Personal recollections by John M Cullen former MD of Scott Wilson Kirkpatrick & Co (Scotland) Ltd. about the early days in the planning of the Glasgow Motorway System. I was asked to comment on drafts. These, when finalised were sent to the Motorway Archive Project for publication by The Institution of Highways + Transportation and others (?) & the Century Autumn 2004.

3 Glasgow Motorways Early History

Scott Wilson Kirkpatrick and Partners (SWK) were approached by Glasgow Corporation early in 1960. The Corporation were preparing their quinquennial review of their development plan which was concerned primarily with urban renewal by comprehensive development. Also, the city centre had a growing traffic problem while the redevelopment proposals offered an opportunity to plan a new city centre relief road. An inner ring road was therefore incorporated into the quinquenniel review proposals.

In the Glasgow Development Plan Quinquennial Review 1960, the Written Statement states ;
(a) that having regard to the anticipated increase in the volume of traffic in the next 15 years, an Inner Ring Road will be essential for the City.
(b) that the said road will require to be of the scale and purpose of an urban motorway rather than a multi-purpose traffic road.
(c) that the construction of the entire road, including a proposed new bridge over the River Clyde Ferry/Shearer Street should if possible, be completed within the next 10 years.
Unknown to us at the time, a motorway network incorporating an inner ring road had been included in the Bruce Report of 1945 produced by Robert Bruce, City Engineer, and also in the Abercromby Report of 1946 (a regional study). The tentative route for an inner ring road was I believe inherited from these reports.

Some of the highest priority Comprehensive Development Areas (CDAs) were on the tentative route of the ring road and before these could be progressed it was essential to determine definitely whether a ring road should be built and if so it would be necessary to design it in sufficient detail for the plans for the various CDAs affected, to be developed.

Henry Grace, one of the senior partners of SWK dealt with the matter . He explained to the Corporation that SWK had no experience of urban road design or of traffic planning but pointed out that no other British Consultant had any relevant experience either. Moreover he said that one of their bright young men, Roy Hodgen, was about to return from a one year post graduate course in transportation planning in the United States..Also they had an association with an American firm of consultants who specialised in this field and one of their partners was prepared to visit Glasgow to give advice. . Mr Grace went on to say that although the American Partner's charging rate would be comparatively high, SWK would be prepared to meet half the cost . I learned later that this offer greatly impressed the Corporation and was the start of an harmonious and fruitful relationship.

SWK were duly appointed and Roy Hodgen came to Glasgow in mid summer to set up a Glasgow Office and take charge of it. Their remit was "to proceed immediately with a limited traffic study which would provide sufficient data for the design of the inner ring road and to produce as a matter of urgency a definitive design for the inner ring road".
When I arrived Roy was very busy setting up an origin destination survey by roadside interview This was concerned only with the inner ring road and involved 31 roadside stations I believe this was the first of its kind in Britain. (Also in Europe I believe.) Unknown to us at the time, the SELNEC (South East Lancashire & North East Cheshire) study started at the same time doing similar things.

My job was to draw up an outline design of the ring road so that traffic assignments could be made and to take a first step towards producing a definitive design for the ring road. The design was to be practical, buildable, able to carry predicted traffic and should define the extent of land to be occupied by the road. It also had to be suitable to produce reliable cost estimates.

The first decision by Roy Hodgen and myself was that it would require to be designed to motorway standards.

This idea was in tune with the radical thinking of the Corporation at this time.

In 1961 a deputation of twelve people took part in a Scottish Mission to the USA to study urban renewal and traffic problems. The members represented the Scottish Office, New Towns and Glasgow Corporation. They visited eight cities on the eastern seaboard plus Pittsburgh, Detroit and Chicago.

I should mention that in the early 1960s I took part in three informal technical visits to Europe. The group included Civil Engineers, Architects and Town Planners. We visited Belgium, France, Germany, Switzerland, Denmark, Sweden, Finland, West Berlin, East Germany and Poland. Much of interest was seen. The new towns outside Stockholm were impressive, especially Valingsby. Tapiola new town outside Helsinki was also impressive. What struck me was that the operational design of the European urban motorways was inferior to those is the USA, but the aesthetic treatment was generally speaking better. The aesthetic treatment of the European roads had a major influence on the design of the Glasgow Motorways.

5 Road Planning Inner Ring Road

It was essential to liaise very closely with the Glasgow Coporation Planning Department since most of the route lay through Comprehensive Development Areas. Fortunately, I had previously worked with two of the town planners most closely connected with these developments , This had been at Cumbernauld new town. Jack Wood, a Civil Engineer, was employed in the Planning Department and played a valuable role in liaising with SWK.
In the first instance it was decided to follow as close as practicable the line already established . An exception was made in respect of the north flank where preliminary examination pointed to a clearly better line which was immediately adopted and was not subsequently changed.
A basic decision was to carry out an origin - destination traffic survey and to produce a traffic matrix for the design year of 1990.
It was necessary to establish geometric design standards for alignment, cross section and operational requirements. Since there were no national standards for urban motorways at this time these standards had to be created from scratch. These were developed from first principles looking to British standards where possible but mostly basing them on American practice. Fortunately , I had gone through a similar process at Cumbernauld which helped to facilitate the process. The establishment of design standards is described in Appendix A.
In view of the large amount of schemes that would have to be drawn up it was also desirable to establish slick labour saving design procedures to expedite the process. This may seem a somewhat peripheral issue but given how vital time proved to be in the entire project any time saving was valuable.
This included a) Defining gradients as a percentage rather than one in so many.

b) Making gradients a round figure

c) Defining vertical curves by their K value (being the horizontal distance (in feet this being in the days of imperial measurements) to effect a change of gradient of one percent. This was American practice.

d) At this stage plans were drawn up at a scale of 1/2500 using ordnance survey maps. Road profiles were drawn to a horizontal scale of 1/2500 and a vertical scale of 1/250 on profile paper.

e) A great labour saving device was a "highway template" that I brought from the US. This was a transparent plastic template with a series of circular slots of various radii. A set of railway curves was also used. Another useful device was a small circular template with holes around the circumference at varying distances from the edge for drawing lines parallel to a curve. This was done by inserting the point of a sharp pencil through a hole the appropriate distance from the edge of a railway curve and drawing it along the edge. This was christened a " doohickie" by a South African graduate .

f) A useful trick was the use of a specially calculated table that listed the railway curve radius that represented the vertical curve K value on a longitudinal profile for any combination of horizontal and vertical scales. This saved time and helped to achieve optimum designs.

It was obvious that radial motorways connecting into the ring road would be required. and that these would for the most part connect to the existing major routes outside the city, including proposed motorways.
Furthermore it was realised that the Inner Ring Road could not be designed without incorporating the interchanges with these radial motorways. So although our remit did not at this time extend beyond the ring road it was necessary to make judgements in respect of the routes of these radial motorways. This process was carried out in a limited time with limited

resources and was fraught with difficulties and had serious future consequences. These radial motorways are as follows:

1) Renfrew Motorway
This was straight forward, heading west from the southwest corner of the ring road to join the proposed Renfrew Bypass (motorway) at the City boundary, following an obvious corridor close to a main line railway. It also passed through a considerable length of slum housing that was part of a C.D.A. When built it became part of the M8.

2) Clydeside Expressway
This road ran to the west immediately to the north of docks and warehouses etc on the north side of the River Clyde. The term expressway has been the source of considerable confusion. Influenced by American practice, we had gone by the definition in American manuals ; " An expressway is a divided arterial highway for through traffic with full or partial control of access and generally with grade separation at intersections." In the event this road was designed (by Halcrows) with full control of access and grade separated junctions. It was virtually a motorway without hard shoulders.

3) Great Western Road
This was an existing major road , wide and with dual carriageway further out from the centre. It was envisaged that this road would be used with fairly minor improvements. A serious misjudgement was to describe this road as an expressway which contributed to the oposition to this route that led to the abandonment of traffic improvements to this route.

4) Maryhill Motorway
This road ran northwest from near the northwest corner of the Ring Road following the line of the Glasgow branch of the Forth and Clyde Canal. This canal had been closed to navigation but kept in being to provide water to industries downstream but could be piped if required. This motorway was cancelled in the mid 70s for environmental / political reasons.

5) Springburn Expressway
This road ran to the north from the north east corner of the ring road. This road was eventually built much as envisioned although with difficulties because it followed the line of an existing arterial road for much of its length. Building new roads on top of existing ones always creates difficulties, such as dealing with utilities and existing traffic.

6) Monkland Motorway
This road ran to the east from the north east corner of the ring road. It followed the line of the abandoned Monkland Canal and connected to the Edinburgh Road A8 at the City Boundary; currently (2004) being upgraded to a motorway. The canal was an ideal route for a motorway as it existed prior to subsequent developments and thus formed a line of severance.It was eventually built at relatively low cost and minimal disturbance or adverse environmental effects. The canal was piped to maintain the supply of water for industrial use downstream.

7) Hamilton Motorway
This road runs eastward from near the south east corner of the Ring Road connecting to the proposed M74 (Hamilton Bypass) at the City Boundary, leading to England via Carlyle. The decision regarding the location of this route was to have crucial implications for the future. Preliminary reconnaissance suggested a route starting south of the River Clyde and generally passing through industrial areas much of it derelict. It also followed the line of the

River Clyde and a main line railway. However the client had objections to this route and suggested that we make use of a route through Glasgow Green following a principal traffic route already designated on the development plans. The design of the ring road proceeded on that basis. It is ironic that after much trials and tribulations the motorway that is planned to be built soon.(the M74 Extension) follows closely this early line that was abandoned so early in the planning process..

8) South Motorway

This road was planned to go south from the middle of the south flank of the ring road. Two difficulties presented themselves.

Firstly, the interchange involved would have been close to interchanges in both directions along the ring road involving traffic operational problems with no satisfactory solution.

Secondly, it seemed that there was no feasible route to the south through that part of the city which was densely developed with good quality property.

The solution that was found was to have two routes some three miles apart,thus avoiding the difficult areas. The western one, later designated the Ayr Motorway (M77), connected to the Renfrew Motorway. This route, remarkably, went to the city boundary almost wholly through open spaces.

The motorway to the east connected to the Hamilton Motorway.

These routes are shown on Drawing No 1.

Some new streets were created in the vicinity of the Ring Road as part of redevelopment plans. These roads were intended to channel traffic movements onto roads with minimal adverse environmental impacts.

Traffic Studies

At this point an OD traffic study had been carried out by interviewing vehicle drivers crossing a cordon surrounding the central area outside the line of the ring road.
The results were coded to zoning areas in and around the City, by retired post office workers working in the office. This data was collated by IBM to produce a matrix of present day (1960) zone to zone traffic. This table of 1960 zone to zone traffic movements were assigned by computer to a representation of the Glasgow road network. The travel time on every segment of the network had been surveyed. The synthesized traffic flows compared well with the observed flows which gave us confidence in the process.

However, before this could be done, and in order to proceed quickly with the road design, as an interim measure, Roy Hodgen assisted by a junior, assigned the inter zonal trips to the ring road manually, a tedious and extensive task.
Through trips were multiplied by three to produce future traffic and trips with an origin or destination in the central area were multiplied by two to produce future traffic. The reason for the lower figure of two was that it was anticipated that future trips to the central area would be limited by controls on the number of parking spaces. This in fact has been achieved. The most radical change was to change planning parking policy in respect of office developments from requiring a minimum number of parking spaces to allowing only a (small) maximum number.
This interim assignment was sufficient to produce an initial design for the ring road for initial studies.
I might mention at this stage, that later, when our brief was extended to the whole city and traffic studies were extended to the whole city, computer assignments were made using an American computer program. When Angus Munro who was responsible for the traffic surveys and analysis and traffic modeling ran the first computer assignment program, he had to travel to Washington DC in America, to find a commercial computer to run the program. This was late 1961 or early 1962. Shortly after, a commercial IBM computer became available in Glasgow which was suitable for this purpose.
The roads were designed to carry traffic volumes predicted for 1990 which meant using population, employment and vehicle ownership projections by zone to produce a 1990 traffic matrix which was then assigned to trial future road networks. Estimates of future growth of car ownership was based on the work of J C Tanner of the Road Research Laboratory. Overall, there was about a threefold increase in traffic projected for the year 1990.
The traffic studies are fully described in the Hodgen / Cullen ICE paper.
Assigned flows on the ring road were up to around 100,000 vehicles per day requiring dual four lanes of motorway. In Glasgow with a low car ownership in UK terms and with a only a few short sections of existing streets with traffic flows more than 20,000 vpd, this was mind boggling.Much of the traffic in Glasgow is from outside the City and many contiguous areas have higgh car ownership levels. Thismakes the car ownership figure for Glasgow alone slightly misleading.
Indeed at this time I would say that not one person in a hundred maybe in a thousand thought that this was for real but just another one of these post war pie-in-the-sky paper exercises that would soon be forgotten. Indeed Henry Grace, senior partner delighted to tell about the time he attended a conversazione at the ICE where a model of the proposed Townhead Interchange was on display.

He observed two elderly gentlemen studying the model and then depart muttering something along the lines of pie in the sky - never be built.

Planning Ring Road continued.....

No acceptable alternative routes were evident for the north flank. However alternative lines were studied for the west, south and east flanks The alternative lines for the south and west flanks were easily rejected. In the case of the east flank this was not so. There was a realistic line further east than the inherited line which I in fact favored.. I suppose one might say on environmental grounds although at that time environmental issues had not received much interest.(In fact, my recollection is that the term environment in its present meaning was not in general use) . However the objective facts, costs and traffic issues were much the same for either line and so the decision was to favour the status quo. Although a small group in Glasgow Corporation were successfully steering the project through the system, a radical change in the route would require the approval of the full planning committee and this may have created difficulties.

The inherited line ran along High Street, the historic original main street of Glasgow, passing close to Glasgow Cathedral and the historic Glasgow Cross.

Mr Fratar, a Partner in Tippets, Abbet, Mc Carthy, Stratton (TAMS) visited Glasgow and approved the principle of an inner ring road and gave general approval to the outline design as presented at that time.

Plans of the Ring Road were finally drawn up at a scale of 1/2500 horizontal. Road profiles at 1/2500 horizontal and 1/250 vertical. These were formally presented to the Corporation in Jan 1963 to complete the original brief, although parts had been completed much earlier to enable CDAs to proceed.

An interim report dated June 1962 (published December 1962) dealt with the road planning of the Inner Ring Road.

I should mention that the proposed route crossed the River Clyde, at this time a major port with docks upriver as far as King George V Bridge in the City Centre. This entailed considerable existing shipping movements under the proposed bridge subsequently called Kingston Bridge. In the end 60 feet clearance was agreed and I understand Clyde Trust were paid £1,000,000 in compensation..

Models were made of the whole of the ring road at a scale of 1/1250 with the vertical scale double. These were for public display but were also useful for everyone concerned. They were made by ourselves quite simply using sheets of cork cut along the contour lines with the strips of drawing stuck on. The roads were cut out of cardboard and supported where on structure by cocktail sticks. These crude models were never the less most useful.

Later, at the final design stage, models were made professionally and used for various purposes. In the case of one interchange, at St Georges Cross, the various roads were set up on the model and the outline design of the retaining walls and slopes and pedestrian walkways designed on it.

Outline Design of the Whole Network

After the outline design of the Inner Ring Road, work started on the complete motorway system and other necessary new roads.
The first system tested was the inner ring road and the radial motorways already described. It was found that there were unacceptably high traffic volumes assigned to certain sections of this system. A north, south and east link motorway was added to the system and this was found to work.
In order to complete the design to a sufficient degree to define the area of land that would have to be reserved and to permit an accurate cost estimate, use was made of the 1/2500 OS maps. These were much out of date so we commissioned aerial photography to up date them and also to add contours sufficiently detailed and accurate for the purpose. This was done only in the relevant corridors and was done quite cheaply.
Aerial photos proved useful in the design process especially when using the stereo viewer. However it was considered vital to reconnoiter the area on the ground.
Following American practice, loops were widely used in the design of interchanges which I believe has been successful. The radius of the loops were generally about 100 feet but one loop was as low as 75 feet radius. It appears that in England the use of loops are less favoured. It may be that the minimum radius adopted is too large. This loop of 75feet radius has been in use since 1970 without any apparent problem, although it should be mentioned that the loop is entered from the surface street direction.
These plans were quickly approved.

Staging
Roy Hodgen then developed the staging of the plans which was most important. The principles were -
1 To give priority to areas of worst congestion.
2 To work outwards from the centre of the city.
3 To work towards stages that would make sense if further road development stopped .
4 To connect with major routes outside the city.
5 To make use of CDAs planned for early implementation.
The principal result was Target One which was a motorway going east to west right across the City (12.5 miles 20 kilometers) connecting to major routes on each side.. By convenient chance this linked directly with the M8 on each side and became the M8.
Within this major target an intermediate target was the north and west flanks of the ring road. This latter target became the focus of activity for implementation after approval was obtained for the Highway Plan.

When developing the design of the Monkland Motorway prior to the construction stage a radical idea emerged. This was to convert an abandoned railway into a special road. joining the motorway. This railway ran north and south through the east side of Glasgow. The proposed route of the East Link Motorway followed the line of the railway. It was envisaged that this would be a two lane two way limited access road with few junctions that could be created very

cheaply. It would have a reduced height clearance. It would have served a useful purpose as a north south distributor road which is lacking to this day. In fact there are proposals now being made to create a new north south distributor road in this area. It would in any case been a useful experiment. However the idea was not accepted.

Procurement

The motorways story began with the planning side of Glasgow Corporation, the Planning Committee and the Planning Department. Shortly after the start of the process when it became apparent that major roads were likely to be required, the Scottish Office and in particular the Scottish Development Department dealing with planning and roads became involved. They were to contribute 75% of the cost of new major roads. Technically I think they were responsible for trunk roads.
A full working party was created containing conveners (chairmen) of and department heads of planning, highways, town clerks departments of Glasgow Corporation. Also from the Scottish Office, heads of administration, planning and roads.
A technical working party was also set up comprising only the technical members.
Reports would be submitted initially to the technical working party and if approved passed on to the full working party. Roy Hodgen wrote all of the many reports submitted. These were produced at amazing speed with little secretarial support and were of a high standard, especially as most of the work was breaking new ground. I was not directly involved but I am not aware that any of these reports were rejected.
I might mention that very little change has occurred between the original motorway plans and what was actually built.

The report on the future highways development, comprising mainly motorways was submitted and approved in 1963. (The published report appeared in 1965. The delay was because all resources were concentrated on preparing documents for the first contract.)
During the planning stage, SWK reported to the planning department headed by Ron Nicol. When it came to implementation responsibility passed to the City Engineer's Department headed by John Armour. Ian Greig was deputy.
The first contracts were given out to Civil Engineering Consultants which was normal practice at that time. SWK- Townhead and Woodside, Fairhursts - Kingston Bridge and Charing Cross. Halcrows,- Clydeside Expressway. John Armour gave the Consultants a sensibly free reign.

The first contract was Townhead Interchange Stage 1.Contract drawings, bills of quantities and specifications were required. This was a major task.
Before starting detailed design, a project report was produced. This report defined the project exactly, the extent, how temporary connections to the existing streets and any road diversions were to be done.Any major drainage woek was defined and any major utility diversions were described and the basic design of bridges was outlined.
It made clear to the client exactly what was being proposed so as to avoid future mis-understandings. It was also useful to hand out to staff who were coming fresh to the project.

I believe this is a vital requirement in procurement process and that most of the procurement disasters of recent years are largely for this reason.

At a later stage the engineering staff of Glasgow Corporation requested that they be allowed to

design some of the motorways and this requested was granted. They undertook the final design of the Monkland Motorway. However they made slow progress and as a result the Renfrew Motorway that was originally planned to follow the Monkland was brought forward. The Monkland Motorway was eventually completed four years after the Renfrew Motorway.

The process followed what was then standard practice. Detailed design of the projects were prepared and specification and bills of quantities prepared . Usually about five contractors would be invited to bid. The lowest tender would be chosen.
The construction would be supervised by The Engineers Representative (commonly referred to as the Resident Engineer) and his staff. The salary of thee staff would be charged directly to the client although the Resident Engineer would report to the project director in the consultant's office. A partner would have ultimate responsibility.
On the completion of the contract the RE with his staff would measure up the work and settle claims for any extra work. This system had been in use for over a century and seems to me to have worked pretty well. On the whole the trust placed on the engineer (consultant) has been justified, the engineer being truly independent and over the years maintaining a self regulating ethos of professionalism and integrity. Nothing is perfect in this imperfect world but the system described is probably at least as good as any other. A great advantage of the system is that most decisions can be taken immediately and there is great flexibility,
As an aside I regret that this arrangement has been eroded in recent years.

Design Costs
At the road planning stage payment was on a time plus expenses basis on a scale set down by Association of Consulting Civil Engineers which I believe was reasonable.
Final design fees were based on a percentage of the construction costs, the percentage varying according to the type and magnitude of the work. These fee scales were set by the Association of Consulting Engineers. On the whole, I think they were reasonable and in my experience, allowed the Consultant to give adequate effort to produce a good design. Certain
ly, the structural form of bridges chosen for the SWK bridges were pretty sophisticated and not the type one would choose if profit was the principal consideration. In fact, when SWK later pursued jobs overseas on a competitive basis they were unable to make use of the Glasgow Motorway bridge types because of their higher design costs.
The cost of planning was about one tenth of one percent of the cost of the complete proposals
The cost of final design was about four percent and site supervision about six percent.

Implementation

SWK started final design in late 1963 on Townhead Interchange - Stage 1.
About a dozen additional engineers and technicians were recruited for this purpose. Brian Mc Kenna came up from the London Head Office to take charge of a bridges section.

The first task was to liaise with W.A.Fairhursts and Partners, who were designing the West Flank of the Ring Road, to define the design standards and details to be used.
This was readily done largely using the standards already developed by SWK. Holfords dealing with townscaping, architectural and landscaping matters were appointed by the Corporation and worked with both Consultants. Their contribution was real and valuable.
The only standard that was not agreed was that of bridge parapet rails. There was a proposal to use a newly marketed aluminium rail but Brian Mc Kenna considered it of inadequate strength. He also strongly believed that the Dof T standard was also inadequate. He developed his own standard which was much stronger. I understand that at a later date the MOT changed their design to a higher standard. Brian was criticized at the time for being uncooperative but time proved him right. Several trucks and buses have crashed through the aluminium rail but as far as I know none has got through Brian's barrier.

A fortuitous and fortunate event happened at this time. W. A.Fairhursts intimated that in view of the extent of taper on the structural approaches to the Kingston Bridge they would prefer that the bridge be dual five lanes instead of dual four. We were happy to agree because significant operational advantages, including system balance, would follow although difficult to prove. Given that failure to complete important parts of the motorway network resulted in an unanticipated huge traffic load on the Kingston Bridge this proved to be very fortunate. The Kingston Bridge was originally designed for a traffic flow of 120,000 vehicles per day. In 1997 it was carrying 165,000 vehicles per day.

A lucky circumstance arose in connection with the design of the road pavement structure. Recent research had shown that a bitumen bound base is stronger than a waterbound macadam base and that an 8inch thick bitumen bound base was as strong as a 10 inch water bound base. However this new standard had not yet been promulgated as official policy so a conservative approach was adopted and a 10 inch bitumen bound base was used. This proved to be fortunate as exceptionally large numbers of heavy vehicles were to use this road and as far as I am aware the road has stood up well over the last 36 years of use.

The Corporation's own lighting department designed the road lighting. They decided to use high mast lighting which was very new at that time. In fact, I believe it was the second time it had ever been used. The large scale model of the complete Townhead Interchange was used to locate the masts in that area. It was also decided that internally lit overhead sign gantries would be used.

The motorway impinged on the Glasgow branch of the Forth and Clyde Canal and although the canal had been closed to navigation since 1963, it was still used to supply substantial quantities

of water to industries downstream.(my recollection is that it was 15 million Gallons per day.) So it had to be piped (by twin pipes 24 inch dia) as was the case with the Monkland canal. As part of a report that was prepared the quality of the water was checked and found to be unexpectedly good. On reflection, this should not have been too surprising, as the top up water to the canal comes from upland sources and no drains were permitted to discharge into the canal. So the boys I watched as a child, skinny dipping in the canal were not unduly at risk after all.
At that time the canal had a negative image largely due to the fact that there was quite a lot of people drowned . Now the canal has a very positive image and indeed the Forth and Clyde canal has recently been restored to permit navigation from the Clyde to the Forth at a cost of £70 million.
The site of the oldest chemical works in the world, at Townhead, lay under the motorway and special measures were required to protect concrete bases from corrosive chemicals in the soil.

The preparation of the contract documents was a daunting task. The Glasgow office had been set up only to do the planning of the Glasgow Motorways and had a small staff. Indeed the award of final design to SWK surprised the partners as they had assumed that this work would go to local firms.
(tabula rasa)

The first task was to define the geometry of the roads both horizontally and vertically. Although only the first stage of Townhead Interchange was to be built in this contract, the geometry of the whole interchange had to be determined, horizontally and vertically.
Not only was this time pre computers, it was pre hand calculators. It was also pre metric. The tools available were Peters eight place tables of trig functions and a machine that could multiply and divide. All key points of the horizontal geometry had to be calculated to the second decimal place of feet. The task was made easier by making all bearings a round number. Curvature was described as degree of curve and the degree of curve was rounded. This permitted the use of Barnett's tables (American) giving all necessary data. Levels were calculated at 25 feet intervals along all roads. This was made easier by defining all gradients as percentages and making them round figures. All vertical IPs (intersection points) were placed at even chainages and all lengths of vertical curves were also made rounded.
It was considered desirable that bridges and elevated structures should have simple horizontal geometry, either on straights or on simple curves. There was one bridge where this was not possible. An interesting solution was devised. The bridge was located entirely on reversing transition curves with the point of contraflection at the centre of the bridge. The rate of change of cross fall was constant across the bridge. Therefore all longitudinal and cross slopes on the bridge deck were straight.

An accurate survey was carried out to establish accurate reference points on the ground. Not easy as the area was still built up at this time and busy streets had to be crossed. This was before the time of measuring distances electronically. The geometric features were also related to a grid system. This system was based on the Ordnance Survey national grid so that all contracts would have a common grid system. A complication that had to be addressed was that at the latitude of

Glasgow, a scale factor applied to OS distances whereas the geometry of the road layout required true distances. These difficulties were resolved.
All this was important since there would be buildings still standing to block the line of sight at the start of the contract and errors just did not bear thinking about.
The calculation of vertical bridge clearances was also critical. These were calculated by the roads section, checked and double checked. The relevant horizontal and vertical geometry was then passed formally to the bridges section where it was checked and double checked. A significant shortfall in bridge clearance discovered during construction did not bear thinking about.
As the geometry was calculated the road lines were plotted on a sheet of permatrace with a 500 feet grid accurately drawn on it which served to check gross errors in the calculations as well of course as a basis for drawing up the various contract drawings.-

Later Road Planning

The achievement of Target One had gone swiftly and smoothly and close to original plans.The only hitch was the delay with the Monkland Motorway to 1980. Progress after that was not so smooth.
The schemes that were being considered for early implementation were the south and east flanks of the Ring Road, Maryhill Motorway, and Ayr Motorway. SWK in conjunction with Holfords prepared a report on the Maryhill Motorway in May 1975, and a report on the Ayr Motorway in November 1975. Both were thorough and beautifully presented reports. Both schemes were abandoned shortly afterwards. The first section of the Ayr Motorway between the M8 and Dumbreck Road with the title of Te Dumbreck Connection. Strict instructions were given by the that must not appear as though it was planned for future extension. The Ayr Motorway was later reinstated. I understand this was due to pressure from Ayrshire politicians.

Strathclyde Region came in to existence in 1975 and ended in 1995. Their policy was to do planning and design in house so obviously they determined strategy in this period.

After four major reports on the East Flank of the Ring Road prepared by SWK and Holfords between 1973 and 1980, this scheme was abandoned, largely due to objections about the impact on Glasgow Green and no doubt by the influence of the green lobby. In the end the recommended scheme passed under Glasgow Green and the River Clyde in cut and cover which I believe made it environmentally acceptable. But even this did not save it. The only remaining Motorway still being planned was the Stirling Motorway (M80). This was designed by Strathclyde Region.

It is ironic that the outline design of the Renfrew Motorway was done in three days by one man, using a red crayon pencil on two sheets of six inch to the mile Ordnance Survey sheets taped together. This has since been built with no real changes. The outline design of the Monkland Motorway was done in two weeks with little subsequent change.
Northcote C Parkinson would surely have found some interesting material here.

By 1981 it was clear that the remainder of the original Highway Plan must be set aside and new plan created. A study was therefore started in 1981. This study took as a starting point only what was built or firmly committed at that time and considered a wide range of alternative networks with a fresh eye. The conclusions of this study led to the scheme which is currently (early 2004) the subject of a public inquiry. This is a five mile length of motorway which extends the M74 to join the Renfrew Motorway at the Kingston Bridge. This motorway will divert large traffic flows from the M8 west of the Kingston Bridge greatly reducing the present congestion.

In this period Townhead Interchange Stage 2 was completed April 1982. the Stirling Motorway (Stepps Bypass, M80) was completed June1992.
M74 Northern Extension to Fullarton Junction completed 1993.
Ayr Motorway opened December 1996.
In the mid 90s a valuable project that increased the capacity of the critical section of the Monkland Motorway and the North Flank was carried out by adding a lane in each direction This scheme was developed by Jack Wood..

Outcome

The development of the plans for the Glasgow Motorways was described in an I.C.E. paper by Hodgen and Cullen in October 1968.

Another I.C,E. paper by Hamilton and Carruthers was published in Feb 1994 "The Glasgow Urban Motorway Network - 25 years on" This dealt mainly with carriageway strengthening and bridge refurbishing.

Having been involved with the project since its start in 1960, I have thought it worthwhile to record how the outcome compares with the original plans.
Although of necessity the motorways extended beyond the Glasgow City boundary, it is convenient to deal with issues within the City boundaries. Firstly, the study was commissioned by Glasgow Corporation and design was focused on the parts within the city, although discussions were held with adjacent roads authorities to ensure that the Glasgow plans were compatible with theirs. Secondly the manner in which traffic surveys had been carried out meant that predicted traffic flows on the proposed road network were valid only within the city boundary (where the outer traffic survey cordon was located.)
The outcome will be described under the following headings.

1 Extent of proposed network actually achieved.
2 Traffic flows - Actual compared with predicted.
3 Speeds - Actual compared with predicted.
4 Accident rates Actual compared with original
5 Operation - capacity etc.
6 Capital costs. Actual compared with original.
7 Road user benefits and cost benefit ratio.

1 Network achieved

Figure One shows the originally proposed network and those parts that have been completed to date. (2004)
In terms of length 52% of the motorways have been completed. However some sections were predicted to carry much higher traffic flows than others. If the calculation is repeated but sections weighted according to predicted volumes then the proportion completed becomes 43%.
If near motorways (Clydeside Expressway and tunnel Approaches, Springburn Expressway) are included the proportion rises to 48%. In short, just under half of the planned system has been built.

The configuration of this limited motorway network funnels large traffic flows onto certain sections leading to much higher flows than the design values causing congestion at peak flow periods. This is particularly so on the M8 between the M77 and M80 junctions.

2 Traffic Flows - Actual compared with Predicted
In the original study separate traffic assignment were made to Target One planned for 1975 and this network was effectively achieved in 1977. The comparison between predicted and actual traffic flows was surprisingly good.

In the design year of 1990 the network achieved, being very incomplete, was entirely different from that planned. It is therefore not possible to make a direct comparison between the projected flow and those actually measured.. Drawing No 3 shows the projected 1990 traffic flows on the planned network and Drawing No 3A shows the 1998 actual flows o n the present system.

It is possible to make some comparison between the total traffic on roads in Glasgow in 1990 compared with the original projections made for 1990 in the following way.
In the Highway Plan study the1961 and 1990 traffic matrices were assigned to the 1961 road network to produce total vehicle miles on each. The 1990 total was larger by a factor of 2.76. Actual growth can obtained by comparing total traffic flows across the River Clyde Screenline counted in 1961 and in 1990. A similar process can be applied to the Glasgow Middle City Cordon. The results are shown in the table below.

	growth factor 1961 to 1990	1961 to 1998	
predicted in Study	2.76	N/A	
River Clyde Screen Line	2.46	2.80	2.44 / 2.76 = 0.88
Glasgow mid-city cordon	2.42	2.90	
average	2.44	2.85	2.85 / 2.76 = 1.03

It can be seen that total traffic in 1990 appears to be 12% less than predicted, but reached predicted levels before 1998.
Total population in the Study area in 1961 was 1,497,000.The projected total for 1990 was1,519,00. In fact, the actual population in 1990, was 1,220,000, a 20% drop. Glasgow and Clydebank had very large falls in population. In 1960 both banks of the River Clyde down river from the City Centre were lined with docks and ship yards which are nearly all gone now. In 1966 Glasgow was the fifth largest port in Britain and it now tiny.

Car ownership is a prime factor in determining traffic levels. The predicted and actual levels are shown in the table below. All figures are cars per hundred persons.

	actual 1961	predicted 1990	actual 1990
low ownership areas	5	23	21
high ownership areas	11	36	39

Given the uncertainties of peering thirty years into the future these various comparisons may be considered satisfactory and do not suggest that any significant changes in the planning and design of the motorways are indicated..

3 Traffic Speeds - Motorways

At the planning stage it was thought that the average speed on the motorways would be about 50mph based on American practice where the operating speed corresponding to a design speed of 60mph is given as 50 mph.
The average speed (spot speed)on the M1 shortly after coming into use in 1959 was 59mph for cars.
When the north and west flanks of the Ring Road were completed in 1971 the average speeds of cars and light vans was 47mph and heavy goods vehicles 35mph.

In 1979 when most of the M8 was completed the average speed (journey speed) of all vehicles on the M8 was measured as 50mph, There was little difference between the speeds of cars and heavy vehicles..
In 1997 a survey measured the average speed of all vehicles on the M8 inside Glasgow as 60mph. This included the effects of delays in the peak traffic periods. Other speed surveys show similar speeds on the other Glasgow motorways.

4 Accident Rates

In order to calculate the reduction in the number of accidents brought about by the use of motorways one must know the accident rate for the motorways and also for the remaining "normal" roads.

Motorway Accident Rates
When the motorways were being planned most urban motorways were in the USA where extensive literature was available and provided much of the information that we used... The accident rate on urban motorways in the USA was one injury accident per million vehicle miles. (This compared with 7.4 for all roads in Glasgow in 1961.)
The first opportunity to obtain a rate for the Glasgow motorways came when the north and west flanks of the ring road were opened to traffic in January 1972. Studies in 1972 showed an accident rate of 0.42 injury accidents per million vehicle miles which was quite gratifying. The accident rate for all British motorways, mainly rural, at that time was 0.26 inj. Accidents per veh mile.

The first chance to obtain an accident rate for motorways in Glasgow other than the Inner Ring Road, which was not typical of the other motorways in Glasgow, due to the frequency of exits and entrances, was when the Renfrew Motorway opened in 1976. The first year of operation produced the astonishingly low value of 0.10 inj acc per veh mile, one tenth of the projected rate and less than a seventieth of the rate for all roads in Glasgow in 1961.
In 1977, the first full year of operation there were no accidents recorded at all other than one on a slip road. As other sections of the Glasgow motorways were completed (especially the Monkland Motorway) a higher rate of 0.15 acc per veh mile was observed.(still very good) It emerged that the Renfrew Motorway has a lower rate than other Glasgow motorways.
Accident rates on normal roads in Glasgow (as well as all roads in Britain) have fallen greatly since 1961. I will now pursue these issues more fully.

From here on accidents will be expressed in terms of vehicle kilometres which is current

practice.(It has been a source of some confusion that we have changed from Imperial to Metric during the course of this project.)
Strathclyde Region carried out a detailed and rigorous study of Glasgow motorway accident rates on the Renfrew Motorway, Inner Ring Road, Monkland Motorway - Stage One, Clyde Tunnel and Clydeside Expressway. These studies covered the years 1976 to 1981. The results are as follows and show the average over these years.

Glasgow Motorway Accident Rates	Injury Accidents per Million Vehicle Kilometres		
	As Observed	Used for Calculations	
Kingston Bridge	0.831		
Rest of Ring Road	0.237		
Whole of Ring Road	0.34	0.34	
Renfrew Motorway	0.064	0.10	Other motorways M80 and M77
Monkland Motorway	0.106	0.10	assumed to be 0.10 also
Clyde Tunnel	0.894		
Clydeside Expressway	0.398	0.40	

None of these results is surprising.
The whole of the Ring Road has frequent entrances and exits and often operates at over capacity.
The higher rate for the Clydeside Expressway, with no hard shoulders, shows the advantages of full motorway standards.
Although the Ring Road and Clydeside Expressway Rates are relatively high they are much lower *than on normal roads* *The Clydeside Expressway although pretty basic and relatively* inexpensive undoubtably represents good value.
The reason for the low rate on the Renfrew Motorway may be that it operates comfortably below capacity and partly that it benefits from the quadruple carriageway section where there is no weaving. It is of interest that an American paper published in 1966 (Highway Research Record Number 99 Effect of Traffic Volumes and Number of Lanes on Freeway Accident Rates Author R T Lundy) demonstrated a marked increase in accident rates with increased traffic volumes for any given number of lanes.

<u>Accident Rates - Normal Roads (non motorway roads)</u>

Injury Accident rates on normal roads in Glasgow have changed so much over the years (from 4.3 Injury Accidents per veh kms in 1961 to 1.54 in 1991), So that, to calculate reductions in accidents achieved by transferring traffic from normal roads to motorways it is necessary to calculate more than one rate.
To calculate Injury Accident (IA) for normal roads in Glasgow for any given year one needs to know the number of injury accidents and then by deducting those occurring on motorways,from the total amount of accidents on the normal roads.
We also need to know the total amount of travel on the normal roads.(which is not easy)
The Highway Plan Report quotes a rate for 1961 of - 7.4 IAs per mill veh <u>miles</u>, equal to 4.60 I As per veh <u>Km</u>. (The Highway Plan states "These figures will be slightly higher than they should be because of the exclusion of some local travel from the survey." I have assumed that the excluded travel amounts to 7%. Producing an adjusted value of 4.3 Injury Accidents per Million Vehicle Kilometres.

Values calculated for other years are shown below

	Glasgow	All British Urban Roads Excluding Motorways	Source
1961	4.2	3.4	Highway Plan Report
1977	1.847	1.609	Lisbon Paper
1991	1.54	0.94	Calculated by JMC Recently

Fig4 illustrates these issues.

Road fatalities in Glasgow have dropped dramatically from 141, in 1997, the year before the first section of motorway opened, to 13 in 2002, a drop of 91%. In the same period, the reduction in road fatalities in the rest of Scotland was 54%.
The transfer of road traffic from surface roads to motorways mainly accounts for this large reduction, but other factors such as the pedestrianisation of the three main shopping streets and the reduction of traffic in the central area.. Also the creation of environmental residential area by the targeted street closures, and the reduction in population must also be factors.
There was a remarkable drop of 36 fatalities in two consecutive years 1974 1975 which followed *significant traffic events, such as the pedestrianisation of Sauchiehall Street and the opening of* the Clydeside Expressway. See Fig No 5

5 Operation - Capacity etc

Document A "Glasgow Inner Ring Road" deals with operational issues affecting the design. The approaches spelled out in this document seem to have been successful. In retrospect the "ramp switching" at the south side of the Kingston Bridge (northbound) almost eliminating weaving has been especially beneficial in allowing the very large traffic flows observed to develop. Southbound, the natural configuration did not require "ramp switching.) The average daily flow on the bridge in 2001 was 165,000 vehicles per day with as much as 185,000 vehicles on one particular day. I believe these volumes are amongst the highest in Europe.
Allowing for the fact that much of the motorway system in recent years operates well over capacity the system appears to function pretty well. An objective measure of this is the low accident rate. The motorway junctions have performed pretty well.

Considerable use was made of loops These have generally been about 100 feet (30 metres)radius The loop at St. Georges Cross is 75 feet (23 metres) radius and I am not aware of any problems arising. I may mention that a loop 60 feet (18 metres) radius was used in an interchange at Cumbernauld without any apparent problems. (A photo of this interchange is shown in "Roads in Urban Areas Ministry of Transport 1966 ")

An unusual feature that follows Californian practice is that at exits from the motorway onto slip roads only one lane exits, the motorway shoulder continuing onto the slip road. A short distance into the slip road the shoulder becomes a second lane. The same principle is applied to an entry slip road. All shoulders are coloured red. This seems to be a more logical and neater treatment than the conventional arrangement. Especially bearing in mind that only one stream of traffic can exit *(in the normal case).*
An interesting feature of the Ring Road is that it exhibits perfect lane balance. That is, each entry slip road joins as an added lane, and each exit is a dropped lane.

Appendix 1 is an extract from the Maryhill Motorway Report which deals with capacity and still expresses my view.

6 Capital Costs -

The estimated cost of the motorways were clearly set out in the Highway Plan and broken down into segments in such a way that comparisons can be made with the outcome costs.
The outcome costs are available from the various brochures prepared at the time of the official opening of each contract. Another source is the details of all the actual disbursements made by the Corporation including for example fees paid to consultants and costs of site supervision and relocation of services.

When the tenders came in for the first contract, Townhead Interchange Stage One, in 1968, the Corporation and the Scottish Development Department were surprised and delighted that the lowest tender was under the original estimate. My recollection was that it was five or ten % less and as a result the extent of the contract was increased.

Some comparisons are as follows

		Planning Estimates	Adjusted Costs	Outcome from Brochures	Outcome from Disbursements
North and West Flanks of Ring Road	Construction	£14.78 x 1.43 =	£21.14	£ 21.26	
	Property	£6.31 x 1.25 =	£7.89	£5.62	
	Total	£21.09	£29.03	£26 .88	£30.66
Renfrew Motorway 1	Construction Costs	£9.64 x2.04 =	£19.67	£20.60	
	Property	£0.81x1.60 =	£1.30		
	Total	£10.45	£20.97		£29.084
Renfrew Motorway 2	Construction Costs	£5.77 x 2.04 =	£11.77	£14.86	
	Property	£0.48 x 1.60 =	£0.77		
	Total		£12.54		£19.29
Monkland Motorway 1	Construction Costs	£3.92 x 2.04 =	£8.00	£6.20	
	Property	£0.58 x 1.60 =	£0.93	£0.70	
	Total	£4.50	£8.93	£6.90	£10.40

Notes
The disbursement costs were given to me by Jim Mc Innes who was the person responsible. These were all the actual payments made by Glasgow Corporation and subsequently Strathclyde Region..
The likely reasons that outcome costs from disbursements are greater than the brochure costs are that the brochure costs do not include design and supervision costs. It is also likely that the brochure construction costs do not include claims by contractors for extra payments not resolved at the time of the official opening. Furthermore, the costs of diversions of some services may not be included.
The factors of 1.43 and 2.04 are the ratio of the earnings index between 1995 and the date of the actual expenditure.
I think it may be concluded that the planning estimates were satisfactory.

Road User Benefits and Cost Benefit Ratios

A benefit not yet mentioned is the saving in fuel in motorway travel.
A survey carried out on the M8 in 1978 using a car found the average fuel consumption was 38.02 miles per gallon. A survey on the normal streets found a rate of 26.16 mpg. A ratio of 1.46
In 1997 I surveyed rates of 49mpg and 37.mpg respectively in a Vauxhall Cavalier (ratio 1.33).
The Cavalier handbook quotes 33.2 mpg simulated urban, 56.5 mpg at a constant 56mph and 44.1 at 75mph. The ratio urban to constant 56mph equals 1.70. The Portugal Report used values of 7.4 litres per 100 kms motorway and 10.9 litres per 100kms. Ratio = 1.47

Road User Benefits Calculations

I am not aware of anything published on the cost benefits of any urban motorways.
In the late 1970s a rare opportunity arose to do a rigorous cost benefit study of the 20 kms of the M8 n Glasgow.
A traffic study was being carried out to assess various alternative future road networks. The Highway Plan traffic model was re-calibrated using current traffic counts. The base plan was the then current situation including the M8. It was a simple matter to remove the M8 links to reproduce the system without the M8. Assignments were made to both networks to establish the savings in time etc
Costs were accurately known from the actual disbursements by Glasgow Corporation and latterly Strathclyde Region.
The" Leitch" Report of the advisory Committee on Trunk Road Assessment was published in October 1977 which gave methods and values to assess benefits of trunk roads.

The first benefit study used a discounting rate of 10% set by the DofT but immediately after the the study was redone using a 7% rate.I believe the rate was subsequently revised to 6%. This rate applies after correcting for inflation. I think it is too high . I have heard that the high figure was set by the treasury was tocompensate for underestimation of road costs being so common.
In any event the benefits here reported are based on the 7% figure. The attached appendix 2 shows the results.They show remarkably good returns for money invested.
In a later paper I used the Glasgow results to make comparisons between the user benefits of urban and rural motorways with remarkable conclusions.

The benefit of one vehicle kilometre of urban travel transferred to motorway is 3.76 higher than is the case with rural motorways. Moreover urban motorways carry, on average, larger volumes. If truly rural motorways only are considered,that is, excluding peri-urban motorways, such as the M25 I found the ratio of urban to rural motorways traffic flows to be about 2.4. When the two factors are combined then the ratio of benefits per kilometre becomes 3.76x 2.4 = 9.02.
Amazing but true!
This information is contained in a paper that I presented the IRF meeting in Rio October 1984.
A major reason for the high road user benefit is the low cost of the motorways. One reason for this is the low cost of property acquisition. In the planning cost estimates, the total property acquisition of the motorways built is only 16% of total costs. These property cost estimates are believed to be substantially correct.

Greater Glasgow Transport Study (GGTS)

This study started in 1964 and was completed in 1967. It was carried out by SWK and TAMS (Tibbets Abbetts Mc Carthy Stratton of New York.
It differed from the Highway Plan Study in that it covered the whole conurbation and included public transport. It was also based to a large extent on home interviews.
It was a massive undertaking including over one hundred detailed technical memos.
It was anticipated that this study would replace the Highway Plan study. In fact it was only narrowly decided to produce the Highway Plan report.
In the event the GGTS study suffered from a few fundamental factors.
The time and money that went into the travel surveys and analysis including the production of a transport model for the future design year, left little scope to use the model to test wide-ranging and realistic future transport options.
It was also unlucky that the timing of the study coincided with high national predictions of population, economic growth and vehicle growth which shortly were to be revised significantly downwards. Also, the predictions of future population in the study area proved to be too high. The predicted traffic flows in Glasgow were between thirty and thirty-five percent higher than the trafffic flows predicted in the Highway Plan study. It was never the less considered that to upgrade the HP proposals would be unrealistic and they were left unchanged. Additional roads proposed by the study outside Glasgow have been subsequently abandoned.
A fundamental flaw in the study which has been pointed out in other transportation studies is that the surveys and transport modelling are so complex and extensive that little time or money is left to use the future traffic models to study realistic future transport schemes.
The main consequence of the GGTS was that on the completion of the GGTS study the nucleus of the team was established in the Glasgow Corporation Planning Department and played a part in formulating transport plans in subsequent years, especially rail plans.

Reflections

Looking back over 44 years certainly helps to see things in perspective.

1 One's first thought is amazement that it has happened at all. So many radical proposals come to naught. So why did it happen?

"There is a tide in the affairs of men that taken at the flood leads on to fortune ; Omitted all the voyage of their life is bound in shallows and in miseries"

A combination of circumstances created the opportunity in 1960 that was grabbed with both hands.

In post war Britain the climate of thinking was disposed towards radical new solutions to problems that would usher in the brave new world. There was a feeling abroad that what was old was bad and what was new was good. Immediately after the war the will was there but not the means and it was not until about 1960 that the means became available. Prior to 1960 the national effort had largely been devoted to making good the ravages of war.

Glasgow's initiative came at the right time. Glasgow was proposing to demolish large areas of slum property and redevelop those areas. They were also aware of traffic problems in the city centre to which solutions were required.

In their Written Statement of their 1960 Quinquenial Report they stated

" (a) that having regard to the anticipated increase in traffic in the next 15 years, an Inner Ring Road will be essential for the City.

(b) that the said road will require to be of the scale and purpose of an urban motorway rather than a multi–purpose traffic road."

Another factor was the creation of institutional arrangements to facilitate the implementation of such solutions as were proposed and accepted. The creation of town planning departments and town planning laws was important. The formation of a working party that included officials from the Scottish Office (who were contributing most of the money) as well as Glasgow Corporation councillors and officials was important. Naturally the character of the individuals involved was also relevant.

A particular local factor was that the tenement dwellings that were earmarked for demolition were privately owned and rented. Due to rent control, rents were uneconomally low so the financial value of the property was low. Also, the Corporation being the housing authority, could make new council houses available to the displaced occupants which made them willing to move.

A critical factor was that it was possible to find routes for motorways with minimal property take. The total original estimate of property acquisition costs for all the motorways built to date was £11.75 million compared with the construction cost estimate of £64.09 million. So the property acquisition costs were only 16% of the total cost.

Environmental issues were not much of a concern at this time. Indeed the word environment in its present usage was not in general use then.

As regards timing, there was a window of opportunity between the start in 1960 and the oil crisis of 1973 during which time the crucial work was done.(The awards for the contracts for Renfrew Motorway Stage I and Renfrew Motorway Stage II were made a few weeks before a universal

moratorium on all civil engineering contracts was imposed.) With the completion of the Renfrew Motorway and the completion of part of the Monkland Motorway, only a short section of straight forward motorway was required to complete the whole length of the M8 motorway across Glasgow.

2 The speed of accomplishment in the early days was great. Traffic surveys based on roadside interviews were used to create future traffic patterns. These were used to arrive at a road network which was designed in sufficient detail to define land take and to permit reliable cost estimates. This was done and approval obtained in three years. Preparation of contract documents started immediately and physical work started on the first motorway contract in November 1965, just over five years from the start of the whole process.

By comparison the M74 Extension within the city first proposed in 1981 is going through a public enquiry currently {early 2004)and is planned to start construction in 2006.

The principal reason for the speed of achievement was Roy Hodgen who worked at an intensity of work and clarity of thought that was remarkable. He produced written reports of great clarity. He left me to get on with the geometrc design etc. Time was saved by generally getting things right first time round. Indeed most of the motorways built to date are very little different from the original planning design.
The managing method was simply get on with it and do it. No mission statements or visions. No committee meeting except those essential like the working party meetings.
The whole process was civil engineering oriented. With the traffic studies directed towards the design of the roads which were designed to be practical and achievable.
Everyone worked with great enthusiasm.

3 Cost estimates at the planning stage proved to be good.

4 Traffic projections proved to be good.

5 The geometric design standards have proved to be good.

6 The routing of motorways away from existing roads has proved to be a good idea.

7 A huge effort was put into the environmental and aesthetic aspects which hopefully shows.

8 The pedestrianisation of the three main shopping streets in the central area has been enormously beneficial. Glasgow is the second largest shopping centre in Britain. The policy to limit vehicle access to the central area by limiting the number of parking places mainly by town planning controls has been successful.
The central area, of course , benefits from the fine Victorian and Georgian buildings that are predominant.
The city now attracts tourists to an extent to an extent unimaginable 40 years ago. It has become a major conference centre.

9 The proposal to create areas of environmental priority by selective street closures has been widely and successfully achieved.

10 The motorways have demonstrated a high benefit cost ratio. B/C = 2.21 NPV/C = 1.21 These values exclude the benefits arising from higher speeds on existing roads. The author is not aware of road user benefits calculations having been published for other urban motorways.

11 The economic benefits per unit of traffic transferred on to urban motorways are much higher than for rural motorways. (about 3.7 times higher)

12 Accident rates on the motorways have been much lower than originally thought. In particular, the reduction in road fatalities in Glasgow from 1967, (the year before the first section of motorway opened), to 2003, has dropped from 141 to 13, a drop of 92%. This compares with a drop of 54% in the rest of Scotland and a drop of 53% in Great Britain in the same period. The value of the accidents saved in this period amounts to £2 billion.

13 By far the least satisfactory outcome is that less than half the planned motorway network has been built, leading to very large traffic flows, far in excess of the forecast design flows, causing delays and unpleasant driving conditions in the morning and evening peak flow periods.

Environmental Impact

There are comparatively few properties affected by the motorways. On the other hand a number of existing arterial roads with fronting tenement houses have experienced a significant reduction in traffic.
It is interesting to note that a good number of new houses and apartment blocks have been built close to existing motorways. There is no noticeable evidence of public concern about adverse environmental effects of the motorways. Both the Marriot Hotel and the Hilton Hotel have been built tight against the motorway slip roads.

Reflections on wider issues.

In the Buchanan Report it was concluded that it was not possible to accommodate the full demand for traffic in British cities. The Glasgow experience does not bear this out. The present motorways and near motorways occupy 2% of the land area of the City. The originally proposed network would occupy about 4.5% of the land . This original network, judging by experience to date, would have reserve capacity in the design year of 1990 and in practice could be "beefed up" to meet likely future needs.

It is widely thought that new roads create their own traffic and it is like "digging a ditch in a bog". Recent traffic counts in Glasgow shows no evidence of induced traffic in Glasgow,

although it is possible that commuting from areas around Glasgow has increased in numbers and distance.

On general issues, I would say that one should work from the general to the particular. That is that in theory, the overall road planning should have preceeded the planning of the Inner Ring Road. However, it is an imperfect world and one must start from where one is at.
I am not sure that small inner ring road with radials, that was once widely advocated, is necessarily a good idea. Professor Smeed (Traffic Problems in Towns Town Planning Review 1964 Vol.XXXV) expressed doubts about this. In practice the geography of the particular city dictates where primary road routes can be located and largely determines the configuration of the primary road network.

The work in Glasgow work was entirely in accord with the principles set out in - New Roads in Towns -Urban Motorway Committee. July 1972.
It was in accord with the principles described in the Buchanan Report.

As regards the finished appearance of the motorways, this is in the eye of the beholder. It is worth restating that an unusual and enormous effort went into this aspect of the design. What can be seen is that nearly all the road alignment is curvilinear and for much of the alignment the horizontal and vertical curves are co-ordinated. Great efforts went into integrating the road into the townscape and of course the landscaping. 9,000 trees were planted on the N8 alone.

A fact that is rarely mentioned is the many fascinating vistas of the City and the hills beyond that can be enjoyed from the motoe ways that are rarely visible from the normal city streets.

BRIEF NOTE ON ACCIDENT REDUCTION IN GLASGOW 1967 TO 2003 **J CULLEN 6 7 04**

Total vehicle miles on motorway and expressway = 22 billion vehicle kms

Calculated number of accidents saved by switching traffic from "normal" roads to motorway or expressway. = 26,000
Reduction in fatalities = 400
ditto serious casualties = 6,300
ditto slight casualties = 25,000
Cost per accident = £76,000
Total cost of accidents saved = £ 1,980 million (2002 values)

Only recently have I had the data and time see how the theoretical calculations compare with the published figures.
The actual (outcome) figures for Glasgow are straight forward.
To assess what they would have been in the absence of the motorways I have assumed that they would have followed the same pattern as the rest of Scotland, and used the year 1967 (the last year before the first motorway was opened) as the point of departure.
Surprisingly the actual savings are larger than the calculated figure.

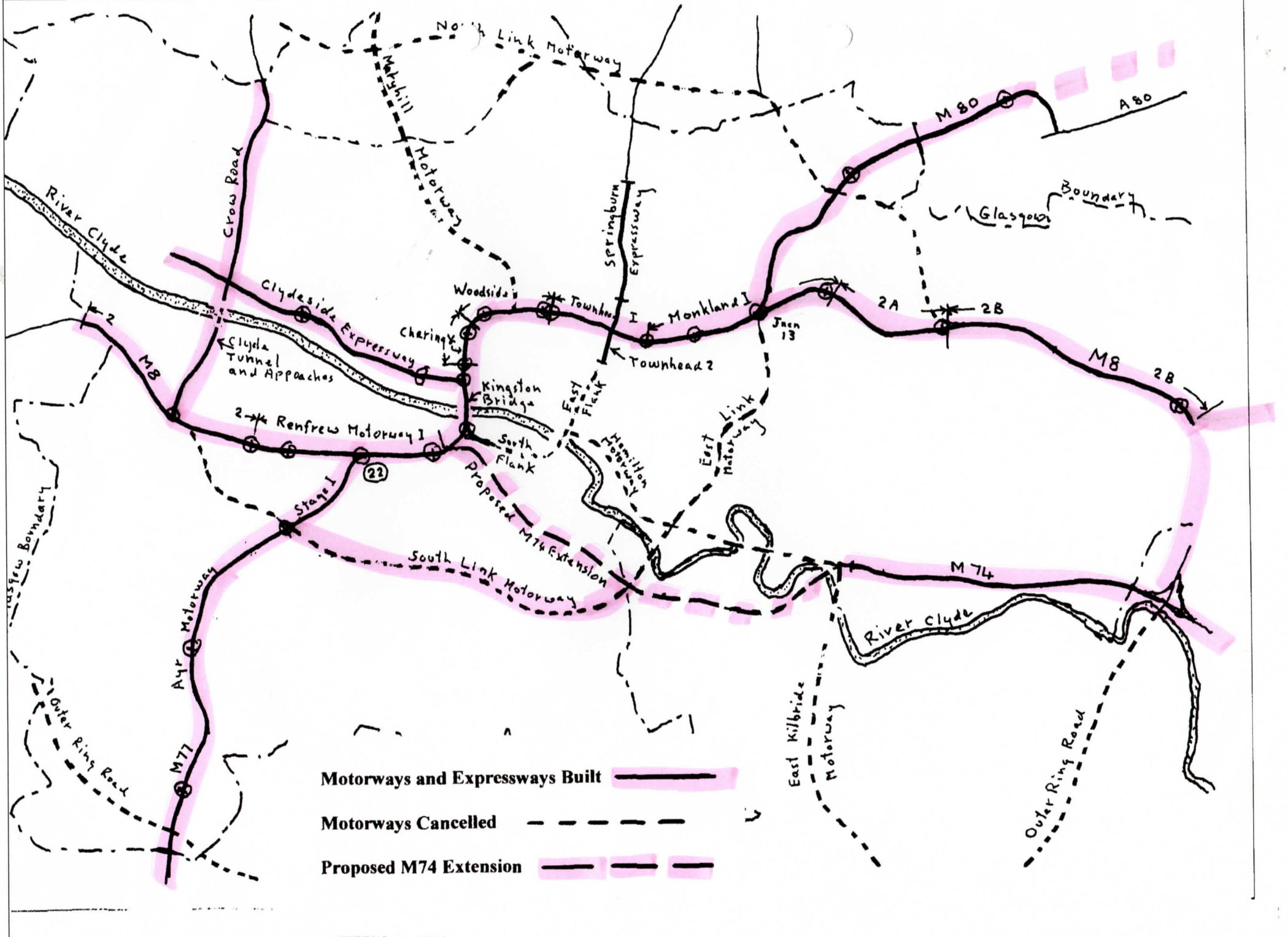
Accident Reduction from 1967 to 2002

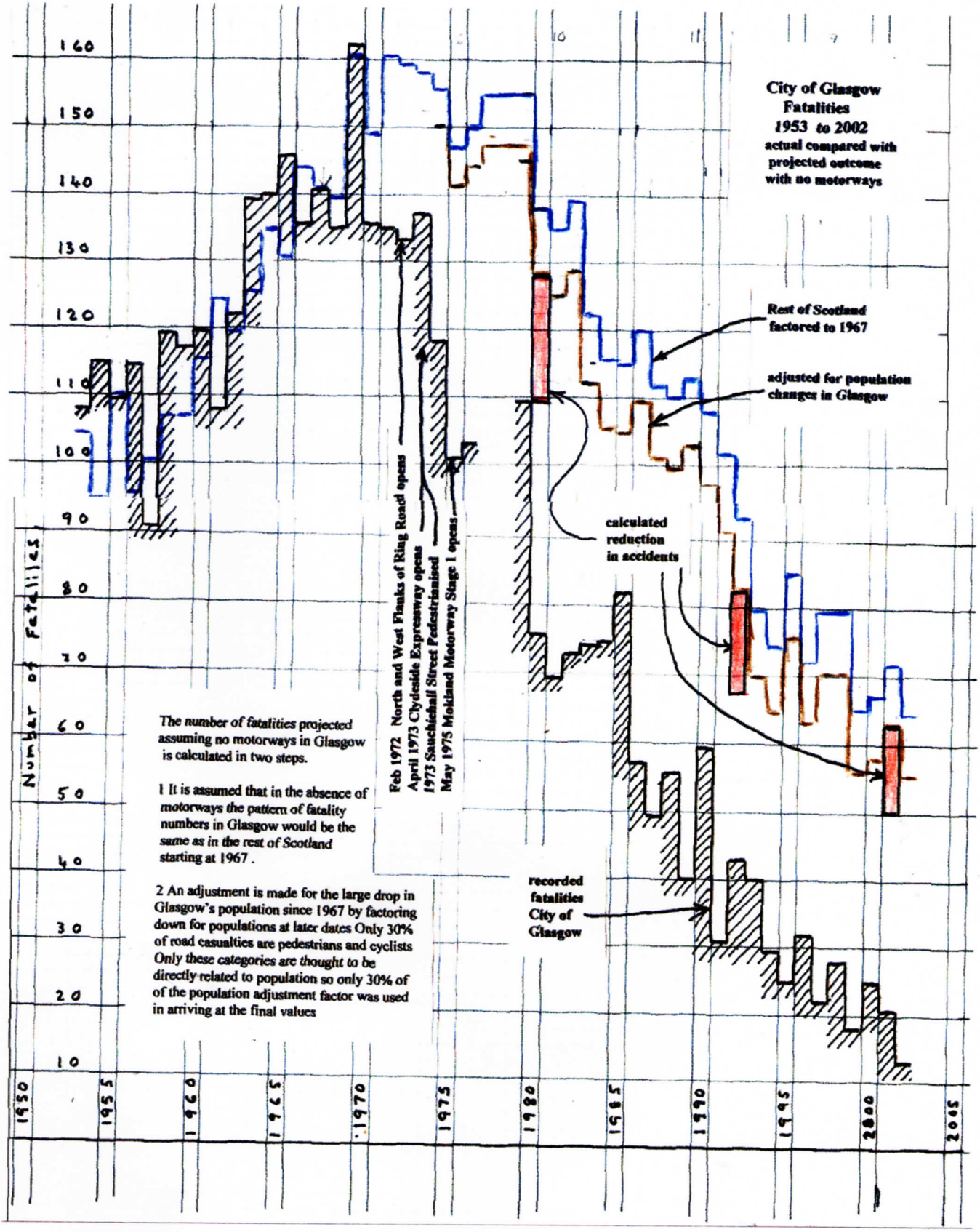
	fatalities			casualties		
year	Glasgow	Rest of Scotland	Great Britain	Glasgow	Rest of Scotland	Great Britain
1967	141	637	7,319	6,152	25,608	370,000
2002	13	291	3,431	2,674	16,583	303,000
difference	128	346	3,888	3,478	9,025	67,000
% diff.	91%	54%	53%	57%	35%	18%

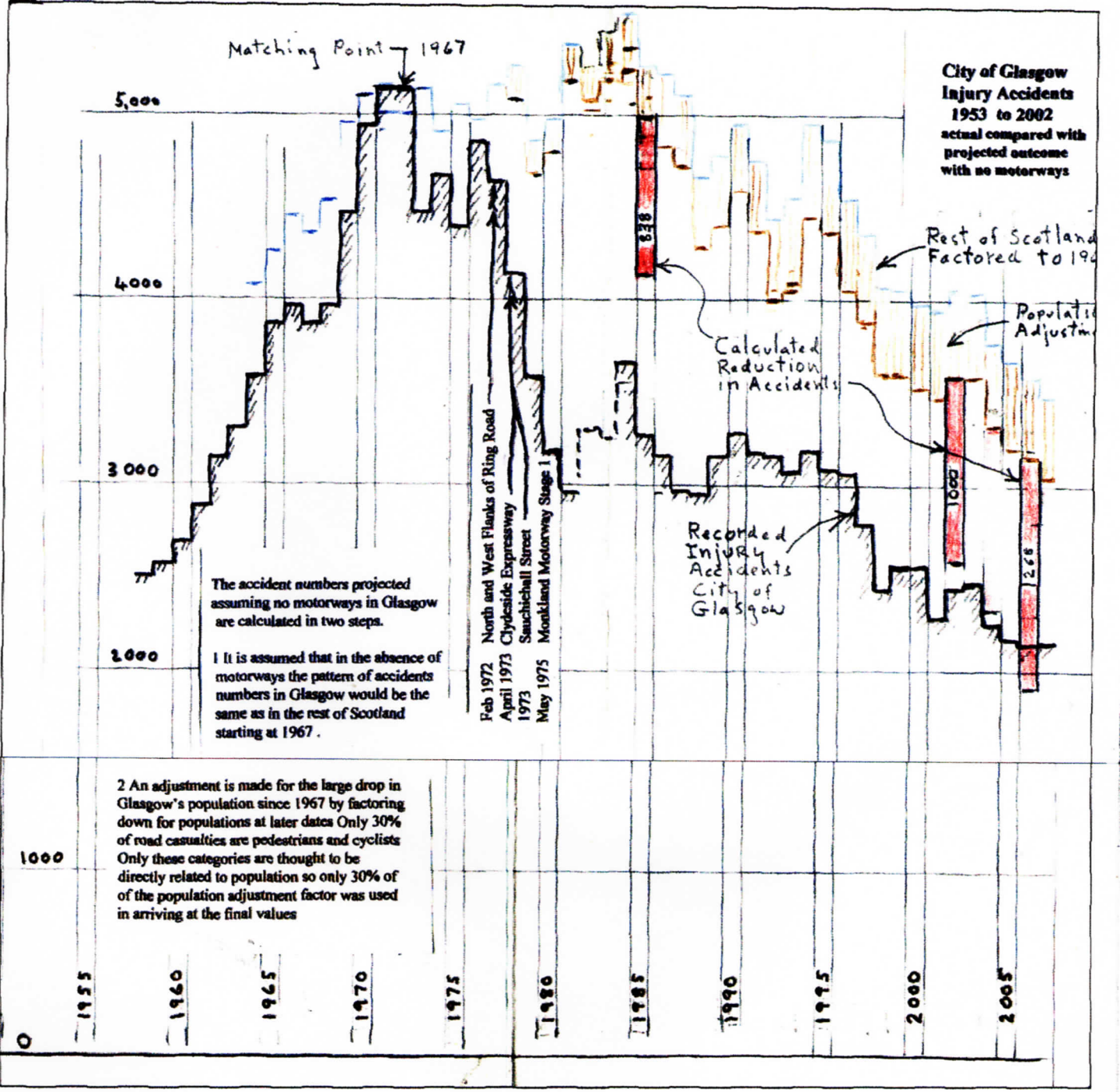
When the accident charts are examined, a remarkable drop in the number of accidents and especially fatalities is seen to occur between 1972 and 1975.This is shown in the table below.

	Glasgow	Rest of Scotland
Fatalities	24% reduction	7.5% reduction
Casualties	31% ditto	5.3% ditto
Accidents	31% ditto	3.4% ditto

Around this period the North and West Flanks of the Inner Ring Road were opened.
Sauchiehall Street was pedestrianised.
The Clydeside Expressway was opened
Monkland Motorway - Stage 1 was opened


North Link Motorway
Maryhill Motorway
Crow Road
River Clyde
Springburn Expressway
M80
A80
Glasgow Boundary
Clydeside Expressway
Woodside
Townhead I
Monkland I
Junction 13
2A
2B
M8
Charing X
Clyde Tunnel and Approaches
Kingston Bridge
Townhead 2
East Flank
East Link Motorway
Hamilton Motorway
Renfrew Motorway 1
South Flank
Stage 1
Proposed M74 Extension
South Link Motorway
M74
River Clyde
Ayr Motorway
M77
Outer Ring Road
East Kilbride Motorway
Motorways and Expressways Built
Motorways Cancelled
Proposed M74 Extension


City of Glasgow
Fatalities
1953 to 2002
actual compared with
projected outcome
with no motorways
Rest of Scotland
factored to 1967
adjusted for population
changes in Glasgow
calculated
reduction
in accidents
recorded
fatalities
City of
Glasgow
Feb 1972 North and West Flanks of Ring Road opens
April 1973 Clydeside Expressway opens
1973 Sauchiehall Street Pedestrianised
May 1975 Mokland Motorway Stage 1 opens
Number of Fatalities
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
The number of fatalities projected assuming no motorways in Glasgow is calculated in two steps.
1 It is assumed that in the absence of motorways the pattern of fatality numbers in Glasgow would be the same as in the rest of Scotland starting at 1967 .
2 An adjustment is made for the large drop in Glasgow's population since 1967 by factoring down for populations at later dates Only 30% of road casualties are pedestrians and cyclists Only these categories are thought to be directly related to population so only 30% of of the population adjustment factor was used in arriving at the final values


Matching Point 1967
5,000
4000
3 000
2000
1000
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
City of Glasgow
Injury Accidents
1953 to 2002
actual compared with
projected outcome
with no motorways
838
Rest of Scotland
Factored to 19
Calculated
Reduction
in Accidents
1000
268
Recorded
Injury
Accidents
City of
Glasgow
Feb 1972 North and West Flanks of Ring Road
April 1973 Clydeside Expressway
1973 Sauchiehall Street
May 1975 Monkland Motorway Stage 1
The accident numbers projected assuming no motorways in Glasgow are calculated in two steps.
1 It is assumed that in the absence of motorways the pattern of accidents numbers in Glasgow would be the same as in the rest of Scotland starting at 1967 .
2 An adjustment is made for the large drop in Glasgow's population since 1967 by factoring down for populations at later dates Only 30% of road casualties are pedestrians and cyclists Only these categories are thought to be directly related to population so only 30% of of the population adjustment factor was used in arriving at the final values

Contract	Date of opening	Length kms			Designed by	Built by
M8 Townhead - Stage 1	April 1968	1.5			Scott Wilson Kirkpatrick	Marples Ridgeway
M8 Kingston Bridge	June 1970	1.5			W. A. Fairhurst	Logan / Marples Ridgeway
M8 Woodside	May 1971	1.3			Scott Wilson Kirkpatrick	Balfour Beatty
M8 Charing Cross	Feb 1972	0.9			W.A. Fairhurst	Whatlings
Total IRR			5.2			
M8 Renfrew Motorway 1	Oct 1976	3.3			Scott Wilson Kirkpatrick	Balfour Beatty
M8 Renfrew Motorway 2	Oct 1976	3.4			W. A. Fairhurst	L. Fairclough
Total length			6.7			
M8 Monkland Motorway 1	May 1975	3.1			Glasgow Corporation	Costain
M8 Monkland Motorway 2A	June 1979	2.1			Strathclyde Region	Whatlings
M8 Monkland Motorway 2B	April 1980	3.5			Strathclyde Region	French / French Kier
Total length			8.7			
Total length M8				20.6		
wnhead Stage 2	April 1992	0.7			Strathclyde Region	?
M80 Stepps Bypass	June 1992	3.8 *			Strathclyde Region	Tarmac
M74 Northern Extension	Late 1993	4.0			Strathclyde Region	Lilley/Kier
			8.5			
M77 Ayr Motorway Stage 1	Aug 1981	1.3			Scott Wilson Kirkpatrick	Whatlings
M77(Dumbreck Rd Connection)						
M77 Ayr Motorway Stage 2	Dec 1996	5.0*			Strathclyde Region	Tarmac
Total length M77			6.3			
Sub total				14.8		
Total length of motorways in City		=		35.4		
Clydeside Expressway	Feb 1972	5.2				

INCOMPLETE