DESCRIPTION AND CRITICAL ANALYSIS OF THE MANAGEMENT OF ROAD AND TRANSPORTATION RESEARCH IN THE REPUBLIC OF SOUTH AFRICA

by

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SYNOPSIS

The dissertation gives the background to the need for management of roads and transportation research in the Republic of South Africa. The close co-operation between researcher and end-user of research findings in the above-mentioned fields and its application into practice, is described.

The advent of autonomy of research institutions in 1986, highlighted the need for a structured approach for the management of road and transportation research. Tasks, previously undertaken mainly by the Division for Road and Transport Research of the Council for Scientific and Industrial Research on behalf of the South African road and transportation authorities, had to be taken over by the Department of Transport. A transition period of five years was given (from 1987 to 1992) to implement a suitable scientifically sound system.

Details towards co-ordination and formalising of needs such as determination, prioritisation, allocation, funding and control of transportation research are given.

KEYWORDS

Autonomy of research
Commercialisation and privatisation
Control of road and transportation research
Department of Transport
Determination, prioritisation, allocation, funding
Formalising of needs
Management
Road and transportation research
South African road and transportation authorities
South African road and transportation infrastructure
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INTRODUCTION AND BACKGROUND

1.1 Introductory setting

The introductory chapter of this dissertation will be utilised to give to the reader an outline of the background to the field of study as well as a description of the subject, followed by a motivation for the study. Details will be given of how the need for the orderly management of road and transportation research was investigated in order to ensure the co-ordination of research undertaken and appropriate dissemination of research results. This will be followed by a description of earlier informal arrangements and highlighted in order to familiarise the reader with specifics pertaining to the field of road and transportation per se. The limits of the study resulting from the principles arising from the framework of autonomy of research organisations, are critically described as the main essence of the dissertation and followed by a short summary of each chapter detailing research results.

It will be indicated in this study that the provision of roads and transportation facilities in South Africa, since the earliest of time, was a matter dictated by need and the resulting use of common sense rather than the application of sound scientific principles. Social and economic development in South Africa eventually indicated to the political and administrative decision-makers the need to a more formal arrangement regarding the management of road and transportation facilities in an organised scientific manner. This commenced by incorporating roads with public works programs in the previous century and eventually with the appointment of the South African Roads Board in 1935.

In order to meet the demands to provide these facilities, in depth knowledge related to roads and transportation engineering, as well as knowledge resulting from the applied sciences was required, and this type of knowledge increased substantially prior to and during World War II.

The need arose to provide and manage this knowledge and expertise in the most formal and scientific way possible to ensure the most economic use of resources. It will be described how the Bituminous Binders Research Unit was established in 1951, later to be incorporated as part of the Council for Scientific and Industrial Research. At universities the fields of road and transportation engineering started to form part of the civil engineering courses and post graduate research projects.
However, up to 1986, with the decision by the South African government towards more autonomy of research institutions, roads and transportation affairs were handled by the relevant institutions on a need-based arrangement of scientific applications to defined problems rather than a formal application of principles of management.

1.2 Purpose of study

Science, and for that reason civil engineering and its fields of roads and transportation as an applied science, exists and eminates from one question 'Why'. It is by way of attempting to give a reply to this question of 'Why', that science and any applied field thereof, advances with an increase in knowledge.

The science of engineering and more specifically the specialist fields of road and transportation engineering, have direct links to the basic sciences of mathematics, physics, chemistry and geology. Engineering can be considered as the practical application of pure science with economic and sociological benefits to mankind. For this reason it is considered of importance to show these origins and their influence on this study of road and transportation research (20).

The advent of research autonomy in 1986 has to be viewed against a background of increasing demands on limited public resources and an increasing paucity of funds for roads and transportation research. At the same time demographic and economic growth dictated increasingly the need for high quality road and transportation infrastructure. Under the former arrangements of a needs driven research program and reasonable availability of funds for road and transportation research, the problem would have been surmountable as indeed was the case up to 1986. It will be researched how the Department of Transport, as the central controlling institution handled the demand for better management in this field up to 1992.

The purpose of this study, therefore, is to research the need to establish a viable system for the management of scientific knowledge related to roads and transportation in South Africa. In order to place this research into perspective, an explanation regarding the growth of the road and transport infrastructure in this country and how this fitted together with the present needs for research and development to provide the South African taxpayer the best possible value for his money, is also offered.
Put in another way, the purpose of this study, therefore arose because in an era of scarcity of funds the relative luxury of research without centrally controlled and co-ordinated management cannot be sustained. This relative scarcity of funds on the part of the government had the net-result of road and transportation research institutions having to fend for themselves financially, that is, the so-called framework for autonomy of 1986. The need thus arose for proper management of scientific knowledge pertaining to the field of research in road and transportation, which is the pivotal point of this study.

1.3 Framework of autonomy in road and transportation research as pivotal point of study

Following the requirements of the South African government in 1986 for research institutions to become more business orientated in their operations (framework autonomy), a transitional period of five years (1987 - 1992) was allowed for (8). The Department of Transport, as the central road and transportation authority, was requested to make arrangements to manage, co-ordinate and monitor all such research funded by government. This dissertation must be viewed in relation to the work undertaken by the Research and Development Advisory Committee as a committee of the South African Roads Board within its legal authority (26).

The Research and Development Advisory Committee established a framework for development towards a centralised and co-ordinated approach to control all transportation research activities. This work done by officials in the Department of Transport up to 1992, within the period envisaged by government, provided the basis for a broader approach towards transportation research to be followed as will be researched in this dissertation. In order to provide a full background to the philosophy followed, some historical aspects pertaining to scientific research and more specifically road and transportation research are provided.

In order to put the arrangements for road and transportation research in a formal perspective regarding work undertaken internationally, reference will be made to the methods employed by a number of associated overseas authorities and institutions considered applicable to the South African road and transportation scene. British and methods used in the United States of America, will be taken into consideration regarding research into roads and transportation per se to provide a background to the arrangements instituted by the Department of Transport between 1987 and 1992 as researched in this dissertation.
Scientific research in South Africa can be considered to have grown from the establishments of higher education founded during the nineteenth century i.e. the South African College (1829) in Cape Town (45:9). At that time no need for applied research into roads and transportation existed. Basic trek routes for ox wagons followed by the first railroads were expanding into the South African hinterland later to form the base of the country's major transportation routes.

The advent of the motor vehicle and the need for a more sophisticated road infrastructure, led to formal arrangements by the Government, around the mid 1920's, to provide this service to the taxpayers (9:2). It will be described that needs for local investigations into the problems regarding road surfaces in the nineteen fifties following World War II, led to the establishment of a formal research unit to investigate tar and bituminous binders for South African roads (30:15 - 44). Following these early steps towards formal road materials research saw the incorporation of the research unit for tar and bituminous binders into the Council for Scientific and Industrial Research in 1951 (17:22). The arrangements regarding formal road and transportation research were aptly described by Kühn in the Alfred Snape Memorial Lecture in April 1983. Kühn gave details of this early research management that formed the basis of the success and recognition of South African practices both nationally and internationally (18:193-204). The advent of framework autonomy in 1986 created a drastic change for all research institutions in South Africa when they had to become more market related and less dependant on official aid.

1.4 Background to study

The effect of autonomy to research institutions, instituted by the Department of National Education in 1986, forms an important part of the motivation for the research work undertaken in this dissertation and will be described in the following chapters.

During the period prior to 1986, research in roads materials initially and subsequently in the broader field of transportation, was undertaken mainly by the Division of Road and Transportation Technology and its foregoing Institutions i.e., Bituminous Binder Research Unit, the National Institute for Transportation and Road Research, all under the auspices of the Council for Scientific and Industrial Research (18:194).

Formal, informal and spontaneous interaction between officials from the various public roads and transportation authorities, as the main funding institutions, led to a dispensation enhancing
research and development in the transportation sector in the early years. Once a research need had been identified and defined, it was left to the major research institutions to administer the undertaking of research to its full extent (18:195).

Since the introduction of a framework of autonomy for research institutions by the Department of National Education in 1986 (8) it became apparent to the Department of Transport that it should institute steps to ensure that responsible administration of funding in respect of road and transportation research took place. At the meeting of the National Transport Commission held in August 1986, the formation of a committee, the Research and Development Advisory Committee, was approved. It was decided that the function of road and transportation research would be handled by this committee and its working groups (22).

The main functions of this committee were:

- To determine the research needs of institutions concerned with roads and transport.
- To define research projects to be financed by the National Transport Commission (since 1988 the South African Roads Board) and participating institutions.
- To prioritise proposed research projects and make recommendations for the funding of the projects.
- To monitor progress and assist institutions in the carrying out of research assignments.
- To collect, store and disseminate information to institutions in practice.
- To evaluate completed research and to promote the implementation of research findings (3:1).

The author, as Chief Engineer: Materials, in the Chief Directorate: National Roads of the Department of Transport, became intimately involved in the activities of the Research and Development Advisory Committee in 1987 and established that the management of research and development in these fields is not unique but generic in the field of public administration. Researching the optimal methods to ensure proper administration of road and transportation research were undertaken in detail over a period of months in 1986 as reflected in official minutes of the Research and Development Advisory Committee and its working groups (22). It also became apparent that nowhere, as far as could be established at the time, has there been an attempt to formally research the funding and co-ordination of road and transportation research within this framework, i.e. up to that point in time research and development in roads and transportation took place on a somewhat unco-ordinated manner. Proposals were left
mainly to researchers and their perceptions of needs rather than to practitioners. Certain themes tended to be in vogue and then offered to roads authorities for consideration as possible research topics and proposals (13).

An outcome of framework autonomy of research institutions was that research could be undertaken by institutions as diverse as universities, technicons, private persons or consultant firms in conjunction, as well as in competition, with the previously established institutions. This increased the likelihood of duplication of work and put a premium on the appropriate co-ordination of research projects (3:1). In order to ensure that research topics, findings and results would be of optimal value to practitioners in transportation, the arrangements, as identified and analysed in this dissertation, were considered worthy of research in the context of public administration. This consideration was to the fact that the previous arrangements were largely on an ad-hoc basis and never documented in this particular context illustrating formal management there-of.

In order to establish the perspective of this area of application in the field of public administration, it is necessary to provide a background to transportation research in general and, more particularly, road and transportation research in the Republic of South Africa.

1.5 Funding of road and transportation research

Funding for research in this specific field does not form a substantial portion of the budgets of the controlling public authorities. Details of these will be touched upon to give the reader an added perspective to the problem and the handling there-of by the transportation authorities.

The details of the main funding authorities, for example, the National Transport Commission and currently the South African Roads Board and their legal status as such, will be given. The position of the Chief Directorate: National Roads of the Department of Transport (at the time) in relation to the National Transport Commission and currently the South African Roads Board will be brought into perspective together with other road and transportation authorities and associated institutions.

Ideally, the need for research should determine the funding needed for this purpose (3:3). First World countries have been found to direct between 3% to 5% of their annual transportation budgets towards research with this figure varying according to needs and
availability of funds (36:10). The annual budget (1992) of the leading South African roads authorities, (provincial and central - excluding Transkei, Bophutatswana, Venda, Ciskei, TBVC and Self Governing Territories) amounted to some R2,000 million so that, in terms of this international norm, the South African transportation research budget should amount to from R60 to R100 million per annum. In the most recent financial years, allocations to research have been of the order of R20 million. This represents a modest research effort of about 1% of the infrastructural budget (24:10). The allocation of an amount of some R20 million in 1992 clearly indicated the need for control and accountability for the expenditure on road and measures established through proper co-ordination and management.

It will be indicated that, prior to 1991, the four provincial roads authorities contributed to their research needs, with the major portion, about 90%, coming from the Department of Transport. Currently all road and transportation research is funded by the Department of Transport (22).

To summarise, research in this dissertation will show that the previous somewhat informal arrangements of road and transportation authorities came to an end when research institutions were required to become more business and market orientated in 1986. In order to cope with the new demands and to ensure research undertaken for the road and transportation authorities was appropriate and optimally suited, arrangements had to be instituted to formalise such work. These arrangements, their formalising, implementing and controls, are the essence of research work undertaken in this dissertation.

1.6 Arrangements in associated fields of research

The following associated fields of study and research became evident during discussions between the author and researchers viz the Human Sciences Research Council, the National Energy Council, the Road Safety Council (currently part of the Department of Transport), the Foundation for Research and Development of the Council for Scientific and Industrial Research and various universities. It was found that these institutions each employ their own system to co-ordinate research and development on an ad-hoc basis. From these discussions it became clear that there is a general concern that in a developing country such as the Republic of South Africa, within a framework of limited financial resources on the one hand with an atmosphere of rising aspirations and demands on the other, research is perceived as a luxury (20).
There is also the further perception that, politically, research is considered a luxury that can hardly be afforded if the basic needs of the major portion of the population for health, education, housing and work opportunities are unfulfilled. The importance, however, of a sound transportation infrastructure to assist in overcoming these sociological and economical problems, are too often overlooked (20).

It was identified by the author, as an official of the Department of Transport, that all institutions undertaking management of research were facing problems of a similar nature. These aspects placed a particular emphasis on control of research, thus giving the management thereof a generic character. Arrangements in 1986 by the Department of National Education forced research institutions into becoming more market related in their operations and less dependant on direct government funding (8).

The Department of Transport, as the leading transportation authority in South Africa, had to accept the role for co-ordinating and management of transportation research in the country. The previously established relationship, particularly with the Council for Scientific and Industrial Research, became greatly reversed. In order to meet the demands for this new task, officials of the Department had to research methods to undertake the work and ensuring that appropriate and cost effective road and transportation research was undertaken within the limited financial resources available for the purpose (22).

The above is undertaken and described, in this dissertation, in order to create some understanding of the diverse and complicated structures and systems of funding and management in respect of research and development of roads and transportation.

1.7 Details of methods followed by the Department of Transport to co-ordinate research and development in the field of transportation

As highlighted in the previous paragraph, it was necessary to establish an appropriate method for the Department of Transport to control all aspects of road and transportation research. In discussing this with officials of various institutions undertaking or controlling research, it became apparent to the author that, by and large, comparable methods are followed by such institutions to identify needs for research leading to quantifying and defining of needs into formal research projects. Thereafter, some process is usually employed to establish the priorities of projects competing for funding within a framework of the budget of the particular institution (20).
Duplication of research work, particularly in associated fields of transportation engineering, road and transport safety, economics and energy is, however, too often a reality. This leads to inefficient utilisation of scarce manpower resources and funding. Methods to guard against possible duplication have to be devised and incorporated in the proper management of projects during the various phases, are the following:

- problem identification,
- project description,
- prioritisation,
- research,
- dissemination,
- application of procedures,
- guidelines,
- policies, and
- prescriptive laws also need to be given proper attention (36:2).

1.8 Terminology

Certain terms, generally encountered in the fields of road and transportation research and used as such in this dissertation may be less known to persons not working in this field and therefore need explanation. This will be provided in the text, where necessary.

1.9 Reference technique

The augmented Harvard method will be used (6:79-124).

1.10 Summary of chapters

Chapter one provides the motivation and outline of study undertaken for this dissertation. It describes the framework of how the author, as an official of the Department of Transport, perceived the research need for co-ordination and management of research as well as the arrangements and implementation to formally undertake the management, co-ordination and monitoring of road and transportation research between 1987 and 1992 (22).
A background to the development of road transportation in South Africa is given in chapter two for the benefit of readers not familiar in this particular field, as well as information on the development of the need for road and transportation research in this country prior to the decision of 1986 when research institutions, according to a governmental decision, had to become more business orientated.

Up to 1986 road and transportation research was undertaken mainly by the National Institute for Transport and Road Research of the Council for Scientific and Industrial Research on a mutually established needs basis for the public roads authorities in South Africa. The decision of government to institute framework autonomy of research institutions (operated according to business principles) and the arrangements to implement governmental control, is described in chapter 3.

In order to ensure long term and continuous benefits from any research, proper financial arrangements are of the greatest importance. The funding of research, control measures and general matters of financial arrangements surrounding road and transportation research are described in chapter 4.

The provision of road and transportation facilities are no different to any other public utility and problems arise in the execution of any of the processes and particularly if many and varied factors are involved. The need for problems to be solved give rise to formal investigations for which needs must be clearly defined. The identification of research needs in transportation is described in chapter 5, followed by descriptions of the processes for management and co-ordination employed for evaluation and prioritisation.

Research by academic and professional persons is expensive and methods clearly defining procedures for selection and monitoring of research projects had to be developed by the Department of Transport. In chapter 6 details of these are given.

Research for the sake of obtaining academic or professional recognition or similar luxuries can not be accommodated in an environment of limited or decreasing resources. All research undertaken needs to be of benefit to the users and operators of the road and transportation systems in this country. With this as an aim, systems were established by the Department of Transport ensuring dissemination of findings into practice and these are given in chapter 6.
The need for co-ordination of transportation research activities, as described in this dissertation, has been identified in various authorities responsible for research. Similar problems arose in countries with which South Africa has ties in the fields of road and transportation. The author used various opportunities offered during official study tours to investigate and discuss problems of this nature in the United States of America and the United Kingdom. An official report following a study tour in 1990, as submitted to the South African Roads Board, will be used as one of the sources of reference (40). Some other countries eg. Australia, are referred to by virtue of comparable conditions to those confronting operators of transportation infrastructure.

Chapter 7 highlights some of the details in order to draw parallels and how a system was devised suitable for South African conditions as well as a summary of the findings and provides some direction for future dispensations.
CHAPTER 2

HISTORICAL DEVELOPMENT OF RESEARCH IN ROAD AND TRANSPORTATION SECTORS OF THE CENTRAL AND PROVINCIAL TRANSPORTATION AUTHORITIES IN THE REPUBLIC OF SOUTH AFRICA

2.1 Introduction

In order to highlight the purpose of this study, which is the need for co-ordination of the management of road and transportation research in this country, it is considered of importance to give some relevant background information. The need for research, however, does not originate without problems that must be solved to improve conditions for the user of road and transportation facilities. Appreciation for this can only be gained if the reader is given some background on the development of such facilities, as well as road and transportation research arrangements up to 1992 following the introduction of framework autonomy of research institutions in the Republic of South Africa in 1986.

2.2 Historical background of the South African transportation infrastructure

Prior to the advent of steam trains during the first half of the previous century, transportation in Southern Africa was solely animal drawn along well-established corridors linking centres of importance which later became formal road links. Steam became the main source of energy for transportation in the latter part of the 19th century and the first half of the 20th century. Foreign expertise was employed in the construction of the railway lines, associated facilities and operation of the coal mines in Southern Africa to provide sources of energy for transportation (34:9).

The established corridors accommodated railway lines and informal tracks for wagons and carts. At major rivers or mountain passes, established fords and earthworks were hacked from mountain sides to provide combined use of facilities. Most steel girder and truss-type bridges were imported pre-fabricated and erected on site by skilled foreign workers. Piers and abutments were masonry built from local rock (34:9). Skills for construction were established through engineering know-how from these skilled foreign workers and passed from one local generation to another with little formal documentation.
The horse and ox as major sources of mobility, apart from steam trains, were replaced by the internal combustion engine in lorries and motorcars in the first half of the twentieth century. During the first decade of the twentieth century the motor-car, and the freight carrying lorry derived from it, started using these corridors giving rise to much needed improvements and the establishing of proper roads. Colonial Works Departments initially and later provincial authorities in Southern Africa were obliged to improve existing tracks and provide roads and bridges to further the development of the country. The administration of such public roads formed an integral part of the activities of public institutions in the advancement of the general welfare and problems regarding construction and maintenance had to be solved within a local framework of available resources (23:11).

An arrangement, following the formation of the Union of South Africa in 1910, was that the responsibility for roads be divided among the four provinces. At the time, railways and not roads, were clearly better suited to provide long distance services linking centres of economic activity and therefore fell under the control of the Union Government (9:1).

The road infrastructure, which was rather underdeveloped at the time, had the further disadvantage of being administered by a plethora of local and provincial authorities. This soon created problems regarding funding of operations and the need for co-ordination became apparent, particularly after World War I. Representations and proposals culminated in 1925 in the formation of a Road- and Bridge Committee under the chairmanship of A D Holmwood, Superintendent for Roads and Works, Transvaal. The Holmwood Committee recommended a network of national, provincial and provincial branch roads of which the national network would be the responsibility of the Union Government (9:1).

By 1929 protagonists of rail traffic noted with concern an increasing growth in road traffic, endangering the investment of the tax payers' money in the established rail network. A Commission of Enquiry into Road Competition under the chairmanship of J C le Roux, was appointed. The findings of the Commission led, amongst others, to a recommendation that a National Roads Board be established (9:1).

The National Roads Board, as proposed by le Roux, had a wider authority than envisaged by Holmwood. Classification and location of roads, co-ordination and standardisation of these within and between provinces were amongst the tasks undertaken. This first reference to
standards led to definition of appropriate specifications and quality control in materials usage in road construction and maintenance circa 1950. It can be considered that the establishment of the National Roads Board was the starting point for the application of local research findings in the development of materials and geometric standards for roads.

Following recommendations of the above le Roux enquiry, the National Roads Act, 1935 (Act 42 of 1935) (26) was promulgated, establishing a National Roads Board and a National Roads Fund under the Minister of the Interior. A programme for some 8600 kilometres of roads was drawn up, with its construction to be funded from a fuel levy of 0.55 cents per litre (3 pence per Imp. gallon) of petrol sold. The intervention of World War II delayed progress to the extent that only about 70 percent of the envisaged length of road had been constructed by 1946 (23:30).

The National Roads Board was replaced by the National Transport Commission in terms of the Transport (Co-ordination) Act, 1948 (Act 44 of 1948) (26). This Commission took over the functions of the National Roads Board (9:37). Section 7 of this Act refers to "further functions relating to infrastructure, technical control..." and can be seen as an indication of establishing appropriate standards and specifications derived from local expertise and investigations following experience gained from constructing roads to suit local conditions and traffic patterns (23:30).

The recommendations by the National Transport Commission in 1961 to the Government [and culminating in the National Roads Act, 1971 (Act 54 of 1971)] placed the responsibility for national road planning, construction and maintenance under its jurisdiction (23:32). It needs to be noted that section 5-6(f) of the 1971 Act allowed the Commission to undertake research on its own or through the Council for Scientific and Industrial Research through co-operation, or with the assistance of other institutions or persons regarding problems identified on roads and/or transportation in the Republic of South Africa (26). This provision was later also contained in the Act on Urban Transport, 1977 (Act 78 of 1977) (26).
2.3 Historical background of research in road and transportation in South Africa

It is appropriate to give a short history of scientific research in South Africa to illustrate the perspective of its application in the field of roads and transportation. In order to illustrate the development of road construction technology from early scientific findings, recording of geological details and the use of it in the solving of practical road engineering construction problems, representative periods were chosen.

2.3.1 Early years up to 1850

The first scientific Academia dei Lincei was established in Italy some fifty years prior to the landing of Jan van Riebeeck at the Cape. This was followed by the establishment of the Royal Society in 1655 in England, clearly marking the starting point of scientific awakening in the Western World. Over the decades following until more or less 1820, various scientists visited South Africa to study the flora, fauna and astronomy of the southern hemisphere (43:8).

The feats of the Baines’s, both father and son, as early road builders in the Cape Colony in the nineteenth century, are well known (34:10). The discovery of the "Blinkwater Monster" fossil near Fort Beaufort in 1844, while blasting for a roadway, was of great importance to scientists in earth science and civil engineering. These findings later gave rise to a series of lectures in London by Dr. Richard Owen resulting in grants enabling him to produce the first geological map of South Africa (34:26,27). Geological maps are generally of great importance to roads engineers when planning projects in obtaining scientific information on the availability and location of natural road building materials like rock sources that can be crushed and used in road foundation layers or concrete, or problem areas like swampy or clay conditions that are to be traversed by a proposed road (20).

This combination of empirical science and the engineer’s mission of harnessing the powers of nature to the benefit of mankind, in the South African context, started with the Baines’s and laid the foundation for a long line of roads and transportation engineers serving the public of, initially, the Cape Colony and, later, the whole of the African sub-continent.
2.3.2 Period 1850 to 1920

From the second half of the previous century, up to 1920, various scientific societies were established in South Africa (45:9). The use of applied science in the provision of roads and transportation, has been part of man's history; whenever he wanted to transport himself, his belongings or his produce, he used some form of transportation or associated facilities. Experience and associated engineering knowledge were to a large extent empirical and easy to grasp by any person vaguely interested in the early days relying on basic land surveyor's knowledge and builders expertise (20).

The most relevant scientific society, pertaining to this study, was the founding of the South African Association of Engineers and Architects in 1892. According to Van Wyk the importance of these early societies cannot clearly be established, except that they promoted science as such (45:9). It was clear, however, that associations as these, were employer orientated furthering vested interests of the professionals involved and not only promoting science as such. It is important to note that the Cape Society of Civil Engineers, established in 1903, made a plea for research into the possible use of tar to be produced from the Iron and Steel Corporation's steelworks for road construction in 1933 (10:7).

The first institutions for higher education were established in the Cape Colony ie the South African College (1829), to become the University of South Africa (1873). By 1916, academic independence regarding examinations was granted to the Universities of Cape Town and Stellenbosch which were under the auspices of the South African College until that time. The University of Cape Town was the first to start training civil engineers later to be employed by public transportation authorities giving shape to appropriate technology for use in South Africa. (45:9)

Since formation of the Union of South Africa, in 1910, major governmental involvement in research did not come from the road and transportation authorities but from the Departments of Agriculture, Forestry and Mining. These authorities relied mainly on a well established rail transport for their produce which was indicative of the priorities of government at the time. The importance of road transportation was still to come, as will be detailed in the next sub-paragraph. The research budget for agriculture was larger than that for any other field until the late 1960's (45:11)
2.3.3 Growing need for scientific road and transport research 1920 to 1951

The advent of the high speed motor vehicle created an ever-growing need for more sophisticated roads. The inflexible rail network started to lose its attractiveness compared to trucks operating from door to door, between larger centres and catering for farm-to-market operations, carrying produce. (20).

Sophistication in transportation brought associated problems that could not be solved by using foreign expertise and knowledge. South Africa with long distances of roads linking areas of diverse climate, ecology and geology soon proved to be a challenge to the roads engineer. Local expertise had to be co-ordinated, defined, evolved and refined to meet these challenges. Problems encountered in the construction, maintenance and operation of roads in South Africa up to that time were researched on an ad-hoc basis by engineers involved with the day-by-day work. Rigden, as the first director of the National Institute for Road Research, at the time, identified the need for a co-ordinated approach for the management of research regarding roads matters (30:1).

2.3.4 Period 1951 to 1956

The involvement of the Council for Scientific and Industrial Research in road research (leading up to actual research being started in 1951) dates back to 1949 when the then Secretary for Commerce and Industry requested the CSIR to further investigate the possibility of steelworks produced tar (virtually a waste product derived from the coal used as fuel in the steel manufacturing process) for black top surfacing of roads in place of bitumen derived from imported crude oil during the refining process for petrol. It was found that the Iron and Steel Corporation, which produced coke-ovens tar and the South African Torbanite Mining and Refining Company which produced shale oil bitumens, were also keenly interested in research on locally produced bituminous binders for use on roads. Discussions in 1950 with the Chief Engineer of the Division of Civil Engineering of the Department of Transport (which had taken over the executive functions of the former National Roads Board) and the Roads Department of the Transvaal Provincial Administration, likewise revealed considerable interest in research on so-called black top road surfacing. A modest research group called the Bituminous Binder Research Unit, funded by Iscor and the Council for
Scientific and Industrial Research was established at the beginning of 1951, with the limited objective of studying the performance of locally produced coke oven tars and shale oil bitumen. In its first year of existence an elaborate road surfacing experiment was constructed on the old Pretoria-Johannesburg national road, and another on a nearby provincial road. Subsequently experimental sections on roads were built in all four provinces and, much later, in Ovamboland in the then South West Africa (Namibia) (14:2).

The Bituminous Binder Research Unit, during its first three years proved to the practice orientated roads engineers the value of a scientific research approach to solving their problems and created favourable conditions for the creation of a broadly-based road research organization (14:3).

This need was investigated by a committee under the chairmanship of Col W P F McLaren, Chief Engineer of the Division of Civil Engineering of the Department of Transport. The National Transport Commission subsequently decided to provide the basic funds for a road research institute and requested the Council for Scientific and Industrial Research to set up a research institute (embracing the Bituminous Binder Research Unit) to undertake road and traffic research. The resulting National Institute for Road Research came into being in September 1955, financed jointly by the National Transport Commission through the Department of Transport, the provinces and the Council for Scientific and Industrial Research (17:2).

2.3.5 Period 1956 to 1970

Since its inception the National Institute for Road Research of the Council for Scientific and Industrial Research functioned in close association with state road authorities. Research work at the National Institute for Road Research was guided by an advisory as well as several steering committees constituted by knowledgeable and experienced roads engineers from the South African road authorities. The dispersed operations of the National Institute for Road Research were finally combined when they were brought together under one roof in a new building at the Scientia campus in Pretoria, erected by the Council for Scientific and Industrial Research. By this time the National Institute for Road Research had gained the confidence of the road authorities and other transportation engineers by helping them define their road
problems in terms amenable to solution by research, stressing the need for full scale experiments and tests on the road, and by assisting them in investigating failures and other problems of their roads. From the outset, Dr P J Rigden, the first director, of the National Institute for Road Research, continually reminded the road authorities that the Institute, though part of the Council for Scientific and Industrial Research, was their Institute and in effect also their responsibility (29:3).

In a paper presented at the First Conference of the Australian Road Research Board in Canberra in 1962, Rigden put forward his views that research and practice share the same objective viz. to build better roads at minimum cost. Therefore, the practising road engineers must see to it that research is aimed in the right direction and that its results are applied in practice. By the same token, research staff must assist the roads engineer with whatever problems they encounter in road building and maintenance. This implied a consultative role for the Institute in addition to its research role, and Rigden was convinced that without this role, the Institute could not function effectively in serving the road industry (28:23).

According to Rigden, road research was defined as essentially a scientifically based activity in the applied field of civil engineering, though its ramifications into road economics and road safety, for example, will take its devotees into fields and disciplines somewhat outside the normal field of the engineer (29:2). He also proposed that the task of research applied to this field be sub-divided as follows:

(i) to study the entire complex of highway activities - economic, planning, design, construction, maintenance and operational - and assist road authorities to delineate and define problems that could be amenable to a research approach;

(ii) to evaluate the relative importance of such problems with the help of various criteria;

(iii) to carry out research into the selected problems with the aim of finding valid and practical solutions, and to evaluate the application of it in practice;

(iv) to encourage and assist road authorities to apply the useful findings of research;
(v) to act as a central clearing house and information centre on new findings and new methods from all over the world, and to assist authorities to apply these and to test them for applicability in the local situation; and

(vi) to give help where necessary to road authorities and others with the training of engineers in particular methods or particular fields of road technology where such training has been absent or inadequate (28:2).

At the time, Rigden defined criteria for planning of research by a research institution as follows:

1) The importance of the particular problem to the road authorities or the community as a whole.

2) The probability of finding a solution and of ensuring full application in practice.

3) The cost of the research and the likely time needed to reach an answer.

4) Potential value in terms of commercial exploitation and the furthering of secondary industry.

5) Value of a project in providing new knowledge, particularly if this knowledge can throw light on a wider area of research interest.

6) Availability of research staff.

7) Possibility of feeding research information available in other countries into the project.

8) Value from a training point of view (29:3).

The National Roads Acts of 1948 (44 of 1948) and 1971 (54 of 1971) and the Act of 1988, allowed the National Transport Commission to undertake or to have research undertaken on its behalf. The National Transport Commission was at the time, since
the inception of National Institute for Road Research, the major financial contributor to road and transportation research in the Republic of South Africa in liaison with the roads authorities regarding identification of needs.

The constituting of an annual research programme was the responsibility of the Road Research Advisory Committee. This Committee consisted of the Chief Engineers of the National Roads Branch of the Department of Transport, the four Provinces and South West Africa Roads Department as well as representatives from universities, municipal government, industry and consulting engineers (20).

Steering Committees dealt with the more detailed aspects of research of the divisions within National Institute for Road Research. These steering committees informed the Road Research Advisory Committee regarding details of new proposals, progress and dissemination of research findings in practice in the fields of Soils and Foundations, Bituminous Materials, Traffic and Safety (29:3). The Steering Committees comprised engineers from mid-management level in the Roads Departments who had special fields of expertise and could give direction to researchers regarding their needs. According to Rigden, the common interest of both researchers and officials created unique co-operation of engineers towards the creation of "better, cheaper and safer roads ... by working together closely". Road authorities and particularly the people concerned with problems warranting research formed a very small group of specialised individuals (29:3). Following from this concern did arise a balance between problem solving and directed research resulting from the close co-operation between researchers and departmental officials and industry.

Financial control was of a flexible nature allowing the National Institute for Road Research reasonable freedom to deploy its resources in manpower and money to the best advantage and to make changes at any time to meet the challenges of research and developments in this field (29:4).

Although the emphasis of research was directed towards roads, road safety research was included in the terms of reference of the Institute when it was established in 1955. A modest start was made by the appointment of two staff members and, by 1960, it was evident that a more intensive effort was required. Difficulty was, however, encountered in obtaining the necessary funds (29:2).
The total road and transportation research amounting to some R520 000 in 1965 was not only directed towards the solving of roads problems but were used also in associated fields of transportation. Starting with surveys on road accident data supplied by the larger cities, provincial and central government institutions, sufficient work had been done by 1970 for the Institute to publish a report summarizing knowledge gleaned from research and accident analysis at the Institute and in other countries on methods of reducing road accidents. This publication drew attention to the importance of programmes to improve roads based on the systematic use of accident data; education of all road users with emphasis on the dangers of alcohol; improved vigilance of drivers and pedestrians; increased use of seat belts and intensified enforcement of the law in respect of excessive speed and driving under the influence of alcohol (20).

2.3.6 Period 1970 to 1986: increasing importance of road and transportation research

From a relative humble start in 1951 with an annual research budget of R15 000 and a staff contingent of eight, the National Institute for Road Research had developed into an institute of international standing by 1970 (14:2). By this time the Institute had a staff of 136 persons and an annual research budget of more than R1 million. According to Kühn research at that time was clearly recognised by the authorities as an essential and practical supporting function of road building and the work of the Institute was largely financed by the Department of Transport, provincial road departments and the Road Safety Council (14:2).

A system of Steering Committees assisted the Director in the choice of research projects (14:2). These projects were approved by the Advisory Committee, but it needs to be pointed out that the research institution led the road authorities to a large extent and assisted them in defining road research needs. This role of the National Institute for Road Research, at the time and up to 1986 should be borne in mind during the discussion of the era of framework autonomy that then followed and the accompanying trauma of transition for a research institution to adapt operating according to business principles with no or very little guaranteed funding for research (14.2).
Up to 1970 research at the National Institute for Road Research was largely roads orientated. A sound research base had been established in this field and useful information was being produced for potential use in practice. A need however, existed for the systematic implementation of this information involving both researchers and road authorities. Research in transportation was confined to traffic statistics which proved to be of value to road authorities (20).

Early in the founding years of the Institute it was realised that attention was required to other important aspects of road and transportation research such as growth and continuity of funding, research management, the development of an appropriate research structure and perhaps most important the effective marketing of research to ensure the practical implementation of research findings. This aim was supported by the management of the National Institute for Road Research as well as the public roads authorities as main contributors of the annual research budget in achieving these objectives and in the ensuing fifteen year period built up the Institute to a research organisation of local and international renown (20).

During the latter half of the 1970's and early 1980's, through natural evolution of the needs of individuals, some researchers in mid-career, moved away from the National Institute for Road and Transportation Research into private practice and also to schools of engineering at universities. This posed some very real threats to the formal and established research of transportation in that research by consultants was seen not only as a lucrative means of enhancing their fields of business while at the same time providing an expanded and fuller service to their clients. Payment for services rendered was on a "time and cost" basis (13).

2.3.7 Period 1987 to 1992: transition to framework autonomy of research institutions

It became clear to public road and transportation authorities around 1987 that unless a co-ordinated approach towards research was adapted research activities were leading to duplicating of work and not to the best advantage of furthering and expanding the knowledge base for road and transportation needs. This also followed from the decision by the South African government in 1986 that research institutions should become less dependant on direct grants and contributions to their budgets and that they become more business directed in their operations. At the same time, the Department
of Transport, as the central road and transportation authority, was requested by the Department of National Education to take control of the management and coordination of all road and transportation related research work (8).

Allowance was made by the government for the transition to take place over a period of five years i.e. up to 1992. Guaranteed funding for research was to be phased out and after 1992 all work had to be competed for according to business principles preferably in a free bidding process. The Department of Transport used this time (five years) to institute procedures along these lines.

2.4 Summary

The importance of a well-established road and transportation infrastructure to the economic welfare of any country is an accepted fact. South Africa, is no exception. Local problems challenge operators and suppliers of such infrastructure which give rise to investigations and research.

The need for road and transportation research followed the economic development of South Africa. The wealth of minerals on the inland plateaus of the sub-continent of Southern Africa led to long transportation routes to export harbours for raw or partly processed materials. Eventually, urban development became more important than the traditionally rural community life and, in recent years, relaxation of control measures curbing urbanisation, led to complex transportation problems.

The need for solutions unique to local problems in the use of road building materials led to the establishment of the Bituminous Binder Research Unit early in 1951. Research was undertaken to study the performance of locally produced tar and bituminous products in road surfacings. The value of scientific research to solve local problems soon became evident and in 1955 the National Transport Commission requested the Council for Scientific and Industrial Research to set up a research institute to undertake road and traffic research. The National Institute for Road Research was founded by the Council in September 1955. Funding for the research work undertaken by the National Institute for Road Research was provided by the National Transport Commission, the four Provinces and the Council for Scientific and Industrial Research.
From a humble start in 1955 the National Institute for Road Research grew in ten years to be an internationally acknowledged road research authority. The needs for research soon grew to accommodate not only road research but all aspects of transportation in South Africa. Road safety research was one of the main topics, apart from traditional road materials research, receiving attention around the late 1970's and early 1980's.

Effective dissemination of research findings and researchers moving to firms of consulting engineers as well as academic careers at various South African universities, broadened the field for researchers. This gave rise to the problems as described and to ensure that future arrangements can be tied to policies that resulted from work done by the Department of Transport.

The value of road and transportation research to the providers and users of the South African road network, gave reason to a structured approach for such research. The need for management and co-ordination arrangements have been described in this chapter and forms an essential part of the background in order to explain the need for research of approaches applied by the Department of Transport when it had to institute formal arrangements regarding co-ordination and management of road and transportation research in South Africa. These approaches were needed following the framework of autonomy of research institutions by the Department of National Education in 1985 and implemented in 1986. Optimal arrangements for the proper administration of road and transportation research then had to be researched and developed by the Department of Transport. These arrangements were directed and researched by the author, as leader of various working groups of the Research and Development Advisory Committee of the South African Roads Board at the time. The need and details of these arrangements are given in chapter 3.
NEED FOR CO-ORDINATION OF AND ARRANGEMENTS FOR TRANSPORTATION RESEARCH IN THE REPUBLIC OF SOUTH AFRICA.

3.1 Introduction

The arrangements for road and transportation research had a needs-based approach that led to formal arrangements with the Council for Scientific and Industrial Research at the time. The National Institute for Transportation and Road Research was, to a large extent, considered the research arm of the public roads authorities in South Africa, as described in Chapter 2. The advent of framework autonomy for research institutions, as detailed in paragraph 2.3.6, brought to an end the era where specific institutions undertook directed research for a particular authority.

The needs for research in the wider fields of transportation, as compared to the original aspects of problems related to road construction materials, opened the field to associated disciplines of economy, sociology, statistics and others to provide transportation authorities with new horizons to analyse problems and create policies to deal with it. These multidisciplinary inputs into transportation research made a more structured approach essential in order to control expenditure of funds ensuring technological results of practical value. The broader principles and arrangements for co-ordination employed by the Department of Transport to ensure appropriate transfer of technology into practice, will be described in this chapter.

3.2 Value of research in transportation

The need for transportation research has been discussed in Chapter 2, but the question that remains is whether a developing country such as South Africa, where a high demand for funds for basic necessities such as housing, health services and education exists, can afford to spend a proportion of such valuable resources on transportation research. Should models, criteria and design procedures developed in first world countries, where such luxuries can be afforded, not be adapted? These questions are often used in arguments by those not familiar
with the technical details of the provision and use of a road infrastructure and obviously such a diverse task covering all facets of transportation will require expert management and appropriate research to ensure good use in practice (21:2).

Money wisely invested in research adding value in roads and transportation is money well spent. Most of the world wide research in this field is undertaken and applied in countries in the northern hemisphere to suit their conditions regarding material, environment, traffic population and behavioural patterns. These conditions differ widely from those in South Africa. Models, criteria and design procedures developed in those countries are usually not (at least not directly) applicable for use in South Africa. Research is required to develop new or to adapt existing procedures to ensure optimum utilization of local materials under local environmental conditions for local demands. The direct adoption of road and transportation research results developed under different conditions and management thereof could prove to be costly (21:4).

Road authorities in South Africa have been actively involved in the funding of research for almost 40 years. This approach of co-ordinating and managing of research has been highly successful and has been one of the main forces that placed South Africa on par, and in some cases, ahead of the rest of the world in the utilization of its own unique conditions in the provision and use of its infrastructure (20).

However, research in South Africa in roads and transportation is now undertaken by a number of institutions such as the Council for Scientific and Industrial Research's, Division of Road and Transport Technology (DRTT), Universities and specialist transportation consultants. These organisations received invitations from the Department of Transport to submit proposals for research to be undertaken in the 1992/93 financial year. Together, the allocated research effort of these organizations was annually (at the time) worth more than R20 million (1991 Rand). Management and co-ordination of such a research effort required expertise of a high standard to ensure that available funds for research in roads and transportation be effectively utilized (13).

3.3 Need for co-ordinated transportation technology management.

The development of a sound technological base for optimum application in practice is founded on directed research and development resulting from a clear definition of needs by the users, suppliers and operators of the transportation infrastructure of a country. Technology can be
considered as a source of knowledge supported by research and leading to successful applications in practice (36:2).

The management of the various phases in this process and particularly the technology resulting from road and transportation research was identified by the Department of Transport as of importance to provide the users of transportation infrastructure in South Africa the best possible value for the funds invested (13).

The leading role of the Department of Transport in establishing a viable transportation infrastructure in Southern Africa is of the utmost importance. In order to maintain this leadership, appropriate policies will have to be developed to accommodate and promote growth within a framework of limited resources. Technology is the key to success, also with reference to the provision of transportation facilities and is the important link between research and development on the one hand, applications in practice on the other, as defined by Van Wyk (45:3).

This balance between research and development technology, and applications in practice is illustrated in figure 3.1:

![Figure 3.1 Balance between technology, research and development and applications in practice (45:58).](image)

It can be deduced that a substantial volume of research and development is needed for a reasonable input into technology which in turn leads to inputs into applications for industry or innovative practices of engineering.
Research forms the first link in the chain and the importance of directed and applicable/appropriate research is essential for a developing country such as the Republic of South Africa. If research is undertaken in an ad-hoc fashion by various transportation authorities, research institutions and universities to satisfy often over-lapping needs, research becomes an expensive luxury hardly affordable by any country and necessitates proper management and co-ordination to ensure results of value in practice (46:240).

A clear need thus exists for the proper management of research that could lead to the development of technological advances to enhance the transportation infrastructure of the Republic of South Africa. This need for better co-ordination in civil engineering research was already highlighted by Kühn at the Annual Transportation Convention (ATC) in 1982 (17:17).

The above-mentioned statements do not indicate past misdirected or irresponsible action by researchers in transportation in the Republic of South Africa. On the contrary, findings of transportation research in the Republic of South Africa is held in high esteem internationally. However, in order to maintain this position in the face of dwindling funds to roads authorities, the need for improved management of appropriate research has become apparent and has manifested itself in the establishment of formal arrangements to co-ordinate research management by the Department of Transport (13).

With the above in mind, arrangements were made for invitations by the Department of Transport to the various roads and transportation authorities to define their needs for transportation research, as well as to identify proposals for research topics, have had limited success at the time, in 1988. A laissez-faire method of allowing researchers to do this had to be resorted to. This invariably led to various currently topical needs being identified by individual researchers and institutions who submit these for consideration, for example research into funding scenarios for roads and transportation authorities in a milieu of change and dwindling resources. This clearly indicated that a problem existed that needed further research to ascertain the optimum methods for management of road and transportation research. With this in mind a seminar was arranged in 1990 (20).

Jordaan (12:13), at the Seminar on Research Management (1990), in acknowledgement of the fact of ever decreasing amounts of money being available for research in transportation, made
the statement that, to ensure that the available money was spent in the most cost-effective way, a robust selection procedure should form part of the management of research. Such a procedure should consist of three phases, viz:

- requests for research proposals,
- evaluation of the received proposals, and
- a prioritisation of proposals (12:13).

Although the requests for proposals phase is the first step in the process, it cannot be considered before the evaluation and prioritisation processes are considered, since the information required from the project proposer must be that which is needed in the other two phases (12:15). A Research and Development Advisory Committee was appointed by the National Transportation Commission (at the time, later succeeded by the South African Roads Board) to handle details of research co-ordination on its behalf. In order to ensure the handling of the vast numbers of research proposals in the best possible way, the Department of Transport appointed the Navplan Consortium, as a specialist consultant body, to assist it in the management of research in the field of transportation (13).

In the evaluation process, undertaken by the Navplan Consortium, the intention was to identify and prioritise research projects which most closely addressed the needs of the transportation industry with the highest probability of success. The prioritised proposed list of projects was submitted for approval by the South African Roads Board and the award of such projects subject to prevailing financial constraints (33:15).

It is, of course, possible that a project perceived as being brilliant during the evaluation phase turns out to be merely good and can during execution become a major disappointment to all concerned. The objective of correct execution is thus to ensure that disappointment is avoided or at least minimized. Sight must not be lost of the fact that research is a high risk activity so that it does not always follow that research will provide the solution to a specific problem. It was stated that risk management is perhaps more important in research than in most other fields of human endeavour and this form of management is of major importance during the execution phase of any research project (33:26).
Following the proposal, evaluation and allocation of the project after approval, close liaison is needed between the controlling authority (the Department of Transport) and the researcher in order to facilitate correct execution of the awarded research project and ensure eventual successful completion of any research. Projects undertaken successfully and managed properly will ensure transfer of technology obtained into practice (33:26).

Contractual obligations by undertakers of research projects must be formally and appropriately structured. Standard memoranda of agreement containing details and prescriptions regarding progress and payment for work done, were attended to (37:2). The memoranda spells out the rights, duties and obligations of both parties to the agreement and hence supports ongoing contact between researcher and client (13).

3.4 Coordinating role of the Research and Development Advisory Committee in research on roads and transportation.

The Research and Development Advisory Committee was established by the National Transport Commission at its meeting held on 29 August 1986. The position of the Research and Development Advisory Committee in the Department of Transport is shown diagrammatically in Figure 3.2.

![Hierarchical structure of research management in the Department of Transport](image)

Figure 3.2 Hierarchical structure of research management in the Department of Transport (44:3)
The Research and Development Advisory Committee of the National Transport Commission (at the time) consisted of voting members and observers without voting rights. At the time (1987) the composition was as follows:

- **Members from the Department of Transport**
  - Chairman
  - Secretary
  - Representative of the Chief Director of National Roads
  - Representative of the Directorate of Transport Systems Planning
  - Representative of the Chief Directorate of Civil Aviation
  - Representative of the Directorate of National Road Safety

- **Members from the Provincial Roads Departments**
  - Executive Director: Transvaal
  - Executive Director: Natal
  - Executive Director: Orange Free State
  - Executive Director: Cape Province

- **Other Members**
  - SA Federation of Civil Engineering Contractors
  - Nominated member (by the Department of Transport)

- **Observers**
  - Representative of the Division of Road and Transport Technology (Transportech), CSIR.
  - Representative of the Universities (Transportation Engineering)
  - Representative of the Technicons
  - Representative of the SA Association of Consulting Engineers
  - SABITA (South African Bitumen and Tar Association) (44:2)

The objectives of the Research and Development Advisory Committee are:

- To determine the research needs of institutions concerned with roads and transport.

- To define research projects to be financed by the National Transport Commission (at the time) and later followed by the South African Roads Board and participating institutions. In this process duplication should be eliminated.
To prioritise proposed research projects and make recommendations for the funding of the projects.

- To monitor progress and assist institutions in the carrying out of research assignments.

- To collect, store and disseminate usable information from related institutions overseas.

- To evaluate completed research and promote the implementation of research findings (37:3).

The Research and Development Advisory Committee was involved in research being financed mainly by the South African Roads Board and the provinces. It was envisaged that urban authorities concerned with roads and transport would also become involved.

A challenging problem facing the Research and Development Advisory Committee was that of ensuring that ongoing and past research would not be duplicated to a significant degree. A further problem was that of ensuring that current information from both local and foreign sources be optimally utilised thus obviating unnecessary research expenditure on such aspects (44:4).

In view of the foregoing, the Research and Development Advisory Committee had an important co-ordinating role to play through involving institutions funding road and transport research. The advisory committee ensured to reduce the risk of research duplication and the optimal use of generated information within the limited funds available for research.

3.4.1 Overall co-ordinating function of Research and Development Advisory Committee

The overall responsibilities of Research and Development Advisory Committee were to advise the South African Roads Board on research funding, to monitor and encourage ongoing research and to ensure that agreed research objectives had been met in a co-ordinated way (22). Some of the more important of these co-ordinating functions are the following:

3.4.1.1 Determination of research needs

Research topics to be considered for funding were traditionally proposed by researchers themselves or sometimes by clients requiring particular problems to be investigated or
developments to be undertaken. This general approach was followed by Research and Development Advisory Committee during its first year of operation, namely 1987/88, when projects for funding during 1988/89 were evaluated and prioritised (12:3).

Subsequently, during 1988/89 the Research and Development Advisory Committee carried out a research needs study to define the subject areas in which research is required and from this information established a research needs profile. This profile has been used in the generation of projects recommended for funding during 1989/90 (33:2).

Attempts were made, some of which proved to be of great value, to persuade clients and other end-users of research information to define research projects which they consider essential to be funded. Agreements could then be entered into with research institutions capable of carrying out the work at acceptable costs (13).

3.4.1.2 Prioritisation and evaluation

Initially, the Research and Development Advisory Committee made use of a single panel for the evaluation and prioritisation of research (1987/88) (44:5). It was however found difficult to obtain panel members with adequate expertise and knowledge in all the subject categories of the research proposals to be evaluated. The following year, 1988/89, four separate evaluation panels consisting of members with specialised knowledge in any one of four subject categories were used with greater success. For the evaluation of the research proposals received for 1990/91 a thorough investigation led to the identification of the main subject areas shown in Figure 3.3. Shown in this diagram are the main areas of endeavour of transportation as such i.e. transportation takes place on land, water or in the air. On land transportation is undertaken by rail or on some element of the road infrastructure of this country. If the road area is viewed in greater detail, there is a need to provide and to manage infrastructure in this particular area. In a similar way each of the other areas can be generically subdivided. From Figure 3.3 seven typical "knowledge areas", shown in Table 3.1, were identified and used as a basis for the establishment of evaluation panels for road transport research. These panels and the percentage of proposals received within each for the 1990/91 financial year, are also shown in Table 3.1 with the corresponding seven "knowledge areas" (44:6).
Some three hundred new research proposals in the field of roads and transportation were received by the South African Roads Board for the 1990/91 financial year (34:3). The total cost of these proposals far exceeded the funds available for research. This meant that the majority of the proposals received could not be funded by the South African Roads Board during the particular financial year, and that a selection needed to be made.

The main objective of the evaluation of these research proposals was to ensure that the limited funds available for research were allocated to those proposals that would yield the highest rate of return to the South African Roads Board. At the same time, the evaluation was not to distract from the needs for basic research and innovative ideas, which may incorporate a high degree of uncertainty (20).
In proposing an approach to prioritisation it was necessary to consider whether all proposals were prioritised in one group, or whether the projects were divided into categories and prioritised within each category. In the latter case, which was eventually adopted, the available funds had then also to be divided among the various categories (44:2).

Experts in each knowledge area, as shown in Table 3.1 below, were selected and invited to serve as members of evaluation panels in respect of these knowledge areas.

<table>
<thead>
<tr>
<th>TABLE 3.1: PANELS AND RESEARCH PROPOSALS (1990/91) (AREAS OF KNOWLEDGE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Road network management 15%</td>
</tr>
<tr>
<td>B Pavement engineering 32%</td>
</tr>
<tr>
<td>C Traffic engineering 21%</td>
</tr>
<tr>
<td>D Transport planning 16%</td>
</tr>
<tr>
<td>E Structures 4%</td>
</tr>
<tr>
<td>F Social sciences 31%</td>
</tr>
<tr>
<td>G Modal operations 9%</td>
</tr>
</tbody>
</table>

(43:8)

Each panellist, of whom there were 35, was then asked to distribute 100 percentage points amongst these seven knowledge areas. A final distribution was then determined by calculating the average percentage points awarded to each knowledge area. (Shown in Table 3.1).

The first step in the prioritisation procedure is to determine the funds available for new research projects. This was done by subtracting the funds required to finance on-going projects and service contracts from the research funds that were expected to be available for the 1990/91 financial year (22).

The funds available to each of the various knowledge areas were calculated by using a factor of importance as perceived by the respective panel members. This was multiplied by the funds available for new research projects giving a proportion to each knowledge area (13).
The procedure devised to select projects to be included in the research programme was as follows (12:4):

(i) Within each knowledge area, project proposals are sorted by order of descending priority value as determined by the evaluation process. Each project is then awarded a priority number, the first character representing the knowledge area and the following digits indicating the relative position in the sorted list. For instance, a priority number of B03 indicates that the project proposal falls into knowledge area B, ie pavement engineering, where it is the third best proposal.

(ii) For each knowledge area, a basket is created in which accepted projects can be stored. For each basket, the available funds are known, as discussed above (Table 3.1).

(iii) Starting from the top of each sorted list, projects are put into the relevant baskets until the funds available to a basket would be exceeded, should a further project be added to that basket. Such a project is then rejected.

(iv) The residual money in each basket is totalled and shown as a reserve which could be used for basic research proposals, synthesis reports and unforeseen expenses.

In this way allocations to Pavement Engineering projects came to 48.4% of the total funds available in 1989/90 giving attention to projects dealing, for example, with "Low volume Roads" (12:3).

The importance of the separately constituted panels handling the categories shown in Table 3.1 for evaluating and allocating research projects is not to be underestimated owing to the fact that specific expertise could be appropriately utilised.

3.5 Widening of the scope for research.

The widening of the scope of transportation research to accommodate all facets, will be discussed under two headings namely policy statement and elements of the transportation research plan.
3.5.1 Policy statement.

The generic aspects of approaches applied to roads and roads aspects of transportation were identified and related proposals for research were initially handled under the categories most suitable as shown in figure 3.3 where allowance was made for land, water and air modes of transportation. The Department of Transport has formulated a policy document to allow for such a wider approach (3:1).

The mission statement of the Department of Transport reads as follows:

"MISSION STATEMENT

The Mission of the Department of Transport is to provide leadership in the planning, development and management of a multimodal integrated transport system for the RSA.

Our role is directed towards achieving national goals in providing mobility in a safe, reliable and affordable manner. This will be done in accordance with the social and economic needs of the RSA.

We will co-operate in the enhancement of a Southern Africa transport system, and will actively participate in international affairs." (3:1).

Following from the above mission statement, transportation research, under the auspices of the Department of Transport, shall be undertaken to ensure:

"enhanced effectiveness and promotion of the execution of the specific tasks of the Department, to analyse appropriate transportation technology for the benefit of all users of South African transportation infrastructure, to enhance the safety of all users of transportation" (3:1).

In order to implement the above-mentioned policy statement and to optimise the investment into transportation research, the Department of Transport will make use of a research management system ensuring that:

- involving all modes of transportation,
- allocation of funds towards appropriate projects with realistic objectives,
- timely dissemination of results, and
- implementation of results at all levels. (3:1)
Elements of the Transportation Research Program

The Department of Transport identified three types of knowledge for any task undertaken within the transportation sector:

- applied knowledge,
- available knowledge, and
- ideal knowledge

For any task presenting problems in execution, reference can usually be made to past experience and or knowledge in the field. If the level of knowledge is sufficient, it can be readily applied towards problem solution, if not, research must be identified and undertaken (3:1).

Such areas of knowledge "short-fall" can be identified as research needs and the transportation research program should address these elements as follows:

- research projects
- development projects, and
- knowledge transfer projects (3:3).

In economic terms, capital investment in road transportation provides direct benefits of reduced travel times, reduced travel costs, improved safety and ease of access (37:1). Achievement of these goals is only possible if decision makers have access to the best possible sources of information provided by appropriate research findings.

The direction provided by the Research and Development Advisory Committee of the South African Roads Board for research to be aimed at:

- proper identification of research needs,
- achieving the stated objectives of research,
- facilitating the implementation of the research output (37:1),

has provided the framework for widening the scope for inclusion of all facets of transportation research.
The generic nature of the framework lends it to the application of any field of endeavour with clearly identified research needs and the co-ordination and management there-off.

3.6 Summary.

Prior to the advent of a framework of autonomy for research institutions (up to 1986) research projects were undertaken in close liaison between roads authorities and the National Institute for Transportation and Road Research of the Council for Scientific and Industrial Research. Limited research were undertaken by universities and consulting engineering firms - these were mostly undertaken for graduate work or under contract with specific details.

A system of control by Steering Committees reporting to a central Advisory Committee of the main road authorities and the National Institute for Transportation and Road Research took place in an atmosphere of mutual trust. Since 1986, changing demands on authorities to make provision for a wider range of facilities such as kombi-taxis and a general decrease in the available funds led to a multi-disciplinary approach to the solution of transportation problems.

Up till the end of the 1970's, the Republic was engaged in completing its road network with major construction of primary routes, including freeways, still taking place in that decade. Problems that required solution were thus aimed at single-disciplinary activities, invariably materials related. The emphasis has since shifted, as illustrated in this Chapter, to optimum utilisation of the road network with consequential needs in terms of traffic engineering, transport economics and the human sciences. Furthermore, the research programme must perforce relinquish its focus on road transport in favour of consideration of all modes of transport by land, sea and air. A multi-disciplinary approach to problem-solving thus becomes essential.

The likelihood exists that no single research organization could have accommodated or provided the variety of sciences required to address the multiplicity of the Republic's transportation problems.

Without the advent of framework autonomy, the Department would have been forced to retain a variety of research organizations in the execution of its research programme as described (37:2). It was soon evident that control of transportation research had to be subjected to
tighter financial and contractual control. Details of the financial aspects of road and transportation research in the Republic of South Africa will be given in chapter 4.

Road and transportation research results obtained from other parts of the world are often not applicable to South African conditions and can only be applied after due investigations. Perspectives gained from overseas experience, however, are invaluable in planning local research strategies. It is therefore important to maintain a transportation research programme aimed at developing new or improving current procedures to ensure the optimum establishment and utilisation of the transportation infrastructure using the basic strategy as described in this chapter.

With the definition of the need for a co-ordinated approach towards the management of road and transport research in South Africa, it became clear that a system for this approach be researched, and applied in practice. There was some urgency in the matter owing to the five year transition period allowed by the South African government (8).
4.1 Introduction

Before any consideration can be given to researching details of a suitable management system for road and transportation research, attention must be given to the funding of such work to be undertaken.

Research is often considered somewhat of a luxury for a developing country such as the Republic of South Africa as described in Chapter 2. The cost of research, however well research is motivated, carried out and implemented, has to be planned and budgeted for in a responsible manner. Road and transport research has to be provided for in annual budgets, drawn up by the various roads and transportation authorities, or an arrangement has to be agreed upon as to how it is to be funded and from what sources.

In order to co-ordinate and manage transportation research, sufficient funding has to be allocated not only to research projects, but also towards the technical and administrative functions to undertake control in an orderly way. Expenditure on transportation research is usually given as a proportion of the total annual expenditure on roads and transportation or as a proportion of the total replacement value of such infrastructure. Some details of this pertinent to South Africa will be given in this chapter. Details regarding funding for research work and payment to undertakers of such work are to be brought into the total perspective for such work together with the total annual funding needs for road and transportation works.

4.2 Transportation research in relation to the value of infrastructure

According to Mitchell (23) the total length of the road network in South Africa, including both rural and urban network for all authorities, came in 1986 to a total of 300 544 km (23:52). Certain elements of the tertiary network have not been defined, at the time, 1991, and this total can be increased somewhat. The replacement value of the network was estimated to be in the order of R80 billion (1992 Rand) clearly illustrating the importance of
this facet of infrastructure to the national economy. The effective provision, maintenance and operation of a national asset of such proportion have to be supported with access to the best possible technology resulting from appropriate research (20).

The total 1986/87 roads budget came to R2 392 million (23:52). This figure for the rural roads authorities has shown a decline in real terms resulting in a total roads budget of R2 020 million (1992 Rand) for 1992/93. These figures exclude accumulated backlogs resulting from the needs for developing underprivileged areas or urban growth.

An essential part of planning and programming of research for budgeting purposes is that of forecasting of costs. This is particularly problematic if agreements are fairly open with fair allowance for basic research. Twiss (42:120) discusses various methods to address the problem i.e. the value of these techniques is, however, dependant upon the quality of the data to which it is applied. Twiss also identifies and discusses (42:122) the problems associated with estimation of costs, duration and the potential benefits in the calculation of priorities of research projects. He finds that, particularly, financial forecasts can, as a result, be grossly in error (42:142). It is therefore essential that the best possible inputs be made at an early stage.

The methods applied in project selection by the Department of Transport will be discussed in chapter 5 of this dissertation. It will be stated, though, that the change from the dispensation of a rather open ended approach to research funding in transportation up to 1986, may have had an influence that is still to be determined. The author is of the opinion that the high standard of research and findings originated by the National Institute for Transportation and Road Research during the 1970’s and early 1980’s may be difficult to repeat under current constraints of limited budgets, open competition for research and contractually binding agreements.

Any public institution has the obligation, by law as well as through professional and moral codes of ethics, to provide the best possible service to the tax payers - usually within a framework of limited resources. It is therefore natural to agree with Twiss that expenditure on research and development ought to satisfy the same financial criteria the institution applies to other uses of funds which have a long term pay off (42:119). It is, however, more difficult to prepare meaningful financial evaluations on research and perhaps more so for those topics dealing with transportation. Worthwhile findings of research leading to improved
policies and resulting services, take a long time to prove their benefits to users. An example of this would be the successful research that led to the high quality crushed stone base course foundation layers constructed for high traffic roadways in South Africa. The relative higher initial cost of construction pays dividends in a substantially longer structural life (20 to 25 years) for the road as a whole before it has to be rebuilt (15). The benefits of a substantially successful research project in practice has to outweigh the cost of development and is in many instances the motivation for research to be accommodated in any budget of an institution. (42:120).

4.3 Funding of transportation research in South Africa (1987-1992)

Research and development are the responsibility of both the public and private sectors of any society. In order to gain some perspective on the South African situation, it is considered of relevance to compare some overseas figures to those applied locally. It has been stated by Deen of the Transportation Research Board of the United States of America, that the United States of America devotes 1.8% of its gross national product to non-defence related research compared to 2.8% for Japan and 2.5% for Germany (1987 figures) (40:2). The Federal Highway Administration (USA) spends 1.5% of its annual budget on research and so do the various State departments of transportation. Deen (39:3) also mentions the fact that with little or no central control of the nation's transportation infrastructure, it is not surprising that research to support that infrastructure is broken into many different program functions, directions and goals. It needs to be stated, though, that since 1985 to 1987 there has been a serious effort by the Federal Highway Administration to coordinate research effort through a program of Technology Transfer with relevant centres being established in most states (40:3).

It has also been confirmed by Jordaan that First World countries tend towards dedicating between 3% and 5% of their transportation budgets to research (12:10). With the annual South African roads infrastructure budget in the order of R2.0 billion a figure in the order of R60 million should be spent on transportation research. (Proposals to the value of R85 million were received for the 1991/92 financial year, indicating the potential perceived need). However, it has been found that only around R20 million could be allocated to transportation research annually (1986-1991) from the total budgets of the traditional roads authorities in the Republic of South Africa (13). This is about 1% of the total annual roads budget of R2.0 billion. The actual figure of 1% would be drastically reduced if the above-mentioned figures as well as costs for urban transportation and other modes of transportation is taken into account (13).
The dispensation of framework autonomy towards research institutions (8), as well as more pronounced efforts by universities and transportation consultants to undertake research have resulted in greater competition for the funds available for transportation research. This underlines the need and importance of proper liaison between authorities and undertakers of research and to establish a basis for equitable funding of research (13).

Traditionally funding for research was provided by the four Provincial Roads Departments (approximately 8% of R20 million) and the Department of Transport (approximately 92% of R20 million) in 1990. As from the 1991/92 financial year the total budget for research is provided for by the Department of Transport. In order to create a reasonable share of funds towards needs in urban areas 15% of the research budget is to be funded from the Urban Transportation Fund. The balance comes from the National Road Fund (22).

After establishing the needs for the seven research categories in road provision and management,

A - Road network management,
B - Pavement engineering (road foundation layers),
C - Traffic engineering,
D - Transport Planning,
E - Structures (bridges),
F - Social sciences (associated with transportation), and
G - Modal operations (shown for 1990/91 in table (3.1) on page 3-11 in the previous chapter),

funding is distributed to cover these in order of importance. The relative importance is judged by a representative of the Research and Development Advisory Committee (38:10).

The extent of allocations into each category can change from year to year as needs alter. Categories can be omitted if the categories reflected in the allocations for the 1991/92 financial year is compared to those for 1990/91 described above (38:10).

Table 4.1 gives details of the 1991/92 research budget for the South African roads authorities as funded from both the National Road Fund and the Urban Transport Fund (38:11).
Table 4.1 Research budget for 1991/92

<table>
<thead>
<tr>
<th>GROUP</th>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needs Service Contracts *</td>
<td>642 000</td>
</tr>
<tr>
<td>Research Service Contracts *</td>
<td>3 821 645</td>
</tr>
<tr>
<td>10 % of cost of 1990/91 projects</td>
<td>1 398 514</td>
</tr>
<tr>
<td>90 % of cost of ongoing projects</td>
<td>2 092 680</td>
</tr>
<tr>
<td><strong>SUB-TOTAL OF COMMITTED FUNDS</strong></td>
<td>7 954 839</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>FUNDS ALLOCATED TO NEW RESEARCH PROJECTS FOR 1991/92</strong></th>
<th>(90% of first year costs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AREA OF INTEREST</strong></td>
<td><strong>PROPORTION OF TOTAL</strong></td>
</tr>
<tr>
<td>Transport Policy and Strategic Management</td>
<td>35,5</td>
</tr>
<tr>
<td>Pavement Engineering</td>
<td>31,0</td>
</tr>
<tr>
<td>Traffic: Design and Operation</td>
<td>30,3</td>
</tr>
<tr>
<td>Structures</td>
<td>3,2</td>
</tr>
<tr>
<td><strong>SUB-TOTAL ALLOCATED TO NEW PROJECTS</strong></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL PROPOSED EXPENDITURE FOR 1991/92**                  | 21 725 700 **

* Special research assignments, for example the operation of the Heavy Vehicle Simulator, the National Black Panel and grant to Viaed

** Shared between National Road Fund (NRF) and Urban Transportation Fund (UTF) in the ratio of 85/15 (38:11)

4.4 Arrangements regarding payment for research

At an early stage in the administration of research by the Department of Transport, it was realised that payment on progress of any transportation research project was the only viable dispensation to use. Invitations for research projects indicated that time and total
estimated cost had to be included as these were factors brought into consideration when applications were reviewed. Approval of projects by the Research and Development Advisory Council was for a fixed amount with no allowance for escalation. (13).

A fair number of projects required sophisticated equipment or computer hardware for which funds were needed. This problem was surmounted by allowing payment of 30% of the contract amount for the first year (if the project was undertaken over more than one year) or 30% of the contract amount for a one year contract. This payment was allowed when sufficient proof was provided of the details and program of the research project. Two further fixed payments of 30% each were made on satisfactory progress reported to regular evaluation and monitoring panel meetings with a final payment of 10% being paid upon satisfactory completion of the project (22).

In order to ensure optimal returns on funds invested in transportation research an up to date research management system has been created. The management system is to ensure that:

- all modes of transport are addressed,
- available funds will be allocated to appropriate projects addressing real needs,
- cost effective completion is achieved,
- results are made available timeously,
- results on all levels are actively implemented (3:1).

According to these arrangements, all competent institutions can compete for undertaking research addressing needs previously defined by the Department of Transport, as described earlier.

4.5 Summary

In order to illustrate the proportion of total road funding details of the research budget for 1991/92 and the periods leading up to it is given.

Total funding for transportation research in South Africa grew from relative insignificant R15 000 annual research budget in 1955 to a peak of more than R20 million in the 1991/92 financial year. This amount represented less than 1% of the total annual road budget of the main South African roads authorities in 1991/92. Some comparisons to road and transporta
tion research in some overseas countries and the amounts annually budgeted for this purpose show that the Republic of South Africa is logging somewhat behind. Details are given of how the road and transportation research funds were allocated to allow for a fair distribution towards special assignments, ongoing work and the new work proposed for 1991/92.

The arrangements for payment for research, as approved, had to be formulated in such a way that progress was ensured. It was found that the agreed funding for a particular research project would be paid in three portions of 30% and a final instalment of 10% upon successful completion of the work.

Once details have been established for a satisfactory payment system for research a system needed to be investigated for the identification, evaluation and prioritisation of research needs.
CHAPTER 5

IDENTIFICATION, EVALUATION AND PRIORITISATION OF RESEARCH NEEDS

5.1 Introduction

Funds available for roads and transportation in general and research in particular, have decreased, in real terms, over the five to six years up to 1992, as indicated in the previous chapter. It is essential to ensure that the most effective use is made of such funds as such underlining the importance of proper identification, evaluation and prioritisation research projects once they have been identified. Many worthwhile research projects can, for a lack of funds, not be undertaken in a particular year. It is therefore essential that the needs for research be clearly identified and allocations of funds towards the various categories as indicated in the previous chapter be properly substantiated. Traditionally, up to 1986 roads, and later, transportation authorities, allowed research topics to be identified and proposed by the researchers themselves (at the time essentially the Division for Road and Transport Technology of the CSIR). This was, to a large extent, undertaken in conjunction with the roads authorities (explained in Chapter 2). Owing to close ties with researchers, control by the various Steering Committees lead to good management and co-ordination of research as well as liaison with practitioners in the field, led, in the opinion of the author, to a "Golden Decade" (1970-1980) of road research per se in South Africa. It is only now, almost ten years later, that advances are taking place internationally leaning heavily on the South African experience regarding non-destructive testing of road foundation layers using the Heavy Vehicle Simular for in-situ testing on existing roads (20).

Bringing about changes to a system of research management for roads and transportation projects in South Africa that has been in operation for almost 30 years, could only be undertaken with care. The transition towards framework autonomy, as mentioned before, provided the opportunity to study and optimise methods previously used in identification, evaluation and prioritisation of research needs. It was identified and used as a point of departure at meetings of the working group, under chairmanship of the author to research such methods and put them into practice as researched results shown in this dissertation (20,22).
The drawing up of a transportation research programme for every year is a sequential process of requesting proposals, followed by evaluating and prioritising of proposals (12:13). Procedures for each of these functions have to be as efficient as possible in order to take up as little time as possible of officials and other specialists in private practice. Details regarding such assistance through the use of panels of experts in the relevant fields, will be given in this chapter.

The above process as well as the subsequent monitoring of research generates a substantial administrative burden on the staff of the Department of Transport (33). In order to cope with the additional administrative and clerical duties resulting from the above, a consortium from the major researchers, as a working group, was needed (22).

5.2 Initial investigations

However, in the first year (1987/88 fiscal year) following full employment of principles towards framework autonomy by research institutions, much the same methods for identification and proposals for research topics as before were followed. Research proposals were invited from all interested institutions. In order to ensure a fair distribution of funds, with the needs of the authorities in mind, the method described in the following paragraphs, were researched and used. Owing to the fact that persons, with the varied and diverse fields of expertise needed to devise and adapt the needed knowledge, were not freely available within the ranks of public institutions, use had to be made of such persons from universities and consulting practices (22). These individuals were grouped into panels of specialists undertaking the various tasks put forward in this chapter.

5.3 Description of needs identification process

During 1988 and 1989 the Research and Development Advisory Committee (the constitution of which was described in paragraph 3.4 of this dissertation) carried out studies to determine the various subject areas, or "Areas of Knowledge" in transportation where research was required (see Table 3.1). These persons, who were experts in various fields of roads and transportation, were requested to indicate their individual areas of preference for research. A profile of needs was compiled from these preferences.
The derived profile was then used to define the subject areas and from that research needs. This needs profile was then employed in the recommendations for research fund allocations in the 1989/90 financial year. This was undertaken in line with international needs as will be described later in this dissertation. The Research and Development Advisory Committee initiated a Transportation Technology Management System study with, as one of its major objectives, the involvement of all major transportation authorities or potential client bodies in the identification and prioritisation of needs. (37:13).

The road, and more generally the transportation industry, operates in a public environment with wide spheres of influence on public life, industry and the economy. A diverse multitude of problems such as the growing use of combi taxis, congestion on township commuter routes, the use of public transport, optimal use of road and building materials, need to be addressed by authorities in order to serve the community in the most equitable manner and, for this reason, the needs for research must be categorised. It was found that a multidimensional classification system, which needed substantial subdivision in several of the dimensions would suit the needs as defined above. In order to deal with problems emerging from these diverse fields of activity a formal systems approach was needed where individuals can manage those areas of their own expertise. With this in mind, the Research and Development Advisory Committee approved the following "Areas of Knowledge" (44:13). It was found by the working group of experts to limit the "Areas of Knowledge" to four and regrouping the seven originally proposed in this way (22).

A: Research into transport policy and strategic management

Rapid changes in the political and economic environment in South Africa necessitate the need for new policies to deal with problems. Multi-faceted needs in providing transportation infrastructure have become complex and can not be dealt within a simplistic fashion. Sophisticated management systems have to be developed and employed most equitably to meet the demand.

B: Research into pavement engineering

Research in this category pertains to all aspects of road foundation layers - particularly durability and economic methods for construction and maintenance of roads.
C: Research into traffic: design and operation

Increasing traffic volumes on roads create congestion, safety hazards and related problems, all with severe economic implications. Research into all facets of traffic related problems form a major proportion of work undertaken.

D: Research into structures

Bridges and traffic related structures form a major part of transportation infrastructure. Optimal use of materials and design methods have to be researched in the South African context to provide solutions to unique local problems (44:13).

These four "Areas of Knowledge" are the responsibility the panels constituted from private practice as well as road authorities, of persons, as appointed by the Research and Development Advisory Committee, with the relative fields of expertise, as will be described. It is clear that some of the areas are more multidisciplinary than others eg policy, strategic management and traffic, which involve, apart from normal civil engineering inputs, knowledge of economy, sociology, psychology, education and environmental sciences. This can best be described by, say, the placing and design of bus stops and the attitude of persons to using it or preferring different modes of commuting to work or for pleasure (13).

Research topics can, within these areas, address any aspect of -
- planning, design and provision of the road network,
- maintenance of existing infrastructure, and
- utilisation of the network (37:1).

With the above in mind, it must be remembered to allow for various modes of transport to be considered, for example;

1. Passenger hauliers
2. Freight hauliers
3. Vehicular aspects
4. Roads
5. Commuter transport
6. Aviation
7. Shipping
8. Other modes of transport
It is often stated that research in any field of endeavour is essential to further development (20). Any research and development undertaken, therefore has to be provided for financially in a responsible way and the results must be perceived as practical and beneficial. Prior to the establishment of a framework to define needs for (transportation) research, a basic source of knowledge needs being identified. It is then necessary to prioritise these defined needs according to available resources. These needs for research can be defined as being the difference between existing knowledge and the total knowledge required to solve a defined problem (37:14). The ideal would then be that all potential researchers, in a particular field, be made aware of this prioritised schedule of needs or potential research projects in order to get their response more directed towards the actual problems and needs for research, of the transportation and roads authorities (13).

5.4 Details of distribution of transportation research needs

During the years 1986 to 1992 following framework autonomy of research institutions, the identification of research needs was handled by road authorities who identified needs. The dispensation since 1992, however, was that such needs, as identified by the researchers had to be brought to the attention of the Research and Development Advisory Committee to coordinate this with actual needs as perceived by the roads authorities (37:15). In order to put the full process regarding the identification into proper perspective, evaluation and prioritisation needs, the developments that took place are described again (3:1).

As described earlier and as research into the process progressed, it soon became evident that, with the various contributors towards proposals in a particular field, the previous arrangement would lead to duplications and other disadvantages in effective identification of research themes and projects. Another aspect that became clear from investigations was that, when the formulation of proposals is left entirely to researchers, certain topics became fashionable; for example transportation problems associated with the third world aspects of transportation in South Africa. When considering proposals for research under these circumstances, careful consideration had to be given to the content and phrasing of the proposal. This highlights the importance of the use of panel members with sufficient expertise to identify the above situation as soon as it became evident. Owing to time limitations this was unfortunately not always possible and, when a tendency towards duplication became evident during monitoring, negotiations had to be entered into between the client and the researchers concerned (37:24).
5.5 Panels of experienced persons for monitoring of transportation research

As already indicated in paragraph 5.2, these four panels of experienced persons have a daunting and important task. Prior to the selection process by the panellists, research has to be undertaken to provide the panellists with lists of research proposals in the best possible way to ensure the selection of the most worthwhile projects for research (13).

Investigations have shown that it was opportune and worthwhile that the same or very similarly constituted panels of experts be used firstly to identify needs for research, secondly to assist in prioritising these before putting them to researchers to make proposals for undertaking the work, and thirdly to evaluate the submissions by researchers. The panellists could thus have an important task using their expertise appropriately and economically. It was clear that highly specialised persons, either in the public or private sectors of the transportation field, could hardly be expected to contribute this amount of time, mostly on a voluntary basis, towards the proper management of research in their respective fields of transportation (22).

Up to 1991 researchers were requested to submit their proposals before June of a particular year for consideration by the Research and Development Advisory Committee in November of the same year. In order to have researchers in a position to start work at the beginning of the following financial year, allocations and approvals by the South African Road Board had to be finalised during January.

A typical example of the sequence of events could be as follows:

<table>
<thead>
<tr>
<th>End June</th>
<th>Submissions by researchers</th>
</tr>
</thead>
<tbody>
<tr>
<td>July to October</td>
<td>Preparing and prioritising proposals for submission</td>
</tr>
<tr>
<td>November</td>
<td>Recommendations for approval</td>
</tr>
<tr>
<td>January</td>
<td>Approval of research projects</td>
</tr>
<tr>
<td>(following year)</td>
<td></td>
</tr>
</tbody>
</table>
February to March : Preparations and contractual agreements entered by researchers following ministerial approval

April : Commencement of research work (37:15), (13).

For the 1992/93 financial year researchers also received the prioritised listings of research needs as described before for their guidance in the formulation of research proposals (37:15).

Prior to submissions being finalised in June 1991 (for 1992/93) researchers received a draft list containing preliminary needs from the Department of Transport. Researchers were allowed to add to the list or modify draft proposals, that in their opinion, merited consideration. A new list of proposals was then submitted to Research and Development and Advisory Committee during May 1991. It was hoped that this would improve the ability of researchers to submit more worthwhile and less duplicative, research proposals. Invitations were then despatched to researchers with these more formalised listings together with guidelines containing instructions on information needed to prepare research proposals for 1992/93 (37:15).

5.6 Constitution of panels of experienced persons to assist the Department of Transport in monitoring research

The various functions involving panel members with specialised expertise in each of the four "Areas of Knowledge", have been mentioned and described to a certain extent. In order to detail the origins and structures further their constitution need to be examined in greater depth.

The focus of the research effort in the Department of Transport is to address all transportation research needs in the most equitable fashion (37:1).

The most efficient way to facilitate a broad based representation from all facets of the transportation industry in South Africa has resulted in the formation of representative panels of knowledgeable persons. The panels have to undertake various functions, some of which have been described previously, but to sum up, they are to: assist in identifying research needs;
evaluate and prioritise research proposals;
monitor and evaluate progress;
ensure successful completion; and
implementation and technology transfer (37:6).

The composition of the panels was two fold - that of voting members (the main financial contributors) and non-voting members various interest group with observer status. It has been found that the interest groups play an important role and the fact that they only have observer status did not reduce their participation in assisting towards meaningful decisions regarding research (44:17).

The panels comprised, with one voting member each:

- Department of Transport
- Cape Provincial Administration
- Natal Provincial Administration
- Orange Free State Provincial Administration
- Transvaal Provincial Administration (44:17).

The various interest groups involved, apart from the client bodies mentioned above, were the following: (one representative per group).

- passenger hauliers
- freight hauliers
- commerce
- urban authorities
- passenger car owners (representative Automobile Association of South Africa)
- road building materials suppliers
- Transport Advisory Council
- Universities (44:18).

Other identifiable or interest groups expressing an interest, were also invited (44:18).
Other institutions undertaking research in transportation elements e.g. the Department of Mineral and Energy Affairs are kept informed of projects with aspects of possible overlap. The importance of liaison in this regard, particularly in a relatively small community such as South Africa is not to be underestimated. Limited manpower and financial resources can be pooled to a significantly greater extent than is currently the case (22).

A satisfactory level of contact exists, for example, between the Department of Transport and the Portland Cement Institute and the South African Bitumen and Tar Association. Both these organizations either undertake research themselves or have research undertaken. It has been found advantageous for the Department of Transport to undertake research in cooperation or have supplementary work involvement (13).

Individual specialists (researchers, academics or consultants) are also involved in an observer capacity on panels.

The potential problem of ethics, involving representatives from a relative small fraternity of specialists, has not arisen and can be ascribed to a very professional attitude of all involved. The potential problem of ownership of ideas when proposing research projects to be reviewed by persons who could be in competition with each other, has been accommodated in the descriptions for submissions and fully taken care of in the memorandum of agreement to undertake research work (12).

Membership of the panels can be reviewed annually or as the need arises (44:14).

5.7 Structure and operation of panels

The effective functioning of research monitoring panels is dependent on the appropriate expertise of the individuals involved. Each of the panels, as described, has a chairman appointed by the Department of Transport. In most cases the chairman will be an official of the Department of Transport. The Chairman and three members of Navplan (up to 1991/92) serve as a management committee to each "Area of Knowledge". For ethical reasons, the officials of Navplan act in an advisory capacity and have no voting rights. Owing to the volume of administrative work in preparing reportage back to the full panel, the function of the said management committee is of great importance (44:18).
Researchers are advised of decisions by panels and the management committee monitor actions taken in respect there-of in addition to dealing with any other problems arising between meetings of the panels (44:19).

The meetings of the panels are scheduled for May and September of each year. Preparations for meetings is a function of the management committee and these preparations have to be finalised two to three weeks prior to each panel meeting. During these meetings progress is monitored and attention given to problems identified for example any areas of duplicating or non-directed work. Additional to this, during the September meetings, project proposals received for the following year are considered for recommendation to the Department of Transport (44:19).

A uniform and structured approach to panel meetings are considered of great importance by the Department of Transport. Guidelines have thus been developed for procedures to be used at panel meetings. Because of the involvement of officials from the various authorities contributing to or benefiting from research undertaken, certain task descriptions were developed for inclusion in their normal duties (24:19).

5.8 Evaluation process for transportation research projects.

Limited funds available (less than 1% of the annual road budget of South Africa as stated -in Chapter 4) for transportation research underlines the importance of the highest possible yield of return on research investment. With limitations of this nature (as well as others, such as knowledgeable manpower), it is important not to "distract from the needs for basic research and innovative ideas" (37:20). It should also be borne in mind that, at the outset and by its very nature, research incorporates a high degree of uncertainty.

The "Areas of Knowledge", as defined in paragraph 5.3, provide the limits within which projects are evaluated. Proposals are allocated numbers in order to identify the knowledge area in a data base specially created for this purpose. Panellists are then provided with all relevant information pertaining to the projects in their "Area of Knowledge" for evaluation.
The following aspects are to be considered:

i) individual project proposals with regard to the
   - problem it addresses,
   - proposed output of the project,
   - resource allocation,
   - duration in years, and
   - cost.

ii) the researcher proposing the project, with reference to his or her:
   - academic qualifications,
   - previous work in research,
   - previous authorship of research publications, and
   - previous experience in general.

iii) the employing research organisation in terms of
   - general areas of research addressed by it in the past, and
   - availability of infrastructure required to support the project (37:20).

Apart from the above, the panel evaluator must keep in mind what costs have been incurred in the particular area, details of ongoing projects and historical background of work in the area of knowledge. As far as possible, details of this nature will normally be provided to the panel member for evaluation by him. It needs to be mentioned that ongoing projects are not re submitted for prioritisation. Any problems regarding overlaps or better proposals on the same theme have to be dealt with in monitoring (22).

Utility analysis, in an adapted form, is used to structure the evaluation in order to have the results in the form of a relative benefit/cost ratio (See Figure 5-1).
Benefits are derived according to a point rating using questions designed to measure:

- the value of the implemented end-product of the project;
- the probability that the research will be successfully completed; and
- the probability of implementation of results.

It is essential for financial planning that researchers are bound to the budget of their work. It is therefore important for panellists to assess the reasonableness of the cost of the project in relation to the effort envisaged by the researcher in the proposal.
The means of all the ratings of a project are calculated and weighted by means of normalising curves. The value for the project determined, reduced by the factors of probabilities above, is its overall benefit (37:21).

Relative cost is a value calculated from the actual cost of the project by use of the following relationship:

Relative cost = e^x
where x = Actual cost/500 000 (37:21).

The advantage of this relationship is that the curve derived, gives all projects reasonable chance in competing with others, whether they are of a high cost category or not.

The Relative Benefit/Cost ratio is then determined as the quotient of the two figures derived above. Details of the calculation of the priority numbers of projects proposal using the relationship shown above, is given in the Addendum. The Addendum provides details of the scientific mathematical methods that resulted from the research undertaken by the working group under the chairmanship of the author (22).

5.9 Prioritisation procedures employed by the Department of Transport for research projects

As agreed between the four provincial roads authorities and the Department of Transport, provision for research will be included in the budget of the Department. The item for research has to provide for ongoing as well as new projects every year (22).

The balance available for allocation to new research projects is derived after commitments from previous years and for uncompleted work, has been taken into account. The balance is then divided according to the average percentage breakdown between the areas of knowledge put forward by the panel members and approved by the Department of Transport.

The procedure to determine which projects are to be included in the draft research programme for approval by the Department, is as follows:

i) Within each knowledge area, project proposals are sorted by order of descending priority value.
ii) For each knowledge area, a basket is created in which accepted projects can be stored. For each basket, the available funds are known, as discussed above.

iii) Starting from the top of each sorted list, projects are put into the relevant basket until the funds available to a basket would be exceeded, the last project added during this process, for which funds are only partially available, is then rejected.

iv) The funds remaining in all the baskets are totalled and shown as a reserve to be used for basic research proposals, synthesis reports and contingencies.

v) The prioritised lists are provided to the Panel Chairmen (Departmental representatives) to ensure that no possible duplication or overlap of research takes place.

vi) The chairmen then propose a final ruling on projects essential to the South African Roads Board and which should accordingly receive top priority.

vii) These rulings are coded into the database to produce revised priority lists which are submitted for comment to and approval by the Research and Development Advisory Committee.

viii) The priority lists are revised again to accommodate any input received from the Research and Development Advisory Committee and then submitted to the South African Roads Board for approval and incorporation in the budget of the Department of Transport.

ix) After approval of the budget, research organisations are informed about the acceptance or rejection of their proposals (37:22).

5.10 Monitoring of approved transportation research projects

The monitoring of approved transportation research projects is another function to be undertaken by the panels with report back by researchers at their May and September meetings of each year. Both ongoing and newly started projects are evaluated and payments for progress is recommended according to the 30:30:30:10 percent ratio previously mentioned in paragraph 4.4.
In order to ensure absolute success of research in terms of the needs defined by the authorities, the ideal would be to establish ongoing contact between researcher and client, but for obvious reasons, this is difficult. The client in this context is defined as the representative of the road authorities who has to undertake monitoring while performing many other normal duties. The monitoring process thus serves as a channel of communication between the two parties to the project (37:24).

Apart from the formal monitoring meetings, less formal discussions early in the project are important. The needs of the client should then be clear to the researcher but contact is important to underline the original understanding and to keep the project optimally directed towards its goal. This should provide ample opportunity for adjustments where needed. Upon completion of the research work there is a commitment from both researcher and client to ensure ready implementation but an "end-of-project" meeting has been found of value in ensuring that this is the case (22).

5.11 Summary

The decrease, in real terms, of funding allocated towards road infrastructure, has had a pronounced influence on resources available for research. The importance of needs identification, compilation of research details and proposals as described in this chapter under guidance of the authorities involved, has been identified. Close liaison between authorities and researchers to define problem areas with a need for investigation and research, is essential and has been found to work very well in this country. Research identified in this way has much greater value to practitioners and is ensured of practical application.

For this purpose the identification of transportation four "Areas of Knowledge", as rationalised from the earlier seven, has greatly assisted the efforts of researchers to categorize their work for example;

A  Transport Policy and Strategic Management  
B  Pavement Engineering  
C  Traffic: Design and Operation  
D  Structures.
In order to ensure that needs for research and eventual implementation of findings are met, a description is provided of the operation of panels of experts to monitor progress of research work. The arrangements and coordination needed for meetings of these panels involve a vast volume of work providing the motivation, as described, of the use of these experts.

The framework provided for a national approach to the management and administration of, initially road research, has already grown into a wider context of management of transportation research as envisaged by the Department of Transport in future (1992 onwards).

A prioritisation process for research projects as proposed or identified, was devised using statistical relationships to ensure that all projects are compared fairly.

Allowance is made to compare project details, expertise of researchers, costs as well as possible end result details regarding probable success and implementation of research findings in practice.

The dissemination of research findings is a matter of concern, not only to researchers but also to funding authorities to ensure that such findings are applied in practice. A description of such methods of dissemination, as researched, is given in chapter 6 as well as some aspects to compare it on an international level.
CHAPTER 6

RESEARCH DISSEMINATION AND TECHNOLOGY TRANSFER IN ROADS AND TRANSPORTATION

6.1 Introduction

When transportation practitioners and engineers are confronted with problems which are not readily explicable or surmountable, they have to resort to specialists for advice or the undertaking formal investigations. Civil engineering and more specific in roads and transportation, is practised with perspectives available from many sectors both locally and internationally. Transportation facilities are supplied to users to suit their own unique needs in a particular environment eg. a rural agricultural society in a wet mountainous area will have different needs to a mining undertaking in an arid coastal area regarding road construction. On the other hand the sociological attitude of a rural society towards mass transportation of people will differ entirely from that of a densely populated industrial area. The authorities tasked with the identification of problems and research needs identification, have to ensure that a problem actually exists prior to expending any resources as explained in the previous chapter. The final aspect of control in the normal sequence of public administration functions can be interpreted as the phase that ensures that the research undertaken, as described, was directed towards and that the goals set, were achieved (22).

The handling of research project reports, their storage and dissemination request, had up to 1986 been handled by the Division for Road and Transport Technology of the Council for Scientific and Industrial Research on behalf of the main clients (roads authorities). It was then considered that the client should handle this function and it was decided to create a section within the Directorate: Research of the Department of Transport, to handle these administrative functions. The Council for Scientific and Industrial Research has been allowed to continue to publish research findings from those projects undertaken for the transportation authorities up to March 1990 as a transitional phase (22).

Two rather difficult issues that arose were those of ownership of interim research findings and the fact that, more often than not, research is undertaken with the object of obtaining further academic degrees by individuals. Academic institutions execute certain rights over work undertaken by post-graduate students and findings of research. This last issue was resolved and will be briefly described later (22).
6.2 Hierarchy and status of transportation research projects

In the early stages (1986) of the management of research and development by the Department of Transport, it was realised that a hierarchy of documentation had to be established. Such a hierarchy would set out a system for the approval, publication and extent of distribution of research findings, information and documents. Table 6-1 gives an explanation of the definitions used.

<table>
<thead>
<tr>
<th>Document Hierarchy</th>
<th>Document Type</th>
<th>Type of Approval</th>
<th>Responsibility for Publication</th>
<th>Distribution of Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLICY STATEMENTS</td>
<td>Official documents</td>
<td>Official approval by road authorities or South African Roads Board</td>
<td>South African Roads Board</td>
<td>General distribution through Department of Transport</td>
</tr>
<tr>
<td>STANDARD FOR PRACTICE</td>
<td>&quot;State of the Art&quot; documents</td>
<td>Technical approval through peer review. Approval for distribution by South African Roads Board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TECHNICAL RECOMMENDATIONS</td>
<td>&quot;Normal&quot; outputs from Research and Development Advisory Committee projects</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>GUIDELINE DOCUMENTS</td>
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<tr>
<td>SYNTHESIS REPORTS</td>
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<tr>
<td>RESEARCH REPORTS</td>
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<tr>
<td>PROJECT REPORTS</td>
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<tr>
<td>INTERIM REPORTS</td>
<td>Approval internal in Research Institutions</td>
<td>Research Institutions</td>
<td>Publication of titles available on request at Department of Transport</td>
<td></td>
</tr>
</tbody>
</table>

Table 6-1: Hierarchy and Status of Reports (37)

It was decided that interim reports would be required in respect of projects with a duration of more than one year, as a means of controlling progress for the year under review. This interim report is also used as a basis of payment to the researcher (22).
Progress reports do not have the same status as interim reports, because they only list activities performed without technical detail. Certain parts of projects, substantially completed, eg. literature surveys, could be considered as interim reports and, if warranted, receive the status of Research Reports (22).

Upon satisfactory completion of a research project and approval by the relevant panel the report is assigned the status of a Project Report. The financial responsibility of the researcher for the project is terminated upon acceptance and approval thereof by the Department of Transport (22).

The panel for the particular area of knowledge has a further responsibility and that is to decide whether the report warrants general distribution. They have to decide whether:

- the report should be subject to review by independent experts in the field, and
- who those experts should be (37:27).

The administrative details of the appointment of such expert(s) have to be attended to as well as arrangements for feedback and amendments to the report where required. The report will then be awarded the status of a Research Report. Reports are held by the Information Centre of the Department of Transport and synopses of approved reports are featured quarterly in the official Transportation Bulletin, published quarterly by the Department (22).

Research findings and reports have an input into the various publications, standards, specifications and policies of the Department of Transport. Research results, as accrued from a project per se, may have limited direct application in practice. It has been found that findings and information need to be formalised or synthesised for inclusion into the above-mentioned departmental documents. Examples of these documents are the following:

- Technical Recommendations for Highways
- Technical Methods for Highways
- Urban Transport Guidelines
- Various Synthesis Documents (37:28)
The Technical Recommendations for Highways series of documents give recommendations to practitioners on various phases of road construction eg. application of bituminous chip seals to road surfaces both as new construction and as maintenance operations. Other documents in the series deal with road foundation layer design, the construction of earth fills and large cuttings in rock for roads and geometric design (22).

In order to ensure quality control of materials handled in road construction, various test methods have been devised and are continually updated from research findings. These test methods and standards are approved by the Department of Transport in liaison with other roads authorities and then accepted as national standards (22).

The unique requirements for solving urban transportation problems indicated clearly separate needs from those normally encountered in rural roads and transportation. In order to assist urban transportation authorities, research findings and dissemination of applicable information were incorporated into a series of Urban Transportation Guidelines (22).

6.3 Implementation and dissemination of transportation research findings

Basic research with no immediate direct application is of little interest to practitioners and a single research report may have limited value to the practitioner in the field. However, if findings from a number of projects dedicated to a certain field are synthesised into a user orientated document, they could have a substantial synergetic influence on the industry.

A convenient forum for researchers to report on their findings is the presentation of technical papers at conferences. The Annual Transportation Convention has provided such a forum (since its inception in 1980) to researchers and practitioners to present and publish research projects funded by the Department of Transport and other authorities. Other conferences providing a forum of this nature include the Conference on Asphalt Pavements in Southern Africa and conferences of the South African Institution for Civil Engineers and the Southern Africa Road Federation (20).

The formal arrangements of improving coordination towards transportation research in South Africa have opened the possibilities to universities to create research institutions not only offering opportunities to graduate research in these fields but to ensure directed research of value (13).
6.4 Legal rights and obligations regarding research information.

Some legal aspects regarding ownership of research information and findings have been identified at an early stage of research and technology management by the Department of Transport. The most prominent of these are when a researcher submits research findings as a thesis for further studies at an educational institution. The dilemma that arises is that the research and its findings as funded by the Department are also claimed by the university as part of its tutorial arrangements with the student (22). Contractually, findings belong to the funding authority and mutual agreement is needed for arrangements to cover possible problems arising from the above. In order to ensure effective dissemination of research findings into practice a formal system is needed that "defines a hierarchy of documentation and spells out the associated responsibilities for approval, publication and extent of distribution (38:25).

In the dispensation prior to 1986 (Framework Autonomy of Research Institutions) no formal coordinated hierarchy of reporting of research projects existed except for reporting to steering committee meetings at the Council for Scientific and Industrial Research for projects undertaken. It was possible that overlapping research could be undertaken by researchers at different institutions for different clients. The coordination undertaken by the Department of Transport regarding appropriate research has addressed this problem with great success in ensuring that resources for road and transportation research have been put to optimal use. The hierarchy used for documents under the previous dispensation was expanded and formalised to ensure proper dissemination of research findings into guideline and policy documents used by road authorities (22).

6.5 Transportation research and development internationally

In order to have a meaningful perspective on the research effort of the South African transportation authorities, it would be of value to highlight some details of the management of transportation research and development internationally.

In comparing research management in Europe and the United States of America, the author had the opportunity during an official visit to Europe and the United States of America in 1990 to visit and discuss and compare research management with authorities in the field. It became clear that they are confronted by similar problems and challenges in the identification of transportation research needs, prioritisation, undertaking of projects and implementation
of results (43:38).

In the United Kingdom the management of research regarding science and engineering is a major undertaking managed by the Science and Engineering Research Council. (It was found during the above-mentioned overseas study tour) (43:46).

It was found that in the United Kingdom a well-established system is in existence under the Science and Engineering Research Council directing transportation research and development to the best advantage of their national economy. This was confirmed by information provided by the Transportation and Roads Research Laboratories in their approach to involve industry and foreign assistance in their research projects and dissemination of information on findings (43:38).

Along the same lines it was found that the growth in needs and appropriate fundings of transportation research in the United States of America has led to a total restructuring of their approach. This involved all institutions and authorities involved with research to coordinate their activities to the best interest of the end user and national economy (43:76).

In order to ensure international coordination to the advantage of South African researchers (individuals as well as authorities), it is of great importance to compare methods for control and management to those employed internationally (43:3).

6.5.1 Science and Engineering Research Council, Great Britain

The Science and Engineering Research Council is the institution that controls all scientific and engineering research in the United Kingdom, their main aims are as follows:

- to carry out research and development in science and technology;
- to encourage and support the above by other institutions;
- to provide equipment and facilities for universities and other institutions; and
- to make grants for post-graduate instruction in science and technology (43:46).

The Science and Engineering Research Council has an annual budget in excess of £350 million (1989) with some 28% directed towards engineering. It is interesting to note that a high premium is placed by this institution on the following aspects of proposed research projects:
Projects typically have a duration of one to three years (43:49).

It is clear that the Science and Engineering Research Council plays a role similar to that of the Foundation for Research and Development (formerly part of the CSIR) in the Republic of South Africa.

Its task is the co-ordination of all research and development in the United Kingdom but with particular efforts directed towards developing export potential in all spheres of technology (43:46).

The transfer of technology in the United Kingdom is further enhanced by so-called "repayment work" undertaken for the Transportation Research Laboratories, which includes:

- contract research
- consultancy
- joint projects with industry
- hire of facilities
- education and training courses (43:41).

The general conditions under which these projects are undertaken are as follows:

Projects undertaken with British industry on behalf of the Secretary of State for Transport, through the Director of the Transport and Road Research Laboratory are subject to contract but the following have been indicated to be the general principles applicable (43:42).

(i) Collaborative work with industry can be undertaken on any project that comes within the general responsibility of the Secretary of State for Transport.
(ii) The Transportation Research Laboratories will tender in the form of rates or of fixed price contracts depending on the nature of the work.

(iii) If several United Kingdom consortia are tendering for a project, the Transportation Research Laboratories reserves the right to be associated with more than one group at the tendering stage. Under those circumstances this institution undertakes to offer the same terms and considerations to each tendering consortium.

(iv) If an item of work is connected with a contractual or other dispute, the Transportation Research Laboratories will not place its services exclusively at the disposal of any one party. The text, investigation or assessment and any report thereon must be open to all parties in the dispute.

(v) Reporting of results will normally be by means of one of the Transportation Research Laboratories' standard reporting procedures (Research Reports or Working Papers). Other procedures will be considered if these are appropriate to the nature of a particular project.

(vi) The results will be owned by industry where industry has provided 50% or more of the funding for a project. The Secretary of State will be entitled to a royalty levied on sales of articles arising from the results of shared cost projects funded to 50%. The Secretary of State reserves the right after the termination of an agreed period to publish the results either in whole or in part if this has not already been done. It is not expected that this right will normally be exercised except where the results are deemed to be in the public interest.

(vii) If, during the progress of the work, discoveries concerned with and relating to the subject matter of the work are made by Crown Servants, the Secretary of State may, after consulting the manufacturer, but in his absolute discretion, secure the ownership of such discoveries by Patent, Registered Design or otherwise in Great Britain and Northern Ireland or elsewhere. The manufacturer shall be entitled to use the results so secured by Patent, Registered Design or otherwise in Great Britain and Northern Ireland, under a free non-exclusive, non-transferable licence (43:43).
6.5.2 Transportation research in the United States of America.

All publications of the Transportation Research Board in the United States of America, contain the following preface (40:2):

"The Transportation Research Board is a unit of the National Research Council, which is the principal working arm of the corporate institution that includes the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The Board's purpose is to bring scientific and technical knowledge to bear on transportation problems by encouraging and conducting research and disseminating information. The Board's program is carried out by some 300 committees, task forces, and panels composed of more than 3,500 administrators, engineers, social scientists, attorneys, educators, and other concerned with transportation, all serving without compensation. The program is supported by state transportation and highway departments, the Federal Highway Administration, the Urban Mass Transportation Administration, the Association of American Railroads, the National Asphalt Pavement Association, the U.S. Army Corps of Engineers, and other organizations and individuals interested in the development of transportation.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purpose of furthering knowledge and of advising the federal government. The Council operates in accordance with general policies determined by the Academy under the authority of its congressional charter of 1863, which established the Academy as a private, nonprofit, self-governing membership corporation. The Council is the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine. The National Academy of Sciences was established in 1863 by Act of Congress as a private, nonprofit, self-governing membership corporation for the furtherance of science and technology, required to advise the federal government upon request within its fields of competence. Under its corporate charter, the Academy established the National Academy of Engineering in 1964 and the Institute of Medicine in 1970" (40:2).

The Transportation Research Board is internationally accepted as a clearing house for all modes of transportation research. Its activities include publishing, a field visit program, information services, special studies and an Annual Meeting (24:1).
6-10

In a study undertaken by the Transportation Research Board in 1984 certain key elements for an acceptable research program were identified:

- Support of top management,
- Support of Research Clients,
- Communication,
- Management Competency,
- Staff Competency, and
- Funding. (24:1).

It has been found that the supporting elements of organisational structure and staffing to undertake successful research projects as well as aspects of needs identification, project selection and prioritisation, management, reporting, technology transfer and implementation as found with various transportation authorities in the United States of America have problems of a similar nature regarding the management of road and transportation as in the Republic of South Africa (43:76).

6.6 Summary

The importance of transportation and road research findings being disseminated into practice and new technologies, is vital. For this purpose an understanding is needed of the hierarchy of and status of South African research results as shown in Table 6-1. A short description of each of the documents in the hierarchy is given and some of its applications highlighted for instance aspects of design standards for highways, materials testing and guidelines for urban transport.

Mention is made in paragraph 6.3 regarding the various forums in South Africa where researchers can present their road and transportation research findings and test it in collaboration with practitioners in the relevant fields. Conferences with a substantial technical content reflecting the actual dissemination of road and transportation research findings have been a great success and widely attended by road and transportation practitioners.

No work undertaken under contract is free from contractual legal and associated problems. Some of these are mentioned in paragraph 6-4 highlighting the importance of appropriate arrangements for handling road and transportation research work during and after completion of such work.
During an official overseas study tour, the author had the opportunity to compare the management of road and transportation research in South Africa with that undertaken in two foreign countries having the greatest influence on arrangements in the Republic of South Africa.

Details of research management in the United Kingdom were investigated at the Science and Engineering Research Council. The main aims are directed to advance research and development in science and technology at appropriate institutions as well as providing grants towards post-graduate instruction and studies. The Council ensures dissemination of research findings into the national economy of Great Britain with arrangements towards patent rights of discoveries.

In the United States of America all road and transportation research is co-ordinated by the Transportation Research Board which is internationally accepted as a clearing house for all aspects of research. The Board confirms the importance of research being undertaken in support of all the activities of transportation authorities in the United States of America by proper identification, management, technology transfer and implementation of findings.
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This study was undertaken to illustrate and bring forward the approaches of institutions and authorities in their handling of transportation research. The local findings were compared very briefly to the work undertaken by some major undertakers of transportation research internationally, which confirmed the views of the author that current South African practice as put into operation in the five years, following framework autonomy of research institutions in this country, has been accepted and is operating satisfactorily.

7.2 Summary of content of study

This final chapter of the dissertation will give a short summary of the previous chapters. Conclusions to be drawn from the work as described, will be given, as well as some recommendations for the future handling of road and transportation research in South Africa.

The operation of transportation facilities and road infrastructure generally take place in a politically sensitive milieu. On the other hand, details of provision and costs of these facilities are usually handled by professionals and may be of a highly technical content but publicly accountable. In consequence, it is often difficult to provide reasonable explanations regarding the needs for research and development that can enhance facilities to the benefit of end users and the national economy as a whole.

In order to substantiate the need for the orderly management of road and transportation research in the Republic of South Africa, substantial background is provided in chapters 1 and 2 regarding the road infrastructure and associated technology. Research and development in South Africa has grown through a number of well-managed stages since the early 1950's with the establishment of the Bituminous Binder Unit which soon grew into the National Institute for Road Research by 1955.
It was soon clear that roads were only a facet of the total transportation infrastructure that had to be provided and maintained. Associated problems, unique to South African conditions had to be managed optimally by authorities and operators. This, as well as developments resulting from the framework autonomy of research institutions in 1985, led to a closer involvement of authorities providing funding for research, described in chapters 2 and 3.

The funding authorities being directly accountable for expenditure on research, had to create methodologies of financial control for work undertaken. Details of arrangements regarding funding of transportation research are provide in chapter 4.

Up to 1985, close ties existed between the Division for Road and Transport Technology of the Council for Scientific and Industrial Research and the major transportation and roads authorities. This facilitated the identification, evaluation and prioritisation of research needs.

In an environment of limited resources both financially and of professional proficiency, it is essential that research needs are selected with greatest care. Monitoring of projects approved have to be undertaken in a responsible way and against this background, systems were developed to suit South African needs. The four "Areas of Knowledge", as described in chapter 5, have to be kept in mind when monitoring research in road and transportation as this is a way to ensure dissemination of findings into practice.

Research findings can have a pronounced influence on the economic viability of projects undertaken in practice. If such findings are not disseminated to practitioners, the expenditure on research would have been ineffective and of no economic significance. A substantial list of documents have been published under the auspices of the Department of Transport disseminating research findings into guidelines and specifications for practical use. Chapter 6 provides an outline of what has been achieved to date in providing practitioners in the fields of roads and transportation with guideline documents as well as highlighting research findings at South African conferences specialising in these fields.

In order to have a balanced perspective of local achievements regarding the administration of research and development, in a South African context, it was necessary to compare local procedures to those established elsewhere. It was decided to highlight some aspects of road and transportation research with authorities that have been more readily accessible over the years, for example the United Kingdom and the United States of America. Certain details, as given in chapter 6, indicate that similarities exist.
7.3 Conclusions

The coordinating role of the Department of Transport in all transportation related matters in South Africa places the responsibility for identification of research needs on the officials involved. The growing needs of the South African transportation industry in a rapidly changing political environment, led to a decision by the Minister of Transport (at the time) to broaden the base for appropriate research in 1992. Using the concepts and experience since 1986 as researched in this dissertation a new transportation research approach was embarked upon.

From the researched details set forth in this dissertation, it is clear that the methods applied by South African transportation and roads authorities have resulted in a responsible and accountable means of administrating research and development. Principles applied here can be extended for use in associated and other fields of research and development - particularly details of prioritisation and monitoring of research projects.

The main reason for undertaking this research was, as stated in chapter 1, to meet the need for the proper management of road and transportation research following the framework of autonomy of research institutions in 1986. Details given in the dissertation outline and give particulars of how the Department of Transport created a feasible system for the handling of such research in responsible and accountable way. Furthermore, details as researched and presented in this dissertation, formed the framework for the identification of research needs, prioritisation there-of, and instituting control measures for use during research work being undertaken by researchers in the fields of roads and transportation. Completed research with indications of successful application into practice was shown to be of great importance and has to be structured to benefit practitioners.

Unfortunately the provision of appropriate road and transportation facilities are often taken for granted by the travelling public - not even considering the research of optimal design solutions. The funds spent on this public sector commitment are often questioned. With this in mind, when details of how research are undertaken and provided in a dissertation of this nature, it was considered of importance to give some details of roads and transportation
in South Africa regarding its development and as a science in its own right. To illustrate that these developments did not take place in isolation or out of step with international practice, some details of comparison (although briefly) were highlighted in the dissertation.

Details established during the period since 1986 for administration of research and development, have facilitated changes to the structure of control by the Department of Transport with the implementation of a Ministerial Committee in 1992 to undertake the tasks previously undertaken by the Research and Development Advisory Committee of the South African Roads Board. However, this approach was found to have many unforeseen problems and it was decided to resort back to the system as researched and detailed in this dissertation.

7.4 Recommendations

In line with the mission statement of the Department of Transport, it is committed to provide means and facilities for appropriate road and transportation research and development. In this way, effective execution of transportation projects will be ensured with the latest technology available to operators and providers of transport facilities. This must be undertaken to enhance the safety of all users of facilities to their best advantage as well as the national economy. Research into the fields of roads and transportation must therefore be undertaken to make the best possible use of public resources. In this dissertation a method has been researched and detailed for use by practitioners to identify, prioritise, manage and co-ordinate road and transportation research in the Republic of South Africa.

In order to meet the challenges of a new political dispensation in the Republic of South Africa methods described in this dissertation can be readily modified for use in other fields of endeavour. The new dispensation of more provinces, each with an own transportation authority, will increase the need towards greater coordination of road and transportation research. It is furthermore hoped that this foundation for an appropriate system especially suited to this part of the African continent, can fruitfully lend itself to be utilised in service of all sub Saharan countries and their transportation authorities.
OPSOMMING

Die verhandeling gee die agtergrond tot die behoefte vir die bestuur van pad- en vervoernavorsing in die Republiek van Suid-Afrika. Die noue samewerking tussen navorser en gebruiker van navorsingsbevindings in bogemelde velde en die toepassing daarvan in die praktyk, word beskryf.

Die voorskrif vir onafhanklikheidwording van navorsingsinstellings in 1986, het die behoefte na vore gebring vir 'n gestrukturierde benadering vir die bestuur van pad- en vervoernavorsing. Take, vantevore hoofsaaklik onderneem deur die Divisie vir Pad- en Vervoernavorsing van die Wetenskaplike en Nywerheids Navorsingsraad, moes deur die Departement van Vervoer oorgeneem word. 'n Oorgangstyd van 5 jaar is gegee (vanaf 1987 tot 1992) om 'n grondig geskikte wetenskaplik aanvaarbare stelsel in werking te stel.

Besonderhede vir koördinering en formalisering van behoeftebepaling, prioritisering, toekenning, befondsing en beheer van pad- en vervoernavorsing word gegee.

SLEUTELWOORDE

Beheer van pad- en vervoernavorsing
Bepaling, privatisering, toekenning, befondsing
Bestuur
Departement van Vervoer
Formalisering van behoeftes
Kommersialisering en privatisering
Onafhanklikheid van navorsingsinstellings
Pad- en vervoernavorsing
Suid-Afrikaanse pad- en vervoerinfrastruktuur
Suid-Afrikaanse pad- en vervoerowerhede
REFERENCES


National Roads Act, 1935 (Act 42 of 1935)
National Transport (Co-ordination) Act, 1948 (Act 44 of 1948)
National Roads Act, 1971 (Act 54 of 1971)
Urban Transport Act, 1977 (Act 78 of 1977)


ADDENDUM
THE EVALUATION OF PROJECT PROPOSALS

DETAILS OF THE CALCULATION OF THE PRIORITY NUMBERS OF PROJECT PROPOSALS

1. Calculation of priority values

The process starts with the calculation of a priority value, PV for every project proposal:

\[
PV = \frac{\text{Benefits}}{\text{Relative cost}}
\]

The benefits are calculated as follows:

\[
\text{Benefits} = [\text{Worth} \times F_s \times F_5 \times F_i] \times [p_i] \times [p'_s \times F_p \times F_l]
\]

Where:

- \([\text{Worth} \times F_s \times F_5 \times F_i]\) = worth of the implemented end product
- \([p_i]\) = probability of implementation

and

- \([p'_s \times F_p \times F_l]\) = probability of the research being successful

The various factors are determined from Figures 1 to 9 as discussed in the following paragraphs. The relationships shown on these figures have been converted to vectors and matrices to enable the calculations to be done on a computer.

The relative cost is calculated as follows:

\[
\text{Relative cost} = e^x
\]

Where:

- \(e\) = base of Napierian logarithms = 2.7183
- \(x = \frac{\text{cost}}{500 \, 000}\)

with: cost = three year total cost discounted at 15% to 1991
The power of e approach has been adopted after an analysis of the discriminatory power of various approaches. The e approach has the advantage that cheap projects will not be accepted only because they are cheap. To be accepted they would have to have acceptable benefits.

2. Worth of the implemented end product

The worth of the implemented end product of the research is taken to be the intrinsic "worth" multiplied by a factor $F_a$ to allow for the relevance of proposals made towards CIN projects, a further factor $F_s$ allowing for the scale of application, and a final factor $F_i$ allowing for the impact of the end product on practice.

![Graph showing determination of worth from relative worth rating](image)

Figure 1: Determination of worth from relative worth rating

Figure 1 shows the relationship used to determine the "worth" of a proposal given the rating of the panel on the relative worth scale. A value of 100 was selected to present the rating value of 7 with a value of 50 being the average value (at a rating value of 4). The third point on the graph was taken as zero worth on a rating of 2 of smaller. This was done so as to be sure that projects with low intrinsic values will not be undertaken.
RATING ON APPROPRIATENESS OF PROPOSAL

Figure 2: Determination of $F_s$ from rating on appropriateness of proposal

In the case of proposals towards Client Identified Needs (CIN) projects it is necessary to take the appropriateness of the particular proposal into account. This is done by means of the $F_s$ factor as is shown in Figure 2. Should the proposal address the CIN extremely well, the factor is taken as 1,00. Should the proposal address the CIN well, the factor is taken as 0,75 and should the proposal not address the CIN well at all, the factor is taken as 0,10. Straight line relationships are assumed between these values.

Figure 3: Determination of $F_s$ from rating on scale of application
Figure 3 shows the relationship assumed to determine the value of $F_i$ from the rating on the "scale of application" question. The departure point here was that an average rating (equal to 4) would indicate a standard scale of application with $F_i = 1$. At the extreme scale ratings, values of $F_i$ equal to 0.2 and 1.5 were used. These points are connected by a straight line relationship below a rating of 4 and a slightly S-shaped curve for ratings above 4 so as to provide relatively more weight than a straight line relationship would have awarded.

![Graph showing relationship between $F_i$ and rating on impact of application](image)

Figure 4: Determination of $F_i$ from rating on impact of application

Figure 4 shows the way in which the $F_i$ factor is determined from the rating on the "impact of application" scale. A value of $F_i = 1.0$ was taken to be the value at the average score (i.e., equal to 4). Also, as for the previous factor, a value of $F_i = 1.5$ was taken at the maximum rating. At the minimum rating of 1, indicating no impact, the value of $F_i$ was taken to be 0.2.
3. Probability of implementation

Figure 5: Contours of $P_i$

Figure 5 shows how the value of the probability of implementation was derived. The graph is a two dimensional diagram, one dimension being the rating on the resistance to implementation scale, the other being the urgency with which the results are awaited by practising engineers. As a departure point it was argued that, if project results are very urgently awaited, and if there would be low resistance to implementation, the probability of implementation, $p$, should be 1.00. On the other hand if the project results are not urgent at all, and the resistance to implementation is very high, the probability of implementation would be very low, say 0.10. Arguing further that at equal ratings on both scales, the probability of implementation would be 0.50, the rest of the graph follows by interpolation.

4. Probability of the research being successful

The probability of the research being successful is taken as the product of the intrinsic probability of success, multiplied by two factors, the first being a factor which takes into account the past performance of the organisation, the other taking the suitability of the infrastructure of the proposing organisation into account.
Figure 6 shows contours of the intrinsic probability of success on a two dimensional graph. The one dimension is the ability of the project leader, and the other is the difficulty of the project. If the project leader is of the highest ability and the project is easy, the intrinsic probability of success, \( P_s \), is taken to be 1.00. On the other hand, if the ability of the project leader is low, and the project most difficult, the probability of success would be very low, say 0.10. A further point was established at the average scale rating of 4 on both dimensions, the probability of success there being taken as 0.75, this probability being the best estimate of successful performance of researchers under average conditions.

The considered opinion was that the two dimensions were of about equal importance, this then implying that the contours are concentric around the 1.00 value at the point where the project is easy and being undertaken by a researcher of very high ability.
Figure 7: Determination of $F_p$

Figure 7 shows the relationship between the factor relating to past performance by the organisation, $F_p$, and the rating on that particular scale. It was argued that should an organisation have a very good track record in research, this would mean that there is no need to reduce the probability of success, and that $F_p$ would be equal to 1,00. On the other hand, an organisation having a bad record in research should be penalised and a value of $F_p = 0,20$ at the other end of the scale was assumed. At a rating of 4, indicating average performance a value of 0,75 was considered to be more realistic than a straight line relationship would have provided.

Figure 8: Determination of $F_I$
Figure 8 shows how the factor relating the effect of adequacy of research infrastructure $F_t$, is taken into account. Should the infrastructure regarding special equipment be extremely suitable, there is no need to reduce the probability of success, and $F_t = 1.00$. On the other hand if the infrastructure is not at all suitable, the probability of success would be very low, and $F_t$ is taken as 0.10. In cases where the rating is 4, indicating adequate infrastructure, a value slightly higher than a straight line between the two extremes would suggest is more reasonable, and a value of $F_t = 0.65$ was assumed.

5. Calculation of priority numbers

Once the priority values have been calculated for all project proposals, the projects are divided into two groups, firstly those proposals addressing Client Identified Needs (CIN) projects and, secondly, proposals addressing needs identified by the research organisation.

For proposals addressing CIN projects the proposals are sorted, by CIN project number, in descending order of priority value. The proposal with the highest priority value addressing, say CIN002 is then awarded a priority number of CIN002-001. The next best proposal would be CIN002-002 and so on.

Within the group containing researcher identified proposals, the proposals are sorted, by knowledge area, in descending order of priority value. The project proposal with the highest priority value in say, knowledge area B, is then awarded a priority number of B01. The next best is B02 and so on, for all the project proposals in all the knowledge areas.

The above approach was followed rather than a normalisation process which would have resulted in percentages between 0 and 100, for the following reasons:

i. A normalisation procedure implies the following very important assumptions:

  o The median (50 percentile) project in every knowledge area is equal in value to the median (50 percentile) project of every other knowledge area.

  o The spread of scores, from high to low, as awarded by all the panels, is about equal.
No justification for any of these two assumptions could be found, on the contrary:

- As the number of proposals by knowledge area represent a view by the proposers of research projects, as to where the need as well as the funds may be present, it is clear that the median projects in different knowledge areas are unlikely to be equal in value.

- From the average ratings awarded by the various panels, and the spread of these ratings, it was very clear that the average and the spread varied considerably between panels.

It is, therefore, clear that the assumptions underlying a normalisation process cannot be substantiated.

ii. The calculation of a percentage rating could lead to comparisons of projects across the boundaries of the various knowledge areas. Disputes, such as say concerning the acceptance of a proposal rated at 60% in knowledge area A, whereas, a proposal rated at 70% in knowledge area B is rejected, are thus a distinct possibility.

iii. The concept of knowledge areas, each with its own panel, and each with its own basket of funds is seen as of critical importance. This approach precludes the calculation of percentage priority ratings.

iv. The calculation of priority numbers, such as proposed, having the form A01, A02, etc, is seen as suitable in deciding which projects should be awarded, while it, at the same time, precludes unwarranted comparisons between knowledge areas.