Funding Characteristics of Transport Research in Australia

Report

The Report is the result of a study of the sources, levels and methods of funding transport research and developmentí (R&D) in Australia, and an investigation of matters pertaining to the effectiveness and efficiency of the transport R&D carried out.

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ISBN 0 644 01959

Printed by Watson Ferguson and Co., Brisbane

FOREWORD

At the June 1981 meeting of the Co-ordinating and General (C&G) Transport Group of the Australian Transport Advisory Council, it was agreed that the Bureau of Transport Economics (BTE) should be asked to carry out an investigation into funding arrangements and levels relating to transport research. On 24 September 1981 the Minister for Transport directed the BTE to carry out such a study in accordance with defined Terms of Reference.

This report presents the results of this study.

In carrying out this study the BTE contacted major State government organisations associated with transport research. Information on the research funding levels of these organisations was requested together with limited information on the nature of the research carried out. The BTE gratefully acknowledges the co-operation of these organisations; the information obtained assisted greatly in developing a comprehensive overview of transport research funding.

In addition, the BTE acknowledges the assistance obtained from officers involved with Project SCORE at the Department of Science and Technology.

This study was carried out in the Bureau's Systems and Information Branch under the general direction of Mr J.W. Moll. All staff of the Information Analysis section contributed to the study (supervised by its Officer-in-Charge, Ms S.M. Gunner). The principal component of the research was carried out by Mr N.R.F. Perry assisted by Mr N. Wuest. Mr Perry was also largely responsible for the preparation of this final report.

G.K.R. Reid
Director

Bureau of Transport Economics
Canberra
March 1982

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SUMMARY

The funding characteristics of transport research have been formally examined only once when the Australian Science and Technology Council (ASTEC) carried out its review of science and technology in Australia for 1977-78. At that time it was noted that the definition of research and development (R&D) employed for the review was comparatively restrictive, omitting coverage of considerable areas of activity which are generally regarded as being included within the scope of transport research. In describing the transport research sector as part of the overall ASTEC review, the Bureau of Transport Economics (BTE) of necessity also adopted the standard definition of R&D. One effect of this was that of the total $12m expenditure on transport research activities approved under the Transport Planning and Research (TP&R) Program in 1976-77, activities coming within the scope of the definition of R&D accounted for only some $4m. Clearly, a substantial proportion of the activities generally considered to be transport research was excluded from the ASTEC review as a consequence of the definitions employed.

In the current study, a considerable amount of attention was given to the adoption of a definition of 'transport research' which would be more representative of the types of activities generally considered to fall within the scope of this term. This resulted in transport research being defined as the R&D activities covered previously by ASTEC, together with various R&D-related activities not included in that definition, but relevant in the overall context of transport research.

In framing the definition of transport research, attention had to be given to the definitions adopted by other agencies reporting statistical information relating to research funding in Australia. This study relies to a large extent on these sources of information, and a high degree of compatibility between the definitions used in this study and those used by these other agencies was essential.

An examination of funding arrangements relating to transport research was carried out for agencies in each of the sectors:

- Commonwealth Government;
- State Government;
- joint Commonwealth/State agencies;
- business enterprises; and
- higher education.

It was found that the flow of transport research funds within and across these sectors is comparatively complex. Tracing these flows in detail in terms of balancing funding levels and expenditure levels is limited by the information available. The study highlights the disparate sources of funding information, many of which tend to consider research finance information only in terms of either the allocation of funds, or in terms of expenditure. As a result, the actual flows of funds from source to final recipient become somewhat confused, and their identification difficult.

The study highlights three programs under which funds for transport research have been distributed from the Commonwealth to the other sectors. The programs are:

- the National Energy Research, Development and Demonstration (NERDD) Program;

- the Industrial Research and Development (IR&D) Grants scheme; and
- the Transport Research and Planning (TP&R) Program (which has been terminated as from 30 June 1981).

From available information it was estimated that between $2m and $3m was funded by the Commonwealth under the NERDD Program in 1980-81 for energy research considered to be closely related to transport. This does not include a further $4m used to fund synthetic fuel technology research under the NERDD Program in that year[1].

Under the IR&D Grants scheme, over $1m was funded in 1979-80 for research classified as belonging to the field of transport.

The Commonwealth funded transport research projects approved under the TP&R Program to a level of $6m in 1980-81 on a matching dollar-for-dollar basis with State governments. A detailed analysis of the projects approved under this Program since 1975 has been carried out in this study. This analysis has included an examination of the nature of the projects approved for funding under the TP&R Program, and illustrates the increased emphasis on 'rail' and 'other transport' following the amendments to the Program initiated with new legislation in 1977. That component of Commonwealth funding of the Australian Road Research Board (ARRB) and the Australian Railway Research and Development Organisation (ARRDO), which previously occurred indirectly under the TP&R Program, has been replaced by direct allocations to these organisations in 1981-82.

The study also includes a review of the problems associated with assessing efficiency and effectiveness of transport research. Financial and other details of projects approved under the TP&R Program are analysed to illustrate certain measures which are commonly held to reflect research effectiveness and efficiency. The study concludes, however, that measures capable of being quantified are unfortunately not very satisfactory in assessing transport research in the broad. On the available evidence (based on average report costs), there is some indication that the later years of the TP&R Program produced some increase in the general efficiency of the transport research undertaken.

In aggregate terms, the study found that total expenditure on all forms of transport research in Australia exceeded $81m in 1980-81 including an estimate of between $2m and $3m on research by port and marine authorities. An additional amount of almost $4m was spent on synthetic fuels research. Slightly over $31m of this total can be attributed to Commonwealth funding of its own transport research activities, its funding of other transport research through the various schemes described above, and its direct funding of other research institutions. It was estimated that some $25m was spent in 1980-81 by the States from their own resources. The most recent information on the private enterprise sector relates to 1978-79 and covers R&D activities only.

In that year, it was estimated that private enterprise funded transport research to a level of some $21m, which includes between $2m and $3m for R&D in the context of conservation of energy associated with transport. National public enterprises involved in transport operations were estimated to have spent some $2m on transport research from their own resources. Comparison with a selected number of developed countries overseas indicates that Australia is spending at least a similar proportion of its total government research funds in the transport field as these other countries, and may be spending a considerably higher proportion.

In conclusion, there is evidence from this study that transport research is perceived by the States to be sufficiently important to warrant continuing financial support. Real levels of expenditure have been maintained despite some reduction in the real level of Commonwealth contributions to the States under the TP&R Program. There is also an

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1. This amount decreased from an estimated $5m in 1979-80 indicating a degree of variability in annual funds made available to this category under the NERDD Program.

indication that funds have been directed towards those areas of transport research excluded in the original TP&R Program, but covered in the revised TP&R legislation enacted in 1977. Although the study has indicated that the States tended to replace reduced Commonwealth funding (in real terms) under the TP&R Program by their own funds, it is not yet clear whether the same degree of substitution of funding will take place following the termination of the TP&R Program.

CHAPTER 1—INTRODUCTION

This report on transport research and development (R&D) in Australia was prepared by the Bureau of Transport Economics (BTE) in response to a directive from the Minister for Transport. The directive followed the endorsement by the Australian Transport Advisory Council (ATAC) of a suggestion by their Advisers that the BTE should investigate funding levels and arrangements for transport R&D. The Minister directed the BTE to carry out the study in the following terms:

> The BTE will undertake a study of the sources, levels and methods of funding transport research and development[1] (R&D) in Australia, and will investigate matters pertaining to the effectiveness and efficiency of the transport R&D carried out.
>
> The study will encompass all modes of transport and will be designed specifically to:
>
> - identify the available sources of funding of transport research and development (R&D) within the government and private sectors in Australia, having regard to alterations to the arrangements for public sector funding which have occurred in the last few years and to the various forms of organisations operating in both sectors;
> - estimate the historical levels of funding of transport R&D from the identified sources, and distinguish where possible between R&D funds used in support of direct commercial ventures and those used to benefit general transport administration;
> - examine the methods of providing R&D funds in the public sector, and assess their impact on the research programs;
> - examine, classify and report on the distribution of types of transport R&D projects undertaken in Australia, and determine the extent to which this distribution has been affected by changed funding levels and arrangements for funding; and
> - review techniques for assessing the effectiveness of transport R&D and, as appropriate, apply these techniques in the Australian context.
>
> The BTE may examine any other matter which it believes relevant to this study.
>
> A draft report will be prepared for consideration by the ATAC Coordinating and General Transport Group at its meeting in December 1981. This report will also be made available to MPCA Advisers for their subsequent consideration.

The remainder of this chapter sets out definitions characterising the nature of R&D considered in this report, and summarises the background to the study, including relevant work carried out previously.

DEFINITIONS

The determination of appropriate definitions characterising R&D is a central issue in this study. There are considerable advantages in adopting generally accepted definitions as far as possible. These advantages relate to considerations of compatibility with other related studies both within Australia and internationally, comparability across different sectors of the economy, and (not insignificantly) the relative ease of obtaining information from published sources which use standard classifications of activities. However, as will be shown, the standard definition of R&D generally used in previous Australian studies was not sufficiently comprehensive for characterising the activities in the transport sector, which are the subject of this report.

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1. Research and development in this context includes some topics such as scientific and technical data collection which are not included in the OECD definition of research and development.

A standard definition of R&D is provided by the Organisation for Economic Co-operation and Development (OECD). This is used by the Department of Science and Technology (DST) (formally the Department of Science and the Environment (DSE)) for Project SCORE (Survey and Comparisons of Research Expenditures) which measures the financial and manpower resources devoted to Australian research and experimental development. The following definition for R&D and a brief explanation of the definition are taken from the Project SCORE report for the year 1976-77 (DSE 1980).

> Research and experimental development comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications.
>
> The OECD definition conveys the notion that R&D activities are to be identified by an appreciable element of novelty, combined with a potential to produce results that are sufficiently general for the stock of knowledge (theoretical and/or practical) to be recognisably increased. Novel or innovative work likely to be of interest to more than one organisation, or to identifiable parts of society, or to society as a whole, is regarded as R&D. However, the concept of novelty is to be associated with the knowledge of 'how' (How does it work? How can this kind of thing be made?) rather than with the actual creation of something which, although new, is made by artistry or by application of techniques that have already been established for that class of object.

The Australian Science and Technology Council (ASTEC) in their report on science and technology in Australia for the fiscal year 1977-78 (ASTEC 1979) made the point that their use of the standard definition of R&D in the transport sector limited their consideration to only part of the total effort in those activities which are commonly held to be transport research.

In deciding which activities should be covered in the current study, an attempt has been made to combine the advantages of using the standard definition of R&D (as described above) with an approach which overcomes the limitations noted by ASTEC.

The Department of Science and Technology surveys Commonwealth Government agencies in order to compile the Science and Technology Statements. Information is collected in two categories: R&D, and science and technology activities (other than R&D). Activities that are in the latter category are listed on the Science and Technology Statement data collection forms. These include activities which are generally considered to be research in the transport sector but excluded under the standard definition of R&D used for Project SCORE.

The 1980-81 Science and Technology Statement reported science and technology activities undertaken in the financial years 1978-79 and 1979-80 and estimated activities in 1980-81 (DST 1981). The Science and Technology Statement which refers to science and technology activities undertaken in 1980-81 and the projected activities for 1981-82 is in preparation. Discussions were held with representatives from the Department of Transport Australia (DoTA), the Australian Bureau of Statistics (ABS) and DST regarding appropriate definitions for this study. To minimise confusion and to allow for a comprehensive coverage of the transport research field, it was decided that the term 'research and development' should be used to refer to those activities included under the Project SCORE definition of R&D, and that the term 'R&D-related activities' should be used to cover the other science and technology activities which are included in this study[1] but which are excluded by the Project SCORE definition.

The 'R&D-related activities' selected from the science and technology activities defined in Appendix I are as follows:

- demonstration of both technical and commercial viability;

---

1. The complete definition of the term 'science and technology activities' and the items included within its scope are given in Appendix I. In the context of the present study it was concluded that not all of these items were closely related to research and development activities in the transport sector. Hence only a selection of these items has been included in the R&D-related activities considered in this study.

- advanced scientific or engineering consulting services;
- policy-related studies using advanced techniques;
- testing, standardisation, metrology and quality control;
- data collection; and
- scientific and technological information and documentation.

These activities represent those which are considered to be relevant in terms of their association with the general scope of transport research.

In summary, the term 'R&D and related activities' refers to the total effort in transport research (in the more general sense), and information presented in this report under the heading 'R&D' may be used for comparative purposes with other studies that use the Project SCORE (that is, the OECD) definition of R&D. The generic term 'transport research' will be used in this report to refer to the totality of transport R&D and related activities.

BACKGROUND

This section contains an account of the sequence of events leading up to the initiation of the current study, and as such provides a contextual background for the study.

In 1977 the BTE was requested by ASTEC to prepare a report on R&D in the transport sector in Australia, as part of ASTEC's investigation into the state of science and technology in Australia.

This report (BTE 1978) was limited by the requirement to comply with the Project SCORE definition of research, with the effect that many activities generally considered to be transport research were excluded. The effect of this restriction was considerable. For example, in the financial year 1976-77, a combined total of $12.0 million was contributed under the *Transport (Planning and Research) Act* 1974 by the States and Commonwealth, although only some $4.3 million could be attributed to R&D falling within the SCORE criteria. Of this latter amount, $2.2 million was a direct contribution to the Australian Road Research Board, leaving an expenditure on R&D within the various State authorities, under the Act, of approximately $2.1 million.

ASTEC report

In the transport section of the ASTEC report, for the year 1977-78, (ASTEC 1979) it was stated that the Project SCORE definitions were observed in order to ensure compatibility with the other parts of the report. However, it was acknowledged that many major problems in transport involve economic and other matters towards which a great deal of research effort is directed, and that this effort was, by definition, not included in the ASTEC considerations. The emphasis in the transport section of the ASTEC report was on R&D in transport hardware, which represents only part of the total effort in transport R&D.

Three major issues were considered in the transport section of the ASTEC report: the state of R&D in transport, information exchange, and funding. The report produced two recommendations in this area; one related to the pre-accident phase of road safety, and the other was 'That the Australian Transport Advisory Council be invited to review methods of providing funds for R&D in transport, including the funding of external transport research by bodies such as the Australian Road Research Board.'

BTE study

At their meeting in February 1981, ATAC Ministers reviewed the ASTEC recommendations and agreed that their advisers should examine and identify possible changes to current arrangements for funding land transport, research planning and demonstration. Advisers decided that the BTE should be asked to identify the sources

and levels of funding of transport R&D, identify arrangements under which assistance is provided by the public and private sectors, and make a preliminary assessment of work in hand. This recommendation was endorsed at the July 1981 meeting of ATAC. The Marine and Ports Council of Australia (MPCA) considered a paper from the Commonwealth Minister for Transport in May 1981 which referred to the ASTEC recommendation. The MPCA asked its Advisers to examine the implications and value of a review of aspects of R&D funding in the sea transport area. It was subsequently agreed that these aspects be included in the BTE study.

SOURCES OF DATA

This study required information relating to the expenditures of public and private sector organisations on transport R&D and related activities, separated into these two categories and categorised by broad program objectives. In addition, information concerning the arrangements under which these general activities were funded was sought.

The availability of expenditure data relating to transport research (that is, R&D and related activities) varied quite widely over the different sectors (Commonwealth, State, business enterprises and higher education). In addition to the coverage of the Australian situation relating to transport research, a limited examination has also been made of the international situation in this regard. The aim of this examination is to provide a rough comparison of the Australian situation with related overseas practices.

Commonwealth sector

As noted above, DST surveys the Commonwealth sector and prepares an annual Science and Technology Statement, which provides expenditures on both R&D and related activities for this sector. Unfortunately the degree of aggregation in the 1980-81 statement precluded a detailed analysis of expenditure on transport research particularly for Departments other than DoTA. The first DST survey related to the financial year 1979-80 so that, at this stage, it is not possible to analyse trends in expenditure across the sector as a whole.

State sector

There are a large number of State government agencies conducting transport research. Information on their R&D expenditure may be obtained from Project SCORE, but in the area of 'R&D-related activities', which is generally much larger in both project numbers and financial expenditures, very little information is available in published form. The co-operation of these agencies was requested in the provision of expenditure data on their overall transport research efforts. The progress reports of the Transport Planning and Research (TP&R) Program (DoTA 1982 and earlier issues) were a useful data source, amenable to a fairly detailed analysis of the States' transport research commitments that were approved for funding under this Program.

Business enterprises

The R&D component of transport research undertaken by private enterprises is reported by Project SCORE. Unfortunately this information is classified by the Australian Standard Industrial Classification (ASIC) code, whereas public sector expenditures are reported by (so-called) socio-economic objective[1]. As there is no direct correspondence between the sets of categories (that is, the ASIC and socio-economic objectives), comparisons across public and private sectors were difficult to establish. This was particularly the case in the area of transport services. Expenditure information on the 'R&D-related activities' component in the private sector was not available. Some indication of the direction of the private enterprise research effort in the transport sector was obtained from information held by the Patents Office.

1. 'Socio-economic objective' is a term used by Project SCORE for categories of research. This term (or its contraction 'Objective') has been maintained where these categories are referred to in this report.

Higher education sector

In the higher education sector it appears that transport research funded intramurally or from special grants is predominantly confined to R&D, and hence is reported in Project SCORE.

It is understood that effort expended by this sector on 'R&D-related activities' is most likely to be funded by public organisations on a consultancy basis. Hence this particular component will be included in the coverage of public sector funding and expenditure on transport research.

Overseas sources

Various publications from the OECD were used to place Australian transport research in an international context. Unfortunately this information refers only to R&D (and not to its related activities) and is not up-to-date. However, it does provide some framework for comparison.

REPORT STRUCTURE

The following chapter (Chapter 2) contains an account of funding sources and arrangements for transport research in Australia. The Commonwealth, State, higher education and business enterprise sectors are included. This provides a framework in which to view the funding levels and expenditure objectives, and the changes that have occurred over recent years. Information on the funding levels and their categorisation is presented in Chapter 3.

Questions of effectiveness and efficiency of transport research carried out in Australia are explored in Chapter 4 and applied to an analysis of the detailed information available in the records of the TP&R Program.

Within the limitations imposed by data availability, the Australian transport R&D effort is given an international perspective in Chapter 5. An account is given of some of the funding arrangements employed by a number of overseas countries.

Chapter 6 concludes the report by highlighting major results and summarising the issues that emerged from the study.

CHAPTER 2—FUNDING SOURCES AND ARRANGEMENTS

This chapter discusses the major sources and flows of funds for transport research in Australia. The various programs and arrangements under which these transport projects have been funded since 1973-74 are outlined together with any alterations in funding arrangements which have occurred.

COMMONWEALTH AGENCIES

Information obtained for the 1980-81 Science and Technology Statement (DST 1981) indicates that seven Commonwealth Government agencies provided funds for transport research during the period 1 July 1978 to 30 June 1981. However, for the Science and Technology Statement, expenditure on R&D (the OECD definition) was allocated to categories (for example, transport) according to the major purpose for which the expenditure was undertaken. Therefore, transport R&D expenditure was not identified in those situations where transport was not the major purpose for which the expenditure was incurred. In addition, expenditure on R&D-related activities was not allocated to socio-economic objectives for the Science and Technology Statement. Hence, in addition to the Science and Technology Statements, other sources were consulted for funding details of transport research carried out by or on behalf of Commonwealth agencies. Table 2.1 represents a list of these agencies compiled from the information available. The following paragraphs discuss briefly each of these agencies in turn, in alphabetical order.

Australian Bureau of Statistics (ABS)

The ABS provides statistical services for the government and private sectors by collecting, compiling, analysing and disseminating social, demographic and economic statistics and related information. The Transport Sub-section of the ABS undertakes these activities in relation to transport statistics. The budget allocation for the Transport Sub-section can therefore be considered as transport R&D or R&D-related activities expenditure depending on the nature of the activity undertaken. Other areas such as the Overseas Trade Section also are involved in transport-related statistical activities.

TABLE 2.1—MAJOR COMMONWEALTH AGENCIES INVOLVED IN FUNDING OR PERFORMING TRANSPORT RESEARCH

Australian Bureau of Statistics
Australian Industrial Research and Development Inventives Board
Bureau of Transport Economics[a]
Commonwealth Scientific and Industrial Research Organisation
Department of the Capital Territory
Department of Defence
Department of Foreign Affairs
Department of Housing and Construction
Department of Industry and Commerce
Department of National Development and Energy
Department of Science and Technology
Department of Transport Australia
National Capital Development Commission
Reserve Bank of Australia

a. Although attached to DoTA, the BTE has been identified separately in this study in view of its specific role as a transport research organisation.

Australian Industrial Research and Development Incentives Board (AIRDIB)

The Australian Industrial Research and Development Incentives Board (AIRDIB) administers the *Industrial Research and Development Incentives Act* 1976 and its predecessor, the *Industrial Research and Development Grants Act* 1967, under which 1975-76 was the last year for which grants were payable. The object of the 1976 Act is to promote the development and improve the efficiency of Australian industry by encouraging industrial research and development[1] in Australia in matters relating to science and technology.

The IR&D Incentives Act came into operation on 1 July 1976 and achieves its objectives primarily through the provision to manufacturing and mining companies of two types of grants, commencement grants and project grants. Commencement grants are intended to encourage companies whose IR&D activities are either non-existent or incipient, to establish or develop a basic capability in industrial research and development. Project grants aim to assist and encourage companies with established research and development facilities to undertake major projects of IR&D. The Act also empowers the Minister for Science and Technology to authorise AIRDIB to make contractual arrangements for the carrying out of industrial research projects which are deemed to be in the public interest.

The secrecy provisions of the Act require that information acquired by AIRDIB concerning the IR&D or other affairs of a company be treated as confidential. However, the Board is able to indicate its total grant commitments for projects classified according to the International Patent Classification System. Several of the categories in this system are transport or transport-related, and grants made for projects in these categories have been included in the expenditure figures contained in Chapter 3 of this report.

Bureau of Transport Economics (BTE)

The present BTE was established on 30 June 1977 following the amalgamation of the Commonwealth Bureau of Roads which had been operating since 1967, with the former BTE which was established in 1971.

The BTE is a professional research body, attached to DoTA, which undertakes independent studies and investigations, over the whole field of transport, to assist the Commonwealth Government in the formulation of transport policy. All of the work of the BTE can be classified as transport research. The BTE is funded entirely by the Commonwealth Government and a small portion of the BTE budget may be allocated to private consultants or universities to assist in the BTE's program of research work.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

The CSIRO is a statutory body created to carry out, on behalf of the Commonwealth, a wide range of research. Although none of the CSIRO Divisions is specifically oriented to transport research, individual projects within many of the Divisions could be covered by the general definition of transport research established previously. For this study the research program of CSIRO was analysed, and expenditure on transport-related projects was estimated by the BTE.

The CSIRO is financed, in the main, by a specific Government vote, although funds are also obtained through grants from the National Energy Research, Development and Demonstration Council (NERDDC), from levies collected from the coal industry under the Coal Levy Research Act, from statutory levies on rural produce and directly from private industry for work undertaken specifically to assist industry.

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1. The definition of IR&D is given in Appendix I.

Department of the Capital Territory (DCT)

The DCT is responsible for the management and administration of the Australian Capital Territory (ACT) and the Jervis Bay Territory. DCT responsibilities include the operation and development of the public transportation system, traffic control systems and the road network within the ACT. Most of the transport research carried out by the DCT is performed in-house. However, the National Capital Development Commission, the Department of Housing and Construction and private consultants are contracted on occasion for studies which cannot be undertaken internally.

Department of Defence

The work of the Department of Defence in the area of transport research is oriented to the needs of the Australian defence force and defence industry.

The bulk of the research performed by the Department of Defence is carried out by its own Defence Science and Technology Organisation (DSTO). DSTO has had a policy of contracting to industry, wherever possible, development work on projects likely to lead to volume production. Research contracts are also placed with tertiary education institutions on occasion.

Department of Foreign Affairs

The Department of Foreign Affairs contributes funds to research and development and related activities through various programs involving agreements with other countries. Australia's development assistance program has, over the past few years, given increasing priority to science and technology projects in Third World countries. Because transport is an essential component in the development of any economy, some of the funds provided by the Department of Foreign Affairs inevitably are allocated to transport research.

Department of Housing and Construction (DHC)

The involvement of DHC in transport research is mainly effected through its contribution to the funding of the Australian Road Research Board (ARRB). Historically, DHC has contributed some 10 per cent of ARRB's budget. Further details of recent ARRB funding arrangements are provided later in this chapter. The DHC also undertakes transport research (primarily related to road technology) for the Department of the Capital Territory and the National Capital Development Commission.

Department of Industry and Commerce (DIC)

The Ship Design Group of the DIC has, in the past, undertaken scientific and technological activity to meet the requirements of the marine industry, primarily with regard to ship design. This program has now been terminated in compliance with a recommendation arising from the Review of Commonwealth functions.

The Government Aircraft Factories (GAF) are involved in the design, development and production of aircraft and components. Although much of the work of GAF is defence oriented, a considerable portion of the GAF budget can be attributed to civil transport research (eg expenditure on development of the Nomad aircraft).

Department of National Development and Energy (DNDE)

The Commonwealth Government established the National Energy Research, Development and Demonstration Council (NERDDC) in 1978 to advise the Minister for National Development and Energy on the development and coordination of a national energy research, development and demonstration (RD&D) program and on support for individual RD&D projects. The Energy Research and Development Division of DNDE administers the program and provides advice to the Minister on energy R&D policy.

Applications for support grants are invited annually by NERDDC. Where appropriate applications are not received in priority technology areas, the Council recommends the commissioning of such projects. A significant portion of the funds provided by NERDDC have gone into areas which are directly related to transport, including areas such as synthetic fuel technology.

Department of Science and Technology (DST)

DST has a broad policy role in relation to science, technology, productivity and fostering innovation in the field of science and technology. Many of the general R&D programs within the Department, such as the Antarctic Ship Design Study, are related to transport. The Bureau of Meteorology within DST undertakes research and related activities which are of direct relevance to shipping and civil aviation.

DST also provides funds for research and development purposes to other government agencies and to private companies and individuals (including researchers in institutions of higher education). The eligibility criteria for projects funded under the various schemes administered by DST cover a wide range of industrial and scientific research activities. Although transport research does not represent a specific category for any of the DST administered schemes, some of the projects to which funds are contributed, such as the Interscan microwave landing system, are obviously transport-related.

Department of Transport Australia (DoTA)

DoTA (including the BTE which, for the present purpose, was treated separately above) is the only Commonwealth Government agency which undertakes general research activities and provides research funds to other agencies specifically and solely in support of the transport function. The Department is involved in all modes of transport and many of the Divisions within DoTA undertake intramural research projects. However, much of DoTA's funding for transport research is distributed to other Commonwealth and State agencies[1], to tertiary education bodies and to private consultants.

The arrangements under which funding is provided to other agencies vary according to the purpose for which the funding is provided. Many research projects are funded on an ad hoc basis from the budget appropriation of the Division for which the research is undertaken. From 1974 until mid-1981 the main mechanism for providing funding to State agencies and to ARRB and ARRDO has been the Transport Planning and Research Program.

Transport Planning and Research Program

The Transport Planning and Research (TP&R) Program was established in 1974 with the passing of the *Transport (Planning and Research) Act* 1974. The Act was administered by DoTA and was introduced to provide assistance to the States' programs of planning and research into roads and urban public transport. For approved projects, two-thirds of the funds were provided by the Commonwealth, with the States contributing the remaining one-third and being responsible for project implementation. Activities funded under this Act included research into urban transport planning, traffic engineering, road construction techniques, data collection and urban rail.

In 1977 the TP&R Act was superseded by the *Transport Planning and Research (Financial Assistance) Act* 1977. The scope of this Act was extended to include planning and research into all modes of land transport and the interface between land transport and other transport modes. Under the 1977 Act the Commonwealth contribution towards project funding was reduced from two-thirds to one-half, beginning in the 1978-79 financial year.

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1. Including the Australian Road Research Board (ARRB) and the Australian Railway Research and Development Organisation (ARRDO).

As part of the Review of Commonwealth Functions, Commonwealth assistance to the States for transport planning and research under the *Transport Planning and Research (Financial Assistance) Act* 1977 was terminated at the end of the 1980-81 financial year. In lieu of assistance provided under this Act to ARRB and ARRDO the 1981-82 Commonwealth budget provided for direct contributions to these organisations through an allocation in DoTA's budget appropriation. Funding arrangements beyond 1981-82 have not yet been finalised.

National Capital Development Commission (NCDC)

The NCDC is responsible for the planning, design and construction of the city of Canberra as the National Capital of Australia. Studies involving transport problems are an important part of the Commission's work. Some of the studies are undertaken internally with funding from the NCDC budget appropriation. The NCDC also contracts work to other government agencies (such as DHC), to academic institutions (such as the Canberra College of Advanced Education) and to commercial consultants.

TABLE 2.2—MAJOR STATE AGENCIES[a] INVOLVED IN FUNDING OR PERFORMING TRANSPORT RESEARCH

State	*Agencies*
New South Wales	Department of Main Roads Maritime Services Board Ministry of Transport (State Transport Study Group) State Rail Authority Traffic Accident Research Unit Urban Transit Authority
Victoria	Country Roads Board Melbourne and Metropolitan Tramways Board Melbourne Metropolitan Board of Works Melbourne Transit Council Ministry of Transport Port of Melbourne Authority Road Safety and Traffic Authority Transport Regulation Board Victorian Railways Board
Queensland	Department of Transport Main Roads Department Metropolitan Transit Authority Port of Brisbane Authority Queensland Railways
Western Australia	Main Roads Department Office of the Director-General of Transport Road Traffic Authority Transport Commission Western Australian Government Railways
South Australia	Department of Marine and Harbours Ministry of Transport Highways Department State Transport Authority
Tasmania	Department of Main Roads Transport Commission

a. Agencies represented in this list were approached for information in support of this study. While not necessarily exhaustive, it is believed that these agencies do represent the most significant transport organisations involved in transport research.

Reserve Bank of Australia

The Reserve Bank provides funds for economic and financial research through its grant scheme. Occasionally the research projects financed by Reserve Bank grants have been transport-related although this is a relatively minor source of transport research funding.

STATE AGENCIES

During the period from July 1974 to June 1981, most State agencies which undertook transport research received funds through the Transport Planning and Research Program administered by DoTA. Port Authorities, however, were not generally included as the TP&R Program excluded sea transport from its funding arrangements.

Table 2.2 lists the major State transport agencies which are believed to undertake or provide funds for transport research and which were asked to contribute information to this study. As is the case with Commonwealth agencies, many State agencies contract transport research activities to other government agencies, to institutions of higher education and to private consultants. Funding for the State share of approved TP&R projects and for non-TP&R projects is generally provided from State consolidated revenues. However, in the case of Port Authorities, funding for research and development and related projects is provided essentially from general revenue collected by the Authority from users of the port.

A summary of the TP&R program by State is presented in Chapter 3 of this report. An analysis of this program is presented in Chapter 4. The annual TP&R Program progress reports provide financial and other details of all projects funded through the TP&R Program. However, transport research projects not included in the TP&R Program but funded exclusively from non-Commonwealth sources are not generally reported in the same degree of detail. This places considerable limitations on the depth to which these projects can be analysed.

COMMONWEALTH/STATE AGENCIES

Australian Road Research Board

The Australian Road Research Board (ARRB) was founded in 1960 and operates as a non-profit public company registered in the State of Victoria. It is controlled by a Board of Directors comprising the heads of the following State and Commonwealth Government Departments:

Commonwealth	—	Department of Housing and Construction
	—	Department of Transport Australia
New South Wales	—	Department of Main Roads
Victoria	—	Country Roads Board
Queensland	—	Main Roads Department
South Australia	—	Highways Department
Western Australia	—	Main Roads Department
Tasmania	—	Department of Main Roads

The objectives of ARRB are:

- to provide a national centre for road research information and for the correlation and coordination of road research activities;
- to ascertain the nature and extent of road research work required;
- to encourage and promote the undertaking of road research, including research into road planning, location, design, safety, materials, construction, maintenance, structures, equipment, traffic, transport, economics, administration, financing,

management, accounting and other matters affecting the provision, upkeep, use, protection and development of roads;

- to provide by means of conferences or symposia, opportunities for the presentation and discussion of the results of road research;
- to make grants for carrying out road research;
- to undertake research studies;
- to publish the results of road research, including those presented at conferences convened by the Board;
- to appoint specialist committees to assist investigations authorised by the Board and to provide financial and other assistance to such committees; and
- to make available to appropriate bodies or persons, information relating to road research matters.

ARRB is funded through contributions from the Commonwealth and State Departments which are represented on its Board of Directors and, beginning in 1979-80, from the Department of Transport and Works, Northern Territory. Historically, the State road authorities have contributed approximately 90 per cent of ARRB's budget (though a proportion of this contribution could be reimbursed by the Commonwealth under the TP&R Program as explained below) with the DHC contributing the remaining 10 per cent. State contributions have been in proportion to the States' share of total Commonwealth grants under the States Grants (Roads) Acts. Until 1976-77 States could claim up to two-thirds of their contributions to ARRB from the Commonwealth under the *Transport (Planning and Research) Act* 1974.

Under the *Transport Planning and Research (Financial Assistance) Act* 1977 the proportion of the States' contributions to ARRB which could be claimed from the Commonwealth was reduced to one-half from 1978-79. Also, the contribution from DHC has been kept constant in dollar terms since 1977-78.

Following the termination of assistance under the TP&R Act in June 1981, DoTA received an allocation for a direct contribution to ARRB, rather than contributing indirectly as had been occurring during the period of the Act. In 1981-82 DoTA is contributing approximately 44 per cent of the ARRB budget, DHC is contributing 7 per cent and the State road authorities are contributing some 49 per cent.

Under the definitions adopted for this study all of the work of ARRB can be considered to fall within the general classification of transport research.

Although most of ARRB's transport research activities are undertaken internally, an average of approximately 10 per cent of its annual budget has been allocated to external research grants over the past five years.

Australian Railway Research and Development Organisation

The Australian Railway Research and Development Organisation (ARRDO) was incorporated in Victoria as a limited company in November 1977. ARRDO is controlled by a Board of Directors comprising the Chief Executive of the State Rail Authority of NSW, the Victorian Railways, the Queensland Government Railways, the Western Australian Government Railways, Australian National (Railways) and DoTA.

ARRDO was established to provide a national centre for the generation and development of analytical research activities and information systems on administrative, economic and technical planning and policy matters relating to Australian railways. ARRDO also undertakes studies and research aimed at:

- the generation of plans for the development of railway systems;

- the improvement of the financial situation of railways commensurate with the commercial and non-commercial roles the railways must fulfil; and
- the improvement of the efficiency of railways through investment and non-investment measures.

Since 1978-79 ARRDO has been funded by the five government rail systems in proportion to their respective annual gross revenues excluding suburban passenger revenues. Under the *Transport Planning and Research (Financial Assistance) Act* 1977 the various State government rail systems could claim one-half of their contributions from the Commonwealth. Australian National (AN) contributed 12.5 per cent of ARRDO's budget in 1978-79, 1979-80 and 1980-81. Thus the Commonwealth indirectly contributed approximately 44 per cent of the ARRDO budget in these years through the TP&R Act.

In 1981-82 the funding arrangements for ARRDO are similar to those for ARRB. With the termination of the TP&R Program, DoTA is making a direct contribution to ARRDO. A similar contribution is provided by the four State railway authorities in aggregate and AN is contributing the remainder of ARRDO's budget. It is understood that this is an interim arrangement only and future funding arrangements have yet to be determined.

Under the definitions adopted for this study all of the work of ARRDO can be considered to fall within the general classification of transport research. Although many research projects are carried out by ARRDO staff, considerable use of consultants is also a feature of ARRDO's operations.

INSTITUTIONS OF HIGHER EDUCATION

Many of the universities, colleges and technical institutions in Australia undertake transport research. Information on the transport R&D expenditure of these institutions was obtained from Project SCORE and institutions of higher education which reported expenditure on transport R&D for 1978-79 are listed in Table 2.3.

Most of the funding for transport research undertaken by institutions of higher education is provided from the operating revenues of the institutions. However, as previously mentioned, many Commonwealth and State government agencies also provide funds, on a contract basis, to these institutions.

BUSINESS ENTERPRISES

The business enterprise sector is both a source of funds for transport research and a major recipient of these funds. As the time and resource contraints for this study did not permit an independent collection[1] of details of transport research expenditure directly from the private sector, only a general summary of funding sources and arrangements is possible in this report. Published information from the ABS Survey of Research and Experimental Development was used to obtain R&D expenditure details for business enterprises in the transport equipment manufacturing industry. Other sources of information include the BTE's 1978 study of transport R&D, and general information on transport research available to the BTE.

Companies

Most of the large transport operators (both freight and passenger) in Australia either undertake transport research work themselves or contract to have this work undertaken for them. This situation also applies to oil companies, and manufacturers of transport equipment. Although it is understood that these types of companies are responsible for the bulk of the transport research in the private sector, it is known that other companies such as engineering firms, mining companies and other large

1. Or at least an independent collection which would have produced reliable results. Such a collection would have required a degree of statistical 'quality control' to ensure that the private organisations supplying information were representative of the private sector as a whole.

TABLE 2.3—INSTITUTIONS OF HIGHER EDUCATION INVOLVED IN FUNDING OR PERFORMING TRANSPORT RESEARCH

State	*Institutions*
New South Wales	Kuringai College of Advanced Education Macquarie University University of Newcastle New South Wales Institute of Technology University of Sydney University of New South Wales University of Wollongong
Victoria	Footscray Institute of Technology La Trobe University Monash University Swinburne College of Technology University of Melbourne Warnambool Institute of Advanced Education
Queensland	James Cook University University of Queensland
South Australia	Flinders University of South Australia South Australian Institute of Technology University of Adelaide
Western Australia	University of Western Australia
Tasmania	University of Tasmania
Australian Capital Territory	Australian National University Canberra College of Advanced Education

businesses in all sectors which transport goods are also involved in carrying out transport research from time to time.

Research and development funds in the private sector are generally provided from company revenues, although certain schemes through which the Government provides funding to private companies for R&D and related projects have been mentioned previously. The converse situation also occurs, whereby direct levies are made on private companies by Government agencies for R&D purposes (for example, the coal levy mentioned in the section on the CSIRO). In the case of subsidiary companies with head offices overseas there may be a transfer of R&D funds between the parent company and the Australian subsidiary, although the extent of this is not known.

Consultants

Consultants are generally recipients of funds from all of the previously discussed sections and organisations (ie Commonwealth and State Government, ARRB, ARRDO, institutions of higher education, and business enterprises). In some instances consultants may undertake projects on their own initiative[1] although expenditure on transport R&D from this source would be very limited.

1. In particular this would be the case where the result would lead to some analytical methodology which the consultant could market commercially.

CHAPTER 3—FUNDING LEVELS

This chapter contains an account of the levels of funding for transport research in Australia.

It is important at the outset to distinguish between 'funding' and 'expenditure'. In some cases, where an organisation's activities are totally funded from internal sources, the terms are effectively synonymous. However in other cases, one organisation or government may wholly or partially fund the research activities of other organisations, and it is here that any confusion relating to the financial transfers between the organisations can result in counting the funding level and the expenditure level separately, thus effectively double-counting the same funds.

The availability of data varies from sector to sector, and this determines whether funding or expenditure information, or both is presented for each sector in this chapter.

In the following, the discussion of transport research funding levels starts with an account of the Commonwealth Government sector which includes Government Departments, the TP&R Program, NERDDC and CSIRO. This is followed by a summary of the State Government sector, and a separate account is provided for ARRB and ARDDO. The description of funding levels in the business enterprise sector does not include the so-called 'R&D-related activities' component of transport research (as defined in this study) since no information on this component has been published. The transport research funding situation in the private non-profit and higher education sectors are outlined, and the chapter concludes with a summary of current funding estimates at the overall national level.

Unless otherwise stated, expenditure and funding information is presented in current terms. However, in order to examine trends, some of this information is also presented in real terms. Ideally the deflator used to estimate real costs should reflect a composite transport research cost index constructed to take account of the changing costs of all components of transport research activities. These components could be expected to be represented in varying proportions for different project types. The compilation of an index incorporating these considerations would be a major study in itself, and so bearing in mind the high labour component of research, increases in the average male wage were used to calculate the deflator in this study.

COMMONWEALTH GOVERNMENT

Departments

Information relating to Commonwealth Government expenditure on transport research was obtained from Project SCORE as well as from the Science and Technology Statement of DST. These sources are outlined in Chapter 1, and a more detailed discussion of their limitations is provided subsequently in the section in Chapter 4 dealing with information issues.

Table 3.1 shows the levels of Commonwealth Government expenditure on transport research activities by agencies identified in the Science and Technology Statement as having performed transport research. This excludes CSIRO, the NERDD Program and the IR&D Grants for which details are provided later in this section. Total R&D expenditure in 1973-74 and 1976-77 was obtained from Project SCORE. A breakdown by agency of R&D expenditure and total transport research expenditure is not available

TABLE 3.1—EXPENDITURE ON TRANSPORT RESEARCH BY COMMONWEALTH GOVERNMENT AGENCIES, 1973-74 TO 1981-82

($'000 current terms)

Agency	Year ending 30 June									
	1974	1977	1979		1980		1981		1982[a]	
	R&D	R&D	R&D	Total	R&D	Total	R&D	Total	R&D	Total
Australian Bureau of Statistics	na	na	188	1 466	146	2 911	225	2 427	na	na
Bureau of Meteorology	na	na	22	2 222	20	2 316	23	2 438	na	na
Bureau of Transport Economics	na	na	32	1 938	40	2 170	77	2 585	64	2 905
Department of Housing and Construction	na	na	259	259	259	259	259	259	259	259
Department of Industry and Commerce	na	na	46	46	16	22	—	16	na	na
Department of Transport Australia (excluding BTE)	na	na	4 383	9 827	4 584	10 304	4 337	11 519	3 660	7 561
Reserve Bank	na	na	6	6	6	6	—	—	na	na
Total	5 911	6 852	4 936	15 764	5 071	17 988	4 921	19 244	na	na

a. Estimated figures.
Sources: DSE (1980), DST (1981), DoTA (unpublished data).

from this source. The figures for the years 1978-79 to 1981-82 were obtained from the Science and Technology Statement. It is not known whether the decrease in R&D expenditure between 1976-77 and 1978-79 resulted from an actual reduction in funding levels, or whether agencies reporting transport research expenditure defined some projects as R&D-related rather than as R&D due to the expanded scope of the Science and Technology survey[1].

Commonwealth Government expenditure on transport research through the agencies identified in Table 3.1 totalled $19.2m in 1980-81. Transport R&D expenditure as previously defined, amounted to some $5m or 26 per cent of total transport research expenditure. DoTA (including the BTE) has contributed approximately 90 per cent of these outlays on transport R&D over the past three years. The proportion of Commonwealth transport research expenditure identified in Table 3.1 which is attributable to DoTA amounted to 75 per cent in 1978-79, 69 per cent in 1979-80 and 73 per cent in 1980-81.

Table 3.2 provides a breakdown of the transport research expenditure of DoTA[2]. Expenditure under the TP&R Program accounted for 57 per cent of R&D expenditure and about 44 per cent of total research expenditure in 1980-81. The operations of the Bureau of Transport Economics represented approximately $2.6m or 18 per cent of total research expenditure by DoTA in 1980-81. Airways facilities research accounted for the bulk of internal R&D expenditure by the Department. Internal expenditure comprised 32 per cent of R&D expenditure and 52 per cent of total research expenditure of DoTA in 1980-81. The termination of funding under the TP&R Program as from 30 June 1981 is reflected in the projected expenditure decrease in 1981-82.

1. Potential interpretation difficulties associated with these two terms (R&D and R&D-related activities) are discussed further, elsewhere in this chapter.

2. This table excludes expenditure for meteorological services from the Bureau of Meteorology as these services were not considered to be R&D-related activities in the present context. In 1980-81 DoTA provided $11.9 m for provision of meteorological services.

TABLE 3.2—EXPENDITURE ON TRANSPORT RESEARCH BY DoTA[a], 1978-79 TO 1981-82

($'000 current terms)

Area of Expenditure	*Year ending 30 June*							
	1979		*1980*		*1981*		*1982*	
	R&D	*Total*	*R&D*	*Total*	*R&D*	*Total*	*R&D*	*Total*
Airways Facilities Research	925	na	1 030	1 030	1 140	3 220	1 205	3 145
	(14)		(11)	(11)	(9)	(3)	(20)	(7)
Regulation of Air Transport	217	na	244	546	132	192	148	208
	(34)		(39)	(17)	(85)	(61)	(86)	(62)
MANS Study	—	na	—	325	—	334	—	387
				(3)		(4)		(3)
Marine Navigational Aids	118	na	160	160	—	41	—	15
	(0)		(0)	(0)		(2)		(7)
Office of Road Safety	523	na	450	450	565	565	679	679
	(67)		(67)	(67)	(47)	(47)	(47)	(47)
Transport Evaluation & Planning	—	na	—	160	—	164	—	182
				(0)		(0)		(0)
Transport Statistics and Related Information	—	na	—	733	—	754	—	833
				(0)		(0)		(0)
Grants for Transport Planning and Research	2 600	na	2 700	6 900	2 500	6 250	1 628	2 122
	(100)		(100)	(100)	(100)	(100)	(100)	(100)
Total (excluding BTE)	4 383	na	4 584	10 304	4 337	11 519	3 660	7 561
	(72)		(70)	(72)	(69)	(59)	(63)	(37)
Bureau of Transport Economics Total (BTE)	32	na	40	2 170	77	2 585	64	2 911
	(6)		(5)	(5)	(8)	(3)	(11)	(3)
Total (DoTA)	4 415	na	4 624	12 474	4 414	14 104	3 724	10 472
	(71)		(69)	(60)	(68)	(48)	(62)	(28)

a. Figures in brackets are percentages of the total expenditure paid to organisations or individuals outside the Department.
b. Estimated figures.
Sources: DSE (1981), DoTA (unpublished data).

Transport Planning and Research Program

Expenditure by the States on transport research has been assisted in the past to varying degrees by Commonwealth Government contributions through the TP&R Program. Table 3.3 summarises the Commonwealth contributions to each of the States for the years 1974-75 to 1980-81. The aggregate figures from Table 3.3 are reflected in Table 3.2 under 'Grants for Transport Planning and Research'.

National Energy Research Development and Demonstration (NERDD) Program

Information relating to the NERDD Program is published by DNDE (DNDE 1980), on a project basis. Expenditure data are provided only in terms of the level of external support and do not include the total project costs. Moreover, it is not possible to obtain annual expenditure data from this source. The ABS has compiled and published statistics describing funding and expenditure on R&D relating to the production, utilisation and conservation of energy in Australia in 1979-80 (ABS 1981a). Table 3.4 is derived from this document and unpublished DNDE data.

Business enterprises spent $3.5m and government and higher education spent $1.3m of the total amount of funding shown in Table 3.4 (ABS 1981a), representing a net flow from government to business enterprises of almost one million dollars. In 1980-81, transport-related energy conservation was funded to a level of $2.5m under the NERDD Program. Estimates of funding from other sources are not available for this year.

TABLE 3.3—COMMONWEALTH GOVERNMENT CONTRIBUTION TO TRANSPORT RESEARCH THROUGH THE TP&R PROGRAM, 1974-75 TO 1980-81

($'000)

Recipient State	Year ending 30 June						
	1975	1976	1977	1978	1979	1980	1981
NSW	1 790	3 420	3 100	3 495	2 484	2 670	2 418
Qld	550	1 270	1 220	1 381	983	1 056	957
Vic	1 570	2 910	2 140	2 411	1 714	1 842	1 668
SA	900	1 150	580	618	469	504	457
WA	690	990	740	744	597	642	582
Tas	160	200	220	195	173	186	168
Australia	5 660	9 940	8 000	8 844	6 420	6 900	6 250

Sources: DoTA 1981 and earlier issues.

TABLE 3.4—FUNDING OF R&D ASSOCIATED WITH TRANSPORT-RELATED ENERGY CONSERVATION, 1979-80

($'000)

Source	Amount of funding
Industry	2 551
Government:	
NERDD Program	1 949
Other	276
Total	4 776

Source: ABS (1981a), DNDE unpublished data.

In addition to transport-related energy conservation, a component of R&D on synthetic fuel technology may be considered to have an association with the transport sector. It has been estimated that in 1979-80 funds totalling $5.0m were made available for work in this area through the NERDD Program; this decreased to $3.8m in 1980-81 (DNDE, unpublished data).

Table 3.5 shows the distribution of expenditure on projects related to transport research in the NERDD Program.

TABLE 3.5—DISTRIBUTION OF EXPENDITURE ON PROJECTS RELATED TO TRANSPORT RESEARCH IN THE NERDD PROGRAM, 1978-79 TO 1980-81

(per cent)

Research activity	Year ending 30 June		
	1979	1980	1981
Synthetic fuels	89.1	72.1	61.3
Fuel conservation	0.5	6.6	17.7
Traffic management	2.1	9.2	5.3
Vehicle design	0.3	4.2	5.8
Electric and hybrid vehicles	8.0	5.6	7.7
Hydrogen	0.0	2.3	2.2
Total	100.0	100.0	100.0

Source: DNDE unpublished data.

The level of funding for transport energy projects by NERDDC is influenced by the number and nature of applications for assistance and grants, hence any trends exhibited in Table 3.5 should be treated with some caution.

Australian Industrial Research and Development Incentives Board
The general funding arrangements for projects supported by the Australian Industrial Research and Development Incentives Board (AIRDIB) were summarised in Chapter 2 of this report.

The confidentiality of individual project type and funding information precludes any detailed analysis of this program as it relates to private sector transport research. However, some information is published which uses the International Patent Classification System to categorise aggregate program funding. The latest information published by AIRDIB refers to industrial research and development (IR&D) grants made in the 1979-80 fiscal year (AIRDIB 1981). In that year, projects in the patent classification 'transporting' (which is a class of manufacturing or mining activities) received commencement grants of $0.17m and project grants of $1.20m.

If it is assumed that IR&D projects funded by AIRDIB grants comply with the Project SCORE definition of R&D[1] and are therefore reported, by Project SCORE, as private enterprise expenditure classified to the 'transport equipment' category, the amount of the IR&D grants should be transferred from this sector to the Commonwealth Government sector in the determination of funding levels (as distinct from expenditure levels). This assumption is made in outlining the aggregate situation in this chapter and elsewhere in this report.

Commonwealth Scientific and Industrial Research Organisation

Data for CSIRO expenditure were taken from CSIRO (1981 and earlier issues). Details of expenditure were given for each major program. However these were further classfied into sub-programs for which individual expenditure figures were not given. Hence in the present analysis, any sub-program that contained a significant transport component was allocated a proportion of the total expenditure according to the number of sub-programs comprising the major program. The expenditure figures in each of the reports mentioned above refer to the previous financial year, and comprise the program's share of salaries, operating costs, and capital costs, together with a proportion of the research support and overhead costs of the Division or Unit in which the work was undertaken.

Reference was also made to CSIRO (1981 and earlier issues) to obtain information on the source of CSIRO funds. However, there was insufficient detail to determine precisely the source of funds for transport research.

Expenditure by CSIRO for transport-related research is detailed in Table 3.6, classified, according to socio-economic objective, by the BTE using the CSIRO project descriptions. The R&D component varied between 70 and 90 per cent of annual expenditures.

Table 3.6 shows that, overall, more than half of the CSIRO's expenditure on transport-related research is devoted to work on more efficient or alternate transport fuels. The next most significant expenditure item relates to air transport which consists entirely of the research and development on the Interscan microwave landing system.

Almost 90 per cent of the CSIRO's expenditure on salaries and general running expenses comes directly from the Commonwealth. Various rural trusts contribute about 5 per cent. However it is unlikely that these funds would be used for transport research. The balance of funds come from NERDDC (1 per cent) and other contributors (4 per cent) which include State Governments and the private sector.

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1. The definitions used by AIRDIB are included in Appendix I.

TABLE 3.6—CSIRO EXPENDITURE ON TRANSPORT-RELATED STUDIES, 1976-77 TO 1979-80

($'000)

Socio-economic objective	Year ending 30 June			
	1977	1978	1979	1980
Air transport	653	575	649	690
Road safety	0	114	0	0
Other road	0	208	264	0
Transport energy	1 555	896	2 627	4 686
Other transport	269	592	1 076	1 503
Total	2 477	2 385	4 616	6 879

STATE GOVERNMENT

The major transport agencies in the States were contacted and asked to provide relevant expenditure data on transport research for the last seven years, where this was not available from other sources. Sufficient detail was requested to allow expenditure to be analysed by socio-economic objective. In addition the component of expenditure on activities meeting the R&D definition was specifically requested. Where the R&D component was not easily identified for each year, the agency records for Project SCORE were used to determine the average proportion of research expenditure on R&D for the years covered by Project SCORE (1976-77 and 1978-79)[1], and this proportion was applied to the research expenditure for each of the other years. Thus the R&D component of the total research expenditure figures should be treated with some caution, particularly for years other than the Project SCORE years.

Examination of agencies' Project SCORE records exposed another area of likely error. It appeared that the various State Road Authorities adopted differing approaches in reporting research expenditure. The expenditure on R&D (as recorded in the Project SCORE forms) as a proportion of planning and research expenditure (from Annual Reports) varied from 3 per cent to 30 per cent. The most likely explanation for this range is variation in the subjective judgements required to determine whether or not particular projects meet the Project SCORE R&D criteria. It was also observed that in some cases R&D on road construction was reported under the socio-economic objective 'construction' while in others this work was reported under 'transport-other road'.

Table 3.7 shows expenditure by State transport agencies on transport research classified by the Project SCORE socio-economic objectives. Table 3.8 provides this information in real terms (using increases in the average male wage to calculate the deflator).

States' expenditure on the R&D components for 1976-77 reported in Table 3.7 is much less than that published in Project SCORE for that year. It is considered that there are two major reasons for this difference. Firstly, the R&D expenditure reported here is based on project costs, and the overhead components are considered likely to be less than those determined by the (then) Department of Science and Environment for Project SCORE. Secondly, in the present study, agencies could allocate expenditure to 'R&D-related activities', a choice that did not exist in Project SCORE. Hence expenditure on projects lying on, or overlapping the boundary of the strict R&D definition may well have been included in Project SCORE since no choice existed to include this expenditure in any other category whereas for the purposes of this study a large proportion of this type of expenditure could have been allocated to 'R&D-related

1. Although in some cases figures for only one year were available.

TABLE 3.7—TRANSPORT RESEARCH EXPENDITURE[a] IN CURRENT TERMS BY STATE AGENCIES, CLASSIFIED BY SOCIO-ECONOMIC OBJECTIVE, 1974-75 TO 1980-81 ($'000)

Socio-economic objective	Year ending 30 June						
	1975	1976	1977	1978	1979	1980	1981
Air transport	0	6	1	4	0	43	62
	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Sea transport	887	952	1 231	1 406	1 876	2 137	2 420
	(0)	(0)	(0)	(0)	(11)	(0)	(0)
Road accidents and safety	1 996	2 308	2 218	2 530	2 615	3 382	3 079
	(533)	(589)	(594)	(627)	(500)	(922)	(859)
Other road							
road works	8 182	10 796	11 437	11 688	13 252	14 490	15 109
	(997)	(1 316)	(1 558)	(1 532)	(1 788)	(2 050)	(2 122)
other	875	1 523	1 790	1 975	1 742	1 948	2 640
	(18)	(24)	(76)	(42)	(25)	(47)	(101)
Rail	3 424	4 255	4 636	5 332	6 482	7 191	8 317
	(136)	(165)	(197)	(230)	(239)	(344)	(562)
Multimodal transport	203	609	391	410	554	603	416
	(0)	(0)	(1)	(4)	(0)	(0)	(0)
Intermodal materials handling	0	0	78	53	56	3	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Other transport	1 020	1 048	1 344	1 225	1 081	1 297	1 448
	(48)	(104)	(86)	(135)	(262)	(114)	(201)
Total	16 587	21 497	23 126	24 623	27 658	31 094	33 491
	(1 732)	(2 198)	(2 512)	(2 570)	(2 825)	(3 477)	(3 845)

a. Total expenditure on R&D and R&D-related activities is given in the table with the R&D component in parentheses.

activities'. Evidence to support this hypothesis is provided in Table 3.1 where the level of R&D expenditure reported for 1974 and 1977 in Project SCORE is greater than that reported in the Science and Technology Statements for later years. The Science and Technology Statements were developed from information which involved judgements as to whether research should be classified as 'R&D' or as 'R&D-related activities', thus providing respondents with a similar choice to that involved in this study.

Due to the above-mentioned difficulties in separating the R&D component of transport research on a consistent basis, it was decided that in this section this component of expenditure would be identified only in Table 3.7. In Tables 3.7 and 3.8 the expenditure on transport research incurred by port and marine authorities is included in the socio-economic objective 'sea transport'. These figures should be considered, at best, as indicative only because of the lack of annual research expenditure data in this area. Research program expenditure, that covered a number of years, was annualised in proportion to the particular port annual revenue. Where this information was not available, research expenditure was assumed to be a constant proportion[1] of the annual revenue of major ports. The only other information referring to expenditure on R&D and R&D-related activities in the ports area is a list of projects prepared in 1978 by the Port Authorities which they considered suitable for Commonwealth funding should the TP&R Program be extended to include marine matters[2]. It was not possible to estimate annual expenditures directly from this list.

1. Estimated in an unpublished 1978 MPCA Working Party Report on Port and Marine Planning and Research.
2. This was contained in the MPCA Working Party Report referred to in the previous footnote.

TABLE 3.8—TRANSPORT RESEARCH EXPENDITURE IN REAL TERMS BY STATE AGENCIES, CLASSIFIED BY SOCIO-ECONOMIC OBJECTIVE, 1974-75 TO 1980-81

($'000 1976-77 prices)

Socio-economic objective	*Year ending 30 June*						
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*
Air transport	0	7	1	4	0	33	42
Sea transport	1 137	1 070	1 231	1 278	1 590	1 644	1 635
Road accidents and safety	2 559	2 593	2 218	2 300	2 216	2 602	2 080
Other road road works	10 490	12 130	11 437	10 625	11 231	11 146	10 209
other	1 122	1 711	1 790	1 795	1 476	1 498	1 784
Rail	4 390	4 781	4 636	4 847	5 493	5 532	5 620
Multimodal transport	260	684	391	373	469	464	281
Intermodal materials handling	—	—	78	48	47	2	—
Other transport	1 308	1 178	1 344	1 114	916	998	978
Total[a]	21 265	24 154	23 126	22 385	23 439	23 918	22 629

a. Columns may not add to totals due to rounding.

TABLE 3.9—TRANSPORT RESEARCH EXPENDITURE IN CURRENT TERMS BY STATE AGENCIES FOR EACH STATE[a], 1974-75 TO 1980-81

($'000)

State	*Year ending 30 June*						
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*
NSW	6 578	7 214	8 291	9 207	9 715	11 424	11 676
Vic	3 502	6 613	5 435	5 446	6 604	7 970	7 975
Qld	1 605	1 938	2 653	2 881	3 659	3 090	3 184
SA	1 348	1 672	1 840	1 884	1 920	1 879	3 178
WA	2 272	2 644	3 117	3 035	3 114	3 773	4 425
Tas	395	464	559	764	770	821	633
Australia	15 700	20 545	21 895	23 217	25 782	28 957	31 071

a. Excludes expenditure in the category 'sea transport'.

Perhaps the most striking result from the data presented in Table 3.8 is the relative constancy of States' expenditures on transport research in real terms. Some increases are evident in real expenditure on rail and sea transport research, but this must be interpreted with some care. The expenditure on sea transport research is subject to a great deal of uncertainty and as a result of the method of estimation, largely reflects increases in port revenues. Changes to the TP&R Program in 1977 provided for the inclusion of rail research related to non-urban rail transport and this is probably associated with the reported increases in rail research expenditure.

The proportion of transport research expenditure on R&D remained constant from 1974-75 to 1978-79 and increased by 10 per cent for the years 1979-80 and 1980-81. R&D represented the highest proportion of research expenditure in the road accidents and safety category.

The expenditure (expressed in current terms) incurred on transport research by each State is shown in Tables 3.9, while Table 3.10 presents these expenditures in real terms.

The 'sea transport' expenditure is excluded from the State aggregates in these tables because of the different funding arrangements for port authorities (outlined in Chapter 2). In addition the measurement uncertainties described above for this category may cause individual State estimates for sea transport to be misleading.

Changes in individual States' expenditures must be interpreted with caution since they are subject to variation from year to year according to the commencement or completion of major projects, as well as any changes in funding priorities.

The Commonwealth contribution to the States through the TP&R Program was subtracted from the State expenditures and Tables 3.11 and 3.12 show State funding of transport research from their own resources. Once again, expenditures by Port Authorities are excluded. In this context it should be noted that port and marine research did not attract direct Commonwealth funding through the TP&R Program.

TABLE 3.10—TRANSPORT RESEARCH EXPENDITURE IN REAL TERMS BY STATE AGENCIES FOR EACH STATE[a], 1974-75 TO 1980-81

($'000 1976-77 prices)

State	Year ending 30 June						
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*
NSW	8 433	8 106	8 291	8 370	8 233	8 788	7 889
Vic	4 490	7 430	5 435	4 951	5 597	6 131	5 389
Qld	2 058	2 178	2 653	2 619	3 101	2 377	2 151
SA	1 728	1 879	1 840	1 713	1 627	1 445	2 147
WA	2 913	2 971	3 117	2 759	2 639	2 902	2 990
Tas	506	521	559	695	653	632	428
Australia[b]	20 128	23 084	21 895	21 106	21 850	22 275	20 994

a. Excludes expenditure in the category 'sea transport'.
b. Columns may not add to totals due to rounding.

TABLE 3.11—TRANSPORT RESEARCH EXPENDITURE IN CURRENT TERMS BY STATE AGENCIES FROM OWN RESOURCES[a] FOR EACH STATE[b], 1974-75 TO 1980-81

($'000)

State	Year ending 30 June						
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*
NSW	4 788	3 794	5 191	5 712	7 231	8 754	9 258
Vic	1 932	3 703	3 295	3 035	4 880	6 128	6 307
Qld	1 055	668	1 433	1 500	2 676	2 034	2 227
SA	448	522	1 260	1 266	1 451	1 375	2 721
WA	1 582	1 654	2 377	2 291	2 517	3 131	3 843
Tas	235	264	339	569	597	635	465
Australia	10 040	10 605	13 895	14 373	19 352	22 057	24 821

a. Excludes Commonwealth component as shown in Table 3.3. The figures shown may still include some small special purpose payments from outside sources.
b. Excludes expenditure in the category of 'sea transport'.

TABLE 3.12—TRANSPORT RESEARCH EXPENDITURE IN REAL TERMS BY STATE AGENCIES FROM OWN RESOURCES[a] FOR EACH STATE[b], 1974-75 TO 1980-81

($'000 1976-77 prices)

State	Year ending 30 June						
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*
NSW	6 138	4 263	5 191	5 193	6 128	6 734	6 255
Vic	2 477	4 161	3 295	2 759	4 136	4 714	4 261
Qld	1 353	751	1 433	1 364	2 268	1 565	1 505
SA	574	587	1 260	1 151	1 230	1 058	1 839
WA	2 028	1 858	2 377	2 083	2 133	2 408	2 597
Tas	301	297	339	517	506	488	314
Australia[c]	12 872	11 916	13 895	13 066	16 400	16 967	16 771

a. Excludes Commonwealth component as shown in Table 3.3. The figures shown may still include some small special purpose payments from outside sources.
b. Excludes expenditure in the category of 'sea transport'.
c. Columns may not add to totals due to rounding.

Again, the R&D components of expenditure on transport research are not identified separately in these tables. The expenditure classification problem between R&D and R&D-related activities outlined previously for the State agencies is compounded by the same problem for the TP&R Program. It was considered that the resulting errors would preclude reasonable estimation.

Comparing the real expenditures (in Tables 3.10 and 3.12) for all States combined it is evident that they maintained their real level of transport research expenditure by contributing more of their own resources (in real terms) over the last three years.

COMMONWEALTH/STATE AGENCIES

Australian Road Research Board

Funding and expenditure data for the Australian Road Research Board (ARRB) were obtained from its annual reports.

The sources of funds for ARRB are detailed in Tables 3.13 and 3.14 in current and real terms respectively. As indicated in the tables, the figures for the States include the contribution from the Commonwealth to the States through the TP&R Program. Hence the Commonwealth contribution to ARRB is much greater than these tables would indicate. With the cessation of this program the Commonwealth in 1981-82 is providing a direct contribution, through DoTA, of $1.6m in addition to the contribution through DHC of $259 000.

In real terms, Commonwealth and State contributions to ARRB have remained relatively constant with no significant fluctuation even over the transition years after the amendments to the TP&R Act in 1977. This implies that the States have made up the decrease in the indirect Commonwealth contributions which would have occurred following the introduction of the 1977 TP&R Act. Table 3.14 shows that in real terms the direct contribution from the Commonwealth (through DHC) has declined, the contributions from NSW have increased and the contributions from the other States remained constant.

TABLE 3.13—CONTRIBUTIONS BY STATES[a] AND COMMONWEALTH IN CURRENT TERMS TO ARRB, 1975-76 TO 1980-81

($'000)

Contributor	Year ending 30 June					
	1976	*1977*	*1978*	*1979*	*1980*	*1981[b]*
NSW	616	714	825	902	963	1 071
Vic	418	485	534	577	625	684
Qld	418	485	536	583	618	695
SA	176	204	216	237	254	279
WA	264	306	320	352	378	419
Tas	88	102	115	128	137	150
NT	..	..	..	..	20	25
Direct Commonwealth	220	255	258	258	260	258
Total	2 200	2 551	2 804	3 037	3 255	3 581

a. State figures include Commonwealth contribution to the States through the TP&R Program.
b. Preliminary figures only.

TABLE 3.14—CONTRIBUTIONS BY STATES[a] AND COMMONWEALTH IN REAL TERMS TO ARRB, 1975-76 TO 1980-81

($'000 1976-77 prices)

Contributor	Year ending 30 June					
	1976	*1977*	*1978*	*1979*	*1980*	*1981[b]*
NSW	692	714	750	764	741	724
Vic	470	485	485	489	481	462
Qld	470	485	487	494	475	469
SA	198	204	196	201	195	188
WA	297	306	291	298	291	283
Tas	99	102	105	108	105	101
NT	..	..	..	..	15	17
Direct Commonwealth	247	255	235	219	200	174
Total	2 473	2 551	2 549	2 573	2 503	2 418

a. State figures include Commonwealth contribution to the States through the TP&R Program.
b. Preliminary figures only.

ARRB's major expenditure item, salaries, is reported to account for over 70 per cent of its total budget[1]. Tables 3.15 and 3.16 show a breakdown of ARRB's expenditure in current and real terms respectively. Although external research grants seem to be only a small component, the spending for the administration and supervision of those grants is included under internal research. The decrease in external grants is attributed not to any deliberate policy but to a lack of suitable projects to support, and general financial constraints.

Accepting the above considerations, both ARRB's funding and expenditure have remained comparatively stable over the years. It will also be noted that ARRB's annual government funding and its corresponding expenditure do not balance in all cases (Tables 3.13 and 3.15) because of the use of reserve funds.

1. This lends support to the use of a wage rate deflator as described previously to estimate expenditures in real terms.

TABLE 3.15—ARRB EXPENDITURE IN CURRENT TERMS BY CATEGORY, 1975-76 TO 1980-81

($'000 current terms)

Category	Year ending 30 June					
	1976	*1977*	*1978*	*1979*	*1980*	*1981*[a]
Internal research	836	1 097	1 356	1 564	1 688	1 862
External research	308	306	324	219	265	179
Information and printing	264	230	295	344	331	358
Support services	704	816	973	1 001	1 026	1 182
Reserves	88	102	—	—	—	—
Total	2 200	2 551	2 948	3 128	3 310	3 581

a. Preliminary figures only.

TABLE 3.16—ARRB EXPENDITURE IN REAL TERMS BY CATEGORY, 1975-76 TO 1980-81

($'000 1976-77 prices)

Category	Year ending 30 June					
	1976	*1977*	*1978*	*1979*	*1980*	*1981*[a]
Internal research	939	1 097	1 233	1 325	1 298	1 258
External research	346	306	295	186	204	121
Information and printing	297	230	268	292	255	242
Support services	791	816	885	848	789	799
Reserves	99	102	—	—	—	—
Total	2 472	2 551	2 681	2 651	2 546	2 420

a. Preliminary figures only.

Australian Railway Research and Development Organisation

ARRDO, established in 1978, is sponsored by the five government-owned rail systems, together with the Department of Transport Australia. The funds made available to ARRDO from the five rail systems are in proportion to their respective annual gross revenues, excluding suburban passenger revenues. In 1978-79 the proportions were as follows:

Public Transport Commission of NSW	30.0 per cent
Queensland Government Railways	27.5 per cent
Victorian Railways	15.0 per cent
Western Australian Government Railways	15.0 per cent
Australian National Railways	12.5 per cent

In addition a special establishment grant of $1m was made in 1979-80, 50 per cent from the Commonwealth Government and 50 per cent from the State railways.

Total annual ARRDO funding currently amounts to $1.75m. In the past the State contributions have been eligible for inclusion in the TP&R Program and hence for Commonwealth financial support. With the cessation of this program the Commonwealth is providing a direct contribution of $770 000 in 1981-82. It is understood that the four State railways are contributing a similar amount, with Australian National maintaining some 12.5 per cent of total ARRDO funding.

ARRDO's initial role was the development of a program of research to determine administrative, economic and technical planning strategies to improve the productivity and efficiency of the Australian railway systems, with particular emphasis on intersystem or national problems.

BUSINESS ENTERPRISES

The Australian Bureau of Statistics (ABS) surveyed the level and distribution of resources devoted to R&D activity by private enterprises in 1976-77 and by business enterprises in 1978-79. In the 1976-77 survey, public sector trading and financial enterprises (that is, those public sector enterprises which attempt to cover their costs of production by sales of goods and services) were included in the General Government Sector. In the 1978-79 survey conducted by the ABS, the Business Enterprise Sector replaced the Private Enterprise Sector of the 1976-77 survey, and the public sector financial enterprises were transferred from the General Government Sector to the Business Enterprise Sector in accordance with OECD guidelines. The amount of R&D expenditure on transport equipment that is involved in this transfer is double counted in this report, since it is also included under government expenditure. However, it refers only to the R&D component and not to the more general transport research expenditure, and is not considered to represent a significant source of error.

When the ABS reported the 1978-79 survey results, some tabulations included a comparison with the 1976-77 survey results, and in these cases the ABS adjusted the 1976-77 results to include data relating to public sector trading and financial enterprises. The 1976-77 figures were only included in Table 3.17 and not in Table 3.18 since the necessary adjustments for Table 3.18 were not reported by the ABS. These surveys were conducted at the request of the (then) Department of Science and the Environment (and its predecessor) as part of Project SCORE.

The tables and analyses in this section do not include data for the period 1973-74. Although the ABS carried out a similar survey covering 1973-74 for the (then) Department of Science in 1975, the transport equipment industry statistics have been subject to revision and would still appear to have a high degree of error associated with them. For example, the level of expenditure on research and development in the transport equipment industry was estimated to be $25.4m for 1973-74 with a standard error of $12.7m (ABS 1981b).

It was realised that a proportion of the R&D classification 'Services to Mining'[1] used in Project SCORE might be transport-oriented. However, a breakdown of the aggregate figure for this classification was not available, and no further details were available from other sources. Total R&D expenditures in this classification ('Services to Mining') were $3.6m in 1976-77 and $4.1m in 1978-79.

Information relating to the R&D efforts of the transport equipment industry is presented in Table 3.17, which shows that $14.6m was expended in 1976-77 on R&D in the transport equipment industry, and that this increased to $15.6m in 1978-79. It is interesting to note that whilst expenditure on R&D increased, total man-years

1. As noted in Chapter 1 the classifications used in reporting statistical R&D information for private enterprise are based on the ASIC codes. Comparisons between these and the socio-economic objectives used in reporting R&D details relating to public organisations are difficult to establish.

TABLE 3.17—RESOURCES EXPENDED ON R&D AND R&D INTENSITY IN THE TRANSPORT EQUIPMENT INDUSTRY, 1976-77 AND 1978-79

	Resources expended on R&D		R&D intensity		Industry R&D intensity	
Year ending 30 June	Expenditure ($'000)	Total R&D effort (man years)	Expenditure[a] (per cent)	Manpower[b] (per cent)	Enterprises[c] (per cent)	Manpower[d] (per cent)
1977	14.6	760.9	0.7	1.4	2.4	0.8
1979	15.6	601.0	0.8	1.3	2.5	0.6

a. Expenditure on research and development expressed as a percentage of the turnover of those enterprises that carried out research and development.
b. Man-years of effort expended on research and development as a percentage of the number of persons employed by those enterprises that carried out research and development.
c. Number of enterprises that carried out research and development as a percentage of the total number of enterprises in the industry.
d. Man-years of effort expended on research and development as a percentage of the number of persons employed by all enterprises in the industry.

Source: ABS (1981b).

associated with that effort decreased from 760.9 man years in 1976-77 to 601 man years in 1978-79. The 'intensity' of R&D in terms of manpower devoted to R&D as a proportion of total manpower in the enterprises, also decreased slightly during this period. This increase in expenditure combined with the decline in R&D effort in terms of manpower may be explained by rising labour costs and the decrease in the proportion of R&D expenditure on wages and salaries relative to capital items and other current works over the period. The proportion of wages and salaries in total R&D expenditure declined from 77.2 per cent in 1976-77 to 63.4 per cent in 1978-79. The percentage of expenditure that was classified as capital expenditure increased from 2.4 per cent to 8.1 per cent during the period, and the proportion of other current expenditure increased from 20.4 per cent to 28.5 per cent during the period. It would therefore appear that R&D in the transport equipment industry became more capital intensive during the period.

Table 3.18 shows the R&D expenditure by private industry as a whole on product classes relating to transport equipment for 1978-79. Comparative information was not available for 1976-77. The total expenditure figures are greater than the aggregates shown in Table 3.17 since they include contributions from enterprises not classified as 'transport industry'. Research and development expenditure on motor vehicles and parts was the most significant source of expenditure in the transport equipment industry, representing 90 per cent of R&D expenditure. This is, perhaps, not surprising given the dominance of the car and car parts industry in the transport equipment manufacturing field in Australia. Approximately 6.5 per cent of the research and development expenditure in these product classes is on railways, rolling stock and locomotives.

TABLE 3.18—R&D EXPENDITURE ON TRANSPORT EQUIPMENT BY PRODUCT CLASS, 1978-79

($'000)

Product class	Expenditure
Motor vehicles and parts	17 411
Ships and boats	256
Railway rolling stock, locomotives	1 249
Aircraft	216
Other transport equipment	205
Total transport equipment	19 337

Source: ABS (1981b).

Data on the payments by business enterprises for technical knowhow are shown in Table 3.19. The data can be considered as providing an indication of the value of purchases and sales of knowledge arising from previous research and development activities. The data show that, in 1978-79, over 98 per cent of payments made for technical knowhow by transport equipment businesses were made to overseas companies and over 94 per cent of this amount was to companies that were related to the Australian enterprise.

These overseas payments by the Australian transport equipment industry for what may be called 'technology transfer' amounted to about $10m in 1978-79, and was $3m more than the overseas payments made in 1976-77.

TABLE 3.19—PAYMENTS FOR TECHNICAL KNOWHOW AND PATENT LICENCE ROYALTIES BY THE AUSTRALIAN TRANSPORT EQUIPMENT INDUSTRY FOR 1976-77 AND 1978-79

Description	*Year ending 30 June*	
	1977	*1979*
Number of enterprises making payments	16	19
Total payments ($m)	7.1	10.1
Proportion (per cent) of payments for—		
patent licence payment and royalties	na	16.2
other technical knowhow	na	83.8
Proportion (per cent) of payments within Australia	na	1.3
Proportion (per cent) of payments made overseas	na	98.7
Proportion (per cent) of overseas payments made to—		
a related enterprise	na	94.5
an unrelated organisation	na	5.5
Proportion (per cent) of overseas payments made to—		
United Kingdom	na	3.4
United States of America	na	15.0
Other overseas	na	81.6

Source: ABS (1981b).

The national public enterprises Qantas, Trans Australia Airlines, Australian National (railways) and Australian National Line are members of the group of public sector trading and financial enterprises. In informal discussions with these organisations it appeared that they incur minimal expenditure on R&D, although they have some involvement with R&D-related activities. However, expenditure on these activities is not explicitly identified in the organisations' accounts[1] and so it is not possible at this stage to report the levels of expenditure involved.

From the discussions to which reference was made above, it appeared that the aggregate expenditure on transport research by the public enterprises is currently of the order of $1.8m[2]. Since this is predominantly on R&D-related activities rather than on R&D, it is not included in the expenditure figures reported in Tables 3.17 and 3.18.

PRIVATE NON-PROFIT ORGANISATIONS

The private non-profit organisations surveyed in 1976-77 by the ABS for Project SCORE reported an expenditure of only $35 000 on transport R&D, which was drawn entirely from State Government funds. The primary emphasis of this R&D related to

1. With the exception of Australian National's contribution to ARRDO.

2. Excluding Australian National's contribution to ARRDO of $0.2m.

road safety, essentially in the engineering sciences although some funds were spent for biological studies. The extent of R&D-related activities expenditure in this sector is not known.

The organisations surveyed in the private non-profit sector in Project SCORE which had transport interests included the motorists' associations, the Australian Academy of Science, the Australian Institute of Urban Studies, the National Safety Council of Australia, the Australian Road Federation, and major Local Government Authorities. Only two of these reported any internal R&D.

It appears that professional associations such as the Chartered Institute of Transport, the Institution of Engineers Australia and the Society of Automotive Engineers were not included in the Private Non-profit sector for Project SCORE. Hence transport R&D expenditure for this sector does not include any expenditure incurred by these bodies.

It is known that professional associations with a transport interest sometimes perform or sponsor work that falls within the definition of transport research used in this study. No estimate of expenditure incurred in these activities is available. However, any such estimate would not be an appropriate measure of resource cost due to the significant voluntary component from members of the associations.

HIGHER EDUCATION

The higher education sector covers tertiary institutions in Australia. The more detailed information on transport R&D in this section was obtained primarily from Project SCORE (DSE 1980) for the academic year 1976. Comparable figures for 1973 on transport R&D were not available from Project SCORE, 1973-74. The higher education sector results for transport R&D from Project SCORE 1978-79 have not yet been published in any disaggregated form.

In 1978 the internal research expenditure[1] in all areas by the higher education sector was $254m (ABS 1982), an absolute increase of some $69m over the 1976 level of expenditure, which also represents an increase in real terms. However, the 1976 level of expenditure was only $42m more than the 1973 level, a decrease in real terms.

Research in tertiary institutions was funded primarily by the Commonwealth Government, as is shown in Table 3.20. In each of the years 1973, 1976 and 1978 the Commonwealth Government funded 95 per cent of all research performed by Australian tertiary institutions. Funding details are not supplied in Table 3.20 for 1978 since they are not published in a form in ABS (1982) that is comparable with the earlier data. The 1978 figures by funding source include overheads whereas the earlier figures do not. As a proportion, expenditure on transport R&D in 1978 was 0.7 per cent of total R&D expenditure (with overheads included) which was the same as in 1976 (with overheads excluded).

Table 3.20 also shows that in 1976 most of the transport R&D in the higher education sector was funded by the Commonwealth Government.

There are several units or schools in the higher education sector specialising in transport. These include the University of New South Wales, University of Tasmania, Royal Melbourne Institute of Technology and Caulfield Institute of Technology.

Project SCORE (DSE 1980) reports that of the 10 460 man-years performed in 1976 in natural science research by the higher education sector, less than one per cent of this was performed in transport R&D. In the social sciences field only 0.4 per cent of the total social sciences research performed was related to transport. In 1976 a total of 104 man-years were devoted to transport R&D in both the natural and social sciences.

The higher education sector transport R&D expenditure for the year 1976 is presented by socio-economic objective in Table 3.21.

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1. Excluding overheads.

TABLE 3.20—EXPENDITURE ON TRANSPORT R&D, AND ALL R&D, IN THE HIGHER EDUCATION SECTOR BY SOURCE OF FUNDING, 1973 AND 1976

($'000)

Year	Category	Source of Funds: Commonwealth	State government	Private enterprise	Private non profit	Overseas	Total
1973	All areas[a]	133 872	1 275	4 250	1 700	567	141 663
1976	All areas	174 377	2 212	1 843	5 161	737	184 330
	Transport[b]	1 211	11	8	30	2	1 261

a. Figures for the transport socio-economic objective were not available for 1973.
b. This category represents the aggregate of all of the socio-economic objectives related to transport R&D.
Source: DSE (1980).

TABLE 3.21—INTRAMURAL TRANSPORT R&D EXPENDITURE IN THE HIGHER EDUCATION SECTOR BY OBJECTIVE, 1976

Socio-economic objective	Amount ($'000)	Proportion (per cent)
Air transport	45	4
Sea transport	89	7
Road accidents and safety	418	33
Other road	350	28
Rail	87	7
Multimodal transport	126	10
Intermodal materials handling	17	1
Other transport	129	10
All transport	1 261	100

Source: DSE (1980).

The proportional breakdown shows that some 60 per cent was devoted to road research activities with R&D relating to air, sea and rail transport individually representing less than 10 per cent.

The Commonwealth Government has several grant schemes, other than general university funding, which provide funds for research and development in the higher education sector. Of these it would appear that the Australian Research Grants Scheme would have the most relevance to the funding of transport research. Transport research projects are included in this scheme in various engineering, humanities, economics and social science categories. The grants in 1981 which related to transport that were approved under this scheme amounted to over $170 000. This represents approximately one per cent of the total research funds made available through this scheme.

SUMMARY OF CURRENT FUNDING ESTIMATES

As noted in the previous discussion, there are substantial data problems in estimating the current level of transport research funding. Up-to-date information is not available in some sectors, and expenditures in the private sector and the higher education sector refer only to R&D activities.

There are also problems associated with reconciling funding and expenditure levels in the various sectors, particularly where financial transfers occur across sectors. Essentially this difficulty in reconciliation is associated with the limited financial information published for both the distributors of funds and the recipients of these

funds. This information tends to be produced by different agencies, often applying varying classification criteria. For example, although information on funding through IR&D Grants or NERDD Program grants is available from the AIRDIB and DNDE respectively, the actual expenditure of these funds is subsumed in the expenditure information for the private sector reported by Project SCORE. Hence in developing overall aggregates for transport research funding, certain broad assumptions have to be made concerning the flows of funds, and the manner in which these flows are represented in the published information sources.

In aggregate terms Commonwealth funding of transport research in 1980-81 amounted to $31.3m. This includes funding through CSIRO, direct and indirect grants to ARRB and ARRDO, funding of the higher education sector transport R&D[1], some funding of private sector transport R&D through the IR&D Program[2] and grants under the NERDD Program in the area of transport-related energy conservation. It excludes an estimated $3.8m in grants under the NERDD Program for synthetic fuel technology.

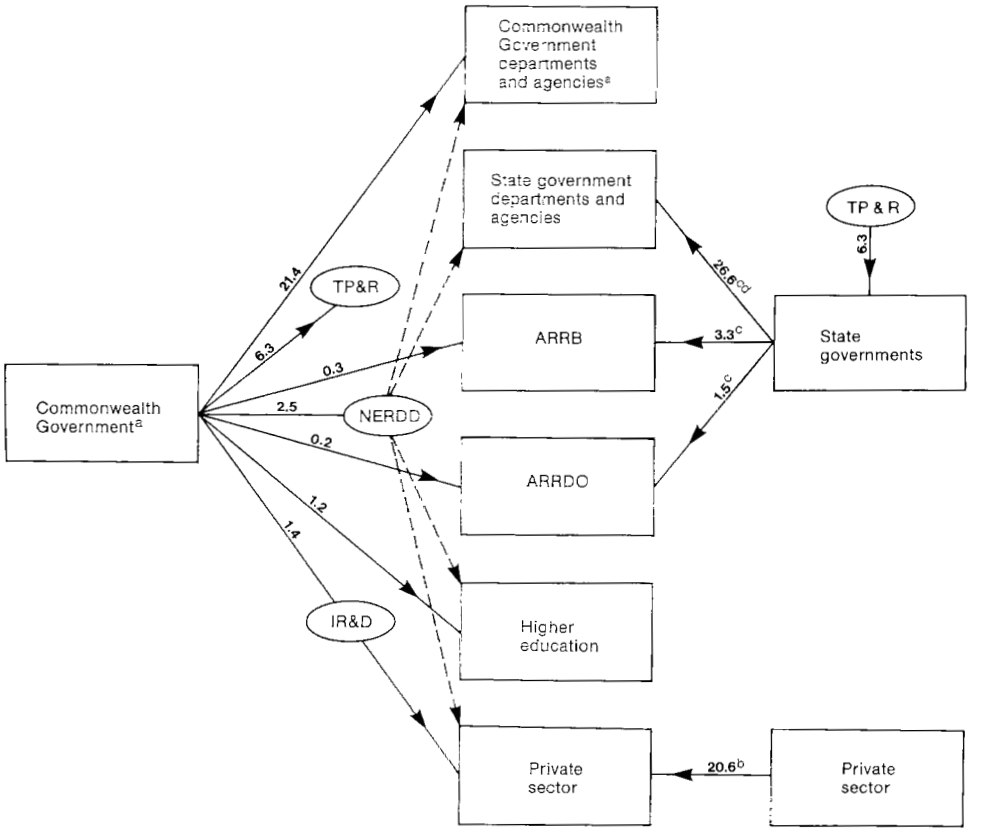
The States were estimated to provide a total of $24.8m from their own resources for transport research in 1980-81[3]. The private enterprise sector funding estimate of $18.0m refers to 1978-79 and to R&D in the transport equipment industry. An additional $2.6m was provided by this sector in 1979-80 for R&D in the context of conservation of energy associated with transport, which also attracted $2.2m from the government sector (including $1.9m under the NERDD Program in that year).

The national public enterprises involved in transport operations were estimated to have spent $2.0m on transport research in 1980-81 from their own resources.

It is acknowledged that local government sponsors and performs activities that fall within the ambit of transport research, predominantly in the area of R&D-related activities. The TP&R Program included some funding of projects with local government involvement although the funding levels involved were relatively low. It is recognised that, overall, local government authorities probably contribute significant resources to survey and planning aspects of urban and rural development. Some of this activity involves transport research in the general sense, but this component is difficult to identify. Unfortunately no published estimates of local government expenditure in this area are available and it is believed that considerable difficulties would be encountered in any attempt to identify this expenditure. Accordingly, the majority of local government expenditure on transport research has not been included in this report.

Summing the sector estimates and including an additional $2.4m for port and marine research, an aggregate national funding estimate of $81.4m can be obtained. This may be taken as a lower bound for transport research funding in 1980-81. It includes some unadjusted figures for research expenditures in previous years where the 1980-81 figures were not available, and includes only the R&D component in the private enterprise and higher education sectors. In addition, this aggregate figure excludes funding of research on synthetic fuels estimated at $3.8m. The major funding flows are identified in Figure 3.1. This is a simplified representation in which some of the more detailed funding arrangements referred to above are aggregated for reasons of clarity.

1. Funding transport R&D in the higher education sector refers to 1976-77.
2. Funding through the IR&D Program refers to 1979-80.
3. This does not include port and marine research, which has been estimated to amount to some $2.4m in 1980-81, although this estimate is subject to a considerable degree of uncertainty.



a. Includes national public transport enterprises.

b. Expenditure refers to the R&D component of transport research (see text for definitions of these terms) for the year 1978–79

c. Includes funds provided through the TP&R Program

d. Includes $0.3m for transport related energy conservation

Figure 3.1
Major transport research funding flows
($m)

CHAPTER 4—CONSIDERATIONS OF EFFECTIVENESS AND EFFICIENCY

This chapter discusses some considerations related to the effectiveness and efficiency of transport research activities in Australia.

The terms 'effectiveness' and 'efficiency' are discussed in the context of the areas of interest of the study. The measurement problems are outlined, and an analysis of the TP&R Program is presented to illustrate these considerations in the public sector. In order to develop a similar picture for the private sector, an examination of patent statistics is presented. One of the points to emerge in this general analysis is the important role of information exchange, and this topic is explored with reference to recent changes in the funding arrangements for transport research. The chapter concludes with some limited international comparisons.

CONCEPTS OF EFFECTIVENESS AND EFFICIENCY

The effectiveness of a research program is the degree to which it achieves its goals. It is important to distinguish effectiveness from efficiency. The concept of efficiency is related to both the output or results of a research program and the resources (funding, manpower) occupied in producing those results.

The concepts of effectiveness and efficiency generally overlap. It is usual for a research program to be subject to resource constraints, so that an effective program (one that achieves its goals) has to be efficient as long as the resource constraints actually do limit research program activity. This may not always be the case. For example, a research activity may attract such a high level of funding and manpower that it is, in effect, unconstrained. This could lead to an effective program that is not efficient. Similarly, if the output, or result, of a program is measured in terms of the degree to which its goals have been achieved, an efficient program must by definition be effective, at least to some degree.

In the case of transport research, the output would be expected to represent ultimately some beneficial change to the transport system, or to its administration. This benefit may be achieved through reduced costs, increased accessibility, savings in travel time, reductions in the numbers of traffic accidents, improved aesthetics and environment, and so on. Techniques are available for ascribing monetary measures to many of these benefits, but these techniques are only satisfactory to a limited extent. It is to this extent that transport research may be amenable to forms of benefit-cost analyses.

However, there are also several problems associated with the identification of benefits of transport research. These problems can be illustrated by one or two examples. A particular research investigation may show that the adoption of a proposal requiring financial expenditure would not be cost-effective. Questions then arise as to whether the benefits of this investigation should be quantified as the net costs foregone in not adopting the proposal, or the value of the resources in other applications. Furthermore, such quantification assumes that without the investigation the proposal would have been initiated. In addition, it is often the case that the same piece of research may have different goals at different levels of management. An administrator may view the effectiveness of a research program entirely differently from the researcher. One part of a research project may be effective in itself but the project as a whole may not achieve its goals.

Considerations such as those presented above clearly cause significant difficulties in quantifying the levels of efficiency and effectiveness of research activities. A considerable volume of literature exists, devoted to the methods of assessing the value of research. Unfortunately, none of this literature appears to be very pertinent in the present context.

Notwithstanding these difficulties, reports that discuss transport research programs (at least in the United States) tend to suggest that benefits far exceed costs, with benefit-cost ratios of approximately 9 to 1 (Peterson 1979).

A number of methods have been used to measure research effectiveness and Peterson (1979) provides the following list of effectiveness measures typical of those which have been used in other analyses:

- the number of reports published in trade magazines;
- the number of awards;
- the number of studies implemented;
- the percentage of studies implemented;
- the overall benefit-cost ratio of the study;
- the number of implementation packages;
- the improvements in operations resulting from research;
- the percentage of research results adopted by others through technology transfer; and
- the size of the research budget.

The overall benefit-cost ratio mentioned in this list could also be considered to be an efficiency measure. With the exception of the final measure shown, the other measures may be converted to forms of efficiency measure by dividing by research program cost. However, as Peterson (1979) points out, some of the above measures 'would not be very meaningful to a highway or transportation administrator who is primarily concerned with getting problems solved'.

An approach has been developed which relates research programs to the advancement or implementation of an organisation's policy. An example of this approach is given by Roberts and Stein (1976) who describe it as a synthesis of management science techniques and system dynamics. It consisted of constructing a so-called Policy Interaction Potential (PIP) Index to evaluate both the projects and the overall program containing them. While it may be possible to carry out an analysis of the Australian effort in transport research along these lines, such an approach appears to be more appropriate to the research programs of individual organisations. At this stage the usefulness of this empirical measure has not been assessed in terms of its applicability to measurement of research efficiency and effectiveness.

In general, a large amount of information is required to produce any reasonable economic measure of the effectiveness and efficiency of transport research. This information may be available for particular programs in some organisations, and indeed it may be argued that effective research management requires this information in any case for systematic program evaluation. It would clearly be a huge task to gather this information (even if it existed) for every transport research program in Australia. Accordingly, the TP&R Program has been selected for analysis, to the level of detail justified by the records available on the individual research projects. It is recognised that this is a far from comprehensive approach, but since the Program covered all States and a variety of transport agencies it is considered to be the most practical approach possible in the present study.

TP&R PROGRAM

The Transport (Planning and Research) Act 1974 applied from the financial year

ending 30 June 1975 to the financial year ending 30 June 1977 (inclusive). Under this Act, Commonwealth financial assistance was made available to the States for planning and research in relation to roads and urban transport on a $2 for $1 matching basis. Funds were appropriated that specifically covered a three year period. Following the expiry of this Act, the Transport Planning and Research (Financial Assistance) Act 1977 was enacted. Under this latter Act, Commonwealth funds were provided annually to the States on a $2 for $1 matching basis in 1977-78 and on a $1 for $1 basis thereafter. The scope of the program was broadened to encompass all forms of land transport and the interface between land and other transport modes. Commonwealth financial assistance to the States under this Act was terminated from 30 June 1981 following a recommendation of the Review of Commonwealth Functions, although provision was made in the 1981-82 Budget for the continuation of Commonwealth financial assistance to ARRB and ARDDO.

The project and project expenditure data presented in this section were derived from the TP&R Program Reports (DoTA 1982 and earlier issues) by aggregating reported actual project expenditures. The resulting aggregations do not exactly correspond to the TP&R Program allocations in each year because the differences between actual and estimated project expenditures resulted in overspending or underspending on individual projects. Any aggregate overspending on a particular agency's projects would have been funded from State government sources.

In carrying out the analysis of the TP&R Program, each project was classified under a Project SCORE socio-economic objective. This classification was carried out by the BTE from the reported project descriptions. As with most exercises of this nature there is inevitably an element of subjectivity in this classification because of a degree of overlap between categories. Each project was assigned only one objective, although different aspects of some projects could refer to more than one objective.

The objective 'road safety' was assigned to all projects which were concerned explicitly with any facet of road safety, irrespective of other project objectives. Projects dealing exclusively with other aspects of road transport were assigned the objective 'other road', and similarly those dealing exclusively with rail transport were assigned the objective 'rail'. The objective 'multimodal transport' was assigned to projects which identified areas of concern including two or more modes of transport. Projects relating specifically to the transfer of materials from one mode of transport to another were assigned the objective 'intermodal materials handling'. The objective 'other transport' was assigned to projects not elsewhere classified. There were three types of projects in this category: those dealing with other modes of transport such as bicycles, ferries, or facilities for pedestrians; those dealing with the internal affairs of transport authorities such as capital works expenditure, training of staff, or the introduction of flexible working hours; and those projects not directly associated with any mode of transport, which included such projects as modelling of river floods and urban area economic development studies.

Furthermore, the objective 'other road' was sub-divided into 'vehicles', 'economics/policy', 'materials/construction', 'environment' and 'energy' for additional analysis. The category 'vehicles' included projects examining design and construction of vehicles, vehicle parts, or performance testing. The 'economics/policy' category included feasibility studies and projects dealing with fare structures, surveys and statistics, demand modelling, and cost-benefit analysis. Studies concerned with the physical aspects of roads, road furniture or bridges were assigned 'materials/construction'. The category 'environment' included noise and vehicle emissions studies, social impact studies, and projects dealing with landscape damage associated with roadworks. Projects concerned with alternative fuels and fuel conservation studies were included in the category 'energy'.

The TP&R Program analysis starts with a description of the funding pattern and its change over time. The number of projects and average project cost in each socio-economic objective, and a related measure of output (number of reports) are used to

provide indicative measures of effectiveness and efficiency.

Estimated TP&R expenditure in each socio-economic objective by year is shown in Table 4.1. These figures refer to expenditure within State agencies only (or contracted externally by the State agencies), and so contributions to ARRB, NAASRA and ARRDO are excluded.

TABLE 4.1—TP&R EXPENDITURE[a] BY SOCIO-ECONOMIC OBJECTIVE IN CURRENT TERMS, 1974-75 TO 1980-81

($'000)

Socio-economic objective	*Year ending 30 June*						
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*
Road accidents and safety	582	747	754	777	700	922	968
Other road	5 786	8 665	6 076	7 812	6 292	7 342	9 422
Rail	141	709	540	805	1 522	1 608	1 161
Multimodal transport	871	1 780	1 787	2 300	1 740	1 046	945
Intermodal materials handling	—	—	—	38	12	6	11
Other transport	29	133	91	418	340	1 149	460
Total transport[b]	7 409	12 034	9 248	12 151	10 605	12 074	12 967

a. Excluding contributions to ARRB, NAASRA and ARRDO.
b. Columns may not add to totals due to rounding.

The same information deflated by an index based on the average male wage is provided in constant (1976-77) prices in Table 4.2.

TABLE 4.2—TP&R EXPENDITURE[a] BY SOCIO-ECONOMIC OBJECTIVE IN REAL TERMS, 1974-75 TO 1980-81

($'000 1976-77 prices)

Socio-economic objective	*Year ending 30 June*						
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*
Road accidents and safety	746	839	754	706	593	710	654
Other road	7 418	9 736	6 076	7 102	5 332	5 648	6 366
Rail	181	796	540	732	1 289	1 237	785
Multimodal transport	1 117	2 000	1 787	2 091	1 474	805	638
Intermodal materials handling	—	—	—	35	10	4	8
Other transport	37	150	91	380	288	884	311
Total transport[b]	9 499	13 521	9 248	11 046	8 987	9 287	8 762

a. Excluding contributions to ARRB, NAASRA and ARRDO.
b. Columns may not add to totals due to rounding.

The total annual TP&R expenditure by the States (including the Commonwealth contribution) has followed an increasing trend in current terms with some fluctuations, and remained within + 11 per cent of the mean in real terms.

The most significant change exhibited in the tables is the increase in expenditure in the rail and other transport categories from the year ended 30 June 1978 onwards. This appears to be a reflection of the provision to include a greater range of projects in these categories under the 1977 Act. In each year the majority of the States' TP&R expenditure was in the category 'other road'. This comprised approximately two-thirds of total expenditure on projects approved for funding under the TP&R Program. Hence for the purpose of an analysis of TP&R expenditure, the Project SCORE socio-economic objective 'other road' is too broad. Tables 4.3 and 4.4 show TP&R expenditure in this category subdivided into expenditure on road vehicles, economic or policy studies associated with roads, road materials/construction, road environmental studies, and energy-related studies associated with road transport.

TABLE 4.3—TP&R EXPENDITURE IN CATEGORY 'OTHER ROAD' IN CURRENT TERMS, 1974-75 TO 1980-81

($'000 current terms)

Category	*Year ending 30 June*						
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*
Vehicles	34	305	209	232	92	39	73
Economics/policy	4 229	6 015	4 030	5 276	4 049	4 839	6 964
Materials/ construction	1 443	2 024	1 747	2 161	1 956	2 143	2 091
Environmental studies	80	321	90	121	148	141	157
Energy	—	—	—	23	46	180	137
Total 'Other road'[a]	5 786	8 665	6 076	7 812	6 292	7 342	9 422

a. Columns may not add to totals due to rounding.

TABLE 4.4—TP&R EXPENDITURE IN CATEGORY 'OTHER ROAD' IN REAL TERMS, 1974-75 TO 1980-81

($'000 1976-77 constant prices)

Category	*Year ending 30 June*						
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*
Vehicles	44	343	209	211	78	30	49
Economics/policy	5 422	6 758	4 030	4 796	3 432	3 722	4 706
Materials/ construction	1 850	2 274	1 747	1 964	1 658	1 648	1 413
Environmental studies	103	360	90	110	125	109	106
Energy	0	0	0	21	39	138	92
Total 'Other road'[a]	7 418	9 736	6 076	7 102	5 332	5 648	6 366

a. Columns may not add to totals due to rounding.

As noted previously, the above tables refer to expenditure within State agencies (including work contracted out by the agencies to higher education institutions and consultants), and so contributions to ARRB, NAASRA and ARDDO were excluded.

The contributions to ARRB, NAASRA and ARDDO through the TP&R Program are shown in Table 4.5.

TABLE 4.5—CONTRIBUTIONS TO ARRB, NAASRA, AND ARRDO THROUGH THE TP&R PROGRAM, 1974-75 TO 1980-81

($'000 current terms)

Organisation	*Year ending 30 June*						
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*
ARRB	1 432	1 630	2 148	2 312	2 585	2 550	3 164
NAASRA	537	320	181	127	129	22	0
ARRDO	0	0	0	131	514	665	1 299
Total	1 969	1 950	2 329	2 570	3 228	3 237	4 463

The major indicative measures of the effectiveness and efficiency of the TP&R Program explored here are the average project cost and reports produced per unit of expenditure for each socio-economic objective[1]. Another indication of effectiveness is the coverage of the program in relation to identified areas of need. Without explicit statements of needs it is difficult to pursue this measure. However, as noted previously, there was a significant increase in expenditure in the categories of rail and other transport following the broadening of the program in 1977 which indicates that from a Commonwealth perspective changing perceived needs were being addressed. Table 4.6 shows the annual number of projects funded through the TP&R Program (excluding ARRB, NAASRA and ARRDO projects) by socio-economic objective. The tables containing data referring to effectiveness and efficiency measures do not contain separate entries for projects judged to be R&D since they relate to the TP&R Program as a whole. The socio-economic objective 'other road' is divided into its previously defined components for more meaningful tabulations.

From Table 4.6 it can be seen that the increased expenditure on rail and other transport after 1977 (noted previously) corresponded with a significant increase in the number of projects in these areas.

Again the qualification should be noted that, in this analysis, each project was assigned to only one objective although different aspects of a project could be relevant to more than one objective.

Although average project cost may be considered as a measure of efficiency, it is not a very satisfactory measure in this case. The size and complexity of projects funded through the TP&R Program varied over a considerable range, tending to detract from the usefulness of this measure. However, it is one of the few measures which can be applied in the present situation, and hence average project cost information, in real terms, is given in Table 4.7.

In interpreting Table 4.7 in an efficiency context it is less valid to compare average costs among transport categories (objectives) than among different years in the same category since the nature of the results of research across the various categories will obviously differ quite widely.

The major point to note from Table 4.7 is that there is no clearly discernable trend in real

1. Expenditure data relating to effectiveness and efficiency measures are provided in real terms for the TP&R Program.

average project costs across all categories. The increase in average real project costs in the category 'other transport' is likely to be associated with the broadening of the Act in 1977. Projects in the category 'Other road—environmental studies' showed decreasing real average costs, although in some years the number of projects was quite small, thus decreasing the significance of this result. However it is also possible that the period of the TP&R Program may have seen the evolution and standardisation of environmental study techniques, reducing unit costs. This may be viewed as an efficiency gain, but it does, of course, assume some constancy of output.

TABLE 4.6—DISTRIBUTION OF TP&R PROJECTS, 1974-75 TO 1980-81

(number of projects)

Socio-economic objective	*Year ending 30 June*							*Total*
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	
Road accidents and safety	21	36	24	24	20	24	28	177
Other road vehicles	3	7	4	5	2	1	4	26
economics/ policy	104	132	94	89	62	69	77	627
materials/ construction	103	106	86	64	64	55	43	521
environmental studies	10	11	7	7	10	10	10	65
energy	—	—	—	1	1	5	4	11
Rail	14	37	24	40	58	62	44	279
Multimodal transport	16	40	34	37	29	27	29	212
Intermodal materials handling	—	—	—	1	1	2	2	6
Other transport	3	12	7	15	16	23	12	88
Total transport	274	381	280	283	263	278	253	2 012

The measurement of project output is, as mentioned previously, fraught with difficulties. There are, in addition, different levels at which project output can be considered. For example, the results of a project can take the form of research reports and recommendations, or the resulting policy changes, flowing from such reports. Again different organisational and managerial strata can be associated with the different forms of output of a project. Without detailed information regarding policy changes, expenditure in relation to output for the TP&R Program can only be assessed at the research level, and the average report cost was selected as the most appropriate of (once again) a generally unsatisfactory set of measures.

Certain caveats must be emphasised in relation to the interpretation of this particular measure. It is understood that documented TP&R project information is incomplete, particularly for the earlier years of the Program. Some projects may have produced one major report, others a plethora of minor reports, and some projects may not have produced any formal reports, even though the results from these projects may well have represented significant contribution to policy determination.

TABLE 4.7—AVERAGE ANNUAL TP&R PROJECT COSTS IN REAL TERMS, 1974-75 TO 1980-81

($'000 1976-77 prices)

Socio-economic objective	*Year ending 30 June*							*All years*
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	
Road accidents and safety	36	23	31	29	30	30	23	28
Other road vehicles	15	49	52	42	39	30	12	37
economics/ policy	52	51	43	54	55	54	61	52
materials/ construction	18	21	20	31	26	30	33	24
environmental studies	10	33	13	16	13	11	11	15
energy	a	a	a	21	39	28	23	26
Rail	13	22	22	18	22	20	18	20
Multimodal transport	70	50	53	57	51	30	22	47
Intermodal materials handling	a	a	a	35	10	2	4	10
Other transport	12	12	13	25	18	38	26	24
Total transport	35	35	33	39	34	33	35	35

a. No expenditure was incurred on projects in this classification for this year.

Taking these points as noted, average report costs by transport category are shown in Table 4.8[1].

Although there are considerable fluctuations from year to year in average report costs, these fluctuations must be viewed in the context of the number of projects classified to a particular category in a given year (Table 4.6). Perhaps the most remarkable aspect illustrated by Table 4.8 is that the average real costs of research reports in the various categories analysed are reasonably similar overall. The comparatively high average costs associated with reports in the category 'Other road—economics/policy' probably reflects the situation that formal reports may not always have been published, rather than that this research field is relatively 'inefficient'. Reports on many such studies may well have been directed specifically at the transport management immediately concerned rather than to the general transport community. It does appear that, overall, average real report costs have tended to decline, with costs for the last three years (shown in Table 4.8) being below the seven-year average for all transport categories combined. Hence, according to this criterion, there is some evidence of an improvement in overall transport research efficiency.

One further point should be made about the average report costs shown in Table 4.8. The number of reports associated with each project for each year was determined by reference to the individual annual project records published in the TP&R Program

1. Average report costs for each year were calculated as follows. Expenditures shown in Tables 4.2 and 4.4 were divided by the estimated number of reports associated with that expenditure. The numbers of reports associated with project expenditure in a financial year was based on their publication dates (when known) or on the date of the TP&R Program *Report identifying them.*

TABLE 4.8—AVERAGE TP&R PROJECT REPORT COSTS IN REAL TERMS, 1974-75 TO 1980-81

($'000 1976-77 prices)

Socio-economic objective	*Year ending 30 June*							*All years*
	1975	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	
Road accident and safety	124	31	42	39	37	20	21	33
Other road vehicles	6	57	30	26	78	[a]	25	31
economics/ policy	65	125	44	77	52	50	50	60
materials/ construction	15	20	33	35	20	26	40	23
environmental studies	9	19	13	16	42	8	27	15
energy	[a]	[a]	[a]	[a]	[a]	69	46	73
Rail	26	66	90	39	18	41	17	29
Multimodal transport	80	54	149	70	28	37	35	53
Intermodal materials handling	[a]	[b]	[a]	17	[a]	[a]	2	8
Other transport	37	50	91	95	26	37	52	43
Total transport	37	49	47	54	30	35	37	40

a. No reports identified in the TP&R Program Report.
b. No expenditure identified in the TP&R Program but a report was identified for this year.

Reports (DoTA 1982 and earlier issues). As mentioned previously, each project was allocated to a Project SCORE socio-economic objective, and further to one of a set of sub-categories in the case of the objective 'other road'. The total number of reports and the total expenditure for each objective were then used to calculate the average report costs for each objective for each year. However, DoTA have published a list of final and interim reports that were provided to DoTA in compliance with the requirements of the Transport Planning and Research Legislation (DoTA 1980), and many reports listed in the individual project records are not on this list. If the information in DoTA (1980) is used, average report costs two to three times higher than those in Table 4.8 are obtained. This discrepancy underlines the uncertainties associated with information in this area, and should be noted when considering the international comparisons reported later in this chapter.

The TP&R Program was concerned with public sector research, which is generally aimed towards influencing transport policies associated with the provision of public goods and the operation of public utilities. The only readily available research data in the private sector, as mentioned in Chapter 3, refers to the manufacturing industries where research is generally directed towards new products and processes. In this context some indication of research output may be gained from information relating to patents. The balance of technological payments provides an indication of overseas R&D imported, and hence a perspective in which to view Australian innovative effort as evidenced by the patents information. These topics are explored in the next section.

ANALYSIS OF PATENT STATISTICS

The balance of technological payments is a measure that may give some indication of the technological situation of a country at an international level, and therefore an indication of the output of its R&D expenditure (OECD 1976).

As each country will wish to 'import' some results of R&D performed elsewhere, the payments for patents, licences and technical knowledge give a measure, imperfect as it may be, of the transfers of research results and technical knowledge at an international level.

It has only been possible for data on the payments for patents, licences and technical knowledge to be presented in a limited form for this report. This information was presented in Table 3.19 in the previous chapter. Furthermore, some indicative information on the letters patent sealed for the 'transporting' category[1] and on the domicile of applicants for patents has been compiled. Table 3.19 revealed that enterprises in the transport equipment industry paid over $10m in 1978-79 for technical information or 'knowhow'. This increased from nearly $5m in 1976-77. In total, Australia's private enterprises expended over $130m for technical information in 1978-79. In this period, Australia's private enterprises received some $15.3m for technical information (ABS 1981b).

Of the total payments made by transport equipment enterprises for technical knowledge, over 98 per cent were to overseas countries in 1978-79, mainly to the United States of America.

Table 4.9 shows the total letters patent sealed for each year from 1973 to 1979 and the proportion of these that were classified as 'transporting'. The table shows that the proportion of letters patent sealed that are classified as 'transporting' has remained fairly constant over the period.

Table 4.10 shows the percentage of applicants for letters patent from various countries of domicile for the years 1976 to 1979. The table shows that until 1979 less than one-third of the applicants for letters patent were from Australia. It can also be noted that approximately an equal proportion of applicants were from the United States as from Australia. Informal advice received from the Patent, Trade Marks and Designs Office indicates that the proportion of applicants from Australia increased by about eight per cent to 41.3 per cent in 1980. Although the table does not show the proportion of patent applications made by Australians in other countries it does indicate the extent to which Australia relies on imported technical information.

TABLE 4.9—LETTERS PATENT SEALED IN AUSTRALIA AND THE PROPORTION CLASSIFIED AS 'TRANSPORTING', 1973 TO 1979

Year	*Total letters patent sealed*	*Proportion 'transporting' (per cent)*
1973	11 670	9.0
1974	12 828	9.7
1975	12 161	8.9
1976	11 074	8.9
1977	9 626	9.9
1978	9 038	9.4
1979	6 513	8.6

Source: Patent, Trade Marks and Designs Office (1980 and earlier issues).

1. The 'transporting' objective under the International Patent Classification (IPC) includes vehicles, railways, ships and other waterborne vessels and related equipment, aircraft and aviation, conveying, hauling and handling. This classification system again differs from the two systems mentioned previously—the OECD socio-economic objectives and that based on the ASIC. Unfortunately, there is no direct compatibility between the IPC and either of the other two systems. However it appears that the OECD's 'transport' objective encompasses the IPC's 'transporting' category which is largely equipment oriented.

TABLE 4.10—DOMICILE OF APPLICANTS FOR LETTERS PATENT IN AUSTRALIA, 1976 TO 1979

(per cent)

Year	Country						
	Total number	Australia	United States	United Kingdom	Japan	West Germany	Other
1976	14 117	30.6	40.6	8.3	6.6	6.5	17.4
1977	14 246	30.6	31.9	7.8	6.4	6.5	16.8
1978	14 131	32.3	30.3	7.7	6.0	6.1	17.6
1979	14 640	32.4	30.1	7.3	7.0	6.5	16.7

Source: Patents, Trade Marks and Designs Office (1980 and earlier issues).

INFORMATION ISSUES

Another issue associated with the effectiveness and efficiency of transport research relates to transfer of information on the nature of the research being carried out. This impacts in basically two ways. Firstly, a knowledge of the type of work being undertaken by other agencies can avoid unnecessary duplication. Secondly, methodologies and results are frequently useful to the work of agencies not previously concerned with transport matters. This is often referred to as 'technology transfer'. The information issues are explored in this section.

The diversity of funding sources and arrangements and the similar diversity of the organisations carrying out transport research is evident from previous chapters of this report. To some extent this is a reflection of the fragmented nature of transport administration and the wide range of activities and diversity of interests encompassed by transport. Information on transport research in Australia is also fragmented and largely unco-ordinated. This section briefly describes the main data sources employed for this study and points out the major gaps in the available information. An outline of developments in transport information systems is then presented.

Data Sources and Limitations

The main sources of information from which this report has been compiled are:

- the Transport Planning and Research Program annual progress reports;
- published data from Project SCORE and the ABS;
- the Science and Technology Statement;
- annual reports and research reports of various organisations; and
- State Government agencies.

As indicated previously in this chapter none of the sources of information could provide a direct measure of efficiency or effectiveness. The Transport Planning and Research Program Reports were the only source which provided sufficient detail on individual projects to enable an analysis of expenditure by transport categories. During a review of the TP&R Program carried out in 1979 by DoTA, most participants in the Program agreed that the reports were a very useful communication link which aided the co-ordination of planning and research programs both within State agencies and between agencies in different States.

Project SCORE data were used for the higher education and the private sectors. Within the time span covered by this study, SCORE data were available for only two years; 1976-77 and 1978-79. The usefulness of this data is also limited by the fact that expenditure on R&D-related activities is not obtained. Another major deficiency in the information for the purposes of this study is that transport R&D is not specifically identified in any of the published SCORE data. The assumption must be made that all

R&D activity undertaken by businesses in the transport equipment manufacturing industries is transport-related. Thus, although Project SCORE is the only source of R&D statistical data for the private, State Government and higher education sectors which is collected on a regular basis, the data have severe limitations[1] for the purposes of studies such as this.

The Science and Technology Statement is an annual collection of R&D and related activities data from the Commonwealth Government sector. The coverage of the science and technology data collection form includes a range of activities which would normally be considered to be R&D-related activities but which are excluded by the R&D definition adopted for Project SCORE. The Science and Technology Statement coverage is therefore more appropriate for this study than the SCORE coverage. However, like Project SCORE, the Science and Technology Statement does not provide details of all Commonwealth expenditure specifically related to transport research. Only the R&D component of expenditure is allocated to broad socio-economic objectives, including those related to transport.

In general, Annual Reports used to obtain some of the data for this study provide only total expenditure on transport research. Definitions of these activities are not provided and undoubtedly vary from organisation to organisation. Assumptions must be made concerning the purpose of the transport research expenditure in order to categorise this expenditure, and, in general in this study, total expenditure was allocated to the socio-economic objective applicable to the main function of the organisation. The research reports of many organisations provide details of projects undertaken but do not generally indicate annual expenditure at the project level.

The detail supplied by State agencies for analysis in this study varied considerably. Many State transport agencies could provide only broad estimates of their R&D and related expenditures (other than expenditures through the TP&R Program) and these estimates were available for varying periods of time. Other organisations provided detailed records of expenditure by project.

The limitations of published (and unpublished) sources of information on transport research in Australia have been summarised above in terms of the problems posed for studies of the type reported here. However, perhaps more importantly, these limitations also impact on the determination of the nature of transport research in the broad. Without adequate indexing and detailing of transport research, duplication of research, inadequate dissemination of research results and general lack of awareness of the existence of related and complementary research will inevitably reduce the efficiency of the research which is carried out. The following section summarises the current situation with regard to Australian transport research information systems, and outlines planned further developments.

Developments in Transport Information Systems

One of the first steps in any research project should be an attempt to determine what information is available concerning the topic being researched. In the case of transport this can be a time consuming process because of the multiplicity of agencies involved in research activities. Many of these agencies throughout Australia have very similar charters and the possibility of duplication of research work is correspondingly high. Until recently there has been no systematic and reasonably comprehensive data base of Australian transport literature covering all modes. This has made the researcher's job even more difficult. However, in recent years a number of Australian transport information systems have been established and others are currently being developed as described below.

In 1975 the Australian Road Research Board (ARRB) began publishing the Australian Road Index (ARI) which is a comprehensive index of literature relevant to roads and

1. The definitional problems outlined in Chapter 3 represent a further complication.

related subjects, by Australians or about Australia. In 1977 a machine-readable version of ARI, the Australian Road Research Documentation system (ARRD), was implemented. About 50 per cent of the material going to ARRD is also sent to the International Road Research Documentation system (IRRD), a computer-based data bank of information in the roads and road transport fields sponsored by the OECD.

The Literature Analysis System—Office of Road Safety (LASORS) was developed in 1978 by the Office of Road Safety in DoTA. LASORS covers literature on all aspects of road safety as well as literature which, though not directly concerned with roads, may be of interest to road safety researchers.

Although the ARRD and LASORS systems are of great benefit to road researchers, because they are literature-based systems. research projects for which no publications have been issued are excluded from these systems. To remedy this problem ARRB commenced an annual survey of Australian Road Research in Progress (ARRIP). The first issue of ARRIP (ARRB 1980), a computer produced guide to Australian road and road transport research projects, indexes all projects identified during a survey carried out in 1980 by ARRB for the International Road Federation and the IRRD data base.

Another recent development in transport information systems is the Australian Transport Literature Information System (ATLIS) which has been developed by the BTE. ATLIS is a computer-based bibliographic information system containing references to current Australian literature dealing with all forms of transport. ATLIS is the only multimodal transport information system covering Australian transport literature, but to avoid unnecessary duplication with the ARRD and LASORS systems it does not include the more specialised material relating to road technology, road traffic management and road safety[1]. New entries to ATLIS are published in quarterly bulletins (beginning with the March Quarter 1981) and are added to the ATLIS data base which is accessible on the computer network AUSINET operated by Australian Consolidated Industries.

In addition to ATLIS, the BTE's information systems development activities will include the Australian Transport Information Directory (ATID) and the Australian Transport Research in Progress system (ATRIP). ATID will be developed as a directory of transport data sources containing details of data collections and of the various organisations involved in the data collection. Like ATLIS it will cover all modes of transport. The ATRIP system will be designed to provide comprehensive and up-to-date details of current transport-related research projects in Australia. As with ARRIP, ATRIP will meet the need for information concerning transport research projects for which reports may not have been issued. At present it is intended that, as a general principle, ATRIP will cover all transport research in Australia. However, because of the existence of ARRIP it is expected that arrangements will be made to ensure that there is minimal duplication in the collection of transport research information, by the two systems. It is hoped that developments such as ATID and ARRIP will to a large extent replace the function of the annual project summary report produced for the TP&R Program, as well as cater for the air and sea modes not presently covered at all in this respect.

In addition to the above mentioned transport research information sources, the major transport research organisations in Australia (ie ARRDO, ARRB, BTE and CSIRO) all publish details of their research programs.

With the development of these various transport information systems, information concerning transport research in Australia should be better co-ordinated and more effective than in the past. The degree to which these goals are met depends to a large extent on the co-operation of agencies which undertake transport research in providing details of their research projects to the relevant information systems.

1. An exception to this relates to projects funded under the TP&R Program. In order to provide a convenient and comprehensive index of literature produced under this Program, all current literature resulting from projects in this Program is being included in ATLIS.

INTERNATIONAL COMPARISONS OF EFFECTIVENESS AND EFFICIENCY

Whilst it is difficult to find meaningful measures of the effectiveness and the efficiency of transport research, it is a problem that is compounded by the difficulty in obtaining appropriate data which will give a perspective on the situation in Australia.

The problems faced when attempting to produce comparative results include the difficulties of discovering data that can be compared with the available Australian data, finding sources of data which are comprehensive enough to allow efficiency and effectiveness measures to be derived, and producing measures which allow some legitimate comparison over the varied data sources and definitions of research. As a result of these difficulties, the measures of effectiveness and efficiency of funding that have been produced in this section are confined to being very broad and simplistic. However these measures may allow some limited perspective to be gained on how effectively and efficiently transport research is undertaken in Australia.

Table 4.11 shows the average report cost and the average project cost by research category for the United States (US) and Britain.

The data for the United States relates to the National Co-operative Highway Research Program (NCHRP) (TRB 1978). This Program seeks practical remedies for pressing operational problems. The Program is funded by each State of the US and the National Academy of Sciences (NAS). A co-operative funding pool of some $3m to $4m is available each year for NCHRP's contract research and for its technical and administrative operation.

TABLE 4.11—AVERAGE REPORT COST AND AVERAGE PROJECT COST OF TRANSPORT RESEARCH BY RESEARCH CATEGORY FOR THE US AND THE UK

Research category	*Average costs*[a]	*United Kingdom 1978 (S£'000)*	*United States 1963-78 (US$'000)*
Transport, economics, administration and land use	Average report cost	12	113
	Average project cost	29	75
Traffic engineering and control	Average report cost	11	183
	Average project cost	28	130
Design of transport structures	Average report cost	1	148
	Average project cost	3	111
Materials, construction and foundations	Average report cost	8	105
	Average project cost	21	78
Maintenance of roads and structures	Average report cost	15	108
	Average project cost	38	88
Vehicles, accident studies and road safety	Average report cost	12	288
	Average project cost	30	192
Other	Average report cost	1	387
	Average project cost	4	106
Aggregate	Average report cost	11	154
	Average project cost	27	102

a. Average costs refer to average cost per report produced or average cost per project as appropriate.

Sources: DOE/DTp (1978); TRB (1978).

The figures for the average project cost may reflect the mission-oriented contract research which is carried out through the NCHRP Program. The program does not carry out a large number of research projects, and about two years elapses between the selection of projects and the issue of research contracts. The relatively high cost of projects reflects the substantial nature of the research undertaken by NCHRP. It will be noted that average report costs are substantially higher than average project costs. This situation arises since not all projects listed by NCHRP resulted in formal published reports.

The figures for the UK in Table 4.11 reflect the results of an analysis of data compiled by the Departments of Environment and Transport (DOE/DTp 1978). These data do not comply with the OECD research definition but are produced on the basis of a wider definition of a research which includes surveys and other information-gathering activities.

Both average cost measures shown in Table 4.11 are substantially lower in the analysis for the UK than in the analysis for the US.

There are a number of reasons for this, including:

- the wider definition of research used in the UK reference, thus covering many smaller projects; and
- the inclusion of working papers, journal articles, conference papers and so on as 'reports' in the UK context, thus lowering the effective average costs of the 'outputs' from these projects.

In addition, as mentioned earlier in this chapter the choice of data source for the TP&R Program project cost analysis affected average costs by a factor of two or three, underlining the uncertainties associated with information in this area.

These problems further highlight the difficulties in comparing transport research effectiveness across international boundaries using empirical measures such as those considered in Table 4.11, and in particular the difficulties in placing Australian transport research 'effectiveness' in an international context.

CHAPTER 5—TRANSPORT R&D FUNDING IN OTHER COUNTRIES

This chapter outlines the level of funding of transport research and development (R&D) in OECD countries and gives a brief overview, where possible, of the arrangements for supporting transport R&D in some of these countries. The countries selected for comparison with Australia are the United Kingdom, West Germany, Canada and New Zealand.

COMPARATIVE R&D EXPENDITURES

The comparative statistics presented in this chapter are derived from the international surveys of R&D conducted by the Organisation for Economic Cooperation and Development (OECD). The available reports (OECD 1978(a) and (b), and OECD 1981) cover data obtained from 1973 to 1980 for countries other than Australia. Project SCORE (DSE 1980) was the source of the Australian figures, and was used instead of the OECD publications to compile this data because it is a more detailed and direct source of information.

There are several problems inherent in comparing international statistics of this kind. These include the inability to distinguish R&D from related activities (this distinction was defined in Chapter 1), loosely drafted national questionnaires for collecting the required information in the various countries, and the difficulties of achieving accurate responses. Although the OECD recognises these problems it has to date only attempted to 'grade' the quality of the data at the simplest level. Unfortunately, the variation in quality does not always emerge clearly from the explanatory notes associated with the data published by the OECD.

Furthermore, there is the question of whether the internal purchasing power of the R&D dollar is distorted when the exchange rate is applied to it. An examination performed by the OECD suggests that although this appeared to be the case in the 1960s, the higher rate of inflation in Europe compared to the United States and the weakening of the American dollar against some currencies, tended to correct the distortion for most OECD countries during the early 1970s.

Different national institutions and cultural attitudes also limit the validity of some comparisons between countries. In this regard, comparisons of the arrangements for R&D based on institutional classifications can be misleading due to different countries' organisational characteristics. This applies to an extent to the breakdown of R&D by type of activity. However, OECD countries are at least relatively similar in their degree of general economic development. and this provides some justification, within the limitations outlined above, for comparisons of transport R&D funding arrangements.

The category 'transport and telecommunications' is used by the OECD in publications dealing with R&D expenditure. For Australia, Project SCORE has the separate categories 'transport' and 'communications', and these are combined in the following comparisons with other OECD countries. The difference between government funding of 'communications' and 'telecommunications' R&D in Australia is considered unlikely to be significant, particularly in comparison with the various uncertainties associated with the identification and measurement of categories of R&D expenditure.

Table 5.1 provides a comparison between the R&D expenditures by governments of selected countries, categorised by socio-economic objective. Unfortunately, the only country in this comparison for which expenditure on transport can be identified

separately from expenditure on telecommunications is Australia. Project SCORE information indicates that transport attracted 2.0 per cent of government R&D funding in 1976-77.

Some limited time-series data are available for OECD countries and this information is summarised in Table 5.2. Table 5.2 indicates during the mid-1970s that, as a proportion of GDP, government R&D expenditure in Australia on transport and communications was high in comparison with other OECD countries. The sharp increase in the proportion of government R&D funds devoted to this socio-economic objective in Australia between 1973-74 and 1976-77 was very largely the result of increased R&D spending on communications. Project SCORE data indicate that the proportion of government R&D funds allocated to transport (excluding communications) remained constant at approximately 2 per cent in the two years being compared. This funding level represents 0.014 per cent of GDP. Table 5.2 indicates that this proportion (which refers only to transport R&D expenditure) is high in relation to many other OECD countries' expenditure on transport and telecommunications R&D combined. In addition, Chapter 3 has indicated that the total government expenditure levels on transport research in Australia have remained constant (in real terms) from the mid-1970s to the latest year considered (1980-81).

It may therefore be concluded that transport research has attracted a comparatively high level of government support in Australia.

TRANSPORT R&D FUNDING IN SELECTED COUNTRIES

This section contains a brief outline of transport research funding arrangements which occur in the OECD countries selected for comparison with Australia. A description of the Australian funding arrangements is given in Chapter 2 of this report.

United Kingdom

In the United Kingdom (UK), transport and telecommunications are grouped together for the purpose of reporting R&D funding. Government funding of transport and telecommunications R&D in the United Kingdom as a proportion of GDP is shown in Table 5.2. This has remained fairly constant from 1974 to 1980. Information from previous years confirms that this proportion has not increased markedly.

The funding arrangements for transport R&D in the UK are in some ways similar to the Australian system, which given a parliamentary system similar to our own and our historic links with Britain may not be surprising. However, the absence of a federal system of government in the UK results in some significant contrasts between the systems. An outline of the British system for funding transport research and development is outlined below.

Many of the UK Ministries fund transport research activity in other agencies. Hence, for example, the Department of the Environment and the Department of Transport have funding arrangements with the Transport and Road Research Laboratory (TRRL), the Hydraulics Research Station and other Government funded research establishments.

Furthermore, R&D funding links exist between the Government and universities. The Department of Education and Science finances research in universities and other external research groups according to the decisions of the Council for Scientific Policy and the University Grants Committee.

There are five Research Councils covering the entire civil science field, and the Council for Scientific Policy assesses their needs and advises the Secretary of State on the allocation of funds to them. The funds are available to be spent, mainly in universities, on research and postgraduate education covering the entire civil science field. A part of this research activity relates to transport research.

The University Grants Committee apportions its financial resources among

TABLE 5.1—PROPORTION OF GOVERNMENT R&D FUNDING BY SOCIO-ECONOMIC OBJECTIVES, AND TOTAL EXPENDITURE, FOR SELECTED COUNTRIES[a]

(per cent)

Socio-economic objectives	*Country*				
	Australia	*Canada*	*West Germany*	*New Zealand*	*United Kingdom*
Agriculture, forestry and fishing	23.9	19.4	1.9	32.6	4.0
Industrial growth	9.3	15.5	9.1	12.2	7.0
Production of energy	4.0	10.5	13.7	7.4	6.1
Transport and telecommunications	6.6[b]	3.9	2.1	1.3	0.6
Urban and rural planning	2.1	0.5	1.6	1.3	1.0
Environmental protection	3.0	1.3	2.1	—	0.8
Health	6.5	8.1	4.2	6.1	1.6
Social development services	2.6	7.9	3.9	4.0	1.0
Earth and atmosphere	7.4	4.9	2.6	15.4	0.8
Advancement of knowledge	21.0	20.0	42.9	15.1	20.5
Civil space	—	—	4.2	—	2.0
Defence	13.6	89.6	11.7	1.6	54.6
Not specified	—	—	—	3.3	—
Total[c]	100	100	100	100	100
Total expenditure (US$m)	717	981	8 641	156	5 203

a. The figures for Canada, New Zealand, the United Kingdom and West Germany refer to the calendar year 1979. The Australian figures are taken from Project SCORE and refer to the financial year 1976-77.
b. Strictly, this refers to the socio-economic objective 'transport and communications', as discussed in the text. However, the distinction is not considered likely to cause a major distortion in the interpretation of this figure.
c. Columns may not add to totals due to rounding.

Sources: DSE (1980), OECD (1981).

universities, providing funds for both their recurrent and capital budgets and hence provides funds for both research and teaching.

Local authorities also perform and sponsor some research for which they raise their own funds (mainly through rates).

Apart from direct government funding through various government departments, the primary sources of finance for transport R&D in the UK are government corporations and authorities, local authorities with private funding sources (for example charitable trusts) and industry.

Tables 5.3 and 5.4 give an indication of the breakdown of research in transport performed and sponsored in Britain from 1975 to 1978. These tables are based on an

TABLE 5.2—GOVERNMENT FUNDING OF TRANSPORT AND TELECOMMUNICATIONS R&D[a] AS A PROPORTION OF GROSS DOMESTIC PRODUCT FOR OECD COUNTRIES, 1973 TO 1980

(per cent)

Country	*Year*							
	1973	*1974*	*1975*	*1976*	*1977*	*1978*	*1979*	*1980*
Australia[b]	na	0.028	na	na	0.052	na	na	na
Belgium	na	na	0.002	0.002	na	na	0.008	0.008
Canada	na	na	0.017	0.015	0.019	0.025	0.017	na
Denmark	na	na	0.003	0.004	0.004	0.003	0.004	0.004
Finland	0.008	0.011	0.009	0.009	0.009	0.009	0.008	0.008
France	na	0.033	0.035	0.033	0.034	0.032	0.032	0.032
Germany	0.012	0.018	0.018	0.014	0.015	0.018	0.024	na
Greece	na	na	na	na	na	na	na	na
Ireland	na	0.008	0.009	0.009	0.008	na	na	na
Italy	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002
Japan	na	na	0.009	0.008	0.007	0.008	0.007	na
Netherlands	0.006	0.009	0.016	0.014	0.016	0.017	0.016	0.016
New Zealand	0.009	0.008	0.008	0.007	0.008	na	na	na
Norway	na	na	na	na	0.043	0.044	0.043	0.041
Portugal	na	na	na	na	na	na	na	na
Spain	na	na	na	0.011	0.008	0.008	na	na
Sweden	na	na	0.029	na	0.040	0.038	0.034	0.029
Switzerland	0.017	0.017	0.019	0.019	0.020	0.025	na	na
Turkey	na	na	na	na	0.078	na	na	na
United Kingdom	0.005	0.007	0.008	0.008	0.006	0.007	0.007	0.007
United States	0.042	0.047	0.039	0.035	0.039	0.037	0.035	0.034

a. Subject to OECD qualifications.

b. Figures for Australia refer to financial years ending 30 June, and are taken from Project SCORE (DSE 1980). These are different from the figures quoted in OECD (1981) for Australia which are for 1974, 'na' and for 1977, 0.015. The 1977 OECD figure for Australia may be derived from Project SCORE by considering government expenditure on transport R&D only (that is, without telecommunications). Project SCORE has a category 'communications' rather than 'telecommunications', and when this expenditure is included a figure of 0.052 is obtained, as shown in the table.

Sources: DSE (1980), OECD (1981).

TABLE 5.3—PROPORTION OF RESEARCH[a] PROJECTS IN ROADS AND TRANSPORT IN THE UK BY SPONSOR, 1975 TO 1978

(per cent of projects)

	Research sponsors								
	Private	*Government*			*Higher education*	*Research establishment*	*Abroad*	*Unknown*	*Total*
		Central	*Corporations authorities*	*Local authorities*					
Year									
1975	9.2	42.6	24.7	6.7	1.9	11.9	2.9	0.1	100
1976	9.4	47.3	20.0	6.2	1.3	14.8	0.8	0.0	100
1977	7.5	46.3	17.5	8.2	2.4	13.9	3.9	0.2	100
1978[b]	5.4	37.4	15.4	8.3	7.7	22.8	2.3	0.7	100

a. As used here the term 'research' is based on the broad definition including R&D related activities.

b. Includes 'surveys' which had been excluded in previous years.

Source: DOE/DTp (1978 and earlier issues).

TABLE 5.4—PROPORTION OF RESEARCH[a] PROJECTS IN ROADS AND TRANSPORT IN THE UK BY PERFORMER, 1975 TO 1978

(per cent of projects)

	Research performers								
	Private	Government			Higher education	Research establishment	Abroad	Unknown	Total
Year		Central	Corporations authorities	Local authorities					
1975	19.4	1.9	4.6	5.9	49.5	18.5	0.2	0.0	100
1976	16.1	1.9	4.5	7.8	37.3	31.7	0.6	0.0	100
1977	18.9	2.3	1.2	9.5	47.3	19.3	0.9	0.5	100
1978[b]	15.8	4.0	7.3	14.0	41.0	17.1	0.4	0.3	100

a As used here the term 'research' is based on the broad definition including R&D related activities.
b. Includes surveys which had been excluded in previous years.
Source: DOE/DTp (1978 and earlier issues).

analysis of research projects published through the Departments of the Environment and of Transport (DOE/DTp 1978 and earlier issues). The published information was prepared from a survey of some 2300 organisations including government departments, local authorities, research associations, universities, nationalised and private industries and consultants.

Table 5.3 shows the distribution of transport research projects by type of organisation directly sponsoring them. It would appear that the central UK Government has maintained a significant proportion of the transport research sponsorship in the UK over the 1975-78 period. The Departments of the Environment, Transport, and Industry are the main distributors of these funds. The major authorities and corporations which provided funds for transport research included the Research Councils, particularly the Science Research Council and the Social Science Research Council, and the British Railways Board. The main research establishment which sponsors transport research is the TRRL, with the Warren Spring Laboratory (which carries out investigations into air pollution), and Hydraulics Research Station also performing some transport research[1]. The local authorities sponsoring transport research represent a wide range of British counties. The private industry organisations involved in transport research included car manufacturing firms, consultants, marine companies, private foundations and trusts, and industry associations. Higher education institutions do not provide significant funds from their own sources for transport research.

Table 5.4 shows the distribution of transport research projects by type of organisation actually performing the projects. The table shows the significant proportion of transport research performed by the higher education sector in Britain. London, Birmingham, Aston, Leeds, Oxford and Sheffield universities appeared to perform a large part of this research. Much of this research is performed in university Engineering Departments and Transport Departments or Units.

As previously mentioned, the research establishment performing most of the transport research is the TRRL. In private industry the majority of transport research is carried out by consultants and industry associations.

West Germany

A characteristic of research in West Germany seems to be the proliferation of small private associations and enterprises which form small research teams to undertake

1. Of course, the UK Government is also the primary source of funds for these research establishments. The analysis presented in Table 5.3 effectively shows the proportion of projects carried out within the research establishments (as in-house activity) or sub-contracted externally.

mainly applied research and consultancy work. These research teams are subsidised from public sources, but are mainly dependent on fees from public and private clients.

Transport research in West Germany is carried out in four principal sectors: State and local authorities, the universities and other academic institutions, foundations and private agencies.

The Federal Government departments and agencies perform and commission transport research, some of which is financed by the National Science Foundation.

Academic institutions perform a proportion of West Germany's transport research. Certain universities have formalised commitments in this area by incorporating institutes of regional and transport science.

The level of public funding of transport and telecommunications research and development in West Germany (as a proportion of GDP) from 1973 to 1979 is shown in Table 5.2. The table shows that the proportion of government resources (as related to GDP) allocated to R&D on transport and telecommunications fluctuated quite markedly over the period shown, although some overall increase is evident.

Canada

Table 5.2 indicates some variations over the years 1975 to 1979 in government R&D funds devoted to transport and telecommunications in Canada as a proportion of GDP. It is understood however that a significant component of these funds was associated with the development of the DASH-7 passenger aircraft. This development was completed by 1978 and has resulted in a reduction in Federal spending on transport R&D in 1979. Of the funds spent on transport R&D approximately 65 per cent was spent in the private sector. More recently Transport Canada has estimated that of the total funds devoted to transport R&D, some 48 per cent is contributed by the Canadian Government, 40 per cent is contributed by industry, and the Canadian Provinces contribute the remaining 12 per cent.

New Zealand

Government funding of research and development in New Zealand tends to be directed more toward the agricultural or physical sciences. Given the agricultural basis of the New Zealand economy this is not particularly surprising. Government funding of R&D in transport and telecommunications remained a fairly constant percentage of GDP between 1973 and 1977 (as shown in Table 5.2). The New Zealand Government itself undertakes over 92 per cent of transport and telecommunications research and development.

There are currently twelve industry research associations in New Zealand, covering the dairy, meat, building, fertiliser manufacture, logging, heavy engineering, coal, concrete, leather and shoe, pottery and ceramics, textile services, and wool industries. The basic idea behind these associations is the provision of a mechanism by which members of the industries combine to undertake research of mutual benefit, normally beyond the capability of the individual undertakings. The associations are independent incorporated bodies controlled by the financing industries. Funds are subsidised by the Government initially on a dollar for dollar basis.

It was proposed that in 1981-82 a Transport Research Association be established on a similar basis to the other industry research associations. The Association was to be funded partly through a Government budgetary appropriation and partly by a levy on transport system users. Issues which have yet to be resolved in relation to a levy on transport system users include:

- which users should be levied;
- whether such users should be levied directly;

- the size of this levy; and
- the mechanism by which the levy is to be collected.

At the time of writing the whole matter of a Transport Research Association remains unresolved.

CHAPTER 6—CONCLUDING REMARKS

The previous chapters in this report have attempted to highlight the diversified nature of transport research in Australia and the multiplicity of organisations involved in funding or performing this research. It is believed that this specific area of activity has been examined only once previously, when, in 1977-78, the Australian Science and Technology Council (ASTEC) reviewed science and technology generally in Australia. This review concluded that the range of transport R&D covered at the time was limited by the requirement that the definition of R&D comply with that used by Project SCORE. The ASTEC review suggested further that a considerable proportion of research effort carried out in the area of transport was not covered by the term 'R&D' as defined.

Following the position taken by ASTEC in 1977-78, it was considered essential in carrying out the current study that the whole range of transport research should be covered as comprehensively as possible. At the same time, considerable reliance had to be placed on published sources of information. Hence the definition of 'research' adopted for this study had to remain compatible as far as possible with the concepts of research used by those sources of information.

It is believed that the definitional restrictions imposed on the ASTEC study have been largely overcome in the present one. The concepts of 'research and development' (as used by Project SCORE and ASTEC) and 'science and technology activities' as used by the Department of Science and Technology, together include the overall field of transport research quite adequately. However, not all elements of the 'science and technology activities' were considered to be closely related to transport research. Hence the R&D-related activities considered to be part of transport research in this study represent appropriate items selected from the 'science and technology activities'.

In seeking out data for this study, significant limitations became apparent in the availability of appropriate information. These limitations extended to:

- lack of comprehensive research funding data;
- limited historical coverage of funds spent on research in various categories;
- variability in degree of detail available across the different sectors involved in transport research; and
- different categorisations used for the types of research carried out.

These limitations were found to apply not only to information on transport research activities, but also to information on Australian research activities as a whole.

In attempting to relate the Australian transport research situation to that overseas, it also became apparent that similar problems applied internationally.

As a result of the uneven data coverage across sectors and organisations, and also over time, it has not been possible to present a complete and consistent picture of funding levels associated with the broad range of transport research. The general thrust in this report has been to present transport research funding information in as much detail as possible for each of the major sectors (Commonwealth, State and Private) and for the major Australian institutions engaged primarily in transport research. A degree of disaggregation of this information has also been attempted where possible to show the relative expenditure levels devoted to research in particular areas covered by the 'transport' classification.

The present analysis indicates that the total expenditure on transport research in Australia in 1980-81 by all sectors exceeded $81m, excluding research on synthetic fuels. The component of this amount funded by the Commonwealth sector (including grants to States and other transport research institutions) is $31m[1]. Total expenditure by the States (from their own resources) on transport research was estimated to amount to $25m in 1980-81. In the current study, total expenditure on transport research (as a whole) by the private sector could not be estimated. Information on private sector research is limited to the information compiled in Project SCORE and related ABS surveys. The fact that these sources restrict their coverage to R&D only implies that expenditure on the so-called R&D-related activities was not available. ABS sources were used to estimate a funding level of around $18m by the private sector in 1978-79 on transport R&D and some $3m on transport-related energy conservation R&D in 1979-80. These amounts were included in the lower limit on the overall Australian expenditure on transport research quoted above. The balance is comprised of an estimated expenditure of $2m on transport research by the national public transport enterprises, and an estimate of between $2m and $3m for port and marine research.

It is of interest to note also that this estimate of total transport research expenditure amounts to some 0.06 per cent of Australia's Gross National Expenditure (GNE). Furthermore, based on information which is now unfortunately rather dated, the government R&D effort on transport and telecommunications in Australia amounted to some 6.6 per cent of total government R&D expenditure. This proportion appears to be considerably higher than that of comparable overseas countries according to information published by the OECD. Unfortunately the information relating to the overseas situation could not be refined to identify the transport R&D expenditure component specifically, although it appears to represent approximately 30 per cent of the government transport and telecommunications R&D expenditure in Australia.

Until its termination in June 1981, the Transport Planning and Research (TP&R) Program administered by DoTA represented the most significant scheme by which the Commonwealth contributed funds to State transport authorities specifically for transport research. However this scheme was limited to land-based transport, and did not extend to research activities related to the air and sea modes directly. The TP&R Program commenced in 1974 and was altered in 1977 both in relation to the relative Commonwealth/State funding contributions and the range of the transport research projects covered. A detailed analysis of the projects approved for funding under the TP&R Program has been presented in this report. This analysis indicated that the States as a whole compensated for decreasing Commonwealth contributions in real terms over the period of the scheme, thus keeping total outlays under the TP&R Program approximately constant (in real terms).

The analysis also revealed a significant increase in the proportions of expenditure on rail transport research and non-mode specific and other transport research under the TP&R program after 1977. This reflected the changed arrangements in that year, extending coverage of the program to mainline rail and the interface with other modes.

A significant by-product of the TP&R Program related to its role as a central register of research in the land transport area. This role not only represented a means for minimising duplication of research effort, but also provided at least some information on the level of resources being devoted to the various areas of land transport research. Chapter 4 has indicated the planned development of alternative information systems to fulfill the role of indexing current Australian research in all modes of transport. However, the success of these alternative information systems will depend on voluntary co-operation, on the part of the agencies carrying out the research, in providing comprehensive and up-to-date information on their research projects. The TP&R program contained a requirement that progress on approved projects be supplied annually.

1. Component values in this paragraph are rounded to nearest $1m.

The aspect central to any determination of the 'worth' of expenditure on transport research relates to its ultimate effectiveness. In common with research in other fields, satisfactory methods of measuring the effectiveness and efficiency of transport research have not been developed. Certain alternative approaches to this aspect were discussed in Chapter 4 of this report and some of these were applied to the TP&R Program. However, as already admitted, the major measures employed, average project and report costs, are very empirical and rather unsatisfactory measures of research effectiveness. Comparison with equivalent measures derived from certain overseas transport research projects emphasises the difficulty of establishing relevant standards for the effectiveness of research projects. Perhaps the most valid use of these statistics is as an indicative measure of research program performance over time. Although there was considerable variation in report costs it was found that in the TP&R Program, overall, average report costs (in real terms) tended to decline over time, indicating some improvement in transport research efficiency according to this criterion.

As observed in Chapter 4, the ultimate worth of transport research depends not on the amount of literature it generates but rather on the effect such research produces on the generation and implementation of policy and the development of new processes and materials. In order to estimate the effectiveness of say the TP&R Program in this way would require thorough investigation of such matters as the degree to which the results of the research influenced policy. Given typical implementation timescales and various distorting influences, tracing the effect of transport research results through to implementation may well be a daunting task.

Investigations into port and marine research expenditure were severely hampered by lack of data. The individual authorities do not publish research program reports, and in many cases research expenditure information was not available. An estimated $2.4m was spent on research by the Port and Marine Authorities in 1980-81. The documentation of at least part of land transport research through the TP&R Program records was not paralleled in port and marine research due to the absence of any centrally funded program with associated reporting requirements. In addition there is no national body with responsibility for port and marine research as there is for road (ARRB) and for rail (ARRDO).

In line with the terms of reference for this study, the general aim has been to produce a descriptive rather than a prescriptive analysis of transport research in Australia. Allowing for problems of inconsistent and rather dated information noted in this report, there seems to be evidence that, in the broad, transport research has attracted a comparatively high level of government support in Australia over the period from the mid 1970s to 1980-81. It was not within the scope of this study to determine the relevance of the transport research projects to which resources are being devoted. However the general significance attached to transport research by the States can be implied from the maintenance of their transport research programs at reasonably constant (real) expenditure levels despite some decline in direct Commonwealth support in real terms.

APPENDIX I—DEFINITIONS

Chapter 1 discussed the concept of 'research and development', and indicated the general scope of this concept as defined by the OECD and adopted by the Department of Science and Technology (DST) for the preparation of their Project SCORE information. Some further details of this definition are presented in this Appendix.

The concept of 'science and technology' (as opposed to R&D) was also outlined in Chapter 1. It was pointed out that the types of activity encompassed by the general term 'transport research' were not all accommodated by the definition of R&D. In fact this emerged as a significant problem in the review of transport research activity included in the ASTEC report in 1978. Chapter 1 of the present report indicated that at least some of the activities classified as 'science and technology' (that is, R&D-related activities) must also be included in any coverage of transport research. Further details of the activities covered in this category are also outlined below.

Finally, in this Appendix, a definition of Industrial Research and Development (IR&D) as specified in the IR&D Grants Act is provided.

RESEARCH AND DEVELOPMENT

The OECD definition of R&D is given in Chapter 1, together with some explanatory notes. It has been argued in this report that the definition and explanation of R&D nevertheless makes for very subjective categorisation of many research activities. Some of the data problems highlighted in Chapter 3 are believed to result from this subjectivity.

The OECD definition stresses novelty of technique rather than novelty of end result or end product. For example, devising and validating a new econometric model is R&D, whereas the econometric modelling of economic systems for policy purposes using established techniques, is not R&D. R&D ceases when work is no longer experimental. Once its primary objective is no longer investigation, an activity can no longer be considered R&D even though it could be regarded as an important part of the total innovative process.

SCIENCE AND TECHNOLOGY

In preparing the Science and Technology Statements (but not Project SCORE) DST (1981) define non-R&D activities in the following terms.

> The following activities, often regarded as research or development, are not included as R&D, but are included as scientific and technological activities (other than R&D), except where they are used primarily for the support of specific R&D programs or where they meet the tests of the R&D definition (through, for example, being aimed primarily at developing new techniques for general application in the particular field of activity);
>
> a. Demonstration of both technical and commercial viability: Demonstration projects and production and operation of pilot plant or equipment aimed at demonstrating both the technical and commercial viability of specific innovatory products or processes.
>
> b. Design for innovative production: Design engineering and 'tooling-up', often following either an experimental development or a demonstration phase and aimed at placing innovatory products or processes on a routine production basis, includes products or processes new to Australia, regardless of whether or not these are well developed elsewhere.

c. Technology transfer, extension services, other active diffusion of scientific and technological skills and know-how: Regular routine work on advising clients, including other sections of an organisation and independent users, to promote use of scientific, technological and management information. This activity includes extension and advisory services organised for farmers and for industry. It involves the transfer of skills, capabilities and 'know-how' to clients.

d. Advanced scientific or engineering consulting services: Consulting services to provide clients, including other sections of an organisation and independent users, with technologically advanced designs, products or processes, or with reports based on advanced scientific or technological analysis. Engineering feasibility studies are included in this category, except where they involve econometric techniques and/or operations research.

e. Policy-related studies using advanced techniques: Policy-related studies using operations research and/or econometric techniques. This category includes feasibility studies involving such techniques.

f. Testing, standardisation, metrology and quality control: Regular routine work on the analysis, checking and testing, by recognised methods, of materials, products, devices and processes, together with the setting up and maintenance of standards, including standards of measurement.

g. Patenting and licensing: Activities relating to patents and licences, systematic work of a scientific, legal and administrative nature on patents and licences.

h. Data collection in the natural sciences: Topographical, geological and hydrological surveying (including prospecting and related activities designed to locate and identify oil and mineral resources), routine astronomical meteorological and seismological observations, surveying of soils and of plants, fish and wildlife resources, routine soil, atmosphere and water monitoring and the routine monitoring of radioactivity levels.

i. Data collection in the social sciences: The gathering of information on human, social, economic and cultural phenomena, usually for the purpose of compiling routine statistics, eg population censuses, production, distribution and consumption statistics, market studies, social and cultural statistics etc.

j. Scientific and technological (S&T) information and documentation: S&T services provided by libraries, archives, information and documentation centres, reference departments, scientific congress centres, data banks and information-processing departments. Such services include S&T bibliographic searches, provision of S&T documents, provision of access to organised S&T information systems and the management of any associated data bases. Support for S&T conferences is included in this category. Systematic work on the translation and editing of S&T books and periodicals (except for textbooks used in school and university courses) is also included.

k. Services associated with scientific and technological collections: S&T services provided by museums of science and/or technology, botanical and zoological gardens and other S&T collections.

l. Scientific and technical education and training: Specialised non-university higher education and training, higher education and training leading to a university degree (except research training of (post) graduate students which is regarded as part of R&D), and organised lifelong training for scientists and engineers.

m. Administration of S&T activities, policy, planning and other studies of S&T: administrative, policy, planning and related activities concerned with S&T which are not an integral part of one of the other defined S&T activities, the Australian Science and Technology Council (ASTEC) and the Policy Division of the Department of Science and Technology are examples falling in this category.

For the purposes of the present study, R&D and related activities appropriate to the transport sector are defined as those activities defined as R&D in the sub-section above together with the activities outlined in paragraphs a, d, e, f, i and j of the science and technology activities also described above.

INDUSTRIAL RESEARCH AND DEVELOPMENT

Industrial research and development (IR&D) is defined in the legislation dealing with

IR&D grants as follows:

Industrial research and development, in relation to a company, means systematic experimentation or analysis in a field of science or technology carried on by the company, or procured by it to be carried out in Australia with the object of—

- acquiring knowledge that may be of use for the purpose of devising or developing new or substantially improved material products or new or substantially improved processes for or in connection with the production or use of material products (including processes for disposing of, or rendering harmless, waste products or emissions resulting from the production or use of material products); or
- applying knowledge for the purpose referred to in sub-paragraph a.

REFERENCES

ABS (1981a), *Research and Experimental Development: Energy Production Utilisation and Conservation All Sectors, Australia 1979-80,* Catalogue 8110.0. ABS, Canberra.

ABS (1981b), *Research and Experimental Development: Business Enterprises, Australia 1978-79,* Catalogue No. 8104.0. ABS, Canberra.

ABS (1982), *Research and Experimental Development: Higher Education Organisations, Australia 1978,* Catalogue No. 8111.0. ABS, Canberra.

ARRB (1980), *Australian Road Research in Progress,* ARRB, Nunawading, Victoria.

ASTEC (1979), *Science and Technology in Australia 1977-78,* AGPS, Canberra.

BTE (1978), *A Review of Transport Research and Development in Australia,* BTE Information Bulletin, AGPS, Canberra.

CSIRO (1981), *CSIRO Research Programs 1980-81,* CSIRO, Melbourne, (and earlier issues).

DNDE (1980), *Compendium of Australian Energy Research, Development and Demonstration Projects,* AGPS, Canberra.

DOE/DTp (1978), *Register of Research and Surveys 1978: Part 3 Roads and Transport,* HMSO, London, England, (and earlier issues).

DoTA (1980), *Transport Planning and Research Program, List of Final and Interim Reports Submitted to 30 June 1980,* DoTA. Canberra.

DoTA (1981), *Annual Report,* AGPS, Canberra, (and earlier issues).

DoTA (1982), *The Transport Planning and Research Program: Report of Progress to 30 June 1981,* AGPS, Canberra, (and earlier issues).

DSE (1980), *Project SCORE: Research and Development in Australia 1976-77,* AGPS, Canberra.

DST (1981), *Science and Technology Statement 1980-81,* AGPS, Canberra.

OECD (1976), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development,* OECD, Paris, France.

OECD (1978a), *International Survey of the Resources Devoted to R&D by OECD Member Countries,* OECD, Paris, France.

OECD (1978b), *Survey of the Resources devoted to Research and Development by OECD Member Countries: The Objectives of Government Research and Development Funding 1970-76,* OECD, Paris, France.

OECD (1981), *Science and Technology Indicators, Basic Statistical Series—Volume A: the Objectives of Government R&D Funding, 1969-1981,* OECD, Paris, France.

Patents, Trade Marks and Design Office (1980), *Annual Report 1979-80,* AGPS, Canberra, 1981.

Peterson, D.E. (1979), Measuring the Effectiveness of a Research Program; *Transportation Research Record 738,* National Academy of Sciences, Washington, DC.

Roberts, D.C. and Stein, M.M. (1976), Innovations in Management of Research and Development; *Transportation Research Record 603,* National Academy of Sciences, Washington, DC.

TRB (1978), *National Highway Research Program—Summary of Progress through 1978,* Transportation Research Board, Washington, DC.

ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AGPS	Australian Government Publishing Service
AIRDIB	Australian Industrial Research and Development Incentives Board
AN	Australian National
ARI	Australian Road Index
ARRB	Australian Road Research Board
ARRD	Australian Road Research Documentation
ARRDO	Australian Railway Research and Development Organisation
ARRIP	Australian Road Research Progress
ASIC	Australian Standard Industrial Classification
ASTEC	Australian Science and Technology Council
ATAC	Australian Transport Advisory Council
ATID	Australian Transport Information Directory
ATLIS	Australian Transport Literature Information System
ATRIP	Australian Transport Research in Progress
AUSINET	Australian Information Network
BTE	Bureau of Transport Economics
C&G	Co-ordinating and General Group
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DC	District of Columbia
DCT	Department of the Capital Territory
DHC	Department of Housing and Construction
DIC	Department of Industry and Commerce
DNDE	Department of National Development and Energy
DOE	Department of the Environment (UK)
DS	Department of Science
DSE	Department of Science and the Environment
DST	Department of Science and Technology
DSTO	Defence Science and Technology Organisation
DTp	Department of Transport (UK)
DoTA	Department of Transport Australia
GAF	Government Aircraft Factories
GDP	Gross Domestic Product

GNE	Gross National Expenditure
HMSO	Her Majesty's Stationery Office
IR&D	Industrial Research and Development
IRRD	International Road Research Documentation
LASORS	Literature Analysis System - Office of Road Safety
m	million
MPCA	Marine and Ports Council of Australia
na	not available
NAASRA	National Association of Australian State Road Authorities
NAS	National Academcy of Sciences
NCDC	National Capital Development Corporation
NCHRP	National Co-operative Highway Research Program
NERDDC	National Energy Research, Development and Demonstration Council
NSW	New South Wales
OECD	Organisation for Economic Co-operation and Development
PIP	Policy Interaction Potential
Qld	Queensland
R&D	Research and Development
RD&D	Research Development and Demonstration
SA	South Australia
SCORE	Survey and Comparison of Research Expenditures
TP&R	Transport Planning and Research
TRB	Transportation Research Board (US)
TRRL	Transport and Road Research Laboratory (UK)
Tas	Tasmania
UK	United Kingdom
US	United States (of America)
Vic	Victoria
WA	Western Australia
—	zero
..	not applicable