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THE COLLEGE OF AERONAUTICS

TRANSPORT SHORT COURSE

24th February - 7th March, 1969

PROJECT REPORT ON MILTON KEYNES

by

Members of the Short Course

PREFACE

The views expressed in this report are those of the course members themselves, and not necessarily those of the College of Aeronautics, nor of the organisation which sent students.

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PART 1 GENERAL INTRODUCTION

1.1 Introduction

1.1.1 This is a project report written by the members of the College of Aeronautics short course held between 24th February and 7th March, 1969.

1.1.2 An Interim Report was presented by the Planning Consultants to the Milton Keynes Development Corporation in December 1968. The report is not a definitive plan for building the City, but it has been prepared through a process of consultations between the Consultants, the Corporation members and staff, and many of the authorities and departments in central and local government who will be responsible for various aspects of the City. The report can be taken as representing the strategic approach of the Corporation towards the new City at this stage of the planning process, but it is not intended to submit proposals for approval by central and local governments until the complete plan is produced at the end of 1969.

1.1.3 The Interim Report has been published at this stage partly to enable limited development work to be started in advance of the Plan, and partly to encourage discussion by the public and organisations and authorities concerned. It is recognised that new views and further examination may make practicable changes desirable and necessary.

1.1.4 The members of the course have been formed into a Working Party to report in conformity with the following terms of reference:

1.2 Terms of reference

1.2.1 A Working Party has been set up to give the Development Corporation an independent assessment of the Interim Report indicating where, in their view, changes or further investigations are needed to improve the transport proposals.

The Working Party has been given three months in which to complete its investigations but has been asked to submit a preliminary paper on Thursday March 6th, giving a survey of the main problem areas it proposes to cover. They have been asked to indicate, by means of such analysis as is possible in the time, the relative significance of the problem to be studied.

The Working Party has been given the following brief as a basis for preparing their paper :-

1.2.2 Land use

The general disposition of land uses described in the Interim Report may be accepted. Any changes will depend on separate consultation with the authorities directly concerned.

1.2.3 Population and employment

The general levels of population growth in the Interim Report may be accepted but comments are invited on the effects of the transport proposals of alternative assumptions on population structure, proportions employed and income growth, both in the designated area and in the surrounding region.

1.2.4 Phased growth

Adequate road and public transport services must be available during all phases of the development. At this point in time an appreciation of transport facilities in the period up to 1980 is required most urgently.

1.2.5 Road systems

The road system proposals are intended to satisfy the requirements of unrestricted 'congestion free' motoring, safety and accessibility related to economy in investment and operating costs. Under what conditions will saturation of the proposed system be reached and how will this influence population growth in the City? Are the proposals extravagant? Could better systems be devised to match the anticipated traffic flows?

1.2.6 Public transport

The Interim Report favours buses on all-purpose roads but leaves options for the subsequent development of separated track systems along the grid road alignments. Under what conditions might a track system be viable?

Decisions will need to be made soon on the type of bus service which should be provided during the years up to 1980.

1.2.7 Overall transport

Are the proposals likely to satisfy the transport requirements of the new city at a reasonable cost? Do they represent a good transport investment compared with feasible alternatives?

1.3 Method of approach

1.3.1 Because of the very short time available for the submission of the preliminary paper, the Working Party decided to divide itself into three groups for the study of

(i) Data analysis

(ii) Road traffic

(iii) Public transport

Each of these studies provides fairly well defined areas in which work can be carried out concurrently. In order to ensure proper co-ordination of effort between the groups, meetings of the complete Working Party were held and considerable informal discussion took place among the groups throughout the project. It had been hoped that towards the end of the project a short time would be available to consider the project on an overall basis; in the event this proved to be impossible and the work had to be curtailed.

1.3.2 The layout of the report reflects this method of working, Part 2 deals with data analysis, Part 3 with Road Traffic, Part 4 with Public Transport, and Part 5 looks at the project as a whole.

1.4 Working Party

The members of the Working Party are as follows :-

Chairman

Mr. G. Wallwork - Freeman Fox and Partners

Data analysis group

* Mr. M.G. Langdon - Royal Aircraft Establishment, Farnborough

Mr. K.T. Thawley - Travers Morgan and Partners

Mr. D.A. Walmsley -

Road traffic group

* Mr. L. Millar - Portsmouth College of Technology

Mr. A.F. Lowe - Bedfordshirt County Council

Mr. E. Rushton - British Railways

Public transport group

* Mr. A.G. Ellis - British Railways

Mr. G.F. Osborne - British Hovercraft Corporation Limited

Mr. M.A. Stockford - Tracked Hovercraft Limited

* Group chairman

1.5 Summary of conclusions

1.5.1 Each of the city layouts examined (see para. 2.1), appeared to have plausible population structures. The road layouts appeared to provide good links between residential and work areas, and could provide adequate capacity, except for a few heavily loaded links in the A3 layout which might require duplication. All the layouts would, at first sight, appear to be worthy of further study into their economics.

1.5.2 An interesting comparison was obtained between two types of gravity model for the Milton Keynes 1979 layout, which produced significant differences at the assignment stage.

1.5.3 It has not been possible to reach any firm conclusions on modal split between public and private transport; it seems unlikely that more than 25% of trips would be by public transport.

1.5.4 A preliminary assignment indicates that with an 80:20 modal split 32% of the 1979 road network will need to be dual 3-lane carriageway.

1.5.5 It seems likely that a number of junctions will have heavy right turning movements which will make it uneconomic to use traffic control signals.

1.5.6 Traffic seems generally high and this is probably explained by the north-south development of the first stage with a spur to the east. Also by 1979 with the fast rate of growth of population there will be about 50% of the total ultimate population, but only just over a third of the new road network. It appears that the traffic situation might improve at 1979 with a more even distribution of traffic.

1.5.7 The total cost of the road network will be approximately £100,000,000.

1.5.8 A 1 Km. grid is about the optimum size.

1.5.9 The suggested road plan would appear to give reasonably good accessibility but only by accepting reduced environmental standards, particularly within the residential areas and central area. This objection could be overcome by the establishment of a clearly defined hierarchy of roads and residential areas.

1.5.10 We consider the grid layout limits the choice of public transport systems to a road based service, and that no fixed track system on a grid alignment would be practicable or of acceptable service quality.

1.5.11 The proposed shuttle service will involve interchange for most journeys. Whilst more sophisticated routing might effect an improvement, the interchange penalty will remain unsatisfactory.

1.5.12 We suggest the layout weighs heavily in favour of the private car, at the expense of public transport.

1.5.13 The mini bus concept as proposed in the Interim Report will be very expensive to operate and fares higher than those charged at present for conventional high capacity buses will be necessary.

1.5.14 We foresee a relatively high proportion of commuter journeys to places outside the area in its early stages of development.

1.5.15 The 1979 public transport system should be orientated, to provide adequate connecting services, via the City Centre, with trains from Bletchley and Wolverton.

1.5.16 Consideration should be given, in conjunction with British Railways, to the future of the Bletchley - Bedford line.

1.5.17 The initial transport system is likely to attract a heavy subsidy.

1.5.18 There may well be a need for the future introduction of a rapid transit system to serve nearby cities, but its internal use would be limited. It is unlikely that an internal guided or fixed track system would be economically practicable.

1.5.19 High costs associated with the dial-a-bus system might rule it out in favour of conventional taxis.

1.5.20 Although the proposed road-based public transport system is within easy access of all citizens of Milton Keynes, the average day to day journey time is nearly twice that of the private motor car. The quality of the service offered appears unlikely to prove sufficiently attractive to draw other than captive users from the private car.

1.5.21 From a public transport aspect the College of Aeronautics A3 layout has some merit although it is impossible to say at this stage whether it is better than the grid network. For this layout rail systems have been dismissed because there are insufficient traffic flows to make them economically viable, but there is possibly a case for buses running on segregated tracks.

1.5.22 Although we do not think that the 1 Km. grid selected for the road network is necessarily wrong, we are not convinced that it has been conclusively shown to be the best solution bearing in mind the combined requirements of both public and private transport.

1.6.8 The effect of cyclists and the possible provision that should be made for them.

1.6.9 The layout and design from traffic considerations of the activity centres.

1.6.10 An alternative road plan based on a hierarchy of highway types and environmental areas.

1.6.11 In view of the limitations placed on the choice of public transport system, the basic grid type layout and land use distribution should be the subject of further study. Involved in this would be the consideration of other forms of tracked transport.

1.6.12 A full cost and cost/benefit study is called for to determine the optimum size of bus and realistic load factors if this is to be the chosen form of transport and the grid mesh layout is maintained.

1.6.13 Further study is clearly required into the routing of buses and interchange arrangements, both for the fully developed city and during the period of construction.

1.6.14 A careful study of potential commuter travel to places outside the city is also required, and would cover the initial years to 1979 and thereafter.

1.6.15 We propose to study a range of alternative road networks to establish whether the 1 kilometre square grid does in fact provide the best solution, having regard to the requirements of both public and private transport.

PART 2 DATA ANALYSIS

2.1 Introduction

There has been no time to assess traffic flows caused by movements other than home to work trips. It is fairly certain that this will provide the peak condition on most road links, though the Saturday shopping traffic might cause congestion near the main shopping centres. An investigation into the overall 24 hour flows will be important in determining the viability of a public transport system.

Three basic networks have been considered: A.3, based on a city layout suited to some form of reserved track public transport system, B.1, based on grid network of primary roads of about 1 mile spacing, and Milton Keynes 1979, the half-way stage of a city based on a grid network of primary roads of 1 kilometre spacing.

The assignment of trips to these networks has been over-simplified in that it considers Milton Keynes as a closed system, in which all the inhabitants work in the city. In practice a number of inhabitants, possible 20%, would work outside, and a similar number of external residents would travel into the city to work. An assessment has been made of the trips in and out of the city on the main roads, but there has been no time to attempt a detailed assignment of these trips to the network within the city.

It is unlikely that the inclusion of these additional trips in and out of the city, and the corresponding removal of some internal trips, would seriously upset the general pattern of movement within the city, except near the main entry and exit roads. Probably the most significant effect in practice would be provided by inhabitants of Newport Pagnell coming to work in Milton Keynes, and this in particular merits further study.

2.2 Examination of evidence and discussion of the Interim Report

2.2.1 Population structure and distribution

The consultants' proposals with regard to population growth and structure are outlined in Chapter 5 of the Interim Report. The population structure envisaged for Milton Keynes at various dates is given in Figure 30 of the Report. In Figure 2.1 of this document we reproduce the 1979 distribution and have superimposed for comparison purposes the existing population for the United Kingdom as a whole. It will be seen that, relatively speaking, the city will have an excess proportion of people in the 0-14 and 25-50 age ranges. From these statistics, it is possible to hypothesize that the number of households consisting of young or middle-aged parents with young childred will be above the national average of today. This, coupled with the complementary 'shortage' of older people, is a point to be borne in mind when planning both the accommodation types and the social facilities which are to be provided.

Some confusion appears to exist with regard to the existing population of the designated area, a figure of 44,300 is mentioned in paragraph 2, chapter 5, while 43,300 is used in paragraph 8. This error may or may not be of significence when projecting forward the growth of existing population.

In checking the consultants' proposals for the development up to 1979, we have assumed their preferred density of 8 dwellings per acre net. The new residential areas shown in Figure 2.2 cover approximately 5.4 sq. miles or 3500 acres. If an average household size of 3.2 persons is assumed, the new areas will house some 89,600 people. If the 44,300 people already resident in the area are assumed to expand at 3% per annum compound, they will add another 58,500 to the city's 1979 population thus giving a total 1979 city size of 148,000. This is some 23,000 in excess of the target for 1979 population. We therefore conclude that the initial development might take place at a lower density than 8 dwellings per acre, but an assumption of 8 would at least err on the pessimistic side as regards density of trip generation.

2.2.2 Employment and Industry

The consultants' proposals on employment (taken as the supply side of the labour market) and industry (the demand side) are set out in Chapter 8 of the Interim Report. The effect of the above-average proportion of middle-aged population, referred to earlier, is again seen in Figure 39 of the Report where an above average proportion of the labour force falls in the 26-45 age group.

If the labour force is expressed as a proportion of the total population however, the Report assumes a mean participation rate of 46% for both 1969 and 1989. This compares with figures of 47% for the U.K. as a whole (1966 Census) and 44% for the future new towns of Runcorn and Redditch. As the Report also assumes a real growth in incomes of 2.5 - 3.5% per year, the validity of assuming that the same proportion of the population will go out to work in 1989 as does so at present seems questionable. While the proportion of the male population who work is fairly stable over long time periods, the proportion of women who want or are prepared to go out to work is more open to change. Viewed against the background of rising incomes and the middle-aged family structure already discussed, we would have thought it prudent to allow for a decline in the proportion of women, and hence in the total population, seeking work. This may have been the train of thought which prompted the South East Regional Planning Council to give a figure of 42-43% participation for 1987.

The lack of information on the precise location of workplaces led to difficulties in trying to synthesize the journey to work patterns. Diagrams such as Figure 46 of the Report are of little use in this respect since there is no scale. A distribution of numbers of workplaces has therefore been assumed by us for use in the traffic forecasting model.

The attraction of industry into the area is a subject which the Report rightly treats with diffidence. However carefully the workplace sites are located and considered by the planner, the final decision as to exactly which company is going to move into the site is beyond his control. From a traffic planning point of view, this makes the prediction of commercial vehicle movements to these sites somewhat hazardous. Various breakdowns of the work opportunities by type of industry are however given in the Report. By shuffling these industries around amongst the various industrial sites, it might be possible, using trip generation techniques, to say that certain sites should not be developed with certain industries of high traffic generating potential if congestion on the road network is to be avoided. This program of work would allow the statement of paragraph 19 of chapter 11 to be checked, this affirms:-

"The disposition and size of the employment areas ....can be subjected to as much variation as is likely to be acceptable on land use grounds without materially affecting the conclusions on the transport pattern."

2.2.3 Car ownership

The brief for the Report mentions a car ownership level of 1.5 cars per household which is in line with the predictions of Tanner et al. However, no level of car ownership is mentioned in the Report and it has since come to light that the traffic consultants are working on a figure of 0.35 cars per head or 1.3 cars per household. The effect that this variation might have in the modal split is unclear.

2.2.4 The transport model

In order to be able to assess quantitatively the Report's proposals for various transport systems, a traffic forecasting model was developed. The model, shown in a diagrammatic - methodological form in Figure 2.3 took as input as many of the demographical features of the Report as it was possible to verify.

2.3 Description of alternative road layouts

We shall first describe the main features of existing development in the designated area; clearly, any proposed road system must fit in with this. The area is bounded to the north-east by the M.1 Motorway, and through the centre runs the A.5 trunk road. In addition, the London Midland region main line railway runs through the area in roughly the same direction. These features suggest that if a grid pattern of roads is chosen, it should be aligned with one axis along a northwest-southeast line.

Existing towns within the designated area are Bletchley, Stony Stratford, Wolverton and New Bradwell. Early development is expected to follow an axis between Bletchley and Wolverton. Newport Pagnell is adjacent to the designated area and should be considered as part of it for transportation purposes.

2.3.1 College of Aeronautics Plan A.3

A plan proposed by the College of Aeronautics (Figure 2.4) represents an attempt to plan the city round a transport facility. It arose from an original suggestion for a transport system based on a monorail line, but it is equally applicable to any system operating on its own right-of-way, such as a duorail, air cushion vehicle, segregated bus or autotaxi.

The railway (or other system) would operate over loops of line passing through the industrial areas, the new city centre and the existing residential areas. Loops intersect to Milton Keynes centre, and in Wolverton and Bletchley where interchange with British Rail would be available.

Residential areas would be dumb-bell shaped, consisting of two overlapping circles of three-eighths mile radius, centred on stations on the railway. Thus, every household would be within a reasonable walking distance of public transport. Each residential unit contains 15,000 people at a density of about 30 persons per acre. A road system consisting of a broad grid at spacings of about 1 mile is proposed. Roads of expressway standard may be required.

It is not easy to see how progressive development could take place around a looped network without leaving long lengths of railway track in open country. Probably developemnt could take place around the loop through Wolverton, Stony Stratford, and Milton Keynes city centre, with a branch line to Bletchley.

2.3.2 College of Aeronautics plan B.1

A second plan proposed by the College is shown in Figure 2.5. This consists of a square grid of about one mile spacing, and it may be necessary for many of the roads to be of urban motorway standard with grade separated intersections. Secondary roads are included midway between the primary roads, and some kind of local access road system would be required. Development during the initial stages would be along the Bletchley-Wolverton axis, with a spur extending towards Newport Pagnell.

2.3.3 Milton Keynes Interim Report proposal

The city plan proposed by the Development Corporation is shown in Figure 2.6. It consists of a square mesh of primary roads at spacings of about one kilometre, with one axis of the grid in a north west-southeast direction. The roads are dual carriageway with two lanes in each direction and the intersections are signal-controlled, except where grade-separation is required at points of high traffic density.

A green-wave system of traffic-light operation is proposed, and it is interesting to note that the square mesh is one of the few configurations in which such a system can operate on all roads.

The planners chose a 1 kilometre grid size because they concluded that grade separation would be required on a 1 mile mesh, at a considerable extra cost. Furthermore, with a 1 kilometre mesh, no point would be further than 5 minutes walk from public transport if a facility operated only on the primary roads.

In addition to this network, a road of motorway standard runs parallel to the A.5 carrying through traffic from a point northwest of Stony Stratford to a point southeast of Bletchley. This leaves the A.5 as an urban primary road. An access point to the motorway is provided near to Milton Keynes city centre, and a motorway cross-town link joins this point to the existing access point at the junction of M.1 and A.50.

The main development during the first decade will be around the existing towns and in the city centre. A spur will be extended towards Newport Pagnell, and in 1979 the city is expected to take the form shown in Figure 2.2.

2.4 Method of Traffic Assignment

2.4.1 Zoning of residential and work areas

In order to estimate the number and distribution of trips in a town it is necessary to break the town down into a number of discrete "zones". The first stage of assigning trips to the transport links is then to calculate the matrix representing travel from each zone to every other zone. To obtain fine detail it is desirable that the zones should be small, and as far as possible homogenous in structure.

In this estimated traffic assignment for Milton Keynes only the journey from home to work has been considered, and it is therefore only necessary to consider two types of zones; those containing homes and those containing work places. The size and shape of individual zones is related to the road network, and they should be sufficiently small not to cause any serious errors in the computed traffic flow in their immediate vicinity. The actual numbers of zones are:-

A.3 - 35 zones

b.1 - 47 zones

Milton Keynes 1979 - 49 zones

The distribution of the individual zones for each layout is as follows :-

a) A.3 layout

(i) 12 "dumb-bell" residential areas, each of 15,000 people of whom 5,250 are in employment, There are two zones to each unit, making a total of 24 zones.

(ii) Bletchley, with a total population of 40,000 and a working population of 14,000. This has been considered as one residential zone.

(iii) Wolverton, with a population of 20,000, and a working population of 7,000. This is one residential zone.

(iv) Four industrial regions, each employing 15,000 people. Three of these are treated as single zones, the fourth is two zones.

(v) One industrial zone at Wolverton, employing 6,000.

(vi) One industrial zone at Bletchley, employing 6,000.

(vii) The Central Business District, divided into two zones of 6.000 each.

The toral population is therefore 240,000 and the assumed working population 84,000, of whom 78,000 actually travel on the network.

The Interim Report on Milton Keynes suggests that the working population should in fact be 47% of the total, giving a figure of 115,000 for the total population of 240,000. Assuming that 95,000 of these would travel on the network, (see section 2.5.2(a)), the computed flows on the network should be increased by a factor of:

$$\frac{95,000}{78,000} = 1.22.$$

However, by 1995 the population is likely to be nearer to the normal for the country, and a working population of 41% of the total might be more reasonable. This would give about 80,000 trips to work on the network, as assumed in the distribution model.

b) B.1 layout

Residential

(i) Bletchley - working population 14,000

(ii) Wolverton - working population 5,000

(iii) New Bradwell - working population 2,000

(iv) Stony Stratford - working population 1,500

(v) The remainder of the working population distributed through the residential area in zones, at between 1500 and 2000 per half mile square.

Work

(vi) Bletchley old industrial site - 6000 jobs

(vii) Wolverton - 6000 jobs

(viii) Four industrial zones each employing 15,000 people

(ix) Bletchley town centre - 2000 jobs

(x) New city centre - 10,000 jobs.

The assumed total population is therefore 240,000, with a working population of 84,000. In the light of the Milton Keynes Interim Report the working population might be as high as 115,000 in which case the computed flows should be increased by a factor of 1.22. However, on the alternative assumption of 49% working population, the flows would be correct.

c) Milton Keynes 1979 layout

Residential

(i) Bletchley, divided into three zones with a total population of 28,000

(ii) Wolverton, one zone of 8,000

(iii) Stony Stratford, one zone of 4,000

(iv) New Bradwell, one zone of 2,000

(v) 27 zones, mostly kilometre squares, with populations varying between 2,000 and 4,000.

Work

(vi) Wolverton - 6,000 jobs

(vii) Old Bletchley - 6,000 jobs

(viii) New Bletchley, divided into three zones, with a total of 6,000 jobs

(ix) Shopping centres in Bletchley, Wolverton and Stony Stratford - total 4,000 jobs

(x) New City Centre - 5,000 jobs

(xi) Seven industrial zones with between 1,500 and 6,000 jobs.

The total population is 120,000, with 55,000 jobs. There are 5,000 jobs in local areas, which do not contribute to work trips on the network. It is assumed that on any particular day a further 5,000 are absent from work (see Section 2.5.2(a)), leaving 45,000 who travel on the network. It is only these workers who are included in the above analysis of jobs.

This is in agreement with the figures given in the Interim Report, so no adjustment is required to the flows devised on this network.

2.4.2 Gravity Model - formation of Trip Matrix

The matrices of trip distribution between origin and destination zones were computed by means of a gravity model. In this the number of trips T_{ij} between zones i and j is given by:

$$T_{ij} = \frac{K.O_i D_j}{(R_{ij})^n}$$

where O_i is the number of origins in Zone i

D_j is the number of destinations in Zone j

R_{ij} is the measure of deterrence to travel

K is a scaling constant

n is a number between 0 and 3.

In this case the travel deterrence R_{ij} was taken simply as the journey time between the two zone centroids. The derivation of this is described in the next section.

A value for n of 2 was chosen for all three layouts. This is of the same order as values commonly taken to derive trip matrices in densely populated areas, and usually gives quite a good fit with data derived from traffic surveys. It does however describe a situation where travel is difficult, owing to road congestion, and implies a strong disincentive to make trips to work which are any longer than strictly necessary.

It was felt that in a new town like Milton Keynes in which it is hoped traffic will flow freely, even at rush hours, the disincentive to long trips to work may be much less, and the inverse square gravity model may be too fierce. A further computation was therefore carried out on the 1979 Milton Keynes layout, with a value for n of unity. The use of this inverse single power gravity model raised the average journey distance from 2.1 to 2.6 miles, and caused a very significant increase in flow on certain links.

2.4.3 Assignment to road layout

In order to assign the trips to appropriate links in the road network it is necessary to find the shortest (time) paths between origins and destinations. In order to do this it is necessary to define the links in the road network in terms of length of link, average speed on it, and turning penalties at junctions.

For each of the networks investigated the complete primary road network was included in the model, and was assumed to operate at a speed of 40 m.p.h. In addition, a notional secondary road network was modelled, with the intention of loading traffic on to the primary road network in a realistic manner. This was assumed to operate at 20 m.p.h. The A.3 and B.1 primary networks were assumed to have grade separated intersections, with various turning penalties to account for the negotiation of roundabouts.

For the Milton Keynes 1979 layout main roads were given turning penalties of 20 seconds for left or right turns, but no penalty was given to traffic going straight on as junctions were assumed to be controlled by traffic lights operating a "green-wave" system. Secondary road junctions were given penalties of 15 seconds for left turn, and 25 seconds for straight on or right turns.

The trip origins and destinations for each zone were applied to the network at suitable nodes in the secondary network. In the Milton Keynes 1979 layouts there were mostly secondary road links within each 1 Km. square zone. A tree building programme was used to find minimum paths between each zone pair, and the trip distribution computed by the gravity model was subsequently assigned to these minimum paths.

It was hoped that the speeds and turning restrictions assumed for the network would ensure that traffic travelling further than to an adjacent zone would use the primary road system for the major part of the trip. This appears to have happened in most cases, but on the A.3 network there are several cases of high traffic flows taking short cuts on secondary roads through residential areas. The network will obviously have to be modified to prevent this.

2.5 Traffic flow estimates

2.5.1 Total journey statistics

A summary of the main statistics for each of the networks is given below :-

Network	Exponent in gravity model	Mean journey length miles	Mean journey time mins.	Average speed m.p.h.	Peak 1-way flow
A.3	$1/T^2$	3.15	7.3	25.9	10483
B.1	$1/T^2$				
MK 1979	$1/T^2$	2.08	4.75	26.3	5087
MK 1979	$1/T$	2.65	5.71	27.8	5989

Notes : (i) The average speeds shown for the MK 1979 layouts are probably rather high, as the primary roads have been assumed to operate at the same speeds as the grade separated primary roads of the A,3 and B.1 layouts.

(ii) The average flows are very much lower than the maximum flows shown. This applies particularly to the A.3 layout, in which high flows are confined to short lengths of the primary network.

The detailed assignment to the Milton Keynes 1979 layout of traffic distributed according to the inverse square gravity model is considered in a later section.

Assignments to the other layouts have not yet been considered in detail. Two points are however worthy of comment :-

(a) Apart from a few links carrying very high densities, the average flows on the A.3 network seems to be remarkably low. Although the primary road network for this was laid out using a small number of high quality roads, it appears that in practice relatively cheap roads would suffice for the majority of links. It would appear to be worth considering the economics of this layout in more detail.

(b) Comparing the inverse square and inverse single power gravity distribution models for the 1979 Milton Keynes layout, it appears that although the average journey length is not changed very much, there are significant differences in some areas of the detailed flow pattern This suggests that although such gravity models may give a useful "broad brush" treatment, they should not be relied upon to give a very detailed prediction of traffic flow in cases where no calibration data is available.

2.5.2 Derivation of peak hour flows

The flows derived above refer to the total journey to work. These flows have to be factored to find the peak flow rate. The factors which have to be considered are :-

(a) Proportion of workers not working on a particular day (sickness, absenteeism, holidays, etc.). This is estimated to be 10%.

(b) Proportion of workers employed close to home, who will walk to work. This is estimated at 10%.

These two effects add up to 20% of the work force, and have already been allowed for in the trip assignment (Section 2.4.1).

(c) It is assumed that 80% of home to work trips will take place in the two hours peak period. In addition there is a proportion of non work trips taking place at the same time, so that the total flow in the peak two hours is increased by about 15%. This gives a total flow in the peak two hours of 95% of the total flow of home to work trips.

(d) Two-thirds of the peak flow is assumed to occur in the peak hour. It will therefore be assumed that peak hourly flow rates are 0.67 x o.95 of the total home to work flows, which, rounding up slightly is 65%.

(e) There will be some sharing of cars, though this is likely to be less in a new town situation than in existing towns. If the average occupancy of a car is 1.2, the peak flow rates should be reduced by this factor. This gives a final reduction factor to derive peak flow rates from total journey to work flows of 0.65/1.2, which is approximately 55%.

(f) So far it is assumed that everyone travels by car. In practice there will be some use of public transport, and the car flow rates will be reduced accordingly. The total flow rates will be reduced by a lower factor as the non car passengers will (it is assumed) travel by bus, and the p.c.u. contribution of the buses must not be overlooked.

2.5.3 External traffic

All the traffic assignments described in this report have ignored the fact that there will be some journeys crossing the boundary between Milton Keynes and the surrounding region. Some estimates of the numbers of these external trips expected in 1981 have been given by Lennox, Clark and Tidbury (C.of A. Memo No. 170), and a summary of their main results is given here. The region around Milton Keynes was divided into zones as shown in Figure 2.7.

Work Journeys into Milton Keynes

An analysis of 1966 Census data for work trips to existing major towns (Bletchley, Bedford, Luton and Northampton) suggests the use of a gravity model of the type;

$$T_{ij} = k.O_i.D_j e^{-m.d_{ij}}$$

Values of the constants assumed for workers of average mobility are;

Male : $m = 0.30$ $k = 40$

Female : $m = 0.35$ $k = 100$

and the deterrence function d_{ij} is taken as pure distance. The higher figures for females imply lower mobility, due to the husband using the family car.

It is assumed that 15% of male and female jobs in Milton Keynes are filled from outside the city. The flows of traffic entering the city from eight sectors is shwon in Figure 2.8. The largest single source of external trips is Newport Pagnell, and we suggest that future traffic assignments should include this town within the Milton Keynes area for analysis purposes.

Work journeys out of Milton Keynes

Estimates of journeys to work outside the city are based on Census date giving the movements of people living in Wolverton and Bletchley. It is assumed that 20% of male and 10% pf female workers from Milton Keynes will work outside the city. The working population in 1981 is expected to be about 60,000, of which 40,000 are male and 20,000 female: hence 10,000 journeys out of the city will be made each day. Of these, about 1,750 are expected to be to the Greater London area: the distribution of the remainder is shown in Figure 2.9.

An extrapolation of present numbers of commuters to London using Bletchley and Wolverton stations shows that about 200 persons per day will be using these stations in 1981, in addition to traffic generated by the presence of the new city. Parking spaces for these travellers will be required in Milton Keynes.

It is not easy to assign road traffic bound for London to any particular route, as the M.1 Motorway will probably be carrying its full capacity even without Milton Keynes traffic. Cars unable to join the motorway will probably follow the A.5, unless a second motorway route is constructed.

Shopping journeys to Milton Keynes

An analysis of Saturday morning shoppers in an existing new town (Stevenage) showed that 40% had come from the surrounding region. Even allowing for the fact that Milton Keynes is surrounded by a less densely populated region, we can expect of the order of 10,000 shoppers in the city centre on Saturday. It may be found that shopping journeys create a bigger traffic flow than work trips in view of the facts that;

(a) the city centre will provide a bigger attraction than the suburban shopping centres, since some of the bigger stores would be situated only in the centre, and

(b) the family car will be both available and necessary for shopping trips on Saturday morning.

The estimated distribution of Saturday shopping journeys is shown in Figure 2.10.

Assignment of External Journeys to the Road Networks

It has not been possible in the time available to assign external journeys to the grid, and we recommend that this should be done in the next stage. However, it is not expected that the addition of these journeys will change the presently available flows by large amounts, except on the roads leading into the city which are very lightly loaded by internal traffic.

2.5.4 Modal Split

It is not possible at present to make any very meaningful estimates of modal split. Using buses on a grid road network it seems unlikely that a public transport system can be provided which will approach the journey times possible by car. An average journey by car will be of the order of 5 or 6 minutes, assuming that traffic flows freely. A comparable journey by bus would take about 10 minutes. If buses serve all four sides of each 1 Km. square, the average walking distance to a bus stop is about 350 yards, giving a total walking time (both ends of the journey) of 7 minutes. Under ideal conditions, with no interchanges, the average walking and waiting time is unlikely to be less than 10 minutes, giving an average total journey time of the order of 20 minutes, 14 or 15 minutes longer than by car. (This may be somewhat pessimistic as walking distances from buses to shops and other centres may be less than average). Under these circumstances a very small proportion (about 5%) of the population to whom a car is available would use public transport, and one must assume that the proportion of trips made by public transport is almost equal to the proportion of people who have no car available, at the time at which they wish to travel. This includes both families without cars, and people who are too young or too old to drive, and people in one car families where someone else is using the car. It is difficult to estimate the proportion of trips to which this applies, but it is unlikely to exceed 20%. The maximum usage of public transport is therefore unlikely to exceed 25%, and may well be much less outside peak hours.

Improved public transport, such as dial-a-bus systems going much closer to people's homes, might improve the situation somewhat, but would be unlikely to make a dramatic change in the situation.

2.6 Recommendations for further study

2.6.1 Traffic Assignments - work trips

We recommend that traffic assignments of journeys to work should be made on all the networks considered, i.e. A.3, B1, and the Interim Report network, taking into account the probable numbers of trips between Milton Keynes and the surrounding region. In particular, we suggest that Newport Pagnell, and to a lesser extent Woburn Sands, should be regarded as part of the Milton Keynes area for transport purposes, whether or not they form part of the administrative area.

2.6.2 Saturday shopping

We recommend that some investigation should take place into traffic assignment for Saturday journeys. The centre of Milton Keynes is likely to prove attractive to shoppers from the outer regions of the city and from outside the city. Particular attention should be paid to the following points :-

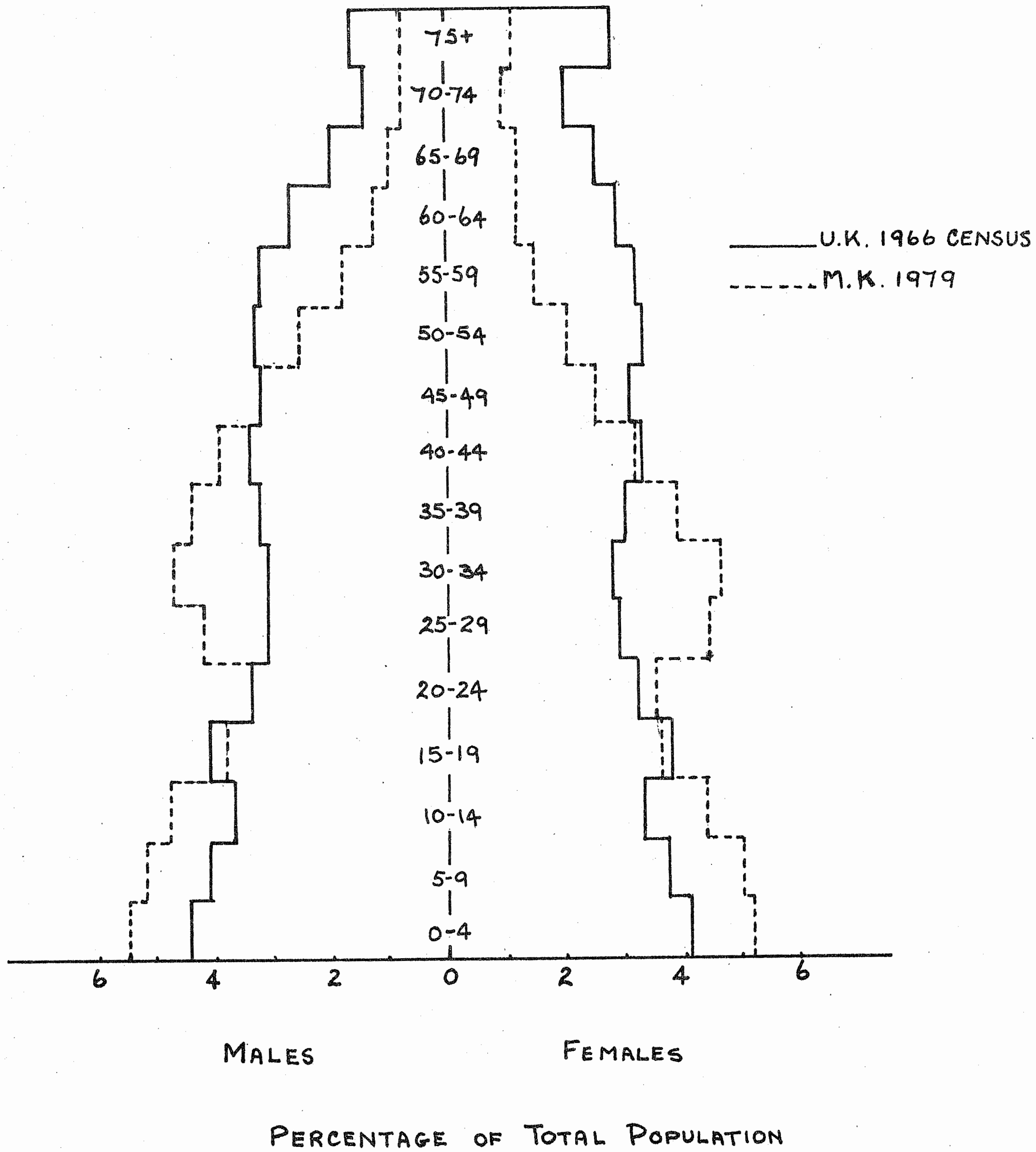
(a) The proportion of shopping journeys from outside the city is likely to be higher than for work journeys. A survey in Stevenage showed that 40% of Saturday shoppers were from outside the town.

(b) The proportion of shopping journeys by car is likely to be higher than for work journeys as the family car will be available, and will be necessary to carry purchases.

2.6.3 Commercial vehicle movements

A synthesis of commercial vehicle movements should be carried out using typical trip generation rates for the different industrial types and a simple distribution model. By allocating industries to different sites in turn, some planning guide lines for location of industry may become apparent, e.g. industries with high traffic generating capacity should not be located at the M.1 interchange industrial site or else the interchange will become saturated with these movements.

Fig. 2.1.



COMPARATIVE AGE STRUCTURE OF POPULATION

FIG. 2.2.

MILTON KEYNES: FIRST STAGE DEVELOPMENT

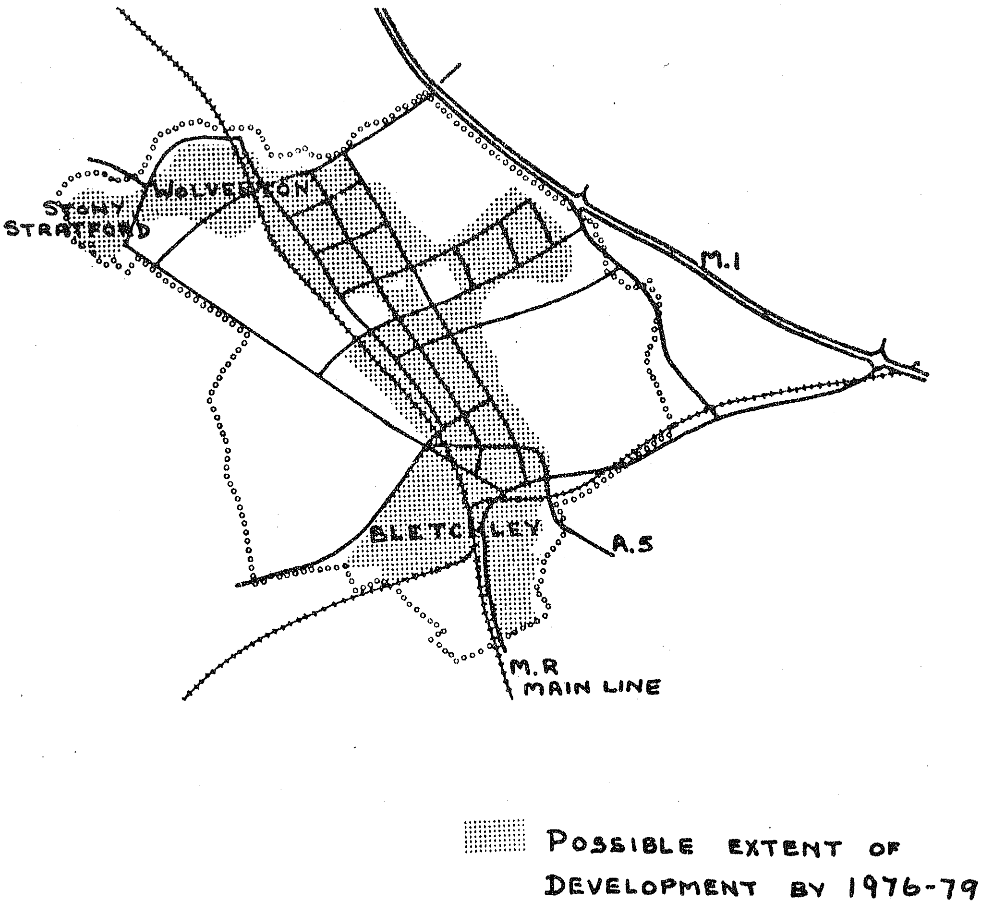
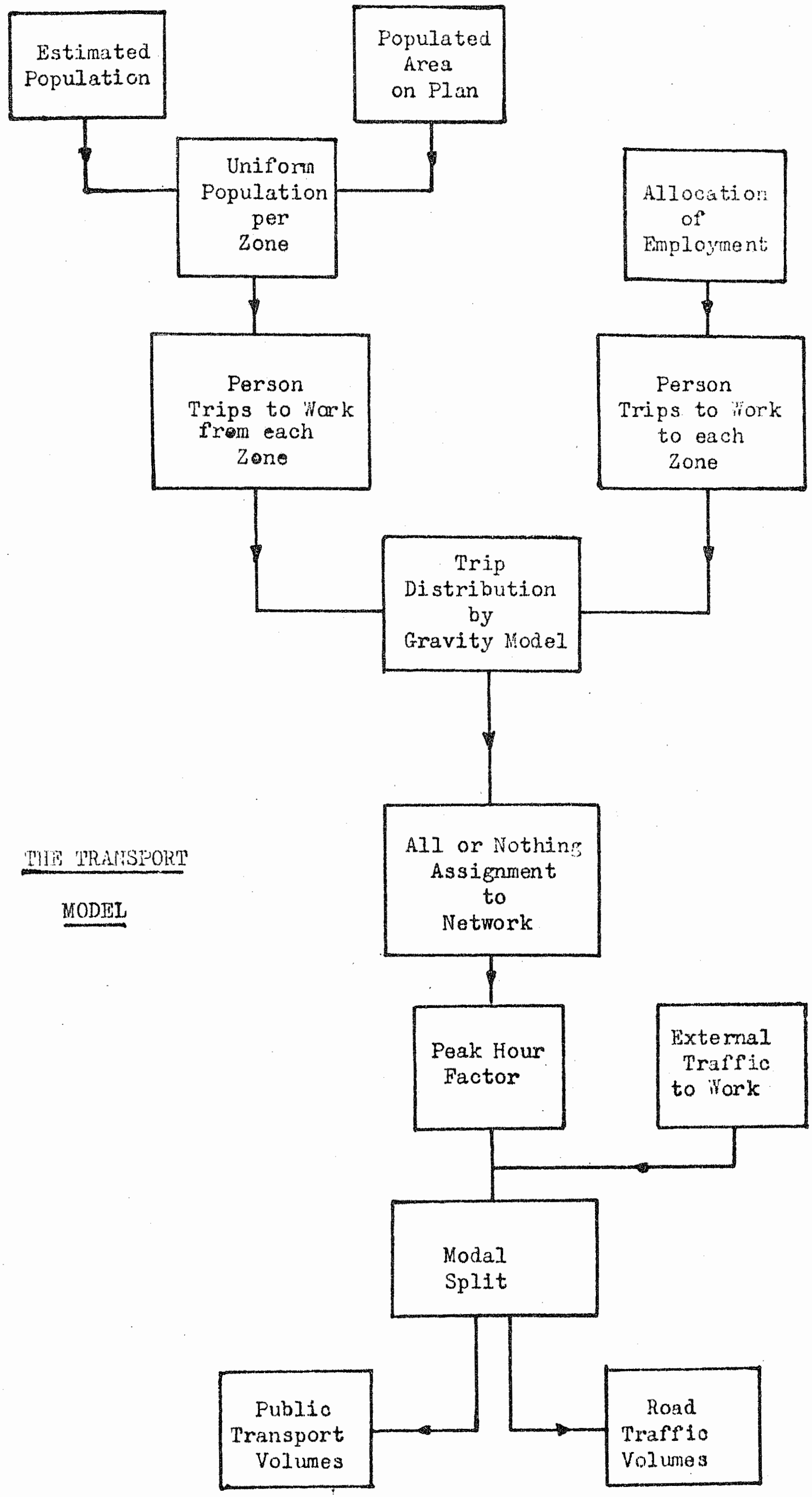


FIG. 2.3.



THE TRANSPORT MODEL

FIGURE

MILTON KEYNES : LAYOUT A 3.

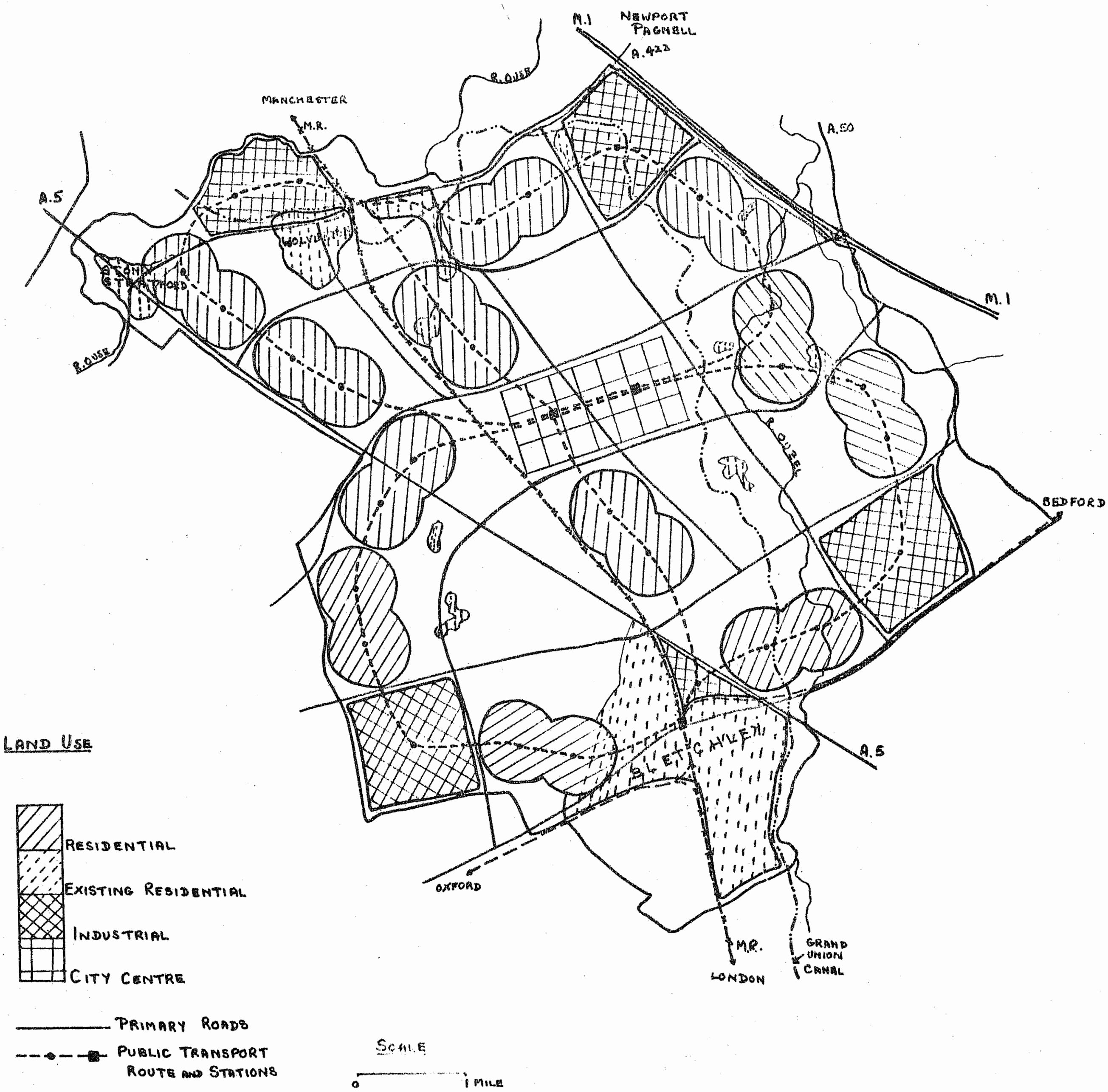


FIGURE 2.5

MILTON KEYNES : LAYOUT B1.

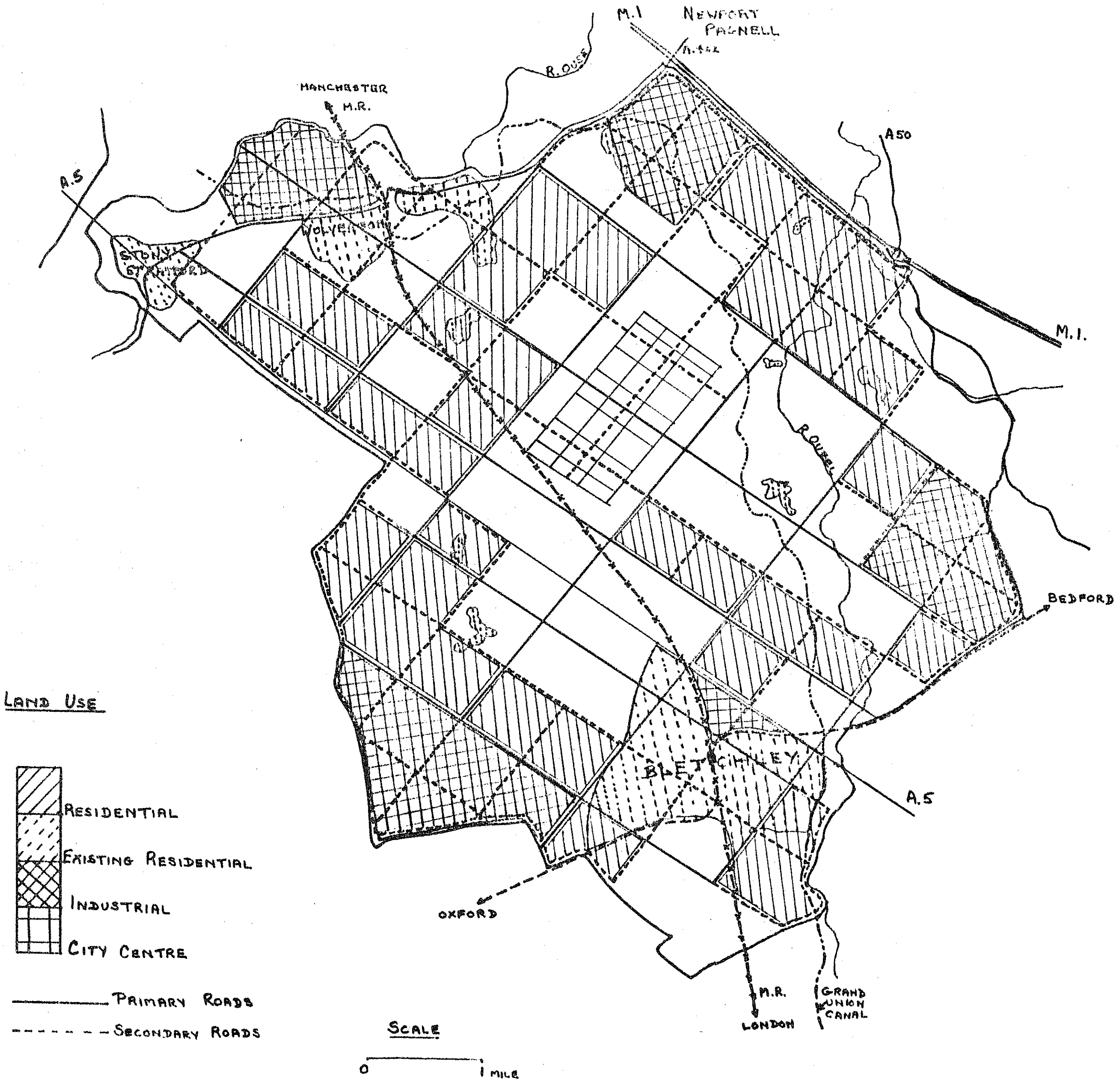


FIG. 2. 6.

MILTON KEYNES : INTERIM PROPOSALS

EXISTING TOWNS AND VILLAGES
NEW RESIDENTIAL AREAS
INDUSTRY
NEW CITY CENTRE
LOCAL CENTRES
SECONDARY SCHOOL GROUP
E HIGHER EDUCATION CAMPUS
H HEALTH CAMPUS

EXPRESSWAY/MOTORWAY
PRIMARY ROAD
RAILWAY

FIG. 2.8.

REGIONAL WORK JOURNEYS TO MILTON KEYNES: 1981

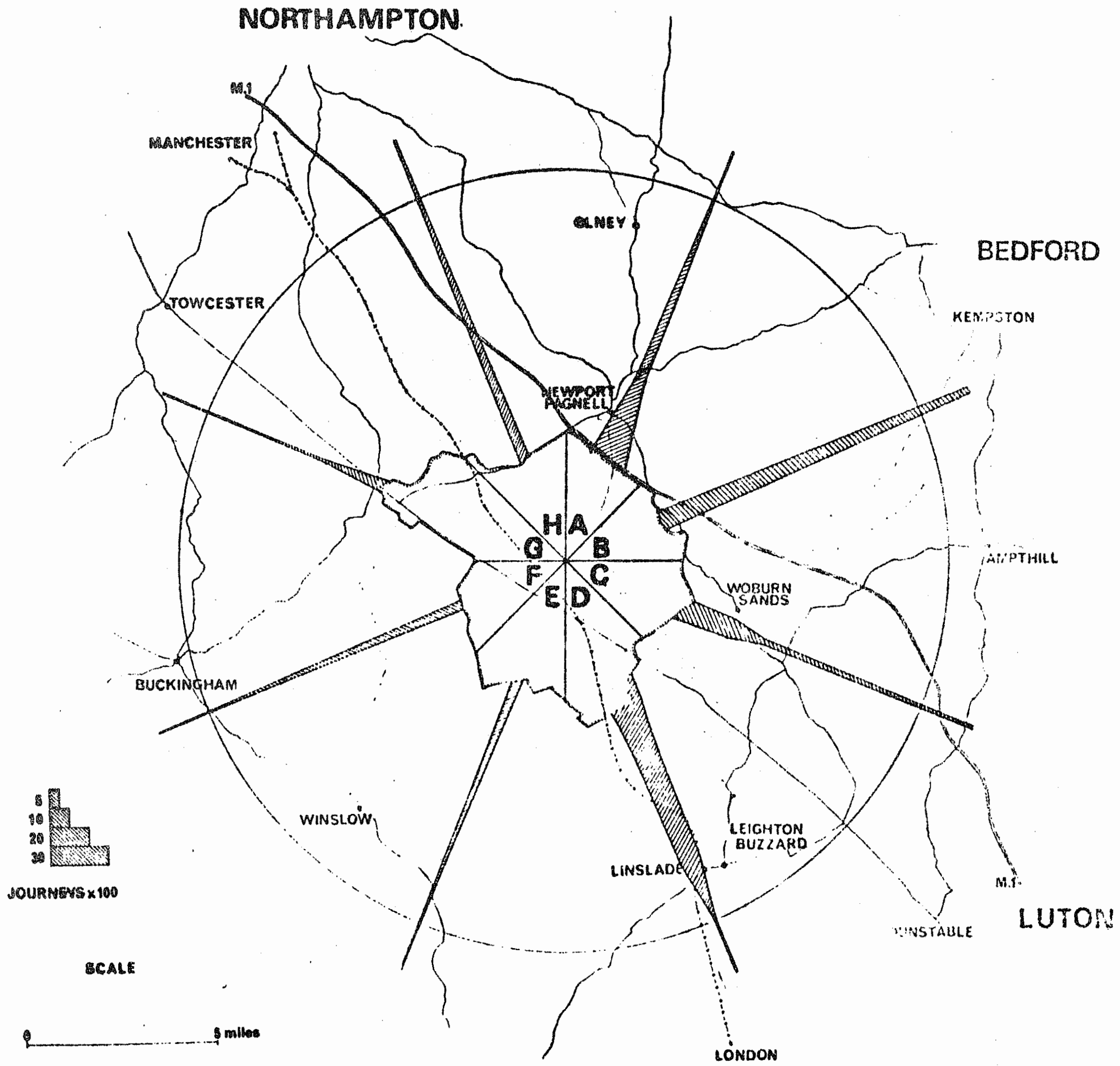


Fig. 2.9.

WORK JOURNEYS FROM MILTON KEYNES: 1981

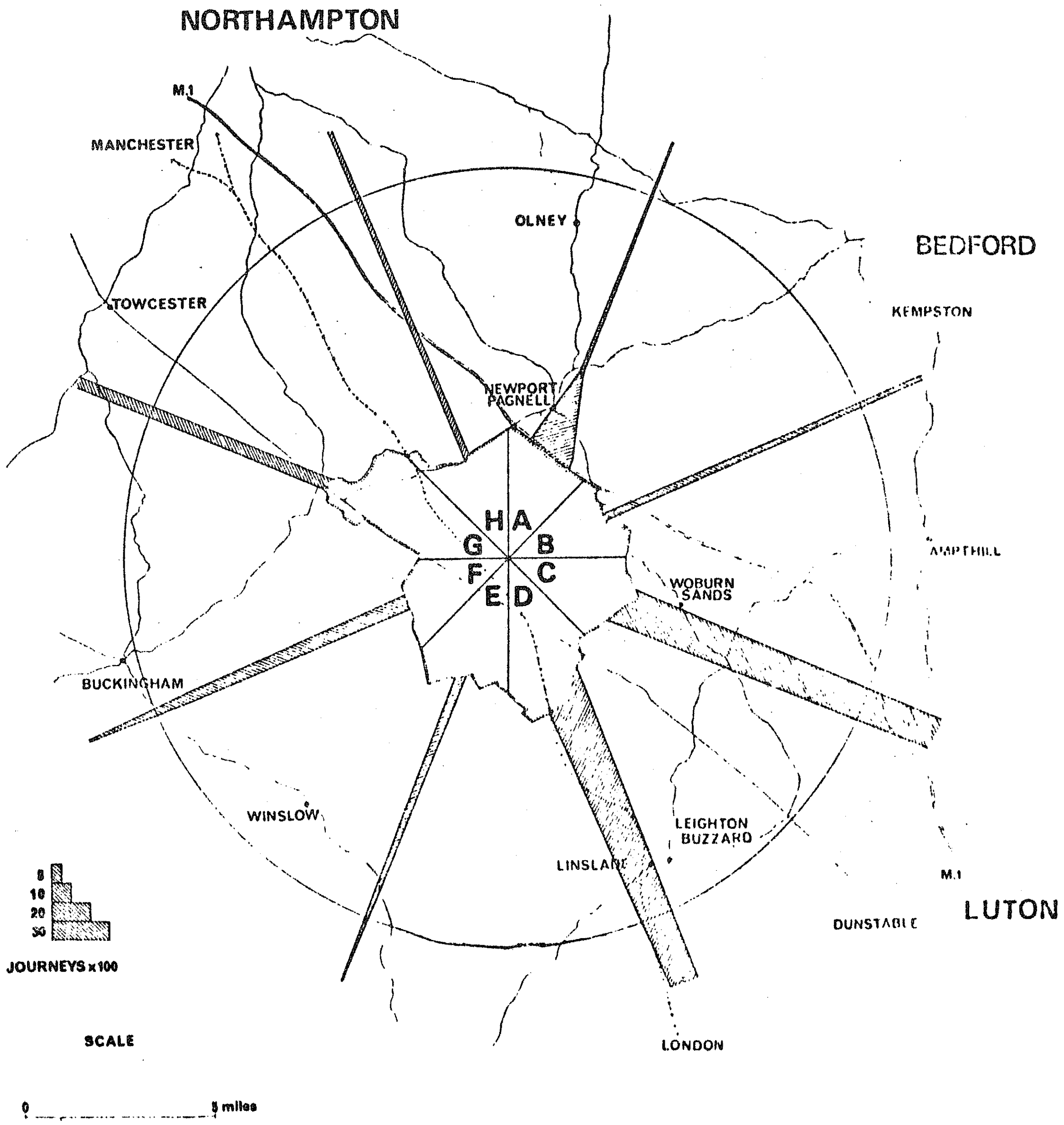
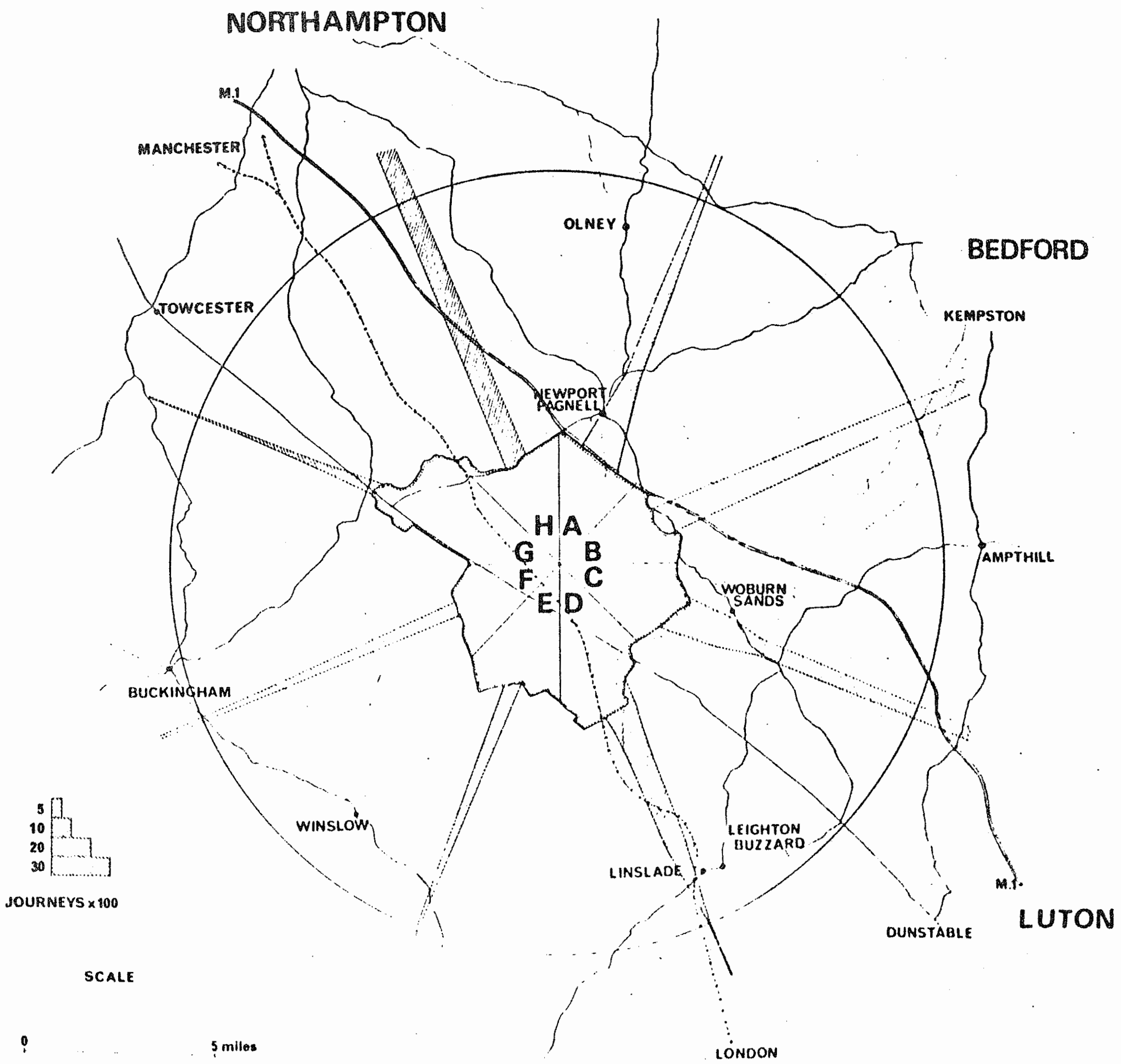


Fig. 2.10.

REGIONAL SATURDAY SHOPPING JOURNEYS TO MILTON KEYNES: 1981



(c) Figures 3.1d and 3.1e would produce more uniform flows (especially Figure 3.1e) than the previous alternatives. A combination of these two distributions, which is proposed, seems the most acceptable solution from a road traffic viewpoint.

This choice, of course, stems directly from the recognition of the private car as the major mode of transport for a small city. (For a large city with fixed track public transport necessarily in mind the solution would be quite different. However, to design a large city would be contrary to the basic aim of new town proposals, which is to reduce or contain the growth of already over-large conurbations.)

Having decided on a policy of employment dispersal, the choice of a grid system of roads seems an obvious and logical proposal. This should produce bi-directional peak flows which will be fairly evenly spread throughout the city.

3.2.2 An independent check on the evidence

In this section a simple method is devised for estimating the number of lane-miles required.

Consider the urban form shown in Figure 3.1a. R_1 and R_2 are the radii of the employment zone and the outer boundary respectively, $g(r)$ the population density at radius r ($R_1 \leqslant r \leqslant R_2$) and $f(r)$ the proportion of the population wishing to travel to the employment zone.

In an annulus of width δr there are $g(r) . 2\pi r . \delta r$ people. The number wishing to travel from this element is $f(r) . g(r) . 2\pi r . \delta r$ and their person-miles is $f(r) . g(r) . 2\pi r^2 . \delta r$.

The total person-miles P is

$$P = 2\pi \int_{R_1}^{R_2} f(r) . g(r) . r^2 dr \tag{1}$$

and the total number travelling Q is

$$Q = 2\pi \int_{R_1}^{R_2} f(r) . g(r) . r dr \tag{2}$$

The mean distance travelled is,

$$\bar{R} = \frac{P}{Q} \tag{3}$$

The problem is further simplified by assuming a uniform density for the population, i.e.

$$g(r) = \sigma \tag{4}$$

and a proportion 'a' of the population employed, where 'a' is independent of r,

$$f(r) = a. \tag{5}$$

Equations (1) and (2) now become,

$$P = 2\pi a\sigma \int_{R_1}^{R_2} r^2 dr = \frac{2\pi}{3} a\sigma (R_2^3 - R_1^3) \tag{6}$$

and

$$Q = 2\pi a\sigma \int_{R_1}^{R_2} r . dr = \pi a\sigma (R_2^2 - R_1^2) \tag{7}$$

The mean distance travelled $\bar{R}$ given by (3) is,

$$\bar{R} = \frac{P}{Q} = \frac{2(R_2^3 - R_1^3)}{3(R_2^2 - R_1^2)} \tag{8}$$

From page 166 of the Interim Report, it can be seen that the area of employment (2400 acres) is only 10% of the total land area, i.e., $R_1^2 << R_2^2$ and hence $R_1^3 << R_2^3$. Therefore, R_1^2 and R_1^3 can be neglected compared with R_2^2 and R_2^3.

From (8),

$$\bar{R} = \frac{2}{3} R_2$$

(For convenience we may drop the suffix and write R_2 as R).

$$\bar{R} = \frac{2}{3} R \tag{9}$$

For the simple model shown in Fig.2.

For this simple model, the person-miles are,

$$P = \frac{2}{3}\pi a\sigma R^3 = \frac{2}{3} aN.R \tag{10}$$

and the total number travelling

$$Q = \pi a\sigma R^2 = aN \tag{11}$$

where N is the total population, given by

$$N = \pi R^2 \sigma \tag{12}$$

For the modal split, we shall ignore walking and cycling and allocate proportions travelling by private and public transport as b_1 and b_2, respectively, where,

$$b_1 + b_2 = 1 \tag{13}$$

The person-miles are now,

$$\left.\begin{array}{lll} \text{(i)} & \text{Private transport,} & \frac{2}{3}aNR.b_1 \\ \text{(ii)} & \text{Public transport,} & \frac{2}{3}aNR.b_2 \end{array}\right\} \tag{14}$$

To convert these to p.c.u. miles, if there are on average C_1 persons / car and C_2 persons / bus, each bus being equivalent to d p.c.u., we have,

$$\left.\begin{array}{lll} \text{(i)} & \text{Private transport,} & \frac{2}{3}aN\frac{b_1}{c_1} \text{ p.c.u. miles} \\ \text{(ii)} & \text{Public transport,} & \frac{2}{3}aN\frac{b_2}{c_2}d \text{ p.c.u. miles} \end{array}\right\} \tag{15}$$

From (15) the total p.c.u. miles is

$$\frac{2}{3}aNR\left\{\frac{b_1}{c_1} + \frac{b_2}{c_2}d\right\} \text{ p.c.u. miles} \tag{16}$$

If this travel takes place in time t hours, the mean flow, $\bar{T}$, is

$$\bar{T} = \frac{2}{3}\frac{aNR}{t}\left\{\frac{b_1}{c_1} + \frac{b_2}{c_2}d\right\} \text{ p.c.u. miles / hr.} \tag{17}$$

If the average design flow is $\bar{f}$ p.c.u. / lane / hour, the total lane requirement, L is,

$$L = \frac{\bar{T}}{\bar{f}} = \frac{2}{3}\frac{aNR}{\bar{f}t}\left(\frac{b_1}{c_1} + \frac{b_2}{c_2}d\right) \text{ lane-miles} \tag{18}$$

3.2.3 Numerical values

Having derived the simple relation for lane-miles given in (18), we can now insert some numerical values.

First, the area of Milton Keynes is 22,000 acres or 34.4 square miles.

Therefore,

$$R = \sqrt{\frac{34.4}{3.14}} \sim 3.3 \text{ miles} \tag{19}$$

The average distance travelled is,

$$\bar{R} = \frac{2}{3}R = 2.2 \text{ miles} \tag{20}$$

Now, suppose we take rather pessimistic values for the other quantities in (18), i.e. high values in the numerator and low values in the demoninator. For example,

N = 250,000 people. (This is said to be the ultimate population).

a = 0.5 (i.e. 50% of the population are employed).

t = 1 hour (i.e. all the traffic flows in peak of one hour duration).

b_1 = 0.8 (80% travel by private car)

b_2 = 0.2 (20% travel by public transport)

c_1 = 1.2 persons / car

c_2 = 20 persons / bus

d = 3 p.c.u./ bus (a slightly high figure)

$\bar{f}$ = 550 p.c.u./ lane / hour.

Substituting these values in (18),

$$L = \frac{0.5 \times 250{,}000 \times 2.2}{550 \times 1} \left(\frac{0.8}{1.2} + \frac{0.2 \times 3}{20} \right)$$

$$= 350 \text{ lane-miles} \qquad (21)$$

The person-miles are,

$$P = \frac{2}{3} \times 0.5 \times 250{,}000 \times 3.3 = 275{,}000 \text{ person-miles} \qquad (22)$$

3.2.4 Comparison of person-miles and lane-miles in the Interim Report with this calculation

The value of 275,000 person-miles derived here agrees well with the value of 268,000 person-miles given on page 146 of the Interim Report. Therefore, this check suggests that the value given in the report is acceptable.

The lane-miles given in the Interim Report are 340 lane-miles. The value calculated here is 350, but this refers to one direction. For the peak hour flows in both the morning and evening for Diagram a, Figure 3.1 the value would be 2 x 350 = 700 lane-miles. The discrepancy by a factor of 2 would be explained if we suppose the Interim Report had taken the peak flow as of two hours duration, whereas here it has been supposed to take place in one hour.*

For diagram e, Figure 3.1, as the distribution is random, the average flows will be approximately equal in opposite directions,

---

* Since writing this, in a lecture by A.C. Kanen (Peat, Marwick & Kates), given to the group, it was stated that a figure of 55% of the work journeys was taken for the traffic during the peak hour. This confirms the hypothesis above.

so the lane-miles needed will be roughly half of those for Diagram a.

This agrees with the assessment in the Interim Report (for a 2-hour peak period). Values are summarised in Table1, those from the Interim Report being shown in brackets.

TABLE 1 ESTIMATED LANE-MILES REQUIRED
80% Private 20% Public Transport

Duration of peak	Diagram a Fig. 3.1	Diagram e Fig. 3.1
1 hour	700	350
2 hours	350 (340)	175 (170)

The modal split used above represents about the highest car traffic likely to be experienced (80%). A minimum ultimate value would perhaps be 50%. On this assumption the lane-miles given in Table 2 have been obtained.

TABLE 2 ESTIMATED LANE-MILES REQUIRED
50% Private 50% Public Transport

Duration of peak	Diagram a Fig.3.1	Diagram e Fig. 3.1
1 hour	490	245
2 hours	245	123

3.2.5 Estimation of lane-miles implied by the Interim Report

The next step is to estimate the lane-miles provision implied by the Interim Report.

Suppose the circle, area A square miles, is divided into squares as shown in Figure 3.3. If each square has a length of side ℓ miles, the number of squares is approximately $\frac{A}{\ell^2}$.

If all the roads were only one way (Figure 3.4a), the lane-miles per square are 4ℓ and the total lane-miles =

$$4\ell . \frac{A}{\ell^2} = 4\frac{A}{\ell} .$$

This, of course, represents the minimum provision under the scheme proposed in the Interim Report.

If half the roads were two lanes each way and half one lane each way, the lane-miles would be $6\frac{A}{\ell}$ (Figure 3.4b).

If all the roads were two lanes each way, the total lane-miles would be $8\frac{A}{\ell}$ (Figure 3.4c).

For 1 Km. squares $\ell \sim \frac{5}{8}$ mile. The lane-miles are given in Table 3.

TABLE 3 ESTIMATES OF LANE-MILES "PROVIDED"

All roads one lane each way (Fig. 3.4a)	220
Half of roads one lane each way, half two lanes each way (Fig. 3.4b)	330
All roads two lanes each way (Fig. 3.4c)	440

Obviously, it is not suggested that the pattern of lanes will follow any of the sketches in Figure 3.4. These are merely intended to give an indication of the relative proportions.

Figure 3.4c would probably represent an over-provision of roads. Figure 3.4a represents an under-provision of roads as the traffic flows indicate that many of them will need to be dual carriageway, some perhaps having 3 lanes each way.

Perhaps Figure 3.4b at 330 lane-miles will represent the right order of magnitude, although the exact distribution of single and dual carriageways will depend on numerical values of traffic distribution. An independent estimate given in Section 3.3.2 below gave a value of 379 lane-miles. This agrees well with the approximate value of 330 lane-miles derived here. These values are considerably higher the 170 to 220 lane-miles estimated on page 146 of the Interim Report.

3.2.6 Gravity models

In the previous discussion it has been assumed that there is no gravitational "attraction", i.e. no desire of people to live near their places of employment. This is a (deliberately) pessimistic assumption, as mentioned previously. Elsewhere in this report calculations of traffic flows have been carried out for gravity models of the form,

$$f(r) \propto \frac{1}{r} \quad \text{and} \quad f(r) \propto \frac{1}{r^2}$$

The latter seems a rather severe form of distribution for a small city where the travel deterrents both in personal time and out-of-pocket expenses are not very large. (The average journey to work is not much more that 2 miles and the city diameter about 7 miles). Perhaps a more realistic function would be

$$f(r) \alpha \frac{1}{r^a} \quad \text{for a between 1.2 and 1.3.}$$

There is some evidence from other studies (e.g. Kushida, J.N.R.), that a better empirical distribution for urban traffic might be an exponential form. Therefore, further theoretical and experimental studies of gravity models applicable to this situation would be useful during the coming months, checking these against actual values obtained in the coming years as Milton Keynes is built.

3.2.7 Growth of cities and travel times

The population N is distributed according to equation (12)

$$\pi\sigma R^2 = N$$

$$\text{or} \quad R \propto \sqrt{N}$$

For travel at speed v and time t,

$$R = vt \propto \sqrt{N}$$

$$\text{or} \quad t \propto \frac{\sqrt{N}}{v} \tag{23}$$

Therefore, even if the growth of a city does not result in lower travel speeds, the increase in travel time is proportional to the square root of the population. From the mean length of the journey to work in Milton Keynes (2.2 miles) at, say, 15 m.p.h., this journey only takes about 10 minutes and about 25 minutes to cross the city. With a city of, say, 4,000,000 population at low density (i.e. a population 16 times as high as Milton Keynes), the corresponding travel times would be about 40 minutes to work and 1 hour 40 minutes to cross the city. Thus, the feature of high density living can be seen to stem, to a large extent, from this desire to reduce travel times as a city grows.

3.2.8 Review

The policy of building new and fairly small cities seems to make sense, in that it avoids increasing and unnecessary waste of time and money due to the traffic build-up in a large expanding city.

From this necessarily brief examination, it does seem feasible to design a city of 250,000 people so that the traffic problem is not a serious one, even for a high car ownership and low residential densities.

Ref.1. Economics, Town Planning and Traffic by D.J. Reynolds, Institute of Economic Affairs, 1966.

(ii) Intersections

number	type	unit cost (£m)	Total cost (£m)
5	6 & 7	0.7	3.5
2	8	0.6	1.2
12	9	0.5	6.0
3	10	0.02	0.06
16	11	0.04	0.64
17	12	0.02	0.34
17	13	0.02	0.34
			12.08

(iii) Internal roads

Assuming total population of 250,000 will need 80,000 houses and each house will require in one form or another 40' frontage onto half width of road then length of internal roads will be

$$\frac{80,000 \times 20}{5280} \text{ miles}$$

$$= 303 \text{ miles}$$

this will allow for access roads to industry and recreational areas.

Cost 303 miles of type 5 at £0.12m/mile = £36.36 M

(iv) Intersections on internal road

Assuming 2 junctions per mile the total cost of junctions will be .. .. 606 at £0.02m = £12.12 M

Total road system cost (i) + (ii) + (iii) + (iv) £94.31 M

Cost per head of population £377

In the earlier stages of development it is reasonable to expect that the figure of £377 per head might be exceeded in that the facilities provided will be in excess of that required.

On the assumption of the fast rate of growth it would seem likely that approximately £50 M will have to be invested in roads by 1979.

3.3 Evidence from other sources

3.3.1 Road capacities

There are two main requirements for a good road network. These are that :-

(i) it is safe

(ii) it permits free flow of traffic at reasonable speeds in peak conditions.

In general the traffic capacity of a network should be balanced against the traffic requirements of the proposed development which it has to serve. The network must be planned as a whole although it will undoubtedly be built by stages to match development. The layout and design must be such that it can carry the ultimate traffic envisaged or at least can be widened or improved as the traffic builds up. Thus for the first stage of development of Milton Keynes great care must be taken to ensure that the initial road network will fit into what is finally needed.

This introduces the problem of predicting future traffic flows. However, a number of methods have been developed in recent years which enable good guesses to be made, particularly where land use and population figures are available.

It is normally accepted that peak flows will be approximately 10% of the average 16 hr. daily flow. The network must be capable of coping with this flow. The link flows can be obtained by one of a number of methods of assignment.

The capacity of a particular length of road is determined by many factors. Some of these factors are :-

(i) width

(ii) gradient - 5% upwards has significant effect

(iii) frontage treatment - restricted access etc.

(iv) waiting restrictions

(v) mixture of traffic - proportion of heavy commercial, P.S.V.'s, cars, cycles, etc.

(vi) pedestrian crossings

(vii) junction treatment - uncontrolled, signal controlled, roundabout or grade separated

(viii) proximity of street furniture.

In considering practical capacities of two-way roads in urban areas, the Ministry of Transport publication "Roads in Urban Areas" reveals clearly the effects of (i), (iii), (iv) and (vii). The capacity in p.c.u.'s per hour for both directions of flow is as follows :

2 lane width	20'	24'
All-purpose road with no frontage access, no standing vehicles permitted and negligible cross traffic	1200	1500
All-purpose street with capacity restricted by waiting vehicles and junctions.	300-500	600-750

It will be noted that increase in width from 20' to 24' in the all-purpose road increases capacity by 25%. The restrictions encountered on the all-purpose street have a dramatic effect and reduce the capacity to between 25% and 50%.

In the latest Ministry of Transport publication relating to "Layout of Roads in Rural Areas" the near proximity of obstructions to the carriageway edge restricts capacity. For example, an obstruction within 2ft. on one side can reduce the theoretical capacity of a 24' carriageway by 9%.

In the same publication the effects of gradient on capacity are detailed. A hill of gradient 1 in 25 and half mile long on a two-lane two way road can have the effect of reducing the capacity of the road from 38% to 66% depending on the percentage of heavy vehicles. This effect will be reduced on dual carriageways.

Perhaps the most likely features to restrict the capacity of a road network are the junctions. This is particularly noticeable in urban areas where there are heavy traffic flows. In fact, more often than not, the capacity of an urban road is governed by the capacity of its junctions. At these points manoevres are made on a common area when there is an at-grade junction. In the uncontrolled situation the junction is an area of high traffic conflict which is reflected in the high accident rates which occur at these points.

In urban areas it is usually necessary to control the main junctions by traffic signals or roundabouts, or to grade separate the conflicting traffic. Where flows are exceptionally heavy, as can be expected at the junctions of Regional Roads and Primary Distributors. It will be essential to provide grade separated junctions. It is noticed that this type of junction is shown in only one place on the Milton Keynes Interim Report although undoubtedly there will be other places where they will be necessary.

Decisions at other junctions in Milton Keynes will not be quite so clear cut. Webster and Newby[1] in their research into the relative merits of roundabouts and traffic signal-controlled intersections concluded among other things that :-

1 Research into the relative merits of roundabouts and traffic signal-controlled intersections - F.V. Webster and R.F. Newby - Proc.Inst.C.E. January 1964.

(i) for a wide range of conditions traffic signal controlled junctions usually require less land than roundabouts, but where there are many right-turners (20% - 40%) the reverse is often true.

(ii) there is some evidence that the accident rate is lower at ordinary 4-way roundabouts than at traffic signals.

More recently linked signal systems have been developed and this may be considered appropriate on the Primary Distributors in Milton Keynes. At intersections on local distributors either traffic signals or roundabouts would be used, the choice depending on the traffic flows and percentage of right-turning traffic. It is generally considered that where the proportion of right turning traffic exceeds 25% then a roundabout is more advantageous.

A recent experiment[1] in Peterborough indicated that a roundabout with a diameter of only 10' was satisfactory to deal with heavy traffic flows. Admittedly the experiment was conducted at a T-junction with wide approach roads. Could the small roundabout be the answer at the junctions in Milton Keynes?

3.3.2 Road costs

In the Interim Report there is no indication of the capital costs of providing the proposed road network. It is understood that the road system will cost approximately 5% of the total capital costs of development.

From the plan showing the interim proposals there would appear to be very approximately

(i) 12.5 miles of Urban Motorway

(ii) 86 miles of combined Primary and Local Distributors.

In the absence of traffic assignments for the complete development it is difficult to make an intelligent guess at the total cost. The problem lies in (ii) above, where to cost accurately it is necessary to know what types of road are required. In fact it is more than likely that certain roads will be single carriageways initially with at-grade junctions but in the ultimate will have to be dual carriageways with grade separate junctions.

The cost of constructing the road network will not be as heavy as constructing a similar system in an existing urban area. In the event it would seem that rural road construction costs would give a reasonable guide.

1 Improving the capacity of roundabouts - Surveyor 29th March, 1969.

3.3.3 Brief comparison of 1 mile and 1 Km. grids

The Interim Report reveals that two grid sizes were examined, one with roads spaced one mile apart and the other with roads one kilometre apart. It was concluded that the 1 Km. grid could be provided at a somewhat lower cost. This would appear to be because a one-mile grid would need grade separated junctions whereas the 1 Km. grid could function with at-grade junctions.

The optimum grid mesh model produced by S.G. Lennox and J.M. Clark[1] points to a grid size of 0.75 miles as the optimum. This is slightly larger than that suggested in the Interim Report, but only marginally so and would seem to indicate that the 1 Km. grid is just about right.

3.3.4 Ability of network to carry traffic loads

It would appear from the limited information available that the grid system can be constructed to cater for the traffic flows envisaged.

Care must be taken with junction design and it may be necessary at a later date to consider certain traffic management measures on heavily loaded sections.

As has been mentioned in Section 3.4.4, access and junctions must be limited to achieve maximum benefit from the network.

3.3.5 1979 Network load implications

Two assignments of traffic to the 1979 network have been made. These were based on person work trips obtained from two different gravity models. One of these models was based on an inverse square law and the other on inverse single power. The latter appears to give heavier flows in nearly every link and it is these figures which will be considered.

The following assumptions will be made :

(i) 65% of person work trips will be made in the peak hour.

(ii) there are 1.2 persons per car.

(iii) there are 20 persons per bus

(iv) external trips are considered to add 25% to the assigned flows

(v) a bus is equivalent to 3 p.c.u.'s.

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1 S.G. Lennox & J.M. Clark: "Urban Transport Systems Analysis" Proc of Symp. on Compatibility of Transport Systems, Loughborough (March 1969).

It is considered that these assumptions will give the worst conditions which can be expected, particularly as it is unlikely that the external trips will be spread over the whole network.

From the above assumptions the following table can be formed which indicates for three different modal splits the factors for reducing person work trips to p.c.u.'s in the peak hour. The last two columns give the person work trips which are equivalent to 600 and 1500 p.c.u.'s in the peak hour. The 600 p.c.u.'s relates to the lane capacity of 24' two-way road and 1500 p.c.u.'s to the capacity of one 24' carriageway of a dual carriageway system.

Modal Split % car : bus	Factor to reduce person work trips to peak hour p.c.u.'s	Person work trips equivalent to 600 p.c.u.'s	Person work trips equivalent to 1500 p.c.u.'s
100 : 0	0.675	890	2220
80 : 20	0.566	1060	2650
50 : 50	0.400	1500	3750

Based upon the above table it is possible to calculate the percentages of roads which will be single 24' carriageway, 2-lane dual carriageways and 3-lane dual carriageways (i.e. in excess of 2-lane dual). (See figures 3.8 to 3.10).

Modal Split % car : bus	Percentages of various types of road: single 24'	dual 24'	in excess dual 24'
100 : 0	30.0	29.0	41.0
80 : 20	36.0	32.0	32.0
50 : 50	45.0	47.5	7.5

This table reveals very clearly the effect of changing the modal split. An inspection of the assignment indicates that with a more even distribution of flows it would be possible to reduce the percentages of dual carriageway. A more even distribution could be obtained by traffic management methods or by limiting capacity at critical points and forcing the driver to take an alternative less congested route.

It was mentioned in Section 3.3.1 that the most likely point which will limit capacity is the junction. To check this traffic flows at three junctions have been investigated. (See Figure 3.8).

Junction 1. In a residential area north east of Bletchley

Junction 2. On M1/A5 link at new city centre

Junction 3. On the outskirts of New Bradwell

Junction 1.

From the assignment turning movements it is found that at this junction there is a large right turning movement. On two legs this is as high as 64% and 55% respectively.

It would appear that junction control should be by a roundabout and not traffic signals. The flows may even warrant the use of a grade separated junction.

Junction 2.

At this junction there is only one leg which has a right turning movement in excess of 25%. This has a value of 39%. Again it would seem that traffic signals will not be the best solution.

Junction 3.

At this junction there are no legs on which the right turning movements exceed 25%. In these circumstances a signal controlled intersection would be satisfactory.

It appears that due to the disposition of the road network for the first stage of development there is a heavy north-south flow which might cause problems at a number of junctions. However, with the development of the complete network and more widely dispersed employment opportunities, the traffic will probably be spread over a wider area thus reducing the flows which appear on the restricted 1979 network.

Very approximately just over a third of the total length of road network will be provided by 1979 to cater for approximately 50% of the population.

3.4 Further discussion of proposed road system

3.4.1 Safety

Residents will want to live in conditions of maximum safety and freedom from the nuisance of moving vehicles and to be able to send their children out to play and to school with the minimum of risk.

To meet this environmental requirement "Traffic in Towns"[1] suggests that traffic volumes on residential access roads should at all times be kept below 360 pcu / hr. for a 24' carriageway assuming average social conditions, while pedestrian segregation is advocated for flows exceeding 375-500 pcu / hr.[2] The interim Report states that "traffic could be kept below 375 pcu / hr." within residential areas, but having regard to the above statistics it is considered that this figure must be treated as an absolute maximum and in certain locations may be unacceptable environmentally.

1 Buchanan C. et al. "Traffic in Towns." London H.M.S.O. 1963

2 O'Flaherty C.A. "Highways." Edward Arnold, London 1967.

No consideration seems to have been given to the question of cyclists. It must be admitted that it is a moot point how many cyclists there will be in the year 2000, but it is felt that the mode may well be retained in the Milton Keynes area which is of flat terrain and conducive to cycling. A study at Bedford in 1965 showed that over 20% of all person trips were made by pedal cycle. The point does not greatly affect the kind of roads to be provided. It is considered that cyclists should not be admitted to the primary roads for obvious reasons of safety and free flow of vehicular traffic. They should be accommodated on cycle tracks or diverted to the less heavily utilised roads.

The layout of the access roads is not mentioned. Care should be taken in the design of these roads to ensure that traffic only undertakes minimum journeys within the residential areas and access roads are not used by extraneous traffic.

The activity centres will attract large volumes of traffic and adequate provision will be required for servicing and parking. Particular attention must be paid to pedestrian safety and vehicle / pedestrian segregation provided where necessary. It is not clear from the report whether separate vehicular access points direct off the primaries will be provided for these centres, or whether the traffic will be required to use the residential access roads. Obviously from safety considerations the latter course could not be endorsed.

It is estimated that during the peak hour approximately 325 pcu/hr. would discharge from each access onto the network. If tidal flow techniques are able to be introduced on the primary then this should not present undue problems. However, where such techniques are not possible owing to intersection difficulties previously discussed, signal control would be necessary at each access point (M.O.T. will sanction the use of signals for minor road flows of more than 180 puc/hr. in both directions[3]). In any case access points serving adjacent residential areas should be staggered, preferebly right-left, to deter straight across movements and reduce accidents.

3.4.2 Accessibility and Environment

Generally it appears that the plan should provide reasonably good accessibility, but this is only accomplished by certain sacrifices in environmental standards. Some cases where accessibility and environment are in conflict are mentioned below.

It may be difficult to keep extraneous traffic away from residential areas as there is no clear hierarchy of roads, added to the fact that a number of activity centres serve several residential areas, and this will inevitably accentuate the problem. Environmentally it is bad to have a primary route located through the centre of an activity centre.

3. M.O.T. Circular 1966. H.M.S.O. London.

It is noted that parking is to be provided in the main shopping area for all who wish to drive there. American studies in medium sized towns have shown that on Saturday afternoon approximately 17% of the vehicle population park in the central area[1]. Relating this to Milton Keynes, 12,000 car parking spaces will be required in 1990 and 20,000 in the year 2000. The surface area required to accommodate these cars would be 75 and 125 acres respectively. If one assumes that multi-storey parks accommodating 500 vehicles are the most economically viable then by 1990 24 garages will be needed, costing approximately £5 million, and by 2000 40 garages costing £8 million. It is a matter of opinion whether such construction would destroy the centre environmentally.

Pedestrian access between adjacent residential areas is to be accomplished by means of pedestrian subways at intervals of approaching 300 yards. Research on the use of existing subways shows that pedestrians will only use the facility provided the new route is quicker than the ground route[2]. Pedestrians will obviously require to be disciplined to use the subways. Even so, the presence of a primary road with limited pedestrian access to cross will inevitably constitute a barrier to pedestrian movement between adjacent residential areas.

3.4.3 Congestion free motoring

The gridiron pattern has some considerable traffic-moving advantages. It encourages an even spread of traffic and in consequence the impact at a particular location is reduced. It facilitates the imposition of very extensive one-way street systems and it is relatively easy for through traffic to by-pass the central area. One objection to the pattern is the high proportion of turning movements often experienced at intersections and Milton Keynes highlights the problem. To maintain congestion free motoring it is felt that special attention should be paid to the design of the junctions as it is at these points that delays will first be experienced.

It may be of interest to consider traffic conditions in the City of Hobart which is well known for its grid pattern of roads and where all intersections are signal controlled and linked. The population is 125,000, car ownership is 0.22 cars/head and the principal roads are all 4-lane. Today congestion is experienced at peak hours at most crossings in the central area and traffic management techniques have been introduced to discourage motorists from entering the central area. New urban freeways are projected to overcome the problem. Milton Keynes could have four times the traffic generated which Hobart has today. It would appear that special attention should therefore be given to ensure that the type of highways and grade of intersections provided at Milton Keynes is sufficient to give congestion free motoring and on the principles indicated in Section 3.3.5.

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1 Siegmaier J.T. "Parking and its relationship to business." Special Report 11-D, Highway Research Board, 1956.

2 Garwood F. & Moore R.L. "Pedestrian Accidents." Traffic Engineering & Control 1962-4

3.5 Conclusions

3.5.1 A preliminary assignment indicates that with an 80:20 modal split 32% of the 1979 road network will need to be dual 3-lane carriageway. It seems likely that a number of junctions will have heavy right turning movements which will make it uneconomic to use traffic control signals.

3.5.2 Traffic seems generally high and this is probably explained by the north-south development of the first stage with a spur to the east. Also by 1979 with the fast rate of growth of population there will be about 50% of the total ultimate population: there is only just over a third of the new road network. It appears that the traffic situation might improve at 1979 with a more even distribution of traffic.

3.5.3 The total cost of the road network will be approximately £100,000,000.

3.5.4 A 1 kilometre grid is about the optimum size.

3.5.5 The suggested road plan would appear to give reasonably good accessibility but only by accepting reduced environmental standards, particularly within the residential areas and central area. This objection could be overcome by the establishment of a clearly defined hierarchy of roads and environmental areas.

3.6 Recommendations for further study

3.6.1 Junction treatment, comparison of traffic control signals, roundabouts, mini-roundabouts and grade separation.

Methods of obtaining a more even distribution of traffic over the area of development.

Effects of regional traffic on the Milton Keynes network.

3.6.' Ensuring that traffic flows in residential areas do not exceed the environmental capacity.

3.6.; The effect of cyclists and the possible provision that should be made for them.

3.6. The layout and design from traffic considerations of the activity centres.

3.6.' An alternative road plan based on a hierarchy of highway types and environmental areas.

Figs. 3.1-4.

Fig. 1. Urban Form

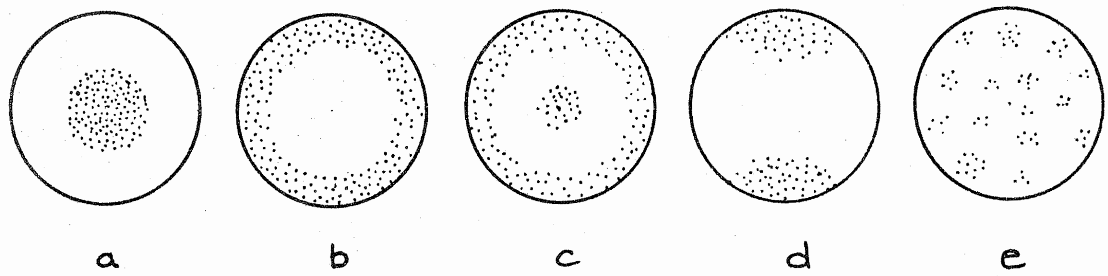


Fig. 2. Simple Model

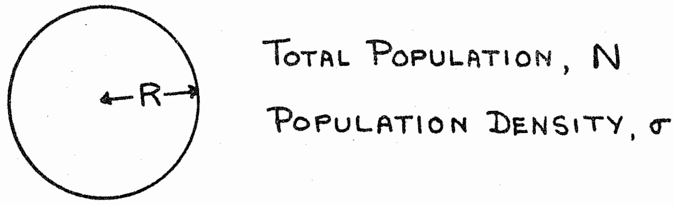


Fig. 3. Square Grid.

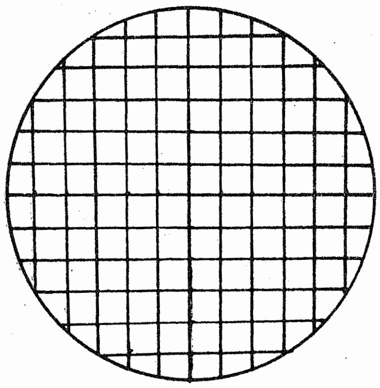


Fig. 4. Some Lane Arrangements.

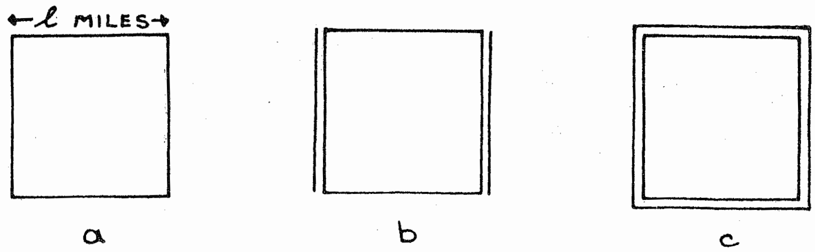
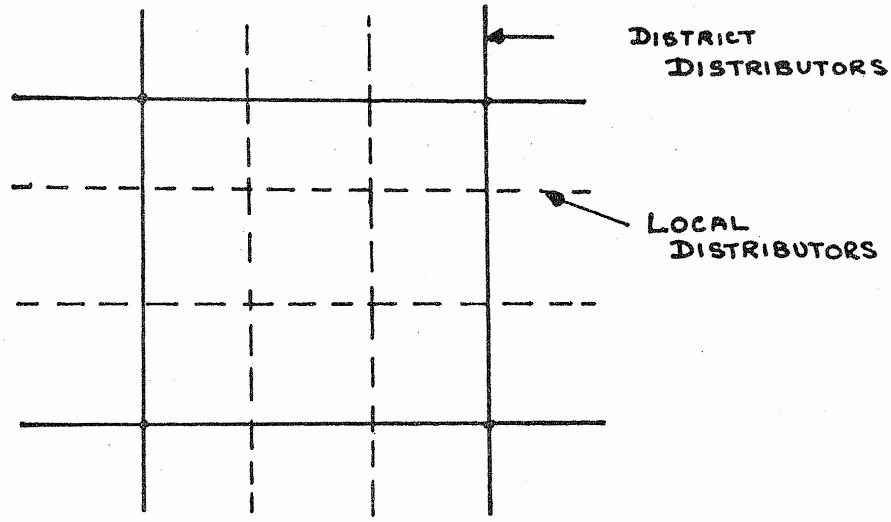
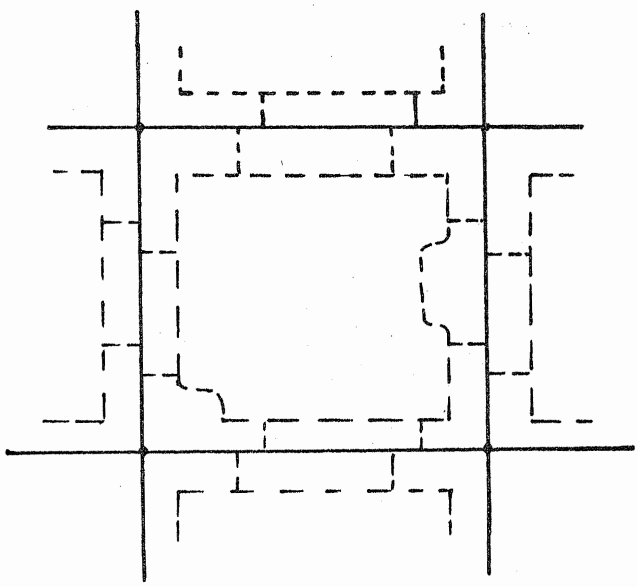


FIG. 3.5.

LAYOUT OF LOCAL DISTRIBUTORS WITHIN RESIDENTIAL AREAS.



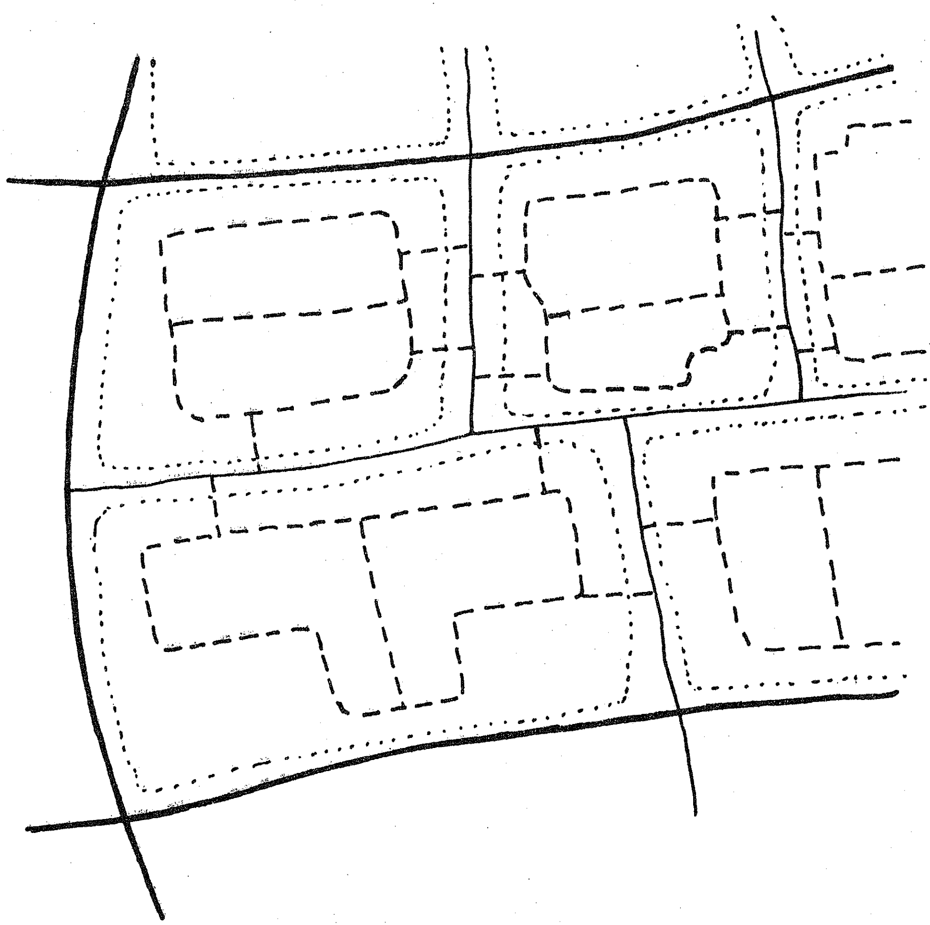
(a) NOT RECOMMENDED



(b) LAYOUT DETERS MOVEMENT OF EXTRANEOUS TRAFFIC BETWEEN RESIDENTIAL AREAS AND RIGHT-LEFT STAGGER INCREASES SAFETY.

FIG. 3.6.

THE PRINCIPLE OF THE HIERARCHY OF DISTRIBUTORS



PRIMARY DISTRIBUTORS
DISTRICT DISTRIBUTORS
LOCAL DISTRIBUTORS
ENVIRONMENTAL AREA BOUNDARIES

Fig. 3.7.

MILTON KEYNES: A POSSIBLE HIGHWAY NETWORK FOR THE YEAR 2000

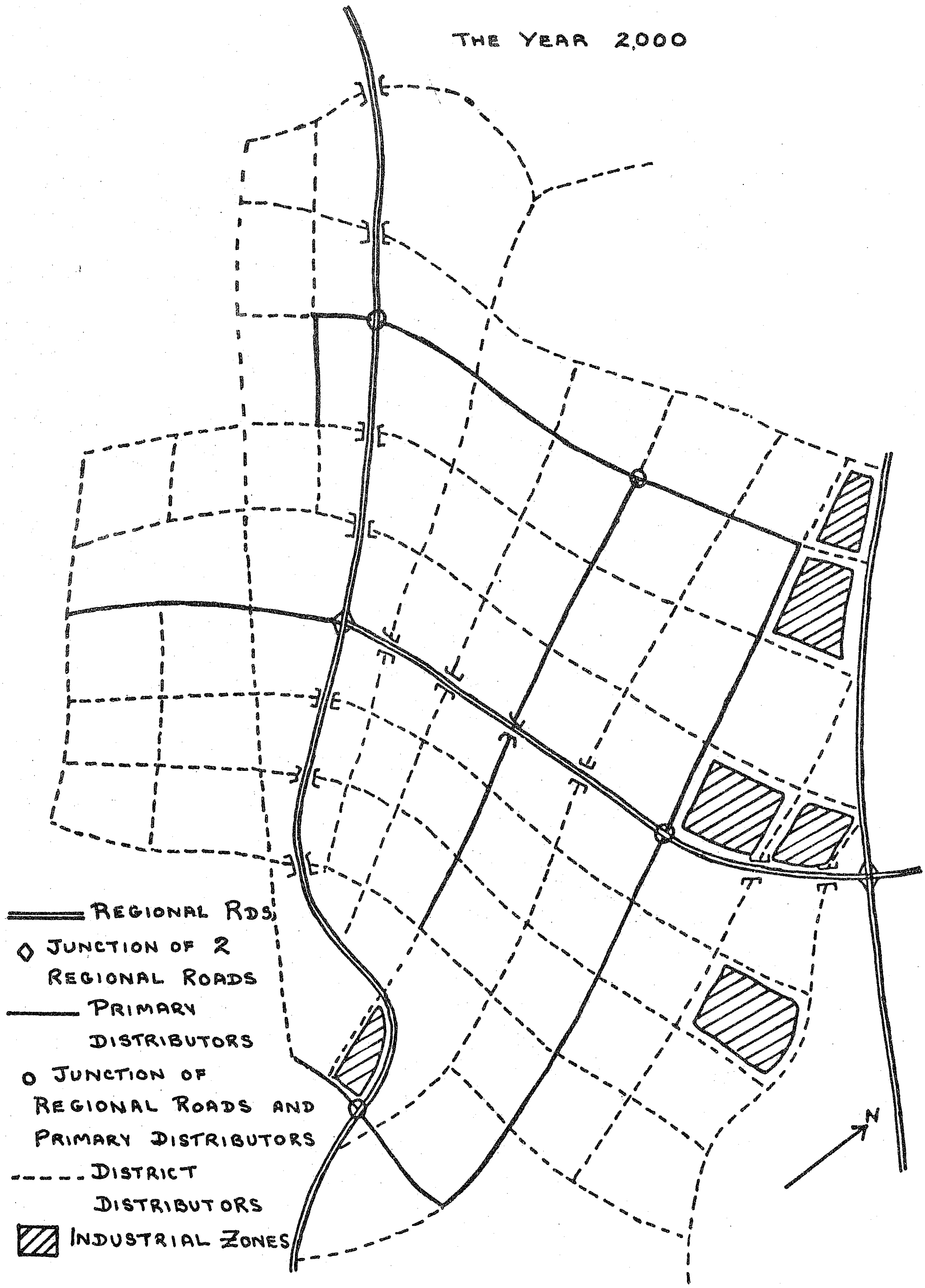
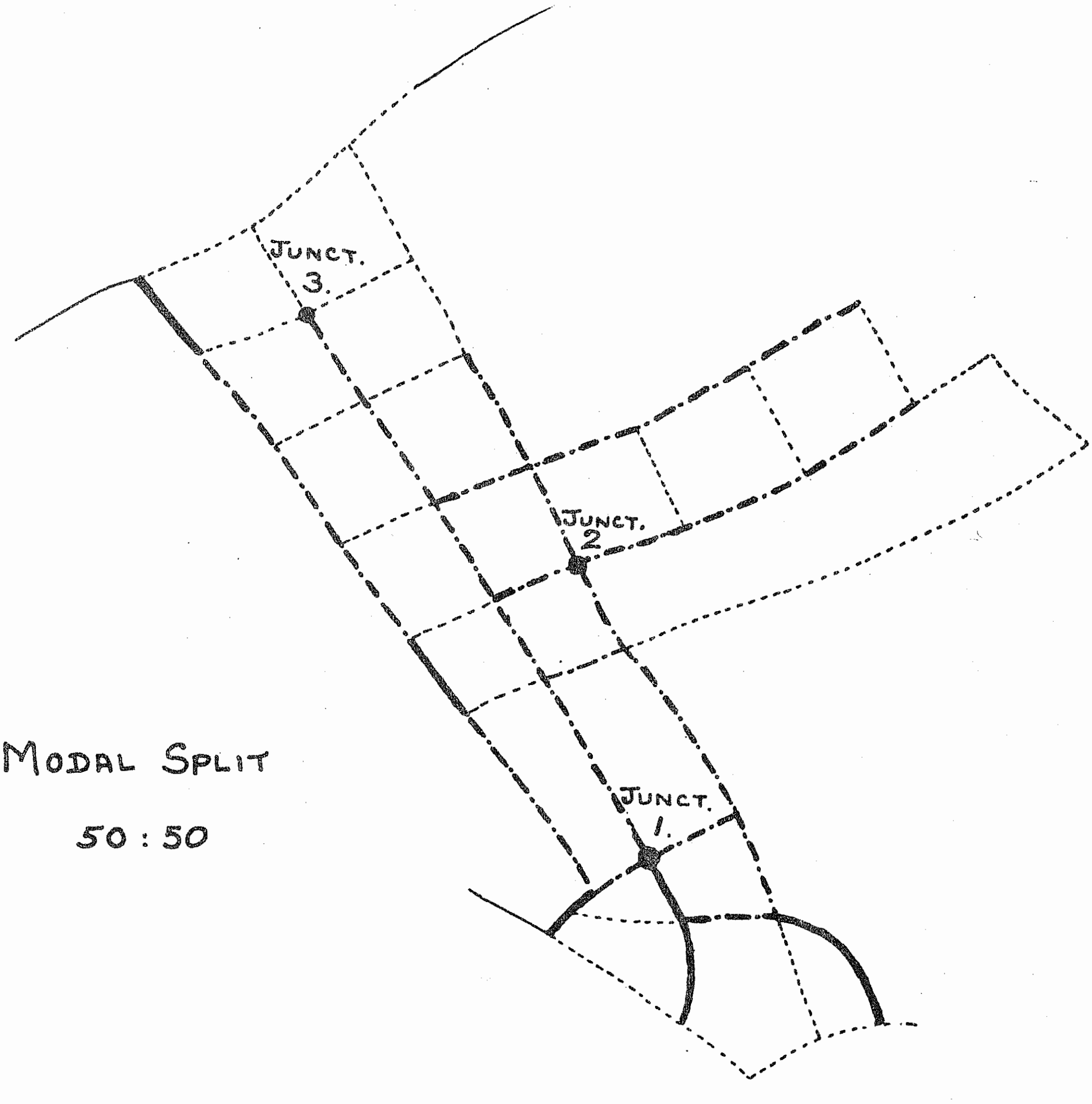


FIG. 3. 8.

MILTON KEYNES 1979 ROAD NETWORK

ROAD WIDTHS REQUIRED



MODAL SPLIT

50 : 50

SINGLE 24'

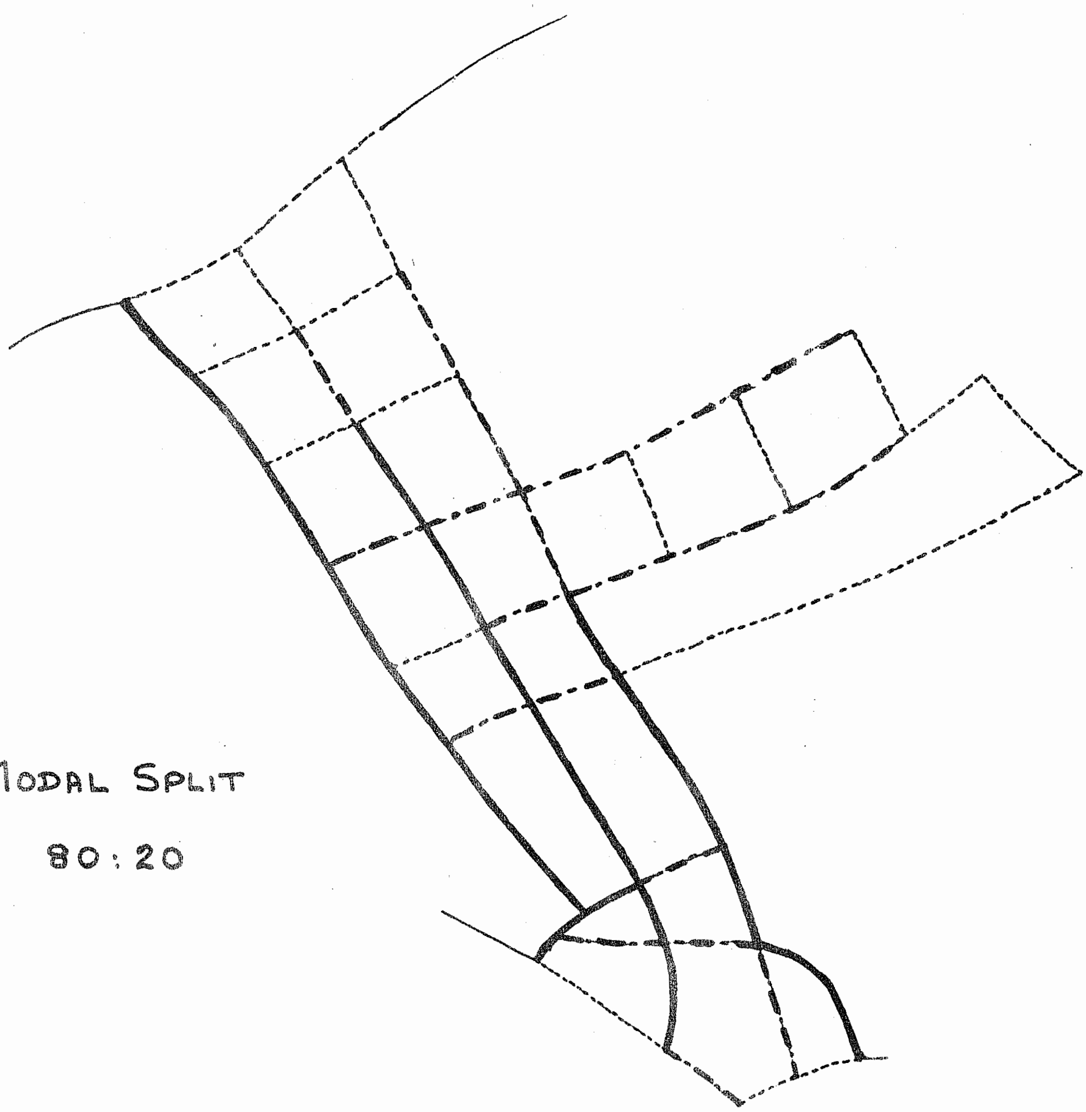
DUAL 24'

IN EXCESS OF DUAL 24'

FIG. 3.9.

MILTON KEYNES 1979 ROAD NETWORK

ROAD WIDTHS REQUIRED



MODAL SPLIT

80:20

SINGLE 24'

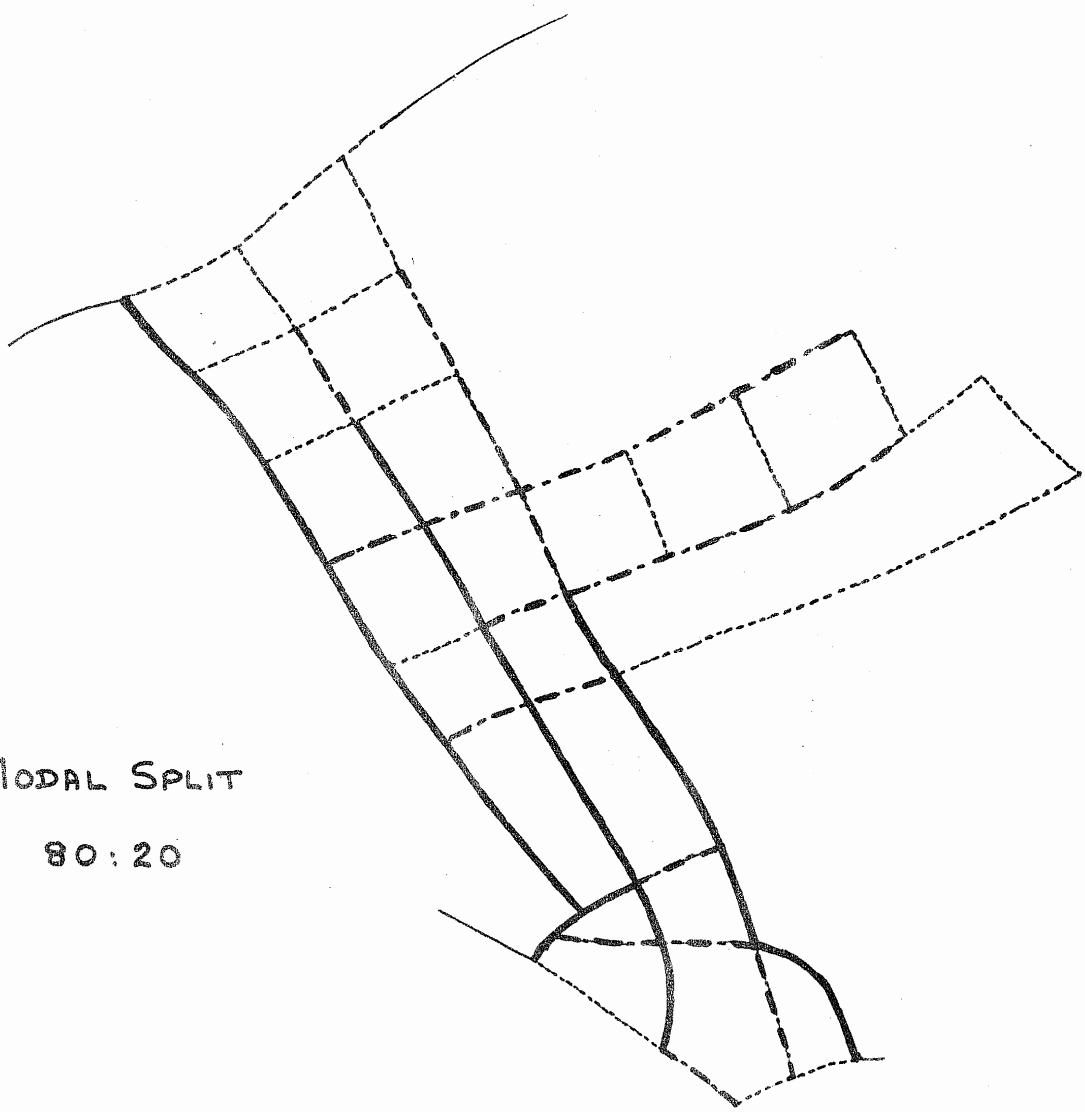
DUAL 24'

IN EXCESS OF DUAL 24'

FIG. 3.9.

MILTON KEYNES 1979 ROAD NETWORK

ROAD WIDTHS REQUIRED



MODAL SPLIT

80:20

.... SINGLE 24'

—·—·— DUAL 24'

———— IN EXCESS OF DUAL 24'

PART 4 PUBLIC TRANSPORT

4.1 Introduction

The Interim Report having made firm proposals for a 1 Km. grid layout, recommends the adoption of a road-based transport system, using small buses. It stresses the need for a cheap, convenient and comfortable system, to provide an attractive alternative to the private car. It makes no comment on the financial aspects of operating such a system, other than to quote certain capital and operating costs.

Whilst recognising the interim nature of the report, and acknowledging that a high standard of service is a pre-requisite for the transport system, the Working Party has a number of comments and suggestions to make on the means of achieving this end.

The report states that 46 different transport systems have been considered. The time scale for the project report has prevented a thorough assessment of these alternatives and our considerations have, therefore, been limited to an examination of the proposals set out in the Interim Report, together with a commentary on the implications and limiting factors on the public transport system of selecting a grid layout. We have, however, also considered certain alternative schemes for which data was available, commented on bus and fixed track systems generally and made certain suggestions for future study.

4.2 Examination of evidence and discussion of the Interim Report

4.2.1 The Grid System

The implications of the grid system on road traffic generally have been referred to in Part 3.

We feel that the adoption of such a layout places severe limitations on the choice of transport, and indeed with the recommended land use, confines the possibilities to one type only, namely a road based service.

Whilst there might be scope for development of a segregated track for buses along the grid alignment, the introduction of a fixed track system in any other form than a basic figure of eight would be impracticable and totally uneconomic. Nor could it provide an acceptable quality of service without substantial support from a road based system.

The Interim Report stresses the need to provide adequate facilities for interchange. It envisages, at any rate initially, a shuttle service operating along each of the grid roads. This would involve interchange for most journeys, and a walk of some distance unless the bus stops were located near intersections, with consequent traffic flow problems.

Whilst careful routing might reduce the need for interchange, we regard the report as optimistic in this respect.

We agree with the view that the use of the car for the journey to work would be attractive. We suggest its attraction is enhanced largely by reason of the limitations placed upon the public transport system by the grid type layout.

4.2.2 Public transport costs

The previous sub-section concluded that the grid road system combined with the land distribution proposed in the Interim Report made all forms of tracked public transport systems uneconomic. Accordingly, in assessing public transport economics in detail, consideration has been restricted to bus systems.

The Interim Report gave the results of a complete cost benefit analysis, but in view of the limited time scale, to undertake such a task for this study would be completely unpractical. Instead, the study was confined to a relatively simple cost analysis, leading to costs / seat mile; the aim of this approach being to demonstrate how expensive is the mini-bus compared with the conventional higher capacity vehicles. For this report the overall operating costs were divided into capital or standing costs, and operating or running costs.

Annual capital costs were assessed to vary from £340 per vehicle for the 14 seat mini-bus to £1240 per vehicle for the 83 seat double decker, and included the cost of garaging, insurance, interest on capital, licence and administration. Crew costs were part of the operating costs and it was assumed that all vehicls, including the 83 seat capacity bus, could each be operated by one man. This is an extrapolation of current practice, but the assumption is thought to be justifiable since it is understood that certain municipal transport undertakings, including London Transport, are contemplating this very move. It was assumed that each vehicle would require two shifts of operators per day although the weekly distance travelled by the vehicle could vary from between 600 to 1000 miles. Since the investigation was aimed at producing the cost to the user, fuel and other direct taxes were considered, but any costs attributable to constructing the grid network were ignored. Other items considered as part of the direct operating costs were tyres, maintenance and depreciation of stock and overheads, but no allowance was made for replacement of stock.

Figure 4.1 shows the basic results of the study and it is immediately apparent that if 14 seat mini-buses are introduced in Milton Keynes then the travelling public or the ratepayers will have to pay dearly for the privilege of riding in them. Shown on the figure are costs / seat mile, and if a realistic overall load factor of (say) 35% is assumed then the break even fare for the 14 seat mini-bus will be in the region of 6d. per mile. This is in excess of the fares currently charged of between 3d. and 5d. per mile and will be of little inducement in prising car travellers from their vehicles.

The text of the Interim Report mentions that estimated passenger volumes are given in Table 2 of page 155 but unfortunately this information has been omitted and therefore it is impossible to derive load factors for their figures. However, although a direct comparison is impossible, the general trends between Figure 4.1 and Table 2 agree reasonably well for the given modal split.

The limitations of the 14 seat bus concept are further exposed if we consider the capital available for the public transport system. In the financing of the city it is likely that a fixed sum will be allotted to public transport, and the transport undertaking will be required to make the best use of the money. Considering the capital cost of the vehicles only, then for a given initial investment the highest number of bus seats that can be offered to the public will arise if 83 seat buses are purchased (see Figure 4.2). Garage and other direct capital costs have been excluded from this calculation on the basis that to a first order they are independent of bus size. Since the size of the bus fleet is largely dictated by the peak hour requirement then the saving shown in Figure 4.2 is reflected back into a saving of capital expenditure.

4.2.3 Public transport level of service

The Interim Report goes into great lengths to describe how and why the bus service, in particular that operated with 14 seat vehicles, offers the highest possible level, or quality, of service.

Since this is a major factor contributing to the adoption of the grid system, we felt that it warranted as thorough an investigation as the time scale permitted.

Level of service is mainly a function of :

(i) the proximity of the system to the public

(ii) the frequency of the service

(iii) the directness of the route

and (iv) the door to door journey time, a combination of (i), (ii) and (iii) above.

These four major factors are all closely interconnected. However, it is felt that in discussing the proposals it will be advantageous to consider each separately before combining as a whole. The private motor car can offer a 'convenience service' that is near to the ultimate; thus this is used as a comparison when discussing the overall convenience of the system.

4.2.3 (i) Proximity of the transport service

Walking distance and hence walking time, are the prime factors to be considered when discussing the proximity of the system. The proposed 1 kilometre square grid road network is excellent in this respect and the average walking distance will be in the order of a quarter mile, say a 5 minute walk.

4.2.3 (ii) Frequency of service

A function of the number of vehicles in the service and the financial attitude of the operator. The aspect of financial attitude of the operator to be considered in this context is how to run his off peak service. The number of vehicles required is determined by the peak load and it is the operator's decision whether to use these continually throughout the day, providing a good service with a low load factor (hence uneconomically) or whether to run economically with a high load factor but with considerable reduction in the frequency of service. No information is available in the Interim Report as to the procedure to be adopted, so further discussion is pointless.

The total number of vehicles required for the system can be calculated if the routes, journey times, peak densities and modal split are known. These can be calculated but in the time scale of this report this was impossible. In order to give some scale to the requirements, however, it can be assumed (substantiated to some degree by the Interim Report) that,

(a) the working population will be 50% of the total population

(b) the average one way journey time will be 20 minutes.

The modal split for the bus service will be considered at the two suggested extremes of 20% and 50%.

Based on the above we get

	Total number of vehicles required		Total number of operators required	
Modal Split	20%	50%	20%	50%
14 seat vehicle	436	1090	862	2160
25 seat vehicle	245	614	485	1220
45 seat vehicle	137	339	272	672
83 seat vehicle	74	184	147	364

These figures are in the order of 20% above those quoted in the report.

It is interesting to note that if a 14 seat vehicle system were adopted for Milton Keynes, and a 50% modal split level were achieved, then nearly 2% of the total work force would be engaged by the public transport system.

The preceding is a crude overall assessment of the transport requirement. However, the report contains further relevant information which enables an investigation of the 'busiest' route to be made. It is stated that the maximum hourly public transport volumes in any direction will be 1500 passengers for a 20% modal split and 3500 passengers for a 50% modal split.

An investigation of the layout of a city shows that these figures are only likely to apply at one of the large industrial areas. These areas are a public transport operator's nightmare since a large number of people have to be moved in a very short period of time. It is therefore essential that this area be further investigated. Figure 4.3 has been calculated assuming the fairly realistic condition that the demand is a sudden input at two finite periods within the peak hour and shows the numbers of vehicles that are required for this one route.

The transport operator must decide what approach to adopt to clear the queue. Basically he has two choices, (a) to have a line of buses waiting with a capacity equal to the demand, (b) to maintain a normal service and gradually reduce the queue. In practice a compromise is usually reached with an emphasis on (a).

The advantages of buses with over 30 seats to meet this demand are obvious, since even at the 20% modal split approximately thirty 25-seat vehicles would be required to queue up, requiring 2-300 yards of parking space. Finally one must consider the considerable time delay of such a fleet of buses attempting individually to gain entrance into the traffic stream. Ignoring these time delays for the present, Figure 4.4 shows the variation in frequency of service with the route density. These curves are calculated for 100% load factor, whereas in practice the peak load factor would probably be nearer 90%, thus requiring a bigger fleet size but increasing the frequency of service.

4.2.3 (iii) Directness of routes

The most important aspect in directness of route is that the number of interchanges should be minimised. The grid system proposed for Milton Keynes restricts this to a maximum of 1 and since the average journey length will only be approximately 1.25 times the straight line point to point distance, this system must be viewed favourably.

4.2.3 (iv) Door to Door Journey Time

This is a function of walking time, frequency of service and directness of route (discussed above) plus the vehicle travelling time and any delay time. The average journey length will be approximately 2.5 miles during the peak period which in a 'no delay' system with a vehicle operating speed of 20 m.p.h. gives a 7.5 minute travelling time for a direct journey.

Let us now consider the delays that might occur. Firstly there is the time at bus stops, and secondly there is the delay period at the stop whilst the bus attempts to re-enter the traffic stream (see para. 4.2.3 (ii)). Let us assume an average delay of 20 seconds / stop. Thirdly the 'green wave' traffic light system proposed is designed for through traffic and is likely to prove a hazard to the bus service: waiting time at traffic lights, say 30 seconds. No allowance will be made for delays due to road congestion since it will be accepted that in general there should be no congestion.

The importance of the frequency of the service on the door to door time is the waiting time involved, and this can be assumed as approximately 0.5 of the scheduled frequency (plus the delays previously discussed if these are not incorporated in the schedule). It must be noted, however, that there is an important proviso to this assumption, which applies when the demand is low with a correspondingly low frequency of service. When this is the case, providing the service is correctly scheduled, (say two vehicles per hour, running on the hour and half-hour), then the waiting time is an allowance made by each individual passenger (probably 2 - 5 minutes), providing a shorter waiting time than many higher frequency services.

The final factor to be considered which influences the door to door journey time is the directness of route. It has already been stated that a high proportion of passengers in Milton Keynes will require a change of route. So far we have calculated the direct route travelling time (7.5 mins.) and to this we must add a further walking and waiting time.

The effect of these variables on the door to door journey time is shown on both an individual and combined basis. The full combination has not been evaluated but sufficient work has been done to establish a door to door time for the range of bases being considered. It has already been stated that the private car operating over congestion free roads with good parking facilities offers a near minimum door to door journey time, hence this time will be calculated and used as a compositor.

The average journey length by public transport = 2.5 miles, therefore, average car journey = 3 miles, allowing for access to primary road and parking.

Assuming a 20 m.p.h. average speed and allowing 5 minutes for starting, parking and walking time, then the door to door journey time will be 14 minutes for the private car. No allowance will be added for delay since the road network is designed for congestion free motoring, and the 'green wave' traffic light system provides an unrestricted through journey.

The door to door journey times for the bus system have been calculated for the four following cases :

A (i) A direct journey in which the passenger walks to the bus stop, boards a waiting bus, is conveyed without any delay or stopping to the stop nearest the destination, and walks the remaining distance.

A (ii) The passenger walks to the bus stop, waits for the next bus, boards it, is conveyed to the stop nearest the destination, stopping at all the traffic lights and scheduled bus stops en route, then walks the remaining distance. This is for a direct route service.

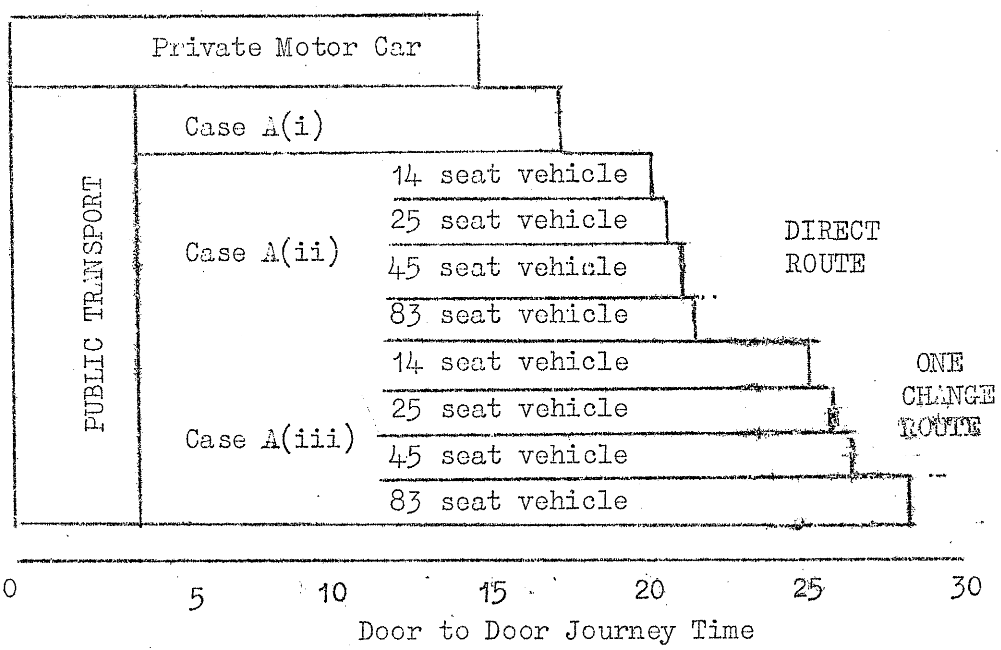
A (iii) Similar to A(ii) but is a one change system, hence a further time penalty is included for walking to the interchange stop and waiting for the next bus.

A (iv) An approximate assessment of the average door to door journey time based upon stopping at all scheduled stops but only some traffic lights.

A(i) has been included since it portrays the ultimate service that a bus transport system, operating on the general highway could achieve.

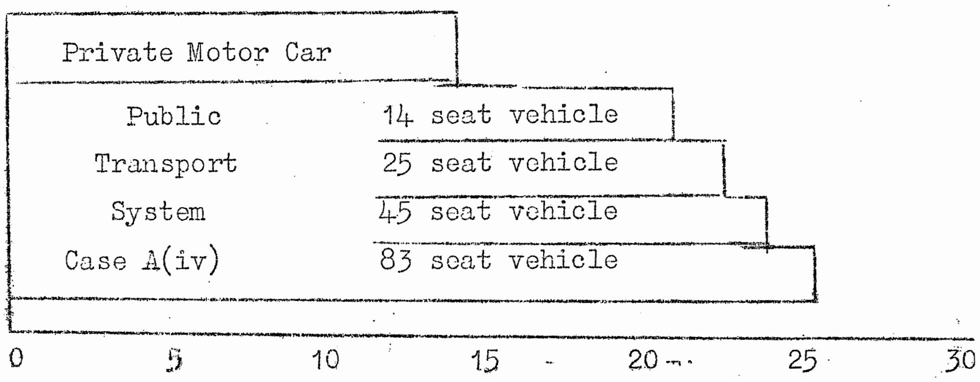
The following block diagrams have been calculated for a peak single route capacity of 1500 passengers per hour:

DOOR TO DOOR JOURNEY TIMES



DOOR TO DOOR JOURNEY TIME

Comparison of average time for the private motor car with the average time for the public transport system.



Door to Door Journey Time.

4.2.3 Summary

The level of service of the proposed Milton Keynes public transport system has been investigated. It is a system that is within easy access of the public. However, since for all sizes of vehicles considered the average door to door journey time for an assumed 2.5 mile route is in the order of 24 minutes, it is not felt that such a system would prove sufficiently attractive to provide even the 20% modal split envisaged. On the basis of this preliminary work no conclusions can be reached as to what vehicle size provides the best level of service. From Section 4.2.2, the cost of the 14 seat vehicle system is approximately twice the cost of any other size vehicle system, and since the time advantage of these small vehicles is low it would appear reasonable to exclude all vehicles below 25 seat capacity from further studies.

4.2.4 The 1979 bus system

The proposed first stage of the development envisages linking Bletchley, Wolverton and Stony Stratford, and then integration with Milton Keynes. This phase will embrace the existing limited industrial areas in Bletchley and Wolverton, but apart from the development of the industrial site east of the city centre and a start on the first part of the centre, together with sewers, roads and services, it appears that construction work will be mainly in residential areas.

This suggests that a high proportion of work journeys within the designated area will be to either Bletchley or Wolverton, and that travel to work outside the area will also be at a relatively high level. The Interim Report assumes an ultimate figure of 25% of the working population who will travel to work outside Milton Keynes. It is possible that in the early stages whilst job opportunities are building up, this figure will be higher.

We see no physical problem in formulating a suitable bus service to cater for the demand.. It should, however, in addition to serving the industrial area to the east, be orientated to serve Bletchley and Wolverton, preferably via the developing City Centre, and should terminate at the main line stations at appropriate times to connect with main line train services to London and Northampton.

It seems likely that there may also be a demand for inter-regional transport to Bedford, and in particular to Luton. Unless it is desired specifically to discourage such movements, it may well be necessary to take early steps to discuss with British Railways the future of the Bletchley-Bedford railway line, the closure of which has already been approved by the Minister of Transport.

The establishment of a bus system, virtually overnight, will involve very substantial capital expenditure. Whilst the traffic flow indications are that there will be a reasonable level of demand, heavy subsidisation is likely to be necessary in the early years of operation.

4.2.5 Future Systems

The Interim Report rightly recognises the need to provide for future technological development in transport.

We have, however, expressed the view in 4.2.1 above, that the adoption of the grid layout limits the choice of practicable and economic systems.

Diagrams X, Y, and Z on page 28 of the Interim Report illustrate possible routes for fixed and automated guided track systems. We consider the introduction of a rapid transit rail system to connect Milton Keynes with other nearby cities may well prove essential. The layout shown in Diagram X might well provide the basis for a practicable inter-regional rapid transit system, but its use to serve Milton Keynes internally would be limited. It would be unreasonable to anticipate that any system based on the layouts illustrated in Diagram Y and Z would provide the basis for an economically practicable scheme.

Whether there will be a demand for dial-a-bus services remains to be seen. Operating costs would be high, and without subsidisation fares might have to be pitched at such a level as to make a commercially operated conventional taxi service a better proposition.

4.3 Further considerations

4.3.1 Tracked systems

We have already expressed the view that assuming the grid layout proposed, no fixed track system would be likely to show economic viability.

If, however, the proposed layout were not adopted, consideration could be given to the introduction of some form of fixed track system. (e.g. College of Aeronautics A3 layout discussed in 4.3.3 below).

There is no reason to suppose on the evidence it has been possible to examine in the time available, that an entirely satisfactory level of service could not be given. As a number of projects such as the Westinghouse Transit Expressway and various tracked air cushion vehicles are under development, these warrant further study, although their economic viability must be in doubt.

4.3.2 Bus systems

(i) The highest proportion of the capital cost of a bus system is the vehicles themselves. A large fleet is required to meet the peak demand which results in either a very low load factor service, or a low frequency of service during the off peak conditions. There are two main possibilities to overcome this: (a) to have a mixed fleet size operating small vehicles during off peak, reinforcing them with large vehicles during the peak only, or (b) to use small vehicles, which are high powered and capable of towing, during off peak and attach passenger trailers to them to meet the peak demand. The preferred method is (b) since only the low capital cost items will be idle during off peak periods. Introduction of a trailer system would require government legislation. It is possible that an economic assessment would show that double deck buses are just as attractive as towed vehicles and require less road and parking space.

(ii) A high percentage of the operating cost of a bus system is crew salaries. In the near future we will see fully automatically controlled vehicles (operating on segregated tracks in all weather conditions) which will require a minimum of staff. The proposed bus system operating on the public highway is unlikely to be able to adopt these advances in technology, and will therefore be at a disadvantage, which will maintain a high fare level.

(iii) Noise and pollution control are becoming increasingly necessary in the modern community. The present day noise level of an accelerating bus (at the kerb side) is 85 - 95 PNDb., and this is on the threshold of annoyance. Similarly the contaminating emissions from the exhaust of a diesel bus is high. Both of these problems can be overcome - at the expense of increased operating costs - however if an electrically powered vehicle becomes practical. this would provide an ideal solution.

(iv) The greater the fleet size, the greater the requirements of garaging and maintenance, hence the greater the expense involved. This is accentuated by smaller vehicles and is another reason why vehicles under 25 seat capacity do not appear economically feasible.

(v) Waiting time is defined in the report as a direct function of the frequency of service - the greater the frequency the lower the waiting time. This is only partially true and since it is a factor which will influence the choice of vehicle size, deserves comment. It is felt far better to provide a service at known times - during the off peak period (say on the hour, quarter past, half past and quarter to), than a rather haphazard service at twice the frequency, say every 7 minutes. The roads are designed to be congestion free, the routes should be relatively short and a bus should be able to maintain its schedule. Thus the waiting time for the passengers for the scheduled service is only what safety factor they wish to employ (say 1 - 2 minutes), whereas with the higher frequency service the average waiting time will be 3.5 minutes.

(vi) Considerable doubt is experienced on vehicle interchange. Unless a complicated routing procedure is adopted, there will be a walk between interchanges of about half a kilometre. Since it cannot surely be envisaged that this will be in a covered walk way, this distance will act as a deterrent from using the system.

4.3.3 College of Aeronautics A.3 layout

The grid road system set out in the Interim Report is aimed at providing the highest cost benefit to the population of Milton Keynes as a whole. Once the grid system was fixed the public transport system was considered in detail, but the restriction was imposed that whatever form it took it must be compatible with the grid and the land distribution. Not unnaturally, the optimum system was found to be a road based system operating over the whole of the grid.

An alternative approach to the problem is to design the city and land distribution around the public transport system. Since the journey time from the home to the bus stop constitutes a significant portion of the overall journey time, then one solution would be to design a linear development; everyone would then have easy access to public transport even though only a few routes would be required. The imposed boundaries of Milton Keynes do not lend themselves to this approach but if a planned development centred on a figure of eight was introduced the desired effect would be obtained. This system was proposed in the College of Aeronautics A.3 plan. A segregated track public transport system was proposed using either suburban trains or buses: more advanced forms of transport could be equally accommodated using the same layout if they were thought economically and technically sound.

For any form of tracked system to be viable, the traffic flows using the network must be reasonably high. For instance, the bus service for the grid layout is expected to cater for flow rates of up to 3,000 passengers per hour, but a fixed track bus system would best be suited to 6,000 passengers per hour. Design flow rates for a railway system would be much higher and probably in the 20,000 to 30,000 passengers per hour range.

The level and type of public service that can be offered is very dependent on the number of people using it. The planners of Milton Keynes foresee that each household will own, on average, 1.5 cars, and unless the public transport system is very attractive, both in price and quality of service, then these cars will be used for work and other internal city journeys. In a great number of cases, especially where the individuals have a long walk (say greater than a quarter mile) to the station, then if the car is available it will be used even though the public transport might be free. The highest estimate of the modal split between public transport and cars is 50%, but more conservative estimates put the figure at 20% or less for Milton Keynes. For the A.3 layout the lower value is probably the most realistic because on average the distance to the public transport is slightly longer than it is for the grid network.

Assuming the 20% modal split applies, then the railway system is rendered unsuitable because its optimum capacity would be too high. On the other hand, the bus on a segregated track might be just feasible if the preliminary traffic flows are realistic. Clearly the time scale of this report is inadequate to arrive at a firm conclusion as to whether the bus system will ever be suitable, but the Working Party believe that it should not be dismissed entirely.

With the A.3 layout, a conventional bus system also will be required, operating across diameters of the loops and serving the park and recreational areas around the River Ousel. These would not need to be of high frequency, although in the peak periods they undoubtedly would be used for the journey to work by a proportion of the inhabitants of the city. Hence to some extent they would detract from the viability of the tracked network and therefore should not be completely overlooked.

4.4 Conclusions

4.4.1 We consider the grid layout limits the choice of public transport systems to a road based service, and that no fixed track system on the grid alignment would be practicable or of acceptable service quality.

4.4.2 The proposed shuttle service will involve interchange for most journeys. Whilst more sophisticated routing might effect an improvement, the interchange penalty will remain unsatisfactory.

4.4.3 We suggest the layout weighs heavily in favour of the private car, at the expense of public transport.

4.4.4 The mini bus concept as proposed in the Interim Report will be very expensive to operate and fares higher than those charged at present for conventional high capacity buses will be necessary.

4.4.5 We foresee a relatively high proportion of commuter journeys to places outside the area in its early stages of development.

4.4.6 The 1979 public transport system should be orientated to provide adequate connecting services, via the City Centre, with trains from Bletchley and Wolverton.

4.4.7 Consideration should be given, in conjunction with British Railways, to the retention of the Bletchley-Bedford line.

4.4.8 The initial transport system is likely to attract a heavy subsidy.

4.4.9 There may well be a need for the future introduction of a rapid transit system to serve nearby cities, but its internal use would be limited. It is unlikely that an internal guided or fixed track system would be economically practicable.

4.4.10 High costs associated with the dial-a-bus system might rule it out in favour of conventional taxis.

4.4.11 Although the proposed road-based public transport system is within easy access of all citizens of Milton Keynes, the average day to day journey time is nearly twice that of the private motor car and is unlikely to prove sufficiently attractive to draw other than captive users from the private car.

4.4.12 From a public transport aspect the College of Aeronautics A.3 layout has some merit although it is impossible to say at this stage whether it is better than the grid network. For this layout rail systems have been dismissed because there are insufficient traffic flows to make them economically viable, but there is possibly a case for buses running on segregated tracks.

4.4.13 Although we do not think that the 1 Km. grid selected for the road network is necessarily wrong, we are not convinced that it has been conclusively shown to be the best solution bearing in mind the combined requirements of both public and private transport.

4.5 Recommendations for Further Study

4.5.1 In view of the limitations placed on the choice of public transport system, the basic grid type layout and land use distribution should be the subject of further study. Involved in this would be the consideration of other forms of tracked transport.

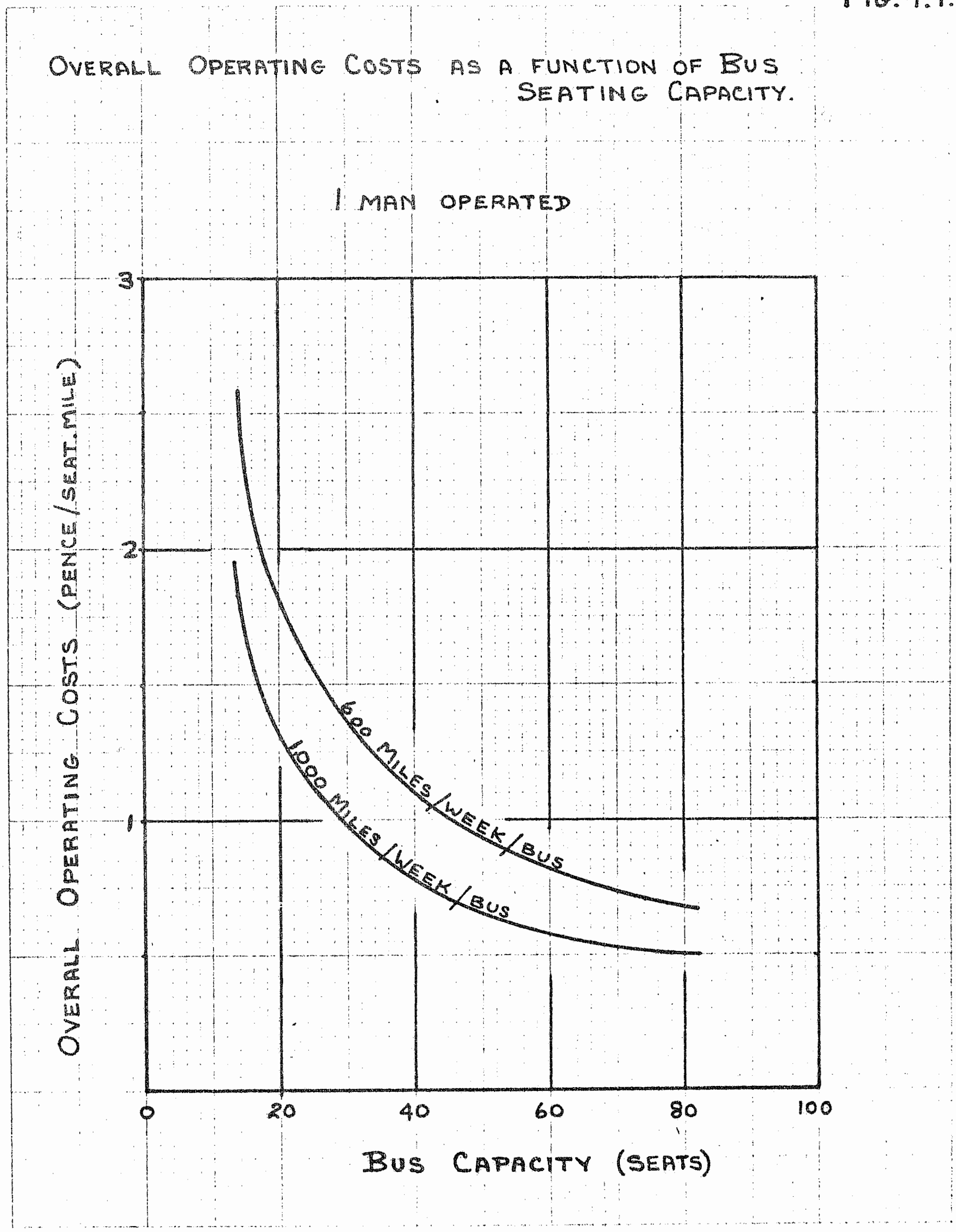
4.5.2 A full cost and cost/benefit study is called for to determine the optimum size of bus and realistic load factors if this is to be the chosen form of transport and the grid mesh layout is maintained.

4.5.3 Further study is clearly required into the routing of buses and interchange arrangements, both for the fully developed city and during the period of construction.

4.5.4 A careful study of potential commuter travel to places outside the city is also required, and would cover the initial years to 1979 and thereafter.

4.5.5 We propose to study a range of alternative road networks to establish whether the 1 kilometre square grid does in fact provide the best solution, having regard to the requirements of both public and private transport.

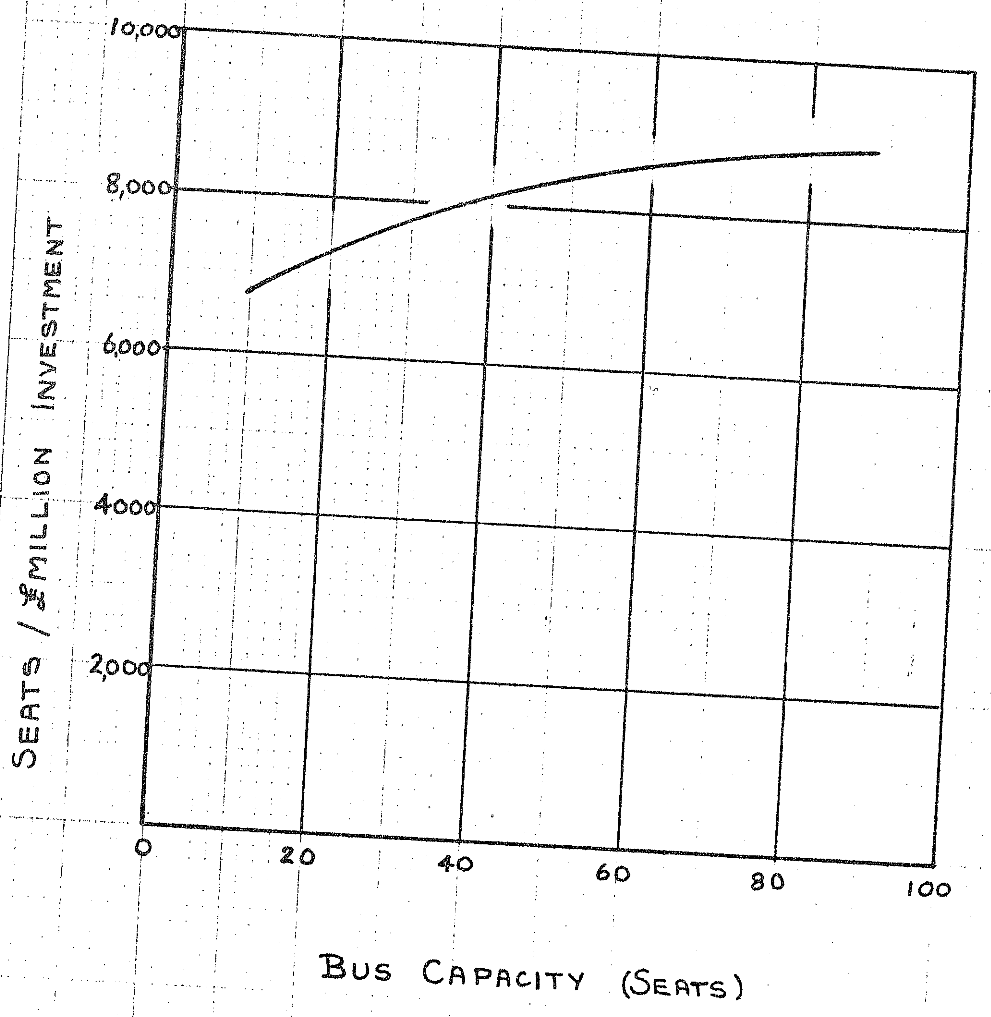
Fig. 4.1.

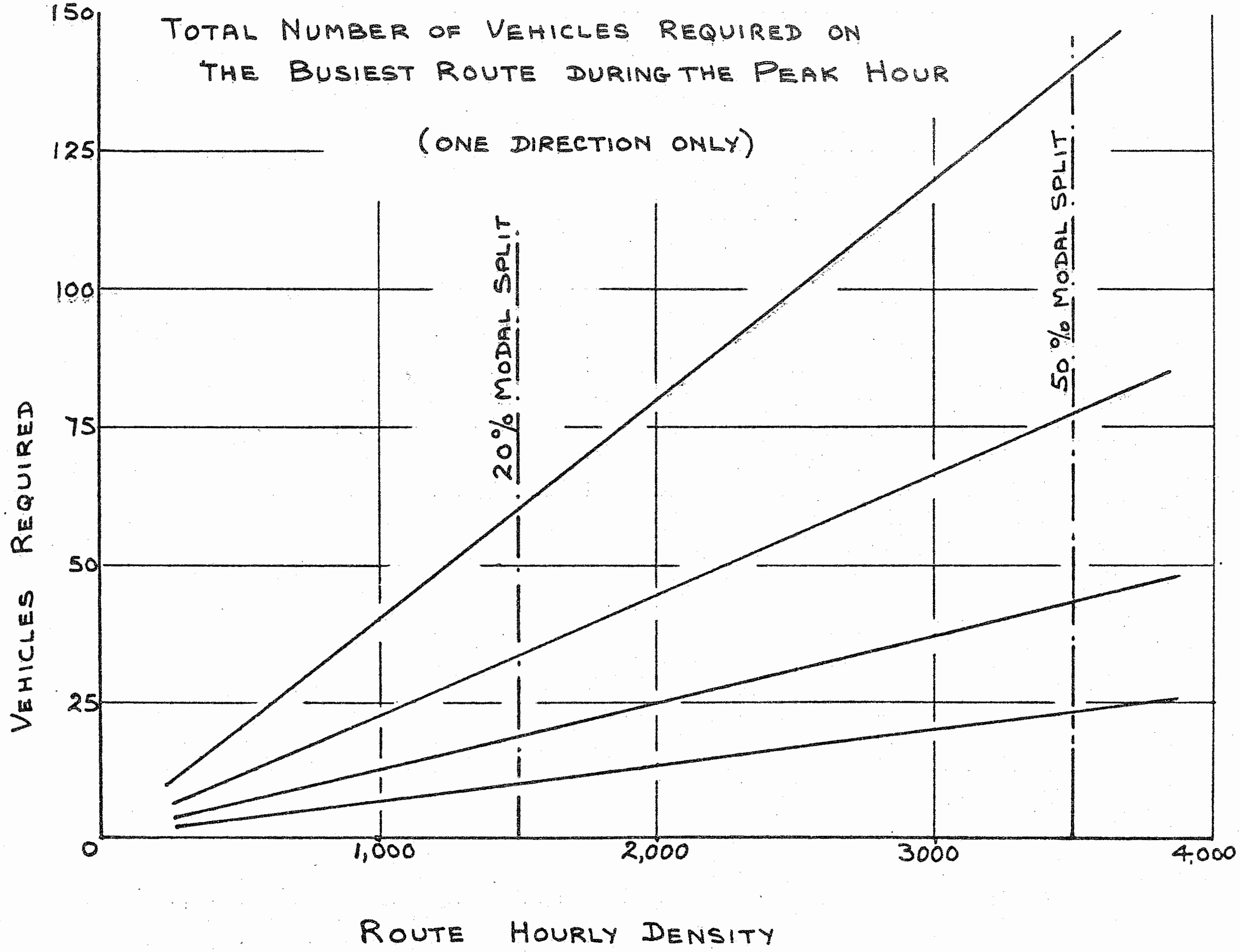


Overall Operating Costs as a function of Bus Seating Capacity.
1 man operated
Overall Operating Costs (pence/seat.mile)
3
2
1
0
20
40
60
80
100
600 miles/week/bus
1000 miles/week/bus
Bus Capacity (seats)

Fig. 4.

Total Vehicle Seats per £ million Capital Investment

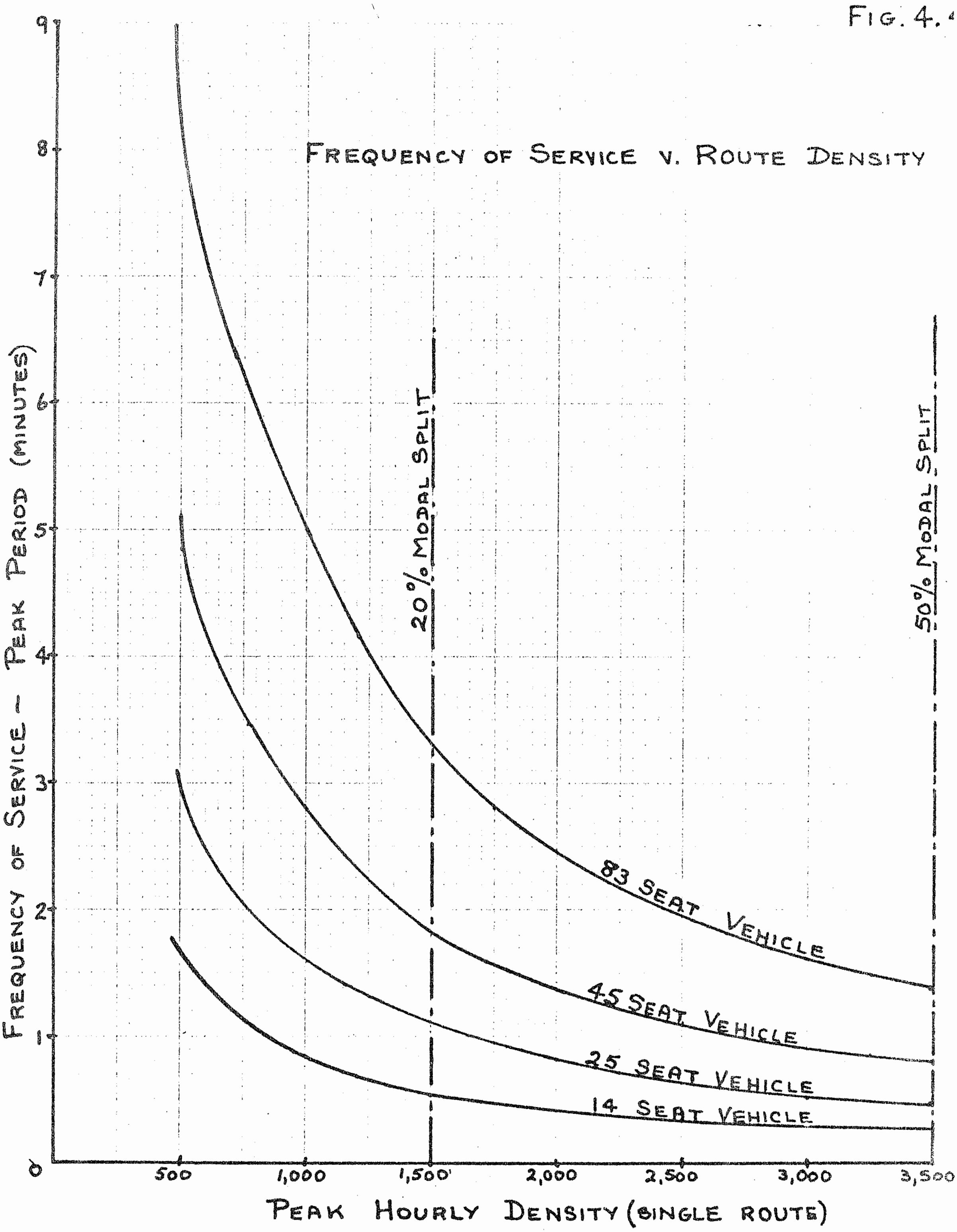




TOTAL NUMBER OF VEHICLES REQUIRED ON THE BUSIEST ROUTE DURING THE PEAK HOUR
(ONE DIRECTION ONLY)
20% MODAL SPLIT
50% MODAL SPLIT
VEHICLES REQUIRED
150
125
100
75
50
25
0
1,000
2,000
3000
4,000
ROUTE HOURLY DENSITY

FIG. 4.3.

FIG. 4.


FREQUENCY OF SERVICE V. ROUTE DENSITY
FREQUENCY OF SERVICE - PEAK PERIOD (MINUTES)
PEAK HOURLY DENSITY (SINGLE ROUTE)
0
1
2
3
4
5
6
7
8
9
500
1,000
1,500
2,000
2,500
3,000
3,500
20% MODAL SPLIT
50% MODAL SPLIT
83 SEAT VEHICLE
45 SEAT VEHICLE
25 SEAT VEHICLE
14 SEAT VEHICLE

PART 5 OVERALL REVIEW

5.1 Introduction

This part of the project report is meant to deal with the question of whether the proposals of the Interim Report, taken as a whole, are likely to satisfy the transport requirements of the new city at a reasonable cost, and whether they represent a good transport investment compared with feasible alternatives. It must be stated at once that no clear answer can be found to these questions at this stage of the Working Party's study. This situation has arisen partly because the Working Party has been fully engaged up till March 6th investigating the various aspects of the Interim Report as discussed in Parts 2 to 4, and so has not been able to meet together to discuss the implications of the various parts and then to formulate their views on the overall plan. It has also arisen because the number of unanswered questions in the first parts of the study is such that it would not be reasonable to try to make an overall appraisal of the plan until more detailed studies have been completed on the various aspects of it. The questions posed for this part of the report will be dealt with in the final report of the Working Party to be submitted at the end of three months. A few general comments on the Interim Report proposals may, however, be appropriate.

5.2 Examination of evidence and discussion of the Interim Report

5.2.1 Most aspects of the Interim Report have already been dealt with at some length, but at this stage it may be useful to consider the chosen network as a whole, rather than from any particular point of view. Before doing so it may be useful to make the point here that any practical plan is essentially a compromise between many conflicting requirements and will contain contestable assumptions about people's future behaviour. We are, therefore, concerned not with whether the plan is perfect, but with whether it provides the best solution which can be found at the present time, or within the reasonably near future. In this respect we have some doubts about the general shape of the network; not because we have any firm evidence against the proposed layout, but because of the lack of firm evidence that sufficient alternative proposals to a square mesh grid have been seriously studied.

5.2.2 Figure 47 in the report shows an unscaled "spider diagram" said to depict the peak hour trip pattern. It is then stated that "an examination of this diagram led to the postulation of a grid type system of roads because it combined good general accessibility for the dispersed land uses of the plan and because it has a high degree of flexibility to adapt to growth and change." In fact, two square grids were reviewed, and one with sides equal to 1 Km. was chosen. It is possible to visualise grids of other geometrical shapes, such as diamond, rectangular, hexagonal or composite grids, etc. which might meet the Figure 47 traffic pattern better while still meeting the other conditions regarding flexibility. It should be noted that the square mesh does provide problems in designing suitable interchanges for public transport routes, and it might be advantageous if some modification could be found for the square grid which provided a more suitable public transport layout without any seriously adverse effects on road traffic.

5.2.3 We are also not convinced that it is possible, without further work, to decide between a mile and a kilometre grid. The present tentative choice has been made, presumably, on the basis that a proportion of, but not all, the intersections on the kilometre grid will have to be made with grade separation. We feel that the number of intersections requiring this treatment cannot be decided until the loadings on the roads and the turning movements applicable to both internal and regional traffic have been forecast on the traffic model and, therefore, it is not yet possible to forecast accurately the comparative cost of the two square grids.

5.3 Conclusions

Although we do not think that the 1 Km. grid selected for the road network is necessarily wrong, we are not convinced that it has been conclusively shown to be the best solution bearing in mind the combined requirements of both public and private transport.

5.4 Recommendations for further study

We propose to study a range of alternative road networks to establish whether the 1 kilometre square grid does in fact provide the best solution, having regard to the requirements of both public and private transport.