S_i}{(D_{ij})^x}}{\displaystyle\sum_{j=1}^{n} \dfrac{S_j}{(D_{ij})^x}}$$

Where: T_{ij} = future trips between zone i and zone j (for all i and j from 1.....n) due to an attraction located in zone j.

T_i = future trips originating in zone i.

S_j = the future size of attracter at zone j.

D_{ij} = travel time between zones i and j.

x = exponent of the travel time.

In practice, the function $\frac{1}{(D_{ij})^x}$ has been expressed as a series of "Travel Time Factors" for different trip purposes, and these are in a form which can be readily used in calculation. (7).

Example: A Residential Area R generates 800 shopping trips per day. Shoppers travel by car to two shopping centres A and B. "A" has 50 retail employees and is 12 minutes from "R" and "B" has 20 retail employees and is 20 minutes from R. A freeway is to be built which will decrease travel time between the residential area R and B to 8 minutes. How many shoppers can be expected to be drawn away from A?

Travel Time (Minutes).	Travel Time Factors for Shopping Trips.
8	1.50
12	0.68
20	0.25

Before Freeway:

$$T_{RA} = T_R \times \frac{S_A \; F_A}{S_A \; F_A + S_B \; F_B}$$

$$= 800 \times \frac{50 \times 0.68}{(50 \times 0.68) + (20 \times 0.25)}$$

T_{RA} = 696 trips to A.

After Freeway:

$$T_{RA} = 800 \times \frac{50 \times 0.68}{(50 \times 0.68) + (20 \times 1.50)}$$

$$T_{RA} = \underline{425 \text{ trips to A}}.$$

Hence 271 trips can be expected to be drawn away from A.

3. SOLUTIONS.

No single step will solve the traffic problem. A comprehensive programme of action, embracing such small details as road pavement markings on one hand and leading up on the other to a fundamental alteration in the traditional shape of our cities is required to make our urban structure and our transportation demands compatible. While no part of this programme can be achieved instantaneously, it can be classified into 3 phases:

Phase 1: Steps which can be immediately implemented. This includes those which can be implemented in small increments, each increment being immediately usable.

Phase 2: Steps which, if planned and commenced now, can be available for use in about 10 years.

Phase 3: Blue sky thinking - possible developments in 20 years to 30 years time. This includes some projects which in the U.S.A. will be nearer to Phase 2.

3.1 Steps immediately Implementable.

3.1.1 Traffic Engineering.

Action involving the smallest investment is the mobilisation of every available modern Traffic Engineering technique, supported by Traffic Enforcement techniques and a continuous Traffic Education Programme. These techniques will be discussed more fully in the next 3 discussions "Theory of Traffic Flow", "Increasing our Road Capacity" and "Road Accidents and Safety".

10/ ... ...

The techniques involve the fullest use of modern traffic control devices such as radar or sonic senser traffic actuated signals (robots) on arterial and collector routes, exhaustive lane marking, high visibility road signs, traffic routing, one-way systems, and closing off certain narrow streets to vehicles during office hours. The latter not only provides pedestrian corridors, but also reduces the time lost at an excessive number of intersections. These narrow roads carry such small volumes that their vehicle capacity is never missed. This has been successfully done in Amsterdam's Kalwer Straat, where the shop owners would start a revolution if the city ever allowed cars back in the street during shopping hours.

A modern approach is to regard transportation on a "Systems concept" both in regard to facilities and to travel modes.

Regarding the roads as part of a system rather than individual facilities, the technique of "Traffic Routing" yields tremendous improvements. One-ways are in this category, so are pedestrian routes down closed-off roads, as well as truck-routes and exclusive bus-lanes.

3.1.2 Mass Transportation Promotion.

To cope with the long range programme there must be a return to use of public transportation. This will be difficult, but can be done. It will require additional services, some changes in technology, changes in financing methods and sales promotion. If you can convince people to drink "so-and-so's Cola" you can make them ride buses.

Several techniques in the U.S.A. are noteworthy. The elimination of conductors on single-deck buses is a great man-power saver. Separate doors are provided for entering and exiting passengers, both doors controlled by the driver. Entering at the front, passengers deposit their fare in a glass container. The one-fare rate structure is used for each route.

Provision of exclusive bus-lanes on wide roads (especially on one-way streets) helps the bus speed.

3.1.3 "Park and Ride".

The only successful system in the whole United States has been the "Park and Ride System" in which the bus or transit line provides parking space at termini and loading points.

In Ohio, the Cleveland Transit System (C.T.S.) and the Shaker Heights Rapid Transit are about the only transit companies making money. On one C.T.S. route alone, ridership increased 151% between 1955 and 1961 while the U.S. average dropped by 25%.

In St. Louis, Missouri, the Bus Company provides free parking on the "Park 'n Ride" System. On opening day they had 130 passengers on their first route. 18 months later the route carried 1,000 passengers a day.

3.2 10 Years hence Programme.

3.2.1 Freeway System.

The systems concept now includes a Freeway Network across the city as an integral and indispensable part of the system. The freeway concept has changed radically since the Lloyd B. Reid report days. He seemed to regard the freeway as a kind cf super by-pass to the Central Business District - a by-pass which could not go round, so it went over. In the modern concept the freeway not only by-passes the C.B.D., nut brings traffic to it and all round it by means of an "inner belt" freeway. Parking garages outside of the inner belt provide all-day parking for workers while parking garages within the "inner belt" supply parking for shopping and business transactions.

Express buses provide fast mass transportation on exclusive bus-lanes on the freeway. Park-and-Ride facilities are located at the off-freeway loading points.

Traffic surveillance systems are incorporated on the freeway. In Detroit's John C. Lodge Freeway television cameras located on all the overpasses provide surveillance of the freeway on 14 television screens in the control centre. Traffic speeds and volumes are continuously measured. Remote-controlled overhead signs can alter the speed limit on each lane to allow shock waves to pass through or slow platoons approaching a congested section. When the volume nears capacity, overhead signs controlled from the surveillance room are illuminated to prohibit further entry onto the entrance ramps to the freeway.

Capacity on this well disciplined road with complete lane control reaches 2,000 vehicles per lane per hour at 55 miles per hour! This means that cars are $1\frac{3}{4}$ seconds apart at 55 miles per hour!

3.2.2 <u>City Planning</u>.

City Planning now concerns itself in planning to minimise transportation. Washington D.C., in its "Plan for the Year 2000" has proposed a corridor development with wedges of open land being brought close to the heart of the city. Transit lines and freeways running in each corridor will be well patronised as the population is more concentrated than in the uncontrolled sprawl.

A similar development is planned in Copenhagen's "Finger Plan".

On the suburb level, city planners base new developments on the neighbourhood unit so that within a unit large enough to support a primary school, no arterial roads intrude. Only traffic with origins or destinations within the neighbourhood unit uses the unit's roads.

Shopping developments are confined to centres with adequate parking and a circulation plan separating vehicles from shoppers who are safe, moving in traffic-free pedestrian malls.

3.3 <u>Future Developments</u>.

Development work is rapidly proceeding in the U.S.A. on the "Electronic Freeway". A full scale prototype of the car to be used has been constructed by General Motors.

On entering the freeway the operator of the vehicle dials his exit. Electronic signals from a tape buried in the freeway take over control of the car. The fuel is automatically metered and if insufficient to reach the dialled exit, the car sent off at the appropriate exit to refuel. When the selected exit is reached alarm signals alert the driver, exit the car and the driver then assumes control again.

The advantage gained by the electronic freeway is that since human reaction time is eliminated, cars can be stacked at ½ second headways and travel at 70 miles per hour, while a conventional freeway can pass only 1 car every 1¾ seconds at about 55 miles per hour at the best capacity.

Further developments are expected in mass transportation with the trend towards elevated and subway type transit on pneumatic tyres with multiple doors for fast loading and unloading and parking facilities at loading points.

Personalised air transportation cannot be overlooked, especially with the concentrated research into Vertical Take-off and Landing craft (V.T.O.L.) for military purposes. Already a prototype "Hoppycopter" has been developed and visitors to the Rand Easter Show saw the experimental "Flying Belt" equipment used by the Bell Rocket Team.

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