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運輸工程研究中心規劃報告

ESTABLISHMENT OF A TRANSPORTATION ENGINEERING RESEARCH CENTER (TERC) FINAL REPORT

交通部運輸研究所

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INSTITUTE OF TRANSPORTATION
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS
REPUBLIC OF CHINA

ESTABLISHMENT OF A TRANSPORTATION ENGINEERING RESEARCH CENTER (TERC)

FINAL REPORT

THE DIVISION OF ROADS AND TRANSPORT TECHNOLOGY OF THE CSIR SOUTH AFRICA

JUNE 1994

EXECUTIVE SUMMARY

The Division of Roads and Transport Technology (Transportek) of the CSIR (formerly the Council for Scientific and Industrial Research) in South Africa was commissioned by the Institute of Transportation (IOT) to assist in the establishment of a Transportation Engineering Research Centre (TERC) to augment its current R&D capabilities. The scope of services to be provided were split into the following three stages:

- **Stage 1**: Review of past planning, needs analysis and strategic planning in collaboration with IOT counterparts and other stakeholders in ROC;
- **Stage 2**: Technical interactions between specialist staff of CSIR and IOT to define specific resource allocations and research direction in the selected focus areas;
- **Stage 3**: Final reporting and development of implementation plans for formal establishment of TERC.

Stage 1
A review of four international transport research organisations was carried out to gain a historical perspective of the issues which are likely to impact on the establishment and development of TERC. In addition, an industry survey was carried out and was aimed at determining the extent and nature of R&D needs of the industry. Information was collected around the following areas:

- primary role and function of TERC;
- types of support services to be offered;
- research needs and priorities;
- potential funding mechanisms;
- relationship of TERC with different sectors of industry;
- relationship of TERC with universities; and
- management structure of TERC.

From the analysis of industry needs the following preliminary technology focus areas were identified:

- railway engineering;
- highway engineering;
- safety systems and traffic engineering;
- engineering laboratory support; and
- information management and technology.

Stage 2
Following the initial survey of needs and expectations, a series of detailed interactions were undertaken in the identified focus areas to establish a perspective of current transportation practice in ROC and of the interface between practice and the transportation research environment. This investigation focused on the following aspects:

- current design methodologies, standards and specifications used in highway and railway engineering;

- practices and methodologies in traffic management;
- existing testing and measuring facilities;
- possible areas of testing facility overlap or duplication;
- availability of human resources in terms of skills levels and specialisation; and
- facilities and skills available at agencies which showed an interest in cooperating with TERC.

The survey of current practice in the identified focus areas allowed for a framework for a strategic plan for TERC to be developed and the following proposed objectives were formulated as part of the plan:

- to draft national standards, procedures and methods for the planning, design, construction and maintenance of roads and railways and for traffic engineering and safety;
- to act as an independent and objective testing and evaluation authority for the transportation industry;
- to provide specialised technical support for engineering agencies engaging in materials testing, quality control and technical analysis;
- to encourage and coordinate the development of new engineering technologies and to promote technology transfer; and
- to play an active role in the development of engineering manpower for the transportation industry.

Stage 3

To assist in structuring an understanding of the technologies required by the transportation industry in ROC, a technology tree was developed for the industry. The principle used was to identify the technologies or knowledge areas underpinning each level of technology, until all the base technologies for an area have been determined.

One benefit of this approach is that a perspective may be built of a technology strategy for a discipline, i.e. of where efforts for development, acquisition or joint venture must be aimed, since own capabilities or lack thereof are easily identified. For the purposes of achieving a better definition of the respective roles of TERC and IOT, the technology tree also provides a basis for allocating technology responsibility within the confines of a particular discipline or project. Based on the concepts introduced and discussed in the report, the current divisions of IOT would tend to aim at technologies higher up in the technology hierarchy, where strategy and policy issues dominate and hard engineering support is of lesser importance. TERC would engage in work towards the lower end of the hierarchy by providing the vital engineering and technological support required to arrive at rational decisions regarding national policies and strategies. A coordinated approach to providing technology support of this nature is lacking in ROC and this has been identified as a primary reason for the fragmented nature of current transportation R&D.

The allocation of responsibilities at the interface of ***standards, procedures & engineering*** and ***planning, policy & strategy*** becomes a matter of negotiation and will largely be determined by the nature of a particular project. The technology tree clearly demarcates the domains of the current IOT Divisions and the proposed TERC focus areas and these may be defined as follows:

- **Current IOT Divisions:** research and development for transportation planning, policy and strategy;
- **TERC:** R&D for engineering and technology support in respect of standards, procedures and services to the current IOT Divisions and industry at large.

To gain maximum benefit, TERC must be fully integrated into the IOT structure and take part in R&D strategy planning and decision-making. However, for the effective integration of TERC into IOT, it will be necessary for the existing IOT Divisions to retain a separate identity. It is therefore recommended that the existing Divisions be renamed the Transportation Policy and Planning Research Group (TPPRG). The recommended organisation structure for IOT shows that TPPRG and TERC are both headed by a Deputy Director General. The Director General of IOT, together with the two deputies, should take responsibility for the coordination for R&D activities between the two units.

By increasing the capabilities of IOT through adding the engineering support provided by TERC, IOT would be ideally positioned as the national coordinator of transportation R&D to prevent the current fragmentation of activities. It should be noted that the technology tree does not expand on the underpinning technologies for marine and air transport, as these are currently provided by other institutions. Policy and planning R&D in these areas would however still rest with TPPRG (as is the case at the moment with the current Divisions of IOT), as would the coordination of research in these areas.

To ensure that R&D plans are aligned with a technology vision for ROC and to ensure effective technology transfer, IOT must coordinate transportation R&D in association with the MOTC Office of Science and Technology Advisors. This implies that IOT plays a central role in developing a transportation technology strategy for the country. A system of steering committees or research advisory panels is suggested to regulate the generation, prioritisation and communication of industry needs to the research sector and also to facilitate the transfer of technology. A model for explaining the interface of IOT with industry has been developed.

Information technology is a key resource and effective management of information will enable TERC and IOT to make a significant impact on industry. This resource is currently not utilised in line with its strategic importance, though initiatives have been put in place to establish a larger data management capability in IOT. Recommendations for expanding this function are presented. While it was initially felt that this function should become part of the TERC structure, detailed investigation has shown that the establishment of a formal computer support function should be a corporate IOT responsibility, either as a new Division or under the control of the current Transportation Information Division.

Having distinguished between the roles of TERC and the existing Divisions of IOT and given recommendations on an IOT structure to accommodated the different roles, the following conclusions and recommendations were made specifically around the establishment of TERC:

- All sectors of the transportation industry expressed a need for the development of the Transportation Engineering Research Centre (TERC) to provide hard engineering support and additional competence in transportation research. It was further acknowledged that TERC should become a centre within the structure of the current Institute of Transportation (IOT).

- Strategic issues were defined for the transportation industry in ROC, from discussions with decision makers and from official documentation regarding the ROC Six-Year Plan. These must guide strategic planning for TERC's research and development actions and are identified as:

    - Accessibility and Mobility in the Transportation System;
    - Environmental Impact of Transportation projects;
    - Transportation Safety;
    - Modal Integration of Transportation Systems;
    - Transport Infrastructure Development and Preservation;
    - Technology Development and Integration.

- TERC should focus on the road and rail sectors of the transportation industry. Discussions showed that the R&D needs of marine transport and aviation are currently catered for by other agencies such as the Institute of Harbour and Marine Technology, the initiatives of the Civil Aeronautics Administration and the current research capabilities of IOT in these areas. The following technology focus and competence areas were identified for TERC:

    Highway Engineering:
    Pavement design and materials
    Construction
    Pavement management and performance
    Structures and geotechnics
    Railway Engineering:
    Track performance and component analysis
    Rolling stock
    Systems management
    Safety Systems and Traffic Engineering:
    Human Factors
    Safety Engineering
    Legal Aspects and Emergency Services
    Traffic Management

    Detailed recommendations regarding technology strategy, potential research areas and projects, the laboratory and support facilities required and the manpower requirements for each competence area are presented.

- The initial establishment costs for TERC should be provided by central government and government should be largely responsible for the ongoing financial support of the centre. As the centre matures, consideration should be given to increased involvement and support from the private sector and other public sector transport authorities on a contractual basis. This is in line with current international trends, particularly those observed in the four transportation research organisations investigated.

- Well-equipped testing facilities and laboratories exist at a number of universities, inter alia, for civil engineering structures at National Taiwan Institute of Technology (NTIT), National Taiwan University (NTU) and National Cheng Kung University (NCKU). Testing laboratories for asphalt materials exist at National Central University (NCU) and NCKU. These facilities can handle routine testing work, but have been set up with the aim of executing very specialised testing. Research at the universities is well advanced and in line with international trends, but transfer and implementation of technological advances to industry does not appear to take place effectively.

- Some of the facilities required by TERC are large and costly to establish and may not be utilised on a full-time basis. It is recommended that consideration is given to the sharing of such facilities where available, especially in the initial phase of TERC's establishment and until the demand justifies investment in its own facilities. Therefore it appears feasible for TERC to cooperate with institutions such as the ARTC, CSIST and universities with appropriate facilities, as some of the facilities offered by these organisations will be required in the TERC research projects.

- From the options identified in the report for establishing a test site for TERC, it is recommended that this facility be located in Tainan as part of the new campus of National Cheng Kung University. An agreement must be negotiated with NCKU for the use of a suitable area of land for this purpose, in terms of which IOT will be responsible for site development, maintenance and operation while being able to interface with the relevant expertise and facilities at this and other universities. Possible sensitivities regarding such an alliance with NCKU must be investigated and managed by IOT.

  Recommendations are given for the different laboratories and support facilities that should be provided on the TERC test site. Provisional resource requirements (manpower and equipment) are also presented.

- One of the key success factors for the implementation of the action plans will be to appoint an appropriate chief executive for TERC. Ideally this appointment should have been part of the initial planning process outlined in this document. This implies that the appointment should be internal to IOT.

An implementation plan is presented in the report to assist IOT in the phasing of the establishment of TERC and prioritisation of the various activities for formal establishment is given. Staffing requirements for the identified focus areas are suggested as part of the manpower plan. However, the successful implementation of the recommendations presented in the report will depend on the speed with which they are accepted by industry and the time taken to obtain official approval to establish TERC from the ROC legislature.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ALF	Accelerated Load Facility
APT	Accelerated Pavement Testing
ARRB	The Australian Road Research Board
ARTC	Automative Research and Testing Centre
ASTM	American Society for Testing and Materials
AVC	Automatic Vehicle Classification
AVI	Automatic Vehicle Identification
B+10	Bachelors degree, plus at least 10 years experience
CAM	Crack Activity Meter
CBR	California Bearing ratio
CSIR	The Council for Scientific and Industrial Research
CSIST	Chung-Shan Institute of Science and Technology
DCI	Data Communications Institute
DORTS	Department of Rapid Transit Systems
DOT	Department of Transport
E-mail	Electronic mail
EP	Electronic Profilometer
GIS	Geographical Information Systems
GPS	Global Positioning Systems
HVS	Heavy Vehicle Simulator
IOT	Institute of Transportation
IVHS	Intelligent Vehicle Highway Systems
km/h	Kilometres per hour
LAN	Local Area Network
LCPC	Laboratoire Central des Ponts et Chaussées
LTPP	Long-term Pavement Performance
M^2	Square metres
M+15	Masters degree, plus at least 15 years experience
Mb	Megabyte
MDD	Multi Depth Deflectometer
MLS	Mobile Load Simulator
MOTC	Ministry of Transportation and Communications
MRT	Mass Rapid Transit
MVDIS	Motor, Violation, Driver Information System
NCKU	National Chen Kung University
NCU	National Central University
NITTR	National Institute for Transport and Road Research
NMS	Novell Management System
NRRI	National Road Research Institute
NTC	National Transport Commission
NTIT	National Taiwan Institute of Technology
NTU	National Taiwan University
ODA	Overseas Development Administration
PC	Personal Computer

PMS	Pavement Management System
POHSR	Provisional Engineering Office of High Speed Rail
R&D	Research and Development
RMS	Road Management System
ROC	Republic of China
RSD	Road Surface Deflectometer
SHRP	Strategic Highways Research Programme
TANEEB	Taiwan Area National Expressway Engineering Bureau
TANFB	Taiwan Area National Freeway Bureau
TERC	Transportation Engineering Research Centre
THB	The Taiwan Highway Bureau
TKU	Tamkang University
TPPRG	Transportation Policy and Planning Research Group
TRA	Taiwan Railway Authority
Transportek	The Division of Roads and Transport Technology
TRB	The Transportation Research Board
TRL	The Transport and Road Research Laboratory
TRUPO	Taipei Railway Underground Project
UK	United Kingdom
USA	United States of America
WIM	Weigh-in-motion

1 INTRODUCTION

1.1 Background and terms of reference

The Institute of Transportation (IOT) is a research and development body with advisory and planning responsibilities within the Ministry of Transportation and Communications (MOTC) of the Republic of China (ROC). It has been given the task of establishing a Transportation Engineering Research Centre (TERC) to augment its current R&D capabilities. Based on its experience over more than four decades as an internationally recognised research organisation, the Division of Roads and Transport Technology (Transportek) of the CSIR in South Africa was commissioned by IOT to assist in the establishment of TERC.

From discussions with senior personnel from IOT, the following objectives were identified for TERC at the start of the project:

- to coordinate transportation engineering research in ROC;
- to resolve engineering technology problems for the transportation industry;
- to enhance the state-of-the-art of transportation engineering research and practice in ROC;
- to oversee the development, promotion and transfer of transportation engineering technology in ROC.

It was furthermore understood that TERC would engage in the following activities in pursuit of these objectives :

- establish, upgrade and maintain norms and standards for transportation engineering in planning, design, construction and maintenance;
- conduct research into base transportation technologies, applied technologies and into the promotion of specialised (pacing) technologies;
- establish and operate an information service to the transportation industry at large;
- manage the engineering/technology aspects of large transportation projects which would include the procurement, evaluation and control of required technologies;
- facilitate enhancement of the quality and standing of transportation engineering in ROC;
- assist related organisations in technology development, transfer and service coordination.

These proposed objectives and activities of TERC were used by the CSIR as a basis for developing the Scope of Services required. As part of the services provided, the objectives and activities of TERC have been modified to form a feasible establishment plan and accommodate the views and needs of the transportation industry in ROC.

The services provided under this contract were divided into three stages which are summarised in Table 1.

1.2 Scope of Services provided

Stage 1
This stage concentrated on a review of existing information, definition of the objectives of TERC and on reaching agreement in principle on the organisational structure and technology focus areas. This involved the following:

- a review of the structures and operating philosophies of four international transportation research organisations to provide IOT with a perspective of current trends in the management of transportation research. This includes the experiences and learning obtained from the ongoing development of Transportek as part of the CSIR;
- discussions with Drs Jyh-Dong Lin and Chien-Chung Lee of National Chung-Yang University, authors of a planning document prepared for IOT, entitled "A Short Term 5-year Research and Development Plan for the Transportation Engineering Research Centre";
- interviews and discussions with individuals and organisations, both in the public and private sector, to identify the various needs and expectations for a research centre such as TERC;
- interactions with counterpart staff of IOT to present the relevant findings and to develop a framework for a strategic plan for TERC;
- development of an action plan for interactions between specialists of the CSIR and IOT in the identified technology focus areas for implementation in Stage 2 of the services.

Stage 2
This stage involved interactions between various CSIR specialists, counterpart IOT staff and industry stakeholders. Current transportation R&D activities, needs and facilities were investigated to gain inputs for the planning of research programmes for the focus areas identified in Stage 1. Preliminary details of the resources required in terms of staffing levels, equipment, office and/or laboratory facilities were also determined.

Stage 3
This stage involved a final review and consolidation of all information gathered in Stages 1 and 2. Recommendations were presented to senior personnel of IOT for finalisation and agreement on the operating philosophy, organisational structure, resource requirements and research programmes for TERC. An implementation plan was developed for the formal establishment of TERC.

TABLE 1 : DESCRIPTION OF ACTIVITIES AND OBJECTIVES

ACTIVITY AND DESCRIPTION		OBJECTIVES
1	*Mobilisation & planning:* Preparation, gathering of relevant information and detailed planning of interactions and logistics for Stage 1	• Gain a perspective of the management of transportation research in the CSIR and other similar international organisations. • Develop a framework for Stage 1 operations. • Organise logistics of visit for Stage 1.
2	*Stage 1:* Review of past planning, needs analysis and strategic planning in collaboration with IOT counterparts and other stakeholders in ROC	• Integrate past planning into Stage 1 operations. • Define and prioritise the major issues in ROC's transportation industry. • Determine the mission and role of TERC. • Determine transportation needs in ROC. • Identify technology focus areas for TERC. • Compile inputs for a strategic plan for TERC. • Finalise detailed planning for Stage 2.
3	*Stage 2:* Technical interactions between specialist staff of CSIR and IOT to define specific resource allocations and research direction in the selected focus areas	• Identify and define detailed research needs and strategic direction for each focus area. • Establish human resources and facility requirements for each focus area. • Plan and schedule generic research activities. • Provide inputs for budgetary purposes.
4	*Stage 3:* Final reporting and development of implementation plans for formal establishment of TERC	• Develop implementation plans for the formal establishment of TERC.

3

1.3 Schedule of Services

The project commenced on 2 August 1993 and the draft final report was scheduled for submission on 5 April 1994. A Schedule of Services is shown in Figure 1 which includes provision for comment by IOT and submission of the final reports to IOT.

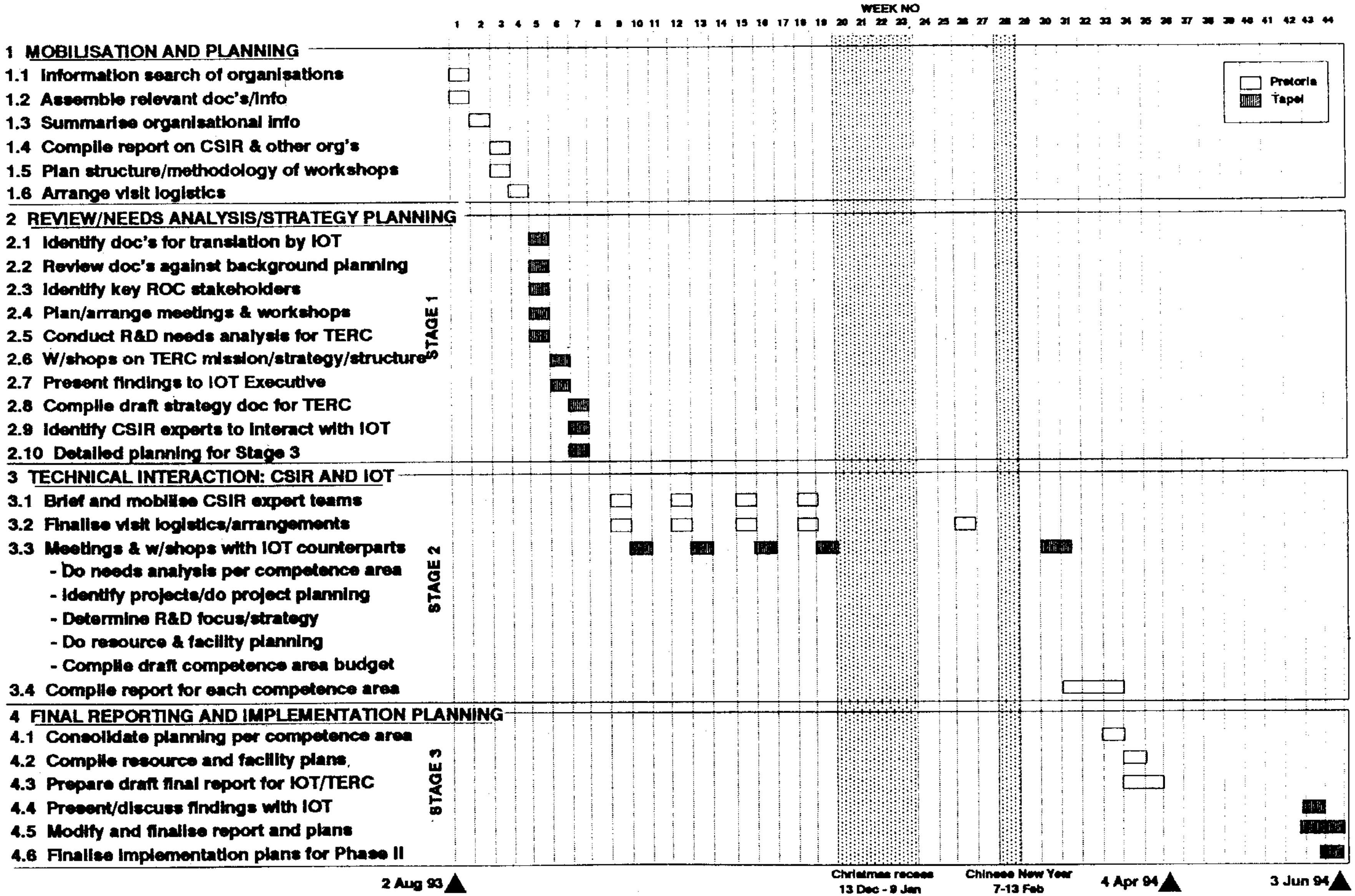
1.4 Project deliverables

The project deliverables as defined in the contract document (Appendix B-2) included:

- a report on organisational structure and operating philosophy of selected international transportation research organisations, including the CSIR;
- framework for a strategic plan for TERC; and
- resource plans, budgets and implementation plans for the technology focus areas and for TERC as a whole;

This report serves to consolidate all of the above and provides detailed recommendations to assist IOT in the establishment of TERC.

FIGURE 1: REVISED SCHEDULE OF SERVICES



2 PERSPECTIVES FROM INTERNATIONAL TRANSPORTATION RESEARCH AGENCIES

In attempting to provide some direction and guidance for the establishment of TERC, profiles of four prominent transport research agencies were compiled. These were the Transportation Research Board (TRB) in the USA, the Transport Research Laboratory (TRL) in the UK, the Australian Road Research Board (ARRB) and the Division of Roads and Transport Technology (Transportek) of the CSIR, in South Africa. The detailed report on these organisations is attached as Appendix A.

In addition, the report in Appendix A contains some thoughts on the management of science and technology, to assist in the compilation of a technology strategy for TERC. A summary of the relevant issues impacting on the establishment of TERC is presented in Section 2.5.

2.1 The Transportation Research Board (TRB)

TRB forms part of the USA's National Research Council and operates as a national coordinator for transportation research. Its main purpose is to manage R&D efforts on behalf of the USA transport industry and, hence, to act as a clearing house for the development and acquisition of transportation technologies. A secondary and small function is to conduct in-house projects in selected areas. The organisation has traditionally been funded from the US federal budget, but since 1990 there has been a shift in emphasis to obtain increased financial support from state- and local government sources. Funding options such as user charges, encouragement of private sector involvement and toll roads are being used. The underlying belief is that the recipients of federal transportation relief should play a larger role in sharing the project costs of research.

The organisation has, over the past two years, experienced a significant increase in top-level interest in and support for innovative research in transportation. Transportation in the USA appears to be emerging once again as an issue of national priority. More attention is being given to the relationship between transportation investment and economic development and to productivity, as well as to fostering modern yet environmentally friendly research. Marine, air and waterway transportation research has become relatively more important to TRB's research profile in the 1990s.

Unlike most other transport research agencies, TRB appears to have no engineering research facilities of its own and contracts all research in this field out to universities, consulting firms and other private sector laboratories. The organisation itself does, however, seem to provide major inputs into strategic and policy issues on a federal level.

2.2 The Transport Research Laboratory (TRL)

TRL was an integral part of the UK Department of Transport (DOT) until April 1992, when it started to function as a self-supporting and semi-privatised executive agency within the DOT. Although TRL is often seen as a government organisation, it views itself as an independent R&D laboratory and is moving towards becoming a fully commercialised operation.

Traditionally, TRL's clients were mainly the DOT and the UK's Overseas Development Administration (ODA), with very few clients emanating from the private sector. However, the proportion of private to public sector clients has been increasing steadily since the late 1980s as the privatisation drive in the UK impacted on their activities. TRL envisages that this trend will continue for some time, but that a culture of greater state responsibility (and perhaps re-nationalisation) will eventually replace it.

The research programme of TRL also reveals this trend towards privatisation outside and within the organisation. In its 1988 programme, TRL invited greater participation from industry in its research activities and offered a consulting and commercial service from its laboratories.

While the volume of TRL research remained approximately constant in real terms in recent years, there has been a marked shift in emphasis, for example, towards environmental concerns and studies of road user behaviour. It is predicted that this trend will continue, at least for the immediate future.

TRL has extensive laboratory, test track and surveillance facilities to support its research programmes.

2.3 The Australian Road Research Board (ARRB)

ARRB is a research centre registered in the state of Victoria in Australia, and is a non-profit public company limited by guarantee. Its members are the Federal Department of Transport and Communication, the eight State and Territory Road Transport Authorities and the Australian Local Government Association. Funding for research is obtained largely from members' contributions. However, there appears to be a trend towards increased funding from contract research. Currently about 80 percent of ARRB's research projects are undertaken as part of the core programmes funded by members, while the remaining 20 percent are funded under contract or partly sponsored by members and industry. ARRB is managed by a Board of Directors, which is appointed by the members to take responsibility for corporate policies, goals and directions, and for overall operation of the organisation.

For the purposes of setting direction and monitoring performance, ARRB relies on the guidance of an Advisory Committee, comprising prominent individuals from government, industry and academia. Traditionally the committee's role has been to give advice on technical issues, but since 1991/92 this role has been broadened to enable the committee to provide a critical and independent perspective on research and related needs of the roads and transport industry and the broader community, and to assess the extent to which ARRB is meeting those needs.

ARRB operates its own laboratory and computer facilities, as well as an extensive library of road literature and a database on road information. The organisation has initiated a strong marketing drive since 1992, in support of its strategy to increase contract income and become more service orientated.

2.4 The Division of Roads and Transport Technology of the CSIR

The Council for Scientific and Industrial Research (CSIR) in South Africa was established in 1945 as a statutory body to undertake research and development in the national interest. The organisation's primary focus was on the advancement of science and technology, with the bulk of its funding coming from a parliamentary grant. In 1986 the CSIR consisted of some 31 national research institutes with about 5000 employees, mostly scientists and engineers.

Transportek originated as a small research unit for bituminous binders under the auspices of the CSIR, in 1949. Its activities gradually expanded to fulfil a greater need from South African road authorities and from 1954 to 1963 it was officially established as the National Road Research Institute (NRRI). As a result of the Driessen Commission's investigation into road transport in the early 1970s, the NRRI was expanded to incorporate transportation and safety research and it was then renamed the National Institute for Transport and Road Research (NITRR).

The Division of Roads and Transport Technology (Transportek) was formed in 1987 as part of the restructuring of the CSIR, to become one of 13 strategic business units. In this process, the CSIR changed its business philosophy from being a science-based and state-run agency to becoming a more autonomous organisation with strong market focus. These changes have enabled the CSIR to reduce its dependence on parliamentary grant income to less than fifty percent in 1993.

Until 1988, funding for transport research was controlled by the Department of Transport and the four provincial road authorities and a rolling three-year funding package for Transportek was negotiated with the National Transport Commission (NTC). As a consequence, in the period 1970 to 1985, Transportek research staff increased to over 300, with an average annual increase in funding of 23,6 percent.

A central part of the operations during this period was the guidance of research programmes through a system of steering committees consisting of prominent officials from road authorities (urban, provincial and national), private sector, industry and universities. These committees, being representative of the various client (funding) authorities, were responsible for the approval of each year's research portfolio and for the monitoring of progress on a quarterly basis. A major benefit of this system was the sustained contact between researcher and practitioner, leading to the successful implementation of research findings.

During this period, most of the transportation-related research in South Africa was conducted by Transportek, with some small programmes at universities. This ensured that transportation research in the country remained focused and coordinated.

Significant changes in transportation research were experienced after 1987, caused by *three* major factors:

- a decrease in the Department of Transport's budget for research;
- changes in the research management system, creating opportunities for consultants and universities to compete for research projects through an open tender process; and

- a change in business focus within the CSIR and Transportek.

The short-term effects of these changes have been that Transportek has had, firstly, to diversify its client base in an effort to counteract the reduction in research income from the Department of Transport, and, secondly, to reduce its staff complement in line with available funds. This necessitated a sharpening of business and technology focus and a more productive use of available skills within Transportek. However, on a general basis, this has also caused a fragmentation of research efforts in the country and reduced strategic perspective with respect to transportation technology development.

The system of research management also changed during this period and currently consists of an administrative section and nine advisory panels to identify needs and monitor progress. This process is more formal than when steering committees were in operation. However, the open tender system requires stricter control. The management system is controlled by the Department of Transport but is currently under review.

Transportek's support infrastructure includes well-equipped soils, materials and geo-chemical laboratories, a large computer network, field survey equipment, road monitoring equipment and three mobile testing machines for accelerated pavement evaluation (Heavy Vehicle Simulators). As an integral part of the CSIR, Transportek has the benefit of the CSIR's extensive information management network as well as access to technologies that impact on but are not directly related to transportation research.

2.5 Issues for consideration in the establishment of TERC

From the investigations reported above, it is believed that the following issues must be taken into account for the establishment and future planning of TERC and transportation research in general in ROC:

- There seems to be a tendency in many countries to reduce government grants for transportation research;

- Involvement of the transportation industry (through advisory bodies or steering committees) in identifying research needs and assisting in advising and monitoring progress seems to hold distinct benefits in reducing the fragmentation of research and improving the chances of implementation. However, it must be stressed that the actual research should be managed and controlled by the research organisation (eg IOT) and the steering bodies should be used to guide and monitor research activities;

- There seems to be an increasing need on the part of industry and governments to hold research organisations accountable for the yields of their investments in research activities;

- All four organisations investigated had different origins, which, to a large extent, has dictated how these organisations have developed and restructured themselves. The case closest to the situation of IOT and TERC, appears to be that of TRL in the UK, an agency that once formed part of the Department of Transport in that country. However, as this organisation has matured, it has also moved towards privatisation and commercialisation to an extent that it strives very strongly to become self-supporting;

- An open tender system for managing contract research has, in the case of South Africa, led to short-term approaches to R&D and an emphasis on applied research that easily loses sight of strategic issues. The need for short-term research outputs should be balanced with a strategic view of technology development and this must receive attention in planning TERC and IOT's role in research management in ROC;

- In South Africa there is now a move towards greater cooperation between Transportek and universities, as well as the inclusion of experts from the private sector in specific projects.

3 INDUSTRY SURVEY

This survey was conducted during Stages 1 and 2 of the project and was aimed at determining the extent and nature of R&D needs of industry. A questionnaire was designed to assist in interviewing a representative cross-section of the private and public sector transportation industry in ROC, and consisted of questions about the following:

- primary role and function of TERC;
- types of support services to be offered:
- research needs and priorities;
- potential funding mechanisms
- relationship of TERC with different sectors of industry;
- relationship of TERC with universities; and
- management structure of TERC.

Appendix B contains a copy of the questionnaire, a summary table of industry responses and a list of organisations/individuals contacted. This analysis shows that industry needs may be categorised in specific technology focus areas and a provisional recommendation was made that TERC be structured around these areas:

- railway engineering;
- highway engineering;
- safety systems and traffic engineering;
- engineering laboratory support; and
- information management and technology.

Following this initial survey of needs and expectations, a series of detailed interactions were undertaken in the identified focus areas to establish a perspective of current transportation practice in ROC and of the interface between practice and the transportation research environment. This investigation focused on the following aspects:

- current design methodologies, standards and specifications used in highway and railway engineering;
- practices and methodologies in traffic management;
- existing testing and measuring facilities;
- possible areas of testing facility overlap or duplication;
- availability of human resources in terms of skills levels and specialisation; and
- facilities and skills available at agencies which showed an interest in cooperating with TERC.

These interviews and visits provided valuable inputs into the planning process with respect to, firstly, planning the facilities and testing equipment required by TERC and, secondly, the expertise and abilities in industry that TERC may wish to make use of.

3.1 Summary of industry R&D needs and expectations of TERC

Results from the industry questionnaire were analysed and the comments summarised in the following sections.

3.1.1 The primary role and function of TERC

The organisations and individuals interviewed agreed that there is a real need for a Transportation Engineering Research Centre, and that it should focus on the road and rail sectors of the transportation industry. It was felt that R&D needs in marine transportation and aviation are currently catered for by other agencies, such as the Institute of Harbour and Marine Technology and the initiatives of the Civil Aeronautics Administration, and also through IOT's current research capabilities in this area.

Discussions with the senior management of IOT indicated that the role and function of TERC have been debated extensively and are well understood by the relevant IOT Divisions. There is general agreement that the centre should provide hard engineering and full-scale laboratory facilities in support of the activities of the various IOT Divisions and other stakeholders in the industry. It seems from the discussions, therefore, that TERC will initially fulfil three roles:

- TERC should provide the engineering support required by the existing IOT Divisions and by industry (e.g. Transportation Safety) to expand their operations and develop new technologies;
- TERC should act as an enabler for the development of engineering competence in areas where IOT currently has limited capabilities (e.g. pavement engineering and materials);
- TERC should standardise and coordinate the collection, processing and management of transportation-related data for use by all sectors of the industry.

The major potential beneficiaries of TERC would be the various highway agencies (TANFB, TANEEB and THB), rail authorities and the transportation and public works departments of the various city governments. Interviews with the various agencies generally confirmed the views of IOT staff, insofar as they all have a need for the development of a national competence to support and enhance their own capabilities in hard engineering.

The consulting engineering and construction firms contacted supported the development of TERC and expressed a willingness to create opportunities for cooperation between the private sector laboratories and the facilities of TERC.

3.1.2 Types of support services to be offered by TERC

From the discussions, the following service areas were highlighted for TERC:

- a highway engineering R&D facility that would aim at establishing the required expertise in road pavement design, construction and maintenance appropriate to the conditions in ROC;
- testing laboratories for road building materials, including cementitious materials, bituminous materials, soils, granular materials and concrete, and the materials used for railway construction;
- testing facilities for structural members of bridges and associated structures, e.g. for steel, concrete and composite members;
- a full-scale testing facility for road pavements, including accelerated testing capabilities and the associated data acquisition systems;
- a railway test track facility to investigate track design and performance and for the evaluation of new products and railway components;
- a traffic engineering laboratory that could supplement the activities of the current IOT Transportation Safety Division;
- traffic flow monitoring systems and equipment and a capability to execute surveys on a national basis;
- road and rail surveillance hardware, inter alia, pavement surface condition assessment equipment, axle load classifiers and specialist survey vehicles;
- a facility to investigate and develop new and advanced transportation technologies such as Intelligent Vehicle Highway System (IVHS) and Automatic Vehicle Identification (AVI) technology.

3.1.3 Research needs

The research needs of the Industry are summarised in Table 2 and are based on the interaction and interviews with a broad cross-section of individuals and organisations representing the various sectors. It should be noted that no priorities were accorded to the needs shown in this table.

TABLE 2: SUMMARY OF INDUSTRY R&D NEEDS

Industry Sector	Highway Engineering	Railway Engineering	Safety Systems and Traffic Engineering	Information Management
Private	• Road design standards and procedures • Construction methods • Materials testing and evaluation • Tunnel ventilation • Geological rock classification system • Safety at construction sites		• Traffic control systems • Environmental issues	
Public	• Standardisation of rehabilitation design methods • Technologies for road maintenance • Construction management/Quality control • Materials and methods for bridge maintenance • Road serviceability and condition assessment • Road management • Provision of surveillance equipment • Long term pavement performance • Databases for construction and user costs • Effects of vehicle overloading • Bridge formula • Design of arrestor beds • Environmental impact of construction	• Construction management • Evaluation of new products and technologies • Development of local products • Manufacturing techniques for railway products • Railway signalling • Noise and vibration in train sets • Economic benefits of High Speed Rail • Tunnel ventilation • Rail/tunnel construction technology • Simulation of dynamic and static loads to evaluate track performance • Monitoring equipment for track performance • Performance of rolling stock • Materials testing and evaluation • Research coordination • Signalling and level crossings	• Coordination of decision making in Government departments • Geometric design standards • Facilities for pedestrians • Traffic control and signalling systems • Road side furniture • Arrestor beds • Parking management • Impact of public transport systems • Design of modal interfaces • Integration of transportation nodes • Integrated transport planning • Effects of traffic congestion • Emission control of vehicles • Incident management systems • IVHS • Motorcycle and pedestrian safety • Driver behaviour and attitudes • Education and training • Identification and improvement of hazardous locations • Safety at road works • Law enforcement strategies and technologies • Accident studies • Emergency systems • Vehicle safety • Control of vehicle overloading	• Standardisation of data collection, processing and dissemination procedures • Decision support modelling packages • Communication systems for the transport industry • Technology scanning and forecasting • Linkage with international information systems
Academic Institutions	• Road management • Coordination of research efforts • Materials testing and evaluation • Pavement engineering • Bridge design code • Performance of bridge joints • Bridge management • Techniques for bridge maintenance and repair			• Centralised transportation databases

14

3.1.4 Potential funding mechanisms for TERC

Most of the individuals interviewed were of the opinion that the initial establishment cost for TERC should be provided by central government and furthermore, that government should be largely responsible for ongoing financial support of the Centre. The private sector and other public sector transport authorities indicated a willingness to support TERC through contract research after establishment. It was felt that, as the organisation matures, provision should be made for increased participation by the private sector. This is in line with current international trends as highlighted in Section 2.

3.1.5 Relationship of TERC with industry

Many individuals interviewed expressed a need for industry to have closer ties with and better access to the research environment, since industry can currently only make their needs known to IOT through MOTC. The only access to research for most public sector agencies and for the private sector is through either the university system or in-house research.

It is believed that this is one of the primary reasons for the fragmented nature of transportation R&D in the ROC and the lack of implementation of research findings through effective technology transfer to industry. This aspect will require serious attention in the establishment of TERC and the formation of research steering bodies should go some way to addressing the problem.

3.1.6 Relationship between TERC and universities

Although strong units of expertise in certain transportation disciplines exist at many universities, the individuals interviewed were all in favour of cooperation with TERC, and of better coordination of R&D activities. The universities represent a source of manpower that could possibly be utilised very effectively by TERC. However, it will be necessary to establish effective exchange mechanisms between the universities and TERC to the benefit of all parties involved.

3.1.7 Management structure of TERC

Few opinions were received about the structure and operations of TERC, since most people interviewed believed that this was a matter for IOT and TERC to resolve internally, and also because organisational structures in the government system are determined by statute. The comments received can nevertheless be summarised as follows:

- an arrangement whereby TERC makes use of "temporary" employees or freelance researchers will allow it more flexibility of resources, at least initially;

- the senior management of TERC must be highly qualified and well experienced and should make it a priority to establish ties with international research organisations and to cooperate with other ROC agencies;
- the incumbent senior executive of TERC should ideally have taken part in the planning process from the start of this project;
- in order to be able to attract the appropriately qualified manpower, IOT/TERC will have to give consideration to the level of remuneration packages.

3.2 Current practice in ROC

In order to gain an understanding of the R&D needs that must be addressed by TERC in its technology focus areas, it was first necessary to assess current practice within the industry and the extent to which further development and technology support is required. Given the time constraints of the project, it was not possible to conduct an in-depth and very detailed evaluation in the various disciplines. Aspects highlighted below are those believed to have a direct bearing on the operations of TERC and are not intended as a definitive analysis of the industry.

3.2.1 Highway Engineering and Structures

Planning
Little emphasis was placed on the planning function during visits and interviews, since R&D in highway planning is one of the primary functions of the current Divisions of IOT.

Design
There is a strong geotechnical design capability in ROC because of the experience of local engineers with a difficult construction environment. Methods are based on US practice and emphasis is placed on rock mechanics, deep foundations for tunnels and structures and the effects of seismic activity on design criteria.

Design practice for structures and bridges is based on USA standards, and for most complex projects, consulting engineers in ROC are well experienced and skilled. A major need appears to be for appropriate maintenance strategies for structures, especially because of damage done by overloaded vehicles. The severe overloading situation has resulted in an increase of the AASHTO bridge design "live load" by 30 percent in the case of the THB and by 25 percent in the case of the TANFB bridge design offices.

Pavement design methods are also based on US practices such as AASHTO, ASTM, Asphalt Institute and California R-value and are based on an 80 kN equivalent axle load. There appears to be two pavement structural design methods in use by the various authorities, and these may be in conflict (i.e. CBR vs R-value). Materials design practices for pavements appear not to take account of latest technologies, nor of the suitability and applicability of methods with regard to specific local conditions.

Construction quality control

Quality control on larger projects is carried out by the engineer while on smaller maintenance projects the road authority will carry out its own control. Documentation on standard specifications for quality control is available and in use. However, their effectiveness and extent of application is unknown. Research needs have been identified in this area, considering the huge investment that the country is making in infrastructure development.

Maintenance

Routine roadway and road reserve maintenance is generally carried out in-house by the various road authorities. Vegetation control is the main activity, consuming about one-third of the maintenance budget. There are no formal maintenance management systems to assist in scheduling and prioritising maintenance activities.

Programmed maintenance is normally done under contract and consists mainly of large-scale surface repairs and/or rehabilitation with an overlay. In view of traffic conditions, most of these activities are carried out at night. A need was expressed to develop rapid-setting patching and overlay materials to allow for quicker trafficking of newly maintained sections. Pavement rehabilitation designs are carried out in-house by the various road authorities and are based on deflection results, while the work is generally carried out under contract with in-house quality control.

TANFB is the only authority with a computerised pavement management system (PMS). As inputs to the system, visual surveys, deflection measurements, skid resistance and roughness measurements are done annually for the 373 km of freeway under the Bureau's control. Aggregate condition indices are calculated for each roadway element and tested against recommended terminal serviceability levels to identify candidate improvement projects. The Bureau is currently in the process of changing its mainframe system to a PC-based system.

The THB identifies rehabilitation projects from annual inspections within each region, as well as from requests from provincial assembly members.

From discussions with the National Taiwan University, it transpired that implementation of PMSs is an area of major concern. The existing PMSs in Taiwan can still be regarded as first generation systems, i.e. making use only of primary condition ratings and survey data and not employing advanced decision-making algorithms.

Monitoring

In addition to the condition assessments carried out by TANFB for input into their pavement management system and described in the maintenance section above, monitoring is also carried out for structures and vehicle overloading.

The structural integrity of bridges is monitored with a sonic viewer attached to a specially designed vehicle.

Vehicle overloading is seen as a major problem by both TANFB and THB and is one of the main causes of damage to bridge decks and expansion joints. A number of fixed and portable weighbridges are used by the Highway Police Bureau to weigh vehicles statically for the enforcement of the axle load limitations. In many cases, overloaded vehicles avoid the permanent weighbridges at toll stations by using alternative routes. The German PAT system is currently used on an experimental basis for weigh-in-motion measurements. This study is controlled by NTU.

Development of data acquisition systems appears to be in an early phase and is not considered to be well coordinated. No standardised databases appear to exist for general use by the industry for road and bridge management purposes.

Research and technology transfer

Although some research projects are undertaken by consultants and road authorities, the majority of research work in highway engineering is carried out at universities and institutes of technology. These include the following institutions which were visited, or with whom discussions were held:

- National Taiwan University (NTU)
- National Central University (NCU)
- National Cheng Kung University (NCKU)
- Tamkang University (TKU)
- National Taiwan Institute of Technology (NTIT)

NTU concentrates mainly on pavement management systems and structural engineering, while NCU and NCKU specialise in pavement engineering and materials. The latter also has specialised facilities for geotechnical and structural research work, as is the case with NTIT. TKU has expertise in non-destructive testing of pavements, back-calculation of elastic properties and software development for rehabilitation design.

Various experimental road pavement sections have been constructed in the past to do research on pavement design and rehabilitation, but it seems that these are not formally monitored and reported on in terms of performance.

The university system and MOTC promotes technology transfer through annual pavement engineering seminars and ad hoc courses, but there appears to be a shortage of qualified and experienced practitioners to play a proactive role in this process.

3.2.2 Railway Engineering

The general impression gained was that little research is currently being carried out either in-house or with universities in the area of railway engineering in terms of track design, maintenance and rolling stock. The Department of Construction Engineering at NTIT is currently doing research on the fatigue life of concrete sleepers and NCKU also has laboratories for railway engineering research.

The discussions with the Department of Rapid Transit Systems (DORTS) indicated that possible areas of research will only become apparent once the rapid transit system is in operation. It appears that construction methods for the system are well understood and that little additional research is required in this area, although the location and identification of underground public utilities during construction has proved to be a major problem.

There also appears to be a lack of coordination between the civil, mechanical and electrical disciplines, which has resulted in unnecessary costs and delays. Improved methods of coordination and project management to facilitate the interface between the various disciplines need to be investigated.

The Provisional Engineering Office of High Speed Rail (POHSR) is planning and designing a high speed rail system linking Taipei and Kaohsiung. The daily ridership forecast for the year 2011 is 187 000 passenger-trips and hence some 234 trains per day are planned, with a capacity of 800 passengers per train. Travel time between Taipei and Kaohsiung will be about 90 minutes.

Passenger demand for this facility was established using a stated preference technique. These surveys were conducted two years ago and have been updated since. Traffic distribution calculations were based on the Gravity Model. Modal choice was studied using the Probit Model for high speed rail and air travel and the Logit Model for bus and car travel. Elasticity of travel cost and travel time was taken into consideration, with an assumed increase in the value of time in the future.

3.2.3 Safety Systems and Traffic Engineering

Human factors

The Transportation Safety Division of IOT has carried out numerous projects on human factors in road safety and is well experienced in this field. In order to promote traffic safety, a specific theme is set for each year, e.g. "Traffic Safety Year", "Driving Courtesy" and "Compliance with the Regulations". Behavioural studies include the effect of alcohol on the physiology of drivers and driver reaction to traffic signs.

Legal aspects

The Highway Police Bureau is responsible for performing general police duties, maintaining traffic order and safety on the freeway and highways, executing highway traffic inspections and control of violations, managing highway traffic accidents, maintaining security on the freeway and highways and enforcing highway laws. The organization compiles and distributes statistics on traffic accidents, violations and assistance rendered to disabled vehicles.

Accident reporting procedures have been developed by IOT for the Police Bureau, and all information thus gathered is stored in a database at the Police Bureau's headquarters. This database may be accessed by IOT for research purposes through a remote computer station. Violations management is adjusted according to information about the major causes of accidents. Roadworthiness of buses and trucks is assessed once a year, and for trucks older than 5 years, every six months. No information is gathered on vehicle overloading and blood alcohol content. The law enforcement effort is assisted by the use of automated techniques such as radar and cameras.

Traffic management

The main tasks of TANFB are road maintenance (see Section 3.2.1), traffic management, road broadening, service for motorists and toll collection. Two task forces have been established: the Freeway Widening Construction Office for the construction of the Hsichih-Wuku viaduct and the Traffic Control Centre for traffic condition monitoring and accident reporting.

Congestion on the freeway is detected automatically from occupancy calculations derived from the data generated by strategically placed detectors. When congestion is noted, police are despatched to assist. Changeable signs display warning messages for motorists.

Computerised traffic control systems have been developed by IOT's Safety Division for some 9 cities around the island. However, implementation is hampered by a shortage of traffic engineering practitioners in many of these cities.

The Department of Transport of the Taipei City Government has a broad range of transportation planning and administration functions, setting policies, collecting and analysing data, supervising traffic control, traffic safety, parking and law enforcement, and managing Taipei tourism activities and public rapid transit.

The transport system in Taipei operates at an inadequate level of service and the many large construction projects in the city add to the congestion. There appears to be no mechanism for timeously identifying incidents and bottlenecks and traffic authorities rely on casual reporting by police, road users and/or engineering staff.

Traffic surveys are conducted annually on major intersections, while special manual counts and surveys are mainly done by students. Some data are captured on video and a small proportion comes from installed inductive loop detectors.

An area-wide traffic counting system for Taiwan does not seem to exist. Permanent traffic counting stations are installed on the freeway and in only two other locations on highways. No temporary or seasonal counting stations are in operation.

Safety engineering

The Transportation Safety Division of IOT conducts research and development work in safety and traffic engineering (including traffic control systems, ramp metering control and parking safety). A number of vehicle safety engineering projects, e.g. high mounted brake lights, automobile safety devices and standards for domestic vehicles, were done in recent years. A large investigation of 340 accident-inducing locations throughout Taiwan was completed in 1991 and over 2 147 locations were identified for immediate improvement. Physical improvement of these sites is the responsibility of the relevant local authorities, but progress has been impeded by a lack of experienced and skilled manpower.

At provincial level THB manages traffic signs, road markings, traffic signals, crash barriers, street lighting, the application of warrants and a road traffic signs manual.

3.2.4 Information Management

Discussions were held with several external organisations who collect data for use by IOT. These organisations (and the data they collect) relate mainly to vehicle registrations, driver registrations and accident records. Existing IOT computer facilities and procedures pertaining to information management were also investigated. Full details of the investigations are given in Appendix C.

Ministry of Transportation and Communication (MOTC)
MOTC assist IOT with the structure and collection of road traffic accident data. A data-base system, designed IOT, is based on data stored on a WANG system at MOTC. Three levels of data are stored by IOT; Fatal/serious, slight injury and damage only.

There is no formal data analysis undertaken by MOTC, or annual reports produced for accident data. IOT carry out ad-hoc analyses for individual and/or research needs. Summary data is written to magnetic tape or a printer by MOTC according to IOT demands.

No other routine transportation, engineering or management databases are maintained by MOTC although some data may be kept at regional offices (for example, a Maintenance Management System is in operation at the Freeway Bureau).

Existing systems are based around WANG and SPARC Workstations. The move to workstation technology was guided by four other Government offices who have already moved in that direction. Therefore existing expertise was available. However, there are moves to downsize towards an open-system/PC environment, including an Ethernet cabling system, (UTP cable) and TCP/IP protocols to link with the WANG and SUN stations. Currently, 25% to 30% of users have access to PC's. This process started in June 1993 and it is planned to replace all terminals with PC's before 1998.

With regard to electronic mail, a public Electronic mail system (X400 based) is seen to be adequate. However, this system does not accommodate individual mail boxes and is unable to automatically advise users of new mail.

It is envisaged that computer links will eventually be established between IOT and MOTC (as well as the Data Communications Institute). This should not be a problem as the trend in both organisations is towards open systems which facilitate easy communication.

Data Communications Institute (DCI) and MVDIS II
A computerised system for the recording of motor, violation and driver information was established on June 1st 1984. This system was replaced by the Motor Vehicle Driver Information System (MVDIS-II) (cost in the region of NT$500m) in March 1994.

Under MVDIS-II, each of eight regional nodes are equipped with two HP9000 database servers, as well as two HP9000 terminal servers. Raw data is kept in an INFORMIX-SQL data-base system and a query system has already been developed.

At present, IOT use data from the MVDIS system but there are no on-line links. DCI perform some data analysis (at a cost) and write the summary data to tape for delivery to IOT. IOT then analyse the data further. DCI could accommodate more open on-line links between their system and IOT if required. Such a link could be established in one of three ways; X.25, TELNET/FTP or dedicated lease line.

National Police Administration

The National Police Administration use computer technology extensively to communicate between National Police Administration, County and Local Police Bureaus (390 AEC Mainframes), local stations (1500 PC's) and police vehicles (2 600 PC notebooks).

Most data (for example accident data) is input at the local police station level. Data is then compiled by the National Police Administration to produce national crime and traffic offence statistics.

All levels of accident data are input by the local police station. However, only the first category of data is used as part of the official police accident statistics. The balance is handed over to IOT (in the form of a computer printout). IOT staff then re-enter the data onto the Wang computer at MOTC.

There are no formal or on-line computer links with DCI. Vehicle registration and driver licence data (from DCI) is stored at the National Police Administration and the data is transferred weekly from DCI by magnetic tape. This is seen to be adequate for their purpose.

Existing computer facilities within IOT

Computers, particularly PCs, are used extensively for data analysis, data modelling and document preparation. Most are used as stand-alone computers, though some have been linked by an Ethernet network to a Novell file server. There are a number of ad-hoc ways that IOT links with other Government organisations. However, these tend to be based on dial-up or baseband modem technology and accessible to only a few (primarily administrative) staff members.

Access to the national accident data-base is via a terminal link to the Wang system housed at MOTC. The personnel section uses a 386 computer to emulate a terminal in order to gain access to a MOTC mainframe (again via modem). An aged System 36 machine is used for the administration of each Division.

Information Technology in the true sense of the word does not appear to be being used effectively in IOT. Computers are used to undertake more complex calculations than were previously possible (albeit much faster, more accurately and at a lower cost) and use is made of word processing technology.

However, Information Technology involves the interlinking of three technologies: word processing, electronic mail and most importantly, computer communications. The latter two technologies are not applied extensively in IOT. For example, the biggest obstacle to electronic mail seems to be the difficulties associated with using Chinese characters on conventional ASCII based computers.

Most Division Chiefs indicated however that easier, faster, electronic links with other IOT researchers as well as other research organisations around the world are desirable. In terms of global communication therefore, the Chinese character issue appears to be of secondary importance.

The network facility and its installation does not appears to have a very high priority within IOT and is being installed on an ad-hoc basis. The successful implementation of Information Technology within IOT will require a strong commitment from the whole management team.

A summary of the computer linkages and need of IOT is shown in Table 3 and the following points are highlighted:

- Currently there is a low percentage of PC's (35% average) connected to a LAN system.
- The present research Divisions of IOT have a need to communicate with other organisations both within Taiwan as well as internationally.
- There is a willingness to use some form of central network based project planning/cost control system to control and manage projects better.

Other identified problems to the implementation of Information Technology within IOT include:

- **Cost and cost saving:** Implementation of Information Technology implies an increased investment in capital equipment as well as higher running costs. However, there is some resistance to this which is reflected by the perceptions of some towards the implementation of Information Technology. The emphasis is mainly on cost with little account being taken of possible benefits.

TABLE 3: SUMMARY OF COMPUTER LINKAGES AND NEEDS OF IOT

	PC's linked to LAN (%)	Desire to link to other:		LAN based project/cost management
		Taiwan	International	
Trans. Systems Planning	59	Y	not sure	Y
Transportation Engineering	31	Y	Y	Y
Trans. Ops. and Management	36	Y	Y	Y
Transportation Safety	33	Y	Y	N
Information Systems	53	?	?	?
Interdisciplinary Research	30	Y	Y	Y
Administration	0	Y	N	N

Two examples illustrate how this impacts on IOT. Firstly the network is only expanded on an ad-hoc basis as and when resources become available. Secondly, there is a reluctance to obtain external and up-to-date accident data from DCI because of the cost involved.

- **Network infrastructure:** Until a basic LAN is in place, there can be little or no progress towards "Information Technology". In addition, computer users within IOT need to be trained in a LAN/Novell environment before IOT can take advantage of any higher level Information Technology.

- **E-mail** (electronic mail) is a significant component of any "Information Technology" strategy and provides the ability for IOT researchers to easily communicate both locally and internationally. In an effort to improve communications and access to information, it will be necessary to implement a complete E-mail system with individual mail boxes.

- **INTERNET** or some other global communication system, is essential to facilitate international communication with other research organisations.

- **Software and hardware standards:** With the exception of pirate software, there are no formal prescribed standards for commonly used software. However, the number of possible software permutations is reduced by verbal recommendations from the designated member of staff.

  Lack of standardisation may become a serious problem or bottleneck in data/document interchange in the future if true Information Technology were to be implemented.

- **Gaps in training and education:** While most researchers and managers are computer literate, there appears to be some gaps in expertise. An investment in training will be required to ensure that all personnel have an understanding of how to use the resources of the LAN fully and also have an understanding of Information Technology to enable them to take advantage of its power and ability to access other resources optimally.

- **Lack of infrastructure, access to expertise and support mechanisms:** Internal user-support for computer users and the network is currently undertaken on an informal basis. However, this support is essential for the encouragement and development of expertise amongst users and has been identified as one of the goals of the proposed new Computer Centre.

3.2.5 Available facilities and expertise for transportation R&D

The Automotive Research and Testing Centre (ARTC) in Hsinchu is a government agency responsible for researching and setting standards for the automotive industry in respect of vehicle safety, noise and exhaust emissions, fuel consumption and personnel training. It is also involved in assisting private enterprises in testing automotive products and components, and performing services needed for other parties, such as consumer groups, insurance companies and the courts. A wide range of tests can be performed, ranging from vehicle crashing to dust penetration; the total value of testing equipment installed is estimated as US$ 25 million. Fuel efficiency standards based on vehicle mass have been set and compliance is required by law. While unleaded fuel has been available for five years, all vehicles produced from July 1994 will be equipped with converters. A full vehicle testing track, skid-pan and vehicle handling facility will be constructed in the Kaohsiung area, with completion scheduled in 1998.

ARTC operates a modern testing facility able to evaluate motor-vehicle components, crash tests and conduct photometric studies. Cooperation with this institution will have to be considered for certain research activities in the area of traffic safety.

The Chung-Shan Institute of Science and Technology (CSIST) also has well-equipped facilities for mechanical and aeronautical engineering work and may have land available for full-scale road and rail testing grounds. This Institute has significant expertise in developing flight simulators, communications systems and data acquisition hardware and software for the defence industry. It also has the advantage of established engineering and electronics workshop support and expressed a keen interest in working with TERC.

CSIST is currently undertaking IVHS development that includes vehicle en-route information, vehicle operation control, operational analysis and dynamic vehicle optimum path selection. Future research will comprise real-time AVI and AVC and integration of existing traffic control and data logging systems. It would be important for IOT to stay in touch with these developments.

Materials testing laboratories at consulting engineering firms tend to perform mostly routine work, with some capability to conduct in-house research and specialised testing. At the public sector authority laboratories, the emphasis is on routine testing work and all specialised testing is therefore contracted to the private sector and universities.

NCKU in Tainan indicated that full-scale testing facilities for highway engineering research, similar to what may be envisaged for TERC, will be built on a test site on the university's new campus of the university. It also became apparent that this university considers itself to be ROC's southern regional centre of expertise in highway engineering.

Well-equipped testing facilities and laboratories exist at a number of universities, inter alia, for civil engineering structures at NTIT, NTU and NCKU. Testing laboratories for asphalt materials exist at NCU and NCKU. These facilities can handle routine testing work, but have been set up with the aim of executing very specialised testing. Research at the universities appears to be well advanced and in line with international trends, but transfer and implementation of technological advances to industry does not appear to take place effectively.

As facilities of the types mentioned above are large and costly to establish, consideration needs to be given to TERC sharing such facilities as and when required and where appropriate, especially in the initial phase of TERC's establishment and until the demand justifies investment in its own facilities.

The TANEEB, being responsible for the planning, design and construction of new freeways, commissions research through consulting firms and universities (a total annual value of NT$ 5 to 10 million). As IOT is a government agency, TANEEB may not appoint it directly for any research work, although TANEEB expressed a need for closer communication and is willing to support TERC.

4 FRAMEWORK FOR A STRATEGIC PLAN FOR TERC

4.1 Strategic issues facing the ROC transportation industry

Attempts to define a role and structure for TERC must be based on a thorough understanding of the external environment with which the organisation will be interacting. From the TERC questionnaires (Appendix B) sent out to various industry stakeholders, discussions with various transport authorities and also from a study of the ROC Six-Year Plan, a list of issues was compiled to guide strategic planning for at least the foreseeable future. This list of issues was also used to guide the identification of R&D needs and the compilation of R&D strategies.

The available information indicated that the problems and challenges facing the transportation industry in ROC could be summarised under six headings, as given in Table 4. These are:

- Accessibility and Mobility
- Environmental Impact
- Transportation Safety
- Transport Integration
- Transport Infrastructure
- Technology Development and Integration

The relevance of this list against possible future scenarios has not been considered, but it must be assumed that priorities and/or issues will change with time. For the short- to medium-term future (i.e. the next five to ten years), however, it is not expected that significant deviation will occur.

In addition to the identified needs shown in Table 2 and the technical issues reflected in Table 4, the following strategic aspects also need to be considered in planning the role, structure and operations of TERC:

- Expansion of the ROC freeway network and a rapidly ageing existing road network are making increasing demands on the technological capabilities in materials engineering, rehabilitation and road management.

- R&D needs of the rail industry are apparent in a number of areas, but as yet lack clear definition. Current issues are more of a policy and planning nature (e.g. the need for guidelines for modal integration) and these fall within the domain of the existing IOT divisions rather than TERC. When the MRT system becomes operational, it is expected that the need for technological support will increase. In addition, once a decision has been made on the future of the high-speed rail link between Taipei and Kaohsiung, technological support around track design and component analysis will be necessary.

- NCKU is an important R&D player in highway, structural and geotechnical engineering and has already developed plans for a full-scale highway testing facility in Tainan, similar to that envisaged for TERC. Thought must be given to mechanisms of cooperation that will ensure optimisation of resources.

TABLE 4: TECHNICAL ISSUES FACING THE ROC TRANSPORTATION INDUSTRY	
Accessibility and mobility	Traffic congestion Commissioning of mass rapid transit systems Traffic control Intelligent Vehicle Highway Systems Incident management Quality of life
Environmental impact	Vehicle emissions/alternative propulsion modes Sources and utilisation of road building materials Construction methods and materials Transport systems planning Eco-tourism Environmental impact assessment Quality of life
Transportation safety	Policies and management systems Engineering/design of vehicles and infrastructure Road user behaviour Traffic control devices Incident management Traffic law enforcement Quality of life
Transport integration	Integrated land use/transport systems and network planning Modal integration Allocation/prioritisation of investment funding Fragmented institutions and systems
Transport infrastructure	Decision support for policy makers Regional transportation impact Design methodology, standards and specifications Infrastructure planning and design Construction methods, equipment and materials Constructability and quality control Maintenance and rehabilitation Equipment and technologies for mass rapid transit systems
Technology development and implementation	Funding and coordination of R&D Utilisation of R&D facilities/expertise Quality and availability of skills and expertise Technology acquisition/development/evaluation/transfer Information technology for the transportation sector

- The availability of manpower to staff TERC could be a constraining factor, especially as far as senior management of the organisation is concerned. From talks with various universities, it seems that engineering graduates are produced in large enough numbers to staff the research ranks of TERC. However, sufficiently experienced and qualified managers may be more difficult to attract. There are a number of researchers and senior staff at universities who would be keen to take part in TERC research programmes and this may be an effective mechanism for countering the shortage of experienced researchers in ROC.

- The interface between IOT and TERC will be an important factor in the operations of the organisation. Some respondents to the TERC questionnaire have asked that the mission and role of the new facility should clearly distinguish it from the current IOT Divisions.

- Transfer of technology from academia and research into practice does not take place effectively in ROC. Industry recognised the effective coordination of R&D and technology transfer initiatives as an urgent need and TERC must also, within the scope of IOT's activities and responsibilities, make a proactive contribution in this field.

- The physical location of field testing facilities to be established by TERC must receive careful consideration to ensure that convenience is balanced with costs of owning and operating the testing facilities. It will be necessary to install effective communications systems between the facilities and TERC, so that computerised transfer of data and information may be done between technicians and research engineers in the IOT/TERC offices. Also, optimal size for this facility has to be determined should land need to be acquired.

- The Public Construction Supervisory Board of the Executive Yuan plans to establish a Ministry of Construction with its own construction research facility. The facilities TERC intends to establish will have to anticipate such efforts.

- Considering the worldwide trend that research funding from governments is decreasing, TERC's operations and interactions with industry should be planned to create opportunities for industry involvement over the medium to longer term.

4.2 Proposed role and function of TERC

From the information collected, the strategic issues listed in Section 4.1 and the discussions with industry, a number of recommendations have been compiled for a strategic plan for TERC. These recommendations would serve as a basis for the final development of a strategic plan for TERC, once the top management structure of the organisation has been appointed. This process must also seek advice from IOT executive and Division Chiefs, to ensure alignment with IOT's mission as outlined in Section 4.2.1.

4.2.1 Proposed mission

TERC forms an integral part of IOT and provides engineering technology and support by developing standards and procedures and by supplying specialised testing facilities and services to the transportation industry in ROC.

4.2.2 Extended mission

In its operation TERC will provide specialist engineering support to the following missions, rules and regulations of IOT:

- Pursue actively the implementation of the transport development projects that have been incorporated into the ROC Six-year National Development Plan;
- Improve transportation management and enhance managerial expertise;
- Encourage the private sector to participate in transportation development projects so as to foster a strong private transportation industry;
- Enhance the competitive edge by expanding the scope of involvement in international transportation activities in support of the nation's economic and political objectives;
- Develop comprehensive transportation plans and accelerate the integration of transportation systems in order to improve the efficiency of transportation services;
- Promote rational development of transportation infrastructure;
- Provide design and R&D of transportation engineering systems;
- Provide support to research and planning in transportation safety;
- Promote the application of transportation research findings and technology transfer;
- Provide liaison and cooperation with local and international transportation research organisations;
- Collect, compile, translate and disseminate transportation information.

4.2.3 Proposed objectives for TERC

The initial aims of TERC are highlighted in IOT's current promotional video material. These have been used as a basis for compiling the following proposed objectives for TERC:

- to draft national standards, procedures and methods for the planning, design, construction and maintenance of roads and railways and for traffic engineering and safety;

- to act as an independent and objective testing and evaluation authority for the transportation industry;

- to provide specialised technical support for engineering agencies engaging in materials testing, quality control and technical analysis;

- to encourage and coordinate the development of new engineering technologies and to promote technology transfer;

- to play an active role in the development of engineering manpower for the transportation industry.

4.2.4 Integration of TERC and IOT

Considerable difficulty was encountered in defining a coherent role and purpose for TERC, specifically as far as the provisional focus area (suggested in Section 3) of safety systems and traffic engineering is concerned. The reason for this was mainly that IOT is already working in these fields and that duplicate structures must be avoided.

A possible solution is proposed in Figure 2. The rationale is that by the very nature of R&D activities, their complexity and engineering content vary considerably. On the one end of the spectrum is found the routine and ad hoc type of testing work and the research associated with it, while the other end requires higher order conceptual thinking to engage in, for example, policy development and strategic planning. Investment in physical resources and testing facilities is high at the "hard" engineering end, while activities such as policy development do not require the same physical resources and level of support but do require senior experienced personnel with an extensive background in national transportation issues.

As proposed in the original planning for TERC, and as stated by IOT management and industry stakeholders, there is a need for an "engineering" facility to provide technical support, and it is thus logical that TERC engages predominantly in the activities related to hard engineering and routine testing. TERC's involvement in R&D tapers off as the "conceptual" content (current IOT domain) of research increases. The examples in Figure 2 demonstrate four conceptual stages of R&D to illustrate the variation in nature and content of work. Examination of these examples and of IOT's proposed relationship with TERC may imply that IOT will have to reconsider its current involvement in certain technologies and/or activities that are of a more routine or hard engineering nature.

The relative involvement of TERC and IOT in any given project will change depending on the nature of the project. The underlying understanding from the mission of IOT is that it is required to have a strategic alliance or partnership with the industry it serves and that TERC is a technology provider operating predominantly in the area of "hard" engineering support.

4.3 Mission success factors

In order for TERC to be successful at its chosen mission, it is believed that the issues discussed below are crucial. These have been obtained from discussions with industry and an analysis of information presented in the previous sections:

- To gain maximum benefit, the new centre must be fully integrated into the IOT structure and take part in R&D strategy planning and decision-making.

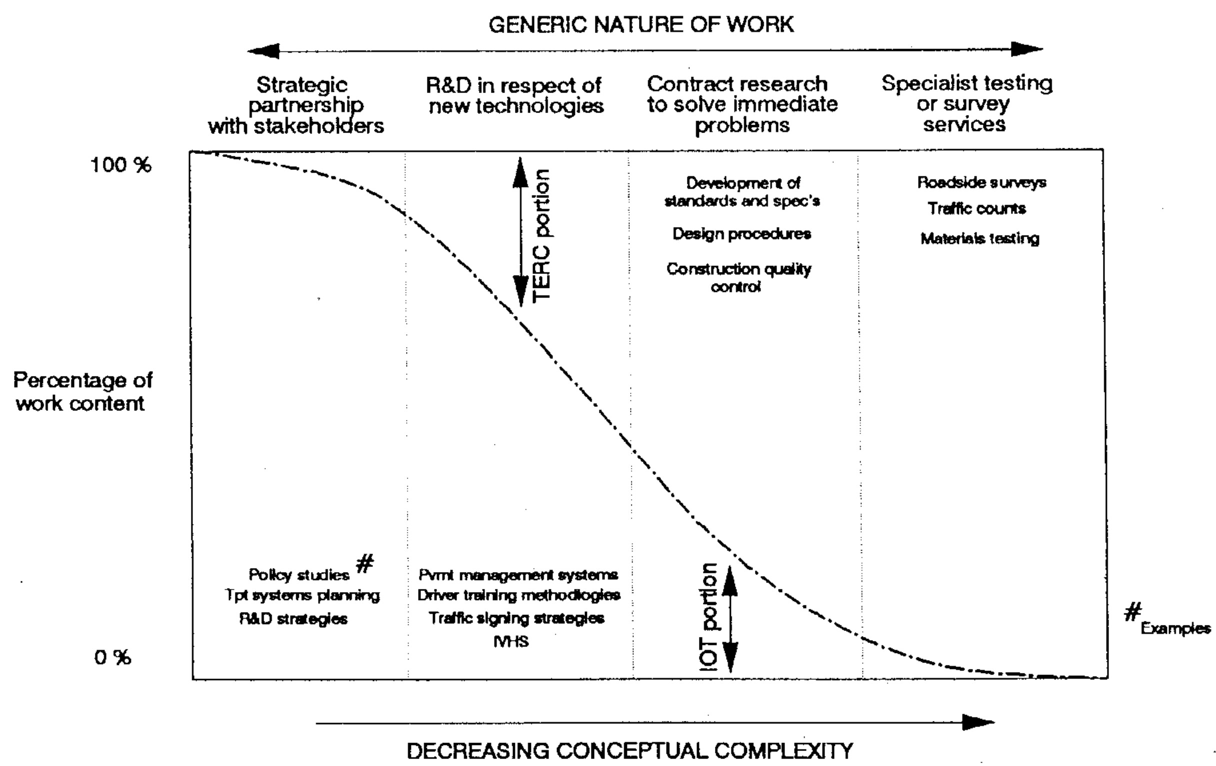


FIGURE 2:
A MODEL FOR DEFINING THE INTERACTION BETWEEN IOT AND TERC AND THEIR RESPECTIVE ROLES

- To ensure that R&D plans are aligned with a technology vision for ROC and to ensure effective technology transfer, IOT must coordinate transportation R&D in association with the MOTC Office of Science and Technology Advisors. This implies that IOT plays a central role in developing a transportation technology strategy for the country.

- TERC must view manpower development for the transportation industry as one of its key objectives.

- Duplication of R&D efforts and facilities in ROC must be avoided and optimal use must be made of available resources.

- TERC must be responsive to the needs of industry and must be able and willing to adapt strategies and plans to accommodate changes in the external environment.

- TERC must build a culture of creativity and innovation, while maintaining a focus on implementation.

- Information technology is a key resource and effective management of information will enable TERC and IOT to make a significant impact on industry.

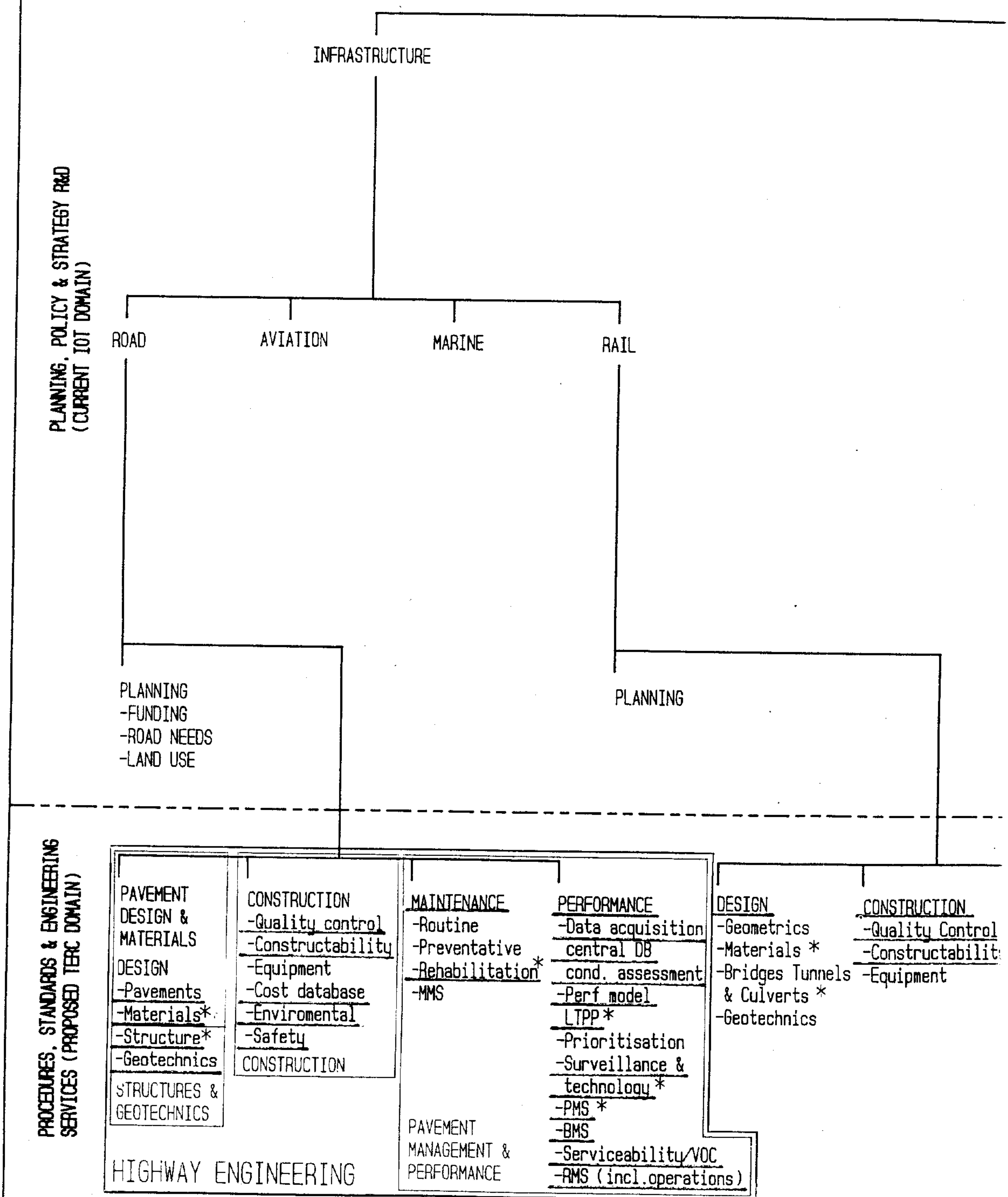
4.4 Technology strategy

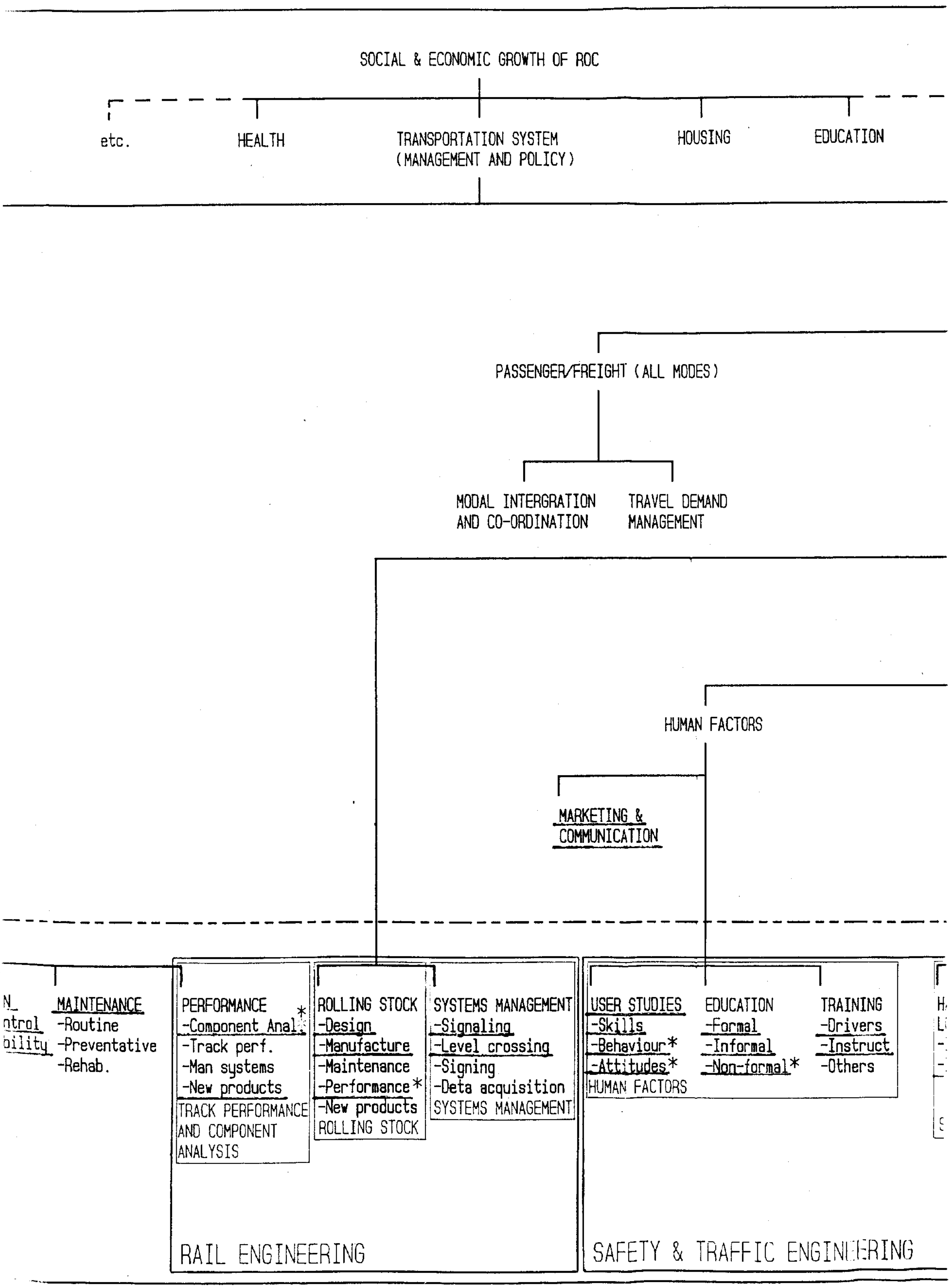
To assist in structuring an understanding of the technologies required by the transportation industry in ROC, a technology tree was developed for the industry. This is shown in Figure 3. The principle used was to identify the technologies or knowledge areas underpinning each level of technology, until all the base technologies for an area have been determined.

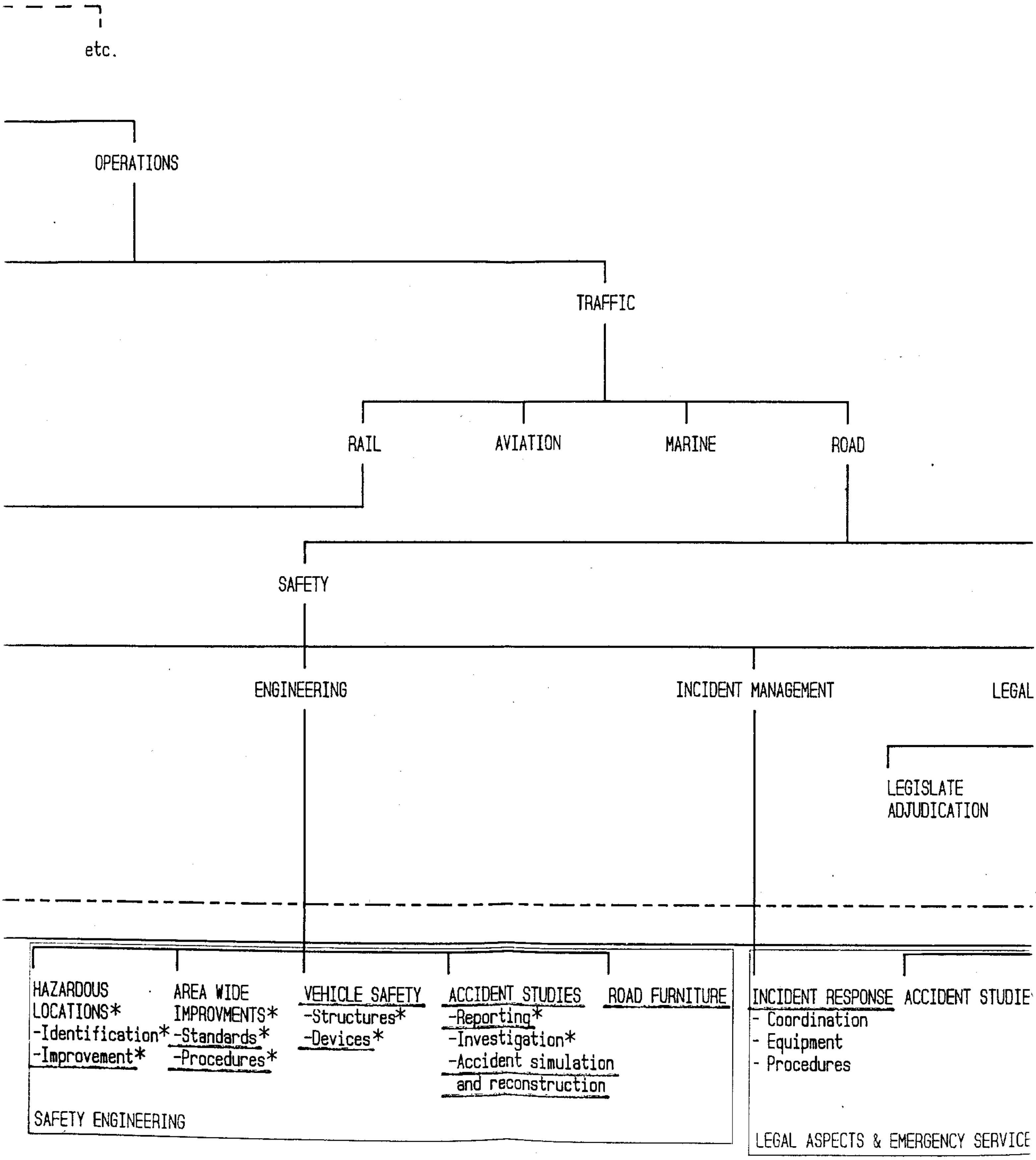
One benefit of this approach is that a perspective may be built of a technology strategy for a discipline, i.e. of where efforts for development, acquisition or joint venture must be aimed, since own capabilities or lack thereof are easily identified. For the purposes of achieving a better definition of the respective roles of TERC and IOT, the technology tree also provides a basis for allocating technology responsibility within the confines of a particular discipline or project. Based on the concepts introduced in Figure 2, IOT would tend to aim at technologies higher up in the technology hierarchy, where strategy and policy issues dominate and hard engineering support is of lesser importance. TERC would engage in work towards the lower end of the hierarchy by providing the vital engineering and technology support required to arrive at rational decisions regarding national policies and strategies. A coordinated approach to providing technology support of this nature is lacking in ROC and this has been identified as a primary reason for the fragmented nature of current transportation R&D.

The allocation of responsibilities at the interface of ***standards, procedures & engineering*** and ***planning, policy & strategy*** becomes a matter of negotiation and will largely be determined by the nature of a particular project. Figure 3 clearly demarcates the domains of the current IOT Divisions and the proposed TERC focus areas and these may be defined as follows:

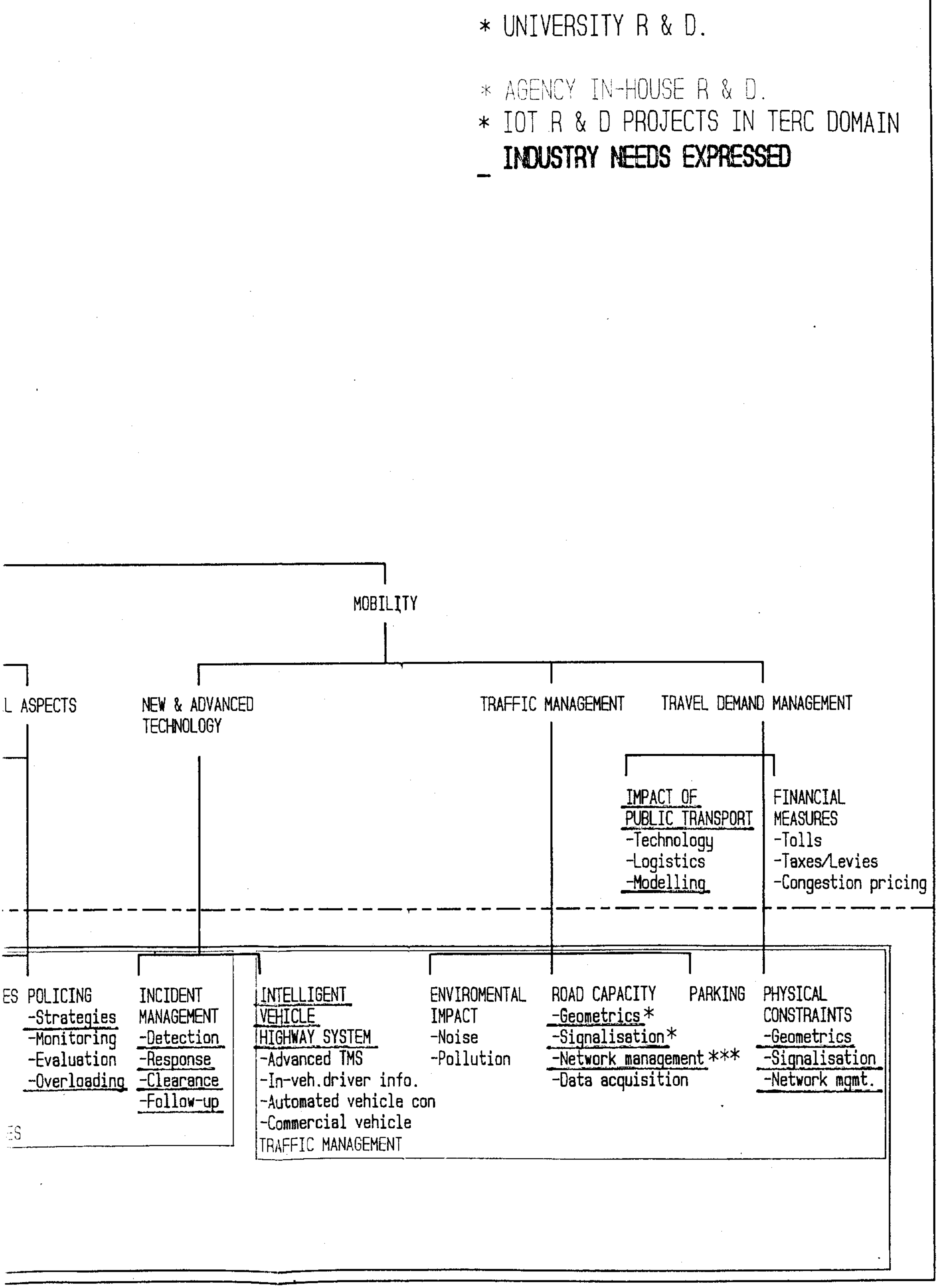
Figure 3
Technology tree for ROC Transport Industry




SOCIAL & ECONOMIC GROWTH OF ROC
etc.
HEALTH
TRANSPORTATION SYSTEM (MANAGEMENT AND POLICY)
HOUSING
EDUCATION
PASSENGER/FREIGHT (ALL MODES)
MODAL INTERGRATION AND CO-ORDINATION
TRAVEL DEMAND MANAGEMENT
HUMAN FACTORS
MARKETING & COMMUNICATION
MAINTENANCE -Routine -Preventative -Rehab.
PERFORMANCE * -Component Anal. -Track perf. -Man systems -New products
TRACK PERFORMANCE AND COMPONENT ANALYSIS
ROLLING STOCK -Design -Manufacture -Maintenance -Performance * -New products
ROLLING STOCK
SYSTEMS MANAGEMENT -Signaling -Level crossing -Signing -Deta acquisition
SYSTEMS MANAGEMENT
USER STUDIES -Skills -Behaviour* -Attitudes*
HUMAN FACTORS
EDUCATION -Formal -Informal -Non-formal*
TRAINING -Drivers -Instruct -Others
RAIL ENGINEERING
SAFETY & TRAFFIC ENGINEERING



etc.
OPERATIONS
TRAFFIC
RAIL
AVIATION
MARINE
ROAD
SAFETY
ENGINEERING
INCIDENT MANAGEMENT
LEGAL
LEGISLATE
ADJUDICATION
HAZARDOUS LOCATIONS*
-Identification*
-Improvement*
AREA WIDE IMPROVMENTS*
-Standards*
-Procedures*
VEHICLE SAFETY
-Structures*
-Devices*
ACCIDENT STUDIES
-Reporting*
-Investigation*
-Accident simulation and reconstruction
ROAD FURNITURE
SAFETY ENGINEERING
INCIDENT RESPONSE
- Coordination
- Equipment
- Procedures
ACCIDENT STUDIE
LEGAL ASPECTS & EMERGENCY SERVICE


* UNIVERSITY R & D.
* AGENCY IN-HOUSE R & D.
* IOT R & D PROJECTS IN TERC DOMAIN
_ INDUSTRY NEEDS EXPRESSED
MOBILITY
L ASPECTS
NEW & ADVANCED TECHNOLOGY
TRAFFIC MANAGEMENT
TRAVEL DEMAND MANAGEMENT
IMPACT OF PUBLIC TRANSPORT
-Technology
-Logistics
-Modelling
FINANCIAL MEASURES
-Tolls
-Taxes/Levies
-Congestion pricing
ES
POLICING
-Strategies
-Monitoring
-Evaluation
-Overloading
INCIDENT MANAGEMENT
-Detection
-Response
-Clearance
-Follow-up
INTELLIGENT VEHICLE HIGHWAY SYSTEM
-Advanced TMS
-In-veh.driver info.
-Automated vehicle con
-Commercial vehicle
TRAFFIC MANAGEMENT
ENVIROMENTAL IMPACT
-Noise
-Pollution
ROAD CAPACITY
-Geometrics *
-Signalisation *
-Network management ***
-Data acquisition
PARKING
PHYSICAL CONSTRAINTS
-Geometrics
-Signalisation
-Network mgmt.
ES

- **Current IOT Divisions:** research and development for transportation planning, policy and strategy;

- **TERC:** R&D for engineering and technology support in respect of standards, procedures and services to the current IOT Divisions and industry at large.

By increasing the capabilities of IOT through adding the engineering support provided by TERC, IOT would be ideally positioned as the national coordinator of transportation R&D. It should be noted that the technology tree in Figure 3 does not expand on the underpinning technologies for marine and air transport, as these are currently provided by other institutions. Policy and planning R&D in these areas would however still rest with the current Divisions of IOT (as is the case at the moment), as would the coordination of research in these areas.

4.4.1 Technology focus areas

Figure 3 also shows that the primary technology focus areas for TERC would remain as originally foreseen, except that information technology and advanced technologies must be regarded as supporting or enabling functions rather than focus areas in themselves. The development of advanced transportation technologies should be undertaken as part of the R&D function in each focus area rather than in isolation as a separate line function, because of the need for focus and direction. Information management systems as a strategic corporate resource must ideally reside with IOT since it underpins that organisation's stated mission and therefore implies possible expansion of the current Transportation Information Division of IOT.

TERC will therefore concentrate on the following focus areas, considering the analysis detailed above and comments and suggestions received from industry:

- highway engineering;
- railway engineering; and
- safety systems and traffic engineering.

In addition to these focus areas, TERC will operate certain facilities and services to industry and in support of the technology focus areas of TERC and the existing divisions of IOT.

Integration of the safety systems and traffic engineering into one area is based on the following rationale:

- attempts to enhance mobility in the transportation system must be in balance with safety needs, and vice versa (mobility and safety needs are opposing forces in the transportation system);
- there are obvious overlaps and linkages between safety and traffic engineering and each of the two technology areas must be managed to enhance the other; and
- these areas are currently managed jointly in the Safety Division of IOT.

4.4.2 Competence areas

The technology tree technique enabled the matching of identified R&D needs with component technologies, such that the required competence areas for a discipline may be mapped. The R&D needs summarised in Table 2 were entered on to the technology tree for each of the focus areas and areas of overlap and/or commonality were then identified. The details of this exercise, showing the competence areas mapped on to technology trees for the focus areas, are presented in Figures 4 through 7. This arrangement ensures that the most urgent needs in industry are addressed. The analysis indicated that TERC needs technological competence in the following areas:

Highway Engineering:

Pavement design and materials
Construction
Pavement management and performance
Structures and geotechnics

Railway Engineering:

Track performance and component analysis
Rolling stock
Systems management

Safety Systems and Traffic Engineering:

Human Factors
Safety Engineering
Legal Aspects and Emergency Services
Traffic Management

Design, construction and maintenance of railway foundations require technologies similar to that required for highways and needs in these areas can thus be dealt with in the highway engineering focus area, at least in the initial phases of establishment. If this proves to be a growth area in the future, consideration may be given to adding this as a competence area within the railway engineering focus area at such a time.

4.4.3 Generic R&D programmes and resource requirements

An analysis of industry needs reported in Table 2 and the technical issues facing the industry outlined in Table 4, were used as a basis for developing strategic direction, generic R&D programmes, manpower and support facilities for each competence area. The details are summarised in Tables 5 and 6. Detailed strategies for each of the technology focus areas are discussed in Section 5 and include:

- strategic issues and R&D needs for each technology focus area;
- strategic objectives for each competence area;
- recommendations on generic R&D programmes;
- recommendations on possible R&D projects (where applicable);

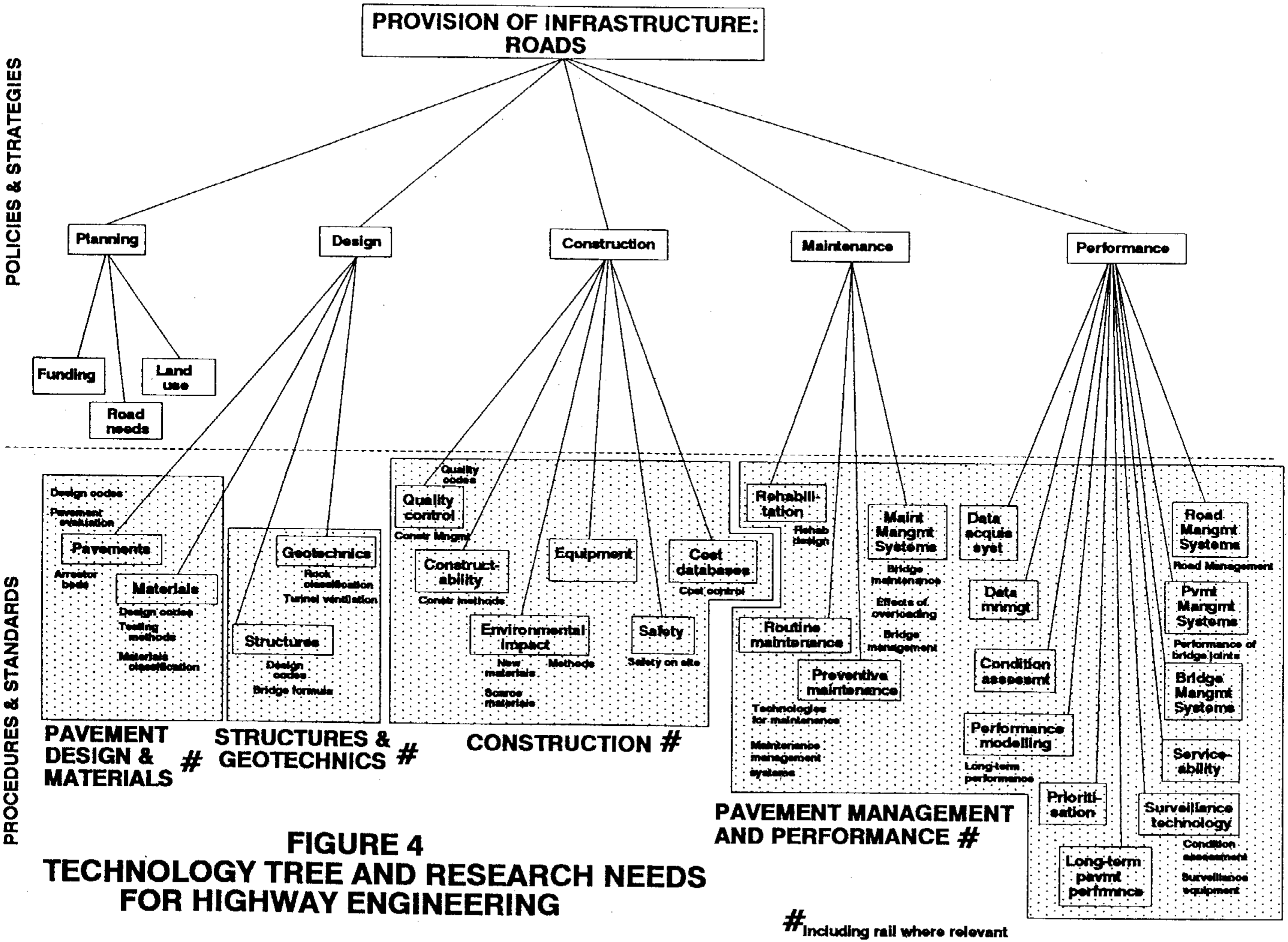


FIGURE 4
TECHNOLOGY TREE AND RESEARCH NEEDS FOR HIGHWAY ENGINEERING

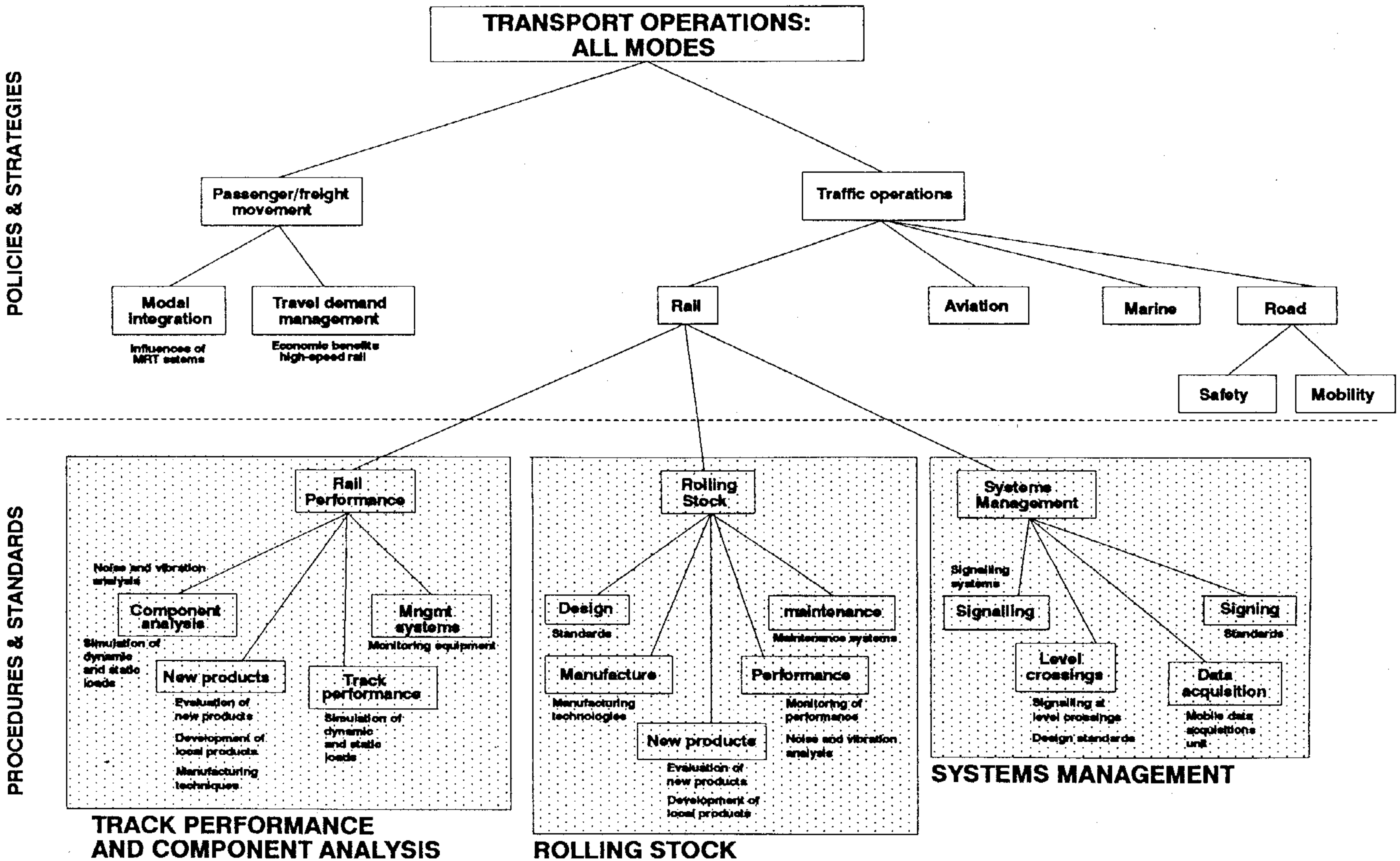


FIGURE 5:
TECHNOLOGY TREE AND RESEARCH NEEDS FOR RAILWAY ENGINEERING

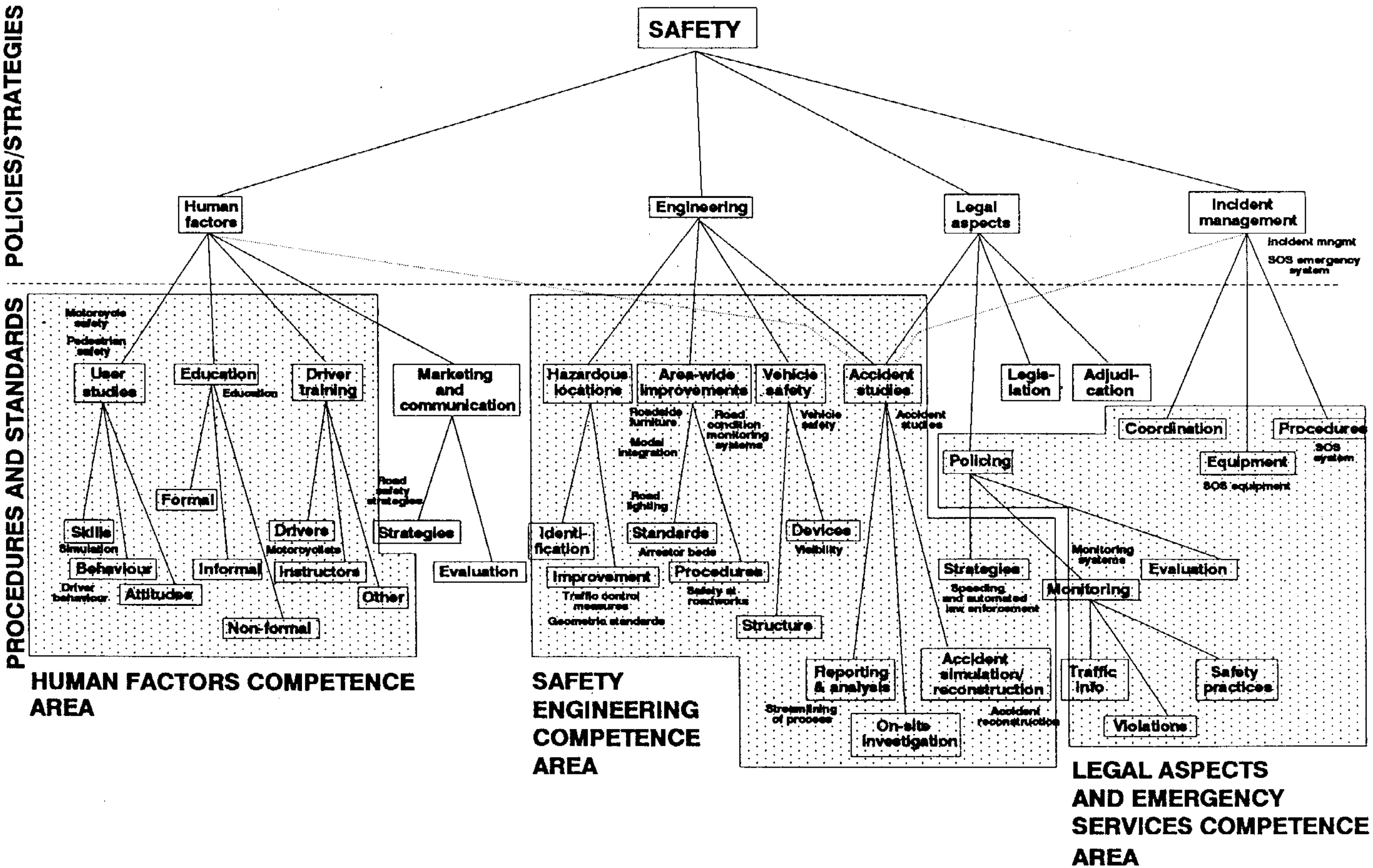


FIGURE 6:
TECHNOLOGY TREE AND RESEARCH NEEDS FOR THE SAFETY DISCIPLINE

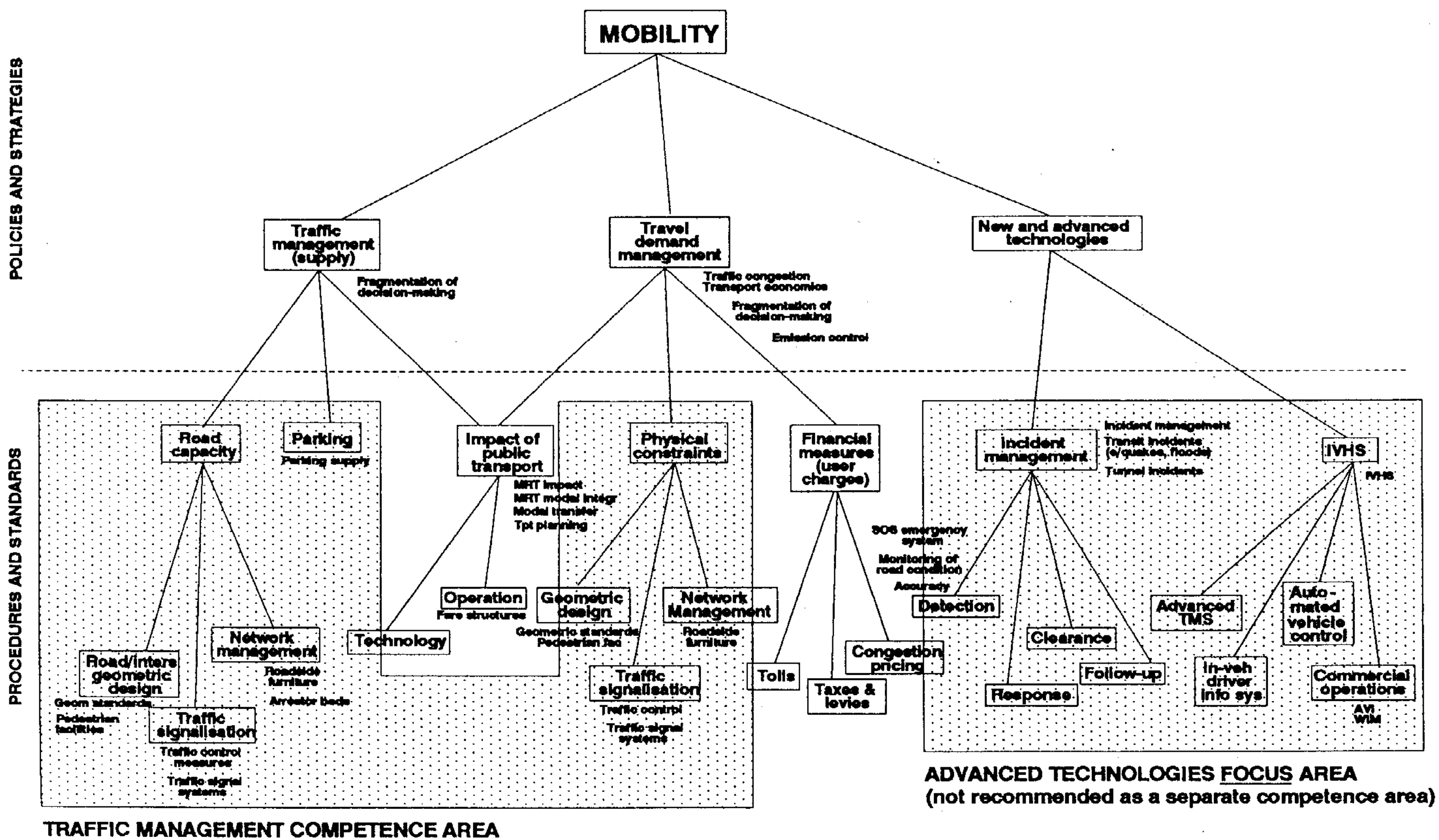


FIGURE 7:
TECHNOLOGY TREE AND RESEARCH NEEDS FOR THE MOBILITY DISCIPLINE

TABLE 5: GENERIC R&D PROGRAMMES AND SUPPORT FACILITIES

COMPETENCE AREAS	TRACK PERF & COMP ANAL	ROLLING STOCK	SYSTEMS MGMNT	PVMNT DESIGN & MTRLS	PVMNT MGMNT & PERF	STRUCTURES & GEOTECHN	CONSTRUCTION	LEGAL ASPECTS & EMERG SERV	HUMAN FACTORS	SAFETY ENG	TRAFFIC MNGMNT
	Rail Engineering			Highway Engineering				Safety Systems & Traffic Eng			
Generic R&D thrust areas or programmes	Development of local products		Signalling & communication	Std design methods & specs	Road mngmnt systems	Bridge mngmnt & maint. sys	Quality control systems	Violation monitoring systems	Driver behaviour training including simulation	Vehicle safety	Geometric design & procedures
	Evaluation of new products			Evaluation & dev of mat'ls	Road surveillance & condition assesmnt	Local classification system for rock & soils	Uniform quality control standards	SOS equipm & procedures	Training/eductn of slow-moving road users	Roadside furniture including at roadworks	
	Track maintenance technology	Evaluation of long term performance	Incident management systems	Accelerated pvmnt testing & evaluation		Tunnel construction tech	Improved construction techniques	Control of vehicle overloading	Formal road safety eduction	Accident reporting & analysis	Traffic counting strategies & equipment
	Accelerated stock testing & evaluation	Maintenance technology	Transport of hazardous materials		Long term pvmt performance	Bridge strengthening & repair tech	Safety & environmental aspects			Accident simulation & reconstruction	Traffic signal cntrl strat & equipment
	Surveillance technology				Technologies for road maint.	Development of local bridge design code	Construction cost control			Identification of hazardous locations	
	Evaluation of long-term track performance				Vehicle operating costs	Flood protection of structures	Construction project mngmnt				Management of traffic flows in road networks
						Effects of axle loads on bridge deterioration		Incident management systems			
										Transportation of hazardous materials	
											Commercial technologies: AVI, AVC, WIM
											Parking management
Support facilities required	Track component testing laboratory			Accelerated testing facility		Hydraulic modelling lab		Electronic workshop & lab	Psychometric lab	Photometric lab	Electronics workshop & lab
	Engineering workshop							Law enforcement equipment	Test site(s)		
	Electronic workshop & lab					Structures lab			Driver simulator		Surveillance equipment
	Soils & mtls testing lab			Soils and materials testing laboratory						Crash test facility	
	Mobile data acquisition unit			Test site(s)						Component testing facility	
					Surveillance equipment & vehicles						
	Computer hardware, software and information support										

41

TABLE 6: SUMMARY OF MANPOWER REQUIREMENTS IN THE FOCUS AREAS

COMPETENCE AREAS	TRACK PERF & COMP ANAL	ROLLING STOCK	SYSTEMS MGMNT	PVMNT DESIGN & MTRLS	PVMNT MGMNT & PERF	STRUCTURES & GEOTECHN	CONSTRUCTION	LEGAL ASPECTS & EMERG. SERVICES	HUMAN FACTORS	SAFETY ENG	TRAFFIC MNGMNT
STAFFING	Rail Engineering			Highway Engineering				Safety Systems & Traffic Eng			
MANAGEMENT	Deputy Director-General +		Secretary +	Assistant							
	M.Sc, Civil Eng 15 years in Railway Engineering			M.Sc, Civil Eng, 15 years in Pavement Design and/or Management				M.Sc, Civil/Tpt Eng, 15 years in Transportation & Traffic Engineering			
	B+10 Eng Mech/Civil	B+10 Mech Eng	B+10 Elec Eng	B+10 Civil Eng/ Geotech Eng	B+10 Tpt Eng	B+10 Structures	B+15 Civil	B+10 Legal	B+10 Soc Sc	B+10 Tpt /Mech	B+10 Tpt/ Traffic
Researchers	2	1	1	3	4	2	4	2	2	2	3
Technical super staff	2	1	1	2	3	2	2	2	2	1	3
Admin	2			2				2			
TOTAL	70										

- manpower requirements per competence area; and
- facility and equipment requirements per competence area.

The information presented in Section 5 is a guideline only, since it is based on an assessment of the current state of the industry, as investigated for this project and set out earlier in this document. Use of this information must take account of changes that may take place in future in terms of technological priorities for the ROC and organisational development during the formal establishment of TERC.

The manpower requirements set out in Table 6 are based on the CSIR's experience in the various focus areas. However, these requirements may require modification if the technological priorities change.

4.5 Suggested structure for IOT

From the technology tree in Figure 3, clear definition is given to the different roles played by the current divisions of IOT and TERC. As these divisions plus TERC will together constitute IOT, it will be necessary for the existing divisions to retain their own identity. For this reason it is recommended that the current divisions of IOT be renamed the Transportation Policy and Planning Research Group (TPPRG), under the control of a Deputy Director General. The proposed structure for IOT is shown in Figure 8.

Coordination and implementation of R&D in the transport industry and technology transfer should be under the direct control of the Director General and his two deputies.

Figure 8 also shows the interface of the support facilities with the divisions of TPPRG and the focus areas of TERC. The laboratory, workshop and test site support will reside in TERC, but may be used by divisions of the TPPRG where required. The management of transport information will continue to be a division of TPPRG and will interface with all divisions/focus areas of IOT.

4.6 Location of TERC

From the structure shown in Figure 8, two distinct elements of TERC are identified; firstly, the focus areas in which research projects will be undertaken and coordinated and secondly, the remote test site which will act as support for TERC and TPPRG.

To optimise and facilitate the efficient management of the new IOT structure and ensure the proper coordination of R&D efforts, it will be necessary for the Deputy Director General of TERC and in-line focus area staff to be located in the new IOT building. This implies that provision will have to be made for an estimated seventy additional members of staff in the new IOT building when TERC is fully established. Investigation of the plans for the new building shows that two floors would be required for this purpose.

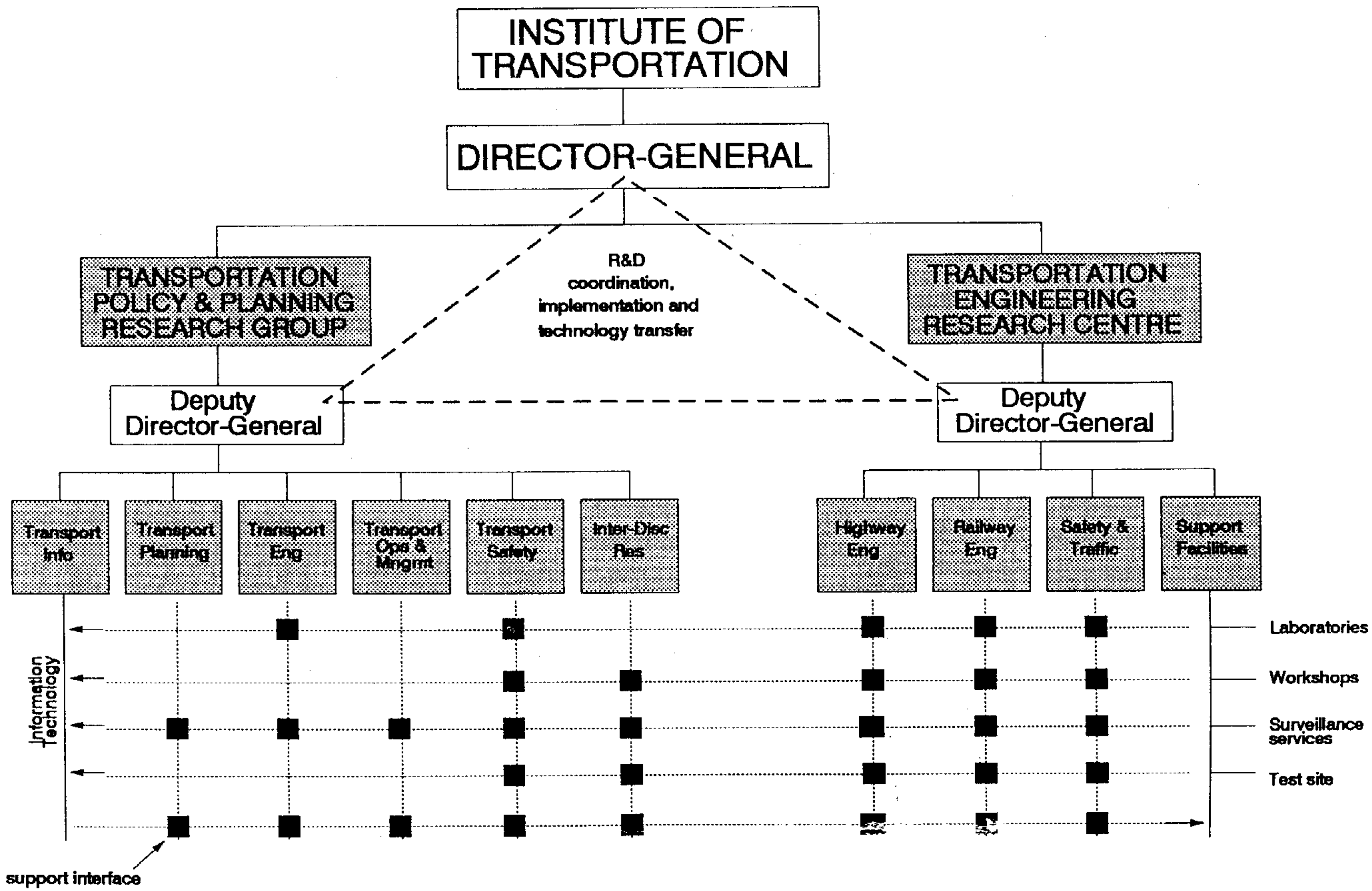


FIGURE 8:
PROPOSED ORGANISATION STRUCTURE FOR IOT, INCORPORATING TERC

In terms of the test site facilities, office accommodation for forty staff members will be required in addition to the test site laboratories, workshops and other facilities discussed in Section 6.1. It is likely that the facility manager will require office space at both locations.

4.7 Interface of IOT/TERC with Industry

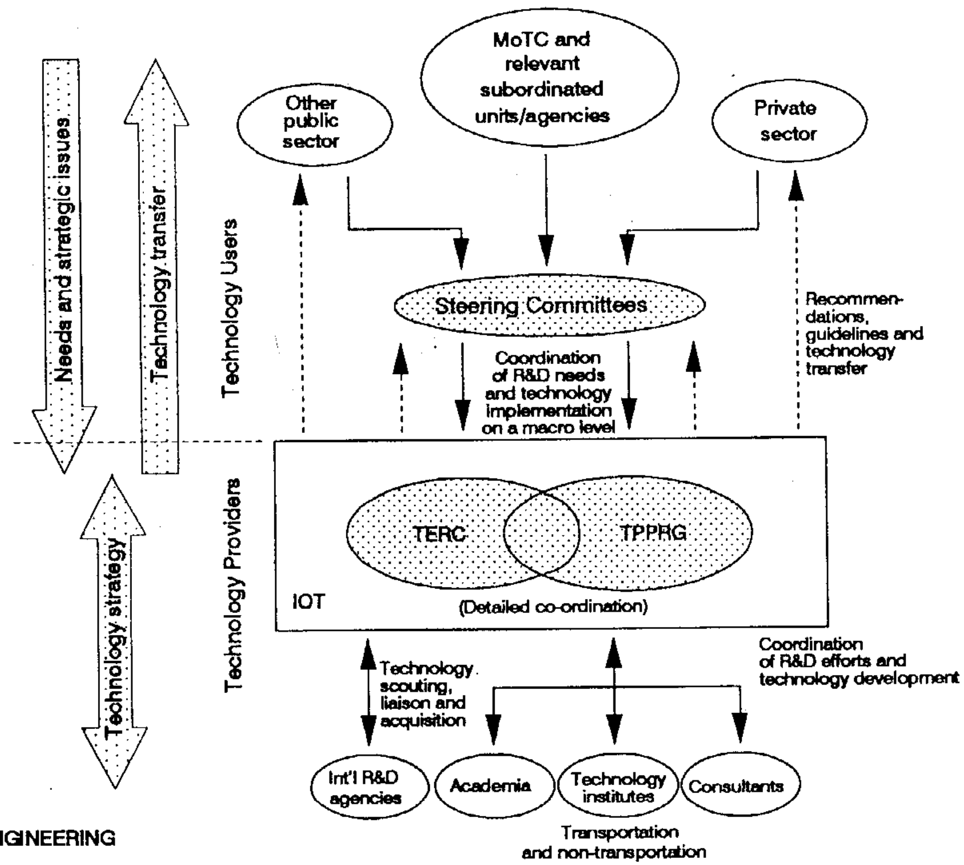
The relationship between IOT/TERC and industry is complex, because organisations ranging from universities to private sector consultants engage in transportation R&D,. each with a legitimate claim to funding and other resources. Discussions on these aspects with IOT management and other stakeholders and within the CSIR project team resulted in a conceptual model which explains the relationship between IOT/TERC and the external environment. This is shown in Figure 9.

In agreement with proposals made at the start of the project, a system of *steering committees* or *research advisory panels* is suggested to regulate the generation, prioritisation and communication of industry needs to the research industry and also to facilitate the transfer of technology. Figure 9 also shows that MOTC will remain the major client organisation in this process, with provision being made for the private and public sectors to contribute. The latter may, for example, include representation from academia and from the provincial and city governments.

The model also indicates that IOT/TERC assumes a leading/coordinating role with respect to the coordination of the R&D effort through, inter alia, liaison and cooperation with domestic and international agencies. On the one end of the spectrum, IOT/TERC may simply act as project manager for efforts undertaken by universities, technology institutes and/or consultants; in some cases, IOT/TERC may wish to engage in joint efforts or may subcontract small portions of projects to these agencies. On the other end of the spectrum, IOT/TERC will conduct projects independently. This approach will serve to accommodate the envisaged phased development of TERC ultimately to become an independent player in selected areas.

Technology transfer to industry becomes the responsibility of IOT/TERC and this is facilitated through both direct contact with industry and through the system of steering committees or research advisory panels. Experience in South Africa has shown that an R&D management strategy that involves the client or recipient of technology in the development process has the best chance of succeeding.

The model also implies that IOT/TERC becomes the custodian of a technology strategy for the ROC transportation industry (in line with the recommendations in Section 4.3) and acts to direct, coordinate and guide the R&D effort. As such IOT/TERC then becomes the vehicle through which transfer of technology to industry may be facilitated.



TERC: TRANSPORTATION ENGINEERING RESEARCH CENTRE
TPPRG: TRANSPORTATION POLICY AND PLANNING RESEARCH GROUP (CURRENT IOT DIVISIONS)

FIGURE 9:
POSITION AND ROLE OF IOT/TERC IN THE TRANSPORTATION SECTOR

5 FOCUS AREA STRATEGIES

Having identified the focus areas in which TERC should concentrate its R&D effort, this section outlines the detailed strategic issues and R&D needs for each area and highlights specific project areas in each of the competence areas. Guidelines are given for the required support facilities from the test site and the manpower in each competence area.

5.1 Highway Engineering

5.1.1 Strategic issues and objectives

The ROC's six-year development plan gives details of a strategy for the construction of new roads and for the maintenance and upgrading of the existing infrastructure. This indicates a significant need for the development of competence and technology in pavement materials design, pavement structural design, pavement performance analysis and road management systems. Currently, there is a lack of implementation of the latest world trends in pavement engineering and technology. There is also a need to transfer technology effectively to and implement it successfully within the road building industry. In addition, there is a need to tie new technological development to improved quality control, road constructability and construction equipment and techniques. In particular, the latest international test methods and technologies need to be acquired to form a basis from which ROC-specific applications, methodologies and technology can be developed.

In contrast to pavement engineering, ROC has a relatively well-developed competence in geotechnical engineering and structures. Thus, while TERC will need a limited competence in the areas of structural and geotechnical engineering to support the highway engineering focus area, this is likely to be relatively small and secondary to the development of other competence areas within the focus area.

From the competence areas shown in the technology tree, (Figure 3) the following objectives have been derived:

- Improvement of competence in highway engineering throughout the ROC (particularly in pavement design methodology and pavement performance evaluation) to form a basis of technology in line with world trends;
- The development of ROC-specific test methods, design criteria, specifications and uniform standards for highway design and construction in ROC;
- Improved maintenance and rehabilitation technology and practice to ensure economic preservation of existing infrastructure;
- Improved coordination of highway engineering research and improved technology transfer to the industry;
- Improved awareness of the environmental impacts of infrastructure projects;

5.1.2 R&D needs

Extensive interviews with a broad cross-section of the transportation industry in ROC provided a perspective of the technology linkages within the industry as shown in the technology tree (Figure 3) and in Table 2. The main components of highway engineering can be divided into design, construction, maintenance and performance, from which the following competence areas were derived to facilitate the achievement of the strategic objectives for the focus area:

- pavement design and materials
- construction
- pavement management and performance
- structures and geotechnics

The general R&D needs in this focus area expressed by industry may be summarised as follows from Table 2:

- specialist capabilities for materials testing, evaluation and classification;
- specialist capabilities in pavement structural analysis and design;
- pavement structural performance evaluation;
- standards and procedures for road design, construction and for maintenance and rehabilitation;
- construction management and quality control;
- standardised surveillance and condition assessment methods for road management systems;
- management systems for pavements, bridges and highway structures;
- materials and methods for bridge design and maintenance;
- effects of vehicle overloading on pavement and bridge structures;
- environmental impact of construction projects;
- coordination of research efforts.

5.1.3 Specific R&D programmes and possible projects

For Highway Engineering, analyses of the needs expressed by industry assisted in the identification of specific areas that should form the nucleus of the research programme for each competence area. These are summarised in Table 7 and described in more detail below, with an indication of possible research projects.

- **Pavement design and materials**

Materials design and evaluation
Current practice in the ROC mainly makes use of USA methodology for materials design (eg the Marshall method for asphalt mix design). These methods are not suitable for innovative materials or very heavily trafficked roads. Internationally, the trend is towards the use of performance-related engineering properties of materials to predict and optimise field

TABLE 7: SUMMARY OF RECOMMENDED R&D PROGRAMMES, PROJECTS AND RESOURCES FOR HIGHWAY ENGINEERING

COMPETENCE AREA	STRATEGIC ISSUES	SPECIFIC R&D PROGRAMMES	PROPOSED R&D PROJECT AREAS	FACILITIES REQUIRED	MANPOWER REQUIRED
Pavement design and materials	Design, construction and management of road infrastructure Environmental impact of infrastructure projects Coordinated technology development and implementation The need for enhanced competence in highway engineering Development of appropriate and uniform standards, specifications and test methods	Materials design and evaluation Pavement structural design methodology Standardisation of design methods and specifications Evaluation of pavement behaviour and performance Accelerated pavement testing and evaluation	ROC-specific materials design methodologies; ROC-specific pavement structural design methodologies; design criteria and specifications for local materials; methods and design criteria for maintenance and rehabilitation; standardised design codes for pavements; use of local materials in treated and untreated layers; test methods for materials; new materials; long-term performance of materials; evaluation of designs through accelerated testing.	Electronics workshop Engineering workshop Accelerated testing facility Materials testing laboratory Full-scale testing grounds	Focus area manager: MEng with 15 years experience in highway engineering (M+15) Admin staff: 2 Competence manager: B+10 (Civil) 3 Research engineers 2 Technical staff
Pavement management and performance		Pavement and maintenance management systems Road surveillance technology and condition assessment Accelerated pavement testing Long-term pavement performance Technologies for road maintenance and rehab Vehicle operating costs	Design of management systems for compatibility; standardisation of surveillance methods and equipment; assessment of serviceability and structural integrity; non-destructive test methods; data analysis and interpretation; performance prediction models; selection of maintenance projects; user cost models and economic evaluation; GPS and GIS; implementation and operation of RMS; decision criteria; performance standards for maintenance; cost data bases.	Electronics workshop Engineering workshop Accelerated testing facility Materials testing laboratory Full-scale testing grounds Surveillance equipment and vehicles Software for database management	Competence manager: B+10 (Transportation) 4 Research engineers 3 Technical staff
Structures and geotechnical engineering		Bridge management and maintenance systems Classification systems for rock and soils Tunnel construction technology Bridge strengthening and repair technology Bridge design procedures, including seismic loading Effects of axle loads on bridges	Development of a bridge design code, with allowance for seismic activity; design of arrestor beds and special structures; performance of bridge joints; identification and prioritisation of maintenance needs; bridge management systems; special techniques for bridge strengthening and repair; effects of overloading; weighbridge management; geological classification of rock and soils; construction techniques for tunnels.	Hydraulic modelling lab, eg at Cheng Kung University Structures lab, eg at NTIT or NCKU Materials testing laboratory Full-scale testing grounds	Competence manager: B+10 (Civil/geotechnical) 2 Research engineers 2 Technical staff
Construction management		Quality control systems and standards Construction techniques Safety/environmental aspects Cost control Project management	Quality management on site: standards and methods; Constructability and the use of local materials, methods and equipment; safety at road works; cost databases; environmental influence of construction works and sourcing of materials; management of projects.	Software for database management	Competence manager: B+15 (Civil) 4 Research engineers 2 Technical staff

49

performance (eg dynamic testing of asphalt). Although some relevant work is conducted at, for example, the NCU and the NCKU, there is still a need to assess technical developments in this area in Europe as well as in the Strategic Highway Research Programme (SHRP) conducted in the USA. This technology should be acquired where necessary to form a basis for developing ROC-specific technology.

Projects in this area should focus on :

- the applicability of international materials design methodologies in the ROC and recommendations for their application and modification;
- the development of ROC-specific methodologies and test methods where necessary;
- the use of performance-related engineering properties to predict field behaviour of materials;
- assessment of innovative construction materials.

Pavement structural design methodologies

Recently there has been significant international developments in the structural analysis and design of pavements. This includes efforts into mechanistic analysis of pavements, technology for backcalculation of pavement layer properties, multi-layer anisotropic analysis of pavement structures, the simulation of dynamic effects in pavement structures and field monitoring of pavement response. ROC needs to assess international trends in this area, obtain technology where necessary and use this as a basis for development of capacity and ROC-specific technology.

Projects in the area should focus on

- mechanistic analysis and design of pavements;
- techniques for backcalculation of pavement structural parameters;
- techniques for measuring dynamic pavement response.

Standardisation of design methods and specifications

The standards and specifications currently used (eg AASHTO, ASTM, Asphalt Institute and the California R-value) need to be standardised for the ROC. This standardisation should take new developments (international and ROC-specific) into account. Work in this area should focus on the harmonisation of design methodologies, standards and specifications as well as the development of manuals for their use in practice.

Evaluation of pavement behaviour and performance

There is an international trend to evaluate the behaviour and performance of pavement structures through long-term pavement performance (LTPP) programmes as well as through accelerated pavement testing (APT) which is briefly discussed below and later, in more detail, in Section 6.1.6. A well-planned LTPP programme can ensure that the vital link between laboratory design and evaluation and actual performance under traffic is developed. From such information (with inputs from an APT programme), relevant ROC transfer functions for the prediction of field performance from laboratory work can be determined. A proper LTPP programme will include well-planned and instrumented trial sections to be monitored over a number of years.

Projects should focus on :

- Experimental design of LTPP trial sections;
- Instrumentation technology for LTPP trial sections;
- Monitoring procedures for LTPP trial sections;
- The design and operation of a database for LTPP information;
- The validation of transfer functions determined from APT testing.

Accelerated pavement testing (APT) and evaluation

APT provides the following capabilities :

- to develop a thorough understanding of the behaviour and performance of different pavement types relative to each other;
- to assess the relative performance of different materials;
- to develop transfer functions which can be used to predict pavement performance from laboratory test results;
- to validate design philosophies and methodologies;
- to investigate the applicability of various rehabilitation options for specific traffic and environmental conditions.

APT work should initially focus on establishing the capability in terms of staff training and acquiring equipment and facilities as well as the development of a strategic plan for an APT research programme.

- **Pavement management and performance**

Pavement and maintenance management systems

Although a few authorities in ROC have initiated the implementation of management systems for road and bridge networks, technology in this area is in urgent need of development and standardisation.

Projects should aim at:

- standardisation of input and output requirements for management systems, to ensure national compatibility;
- the use of global positioning systems (GPS) and geographical information systems (GIS) in road management;
- the development of road user cost models and methodologies for the economic evaluation of transportation projects;
- standards and guidelines for the implementation, operation and upgrading of road management systems;
- development of decision support systems for financial and economic policy making in road management at government level;
- prioritisation and optimisation technologies for the scheduling of projects and utilisation of resources;
- establishment of databases for construction costs, materials, road maintenance and user costs.
- establishment of performance standards for routine and special maintenance;

Road surveillance technologies and condition assessment

New technologies in the area of pavement surveillance and condition assessment are rapidly emerging and are currently being studied by some of the universities in Taiwan. Decisions to invest in the latest available equipment cannot be done without proper feasibility studies, taking into account the condition and availability of equipment already utilised in Taiwan.

Projects should therefore be aimed at:

- evaluation of existing and/or development of appropriate non-destructive testing devices and techniques;
- standardisation of surveillance equipment and data analysis procedures for the assessment of pavement serviceability and structural integrity;
- standardisation of condition survey methods, frequencies and data interpretation;

Long-term pavement performance

A good understanding of local pavement performance and the implications of alternative maintenance and rehabilitation strategies is required to properly manage road networks. Experience around the world has shown that deterioration models developed elsewhere need to be adjusted for local conditions. The potential long-term pavement performance indicated by accelerated pavement testing needs further calibration to incorporate environmental influences and the effect of different maintenance strategies.

There will be significant overlap between the work done in this area and that being undertaken as part of the evaluation of pavement behaviour and performance associated with the pavement materials and design competence. Detailed coordination of the work being done in both areas will be required to prevent duplication.

Projects should be aimed at:

- adjustment of existing and/or development of appropriate performance prediction models and algorithms through long-term pavement performance studies and coordination of all road experiments;
- threshold values and terminal levels for serviceability and structural capacity parameters for use in decision and prediction algorithms;
- efficacy of routine maintenance operations.

- **Construction**

Discussions with various sectors of the industry suggested that quality control and management at construction works were a major problem. It was also stressed that while new materials were constantly being developed and marketed, the understanding to properly construct these materials with the existing equipment needed to be improved.

Quality control

Although two documents for quality control, are used to execute control during construction, concerns were raised by consultants on the applicability of the specifications. Suggestions were made that statistical quality control should be phased in. Identified project areas are:

- development of standard specifications for road and bridge works, elaborating on tolerances, methods of testing, traffic control and contractual payment;
- upgrading of quality control systems and methods, with emphasis on statistical quality assurance and control;

Constructability

This area should concentrate exclusively on construction methods appropriate for local materials, conditions and equipment.

Project management

Several computerised systems for project management and cost control of construction projects are available but there is a need to standardise outputs for management purposes. Research projects should be aimed at the following:

- investigation into appropriate project management and cost control systems;
- development of unit cost databases;
- the implications of project management for organisational development and manpower requirements.

Environmental Issues

Environmental considerations are becoming increasingly more important, both nationally and internationally and greater attention to this in terms of construction projects will need to be given in the future. Projects should be aimed at:

- short- and long-term environmental impacts on the use of construction materials and of construction projects;
- guidelines on environmental impact assessment for construction projects.

- **Structures and Geotechnics**

As discussed in Section 5.1.1, technology and competence in these areas are well developed at universities and with consultants. Therefore, it is not recommended that a large competence be developed in TERC. However, there will be a need to coordinate research in these areas and provide limited support to highway engineering projects which may require assistance in these areas. It is not anticipated that TERC will carry out specific projects in these areas.

5.1.4 Facilities required

The recommended facilities and equipment required per competence area are outlined below.

- **Pavement design and materials**

Essential support facilities for this area will be the materials testing laboratory and the accelerated pavement testing facility. Engineering and electronic workshop support will also be required. An area of approximately one hectare will be required for the construction of test sections.

- **Pavement management and performance**

Initially (one year period) no support facilities will be required other than involvement in the accelerated pavement testing programme in association with the pavement design and material competence area. However, in the longer term, it is envisaged that new surveillance equipment will be developed/purchased and operated by TERC. The rapid, international developments in surveillance technology indicate that less surveillance vehicles will be required in future as different monitoring systems will be fitted to one vehicle. International trends should be thoroughly investigated in the first year of establishment of TERC before decisions are taken to purchase surveillance vehicles. However, provision should be made to shelter four large surveillance vehicles and one support vehicle at the TERC test site.

- **Construction**

No support facilities will be required other than the area allocated for test sections at the test site and the field testing and monitoring devices to assess the performance of the various test sections.

- **Structures and geotechnics**

Facilities for research in these areas are well established at consultants and universities and it is not recommended that additional facilities be developed as part of TERC. Consideration should be given to utilising existing facilities for priority projects identified in this competence area.

5.1.5 Manpower required

The manpower requirements for the Highway Engineering focus area are summarised in Tables 6 and 7.

The manager of this focus area should have a pavement engineering background and should be well-linked with the network of senior managers in the road authorities and senior researchers at the various universities. He/she should have at least a masters degree and a minimum of 15 years experience in pavement engineering and/or pavement management systems. The person will be responsible for establishing a highway engineering competence within TERC, managing the technology within the focus area and interfacing with industry to establish research direction for the area. The following staff is estimated for the four competence areas:

- **Pavement design and materials**

Competence area manager,
Bachelors degree in pavement or geotechnical engineering, with at least 10 years appropriate experience.

Three research engineers,
Bachelors degrees in civil engineering with some experience of pavement or geotechnical engineering.

Two technical support staff,
with civil engineering experience.

- **Pavement management and performance**

Competence area manager,
Bachelors degree in pavement/transportation engineering, with at least 10 years appropriate experience.

Four research engineers,
Bachelors degrees in civil or transportation engineering.

Three technical support staff,
with civil engineering experience.

Although it is envisaged that new surveillance equipment will only be operated by TERC after a period of 2 to 3 years, it would be wise to appoint two senior technicians from the start to assist in the research of appropriate equipment, to become familiar with the requirements for surveillance services and to carry out any testing for LTPP studies. As soon as the most appropriate surveillance equipment for ROC has been identified and developed or purchased, these technicians should be used to operate the equipment as part of the specialist services provided by TERC to the rest of the industry. At this stage, it will be necessary to appoint two new technicians to assist in this competence area.

- **Construction**

Competence area manager,
The needs in this area require an experienced engineer (B Eng) with at least 15 years experience in construction and project management. •

Four research engineers,
Bachelors degrees in civil engineering and some site experience of construction projects would be advisable.

Two technical support staff,
with civil engineering/construction site experience.

- **Structures and Geotechnics**

Competence area manager,
Bachelors degree in civil/geotechnical/structural engineering and at least 10 years experience in structural or geotechnical engineering.

Two research engineers,
Bachelors degrees in civil/geotechnical/structural engineering.

Two technical support staff,
with civil engineering experience. It is recommended that technical support staff are only appointed if research needs in this area become a high priority.

5.2 Railway Engineering

5.2.1 Strategic Issues

Investigation of the railway engineering focus area identified the following major strategic issues:

- The need for standards, specifications and test methods for rail infrastructure development;
- The need for integration with other modes of transport;
- Environmental impact of rail systems;
- Commissioning of the mass rapid transit system;
- Management of rail infrastructure.

There currently appears to be no strong research competence in railway engineering at any transport authority or research organisation and TERC is seen as the ideal organisation through which this capability could be built. The strategic objectives to be achieved through the competence areas identified in the technology tree would be:

- Increased research competence in railway engineering throughout the ROC;
- Promotion of modal integration in the transportation system (in association with the Safety Systems and Traffic Engineering focus area);
- Improved coordination and transfer of railway engineering research to the industry;
- Improved awareness of the environmental impacts of infrastructure projects (in association with the Highway Engineering focus area);
- Support of industry through the development and evaluation of local products.

5.2.2 R&D Needs

Discussions with the three major rail organisations (TRA, TRUPO and DORTS) identified six competence areas as shown in the technology tree (Figure 3). However, it is felt that design, construction and maintenance of railway systems have significant overlap with the Highway Engineering focus area and any needs in this area could be managed as part of the Highway Engineering project portfolio. If through time, these areas become a priority, consideration should then be given to expanding the Railway Engineering competence areas. Initial emphasis should therefore be given to the following three competence areas:

- Track performance and component analysis;
- Rolling stock;
- Systems management.

The following specific R&D areas (also shown in Table 2) were identified from the discussions:

- Evaluation of new products (both local and international);
- Development of local products;
- Accelerated track testing and evaluation;
- Surveillance technology;
- Track maintenance technology;
- Evaluation of long term track performance;
- Signalling and communication;
- Incident management systems;
- Transport of hazardous materials.

5.2.3 Specific R&D programmes and possible projects

Based on the needs expressed by the industry, various R&D project areas for each competence area were identified. These are summarised in Table 8 and described in more detail below.

It should be noted that in the Railway Engineering focus area, no indication of possible research projects are given in this report. Whilst an urgent need for research in railway engineering was expressed, it was very difficult to identify specific research projects. It is likely that individual projects in the competence areas will only become apparent once the mass rapid transit systems have been operating for a significant period of time and a decision to implement high-speed rail technology has been finalised.

Consequently, it is recommended that the Rail Engineering focus area is kept relatively small and its first task should be to undertake an in-depth, detailed analysis of R&D needs and potential projects in the area.

TABLE 8: SUMMARY OF RECOMMENDED R&D PROGRAMMES, PROJECTS AND RESOURCES FOR RAILWAY ENGINEERING

COMPETENCE AREA	STRATEGIC ISSUES	SPECIFIC R&D PROGRAMMES	PROPOSED R&D PROJECT AREAS	FACILITIES REQUIRED	MANPOWER REQUIRED
Track performance and component analysis	Commissioning of mass rapid transit systems Environmental impact of rail systems Integration with other modes of transport Standards, specifications and test methods for infrastructure development Management of rail infrastructure	Development of local products Evaluation of new products Track maintenance technology Accelerated track testing and evaluation Surveillance technology Evaluation of long-term track performance	Development of test methods for track components and materials sourced locally and overseas; development of local manufacturing skills and product standards; accelerated testing of track components; surveillance methods and equipment for track maintenance; methods and systems for track maintenance management; long-term performance of rail tracks.	Track component testing laboratory including testing trench and load frame Engineering workshop Electronic workshop Soils and materials lab Mobile data acquisition unit	Focus area manager: MEng with 15 years experience in railway engineering (M+15) Admin staff: 2 Competence manager. B+10 (mech eng) 2 Research engineers 2 Technicians
Rolling stock		Development of local products Evaluation of new products Evaluation of long-term performance Maintenance technology	Test methods and standards for rolling stock; long-term performance of stock components; development of manufacturing skills and product standards; maintenance methods and materials for rolling stock.	Track component testing laboratory Engineering workshop Electronic workshop	Competence manager: B+10 (mech eng) 1 Research engineer 1 Technician
Systems management		Signalling and communication Incident management systems Transport of hazardous materials	New and advanced technologies for signalling and communication; systems for management of emergency situations; standards and guidelines for transporting hazardous materials; standardisation of data acquisition systems for rail management.	Engineering workshop Electronic workshop	Competence manager: B+10 (electrical eng) 1 Research engineer 1 Technician

58

- **Track performance and component analysis**

Evaluation of new products
Many new products come on to the railway market from overseas countries. In many cases the performance and suitability of the products have not been evaluated in terms of local conditions. A distinct need was identified to evaluate each new product before it is exposed to the general market. Each product would form its own project as and when required.

Development of local products
Research in this area should focus on the development of local skills and manufacturing techniques to develop local products to further stimulate industry in ROC. The first task in this area will be to identify specific products suitable for local development.

Accelerated track testing and evaluation; surveillance technology
This area is directly linked to the development and evaluation of new products, especially where the performance of components needs to be tested, both in the laboratory under controlled conditions and in the field under operating conditions.

Track maintenance technology
Track maintenance forms a significant part of a railway organisation's budget. A need was expressed for research into improved track maintenance procedures to assist in the optimisation of maintenance activities.

Evaluation of long-term track performance
Projects in this area will be essential for evaluating the long-term effectiveness of new products and maintenance procedures.

- **Rolling stock**

Product evaluation and development
Similar to the Track Performance and Component Analysis competence area, the main emphasis will be on evaluation of new products and the development of local products. The comments given in the previous section would also apply to this competence area.

Maintenance technology and evaluation of long term performance
DORTS has a two kilometre track facility for testing rolling stock components. However, there appears to be limited research expertise in the evaluation of long-term performance and maintenance of new, local and international components. It is likely that TERC and DORTS could conduct joint research projects in this area.

- **Systems management**

Signalling and communication
No specific needs were identified by the rail authorities in this area. However, a general need was expressed for TERC to develop expertise in advanced signalling and communication technology by keeping abreast of international developments.

Incident management systems and transport of hazardous materials
The management of incidents including hazardous spills has become increasingly more important world wide. Although a need for a research competence in this area was not expressed, it is felt that TERC should investigate the development of such a thrust area to keep abreast of current international trends.

5.2.4 Facilities required

The recommended facilities and equipment required for the competence areas are summarised in Table 8.

- **Track performance and component analysis**

A track component testing laboratory will be essential for this area to investigate track design and the performance of the various components of track construction. A mobile data acquisition unit and surveillance equipment will also be required to obtain data on in-service performance of track construction and components for inputs into optimising rail maintenance procedures.

Support will be required from the engineering and electronic workshops and the materials testing laboratory.

- **Rolling stock**

As discussed in Section 5.2.3, collaboration and agreement with DORTS will be required to use their existing two kilometre test track facility to evaluate new local and international products which may be developed. Engineering and electronic workshop support will also be required.

- **Systems management**

The only support facilities required in this area will be the electronic workshop and laboratory and the engineering workshop.

5.2.5 Manpower required

The manpower requirements for the Railway Engineering focus area are summarised in Tables 6 and 8.

The manager of this focus area should have a railway engineering background, with a masters degree and a minimum of 15 years experience in railway engineering. The person will be primarily responsible for establishing research direction and will manage the technologies in the three identified competence areas and in the other areas of railway design, construction and maintenance which may be carried out in the Highway Engineering focus area.

The following staff will be required in the three identified competence areas:

- **Track Performance and Component Analysis**

Competence area manager,
Bachelors degree in civil/mechanical engineering with at least 10 years appropriate experience;

Two research engineers,
Bachelors degree in civil/mechanical engineering;

Two technical support staff,
Civil or mechanical engineering expertise.

- **Rolling Stock**

Competence area manager,
Bachelors degree in mechanical engineering with at least 10 years appropriate experience;

One research engineers,
Bachelors degree in mechanical engineering;

One technical support staff,
Mechanical engineering expertise.

- **Systems Management**

Competence area manager,
Bachelors degree in electrical engineering with at least 10 years appropriate experience;

One research engineers,
Bachelors degree in electrical engineering;

One technical support staff,
Electrical engineering expertise.

Earlier recommendations suggest that this focus area should not be included in the initial establishment of TERC. However, it will be necessary to appoint the focus area manager with an assistant at competence manager level to have in-depth discussions with the various rail authorities to identify specific project areas. They should also be responsible for establishing the Track Component Testing Laboratory and for obtaining a mobile data acquisition unit and appropriate surveillance equipment. This will be taken into account in the implementation plan outlined in Section 8.

5.3 Safety Systems and Traffic Engineering

5.3.1 Strategic issues

The following are considered to be the major strategic issues facing this focus area (Table 4):

- accessibility and mobility;
- environmental impact;
- transport integration; and
- transportation safety.

Severe traffic congestion, increasing accident costs and pollution are some of the major side effects to be addressed.

The improvement of accessibility to and mobility within Taiwan cities are major priorities. Expediting the implementation of mass rapid transit systems, improved traffic control, incident management systems and the implementation of IVHS are initiatives most likely to produce tangible results in response to these needs. The integration of transportation systems also offers significant benefits, through improved land-use/transport planning and modal integration.

The improvement of transportation safety will improve the quality of life in ROC. Although several successful traffic safety research projects have been conducted in ROC, the approach is perceived to have been rather fragmented. A major challenge for the road safety authorities will be to develop a road traffic safety policy and an effective traffic safety management system to implement such a policy.

In order to address these needs successfully, this focus area has to structure its R&D plans to aim at the following strategic objectives:

- establish a safer traffic environment;
- enhance mobility for all road users;
- reduce the negative environmental impacts of traffic;
- promote modal integration in the transportation system;
- improve traffic law enforcement;
- improve the safety features of all kinds of vehicles, including motor cycles; and
- develop education and training programmes that will effectively reach the entire ROC population.

5.3.2 R&D Needs

The major R&D needs in traffic safety identified by industry stakeholders during interviews and discussions, are the following (Table 2):

- modification of road user behaviour;
- more advanced systems to conduct proper traffic law enforcement;
- improved safety features for all vehicles;

- improved traffic safety for pedestrians;
- education and training for traffic safety;
- improvements to road safety infrastructure; and
- incident management systems and accident/collision studies.

The identified R&D needs that are related to traffic engineering include the following:

- traffic control and signalling systems;
- environmental pollution: vehicle emissions and noise;
- coordination of planning and operational decision-making on government level;
- geometric design standards;
- arrestor beds on steep grades;
- parking management systems;
- IVHS;
- the design of modal interfaces;
- integrated transport planning for ROC; and
- integration of transport modes.

In generic terms, the above suggests that traffic management R&D should focus on providing engineering technology and support to IOT and industry in respect of road supply and travel demand management. The main thrust of the work should be in the areas of road network management, traffic signalisation and geometric design.

For the focus area as a whole the analysis of needs indicate that efforts must concentrate on:

- the development of relevant technologies and techniques, methodologies and procedures; and
- the preparation of standard specifications, guidelines, manuals and codes of practice.

5.3.3 Specific R&D programmes and possible projects

For traffic safety, analyses of available road accident data and the needs expressed by industry pointed to specific areas that should form the nucleus of the research programme. These are summarised in Table 9 and described in more detail below for each competence area, with an indication of possible research projects.

- **Legal aspects and emergency services**

Violation monitoring systems

The availability of information about traffic violations (moving and stationary) will enhance decision-making on selective law enforcement. Projects in this area should focus on:

- analyses of traffic violations to identify frequencies, trends and other parameters required for planning;

TABLE 9: SUMMARY OF RECOMMENDED R&D PROGRAMMES, PROJECTS AND RESOURCES FOR SAFETY SYSTEMS AND TRAFFIC ENGINEERING

COMPETENCE AREA	STRATEGIC ISSUES	SPECIFIC R&D PROGRAMMES	PROPOSED R&D PROJECT AREAS	FACILITIES REQUIRED	MANPOWER REQUIRED
Safety Engineering	Transport integration Transportation safety Environmental impacts of traffic Improved law enforcement Improved awareness, skill and attitude of road users	Vehicle safety Roadside furniture Accident reporting and analysis Identification of hazardous locations Accident simulation and reconstruction Traffic control devices Modal integration Adverse climatic effects	Visibility of vehicles; seat belts and restraints; helmets for motor cyclists; roadworthiness of vehicles; bus safety standards; underriding protection for heavy vehicles; safe passing of long vehicles; head rests in cars; splash/spray on wet roads; brake systems; design and placement of road furniture; visibility of features; lighting at night; road signing; construction sites; road identification; procedures for accident reporting; communication of safety statistics; monitoring of area-wide improvements; accident simulation; traffic control devices; safety at modal interfaces; effects of climate on safety.	ARTC facilities for photometric tests, crash tests and component tests; smaller test equipment to be owned by TERC	Focus area manager: MEng with 15 years experience (M+15) Admin staff: 2 Competence manager B+10 (traffic/transportation) 2 research engineers 2 technicians
Legal aspects and emergency services		Violation monitoring systems Incident management systems Control of vehicle overloading Traffic legislation and adjudication	Analysis of traffic violation statistics; development of violation monitoring systems; strategies and implementation of incident management systems; technologies for weigh-in-motion; weighbridge management; overloading legislation; study of penal measures; prosecution of transgressors; traffic law enforcement equipment.	Electronics laboratory and workshop	Competence manager B+10 (law) 2 research staff 2 technical support staff
Human factors		Driver behaviour & training Training of unprotected road users Road safety education	Training manual for drivers; study of driver behaviour; rehabilitation of offenders; improved visibility of unprotected users; identification of risk groups; publicity and awareness; safety education at school; education of adults.	Psychometric laboratory Driver simulator on test site	Competence manager: B+10 (social sciences) 2 research staff 2 technical support staff
Traffic management	Improved accessibility and mobility Transport integration Environmental impacts of traffic	Geometric design standards and procedures Roadside furniture Traffic counting Identification of hazardous locations Traffic signalling and control Modal integration Management of traffic flows Advanced technologies	Local design standards; roadside furniture; systems for, and approaches to traffic counting; traffic control systems, hardware and strategies; modal integration guidelines; traffic flow control measures; traffic signalisation; parking management and standards; IVHS.	Electronics laboratory and workshop Large scale testing facility for IVHS, etc	Competence manager. B+10 (traffic/transportation) 3 research staff 3 technical support staff

64

- development of violation control monitoring systems, eg for red light violations, following distance, overtaking, alcohol, seat belts, speed, overloading and roadworthiness.

Incident management systems

MOTC has a central role to play in developing a policy on incident management and the procedures to be followed. Incident management systems are needed to coordinate activities, improve or simplify communications, provide a better service to the public and improve the deployment of the various organisations involved in these operations. The need for incident management systems is not only required on freeways but also on all strategic or high-volume roads and for mass rapid transit systems. Research in this area must focus on the following:

- the development of strategies to initiate the process of incident management on all levels;
- strategies and procedures to deal with operational aspects;
- infrastructure requirements, eg SOS equipment;
- management of hazardous spills; and
- management systems to cope with natural disasters, eg floods and earthquakes.

Control of vehicle overloading

Vehicle overloading causes serious damage to road pavements and is a safety hazard. Most freight in Taiwan is transported by road and regular surveillance of the situation is necessary. Areas to be focused on are:

- appropriate technologies to screen overloaded vehicles, eg weigh-in-motion technology (WIM);
- the installation of weigh bridges and monitoring systems; and
- effective legislation to control overloading.

Traffic legislation and adjudication

Penalties embodied in traffic legislation should be sufficient to serve as a preventive measure, and must be supported by appropriate law enforcement efforts to ensure the effective and visible apprehension of transgressors. A variety of measures are necessary to ensure that drivers adhere to traffic regulations, such as the monitoring of drinking and driving, spot checks on the wearing of seat belts and road worthiness checks. A variety of penal measures have been implemented in various countries with varying degrees of success, i.e. suspension of licences, social duty for traffic offenders and short-term imprisonment.

The administration of traffic offences is very often a cumbersome process and many offenders are not prosecuted. The penal effect of traffic legislation is hence diluted and discredited and drivers would tend to intentionally disregard traffic rules as a result.

The following research must be conducted:

- a study of penal measures available elsewhere in the world in terms of its applicability and implementation in Taiwan;

- the development of effective monitoring and administrative systems (eg a points demerit system for serious transgressions) to ensure the prosecution of traffic offenders;
- the standardisation of court procedures; and
- evaluation of equipment available to enforce traffic legislation.

- **Human factors**

Driver behaviour, driver training and simulation
Adherence to the rules of the road and traffic regulations is an area of concern for road authorities in Taiwan. In 1992 TANFB reported that on the national freeway the major causes of road accidents were "improper driving" and "tailgating". These aspects contributed to an estimated 69 percent of all incidents.

The problem is often related to the attitudes of drivers, but also to a lack of appropriate skills, especially in the case of heavy and articulated vehicles. Driver training and education are therefore required to correct the problem. This implies that new drivers must receive tuition at driving schools before they can apply for a driver's license, or that certain traffic offenders' licences might be suspended until they have passed a driver training programme. In certain cases professional drivers may need to be trained.

Driving schools exist in Taiwan but attendance is not compulsory. These driving schools must be operated to certain minimum standards, and regulations should also address the training of driver instructors.

The research focus in this area must be on the following:

- the development of a training manual for new prospective drivers;
- tuition in driving schools for all new drivers and for drivers in need of rehabilitation;
- a study of the factors causing abnormal driver behaviour, especially with regard to attitudes and skills (both in practice and by using a driver simulator); and
- the introduction of a points demerit system for traffic offenders.

Training and education of unprotected road-users
Incidents involving unprotected road-users (pedestrians, pedal cyclists and motor cyclists) constitute about 40 percent of the road fatalities in Taiwan and in the majority of cases no formal training in road safety practices had been received. Statistics show that a large proportion of those involved in road accidents are older than 20 years of age and are predominantly male. Only radio programmes are currently used to educate adults, while cyclist training and pedestrian safety are promoted in some schools.

Efforts should be aimed at:

- improved visibility of unprotected road users;
- the identification of the target groups most at risk; and
- the development of publicity and educational material to address the target groups.

Road safety education

Road safety education as part of the formal education and schooling process is considered essential to cultivate the correct attitudes towards traffic safety. Two schools of thought exist on the format of this education namely, the establishment of a separate subject in the school curricula, or the integration of road safety education into other subject matter (e.g. mathematics).

Although road safety education was implemented in Taiwan schools about three years ago, it is not compulsory and depends largely on the attitude of the school principal.

Adults (existing drivers) need to be educated in the latest traffic developments (e.g. new road signs and markings and legislation). No national publicity or awareness campaigns are currently conducted but on-site education is often given at road improvement areas.

A research programme should focus on the following:

- the most appropriate format of road safety education in schools;
- a training programme for teachers to promote traffic safety in schools; and
- the development and implementation of effective communication measures to train and inform adults (existing drivers) about traffic regulations and control measures.
- **Safety engineering**

Vehicle safety

Road accident statistics for 1992 showed that most road fatalities and injuries involved passenger cars, commercial vehicles and motor cycles. Head injury is the most frequent type of injury in motor cycle accidents and the usage of helmets is therefore considered vital for these unprotected road-users. Some initiatives were recently launched to address this need and ongoing monitoring will be required to evaluate the success of such initiatives.

TANFB (Annual Report, 1992) reported that on freeways, accident rates were the highest for heavy trucks and tractor trailers.

The improvement of vehicle safety features can contribute to reduce casualties. Areas to investigate include:

- improved visibility of commercial vehicles, motor cycles, buses and pedal cycles;
- compulsory seat belt wearing on rear seats of passenger cars;
- specifications for child restraint systems;
- compulsory use of helmets for all motor cycle riders;
- road worthiness of vehicles (periodic testing of certain classes of vehicles, as suggested by IOT);
- bus safety standards (structural strength, inflammability of interior, etc);
- underriding protection for heavy vehicles;
- measures to ensure the safe passing of long vehicles;
- the effect of head rests in reducing spinal injuries;
- splash and spray generated by heavy vehicles on wet roads; and
- anti-lock brake systems for heavy vehicles.

Roadside furniture (including road construction sites)

The safeguarding of roadside furniture reduces road casualties and replacement costs. In 1992 alone, TANFB reported 4 765 events in which roadside facilities were damaged. Items mostly involved were guard rails, reinforced concrete posts, off-set blocks, trees and fences. Research projects should focus on the following aspects:

- safe design features;
- placement/proximity of facilities;
- visibility of facilities; and
- lighting and night-time accidents.

Road construction sites present serious road safety problems if not properly demarcated, for both road users and construction workers. Areas to be covered by research include:

- a distinctive road signing (different colour system) and marking system;
- detailed layout configurations for different road construction sites (road closures, lane closure, shoulder work, roadside maintenance etc); and
- procedures to maintain equipment in a good state of repair.

Accident reporting and analysis procedures

Proper accident reporting forms the backbone of an efficient hazardous location identification and elimination programme. Discussions with staff of the Transportation Safety Division of IOT revealed that the current reporting procedure is inadequate. No comprehensive annual report on accident statistics for the whole of Taiwan could be traced. Problems are experienced with the description of accident locations and also with the underreporting of road accidents. Furthermore, analysis procedures need improvement to eliminate duplication of records.

Research in this area should be focused on the following:

- proper road marker/identification systems (urban and rural) to locate accident locations more accurately;
- procedures to train the police to use these systems and to complete the accident report forms more accurately;
- procedures to ensure proper accident reporting by the driving public;
- identification of analysis procedures to upgrade the system of processing and reporting;
- compilation of a system to provide annual accident statistics for Taiwan;
- occurrence, frequency and reporting on night-time accidents.

Identification of hazardous locations

Road authorities in many countries are of the opinion that the identification and elimination of hazardous locations are the most cost-effective short-term measures to improve road safety. The current IOT research programme shows that 12 projects in this field have already been conducted in conjunction with road authorities. A manual on the development of improvement projects for accident-prone locations in Taiwan was published (IOT Annual Report, 1992).

Although good progress has been made in this field, the monitoring and evaluation of the success of countermeasures need to be researched. These results will provide good inputs for the general application of countermeasures and can only enhance the applicability of the above-mentioned manual.

Accident simulation and reconstruction

The Transportation Safety Division of IOT expressed the need to be competent in the area of accident simulation and reconstruction. In the case of major road incidents, eg a bus accident with multiple fatalities or injuries, specialised expert witness is often required in court on the causes of these collisions. Apart from extensive experience in the field of accident investigation, specialised training is required in accident simulation and reconstruction.

The research focus in this area should be on the following:

- the training of personnel in accident simulation and reconstruction (courses in reconstruction/computerised analysis are presented annually at a number of US universities, e.g. North Western and Florida);
- usage of data obtained from accident simulation and reconstruction studies for research into causative factors in major road accidents.

Traffic control devices for road safety

Traffic control devices (signals, signs, road markings, etc) are costly items and provision and maintenance must be properly managed. In addition, the ROC traffic control devices should be aligned with the international stylised signing systems (eg the Geneva Convention on Traffic Signs). The Manual on Planning and Design for Traffic Control Devices (IOT Annual report, 1992) could be used for this purpose. Research in this area will not only promote road safety but will also ensure the most cost-effective use of these control devices.

Speeding is recognised as one of causative factors in road accidents in Taiwan. To deal with this problem, traffic calming techniques (such as mini-roundabouts, road narrowing and speed humps) have been developed in several countries. The appropriateness of these techniques for Taiwan should be evaluated.

Areas to be investigated include the following:

- surveys of traffic control systems in use in other countries;
- aligning the Manual on Planning and Design of Traffic Control Devices with international practice;
- investigation of the appropriateness of traffic calming measures and the drafting of national standards;
- specifications for the light intensity of traffic signals;
- durability studies on road sign materials; and
- humidity effects (fog and rain) on the retroreflective properties of road signs.

Modal integration from a safety perspective

The planning of new public transport systems in Taiwan cities (underground, mass rail transit and bus systems) includes the co-ordination of safe circulation systems for users between the different modes. No guidelines have been developed but will be necessary when the MRT and other systems become operational in the various cities.

Research should focus on:

- standards and guidelines for transportation authorities to provide safe circulation systems.

Adverse climatic conditions and traffic safety
Accident statistics for 1992 show that one-third of all road accidents in Taiwan occur during inclement weather conditions. Fog is a general phenomenon in the Taiwan area and research should be focused on technologies to assist road users in times of poor visibility.

Research projects in the following areas could be beneficial:

- automatic speed limit reduction in wet weather (linked to variable message signs on freeways);
- fog detection warning systems; and
- wind monitoring systems.

- **Traffic management**

Geometric design standards and procedures
Studies of the efficiency of various elements of road and intersection design need to be conducted. Among the main aspects of urban networks are the types of intersection (including traffic circles or roundabouts), public transport termini, urban interchanges, lane width, configuration and curb radii. In the context of rural roads, important aspects are passing and climbing lanes, horizontal and vertical alignment, access to bridges and tunnels and arrestor beds.

Research should be focused on:

- the development of local standards;
- adaptation of overseas procedures for local conditions;

Roadside furniture
Comments made under the safety engineering competence area are also of relevance here, and this provides an example of the important interface that needs to be established between safety experts and traffic engineers in the research effort.

Traffic counting, strategies and equipment
Information on traffic volumes, vehicle classification, occupancy and loading, peak periods and seasonal flows, constitutes the basis of an integrated traffic management system. Limited system capabilities were observed during assessment of the current situation in Taiwan. For example, traffic counting on highways appears to be limited to two experimental stations for the whole of the Taiwan area.

Research should be directed at the development of a comprehensive traffic counting strategy for the ROC.

Traffic signal control, strategies and equipment

The traffic congestion currently being experienced in most Taiwanese cities can be eased through effective signalisation. This is an extensive work area, encompassing aspects ranging from fixed-time control of an isolated intersection to real-time on-line optimisation of large traffic signal networks. It also covers special applications of traffic signals, eg in road tunnels, at roadworks and for allocation of priority to public transport or emergency vehicles.

The work to be done in this field includes:

- the development of standard procedures for systems design, evaluation and monitoring;
- standardisation and testing of controllers, computers and communications systems; and
- development, testing and standardisation of data logging and detection equipment.

Identification of hazardous locations

See comments made in this regard under safety engineering.

Modal integration

The research to be done in this area includes:

- location and geometric design of modal transfer points;
- scheduling of operations;
- compatibility of modal capacities;
- integrated fair policies and systems;
- information systems.

See also comments made in this regard under safety engineering.

Management of traffic flows in road networks

The work in this field is concerned with the control of traffic flows by means of, inter alia, one-way street systems, application of traffic signs and markings, reversible traffic lanes, clearways and high occupancy vehicle lanes. These measures can be used in Taiwanese cities to either increase capacity and relieve congestion or to minimise adverse impacts of traffic, such as accidents, noise or pollution. The attainment of the latter objective can be enhanced by additional actions such as traffic calming measures, access restrictions for specific vehicle classes, pedestrian malls and reduced speed limits.

Parking management is also one of the major tools of traffic management and includes the provision of on-street and off-street parking, loading bays, location of parking facilities, design standards, fee structures, operation policies and information systems to guide drivers to available parking facilities.

The research to be conducted in this work area are:

- national policies on the management of traffic flows;
- the development of standards and guidelines for the various control measures;

- development of technologies with regard to detection and information, pre- and post-payment, and interface with traffic signal control; and
- guidelines on parking management, including parking standards.

Advanced technologies
International developments in the application of advanced technologies for road transport indicate that considerable improvement of the quality of traffic flow is achievable.

Research in this area should be focused on:

- the implementation of automatic vehicle identification and classification systems (AVI and AVC); and
- the implementation of intelligent vehicle-highway systems (IVHS).

5.3.4 Facilities required

The recommended facilities and equipment required per competence area are detailed below. In some cases these facilities could be shared with other TERC competence areas, while in others existing facilities outside IOT could be utilised.

Safety engineering

Photometric laboratory,
The existing facilities at ARTC in Hsinchu can be used. The instruments to be used regularly by TERC staff would be those required to test the following:

- retroreflectivity of signs and other devices on vehicles
- surface colours of materials or light sources; and
- vehicle headlight and supplementary light intensity distribution.

Crash test facility,
The equipment currently available at ARTC could be used.

Component testing facility,
Existing facilities at ARTC can also be used for this purpose. Components to be tested could include seat belts, door locks, seats, bumpers, lights and reflectors.

- **Human factors**

Psychometric laboratory
Selection batteries for different categories of drivers (light motor vehicles, heavy vehicles, etc) have to be developed to identify high risk drivers and to assess drivers' levels of proficiency. This laboratory will have to be established at the TERC/IOT offices, to have it in close proximity for research work.

Driver simulator facility
This facility can be used to conduct research on driver skills in areas such as performance under stress, concentration ability and reaction time. It can also be used for the selection of professional drivers, identification of high risk drivers and the testing of new training methods.

- **Legal aspects and emergency services**

Electronic workshop and laboratory
This facility is required to evaluate and calibrate the large variety of equipment for law enforcement available on the world market, especially in the areas of speed enforcement and blood alcohol content testing. Most other vehicle components can be tested in the photometric laboratory or other facilities available at ARTC.

- **Traffic management**

Traffic surveillance laboratory
The main emphasis in this case will be on the development and testing of traffic detection and counting equipment, and this could also be done by the electronics workshop and laboratory.

Electronic workshop and laboratory
This facility will also do testing of equipment associated with traffic control and advanced technologies.

Test site facility
Various tests on traffic characteristics, geometric design elements and IVHS will be required and a full-scale testing grounds will be necessary for this purpose.

5.3.5 Manpower required

The manpower requirements for the Safety Systems and Traffic Engineering focus area are summarised in Tables 6 and 9.

The manager of this focus area should have a transportation background, preferably with a masters degree and at least 15 years experience in traffic and transportation. This person will be responsible for setting research direction and managing the technology within this focus area. The following staff is recommended for the four competence areas under the control of the focus area manager:

- **Safety Engineering**

Competence area manager,
Bachelors degree in traffic/transportation/mechanical engineering, with at least 10 years appropriate experience.

Two research officers,
Bachelors degrees in traffic/transportation/mechanical engineering.

Two technical support staff,
with traffic or mechanical engineering experience.

- **Human factors**

Competence area manager,
Bachelors degree in the social sciences with at least 10 years appropriate experience.

Two research officers,
Bachelors degrees in psychology/sociology and education.

Two technical support staff.

- **Legal aspects and emergency services**

Competence area manager,
Bachelors degree with at least 10 years criminal law or similar experience.

Two research officers,
One bachelors degree in law and experience in law enforcement.

Two technical support staff.

- **Traffic management**

Competence area manager,
Bachelors degree in traffic engineering with at least 10 years transportation/traffic engineering experience.

Three research officers,
Bachelors degrees in transportation/traffic, also in electronic engineering.

Three technical support staff,
Experience in traffic engineering and electronics.

6 SUPPORT FACILITY STRATEGY

6.1 TERC facilities

From the detailed information provided in Section 5 for each focus area, a summary of facilities needed, floor/land space required, estimated cost figures for budgetary purposes and manpower requirements is given in Table 10. Detailed equipment lists and estimated purchase prices or establishment costs for each facility (where available) are given in Appendix D.

It should be noted that more accurate cost figures for the various pieces of equipment and facilities will have to be obtained closer to the actual establishment dates. The figures provided here have been compiled for provisional budget purposes only and are likely to change, depending on the time of establishment, exchange rates and availability of specific pieces of equipment in ROC.

6.1.1 Testing grounds to accommodate TERC support facilities

For ease of management and to avoid access problems and pollution in the city, it is recommended that all TERC support facilities, with the exception of the psychometric testing laboratory, be located on a remote site. Based on the CSIR's experience, a minimum of four hectares of land will be required to accommodate the recommended laboratories and offices, a test track and sufficient space to build experimental sections for accelerated testing.

The following options appear to be available for the establishment of the required testing grounds:

- Establish a new testing site close to Taipei within driving distance of the central IOT office. If this option is selected, a significant period of time will be required to identify and purchase a suitable piece of land for establishing the testing grounds. No estimate of cost could be given for this.

- Establish the TERC testing site in Tainan as part of the new campus of NCKU under the direct control of IOT. The advantages of locating the test site in Tainan is that the land has already been made available for the new university campus and NCKU have already submitted a motivation to IOT suggesting that the TERC test site should be established at that location. In addition, NCKU has well established structural, geotechnical and hydraulic testing facilities which could be used to support the activities of TERC, especially in the early phases of establishment. Engineering workshop facilities are also available at NCKU and it may be possible for TERC to share these facilities rather than establish a new workshop immediately.

TABLE 10: SUMMARY OF FACILITY REQUIREMENTS AND ESTABLISHMENT COSTS

FACILITY		SPACE REQUIRED m^2 or ha	ESTIMATED COST (US$ millions)	MANPOWER REQUIREMENTS			
				Management	Technical staff	Technicians or artisans	Admin staff
Testing grounds, to accommodate all of the facilities listed below		4 ha	IOT to negotiate	1 (M+15) Civil/Mech	-	2 Maintenance	2 Secretary/Admin support
Track and component testing lab		450 m^2	2,28	1 (B+10) Mech Eng	-	3 Rail/Mech	
Engineering workshop	Workshop	275 m^2	0,17			3 Fitter/Turner	
	Storeroom	30 m^2					
Electronic laboratory and workshop		50 m^2	0,04		2 Engineers	2 Elec tech	
Soils and materials lab	Laboratory	600 m^2	0,60 (SHRP test equipment extra 1,0)	1 (B+10) Civil/Soils	4 Engineer/ Technician	7 Support staff	
	Storeroom	200 m^2					
Accelerated pavement testing facility		-	1,50		1 Engineer	3 Support staff	
Pavement testing and surveillance equipment; garage facilities		100 m^2	1,00		1 Engineer	2 Support staff	
Psychometric testing laboratory at IOT		80 m^2	Part of new IOT building			1 Support staff	
Driver simulator (Austrian ART-90)		40 m^2	0,04		1 Engineer		
Traffic surveillance laboratory		60 m^2	0,02			1 Support staff	
Mobile rail testing unit		-	1,00		1 Engineer	1 Support staff	

76

The main disadvantage of locating the test site in Tainan would be travelling. However, there are regular flights between Tainan and Sungshan Airport in Taipei which is close to the new IOT buildings. Travel time from IOT/TERC to a test site in Tainan would be between one and two hours which is likely to be similar to the driving time from IOT/TERC to a test site located outside Taipei. The only difference would be an increase in travel costs to fly to Tainan.

Another disadvantage of locating the test site on grounds provided by NCKU is that IOT/TERC could be seen to be biased towards one university which could cause problems with other universities operating in the areas of highway engineering and safety systems and traffic engineering.

From the options available, it would appear that the advantages of locating the TERC test site in Tainan far outweigh the disadvantages. If this option is selected it will be necessary for IOT to ensure that the needs and expectations of other universities are accommodated.

6.1.2 Track component testing laboratory

This facility will be specifically related to the Railway Engineering focus area and details of the equipment needs for this laboratory are as follows:

- A track trench (16 m x 4 m x 1.5 m deep) for the simulation of dynamic loads on a section of rail, sleepers, balast and up to 1.5 m of formation;
- Appropriate monitoring equipment, e.g. multi-depth deflectometers, accelerometers and strain gauges for the track trench;
- Load frame for the track trench with a recommended maximum vertical load of 500 kN for static and dynamic loading;
- Control centre for monitoring strains, accelerations and deflections recorded in the track trench;
- Central hydraulic power supply.

Information obtained from the South African rail authorities show that a similar facility established by them in 1983 cost R2,3 million, which inflated to today's costs would be in the order of R8 million (US$ 2,28 m). While space for this facility needs to be allocated in the planning of the test site (a covered structure of 450 m^2), this may not be a priority for initial establishment.

6.1.3 Engineering workshop

A small engineering workshop will be required with floor space of about 275 m^2 for the workshop and 30 m^2 for a storeroom. A list of typical equipment which will be required is given in Appendix D with an estimated procurement cost of US$ 170 000.

Although engineering workshop support will be essential for the maintenance and repair of all equipment on the test site, as discussed earlier, this support could be provided by NCKU during the initial phases of establishment.

6.1.4 Electronic laboratory and workshop

The main emphasis in this area will be to provide electronic workshop support and development facilities for data acquisition equipment. The facility will be required by all three focus areas and a list of basic equipment which will be required is given in Appendix D with a total estimated procurement cost of US$ 40 000. The floor space required will be about 50 m^2.

As much of the work in this area will overlap with the engineering workshop support, it is recommended that this facility is located adjacent to the engineering workshop.

6.1.5 Materials testing laboratory

The establishment of this laboratory will be essential for the success of TERC and should be seen as the first priority for the establishment of the test site. The facility should be separated into three distinct laboratories covering soils and aggregate testing, bituminous materials testing and cementitious materials testing. Each laboratory would require approximately 200 m^2 of floor space and would need to be interlinked. In addition, office space to accommodate twelve people would be required and a further 200 m^2 for sample reception and storage.

Observations of routine test laboratories showed that the testing of steel for concrete structures is given a high priority. It is recommended that provision for this type of testing is incorporated into the cementitious materials section of the laboratory. A universal load frame will be required for tensile testing along with a mass spectrometer and x-ray diffraction facility for assessing the chemical composition of the material. Account of this has to be taken in the equipment list of Appendix D-4.

A comprehensive list of typical tests that would be carried out in the laboratory and the equipment required is given in Appendix D. The equipment procurement costs to establish a routine laboratory are estimated at US$ 600 000 which would exclude the cost of work benches and other necessary laboratory fitments.

It should be noted that this cost also excludes the specialised testing equipment being developed as part of the SHRP programme in the USA. If the tests developed as part of this programme become routine requirements, it is estimated that an additional US$ 1 million will be required to purchase the equipment. Provision should be made for this in the phased financial plan approximately two years after establishment.

6.1.6 Accelerated pavement testing facility

Internationally, APT is recognised as an essential element of a coordinated pavement research programme. In South Africa it has a proud history over the last 20 years where the technology has yielded significant benefits to the industry. These benefits include, amongst others the following :

- the development of a thorough understanding of the behaviour and performance of different pavement types relative to each other;
- the assessment of the relative performance of different materials (including performance assessment of innovative materials);
- the development of transfer functions which can be used to predict pavement performance from laboratory test results;
- the validation of design philosophies and methodologies;
- the evaluation of the applicability of various rehabilitation options for specific routes;
- the validation of materials design methods and laboratory test methods, and
- the optimisation of expenditure on road structures through the reduction of pavement layer thicknesses.

This work led to the development of a sound pavement engineering technology in South Africa which is recognised world wide. It had a major impact on road engineering technology in South Africa and this technology is currently being exported to California in the USA. In recent research papers it has been shown that the APT programme in South Africa has saved the country in the order of US$ 17 million per year over the last 20 years. The cost of the research programme (operating three machines country-wide) was in the order of US$ 1,45 million per year.

The APT programme in South Africa has generated some invaluable information and data on APT over the last 20 years. This information is contained in a database (between one and two Gbyte) for which a user-friendly interface is currently being developed.

- **Technologies available**

There are a number of fixed track APT systems in the world of which the facility of LCPC at Nantes in France is probably the best known. However, the latest international trend is towards mobile systems which can be used on actual in-service road pavements. Currently commercially available mobile systems include the Accelerated Loading Facility (ALF) and the Heavy Vehicle Simulator (HVS). The Texas DOT is in the process of developing a prototype Mobile Load Simulator (MLS) but this is not yet commercially available.

All these systems have advantages and disadvantages which are summarised below.

Mobility
The HVS was designed to be extremely mobile and can be easily transported from one site to another (under its own power over short distances and hauled with a tractor over long distances). Both the ALF and the MLS are less mobile and significant time is lost due to preparation for the move and installation after a move. The MLS, for example, has to be split into two parts in order to be transported.

Speed during testing
The MLS was designed to be able to test at 30 km/h (this has not yet been achieved with the prototype); the ALF tests at approximately 15 km/h while the maximum speed for the HVS Mark III is 14 km/h. Current improvements to the HVS (Mark IV) is aimed at allowing testing at 20 km/h.

Loading
The MLS makes use of actual truck suspension systems forced underneath a "drifting beam" to provide loading. This has the advantage of simulating some dynamic effects of real suspensions albeit at relatively low speed (30 km/h). The disadvantage is that the load cannot be controlled at a fixed level, which complicates data analysis significantly. The loading is unidirectional. The ALF uses static loading in a unidirectional loading system with ramps at each end. The disadvantage of this setup is that the loading impacts on the road surface with significant force which influences the results observed. The HVS uses a hydraulic system of loading which is much more flexible and allows the load to be controlled at a constant level or to simulate dynamic loading through control with servo-hydraulic valve systems. This allows for both unidirectional and bidirectional traffic to be simulated.

Environmental control
The HVS technology has been developed to allow the use of environmental control systems such as moisture control on the road and in the pavement structure, temperature control (from as low as -5°C to 60 °C) as well as the simulation of accelerated ageing of asphalt surfaces prior to testing. These systems do not exist with the ALF or the MLS.

Associated technology
The HVS system includes associated pavement instrumentation and measurement technologies such as the multi-depth deflectometer (MDD), the road surface deflectometer (RSD), the electronic profilometer (EP), the Crack-activity Meter (CAM) and a data acquisition, data processing and data base system. This does not exist with either the ALF or the MLS.

The HVS has a history of production work over the last 20 years whereas the ALF has only been productive in the last five years and the MLS is still in the prototype phase.

Current costs for the South African HVS would be as follows:

Approximate purchase price	US$ 1.2 to 1.5 million
Running cost	US$ 8 000/month
Staffing	1 operator
	3 support staff

Additional equipment	Computers MDD's RSD

It is estimated that training and technology transfer of the accelerated testing technology developed at Transportek would take about one year and the following expatriate specialists would be required to effect this in Taiwan:

1 operator	1 man-year
1 research engineer	1 man-year
1 research technician	1 man-year
1 pavement specialist	1 man-month
1 programme manager	1 man-month

6.1.7 Pavement surveillance equipment

It is not recommended that pavement surveillance equipment is purchased immediately as an in-depth analysis will be required of current international trends.

An assessment will also be required of the current surveillance equipment being used in ROC and its suitability to local conditions. Provision should be made in the planning of the test site for garage facilities for four pavement surveillance vehicles. The area required is shown in Table 10.

6.1.8 Psychometric testing laboratory at IOT

It is recommended that this laboratory be located in the new IOT building as no test equipment will be required. The facility will be in the form of a classroom of about 80 m^2 with tables and chairs to accommodate thirty people and will be used to assess driver attitudes and levels of proficiency. Office space will also be required for the responsible technician. Establishment costs will be minimal and should be considered as part of the costs of the new IOT building.

6.1.9 Driver simulator

This facility can be used to undertake research on driver skills in terms of performance under stress, concentration ability and reaction time. Various examples of driver simulators are available, such as:

- Trygg-Hansa truck driving simulator (Sweden)
- TRL passenger car simulator (UK)
- Military simulators (Netherlands)

For the purpose of TERC, it is considered that a driver selection simulator similar to the Austrian Vienna Test System or ART-90 apparatus would be the most appropriate. The approximate cost is US$ 40 000 and would require floor space of about 40 m^2.

6.1.10 Traffic surveillance laboratory

This laboratory will concentrate on the development of traffic data logging equipment and the testing of this equipment under operating conditions (predominantly mechanical aspects).

The instrumentation for the laboratory will consist of a set of general tools, capacitance meter and multimeter. The estimated cost of this instrumentation is US$ 20 000 and floor area of about 60 m^2 will be required. Specialised apparatus such as ovens, freezers and degassifiers are not recommended to be purchased for the dedicated use of TERC as facilities already exist with organisations such as CSIST.

6.1.11 Mobile rail testing unit

The mobile rail testing unit is a five-axle articulated vehicle and will require garage facilities at the TERC test site. An estimated cost for the same facility in South Africa which includes the truck tractor, trailer and computer units would be US$ 1 million.

However, it is recommended that a detailed investigation is carried out into the necessity for such equipment before a decision is taken to purchase. This should be one of the first tasks carried out by staff in the Railway Engineering focus area.

6.1.12 Test track and experimental sections

A surfaced test track facility (200 m x 15 m wide) will be required at the test site for testing various traffic characteristics, aspects associated with alternative geometric design elements and IVHS.

Approximately one hectare of the test site will need to be designated for the construction of experimental sections associated with the research in the areas of materials design and evaluation, pavement performance and construction. Test sections for APT would also be constructed in this section of the test site.

6.1.13 Manpower requirements

The manpower requirements and their professional qualifications for each facility are shown in Table 10. These recommendations are based on the experiences of the CSIR in managing support facilities of this nature as part of the overall research capabilities related to road and transport technology.

It will be important to appoint a facility manager as soon as possible to supervise and manage the establishment of the test site facilities, once a decision has been made on its location. As the establishment of the soils and materials laboratory is seen as the first priority, it will also be necessary to appoint a suitably qualified manager in this area to assist the facility manager in establishing the test site facilities.

6.2 IOT/TERC Information Management Systems

The following short-term actions were identified as necessary to create an enabling climate for Information Technology within IOT and TERC:

- Establish a formal Computer Support Function within IOT (with at least 2nd level functions as defined in Appendix C) either under the control of the current Information Systems Division or as a separate Division, BUT not as part of TERC.

  This function would then act in support of both the current IOT Divisions and TERC.

- Provide sufficient manpower and financial resources in order to fully complete the basic network installation as soon as possible. A basic network should be configured to a standard similar to that detailed in Appendix C.

- Install the Novell Management System (NMS) software to monitor the IOT network. Complaints that the existing system is slow indicate abnormally high traffic, Ethernet traffic collisions or faulty components. Such a system will help identify and resolve these and other problems.

- Develop a written standard as a guide/policy in terms of the software packages (eg word-processing) to be used. This proposed standard may simply describe a document interchange format (eg MS-Word or WordPerfect).

- Create an awareness of Information Technology through training programmes.

- Expand the availability of external computer links, which include:

  - Install a fax gateway card in the file server to handle outgoing and incoming faxes;

  - Install an ASYNC card to handle dial-up lines;

  - Install an X25 gateway (card in fileserver) to facilitate links to the MVIDS II system at DCI (an ASYNC line could possibly be used for this);

  - Provide access to INTERNET (possibly via TAINET) to enable IOT computer users to contact fellow researchers around the world and allow other overseas research institutions to make contact with IOT. This would also require personal E-mail boxes.

- Install a professional, easy to use E-mail system (PC based and with X400, SMTP and MHS gateway facilities) and make it available to all network users in IOT/TERC. The selected system should preferably have both Chinese and English versions and user names should match the Novell (8 character) login names.

- Ensure that the new IOT building and any TERC remote sites have (where practical) UTP level 5 cabling installed to every office and laboratory.

- In terms of the more traditional Information Technology drive, the broad goal for the new Computer Centre should be to become a transport industry information provider (through the development of the proposed 48 data-base sub systems). Many of the above proposed actions are ultimately geared towards IOT and TERC fulfilling this role.

Most of the above actions, systems and skills are applicable to the new IOT building including TERC and to the TERC remote laboratories.

6.2.1 Strategic actions: Cost estimates

Assuming the Institute of Transport (IOT) is re-organised into the proposed IOT/TPPRG/TERC structure, and IT technology is accepted, cost implications can be divided into three areas:

- Upgrading of the existing 101 PC stations in IOT by linking to a network facility to enable users to take full advantage of the IT possibilities proposed;

- Incorporation of a further 70 computer stations into the network to accommodate TERC personnel whose offices will be in the new IOT building;

- Installation of 40 PC stations at a remote off-site laboratory facility as part of a new TERC laboratory and test site facility.

The cost estimates given in Table 11 are based on typical list prices in the South African market, expressed in US dollar terms.

6.2.2 Upgrading requirements for existing IOT computer system

If the existing 101 PC's in IOT are linked by a network system, existing users will be able to take advantage of the network environment, share expensive resources as well as take part in information sharing, both locally and internationally.

It is assumed that the existing computers are stand-alone workstations and will have no impact on the number of software licences required. Electronic mail licences will be required. It is further assumed that sixty computers already have network cards, and that no back-up system is in place.

In addition, one fully experienced computer technician, plus two assistants will be required to provide a reasonable and full time hardware maintenance and support service to IOT/TPPRG/TERC.

Second level support, software installation and upgrades as well as system expansion could be handled if necessary by other staff within the proposed Computer Centre.

TABLE 11: UPGRADING COSTS FOR EXISTING IOT COMPUTERS				
ITEM	Amount	Unit Cost (US $)	Priority	Total Cost (US $)
Novell Management System	1	2700	1	2700
Upgrade to Novell (3.12) 100 user licence*	1	3700	1	3700
Tape streamer (2Gb) with software and 20 tapes	1	3500	1	3500
Network points	0	-	-	0
Network cards: (3-Com 3C509)	41	150	1	6150
UTP cable 12-port hubs	4	1100	1	4400
Fax gateway: (Winfax Pro or similar to accommodated Chinese characters - 5 concurrent licences and 1 modem with dedicated line and "Network Connect" for management and auditing)	1	1500	1	1500
X25 gateway (Newport XCI hardware and software)	1	2700	2	2700
8 port ASYNC dial in gateway (including software and 4 modems)	1	5700	2	5700
E-Mail server software plus 100 licence (MS-Mail- 3.2)	1	5800	1	5800
E-mail gateway: (Netware Global MHS - 100 user)	1	2400	1	2400

*50 Users are considered to be adequate for current usage. A 100-user licence will be required when all the current IOT PCs are linked to the network and provision has been made for this.

6.2.3 Computer requirements for TERC

In addition to the existing 101 PC's, it is expected that a further 70 people will be recruited (and therefore 70 new PC's will be added to the network) for the TERC. These new staff members will be housed in the new IOT building and the total requirements for the new IOT building are shown in Table 12.

It is assumed that these computers will be new installations and will be connected to the existing LAN. Many of the resources of the existing LAN (eg gateways, printers, management system, tape streamer) can be shared amongst these new users. However, it is expected that a new 2Mb hard drive will be required, possibly in a new, second file server.

Software licences will also have to be expanded. An amount has been included for general software in the schedule in Table 12. The Novell licence will also need to be further upgraded to accommodate the new users, and the E-mail licence will have to further expanded.

In addition to the two support staff mentioned in Section 6.2.2, an extra technician may have to be appointed due to the increased workload. There should be no real increase in the amount of second level support or software installations required.

TABLE 12: ADDITIONAL COMPUTER REQUIREMENTS FOR THE NEW IOT BUILDING TO INCLUDE TERC

ITEM	Amount	Unit Cost (US $)	Priority	Total Cost (US $)
486DX computer stations (complete)	70	2800	1	196000
Upgrade to Novell (3.12) 250 user licence	1	5500	1	5500
2 Gb hard drive	1	2200	1	2200
Second file server (AST 486DX-2, 32 Mb memory, SCASI-2 controller + EISA NIC)	1	8600	1	8600
Network points (cabling)	70	100	1	7000
UTP Cable 12-port hubs	6	1100	1	6600
Network cards (3-Com 3C509)	70	150	1	10500
Laser printers (postscript)	1	7000	2	7000
Laser printer (PCL)	2	3000	1	6000
E-mail licences (MS-Mail 3.2 - 100 user)	1	4800	1	4800
Application software licences	70	600	1	42000

6.2.4 Computer requirements for TERC test site

Estimates of computer requirements for the TERC test site (Table 13) are based on the establishment of one remote laboratory, employing 40 people, all of which will be required to use a PC. It is also assumed that a PC based network will be established and that most users will work in a Windows environment.

A qualified technician and one assistant will be required for hardware maintenance (both PC and LAN), the installation of a new operating system, application software and upgrades to the system. They will also be responsible for ensuring that external links (to IOT, DCI and MOTC) are maintained and operational on a 24 hour basis and should be managed centrally by the IOT Computer Centre Manager.

The recommendations given in Table 13 are based on an assumption that an internal E-mail system will be in place to allow for cost-effective internal communications and file transfer. External gateways are provided to allow for external communication links with other organisations.

PIP-MAIL could be used for external communication but would require the installation of a number of dial-up modems. If this system is also used for internal communication, it will require two outside telephone calls. This would be inconvenient, costly and could inhibit communications within the organisation.

TABLE 13: COMPUTER REQUIREMENTS FOR TERC TEST SITE				
ITEM	Amount	Unit Cost (US $)	Priority	Total Cost (US $)
486DX computer stations (complete)	40	2800	1	112000
Novell 50 user licence	1	4400	1	4400
Novell Management System	1	2700	2	2700
1 Gb hard drive and new file server (as above)	1	9900	1	9900
Tape streamer (2Mb), software and 20 tapes	1	3500	1	3500
Fax gateway: (Winfax Pro or similar to accommodated Chinese characters - 5 concurrent licences and 1 modem with dedicated line and "Network Connect" for management and auditing)	1	1500	2	1500
8 port ASYNC dial in gateway (including software and 3 modems)	2	5100	2	10200
Electronic mail gateway (Global MHS 50 user licence)	1	1400	1	1400
X25 gateway (Newport XCI hardware and software)	1	2700	2	2700
Laboratory management system	1	10000	1	10000
Laser printers (PCL)	2	3000	1	6000
Laser printer (postscript)	1	7000	1	7000
Network points	40	100	1	4000
Network cards (3-Com 3C509)	40	150	1	6000
UTP cable 12-port hubs	4	1100	1	4400
E-mail server software plus 2x20 user licences	1	2500	1	2500
Application software licences	40	600	1	24000

7 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations have been made from the investigation:

- All sectors of the transportation industry expressed a need for the development of the Transportation Engineering Research Centre (TERC) to provide hard engineering support and additional competence in transportation research. It was further acknowledged that TERC should become a centre within the structure of the current Institute of Transportation (IOT).

- TERC should focus on the road and rail sectors of the transportation industry. Discussions showed that the R&D needs of marine transport and aviation are currently catered for by other agencies such as the Institute of Harbour and Marine Technology, the initiatives of the Civil Aeronautics Administration and the current research capabilities of IOT in these areas. The following technology focus and competence areas were identified for TERC:

  Highway Engineering:
  Pavement design and materials
  Construction
  Pavement management and performance
  Structures and geotechnics

  Railway Engineering:
  Track performance and component analysis
  Rolling stock
  Systems management

  Safety Systems and Traffic Engineering:
  Human Factors
  Safety Engineering
  Legal Aspects and Emergency Services
  Traffic Management

- The initial establishment costs for TERC should be provided by central government and government should be largely responsible for the ongoing financial support of the centre. As the centre matures, consideration should be given to increased involvement and support from the private sector and other public sector transport authorities on a contractual basis. This is in line with current international trends, particularly those observed in the transportation research organisations highlighted in Section 2.

- Current transportation R&D in the ROC is highly fragmented and there is a lack of implementation of research findings and absence of mechanisms for effective technology transfer to the industry. IOT should take the initiative in coordinating R&D efforts in the transportation industry. A system of steering committees or research advisory panels is suggested to regulate the generation, prioritisation and communication of industry needs to the research sector and also to facilitate the transfer of technology.

- To ensure that R&D plans are aligned with a technology vision for ROC and to ensure effective technology transfer, IOT must coordinate transportation R&D in association with the MOTC Office of Science and Technology Advisors. This implies that IOT plays a central role in developing a transportation technology strategy for the country.

- A model for interface with industry is recommended (Figure 10) which implies that IOT becomes the custodian of a technology strategy for the ROC transportation industry and acts to direct, coordinate and guide the R&D effort. As such IOT then becomes the vehicle through which transfer of technology to industry is facilitated.

- Well-equipped testing facilities and laboratories exist at a number of universities, inter alia, for civil engineering structures at NTIT, NTU and NCKU. Testing laboratories for asphalt materials exist at NCU and NCKU. These facilities can handle routine testing work, but have been set up with the aim of executing very specialised testing. Research at the universities is well advanced and in line with international trends, but transfer and implementation of technological advances to industry does not appear to take place effectively.

- Some of the facilities required by TERC are large and costly to establish and may not be utilised on a full-time basis. It is recommended that consideration is given to the sharing of such facilities where available, especially in the initial phase of TERC's establishment and until the demand justifies investment in its own facilities. Therefore, it appears feasible for TERC to cooperate with institutions such as the ARTC, CSIST and universities with appropriate facilities, as some of the facilities offered by these organisations will be required in the TERC research projects.

- Strategic issues were defined for the transportation industry in ROC, from discussions with decision makers and from official documentation regarding the ROC Six-Year Plan. These must guide strategic planning for TERC's research and development actions and are identified as:

  - Accessibility and Mobility in the Transportation System;
  - Environmental Impact of Transportation projects;
  - Transportation Safety;
  - Modal Integration of Transportation Systems;
  - Transport Infrastructure Development and Preservation;
  - Technology Development and Integration.

- To gain maximum benefit, TERC must be fully integrated into the IOT structure and take part in R&D strategy planning and decision-making. The technology tree shown in Figure 3 was used as a basis for developing recommendations about the respective roles of TERC and IOT in a new integrated corporate IOT structure. These roles could be defined as follows:

- **Current IOT Divisions**: responsible for the research and development of transportation planning, policy and strategy;

- **TERC**: responsible for research and development in engineering and technology for standards, procedures and services in support of the current IOT divisions and industry at large.

It is further recommended, for the effective integration of TERC into IOT, that the existing IOT Divisions retain a separate identity and be renamed the Transportation Policy and Planning Research Group (TPPRG).

- Information technology is a key resource and effective management of information will enable TERC and IOT to make a significant impact on industry. This resource is currently not utilised in line with its strategic importance, though initiatives have been put in place to establish a larger data management capability in IOT. Recommendations for expanding this function are given in Section 6.2. While it was initially felt that this function should become part of the TERC structure, detailed investigation has shown that the establishment of a formal computer support function should be a corporate IOT responsibility, either as a new Division or under the control of the current Transportation Information Division.

- The recommended organisation structure for IOT is given in Figure 8, and shows that TPPRG and TERC are both headed by a Deputy Director General. The Director General of IOT, together with the two deputies, should take responsibility for the coordination for R&D activities between the two units.

- Detailed recommendations for technology strategies, proposed R&D project areas, facility and manpower requirements are given in Tables 5 to 9 for each of the TERC focus areas.

- From the options identified in Section 6.1.1 for establishing a test site for TERC, it is recommended that this facility be located in Tainan as part of the new campus of National Cheng Kung University. An agreement must be negotiated with NCKU for the use of a suitable area of land for this purpose, in terms of which IOT will be responsible for site development, maintenance and operation while being able to interface with the relevant expertise and facilities at this and other universities. Possible sensitivities regarding such an alliance with NCKU must be investigated and managed by IOT.

- Recommendations regarding the facilities required on this test site are given in Table 10, along with details of floor space and manpower requirements.

- One of the key success factors for the implementation of the action plans will be to appoint an appropriate chief executive for TERC. Ideally this appointment should have been part of the initial planning process outlined in this document. This implies that the appointment should be internal to IOT.

8 IMPLEMENTATION PLAN FOR TERC

Implementation of the recommendations and findings from this project depends on, firstly, the speed with which acceptance may be gained in industry of these recommendations and, secondly, the time required for official approval of establishment to be granted by the ROC legislature.

8.1 Prioritisation and phasing of implementation

Table 14 gives a breakdown of activities to be executed in terms of establishment. Priorities allocated agree with recommendations given earlier, eg that there is an urgent need in ROC for a focused R&D effort in pavement engineering and that a number of uncertainties must still be clarified in respect of railway engineering. Also indicated in Table 14 are the estimated durations (in months) for each of the activities, and the chronological order of activities. On the basis of this information, a Gantt chart has been compiled to show the expected scheduling of these activities. This is shown in Figure 10.

The following issues are apparent from this analysis:

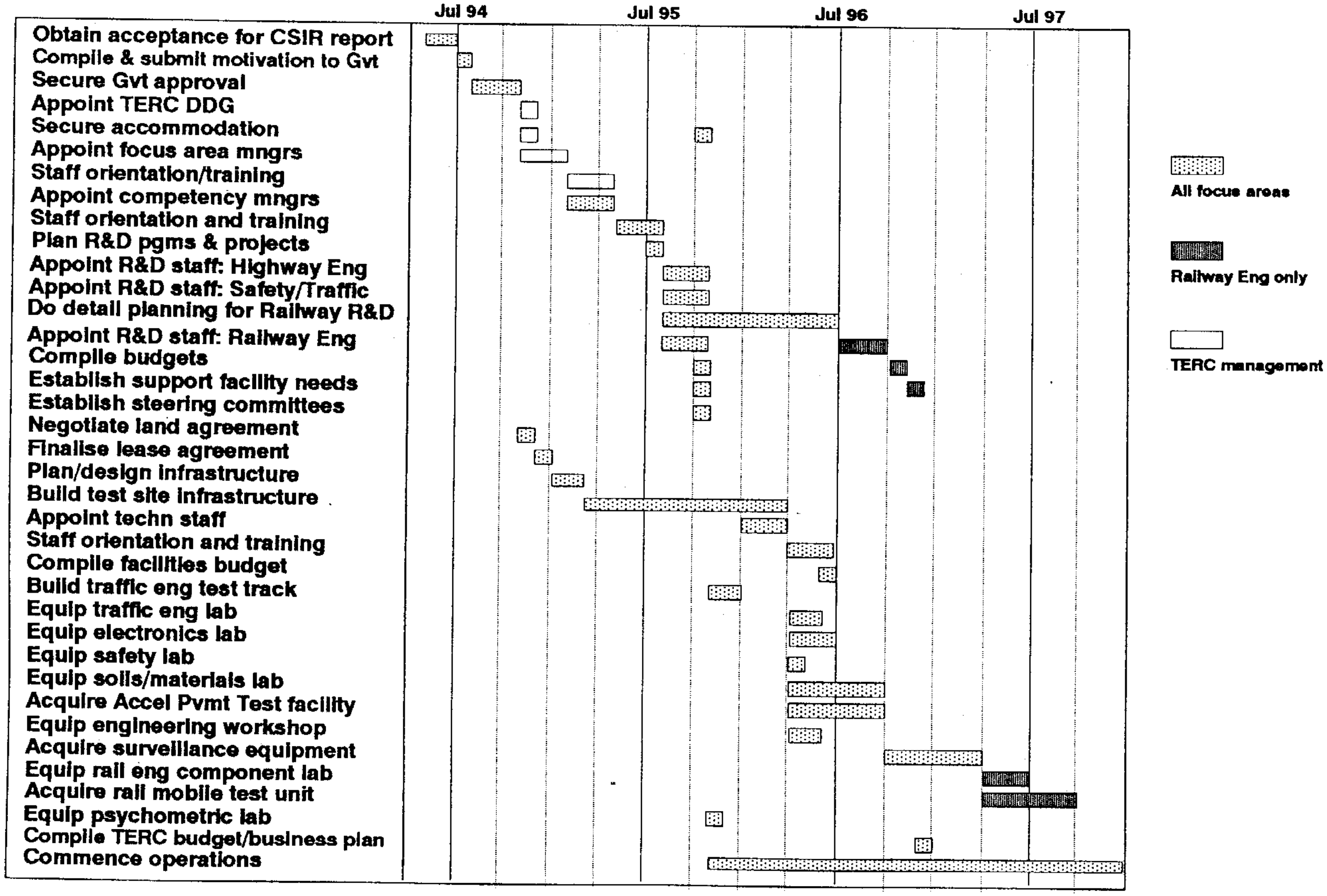
- It is unlikely that any R&D activities in the new centre will commence before the second quarter of the 1995/96 fiscal year, i.e. around November 1995;
- Construction of the infrastructure on a testing grounds for TERC could take until April 1996 to complete;
- Considering the additional investigations needed in the railway engineering focus area, R&D activities in this area could commence by the end of the 1996 calender year;
- It would be important to appoint the management structure of the new centre as soon as possible after approval for establishment has been confirmed, in order that organisational development be facilitated under this leadership;
- The bulk of capital costs for establishment of the various labs and facilities would be incurred between April and September 1996, and this needs to be accounted for in the financial plan for establishing TERC.

TABLE 14: WORK BREAKDOWN STRUCTURE FOR ESTABLISHMENT OF TERC						
	ACTIVITY	SUB-ACTIVITIES AND TASKS		PRIORITY	DURATION (MONTHS)	PRECEDED BY
1.	Obtain approval from MOTC/Legislature	1.1	Obtain acceptance for CSIR report	A	2	-
		1.2	Compile motivation		1	1.1
		1.3	Secure approval		3	1.2
2.	Establish TERC corporate structure	2.1	Appoint TERC Dep Dir-Genl and admin staff	A	1	1.3
		2.2	Secure accommodation in IOT building		0.5	1.3
		2.3	Appoint focus area managers and facility manager:		-	-
		2.3.1	Compile requirements and advertise		1.5	1.3
		2.3.2	Compile select list and interview		1.5	2.3.1
		2.3.3	Negotiate and appoint		0.5	2.3.2
		2.4	Compile consolidated TERC budget and business plan		0.5	2 1,2.3,3.6,4.6,5.6,6 7
		2.5	Do staff orientation and training		3	2.3.3
3.	Establish Highway Engineering focus area	3.1	Appoint competency managers	A	3	2.3.3
		3.2	Do staff orientation and training		3	3.1
		3.3	Plan research programmes and projects		1	3.2
		3.4	Appoint research staff		3	3.3
		3.5	Secure accommodation in IOT building		1	3.3
		3.6	Compile focus area consolidated budget		0.5	3.3
		3.7	Establish support facility needs		0.5	3.3
		3.8	Establish focus area steering committee		1	3.3
4.	Establish Railway Engineering focus area	4.1	Appoint competency managers	B	3	2.3.3
		4.2	Do staff orientation and training		3	4.1
		4.3	Plan research programmes and projects		1	4.2
		4.4	Appoint research staff		3	4.3
		4.5	Secure accommodation in IOT building		1	4.3
		4.6	Compile focus area consolidated budget		0.5	4.3
		4.7	Establish support facility needs		0.5	4.3
		4.8	Establish focus area steering committee		1	4.3
5.	Establish Safety/ Traffic focus area	5.1	Appoint competency managers	A	3	2.3.3
		5.2	Do staff orientation and training		3	5.1
		5.3	Plan research programmes and projects		1	5.2
		5.4	Appoint research staff		3	5.3
		5.5	Secure accommodation in IOT building		1	5.3
		5.6	Compile focus area consolidated budget		0.5	5.3
		5.7	Establish support facility needs		0.5	5.3
		5.8	Establish focus area steering committee		1	5.3
6.	Establish Support Facilities	6.1	Acquire land for testing grounds:	A	-	-
		6.1.1	Negotiate with National Cheng Kung University	-	1	1.3
		6.1.2	Finalise agreement	-	1	6.1.1
		6.2	Do detailed planning and designs for infrastructure	A	2	6.1.2
		6.3	Purchase equipment and facilities:	-	-	-
		6.3.1	Build traffic engineering test track	A	2	6.2,5.7
		6.3.2	Equip traffic engineering laboratory	A	2	6.4,5.7
		6.3.3	Equip electronics laboratory	B	3	6.4
		6.3.4	Equip safety laboratory	A	1	6.4,5.7
		6.3.5	Equip soils/materials laboratory	A	6	6.4,3.7
		6.3.6	Acquire Accelerated Pavement Testing Facility	A	6	6.4,3.7
		6.3.7	Equip engineering workshop	B	2	6.4
		6.3.8	Acquire surveillance equipment	C	6	6.4,3.7
		6.3.9	Equip rail engineering component laboratory	C	3	6.4,4.7
		6.3.10	Acquire rail mobile test unit	C	6	6.4,4.7
		6.3.11	Equip psychometric laboratory	A	1	5.7
		6.4	Build infrastructure	A	12	6.2
		6.5	Appoint technical staff	B	3	6.4
		6.6	Do staff orientation and training	B	3	6.5
		6.7	Compile facilities budget	A	0.5	6.2

Note: A = short-term (3 to 6 months)
B = medium-term (6 to 18 months)
C = long-term (18 months +)

93

FIGURE 10: WORK SCHEDULE FOR ESTABLISHMENT OF TERC



8.2 Manpower plan

8.2.1 Recruitment

The eventual manpower requirements for TERC, based on the needs analyses reported in this document, are summarised in Table 15.

TABLE 15: STAFFING REQUIREMENTS FOR TERC

STAFF CATEGORY	RAILWAY ENGINEERING	HIGHWAY ENGINEERING	SAFETY/ TRAFFIC	FACILITIES
Top Management	Deputy Dir-Genl + Pers Asst + Tech Asst (3 in total)			
Focus Area Manager	M+15 (Rail)	M+15 (Civil)	M+15 (Tpt)	M+15 (Civil or Mech)
Competence Area Manager	B+10 (Mech) B+10 (Mech) B+10 (Elect)	B+10 (Geot) B+10 (Tpt) B+10 (Struc) B+15 (Civil)	B+10 (Legal) B+10 (Social) B+10 (Tpt/Mech) B+10 (Traff Eng)	B+10 (Mech) B+10 (Civil)
Researcher/ engineer	4	13	9	10
Technician	4	9	8	25
Administrative	2	2	2	2
Total	14	29	24	38
Grand Total	108			

Note:
1. See Section 6.2 for recommendations regarding manpower requirements in information technology. These requirements are not included here as it is recommended that this area remains as part of the current IOT divisions.
2. B+10 refers to a bachelors degree with at least 10 years relevant experience.
3. M+15 refers to a Masters degree with at least 15 years relevant experience.

Recruitment should commence with the appointment of the chief executive of the centre, on an expected level of Deputy Director General, hopefully as early as November 1994. Starting February 1995, this must be followed by the appointment of the various focus area managers. This team's first task will be to compile a detailed R&D plan and project portfolios for TERC. This plan will serve as the basis for recruitment of R&D staff, compilation of operation budgets and for determining the detailed requirements for support services.

The bulk of TERC staff will be appointed initially in the two focus areas of Highway Engineering and Safety Systems and Traffic Engineering. This is planned for the period October to November 1995.

For Railway Engineering, numbers and type of staff given in Table 15 can only be provisional, given the fact that the needs analysis for this study area must be expanded. Appointment of staff for this area has been planned for around September 1996, although this could conceivably be earlier.

Technical staff for the support facilities can only be appointed once the infrastructure of the testing grounds has been completed, and therefore this has been planned for between December 1995 and March 1996.

The preparatory work that has to be done for these recruitment activities include the following:

- compilation of job descriptions and personal skills/competence requirements for the various positions;
- placing of advertisements where applicable, and/or deciding on other recruitment strategies, for example to contact overseas Chinese professionals or personal acquaintances;
- establishing the remuneration and reward structures for TERC; and
- putting in place the appropriate policies for human resource management and career path development.

All of the above are required in order to be able to negotiate salary packages and employment conditions with the incumbents in the various positions.

8.2.2 Manpower development

Experience in the CSIR has shown that manpower development actions form a strategic and important part of human resource management. Apart from the need to maintain the technical proficiency of R&D staff through further study or training interventions, it is also necessary to develop a wider range of skills. Furthermore, the CSIR has determined that as a minimum, each employee should aim to attend at least three days of training and development per year. However, it should be noted that significantly more time for training (at least 2 man months/year) will be needed in the first two years of establishment, especially for the senior management of TERC.

Aspects that could be covered in a manpower development plan, include:

- **Technical skills development:**
    - incentives for further study in the same or related fields;
    - financial assistance for overseas tours of study and the attendance of and lecturing at conferences, specifically on international level;
    - recognition for publishing in prestigious international journals; and
    - policy toward maintaining a relationship with the practicalities of the profession.

- **Managerial skills:**

    - motivation for attendance of ad hoc and university courses in leadership and business administration (even on post-graduate level);
    - mandatory attendance of courses in project management, leadership, time management, interpersonal skills;

- **Other:**

    - technical report writing;
    - communication skills: language courses to improve proficiency in other languages;
    - computer hardware and software skills.

It may also be necessary for TERC to concentrate on specific aspects of manpower development which must be determined in a training needs analysis.

8.2.3 Career path planning

There is a worldwide trend in organisations to flatten their hierarchical structures (and hence to remove layers of management), in an attempt to improve organisational responsiveness and internal communications. Also, there is a move toward a work ethic that involves workgroups or project teams rather than individuals. These concepts have proved especially worthwhile for technology-based organisations (such as the CSIR) and in dynamic environments where tasks are complex.

At the same time, human resource management is increasingly being based on models of human competence, ie on an understanding of the individual characteristics and traits that are required for effective job performance. Recruitment and placement, performance management, training and development and remuneration and reward structures could also be based on human competence.

These developments hold important implications for career path planning in an organisation and should be taken account of in designing the administrative systems for TERC.

9 ACKNOWLEDGEMENT

The help and assistance provided by the many staff members of IOT is greatfully acknowledged. Their inputs and insights have contributed greatly to the CSIR project team gaining an understanding of the R&D needs of the transportation industry in ROC. The time given for discussions by the various individuals throughout the industry, is also greatly appreciated.

This report is submitted with the approval of the Director of the Division of Roads and Transport Technology, CSIR.

APPENDIX A

BACKGROUND REPORT IOT/93/1
PROFILES OF SOME INTERNATIONAL RESEARCH ORGANISATIONS AND THOUGHTS ON THE MANAGEMENT OF TECHNOLOGY

BACKGROUND REPORT FOR THE ESTABLISHMENT OF A TRANSPORTATION ENGINEERING RESEARCH CENTRE (TERC) FOR THE INSTITUTE OF TRANSPORTATION, MINISTRY OF TRANSPORTATION AND COMMUNICATIONS REPUBLIC OF CHINA

Profiles of some international research organisations and thoughts on the management of technology

Prepared by: **HW du Plessis**
V Skutil
LR Sampson

August 1993

Confidential Contract Report IOT/93/1

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CONTENTS

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1. INTRODUCTION

The Institute of Transportation (IOT) of the Ministry of Transportation and Communications (MOTC), the Republic of China (ROC), has been assigned the responsibility of establishing a research centre for transportation engineering in Taiwan. While some preliminary planning has been carried out, the mission, role, function and organisational structure of this institution have not yet been determined.

The IOT has contracted the Division of Roads and Transport Technology (TRANSPORTEK) of the CSIR in South Africa to determine strategy and structure and to compile implementation plans for the proposed Transportation Engineering Research Centre (TERC). The process to be followed will take place over some 8 months in a collaborative effort between TRANSPORTEK and IOT, in the following stages:

- Stage 1: Strategic review and planning
- Stage 2: Technical liaison between TRANSPORTEK and the IOT to establish TERC's R&D portfolio
- Stage 3: Finalisation of preparatory work and compilation of implementation plans and budgets

In preparation for Stage 1, a detailed survey is herewith presented of four prominent transportation research organisations, viz the Transportation Research Board (TRB) in the USA, the Transport and Road Research Laboratory (TRRL) in Britain, the Australian Road Research Board (ARRB) and TRANSPORTEK. It is hoped that the perspectives gained from this survey will create the understanding required to efficiently deal with the tasks described above.

In addition, an investigation was done of the latest thinking on the subject of technology management, since this impacts on the business of TERC. Some thoughts in this area have also been recorded in this report.

Finally, this document presents some conclusions on the above and makes recommendations for a framework within which the work of Stages 1 and 2 may be approached.

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PROFILE :
THE TRANSPORTATION RESEARCH BOARD (TRB)

1. BACKGROUND AND HISTORY

The Transportation Research Board (TRB) forms part of the USA's National Research Council, the operating arm of the National Academy of Sciences, and has been fostering research in transportation for over 73 years.

At the end of World War I, many individuals and organisations recognised the need for improvement of the nation's highway system. This need led to the passage of the Federal-Aid Road Act of 1916, which provided for federal funding ($75 million) for highway construction and established a precedent-setting federal-state partnership whereby federal aid would be matched by the states and the program administered by state highway departments. Thus begun what was to become a massive national program of highway planning, design, construction, and research.

The swift transition from horse to motor after World War I prepared the scene for huge transportation expenditure and at the beginning of the 1920s the United States' GDP was growing faster than the population. The climate was favourable for investment in research and development. Research programs were established by many states to address the challenge of adapting roads, bridges and highways to accommodate motor vehicles.

<u>The establishment of the Highway Research Board in the 1920s</u>

By 1920 public officials had recognised that a decentralised highway research program required an **organisation to serve as a national clearinghouse - a centre of communications for the growing number of autonomous, isolated research units.** Thus, in November 1920, the National Research Council created the Advisory Board on Highway Research at the request of the U.S Bureau of Public Roads (now the Federal Highway Administration), the state highway departments acting through the American Association of State Highway Officials (now the American Association of State Highway and Transportation Officials), and a number of highway-oriented organisations and educated institutions.

In 1924 the name of the Board was changed to the Highway Research Board (HRB). The purpose of the new Board was to stimulate, correlate, and disseminate the findings of highway research and to undertake special highway research projects as appropriate. Over the years HRB expanded its activities. In 1962 the National Cooperative Highway Research Program was established to enable state highway departments to pool their resources for systematic, well-designed research on common problems; at the same time, the Highway Research Information Service was created to provide state highway departments with a source of published findings and ongoing research projects.

Attendance at the annual meeting of HRB continued to grow in the 1960s, drawing more than 3 000 highway transportation professionals to Washington D.C. each year.

Development of the Transportation Research Board (TRB)

During the late 1960s the HRB expanded its scope to encompass all modes of transportation and the interactions of transportation with other aspects of society. In March 1974 the Board's name was changed to the Transportation Research Board (TRB), in recognition of its increased emphasis on this broader approach to all transportation problems and needs.

With the success of its highway research programme well established, the Board began to initiate other modal activities : first public transit and railroads, then trucking and aviation and later marine transportation. Attendance at the annual meetings soared and the number of committees within the organisation expanded.

1981 was a milestone year in the history of TRB. With the restructuring of the National Research Council, TRB became a major unit reporting directly to the Governing Board of the Research Council. In the same year, the Executive Committee decided to involve the Board in transportation policy analysis and recommendations.

2. MISSION, GOALS AND OBJECTIVES OF TRB

The mission of TRB

The mission of TRB is to:

- advance knowledge concerning the characteristics and performance of transportation systems through the stimulation of research and dissemination of information derived therefrom;

- assist governmental or other agencies in the resolution of specific problems related to transportation policy, existing or new transportation systems, or the components of such systems; and to

- increase the productivity and competence of the practising transportation professional by providing access to the latest and best results of transportation research.

During 1990 and 1991, the Transportation Research Board Executive Committee was engaged in a process of strategic planning. It referred to the process as one that "*identifies five-year goals and special initiatives, proposes projects and studies, and sets forth a plan for implementation*".

TRB's five-year goals

After having reviewed TRB's mission, assessing the state of transportation, assessing opportunities, identifying critical issues, evaluating the Board's position within the industry and looking at TRB's strengths and weaknesses, the Executive Committee developed the following short-term goals to guide TRB's efforts during the period 1992-1996. It aims:

- to strengthen TRB's activities in the non-highway modes, while maintaining its role in contributing to improved highway transportation;

- to increase TRB's contribution to decision making on transportation policy issues, with special emphasis on cross-cutting issues and modal and multi-modal areas beyond its more traditional scope;

- to examine how transportation influences and is influenced by other issues of national and international significance, with emphasis on determining how its leverage can be used effectively to help remedy or resolve these issues;

- to contribute to the research and development of new transportation technologies and innovative practices in the United States; and it aims to

- target activities to accelerate the application of new technology and innovative practice by transportation practitioners.

Five-year special initiatives

The Board's five-year special initiatives are strongly related to its five-year goals. The eleven initiatives are grouped into three broad categories: **First**, activities aimed at expanding TRB's outreach into modes or subjects in which the Board's current visibility and influence are limited. **Second**, activities aimed at expanding its outreach into economic or geographic sectors in which current TRB activity is limited. **Third**, a category of new, updated or expanded activities that require internal organisational or other change within TRB. These initiatives are significant in providing insight into emerging trends within TRB's profile of activities and areas of market penetration. The initiatives may be summarised as follows:

- **The "Expand Modal and Subject Area" outreach:**
  - Expand activity in areas of environment and energy
  - Expand activity in aviation
  - Increase activity in transportation and national/security emergencies
  - Establish TRB capability in commercial space transportation and
  - Expand TRB activity in water transportation

- **The "Expand Sector" outreach:**
  - Increase international outreach and
  - Expand links to the private sector

- **The "New or Updated Activities Requiring Internal Change" initiative:**
    - Extend Cooperative Research Programs to other modes
    - Establish Institute for Strategic Transportation Studies
    - Create advisory mechanisms for federal research transportation and
    - Modernize Transportation Research Information Services

3. INTERNAL ORGANISATION

3.1 Overview

The policies and activities of TRB are determined and directed by its Executive Committee. The committee is composed of prominent transportation leaders and acts within the constraints of the overall policies of the National Research Council.

TRB is organised into five operating divisions:
- Technical Activities Division;
- Studies and Information Services Division;
- Administration and Finance Division;
- Cooperative Research Programs Division; and the
- Special Programs Division.

The Special Programs Division was only established in July 1992 and each of the Divisions is broken down into smaller operational cells, referred to as either projects or groups, and run by committees.

3.2 TRB's activity profile and responsibilities of structural units

3.2.1 Technical Activities Division

This division has 178 standing committees and task forces, involving the services of more than 2 900 volunteers.

The standing committees are organised into five groups:
- Transportation Systems Planning and Administration;
- Design and Construction of Transportation Facilities;
- Operation, Safety and Maintenance of Transportation Facilities;
- Legal Resources; and
- Intergroup Resources and Issues.

The Technical Activities Division is responsible for committee and task force activities, field visit programmes, the Annual Meeting, conferences and workshops, responses to inquiries in cooperation with Library and Information Services and for TRB's publications.

The Division has a council which provides a forum for interchange and interaction among the five groups, between the groups and the TRB Executive Committee, and between the groups and the TRB senior staff. The Division A Council meets regularly with the TRB Executive Committee.

3.2.2 Studies and Information Services Division

This division falls under the direction of the Executive Sub-committee on Planning and Policy Review and until its name change in 1992, was called the Special Projects Division. It is responsible for conducting policy studies under contract, maintaining and operating computer-based research information services, producing synthesis of current practice in highway and transit operations and maintaining the Research Board's library.

The Division is organised into four operational units:
- A committee responsible for planning and policy review;
- A group which conducts the research projects;
- A computer-based information services unit; and
- A group responsible for the syntheses of current practice

3.2.3 Administration and Finance Division

Division C is comprised of the approximately 100 support staff of TRB. It provides personnel and other administrative support, financial management of contracts and grants that support the work of TRB, administration of the publications program and maintenance of affiliate and sponsor services. The division's staff also serve as liaison to the National Research Council/National Academy of Sciences administrative and financial offices and the National Academy Press, which serves as publisher of TRB books and all other NRC reports.

The Division is comprised of:
- A group responsible for financial management of TRB;
- A group responsible for publications; and
- A group responsible for TRB's affiliate and sponsor services

3.2.4 Cooperative Research Programs Division

This Division administers TRB's two cooperative research programs.

3.2.5 Special Programmes Division

Because this division was only established in 1992, no information regarding its responsibilities and activities has been published yet.

4. ACTIVITIES

In order to provide a more detailed analysis of TRB's spectrum of activities, the primary activities of each of the Divisions during the course of 1992 are discussed below while general activities and responsibilities are also referred to.

4.1 Technical Activities Division

Group One: Transportation Systems Planning Administration

Transportation Systems Planning
TRB's activity in this area increased in the 1990s. During the fiscal year 1992 conferences were convened by the organisation on: Moving Urban America; Changing Transportation Data Needs - New Data for a New Era; and on Transportation Planning, Programming and Finance.

Administration, Finance and Economics
The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) legislation stimulated this group (more specifically its finance, administration and economics committees) into reexamining economic measures, such as congestion pricing techniques, as means of reducing urban traffic congestion. The finance and economics committees were also involved in addressing the pricing of transportation services and economic development.

Environmental Activities
The Division also held a national Conference on Transportation Environmental Research Needs in November 1991. At the event, a national environmental research agenda, using some 400 proposed research projects from the states and committees, was developed. Ten of these projects have since been recommended for the National Cooperative Highway Research Program (NCHRP). An ad hoc Committee on TRB Environmental Activities was also created. It is responsible for recommending areas in which current TRB activities might be expanded or modified in the environmental arena.

Multimodal Freight Transportation
During the course of the year, committees from TRB's Group One and Two, participated in the 16th Annual Ports and Waterways Conference. The scope of the discussions incorporated issues of international trade and logistics, in addition to the traditional issues of ports, inland waterways, and intermodal freight flows.

Marine Transportation
A special workshop on Strategic Planning in Marine Transportation was held and its findings published. The study identified intermodal focus areas and the need for and office of intermodalism within the U.S Department of Transportation (subsequently created). Two new committees were also created to concentrate on marine environmental issues and ferry transportation. The Inland Waterways Committee developed two subcommittees to examine inland waterways engineering issues and logistics. The committee has also been engaged in research related to technologies, funding, and planning to maintain the nation's waterway infrastructure.

Rail and Truck
As regards rail, a research needs statement that had been developed by the Committee was accepted by the American Association of State Highway and Transportation's (AASHTO) Standing Committee on Railways and subsequently approved for funding as an NCHRP project. As regards the Board's activities in the field of truck research, the Committee on Motor Vehicle Size and Weight published Transportation Research Circular 399 - Truck Research Profiles: 1991 Update.

Public Transportation
In light of the increased funding for transit research, the committees stepped up their activities in identifying and ranking research needs during the fiscal year 1991/92. 250 research problem statements were compiled for possible use in the Transit Cooperative Research Programme (TCRP). About 50 of these were then accepted by the TCRP for the first year of the TCRP programme. The 10th annual conference of National Public Transportation, which attracted the largest audience ever, 625 participants, was also held during the course of the year.

Aviation Activities
The committees on Aviation held three conferences during 1991/92 - A conference on Aviation Systems Planning, one on Future Aviation Activities and a workshop on Helicopter Operating Economics.

Group Two: Design and Construction of Transportation Facilities

Design, Pavements and Structures
During the course of 1991/92 this committee published two papers dealing with the evaluation criteria for roadside safety features. The Committee also sponsored a symposium on highway/roadside safety management systems that generated a set of problem statements associated with these new systems.

Soils, Geology and Foundations
Among other things, the Committee on Geosynthetics cosponsored a speciality conference in August 1991 on Geosynthetic-Reinforced Soil Retaining Walls.

Railway Systems
In October 1991 the Committee on Railway Maintenance conducted a one-day workshop on Systems To Detect Defective Wood Crossties and Methods to Prolong Their Useful Life. In January 1992 it published Transportation Research Circular 387 - Research Problem Statements: Safety Factors Related to High-Speed Rail and Maglev Passenger Systems. These research problem statements had been generated from a 1991 workshop cosponsored by the Federal Railroad Administration.

Group Three: Operation, Safety and Maintenance

Facilities and Operations
Several traffic operations and management areas were focused on as particular research, development and implementation issues for TRB committees in this field of interest. These included: Congestion: measurement, management and relief; Older driver needs; minimum levels of maintained retroreflectivity; highway capacity analysis; and intelligent vehicle-highway systems (which is an expanding area of interest with numerous TRB committees examining the topic).

Safety
The subject of older drivers remained one of concern for TRB staff. Yet, renewed attention was given to high-risk drivers. Continued emphasis on alcohol, other drugs, and occupant restraints were among topics of research examined during the year.

Maintenance
TRB's maintenance committees conducted workshops on bridge management systems and equipment management. New concerns and research interests included: integration of maintenance management systems with other transportation management systems; evaluation of new technologies to improve the efficiency and effectiveness of maintenance management systems; development and use of bridge management systems; and the impact of environmental regulations on maintenance activities programs.

Group Four: Legal Resources

TRB held the 30th Annual Workshop on Transportation Law in July 1991. Several committees addressed (and are still addressing) issues that cross conventional fields of technical research. Chief among these are the growing concern about environmental pollution because of the presence of hazardous waste material in transportation facilities and the increasing interest of state and local transportation agencies in establishing risk management programs to reduce their exposure to tort liability. An ad hoc planning group was also established to explore efficient ways to consider hazardous waste pollution issues.

Group Five: Intergroup Resources

Some of the major highlights of this group during 1991/92 included the following: a new task force on Global Non-Motorized Transportation was created; and the Committee on International Activities held its first overseas committee meeting in Paris, France (At the Permanent International Association of Road Congress). The committee also met with the Institute National de Recherche sur les Transport et leur Securite and others to discuss mutual interests. There was also planning towards a 1993 meeting with a focus on the impact of European integration on transportation policies - an issue that has broad implications for increased globalization and transportation competition.

4.2 Studies and Information Services Division

Subcommittee on Planning and Policy Review

This committee's tasks include the following: identifying major transportation problems; advising the Executive Committee and staff on the selection, scope and execution of policy-oriented studies within TRB; preparing lists of critical transportation issues for consideration by the Executive Committee; advising the Director of Studies and Information Services on goals and direction for activities of the division; and acting for the Executive Committee on matters that require action by TRB between regular Executive Committee meetings.

Projects

During the fiscal year 1991/92 TRB completed six policy studies and continued work on four other projects. These research activities are listed below.

Completed Projects (Titles)
- Air Passenger Service and Safety Since Deregulation;
- High-Speed Ground Transportation in the United States;
- Intelligent Vehicle-Highway Systems
- Highway Deicing
- Data for National Transportation Policy Making; and
- Marine Container Transportation

Ongoing Projects (Titles)
- Research and Technology Coordinating Committee;
- Critique of Federal Research Program on Magnetic Levitation Systems;
- Assessment of a National Hazardous Materials Shipment Tracking System; and
- Landside Access to U.S. ports

New Projects (Titles)
- Study of the Federal Employers' Liability Act;
- Feasibility Study of a Transit Research Coordinating Council; and
- Study of Urban Transportation Pricing

Computer-Based Information Services

TRB's computer services include the following: A computer-based information storage and retrieval system; A series of abstract bulletins on transportation topics; A technical inquiry response services; and A `hot topics' service for monthly dissemination of bibliographies on highway and urban transportation issues.

Library

TRB offers its clients an excellent library service. Its library housed over 20 000 books, reports and microfiche in 1991/92. It also receives approximately 370 journals, many of which are routed to staff. For a small annual fee, TRB Library Affiliates receive the full array of TRB library reference services and are offered a 25% discount on TRIS inquiry services, orders for single copies of publications and photocopies.

Synthesis of Current Practice
As part of the NCHRP, the Division published the following synthesis of current highway practice during fiscal year 1991/92: Fabrics in Asphalt Overlays and Pavement Maintenance; Signal Timing Improvement Practices; Short-Term Responsive Maintenance Practices; Moisture Damage in Asphalt Concrete; Bridge Paint: Removal, Containment and Disposal; Freeway Corridor Management; and Truck Escape Ramps.

4.3 Administration and Finance Division

Financial Management
The Administration and Financial Division is responsible for the preparation of the TRB's operating budgets, expenditure controls, verification of accounts and administration of contracts and grants.

Affiliate and Sponsor Services
The affiliates program, which includes individual affiliates and three categories of organisational affiliates is, in effect, a worldwide network that contributes to the support of the Board's work and serves to disseminate the flow of information on transportation research, technology, and practice worldwide.

Individual and student affiliate benefits include use of the Library, special registration fees for the Annual Meeting, reduced fees for the use of TRB computer-based information services, free subscription to TR News, and discounts on most books and reports. Sponsor and contributing affiliates receive all publications at no additional cost.

The affiliates program is very much tied to the publications program. The purpose of the publications program is to disseminate current information and research on transportation policy and practice as broadly as possible. It is to realise this goal that TRB has maintained a selective distribution program to TRB sponsors and affiliates that allows them to receive automatically those publications that are of specific interest to them.

4.4 Cooperative Research Programs Division

The National Cooperative Highway Research Program (NCHRP)
This is a unique applied research program designed to respond to the needs of state highway and transportation departments by solving pressing operational problems in highway transportation. It has been sponsored by AASHTO since 1962 in cooperation with the Federal Highway Administration (FHWA) and has over the years administered 570 research projects and related and additional publications.

Each NCHRP study is conducted according to an approved research plan under the guidance of an advisory panel composed of technical specialists and experienced practitioners. To be successful in its role, NCHRP places an emphasis on working with its customers - practitioners who are expected to use the research results. NCHRP's most important asset in carrying out its mission is its close relationship with

AASHTO committees. Experience has shown that AASHTO committees are more likely to use results when: the committee itself identifies and requests needed research; the members of the committee serve on the advisory panel that guides the study; and when the findings and recommendations are presented to the committee at the conclusion of the study. NCHRP projects thus frequently include these steps.

NCHRP studies particularly important to AASHTO and which were completed during 1991/92 included: A study of Domestic Freight Research and Policy; Research (a study) into certain aspects of the relationship between transportation investment and economic development; research into alternative revenue sources of highway funding; and the development of a comprehensive document on metric conversion. (This is now being considered for adoption by AASHTO).

Transit Cooperative Research Program (TCRP)
In September 1991 the Urban Mass Transit Administration sponsored National Cooperative Transit Research and Development Program was completed after eleven years of operation. NCTRP was replaced by TCRP which is a greatly expanded transit program, sponsored by FTA and modeled after NCHRP. (In May 1992 U.S. Secretary of Transportation announced an FTA grant of $8.9 million to TRB and, along with National Academy of Sciences (NAS) and the Transit Development Corporation (TDC) executed a Memoranda Agreement linking the three organisations cooperating in TCRP. This grant, represented the first award of up to $88 million authorised for TCRP by ISTEA during the next six years). The new program, it was decided, will focus on research projects and other technical activities and respond to the transit industry's operating needs. Its approach is designed to deal with practical solutions to everyday problems encountered in the operating environment. Research topics for TCRP are selected by the Board of Directors of TDC.

Future Programs
In addition to NCHRP and TCRP activities, two additional cooperative research programmes were being explored by this Division during the course of 1991/92. The first is an aviation research program modeled after NCHRP. The second, proposed by the U.S Department of Transportation's Maritime Administration, proposes establishing a cooperative water way research program, also modeled after NCHRP. This program would concentrate on issues such as resource productivity, transportation efficiency, operational safety, and environmental quality of the nation's waterways.

5. TRB STAFF

Numbers and office bearers

The research organisation, excluding the Executive Committee and working committees, has a staff complement of approximately 100. The chairman of TRB's Executive Committee is currently Mr William Millar, Executive Director of the Port Authority of Allegheny County, Pittsburgh, Pennsylvania. TRB's Executive Director is Thomas Deen. The Directors of the various divisions are:

Technical activities division:	Robert Spicher
Studies and information services division:	Robert Skinner Jr
Administration and finance division:	Marcia Appel
Cooperative research programmes division:	Robert Reilly
Special programmes division:	Neil Hawks

6. PUBLICATIONS

Through its distribution of books, reports, working papers and periodicals TRB disseminates transportation research results and technological developments worldwide. The Board is valued for its role as a generator of information on: the state of the art in specific areas of transportation; results of transportation research; major national transportation policy issues; and reports analyzing research needs.

The organisation's series of publication is as follows:

TR News
This is a bimonthly magazine that contains discussions of the activities and programs of the Board and transportation activities of government and industry in the United States and other countries. It also features topical articles and announces upcoming TRB publications and meetings.

Special Reports
These present the results of the congressionally mandated policy studies and proceedings of conferences and workshops held by TRB.

State of the Art Reports
These reports, prepared solely by TRB staff and committees, summarize and evaluate the current status of research in a particular area.

Transportation Research Circulars
These documents contain TRB committee reports that are perceived to be of immediate, rather than of long-term interest.

National Cooperative Highway and Transit Research and Development Program Reports
These documents are comprised of the final reports (results) of research conducted under either the NCHRP or the NCTRP.

The NCHRP and NCTRP Synthesis
These reports present existing information on selected topics and points the way towards recommended practices.

The NCHRP and NCTRP Research Results Digests
These are published to provide early awareness of research results emanating from projects before the publication of the final report presents all the results.

The Legal Research Digests
These provide early awareness and encourage application of research results emanating from the continuing NCHRP Project and suggest legal problems seen to be arising from Highway Programs.

TRIS Abstracts

Various miscellaneous publications

Transportation Research Records
Each Transportation Research Record contains technical papers on a given subject. The papers are usually prepare for TRB Annual Meetings and accepted for publication through TRB's peer review process. The Research Records are presented in approximately 50 issues a year and represent more than half of the total material prepared and disseminated by TRB.

Exceptional Volumes
Occasionally, TRB has the opportunity to present exceptional volumes outside the regular publications series listed above. Bridge Aesthetics Around the World, printed in late 1991, is an example of this form of publication.

7. FINANCES

7.1 TRB's clients and organisational affiliates

In its endeavour to conduct research into transport issues and disseminate information, TRB receives support (pecuniary, political and in a human capital input sense) from three groups or organisational associates. These three groups of **collaborators** are identified below and their support functions summarised.

The Sponsors

The Sponsors are the principal supporters of TRB and may be government or private sector institutions. The fees for sponsors and the allocation of TRB activities on their behalf are negotiated with each sponsor to best serve its particular needs. A holistic perspective is however also at play in the identification of the most efficient application of research funds. The aim is to provide fundamental support for TRB programs and activities of interest to the entire community. The number of financial sponsors, in addition to the 50 states and the District of Columbia, has recently increased to 11.

Current sponsors of TRB include: The highway and transportation departments of the 50 states; the District of Columbia and Puerto Rico; modal administrations of the U.S Department of Transportation including the Federal Highway Administration, the Federal Mass Transit Administration, the Federal Railroad Administration, the National Highway Traffic Safety Administration, the Research and Special Programs Administration and the Maritime Administration; the U.S. Army Corps of Engineers;

the Association of American Railroads; the National Asphalt Pavement Association; the Motor Vehicle Manufacturers Association of the U.S; and the American Public Transit Association (which only joined in the 1993 fiscal year).

Sustaining Affiliates

These are affiliates which support TRB at a level considerably higher than the direct cost to TRB of the publications and other services they receive. In fiscal year 1992 there were five of these organisations: the Asphalt Institute; the Ministry of Transportation and Communications, Province of Ontario, Canada; the Minnesota Mining and Manufacturing Company; the Port Authority of New York and New Jersey; and the Portland Cement Association.

Contributing Affiliates

Contributing affiliates are comprised of government agencies, academic organisations, private organisations and consultants. Their fees (funding of TRB's activities) are determined on a more commercial basis than the above two groups of TRB affiliates. The fees of the contributing affiliates are determined by the level of benefits the contributing affiliates elect to receive. The annual fees during 1991/92 ranged between $1 260, $2 500 and $3 250.

A sample of TRB's contributing affiliates is provided below. This is by no means a complete list, and it comprises clients from the public sector, the academic arena and private sector. Many affiliates are from international organisations.

Government Agencies or Academic Organisations:
United States
Broward County, Fort Lauderdale, Florida
Chicago Area Transportation Study, Chicago, Illinois
King County Department of Public Works, Seattle, Washington
City of Omaho, Nebraska
National Transportation Safety Board, Washington
Eno Foundation for Transportation, Inc, Vienna, Virginia
University of Central Florida, Orlando, Florida
Orange County Environmental Management Agency
Purdue University, West Lafayette, Indiana
California Energy Commission, Sacremento
University of New Mexico, Albuquerque
Washington Metro Area Transit Authority, Washington, District of Columbia
Australia
Australian Road Research Board
Queensland Department of Transport, Brisbane
Tasmania State Office Library
Canada
Alberta Research Council
Transport Canada, Ottawa, Ontario

Republic of China
Taipei Rapid Transit Company Ltd, Taipei, Taiwan
Egypt
Cairo University (The Genera Authority of Roads and Bridges, Ministry of Transport)
Britain
Oxford University, Transport Studies Unit
Japan
Japan Transport Economics Research Centre (Washington, District of Columbia)
South Africa
Roads Technical Library, Pietermaritzburg, Natal
Directorate of Land Transport, Department of Transport, Pretoria
India
Central Road Research Unit, New Delhi

Private Organisations:
United States
Commuter Transportation Services, LA, California
American Automobile Association, Florida
World Bank, Washington
Salt Institute, Virginia
E-Pxy Industries Inc., New York
Japan
Japan Road Association, Tokyo
Greece
Association of Greek Cement Industry, Athens

Consultants:
United States
AISC Marketing Inc., Pittsburgh, Pennsylvania
Centennial Engineering, Inc. Arvada, Colorado
Western Highway Institute, San Bruno, California
Century Engineering, Inc. Towson, Maryland
The LPA Group, Columbia
Texas Research and Development Foundation, Austin, Texas
Canada
FENCO Engineers Inc. Willowdale, Ontario
South Africa
BS Bergman & Partners Inc, Pretoria
Stewart Scott International, Sandton, Johannesburg
Japan
Chijoda Engineering Consultants, Co Ltd. Tokyo

7.2 Changing sources of funding

After the US Government announced forthcoming policy shifts in transportation policy early in 1990, TRB was impacted (even if only marginally) by the tide of privatisation, commercialisation and contracting out which was sweeping developed capitalist economies, and particularly the USA and UK, in the late 1980s.

Soon after news was given of policies to come, the White House explained that the goal was reduced dependence on federal money as well as a stronger partnership with other levels of government, and added that the federal government will continue to have a major role even though ways were being investigated of raising money at the local level. The government decided that much of the burden must be shifted to state and local governments through options like user fees, private development and toll roads. The underlying belief was that the recipients of federal transportation aid should pay a larger share of project costs.

TRB has had to contend with a relative shift in the components of its funding, having to seek more funds from local government and private sector sponsors and being able to rely on less support from the federal government than it had traditionally come to expect.

7.3 Statement of income and expenditures

Table 2-1: Income and expenditure for the fiscal year ending 30 June 1992

Item	Federal ($)	State ($)	Other ($)	Total ($)
Income:				
Technical Activities Program Subtotal (Contract income and sponsorships)	**3 010 957**	**3 883 160**	**3 543 765**	**10 437 882**
Cooperative Research Programs:				
NCHRP Subtotal	**68 245**	**9 000 811**	**38 763**	**9 107 819**
NCTRDP Subtotal	**69 928**		**1 752**	**71 680**
Cooperative Research Programs Subtotal	**138 173**	**9 000 811**	**40 515**	**9 179 499**
Total Income	**3 149 130**	**12 883 971**	**3 584 280**	**19 617 381**
Expenditures By Activity:				
Technical Activities Program				
Special Projects (studies, conferences, workshops)	1 550 957		777 919	2 328 876
Transportation Research Information Services	413 750	415 028	486 105	1 314 883
Subtotal	**1 964 707**	**415 028**	**1 264 024**	**3 643 759**
Continuing Activities				
Field visits and committee activities	615 620	2 362 653	1 776 061	4 754 334
Annual meeting	91 662	183 323	297 000	571 985
Publications	338 968	922 156	200 680	1 461 804
Subtotal	**1 046 250**	**3 468 132**	**2 273 741**	**6 788 123**
Technical Activities Program Total	**3 010 957**	**3 883 160**	**3 537 765**	**10 431 882**
Cooperative Research Programs				
National Cooperative Highway Research Program				
Technical direction		3 355 960		3 355 960
Reports and panels		673 303	38 763	712 066
Research	68 245	4 971 548		5 039 793
Subtotal	**68 245**	**9 000 811**	**38 763**	**9 107 819**
National Cooperative Transit Research and Development Program				
Technical Direction	50 614			50 614
Reports and panels			1 752	1 752
Research	19 314			19 314
Subtotal	**69 928**		**1 752**	**71 680**
Cooperative Research Programs Total	**138 173**	**9 000 811**	**40 515**	**9 179 499**
Total Expenditure by Activity	**3 149 130**	**12 883 971**	**3 578 280**	**19 611 381**

(Source: TRB, Annual Report, 1992, p.30)

8. CONCLUSIONS

TRB recently stated that they have been experiencing a virtual explosion of top-level interest in and support for more transportation innovation in the past two years. It appears that, in the US at least, transportation has once again emerged as a national priority. More attention is being given to the relationship between transportation investment and economic development and enhancing productivity as well as fostering modern yet environmentally friendly research. Marine, air and waterway transportation research has become relatively more important to TRB's research profile in the 1990s.

The growing demands for additional standing committees and sessions at annual meetings and increased requests for research projects and publication of material has presented the organisation with a whole set of inviting challenges. As its customers' needs expand, the organisation is considering alternative ways to fulfil those needs.

TRB considers itself to be well positioned to make even greater contributions to the future of transportation. Its growing strengths in the technical areas and all modes of transportation, together with its more recently established reputation in policy-related work, make TRB a major player in transportation research efforts as the US enters a period of decision making on transportation policy and technological development.

The expansion of the demand for transportation research will require the Board to stay responsive in such areas as highway and airport capacity, deterioration of highways and bridges, the relationship between transportation and economic development, environmental and energy concerns, technological developments including intelligent vehicle-highway systems and high-speed ground transportation and urban congestion issues, including expanded transit development.

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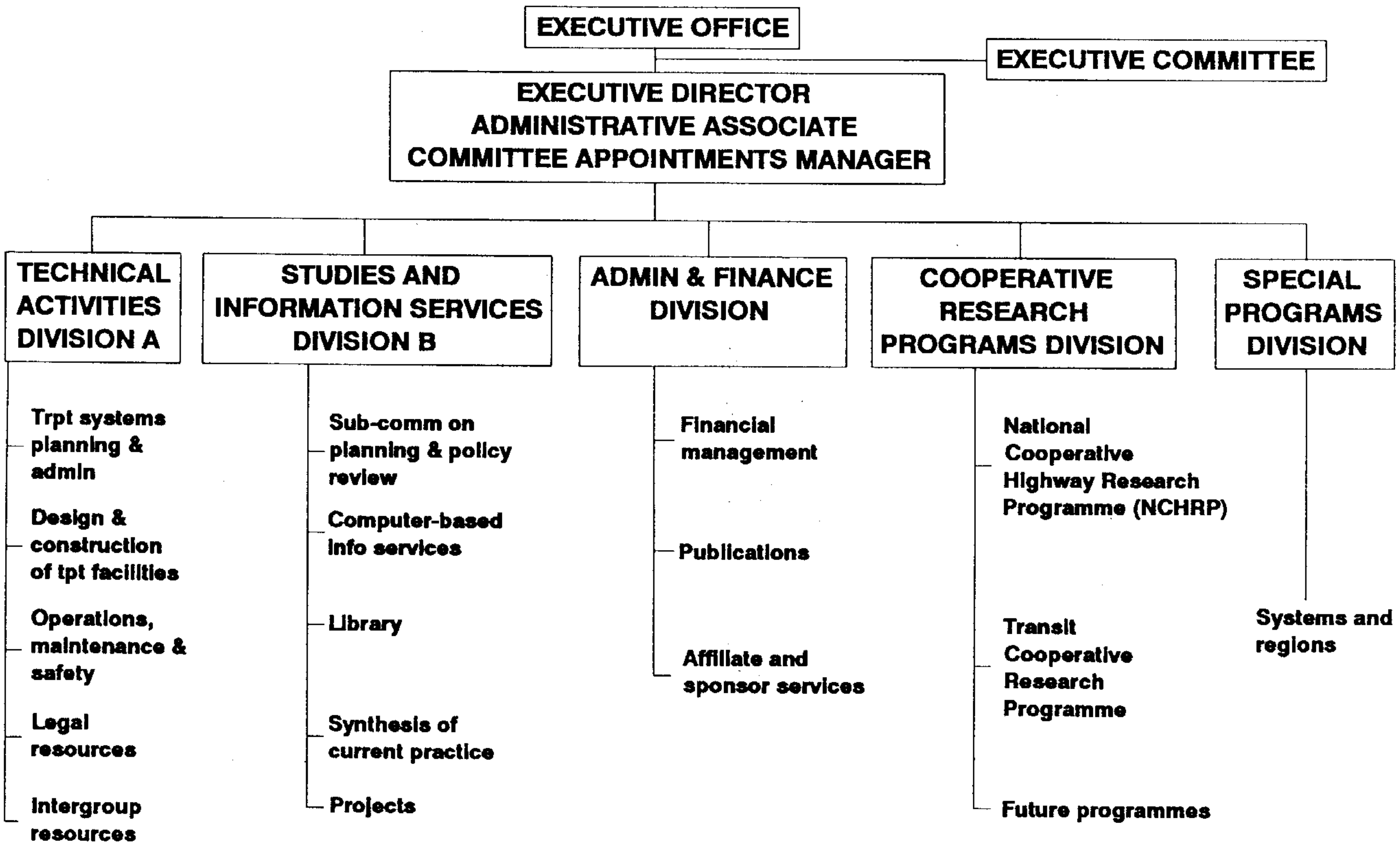
TRANSPORTATION RESEARCH BOARD
National Research Council



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PROFILE: THE TRANSPORT AND ROAD RESEARCH LABORATORY

1. BACKGROUND AND INTRODUCTION

The Transport and Road Research Laboratory (TRRL) became an agency of Britain's Department of Transport in April 1992, prior to which it simply formed part of the same department. The organisation has been described as an "official research centre" and also as "a government-funded independent research authority" and "the Government's Transport and Road Research Laboratory" by the printed media. According to TRRL itself, the Laboratory is recognised for its expertise as a research and development establishment of international standing.

The organisation operates from premises in Crowthorne, England.

2. INTERNAL ORGANISATION

The Laboratory is headed by an executive team of three directors, namely the Executive Director, Deputy Director and Assistant Director.

The Deputy Director is the line manager for staff in the research groups and is responsible for the overall conduct of research, including attainment of research objectives, maintenance of research standards and the career management of research staff. The Assistant Director is the line manager for staff in the support services and is responsible for financial, contractual, administrative, site and other matters that bear on the operation of the Laboratory.

The internal structure of the research component of the Laboratory is comprised of five Operating Groups (Programmes), ie the:

- Highways Group;
- Structures Group;
- Road Users Group;
- Vehicles Group; and
- Traffic Group.

The Groups are subdivided further and organised into various divisions, as indicated hereunder:

<u>The Highways Group</u>:	• Materials and Construction Division • Pavement Engineering Division
<u>The Structures Group</u>:	• Ground Engineering Division • Bridges Division
<u>The Road Users Group</u>:	• Road User Safety Division • Road User Behaviour Division
<u>The Vehicles Group</u>:	• Vehicles and Environment Division • Vehicle Safety Division

Traffic Group:
- Traffic Operations Division
- Traffic Safety Division
- Transport Demand Division

In addition to the various Groups and Divisions, the Laboratory's organisational structure includes a number of units and a branch, namely the:

- Noise and Vibration Unit;
- Structural Analysis Unit;
- Overseas Unit; and the
- Scottish Branch

Visitors

Outside advice on matters affecting the conduct and direction of TRRL research is given by a distinguished panel of Visitors chosen from industry, local government, consultants, research associations and the academic world. Two or three visitors are attached to each Group at the Laboratory. They are encouraged to comment on any aspect of research strategy or application, and they have right of access to Ministers and Senior Officials in the Department of Transport.

3. STAFF

The Laboratory has a graduate research staff of about 330, including teams of people with skills in:

- electrical engineering
- mechanical engineering
- civil engineering
- specialist vehicles
- technical photography
- film and video production
- technical publishing
- research documentation database
- contracts negotiation
- main-frame computing

These teams of people provide the support to the research scientists and engineers who are also characterised by a diverse skills mix.

4. OUTPUTS, PRODUCTS AND SERVICES

The Laboratory's Research Report for 1988 groups and summarises its outputs into seven categories, as follows:

- Advice: This service is incorporated in policy codes of practice, teaching material and legislation

- **Publications:** Research reports, Contractor Reports, Application Guides, Digests of Publications, Press Notices and Leaflets.

- **Seminars and Workshops**

- **Films and Videos**

- **Bibliographic Databases:** Abstracts of reports are stored in the OECD International Road Research Documentation (IRRD) database which is held by the Library. IRRD is also available on the European Space Agency's Information Retrieval Service. Thus, abstracts of TRRL reports are disseminated worldwide. Searches for specific topics are offered by the Library.

- **External Publications:** Scientific Journals, Technical Journals, British Standards, OECD Reports and Conference Proceedings.

5. ACTIVITIES AND AN INSIGHT INTO TRRL'S COLLABORATORS

5.1 Summary - a broad overview of the laboratory's activities

The Laboratory provides technical and scientific advice and information to help in formulating, developing and implementing government policies relating to roads and transport, including their interaction with urban and regional planning. The Laboratory contributes to, and gains from, international collaborative studies, cooperative research programmes with industry, and from the standard contracts between scientists. It also has formal and bilateral links with developing countries through the TRRL Overseas Unit, and work on overseas problems is undertaken in all subject areas covered by the Laboratory. TRRL's extensive research and development expertise is used by central and local government, industry, transport consultants, and transport operators in the United Kingdom and overseas.

5.2 Research programmes and responsibilities of the various groups and units

The Laboratory's research programme is approved by Government and, for 1991/92, comprised over 400 individual projects. Following below is a short description of the activities of each Group.

3-4

The Highways Group's Research Programme

Aim:
The primary aim of this research programme is to get better value for the money invested in road construction and maintenance whilst simultaneously seeking to minimise delays caused by road works.

Application/Benefits of the Research:
The results of the research contribute to Standards and Advice Notes issued by the Department of Transport and the Scottish Office Environment Department. The research also contributes to British Standard Specifications.

Collaborators:
Local Highway Authorities collaborate in much of the research and benefit from its results. There is also collaboration with academic institutions and an increasing programme of research is conducted for the private sector.

The Materials and Construction Division's Research

In this research programme, the aim is to improve specifications for unbound, bitumen-bound and cement-bound materials and their constituent aggregates and to assess new developments and processes. The primary topics cover those materials that are used in large quantities such as aggregates, rolled asphalt, bitumen macadam, surface dressing, cement bound roadbase and pavement quality concrete. More specialist materials such as surfacings for steel bridge decks and joint sealants for concrete pavements are also studied. Recycling processes for bituminous pavements are also evaluated by this division. Machines to measure and monitor skid resistance are being developed.

The research projects in this division are divided into the:
- Aggregates Research Project;
- Bituminous Materials Project;
- Concrete Pavements Project; and the
- Maintenance Processes Project.

The Pavement Engineering Division's Activities

Here, the aim has been to improve the cost effectiveness of all civil engineering works on highways, from trench reinstatement to the strategic programming of major motorway maintenance. The research programme is formulated in consultation with the Department of Transport and the results are used by the Department in preparing standards and specifications and in managing the trunk road network. Local Authorities provide valuable assistance in carrying out the research programme and benefit from its results. There is also collaboration with academic institutions and industry.

The research units of this Division are the:
• Pavement Structures Unit;
• Pavement Testing and Traffic Unit;
• Road Monitoring Unit;
• Road Performance Unit; and the
• Pavement Management Unit.

The Structures Group's Research Programme

Aim:
The objective is to get better value for the money spent on highway structures by development of more affordable and durable forms of construction and improved methods of maintaining existing structures.

The research work:
The work of the group is concerned with design, construction, assessment and maintenance of highway structures.

Implementation of results:
Results are implemented through British Standards and Departmental Standards and Specifications, the publication of reports and papers and close liaison with designers, contractors and highway authorities.

The Ground Engineering Division:
This Division investigates the design, construction and performance of earthworks, earth-retaining structures including cut-and-cover tunnels, pipelines and drains, culverts, foundations and bored tunnels in order for the highway engineer to provide them at minimal overall cost. Soil/structure interactions are a recurring theme in this Division's research and includes the following projects:
• Earth Retaining Structure and Foundations Project;
• Soil Structures and Strengthening Systems Project;
• Earthworks Construction and Behaviour Project; and the
• Ground Properties and Pipelines Project.

The Bridges Division:
Research by this Division concentrates mainly on developing methods to assess the structural behaviour under load of existing bridges of steel, concrete, brick and masonry, and on developing methods to detect defects, understanding how defects arise and methods of repair and prevention to maintain the serviceability of the bridge stock. The Division uses its extensive special facilities for testing large structural units under static and dynamic loads and for carrying out long duration fatigue tests. This Division's research projects include:
• Structural Assessment;
• Structural Loading; and
• Durability and Repair of Concrete.

The Road User Group's Research Activities

Objectives:
The objectives of the work in the Road User Group are to analyze road accident trends, to gain an understanding of those factors in accident causation which arise from road user errors, and to devise, improve and monitor the effectiveness of accident countermeasures.

The Road User Safety Division:
This Division undertakes research to identify and understand the factors involved in road accidents and the contribution which this understanding can make to road safety policy and future remedial measures. The main topics of research are: the maintenance of accident databases and the analysis of accident trends; the role of alcohol in road accidents; the economics of injury; road safety education for school and pre-school children; training for drivers; public attitudes to road safety issues; and the effects of publicity on attitudes and behaviour.

The research groups in this Division are divided into:
- Accident Data;
- Statistics;
- Alcohol;
- Injury Cost and Accident Causation;
- Training; and
- Road Safety Education.

The activities of the Road User Behaviour Division:
This Division's research activities objectives are to establish accident liability of road users, to understand the factors which influence their behaviour and to assess remedial measures. The main topics researched are: Behaviourial studies; Pedestrians; Signs; Impairment; Compliance and Deterrence; Accident Modelling and Statistical Techniques.

Accordingly, research projects/units include:
- Behaviourial Studies;
- Pedestrians;
- Signs;
- Impairment Testing;
- Accident Models and Surveys; and
- Statistical Consultants.

The Vehicles Group's Research Profile

Aims:
The Group's research is aimed at ensuring that road vehicles are designed for maximum safety and minimum damage to the environment.

Scope of research and applications:
Much of the work demonstrates what vehicle improvements are achievable and practicable, and therefore what degree of regulation is applicable. It also looks at ways of ensuring compliance. Output from the work is applied by the Department of Transport Divisions with policy and regulatory responsibilities for vehicles and roads, and is used extensively in European and other international forums. The research work is also applied by vehicle manufacturers, commercial vehicle operators and local authorities.

Vehicles and Environment Division:
This Division is concerned with all aspects of the environmental impact of roads and traffic, with the loads applied by heavy vehicles to the highway infrastructure, with the control of vehicle weights in the road freight industry and with transport for disabled people. Research on environmental assessment methods is implemented through the Department of Transport's Manual of Environmental Assessment. The Division works closely with the Department's Disability Unit on the use of private and public transport by disabled people.

The Division's Projects include:
- Air Pollution;
- Environmental Appraisal;
- Freight;
- Commercial Vehicles; and
- Transport for Disabled People.

Vehicle Safety Division:
The aim of this research programme is to improve the design and operation of vehicles both for accident avoidance (primary safety) and for the protection of road users involved in accidents (secondary safety). Accident investigations are used to identify areas where research is likely to prove most effective and much of the research is done to support legislative action. The main topics covered under primary safety relate to braking, stability and handling of vehicles, improved lighting and driver's aids. Activity in the area of secondary safety includes the development of improved occupant restraint systems, and investigations of the crush characteristics of cars for providing improved levels of protection for occupants in frontal and side impacts as well as for truck pedestrians. Work is also done on the testing and specification of safety fences and bridge parapets, to restrain vehicles from leaving the road.

Research Projects include:
- Primary Safety and Testing;
- Accident Investigation and Lighting;
- Occupant and Pedestrian Protection;
- Motorcycle Safety; and
- Analytical Studies.

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The Traffic Group's Research Activities

Aims:
The main aim is to optimise use of the road network by reducing congestion, accidents, routing errors, and other forms of waste which currently costs UK road users billions of pounds per year. The Group also aims to improve the quality and economy of UK transportation by helping to meet the Department's research requirements on transport and land use.

Collaborators:
Much of the Group's activity profile is carried out cooperatively with the police, highway authorities and consultants.

Application of research results
The research results of this section of TRRL assist Department of Transport Policy Directorates in the formulation of their advice to Ministers as well as the advice given to Local Highway Authorities on methods of traffic control.

Training:
The issue of computer programs for use by traffic engineers at home and overseas is supported by training workshops.

The Activities of the Traffic Operations Division:
This programme carries out research into systems and procedures for improving the operation of both urban and inter-urban roads. The primary objective is to develop methods of alleviating traffic congestion but the impact on accident risk is also assessed. Motorway research includes the development of strategies to operate the network efficiently. New information systems such as dynamic route guidance and Radio Data System (RDS) are being assessed to determine how they can be used to reduce travel delays on all types of road. Research is also conducted by the programme into the design and control of junctions. About 20% of the work of the Division is done jointly with European partners within the DRIVE programme.

Projects include:
- Roadworks;
- Traffic Flows;
- Motorway Modelling;
- Urban Traffic Control;
- Driver Information Systems;
- Junctions;
- Network Management; and
- International Coordination.

The Activities of the Traffic Safety Division:
The aim of this Division's research profile is to reduce accidents and traffic delay by better urban traffic management and improved road and junction design. The trade-offs between accident risk and traffic capacity are given high priority. Traffic `calming' techniques are developed and assessed by this group of researchers. The Division collaborates in its research activities with European partners including the EC DRIVE programme.

Research Projects of the Traffic Safety Division are:
• Accident Risk;
• Engineering and Planning;
• Network Safety (1) & (2);
• Safety Appraisal; and
• Transport Demand.

The Activities of the Transport Demand Division:
This Division aims to meet the Department's research requirements in public transport, transport and land use, traffic appraisal and parking. The structure of the bus industry after deregulation is being studied by the Division. Work is also being done on the taxi and private hire vehicle industry and the effect of buses on congestion. Traffic appraisal work within the Division is using modelling techniques for studies of highway improvements, traffic generation and traveller's response congestion. Research into parking enforcement, compliance and innovation in on-street parking is also in progress.

The titles of this Division's research projects include:
• Public Transport;
• Traffic Appraisal;
• Transport and Land Use;
• Parking and Restraint; and
• Congestion.

The Overseas Unit - TRRL's roles in developing economies

Developmental aims/priorities:
TRRL's Overseas Unit aims to find practical solutions to the transport problems of developing countries, particularly in the roads sector.

Funding:
TRRL's activities in the area of development are funded by the Overseas Development Administration (ODA) as part of the British Government's overseas aid programme. Because ODA recognises that road transport plays an important part in the economic growth of developing countries, it funds a research programme at TRRL geared essentially to application, whether in policy areas or in engineering technology.

Scope of the Research Programme:
The Unit's research programme is directed towards the special conditions encountered in tropical and subtropical environments. It covers the planning, design, construction and maintenance of roads and the safety and operation of vehicles using the road network.

Methodology:
Individual research projects are pursued through a combination of long-term tours overseas, short-term visits and home-based research. Results are made available in practical guides, research reports and technical papers. Advice is also given directly to overseas governments (and other collaborators) by means of regional overseas courses and by courses in the UK.

Collaborators:
Abroad, the Unit works where possible with local research organisations or Ministries of Works and Transport. The unit regards the building of local expertise as an important part of TRRL's work.

The Noise and Vibration Unit

Research Focus:
The Noise and Vibration Unit is concerned with carrying out research to reduce the generation, propagation and environmental impact of noise and vibration from road vehicles and from traffic streams.

Expertise:
In conducting this work the Unit has developed expertise in the areas of prediction modelling, psycho-ascetics, environmental monitoring and quiet vehicle development and testing.

Partners in research:
The work involves technical liaison with overseas organisations particularly with regard to the development of European and international standards.

Current Work:
Work of the Unit includes the development of methods for calculating noise near roads including the effects of noise barriers with absorptive features; studies of tyre/road surface noise particularly with regard to the development of acoustically absorbing road surfaces; and the development of vehicle noise test procedures.

The Activities of the Scottish Branch of TRRL

Aims:
The main aim of the research activities conducted by this Branch of TRRL is to obtain better value for the money spent on road construction and maintenance.

Application of Results:
The results of the research contribute to the Standards, Advice Notes and Technical Memoranda issued by the Scottish Office Environment Department and the Department of Transport.

Topics:
The main topics covered by this Branch are: rock excavation and soil suitability for earthworking; the development and use of design mix asphalts, and the deterioration of structural concrete.

5.3 Basic research - the discretionary programme

In addition to the research profile described above, the UK Government have since 1989 supported a programme of research which gives TRRL's Director the discretion to sponsor innovatory ideas of TRRL research staff. This discretionary programme takes account of independent advice from distinguished individuals (TRRL Visitors) who are chosen form the private sector, local government and universities. The more promising ideas are developed to the point where they can attract customer support.

5.4 Emerging trends in TRRL research

The volume of TRRL research has remained approximately constant in real terms in recent years. However, there have been marked shifts in emphasis, for example towards environmental concerns and studies of road user behaviour. It was envisaged that beyond the 1991/92 year there are likely to be further changes in the research programme as TRRL becomes an Executive Agency within the Department of Transport.

6. CUSTOMERS - TRENDS AND SOURCES OF FUNDING

The Laboratory's customers are mainly from the Department of Transport, but a substantial volume of work is also undertaken for the Overseas Development Administration (ODA). A few of the organisation's clients have in the past emanated from the private sector and the proportion of private to public sector clients has been rising steadily since the late 1980s as the privatisation drive in the UK impacted on TRRL's activities. TRRL envisages that this trend will continue for some time, but that a culture of greater state responsibility and perhaps even re-nationalisation will eventually replace it.

The research programmes of TRRL also reveal this trend towards greater commercialisation outside and within the organisation. In its 1988 Research Programme, TRRL states that: "Proposals entirely funded and controlled by industry would also be welcome. These need not be limited to topics covered by the Department of Transport's research programme. They might seek R&D activity, but they might also seek consultancy support or the use of the Laboratory's facilities. To increase its level of co-operative contact with the private sector, a new Unit is being set up at Crowthorne to focus these activities".

7. FACILITIES

The Laboratory boasts has computing facilities, extensive state-of-the-art laboratories, a library with over 200 000 books and pamphlets, 700 journals, and an international roads and transport database.

8. FINANCES

8.1 Introduction

Detailed information as regards the Laboratory's financial position was not available at the time of writing this report. This information will be publicised in the soon to be released Annual Report for the Agency, in late 1993. Sketchy information could however be gathered and this includes information on the size of the resources allocated to some of the Groups, Divisions and Units during the course of 1991/92. This is presented below.

8.2 Allocation of resources per TRRL division for 1991/92

Table 3-1: Resources allocated for internal and external work during 1991/92

Division	Amount allocated, Pounds (million)
Materials and Construction Division	2.0
Pavement Engineering Division	2.1
Ground Engineering Division	2.8
Bridges Division	3.5
Road User Safety Division	2.5
Road User Behaviour Division	2.2
Vehicles and Environment Division	3.7
Vehicle Safety Division	4.5
Traffic Operations Division	2.5
Traffic Safety Division	2.1
Transport Demand Division	2.0
Total	**29.9**

(Source: TRRL Research Programme, 1991/92, pp.1-24).

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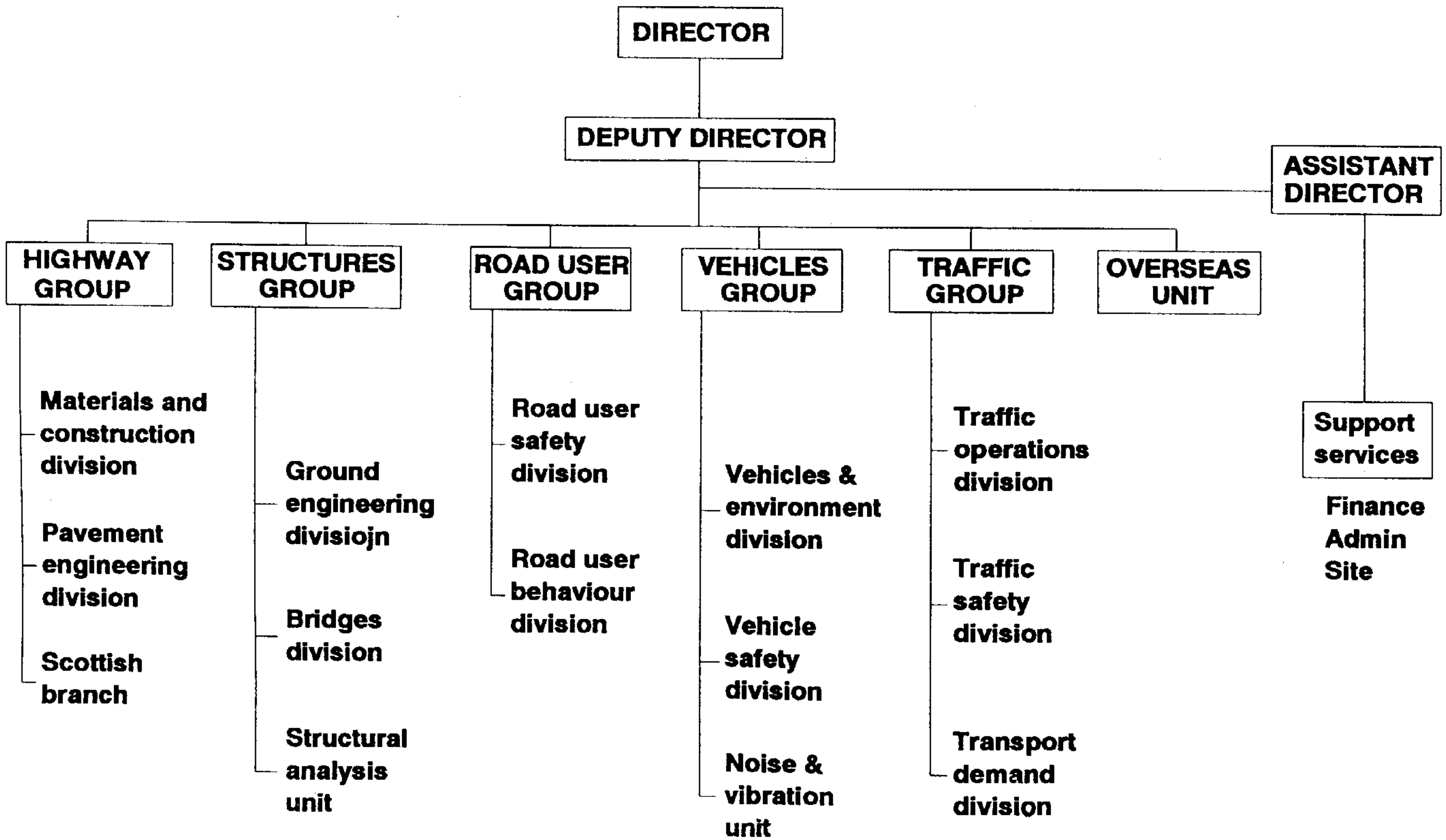
TRANSPORT AND ROAD RESEARCH LABORATORY



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PROFILE: THE AUSTRALIAN ROAD RESEARCH BOARD (ARRB)

1. INTRODUCTION AND BACKGROUND

The Australian Road Research Board (ARRB) is an official research centre registered in the State of Victoria, Australia and a non-profit public company limited by guarantee. Its members are the Federal Department of Transport and Communications, the eight State and Territory Road Transport Authorities and the Australian Local Government Association. The organisation operates from Vermont South in the State of Victoria.

ARRB was formed in 1960 as a co-operative venture between various Government Departments involved in roads and road transport. In May 1989, the Australian Council of Local Government Associations became a member of the Board and its Vice President became a Director at the same time. This expansion, which formally included local government participation in the Board at Director level, followed a period of negotiation and preceded a contribution to expenditure from local government road funds.

The internal organisation of ARRB was reviewed during the late 1980s and a flat management structure was developed during the course of 1989/1990.

2. GOALS AND OBJECTIVES OF ARRB

ARRB's goals are incorporated in the relevant Australian Companies Act. The organisation's Annual Report for the year 1986/1987 lists its objectives as follows:

- To provide a national centre for road research information and for the correlation and co-ordination of road research activities.
- To ascertain the nature and extent of road research 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 available 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.
- To make available to appropriate bodies of persons, information relating to road research matters.

ARRB believes that research is an investment. It aims to ensure that its customers get maximum value from research and because research underpins innovation, ARRB believes that the return on investment should be measurable by impacts in practice.

ARRB prides itself in having completed numerous successful projects over the years, in the sense that these have led to significant changes in practices and procedures.

The organisation has not, in the 1990s, abandoned its primary goal of ensuring that its research projects yield practical and pecuniary results. Indeed, 1991/92 saw ARRB reiterate its commitment to this "value for money" approach to research. To further increase the effectiveness of the research programme, this year saw ARRB:

- improve its focus on issues of greatest concern to practitioners;
- develop a much closer association with the client during the project;
- reinforce its determination to deliver outputs on time and in user friendly formats; and
- extend its program of technology transfer.

3. INTERNAL ORGANISATION

3.1 Members and Directors

Member Directors, non-member Directors and Ordinary Members of ARRB comprise prominent figures from public and private sector industry and from academic institutions. Members meet annually to review the company's performance and to provide guidance to the Board of Directors, which overviews and leads the company between Annual General Meetings.

The Board of Directors is appointed by the Members and it is responsible for corporate policies, goals and directions and for overall operation of the organisation.

3.2 The Advisory Committee

The Advisory Committee comprises senior persons from government, industry and the academic arena. Traditionally, the Advisory Committee's role has been to advise the Board on technical issues.

In 1991/1992 it was decided that the role of the Advisory Committee should be broadened to incorporate a more strategic approach rather than research needs alone and that it should henceforth meet for a formal session with the Board of Directors at least once annually.

The joint meeting of 1991/92 included discussions on improving communication with the Board, the role of the Advisory Committee and the possibility of the Committee advising on more than just technical issues. One of the outcomes of this landmark meeting was that the Chairman of the Advisory Committee will attend all future Board meetings to provide a direct link between the Committee and the Board. The Committee was also given a new mission, namely to provide the Board of Directors with a critical independent perspective on the research and related service needs of the roads and road transport industry and of the broader community, and assess the extent to which ARRB is meeting those needs.

The Committee can examine, comment upon or make recommendations with respect to any of ARRB's operations. However, its primary foci are the relevance and strategic directioning of the research and related services programmes and the technical quality of the outputs.

The Advisory Committee usually meets twice a year, in the first and third quarters. At the first meeting the strategic directions of ARRB's research program are reviewed and at the second, the proposed research program for the forthcoming financial year is examined in detail. The Committee typically endorses but refines the research directions of ARRB's strategic planning documents. For example, in 1991/92 the Committee recommended that ARRB re-include the social and economic costs of environmental issues in the plan at the earliest possible opportunity. It also recommended that high priority be given to the effect of Travel Demand Management on total transport travel, efficiency travel, mode use, business viability and environmental and social impacts of alternative urban forms.

3.3 The Local Government Committee

Like the Advisory Committee, the Local Government Committee meets at least twice a year. This committee consists of prominent officials from various local government bodies and municipalities. At its meetings during the 1991/92 financial year, key items for discussion of this committee were:

- the adoption of a technology transfer strategy and programme of activities;
- arrangements for funding from Local Government;
- the ARRB research programme and priorities for 1992/93; and
- new appointments.

In reviewing the future research needs of Local Government, priority was given by the Committee to the following key projects:

- Unsealed Roads - the production of a manual on "good practice" for the construction and maintenance of unsealed roads;
- Quality Assurance (QA) - the conduct of a review of the QA systems that are being implemented by Councils, the effectiveness of these systems and further actions to be taken;
- Speed and Design of Urban Non-Arterials - the continuation of a study to improve the levels of safety and amenity in local streets.

These projects were included in the ARRB's research programme for 1992/93.

3.4 The Audit Committee

The internal Audit Committee of the Board comprises members from each of the above committees, and two members representing management. The Committee meets at least once a year to discuss a wide range of issues, including a financial review.

3.5 Internal management

ARRB is organised into six programmes under its Executive Director, Dr Ian Johnston. These business units are the:

- Road Infrastructure Programme
- Road Safety and the Environment Programme
- Transport Efficiency Programme
- Engineering Services Programme
- Research Applications Programme

4. STAFF

ARRB's staff complement of 125 includes a graduate research staff of some 65. Developing its human resources is a high priority for ARRB. A training program that was launched to enhance the communication skills of its staff continued into 1992 and 1993. In-house seminars are also used to provide opportunities for staff to refine their presentation skills, develop confidence and receive feedback from other staff members.

New Occupational Health and Safety and Equal Employment Opportunity policies were put in force in 1991.

5. FACILITIES

ARRB maintains an extensive library (about 35 000 volumes and journals) of road literature and a database on road information, in addition to its computer facilities and laboratories.

6. MARKETING

ARRB has a strong marketing drive. The organisation believes that there is great potential for additional contract work and a process of investigating new markets and expanding on traditional areas of market penetration was initiated in 1992.

7. ACTIVITIES

7.1 Introduction

ARRB is constituted to act as an information centre and to undertake and sponsor a comprehensive range of road and road transport research related to the design, planning, construction, maintenance and use of roads. The company disseminates the information it generates through conferences, symposia and publications.

7.2 Research projects, clients and collaborators

Highlights of ARRB's research programme for 1991/92 are summarised below:

The Accelerated Loading Facility Program (ALF)

This is the largest and the most expensive project ever undertaken at ARRB. ALF is used to address issues of major concern to road designers. During 1991/92, a seventh trial (of asphalt and cement-treated crushed rock - CTCR) and an eighth trial (of geotextile reinforced seals) were completed.

The fatigue life relationships for asphalt and CTCR currently recommended in the AUSTROADS Pavement Design Guide, or as adopted by individual road authorities, are largely derived from overseas laboratory testing and field performance data. The main aim of the Mulgrave ALF trial (seventh trial), which was conducted by VIC ROADS and ARRB, was to examine the fatigue performance of asphalt and CTCR under Australian conditions.

The main purpose of the eighth trial was to examine the performance of low cost pavements subjected to intermittent flooding, particularly geotextile seal reinforced pavements placed directly onto a black clay soil subgrade.

Quality in Construction

In conjunction with Road Authorities, ARRB has undertaken a number of projects aimed at improving construction quality. The need to carry out audit testing on road construction materials to validate contractors' quality assurance test results was recognised by the AUSTROADS Materials Technology Liaison Group. As a result, VIC ROADS requested ARRB to undertake work on statistical audit testing techniques on a contract research basis. Procedures were developed which recommended sampling methods, data treatment, decision-making processes and guidelines for formulating specification clauses. Operational recommendations were also highlighted.

Examination of car users' perceptions of the ride quality of roads

Fiscal year 1992 saw ARRB complete a pilot investigation into the relationship between users' perceptions of ride quality and road roughness, the acceptability of a specific level of road roughness for trips of different length and how far users were prepared to travel to avoid rough roads. The investigation was undertaken at the request of AUSTROADS. Recommendations were made on conclusion of the research for further work to overcome the limitations of the pilot study.

Measuring of pavement condition

AUSTROADS is pursing the development of nationally consistent indicators of pavement condition to provide measures of the health and serviceability of pavements.

Improving bitumen and asphalt through research

Australia is one of the world leaders in low cost pavements and a central element in the system is the bituminous surfacing which provides a good running surface for traffic and waterproofs the pavement structure. ARRB's work in this area has been integrated with AUSTROADS studies to provide a wide base of expertise and to ensure effective implementation of the final products.

The Evaluation of Pavement Management System (PMS) for Local Government

Local Government required help in determining which type of Pavement Management System best met the needs of individual authorities. ARRB undertook an evaluation of PMS software packages on the market as at 31 May 1992. A report was produced by ARRB summarising the main findings of its evaluation. It was prepared to assist those Councils wishing to purchase a PMS package in the 1991/92 fiscal year. The report was designed to highlight the particular features of each product and so enable Councils to decide which package would best meet their needs.

Managing road assets

The VIC ROADS/Local Government Arterial Roads Asset Management Study is aimed at developing a maintenance strategy for the Victorian arterial road network. This strategy will ensure the future condition of arterial road pavements satisfies community expectation, and maximises economic benefits by relating pavement condition standards to road user costs.

The development of an Expert System to determine speed limits

In the 1980s, an ARRB project developed an Advisor based on an expert system to assist in speed zone determination in Victoria. During the course of fiscal year 1992, ARRB carried out a thorough review of the Advisor in operation and proposed a number of revisions.

Accident costs for project planning and evaluation

1991/92 saw the completion of a major ARRB project to determine accident costs for use in evaluating the effects of potential or implemented safety treatments and countermeasures.

7.3 ARRB's technology transfer program

ARRB subscribes to the view that the effectiveness of research depends, in the final analysis, on the take-up rate of the findings by practitioners. The Board thus places a premium on ensuring that its findings are not only popularised but also understood. Towards this objective the Board uses a range of tools which are used to form the core of its technology transfer programme. These are discussed below:

Publications
ARRB publishes a range of journals, research reports and databases. These include Journals, Proceedings of the ARRB Biennial Conference, Research Reports (irregular), the INROADS Database, Annual Reports, Special Reports and Internal Reports. During 1991/92 the publishing programme released 19 research reports, one special report, eleven issues of Briefing, one conference proceedings, four issues of the Journal, 26 issues of Roadlit, and 52 working documents.

Seminars
Like most research organisations, ARRB is very active as regards the convention of seminars. During the course of 1991/92 a number of seminars were held across Australia on a variety of topics, including:

- **Delineation on rural roads** - In this seminar practitioners in four states were given findings from ARRB's long history of research and the latest information on design, installation and maintenance of different approaches to delineation). Similar seminars were held during 1992/93.

- **Improving safety at railway level crossings** - This conference focused on the options for low cost level crossing treatments, the issues surrounding their introduction and how to get them into practice.

- **The SIDRA software package** - This seminar session involved training courses held in Melbourne and Perth in association with VICROADS and MRD WA respectively.

- **ARRB and the transport consulting industry** - Consultants were invited to discuss emerging issues in the transport field which ARRB might address, including possible co-operative research projects.

- **Road Technology and the Environment** - sponsored by AUSTROADS to develop a strategic response on these issues.

Information Services
ARRB's Information Services unit forms another part of the Research Applications programme. It is seen to have a vital role in the Board's technology transfer process. Information Services' activities include:
- Organising information days for ARRB's staff complement
- Serving the hundreds of consultants, researchers and students who visit ARRB

- Operating an inter-library loan service
- Maintaining and updating existing in-house databases and expanding national and international databases through updates of the latest Australian road and research publications.

<u>**Other activities**</u> include the compilation of mailing lists and execution of market surveys, arranging visits to a large clientele in Australia, receiving overseas delegations, coordinating overseas trips to conferences and research organisations and monitoring and evaluation of the results of actions taken.

8. FINANCIAL POSITION

8.1 Introduction

In the 1980s, the Board depended for the bulk of its finance on the contributions of its Member Authorities. The 1991/92 financial year saw a proposal by the Board of Directors to increase the use of external resources to help ARRB's research quickly address current issues. This was endorsed by the Advisory Committee.

The company is exempt from the payment of income tax, provided its principal activity continues to be transport research.

8.2 Sources of income and operating expenses

About 80% of ARRB's research projects are undertaken as part of the core programs funded by members. The remaining 20% are funded under contract or partly sponsored by members and industry.

Table 4-1: Statement of Income and Expenses for the year ended 30 June 1992

Item	1992 $'000	1991 $'000
Income:		
Operating		
Members' Contributions		
Commonwealth Government	2200	2200
State Government	3166	3049
Local Government	123	154
Contract Income		
Engineering Services	1133	1210
ALF	611	656
Research	746	727
Other Income		
Publication Income	251	247
Conference Income	51	433
Sundry	37	32
Non-Operating		
Interest on deposits	232	387
Profit on disposal of fixed assets	19	4
Total Income	**8569**	**9099**
Expenses:		
Administration Costs		
Communications	157	159
Maintenance: buildings & grounds	369	394
Maintenance: computer	92	135
Office supplies, software	74	113
Sundry	341	217
Auditors' remuneration	27	18
Bad and doubtful debts	-	42
Conference expenditure	2	361
Consulting	201	252
Depreciation of fixed assets	736	748
Employee provision expenses	80	97
Wages and salaries	4773	4515
Other salary costs		
Payroll tax	286	288
Staff training and recruitment	39	58
Superannuation	132	128
Workcare	56	85
Fringe benefits tax	12	25
Contract expenditure	532	1139
Research Costs	350	333
Travel	258	154
Grants	104	37
Total Expenses	**8619**	**9298**
Operating Surplus/(Deficit)	**(50)**	**(199)**

(Source: Annual Report, 1991/92, p.39)

9. CONCLUSIONS

The Corporate planning process undertaken during the course of 1991/92 generated a general consensus that two key directional changes were required for ARRB:

- First, it was decided that ARRB should broaden its focus to include the provision of research services to the entire transport industry and not just the road sector. The principal activities of the company during the financial year were amended to include the undertaking of research on a fee-for-service basis in the field of broader transport research, where previously the Board had been limited to road research.

- Second, it was agreed that ARRB should increase its move towards commercialisation of its products and services.

Accordingly, significant effort has been directed since 1991 to enhancing ARRB's performance in transferring its knowledge to practitioners. Staff have participated in communications training, local government has been given a special focus, publications have been upgraded and media coverage expanded. These efforts are set to continue as ARRB becomes more service orientated.

10. REFERENCES

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Pacific Research Centres: A directory of organisations in science, technology, agriculture and medicine, Longman Group Ltd, UK, 1988.

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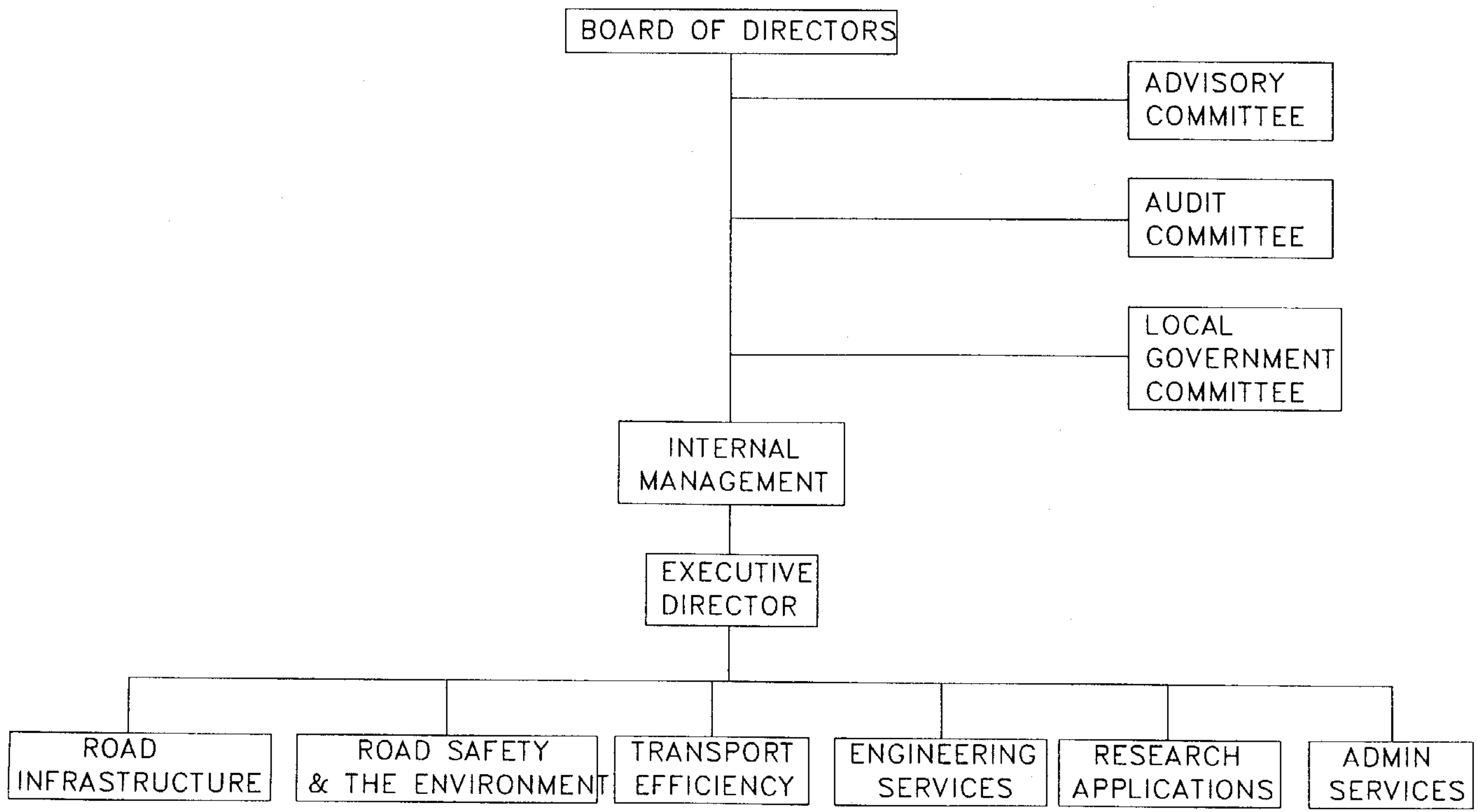
AUSTRALIAN ROAD RESEARCH BOARD



5

PROFILE: THE CSIR AND THE DIVISION OF ROADS AND TRANSPORT TECHNOLOGY (TRANSPORTEK)

1. INTRODUCTION AND BACKGROUND TO RESEARCH IN THE RSA

1.1 The early history and development of the CSIR

In the period between its inception in 1945 and 1987, the CSIR established itself as a world-renowned research organisation consisting of 31 national research institutes and operational units, and over 5 000 staff members. The organisation was created through an act of Parliament as a statutory body operating under the umbrella of the Department of Trade and Industry and funding in this period came mainly from a parliamentary grant.

Between the years 1979 and 1983, it became apparent that pressures felt by other research organisations in the world, and the particular realities of South Africa, required a strategic decision as to the mission and operations of the CSIR. In response, the CSIR Board commissioned a study into the funding of the natural and engineering sciences early in 1983. The outcome of this study, together with a White Paper on Industrial Development Strategy in the RSA, identified the CSIR as the organisation that should take the lead in the effective transfer of technology to industry in South Africa.

In June 1985 the CSIR Board approved an in-depth management review to be carried out and after a lengthy period of strategic planning the organisation underwent significant restructuring in 1987 and early 1988.

1.2 The new CSIR

Under the new dispensation the CSIR obtained more freedom to manage its affairs within the limits of the amended CSIR Act, but it remained a statutory body under the umbrella of the Department of Trade and Industry. The organisation's restated mission reflects the change adequately:

> *The CSIR's business is to perform research and development to gain technology and thereafter to ensure its implementation in order to:*
>
> - *be the technology partner of South African industry in both the formal and informal sectors to promote economic growth;*
> - *provide scientific and technological support to enhance decision-making in the public and private sectors;*
> - *provide technology solutions that improve the quality of life in urban and rural developing communities.*

A new executive and managerial team was appointed in early 1988 and the organisation was at the same time restructured into thirteen independent strategic business units or operating divisions, each focusing on a different sector of the market; these are the Divisions of

- Manufacturing and Aeronautical Systems Technology (AEROTEK);
- Building Technology (BOUTEK);
- Earth, Marine and Atmospheric Science and Technology (EMATEK);
- Energy Technology (ENERTEK);
- Food Science and Technology (FOODTEK);
- Forest Science and Technology (FORESTEK);
- Information Services (INFOTEK);
- Materials Science and Technology (MATTEK);
- Microelectronic and Communications Technology (MIKOMTEK);
- Roads and Transport Technology (TRANSPORTEK);
- Textile Technology (TEXTEK);
- Water Technology (WATERTEK); and
- Mining Technology (MININGTEK).

In addition to the above, three corporate programmes have been established in response to market needs, in order to deliberately muster relevant expertise from across the CSIR; these are Environmental Services, Mining Services and Technology for Developing Communities.

The top management structure of the CSIR consists of the President, Dr JB Clark, and five vice-presidents, one each for the staff functions of Human Resources, Finances, and Marketing and Business Development and two vice-presidents of Operations. This executive team answers to the CSIR Board, a body apppointed by the Minister of Trade and Industry to include private sector representatives from across industry. Chairman of the CSIR Board is currently Mr Paul duP Kruger, also the CEO of SASOL. The current total staff complement of the CSIR is just over 3 000.

The thirteen operating divisions provide a broad base of specialist expertise which enables the CSIR to adopt a holistic approach in serving the needs clients of any particular strategic unit. The CSIR's ability to provide a multi-disciplinary service, thus providing clients access to expertise from accross all divisions, is a strength that the organisation is very consciously building upon.

1.3 Business philosophy of the CSIR

The business philosophy of the CSIR prior to 1987 was primarily science-based through an ostensibly state-run organisation. Since 1987 it has changed fundamentally to an organisation that actively seeks technology partnership with industry. Changing national priorities in South Africa urges the CSIR to contribute to the creation of wealth through the development and implementation of technology and in this endeavour close liaison is pursued with industry and the community.

The extent to which the CSIR has been able to put this philosophy into practice since its restructuring is apparent from Figure 1, which presents the trends in revenue since 1983/84 from the parliamentary grant and from external (contract) income. Within ten years, and especially since its restructuring in 1987/88, the organisation has been able to reduce its dependence on the former from about two-thirds of total income to less than fifty percent. Total external (contract) income during the 1992/93 financial year was R209 million, some 6 percent up from the previous year.

Business emphasis will increasingly be on building stronger linkages with industry and on product development, as opposed to the pre-1987 focus on research in science and engineering. For example, it is estimated that the 1993/94 income from new products launched will constitute some 10 percent of total revenue.

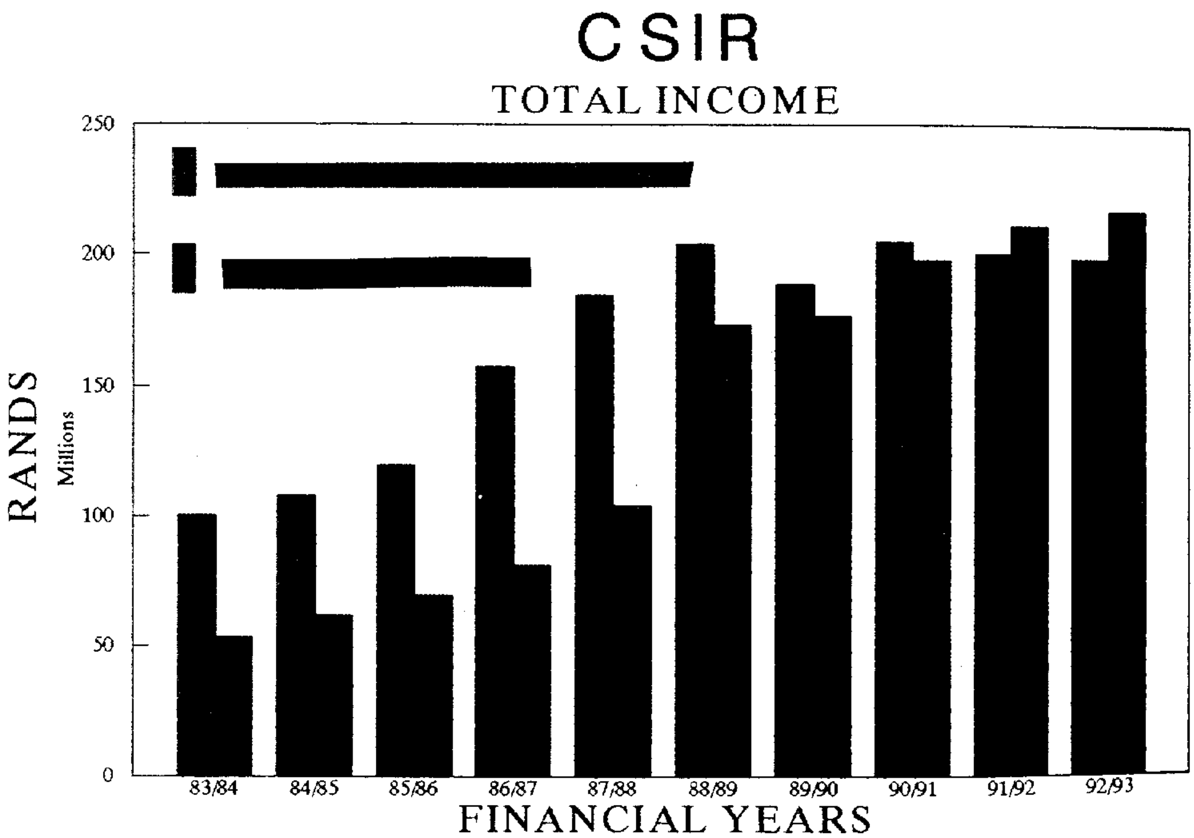
An integral part of the CSIR's business philosophy is its approach to the management of technology, and in particular the corporate policies regarding innovation and product development. In addition to setting deliberate goals in terms of new products launched per annum, a system of allocating and coordinating the use of discretionary funding for innovation and positioning has been developed.

In terms of the CSIR's interaction with industry, a system of increasing complexity of relationships have been designed, to be able to take account of the diversity of needs encountered. This approach is explained in Table 5-1 below.

Table 5-1: Levels of service offered to industry

Level	Character	Relationship	Example
Level 1: Provider of specialist services	Use of existing knowledge, low level of value addition	Strictly contract	Analytical/testing services
Level 2: Contract research to solve immediate problems	Extension of existing knowledge in well-defined area, synthesis and adaptation of current technology	Mostly contract Intellectual property negotiated	Production problems
Level 3: Contract research to produce a new product or process	Generation of new knowledge to enable a significant advance	Contract and/or operational alliances	Totally new product or process
Level 4: Strategic partnership	Relationship stretches beyond a single project or contract, often a strategic alliance, designed to build new business and broaden the client's technological capabilities, high level of trust	Partnership Shared intellectual ownership	CSIR involved in longer-term strategic thinking around the future of the client

FIGURE 1


CSIR
TOTAL INCOME
[redacted]
[redacted]
RANDS
Millions
250
200
150
100
50
0
83/84
84/85
85/86
86/87
87/88
88/89
89/90
90/91
91/92
92/93
FINANCIAL YEARS

2. TRANSPORTATION RESEARCH IN THE RSA

2.1 The National Institute for Transport and Road Research (NITRR)

The CSIR's involvement in transport and road research dates back to 1949, with the establishment of the then Bituminous Binder Research Unit, which was set up to investigate matters related to road surfacing technology in South Africa. The results that emanated from the first road surfacing experiments inspired the funding agencies to submit a memorandum to the National Transport Commission (NTC) of the SA Department of Transport, to stress the need for unbiased and objective road research. The NTC was urged to make funds available from the National Road Fund to support the further development of road research under the auspices of the CSIR.

The NTC and the Department of Transport decided in the early 1950s to assist the CSIR in the establishment of a National Road Research Institute (NRRI), which was then officially formed in 1954 to incorporate the Bituminous Binder Research Unit as one of its divisions. The activities of the Unit was expanded to incorporate the CSIR's Soil Mechanics Division. Various other research divisions were also created, but it was not until 1963 that all parts of the new Institute were brought together under one roof on the main CSIR campus in Pretoria, where it is still situated today.

During the early 1970s, growing concern over transportation problems in the rapidly developing urban areas in South Africa led to a comprehensive investigation of urban transportation matters by the Driessen Committee. Among the recommendations passed were certain proposals that all aspects of urban transport research, including transport planning, traffic control, goods transport, public transport, parking management and traffic management be undertaken by the NRRI, with additional funding. The Institute was then renamed the National Institute for Transport and Road Research (NITRR), and was subsequently expanded and reorganised into three branches: Roads, Transportation and Safety.

Financing of research at the NITRR was, until 1971, done on a year-to-year basis through the Department of Transport. In 1971 the provincial road authorities, which contributed the bulk of research funds, were approached to establish a more rational basis of funding and a rolling three-year funding package was then negotiated and approved by the NTC. Research funding was thereafter made available from contributions by the road authorities, from the National Road Fund and also from the Urban Transportation Fund. Contributions from these funds were annually adjusted to provide for a steady growth in research grants.

The NITRR research staff increased from 124 in 1970 to 328 in 1985, an average annual growth of 6,7 percent. During the same period, research funds increased by an average of 23,6 percent per annum.

A central part of the operations of the NITRR during this period was the management of its research programmes through a system of steering committees that consisted of prominent officials from private sector, universities and the funding agencies (provincial and national road authorities). These committees were responsible for approval of each year's research portfolio and for the monitoring of progress on a quarterly basis. A major benefit of this system was the contact it brought about between researcher and practitioner and this communication was largely responsible for the NITRR's very pragmatic approach to research and for the successful implementation of results. With the restructuring of the CSIR and a parallel change in the administration of research funding, this system was abandoned in 1987 (see comments below).

In the period leading up to about 1985, most of the transportation-related research in South Africa was conducted by the CSIR. Smaller programmes ran at some universities but the NITRR was very much the hub of activity. To an extent this ensured a focused approach to transportation research in South Africa.

2.2 Establishment of the Division of Roads and Transport Technology (TRANSPORTEK)

2.2.1 Background and recent history

During the strategic planning period leading up to the restructuring of the CSIR, it became clear that roads and transport related research had to remain part of the CSIR's core business. Transportation plays a vital role in the economic growth of a country and as such would have to be a focus area for the CSIR in terms of its stated mission to serve industry at large.

Transportek, like the other strategic units of the CSIR, was thus formed as an operationally independent division. Where previously, as the NITRR, it consisted of three branches, the new strategy called for a flat management structure and a number of internal strategic business units or programmes to be established, each focusing on a different sector of the transportation market. The mission of the Division of Roads and Transport Technology is

> *To acquire, develop and transfer technology in support of and in partnership with the transport industry with the aim of facilitating safe and affordable mobility and sustainable socio-economic development.*

At about the same time as the restructuring initiatives, the transport authorities in South Africa decided to move away from a system of unilaterally granting funds for transportation research and established a consortium of research managers to administer the allocation of funding to participating (competing) contractors. Significant effort is expended to identify transportation research needs in the country, based on which contractors are then invited to submit proposals for projects to carry out the work. Emphasis is placed on short- to medium term projects that would yield implementable results. Opportunity is also provided for tenderers to propose projects that they may deem important in terms of their views of research and technology needs.

The participating organisations include TRANSPORTEK, several universities and tertiary institutions, consulting engineers and even public sector bodies. This development resulted in a considerable decrease in the level of funding TRANSPORTEK received from its main client, because available funding is now distributed between the participating bodies. Consequently, TRANSPORTEK's operations had to be cut back dramatically and staff levels have been reduced by about half since 1987.

By way of a proactive response to these events, TRANSPORTEK has since 1988 significantly expanded its operations into other markets. A deliberate strategy to diversify was put into action, which included marketing initiatives into southern Africa beyond the country's borders, the private sector transportation industry in South Africa and international markets. A product development drive, aimed at commercialising certain core technologies, was also started.

The results of these efforts are evident from Figure 2, which depicts the trend in TRANSPORTEK's dependence on research funding from the state road authorities. For the 1993/94 financial year, it is estimated that total income will reach some R17,8 million, just over 60 percent of which will be from contracts with South African road authorities and other public sector bodies.

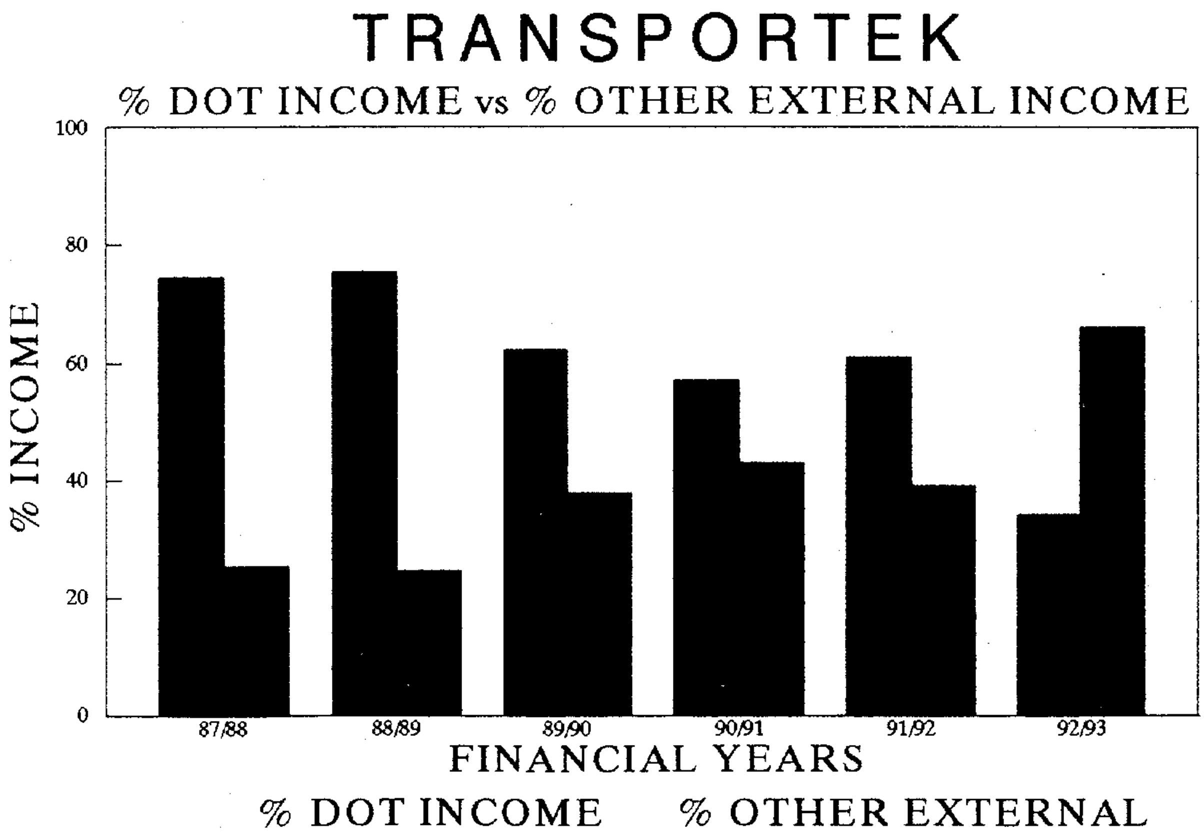
Particular examples of successful diversification include assignments in the southern Africa for the World Bank and the Ministries of Works in Malawi, Botswana and Transkei, contract work for the road authority in Mauritius, a road development assignment in Oman, a research contract with the private sector (Southern Africa Bitumen and Tar Association) and cooperative research efforts with transportation authorities in the United States. In addition, several successful product innovations have been commercialised and some income from royalties and licences have already been realised.

2.2.2 Internal organisation

Transportek's internal structure currently consists of five Research Programmes, in addition to its staff functions of human resource management, marketing/business development and financial services. These programmes function as independent business units, but areas of research are not mutually exclusive. Research activities in these fields require a substantial degree of cross-programme cooperation in order to address the needs of the market effectively. The five units are:

- ***Road Engineering***, where research is directed at pavement and materials analysis, bitumen and asphalt technology, specialist laboratory testing of materials and the evaluation of bridge structures. A particular highlight of the work done in this area is the Heavy Vehicle Simulator, the first fully mobile traffic load simulator of its kind, now having seen some 15 years of extensive testing on South Africa's road system.

FIGURE 2


TRANSPORTEK
% DOT INCOME vs % OTHER EXTERNAL INCOME
100
80
60
40
20
0
% INCOME
87/88
88/89
89/90
90/91
91/92
92/93
FINANCIAL YEARS
% DOT INCOME
% OTHER EXTERNAL

- *The Infrastructure Management and Surveillance Services Programme*, which conducts research into the strategic management of infrastructure, road management systems, urbanisation and transport planning. Activities in this programme have been responsible for the implementation of paved and unpaved road management systems throughout South Africa and significant advances are also being made with respect to the monitoring of road condition using mechanical means and the implementation of decision support systems for transportation authorities.

- ***Transport Operations***, which facilitates research in areas of freight transport, passenger transport, traffic engineering, traffic management, and special operations such as minibus taxis. This programme has recently introduced a weighbridge management system for use by rural road authorities to aid law enforcement and road management, which has now been successfully implemented in South Africa and Malawi.

- ***Traffic Safety Technology***, focusing on traffic safety management, accident investigations, driver training, pedestrian safety and road safety engineering. Staff from this programme were instrumental in the development and implementation of a systems approach to traffic safety management in South Africa.

- ***Strategy and Transport Policy***, focusing on research activities in the fields of decision support in strategic management, policy formulation and infrastructure analysis.

The organisational structure of the Division follows what is commonly referred to as a "flat structure", which significantly enhances communication and flexibility to deal with day-to-day demands. The Division Director is assisted by a management team consisting of the five programme managers and the heads of the human resources, finance and business development functions. Within each programme, operations are managed by the programme manager and his project managers. The latter layer of management takes responsibility for the planning, coordination and execution of a portfolio of projects, while each project is the responsibility of a qualified professional engineer or scientist. Support staff and technicians see to the technical work, surveys, laboratory testing and data processing.

2.2.3 Human resources

The staff complement of the Division currently totals 148 permanent employees, in addition to a number of semi-permanent consulting staff. A hierarchical staff breakdown is as follows:

Line Programme Managers:	5
Project Managers:	19
Engineers and scientists:	48
Technicians and research assistants:	51
Administrative and support staff:	25

Academic qualifications include 8 PhD's, 16 Masters degrees and 77 Bachelors of Science/Engineering and Diploma holders. The CSIR views its employees as one of its most important assets and the staff development programme requires each staff member to commit at least three days per annum to training and development. Assistance is also provided to ensure that academic qualifications are furthered and research staff feature prominently at conferences and seminars.

The areas of expertise covered by TRANSPORTEK's staff include civil engineering, structural engineering, transportation engineering, mechanical engineering, electronics engineering, transport economics, mathematics and statistics, chemistry, operations research, computer science, town and regional planning, engineering geology and environmental sciences.

2.2.4 Facilities

The Division's support infrastructure include well-equipped soils-, materials- and chemistry laboratories, a large computer network, field survey equipment, road monitoring equipment and three operational Heavy Vehicle Simulator Machines. A particular resource is the Product Development Centre, where a team of engineers and technicians devote their time to the process of innovation and commercialisation. A further benefit is that TRANSPORTEK has access to the facilities of the whole CSIR. These would include an information centre with its library and on-line access to international data bases.

2.2.5 Outputs and products

TRANSPORTEK seeks implementation of its endeavours through the following:

- confidential reports for clients, resulting from contract work
- technical reports, resulting from research activities
- conference papers and articles in scientific and engineering journals
- guideline manuals and recommendations for engineering practice
- physical products sold in the marketplace
- specialist materials testing for public and private sector clients
- organising and hosting conferences and training seminars.

A particular feature in TRANSPORTEK's service to industry is its active role in the production of the Department of Transport's industry publications, eg the Technical Recommendations for Highways (TRH), Technical Methods for Highways (TMH) and Urban Transportation Guidelines (UTG) series of manuals and booklets. As a result of close contact with industry, the Division is able to use this avenue as an implementation tool to ensure that research results find their way to the practitioner.

2.2.6 Future perspective

TRANSPORTEK is actively engaged in high-tech R&D aimed at keeping itself at the cutting edge of transportation technology, but is at the same time with diligence seeking ways of appropriately serving the developing communities of South Africa. These two thrusts will remain at the core of the Division's strategy and will be important in terms of ensuring its continued and increasing role as technology agent in the sub-continent.

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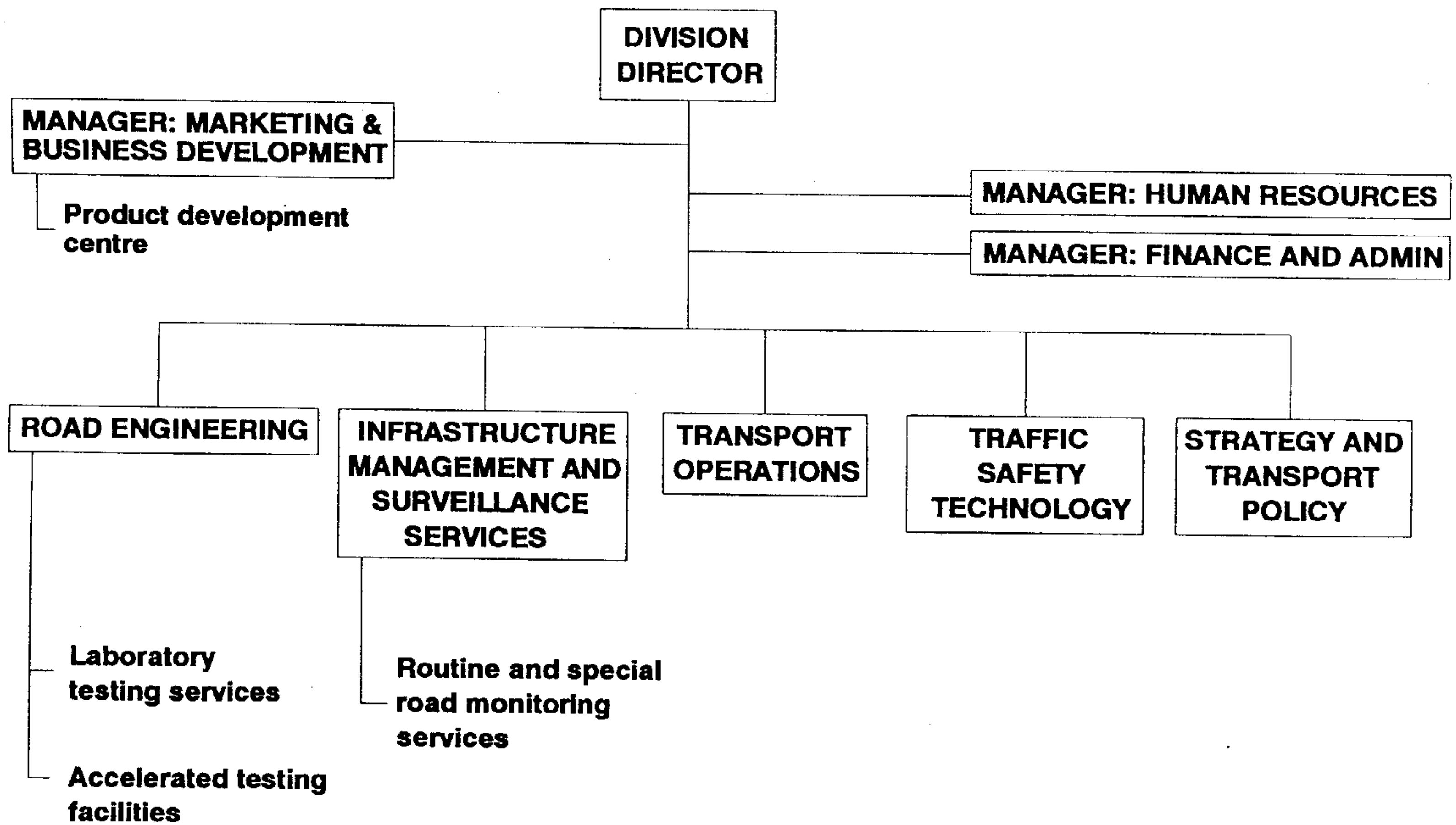
DIVISION OF ROADS AND TRANSPORT TECHNOLOGY

CSIR



6

THE MANAGEMENT OF SCIENCE AND TECHNOLOGY: THEORY AND ASSUMPTIONS FOR THE ESTABLISHMENT AND OPERATION OF THE TRANSPORTATION ENGINEERING RESEARCH CENTRE (TERC)

1. INTRODUCTION: STRATEGIC PLANNING CONCEPTS

The use of planning as a technique to improve the performance of a corporation was identified as early as 1916 and the first writings on the art of management stated that "...management means looking ahead - if foresight is not the whole of management, at least it is an essential part of it. To foresee in this context means both to assess the future and to make provisions for it" (Bhalla, 1987). Developments of thinking in this arena progressed through the following phases:

- *Long range planning*: planning systems were developed in an attempt to deal with diverse businesses by predicting the future of each business and providing for the resources required in an orderly fashion.
- *Strategic planning*: emphasis was placed on directing the corporation's resources into the most promising areas, taking account of the present environment and an anticipated future.
- *Portfolio planning*: techniques such as experience curves and product life cycle analysis are used to explain product/market cost behaviour and the dynamics of international business competition; these concepts emphasise the division of an organisation into a portfolio of homogenous and autonomous businesses.
- *Integrative planning*: this system utilizes the positive attributes of portfolio planning, but corrects it for its deficiencies by emphasising the synergy to be obtained from integrating divergent business areas in a corporation and by addressing of internal growth through technology and market integration. Large corporations such as General Electric have been able to perfect this approach.

The most recent thinking in terms of a strategic approach to business planning is that it consists of three basic components:

- *Premises*: the points of departure of a management team regarding their business are important in terms of identifying scope and direction. If management has an overly emphasised financial orientation, with no regard for its employees, customers, suppliers and social concerns, the viability of the business will suffer in the long term. Values of the management pervades every aspect of planning and impacts on the means chosen to accomplish objectives.

- *Planning*: the goal of planning is to take advantage of future opportunities and to foresee future threats so that actions can be taken to minimise their impact, while meeting overall corporate objectives. In order to achieve this, a company must understand its inherent strengths and weaknesses. The formal planning process takes place in four stages:
  - <u>objective setting</u>, to define the strategic direction of the organisation;
  - <u>strategic planning</u>, to set out a plan in pursuit of these objectives;
  - <u>operational planning</u>, to define short-term objectives, assign responsibilities and allocate resources; and
  - <u>interaction</u> or continuous feedback of functional plans to see if they achieve the objectives.

- *Implementation and review*: as the various functional elements of the plan are executed, it is imperative that the assumptions and logic of the plan be tested against the developing reality. Minor deviations are revised, while major deviations may require a repeat of the planning process.

It seems clear from the above that business planning is an iterative rather than static process and that management needs to revisit their thinking continuously in order to ensure that the plan remains relevant and effective.

Strategic planning responsibility within an organisation rests with three levels:

- *Corporate level responsibility*: selecting the business in which the firm will participate; allocating resources; setting of overall objectives; establishing policies and procedures; and establishing the organisation's management structure.
- *Business level responsibilities*: assessment of the industry in which the organisation is operating; competitor analysis; business strength evaluation; product/service portfolio analysis; and resource allocation.
- *Functional level responsibilities*: determining how various functions will support corporate strategies; and integration of functional plans to ensure synergy and optimum support.

The above gives some perspective as to the processes that will have to be initiated in terms of establishing TERC. Obviously a capacity to have this thinking firmly entrenched will have to be acquired, to ensure that value is derived therefrom beyond the official forming of the organisation.

2. TECHNOLOGY MANAGEMENT: PRINCIPLES AND GUIDELINES

Technology management forms a critical component of corporate strategy. A well thought-through technology management plan will aim at exploiting the competitive advantages inherent in core organisation competencies, products and services, in order to facilitate the achievement of strategic objectives. Therefore, corporate strategy should clearly identify the business of the organisation and the product/service mix it plans to put into the market. Simply stated, it is the purpose of technology to support the execution of strategy. The relationship between technology strategy and corporate strategy is shown in Figure 3.

Philosophies regarding the management of science and technology were first based on the notion that basic research leads to new knowledge, and that it therefore creates the "fund" from which practical applications of knowledge must be drawn. Theories about R&D were formed to represent a so-called "*science/technology push model*", which states that new products and processes result from a process initiated by basic research, followed by applied research and technology development (see Figure 4). Various studies conducted through the years revealed the deficiencies of this approach and this led to a tendency to divest from academic/basic research initiatives.

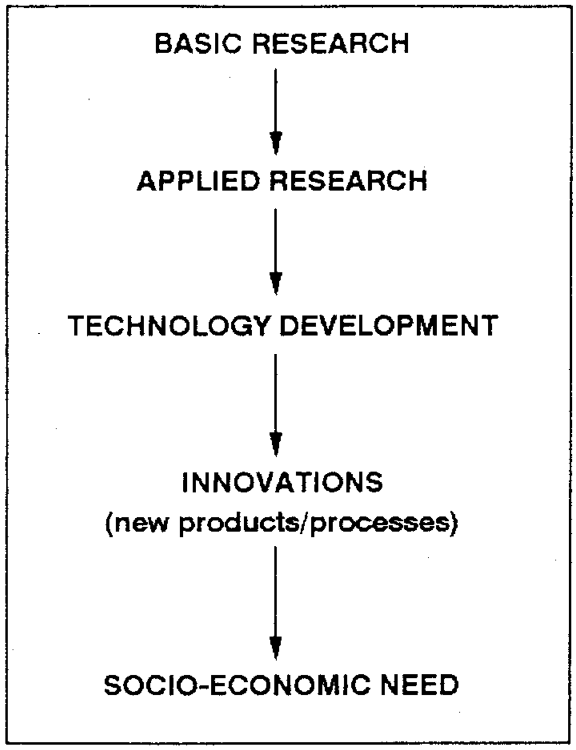


FIGURE 4
SCIENCE/TECHNOLOGY PUSH MODEL

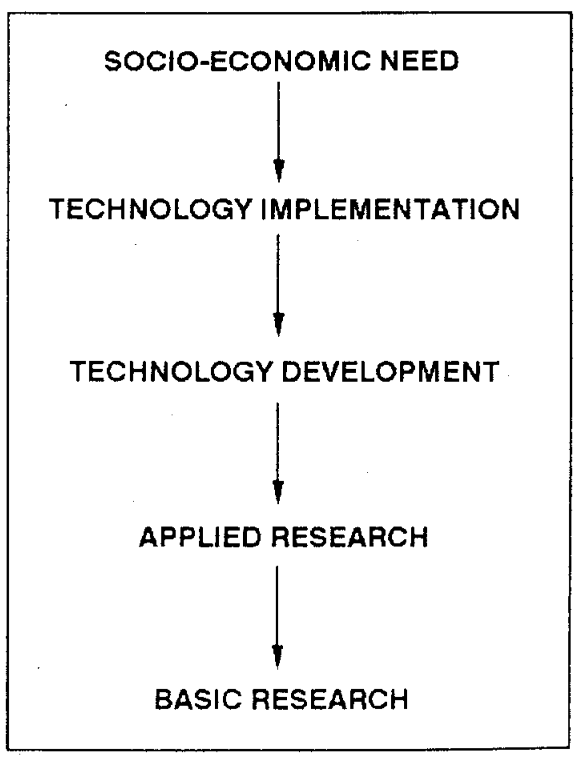


FIGURE 5
MARKET PULL MODEL

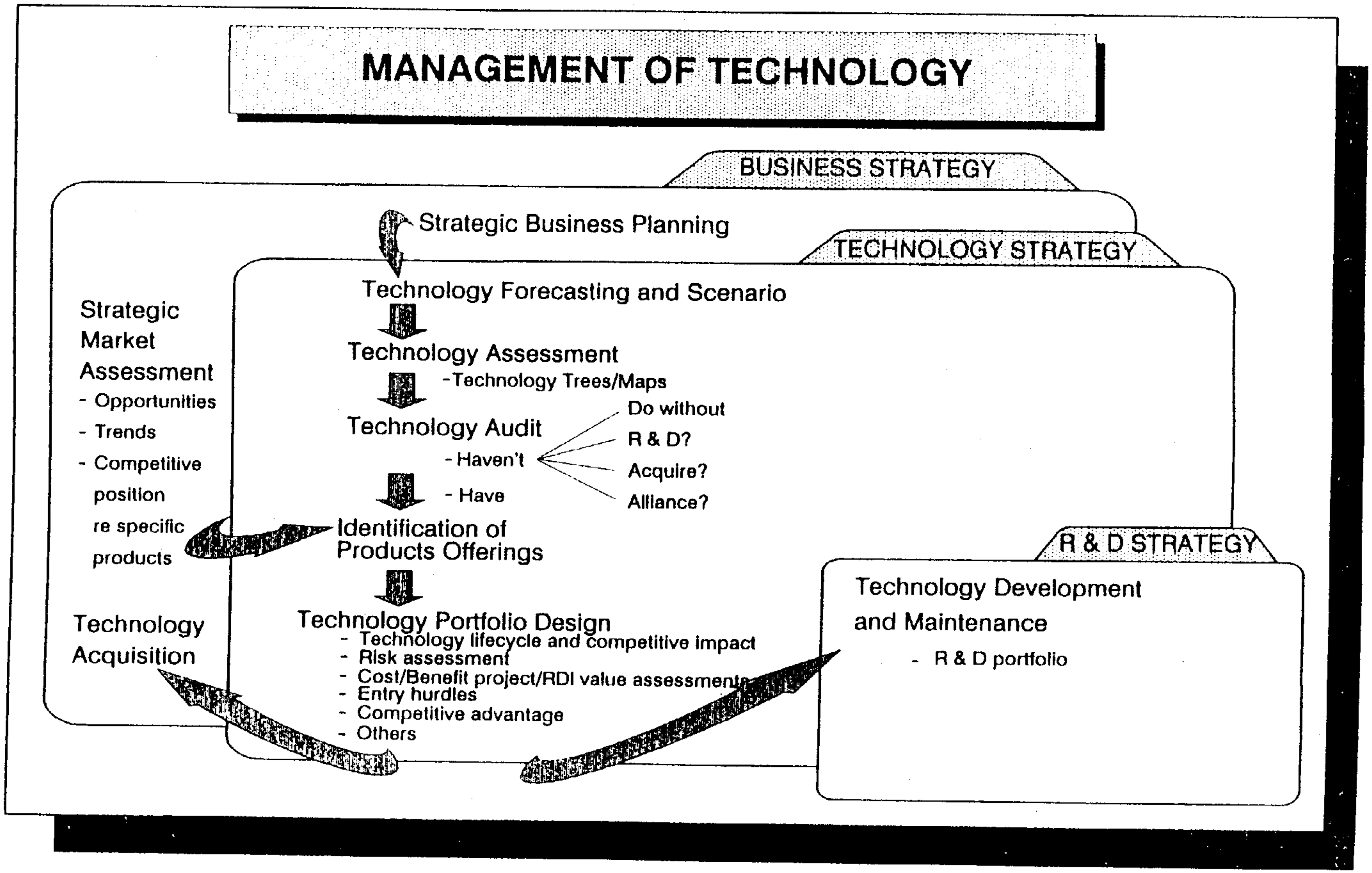

MANAGEMENT OF TECHNOLOGY
BUSINESS STRATEGY
Strategic Business Planning
TECHNOLOGY STRATEGY
Technology Forecasting and Scenario
Strategic
Market
Assessment
- Opportunities
- Trends
- Competitive
position
re specific
products
Technology Assessment
-Technology Trees/Maps
Technology Audit
- Haven't
- Have
Do without
R & D?
Acquire?
Alliance?
Identification of
Products Offerings
R & D STRATEGY
Technology Development
and Maintenance
- R & D portfolio
Technology
Acquisition
Technology Portfolio Design
- Technology lifecycle and competitive impact
- Risk assessment
- Cost/Benefit project/RDI value assessments
- Entry hurdles
- Competitive advantage
- Others

FIGURE 3

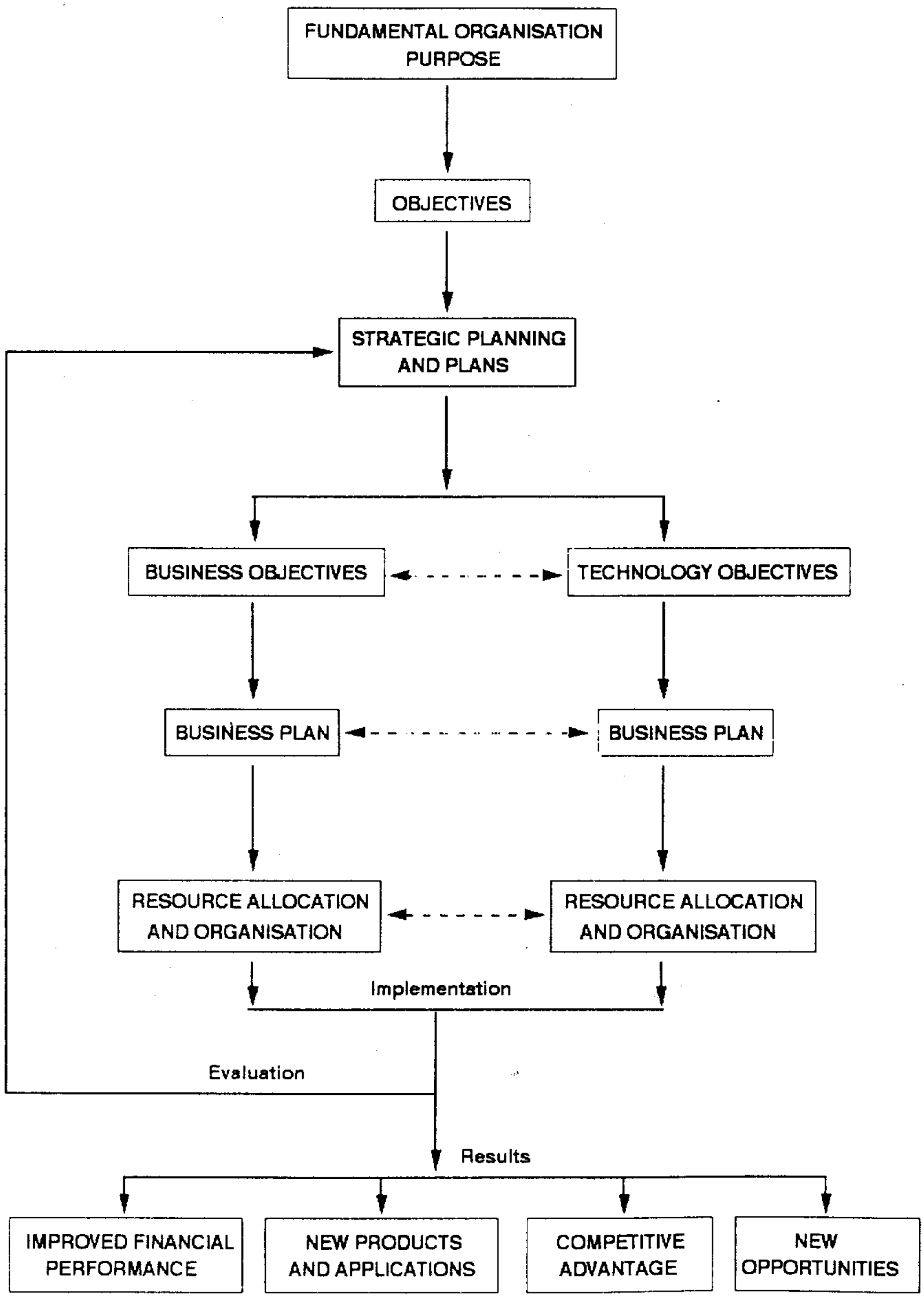


FIGURE 6: INTEGRATED TECHNOLOGY/BUSINESS PLAN MODEL

Studies of innovation showed that neither basic research nor applied science and technology alone adequately describe the successful innovation process. While it is important to realise that all the components indicated in Figure 4 must be present for successful innovations, no simplistic model can do justice to the fact that it is a combination of a number of factors which intermesh and interact to produce successful results.

An alternative model of innovation states that innovations are an outcome of demands generated by market forces, which arise from socio-economic needs. The recognition of these needs force technological innovations, which draw upon applied and basic science to create the hardware which ultimately fulfils the socio-economic need. This model was termed the "*market pull model*", as shown in Figure 5.

Neither of these approaches takes account of the strategic importance of a technology management plan for the corporation and, as has often happened, this led to a lack of understanding between technologists and businessmen, attempts to force-fit business and technology rather than integrate it, and a lack of technical planning. One of the important lessons learnt by business is that technology plans must be incorporated into business plans, and the need for long-range planning.

The following recommendations are important in terms of the effective management of technology:

- *Technology planning* must form an integral part of business planning;
- *Applied research*, technology and its implementation, and business must move in unison, staffing each area with the right skills and talents;
- *Technology management* must have strong leadership to provide challenge, direction and flexibility.

It is indeed true that a successful integration of technology and business planning can impact markedly on the business, by:

- utilising technology resources to create a business edge;
- recognising threats, opportunities and needs from a technology viewpoint and integrating these with business plans; and by
- developing products and services ahead of the competition in areas identified by the integrated technology/business plans.

Figure 6 explains the concept of integrated technology/business planning.

3. A STRATEGIC APPROACH TO TECHNOLOGY MANAGEMENT

Deciding what R&D to undertake and at what level of resources and priority is one of the most critical issues facing management today. Corporate management is increasingly realising that the most decisive factor in the overall success of R&D is the selection of strategically worthwhile R&D goals and that the allocation of resources and establishment of policies to execute the goals must be determined by senior management in a timely and effective fashion.

Apart from the need to operate a viable business entity, other reasons for focusing on effective management of R&D is, firstly, the availability of technical talent. Demands for qualified scientists and engineers far exceed the supply, and this is perceived to be a worldwide phenomenon. Secondly, the increasingly competitive environment in which corporations have to operate demands a rapid and sustained introduction of high-quality, innovative, cost-effective new products and services.

It has been proposed by Roussel, Saad and Erickson (1991) that corporations should, in order to confront these challenges effectively, enter the era of *third generation R&D*, which asks corporate, business and R&D managers to work together in partnership to establish overall R&D strategies that are tightly linked to corporate and business strategies and vision and that focus on providing value to customers and stakeholders in perpetuity.

In the environment of the Institute of Transportation (IOT) and its to be formed transportation engineering research centre (TERC), the relevance of the above is considered to be the role of TERC viz-a-viz the strategic objectives and national priorities of the Ministry of Transportation and Communications of ROC. The contribution of effective R&D management in this environment will be to add value to technologies, however acquired or gained, in response to the needs of MOTC agencies, the transportation industry at large and, ultimately, the public. Equally important, effective R&D management should in the final analysis be aimed at enhancing the competitiveness of the country. There is no question that the successful economic track record of ROC provides for an excellent basis to establish such strategies also in the transportation industry.

In the ROC, the purpose of an R&D strategy for TERC may therefore be stated as wanting to:

- defend, expand and support existing business (the industry as large);
- drive new business (provide a basis for development of new or enhanced competences in the industry); and to
- broaden and deepen the organisation's (industry's) technological capabilities.

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7

CONCLUSIONS AND RECOMMENDATIONS

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APPENDIX B

INDUSTRY QUESTIONNAIRE AND INTERVIEW RESULTS

B - 1 Questionnaire

B - 2 Organisations contacted for initial investigation

B - 3 Summary of industry research needs and comments

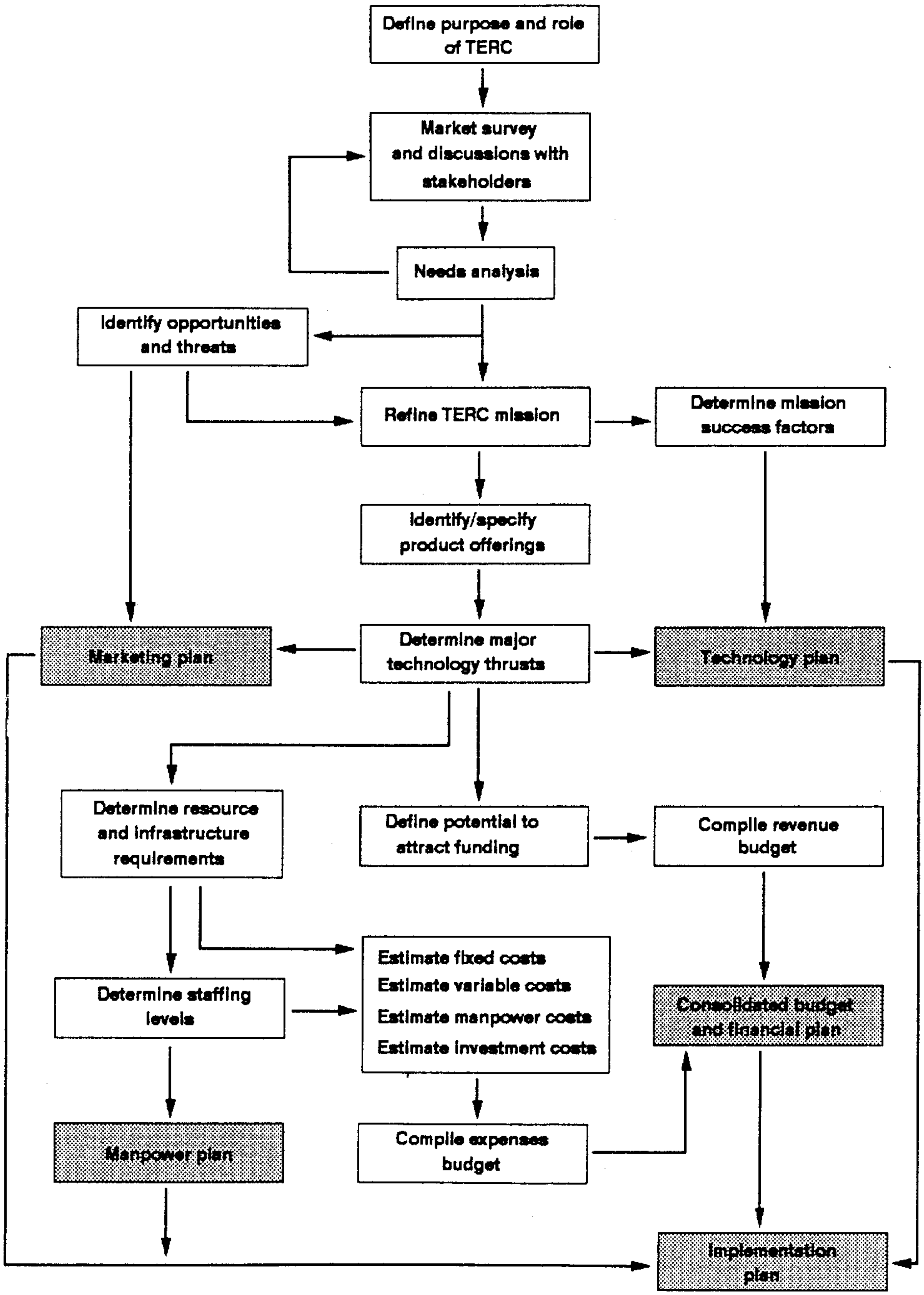

FIGURE 7: BUSINESS PLANNING PROCESS AND OUTPUTS FOR TERC

1. CONCLUSIONS

1.1 Survey of research organisations

This report is aimed at providing some direction and guidance for the efforts required to establish a Transportation Engineering Research Centre (TERC) for the Institute of Transportation (IOT) in ROC. In an attempt to learn from the established transport research institutions in the world, profiles of four prominent agencies were compiled, ie the Transportation Research Board (TRB) in the USA, the Transport and Road Research Laboratory (TRRL) in the UK, the Australian Road Research Board (ARRB) and the Division of Roads and Transport Technology (TRANSPORTEK) of the CSIR in South Africa.

These profiles showed that there appears to be a worldwide trend for research organisations to be under threat as far as funding of their operations are concerned. Consequently, those organisations surveyed have all initiated actions to decrease their dependence on grant funding from the state, by diversifying operations and becoming more customer or market focused. While this in itself will ensure that R&D is aimed at serving the socio-economic needs of society, there is some concern that the importance of basic research may be discounted in the process.

Commercialisation of activities, coupled with a technology management approach that would be in support of such a strategy, has been attempted with varying degrees of success but it would appear from the organisations surveyed that the CSIR has progressed further down this path and with good results to date.

1.2 Strategic management of technology

Writings reviewed on this topic, and perspectives gained from the CSIR's approach to technology management, concur that there must be a tight link between technology planning and overall (corporate) business planning. In the ROC environment this will require the management of IOT and TERC to align their business strategy with state policies and that R&D management should aim to support and expand industry.

2. RECOMMENDATIONS

In the first instance, it is important that the business planning process for TERC takes a strategic view with respect to the market it intends to serve, the technologies it wishes to engage in and the operational approach to be followed. Specifically, issues related to funding of R&D and the trends that are evident in other countries must be examined for the impact these are likely to have.

Secondly, TERC's approach to technology management must be aligned with its overall business strategy, in order that support is provided in the organisation's pursuit of strategic objectives. The notes that have been compiled in the previous chapter, and evidence from organisations that have been able to do this successfully, should be used to guide planning efforts. Figure 7 provides a suggested approach for the planning effort to be engaged in and will also serve as a framework for assessing progress.

APPENDIX B-1

QUESTIONNAIRE

TERC QUESTIONNAIRE

NAME : ____

POSITION : ____

ORGANISATION : ____

DATE : ____

1. Is transportation a serious or priority issue in the ROC? Please justify.

2. Would transportation in the ROC benefit from more investment in research and development?

3. What, in your opinion, should be the primary function of the TERC?

4. Which other functions or services should TERC perform or provide, eg specialist materials testing laboratories, special apparatus, etc?

5. What particular research needs do you and your organisation have?

____

____

6. Are there any other issues or needs related to transportation in the ROC, other than those listed under 5, that TERC should take account of?

____

____

7. How would your organisation wish to interact with TERC?

____

____

8. Will your organisation be will to contract TERC for research and development work and/or specialist consulting work?

____

____

9. Should TERC be wholly funded by government? Please justify.

____

____

10. What role should universities play in transportation research and development in ROC?

____

____

11. Should TERC form alliances with other research organisations in the ROC and internationally? Please justify.

____

____

12. Which suggestions do you have for the management of operations of TERC?

____

____

Thank you sincerely for completing this questionnaire. If you have any additional comments or remarks, please enter these overleaf.

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APPENDIX B-2

ORGANIZATIONS CONTACTED FOR INITIAL INVESTIGATION

ORGANISATIONS CONTACTED AND INTERVIEWED

ORGANISATION	SECTOR	CONTACT PERSON	DESIGNATION	TELEPHONE	FAX
BES Engineering Corporation	Private sector construction	Kuo, I-Yen	General Manager, Civil Construction Department	(2) 775 9455	(2) 731 4901
China Engineering Consultants Inc (CECI)	Private sector consulting	Shieh, Dah-Yung	Manager Dept of Transportation and Civil Eng	(2) 736 3567	(2) 735 8006
Sinotech	Private sector consulting	Chang, Chi-Tso	Vice President	(2) 769 2131	(2) 765 5010
Environmental Protection Agency (EPA)	Public sector Environment	Young, Chea-Yuan	Deputy Director General	(2) 311 7722 ext 2751	(2) 311 3185
Taipei City Gvt Public Works Department	Public sector Roads	Juang, Wu-Sheong	Head, 1st Division	(2) 541 7984	
Public Construction Supervisory Board	Public sector Construction	Li, John C	Deputy Executive Secretary	(2) 388 4962	(2) 331 5808
Engineering Office of Taipei Underground Rail	Public sector Construction	Chang, Chin-Chu	Deputy Director General	(2) 349 6605	(2) 349 6606
Engineering Office of High Speed Rail	Public sector Construction	Wang, Ming-Hsiung	Section Chief: Geotechnical Engineering	(2) 349 5849	(2) 311 1139
Taiwan Area National Expressway Engineering Bureau (TANEEB)	Public sector Design and Construction	Liaw, Tony	Chief R&D Section	(2) 515 6777	(2) 504 1281
National Bureau of Standards	Public sector Standards	Chang, Angela M H	Deputy Director, Dept of Weights and Measures	(2) 732 0499	(2) 735 5769
Taiwan Highway Bureau (THB)	Public sector Provincial Government	Chen, George S Y	Director General	(2) 311 0929	(2) 381 1394
Taiwan Area National Freeway Bureau (TANFB)	Public Sector Road management	Ou, Huei-Jeng	Deputy Director General	(2) 909 3202	(2) 909 3218

ORGANISATIONS CONTACTED AND INTERVIEWED (CONTINUED)

ORGANISATION	SECTOR	CONTACT PERSON	DESIGNATION	TELEPHONE	FAX
National Science Council	Public sector	Hsieh, Charng-Horng	Vice-Chairman	(2) 737 7506	(2) 737 7668
Taiwan Housing and Urban Development Bureau	Public sector Provincial Government	Jou, Chau-Sheng	Chief: Road Engineering Dept	(2) 781 9462	-
National Taiwan University	Academic/Public sector	Chou Chia-Pei	Associate Professor: Dept of Civil Engineering	(2) 362 5920 ext 302	(2) 363 3971
National Central University	Academic/Public sector	Lin, Jyh-Dong	Associate Professor and Head: Dept of Civil Engineering	(3) 425 5239	(3) 425 2960
Automotive Research and Testing Centre (ARTC)	Public sector	Chung, Michael	Unknown	(2) 703 0171	(2) 701 6240
Institute of Transportation (IOT)	Public sector Research	Chang CJ Dr Feng, Cheng-Min Dr Hou Ho-Shong Dr Yang Chiu Lin	Director General Deputy Director General Chief: Tpt Eng Div Chief: Inter-Disc Res Div Chief: Tpt Ops Div Chief: Tpt Safety Div	(2) 712-3121	(2) 717 6381 (2) 712 0223

APPENDIX B-3

SUMMARY OF INDUSTRY RESEARCH NEEDS AND COMMENTS

SUMMARY OF INDUSTRY RESEARCH NEEDS AND OTHER COMMENTS

ORGANISATION	PRIMARY FOCUS AREAS OF TERC	OTHER REQUIRED SERVICES	R&D NEEDS OF RESPONDENT	FUNDING AND OPERATION OF TERC
BES Engineering Corporation	Technologies to improve and maintain the transportation network; Solutions for problems encountered during design and construction.	Development of design methodologies and construction techniques	Improved construction techniques Improved usage of available and new construction materials	Government to fund less than half of TERC's budget; balance through contract work and private sector participation
China Engineering Consultants Inc (CECI)	Pavement design and materials; Bridge structures: foundation engineering, structural analysis, seismic studies; Computerised traffic management and control systems; Traffic safety systems.	Standardisation of codes and specifications		Mainly from central government, yet private sector may contribute through contracting TERC for specialist consulting assignments.
Sinotech Engineering Consultants Inc	Upgrading and development of ROC's engineering technologies in design, construction and maintenance of transportation systems.	Expertise on tunnel ventilation; Rock classification; Materials testing services; Environmental issues; Traffic control systems.	Local geological rock classification system, Tunnel ventilation technology; Testing of bituminous materials.	Wholly funded by government
Environmental Protection Agency (EPA)	Road transportation, especially road condition assessment and control of noise	Control of noise generated by airports; Standardisation of roadbuilding specifications.		TERC should not duplicate existing facilities (eg ARTC).
Taipei City Gvt: Dept of Public Works	Development of a pragmatic approach to pavement engineering technology in ROC, including roadway maintenance and standards/specifications.		Technologies for road maintenance; Modelling of driver behaviour; Safety at roadworks; Standardisation of specifications; Control of heavy vehicle overloading; Holistic approach to transporattion planning for Taipei city.	TERC must operate as an independent, objective agent and against this requirement, funding sources must be carefully considered.
Engng Office of the Taipei Underground Rail (TRUPO)	Development of transportation technologies		Rail/Tunnel construction technology; construction management; integrated transportation planning for Taipei city.	Partially funded by government.

SUMMARY OF INDUSTRY RESEARCH NEEDS AND OTHER COMMENTS (CONTINUED)

ORGANISATION	PRIMARY FOCUS AREAS OF TERC	OTHER REQUIRED SERVICES	R&D NEEDS OF RESPONDENT	FUNDING AND OPERATION OF TERC
Taiwan Area National Expressway Engineering Bureau (TANEEB)	Pavement engineering			Greater proportion funded by government but also some from other public sector agencies and contract income from private sector TERC should play a coordinating role in ROC's research efforts aim to strike a balance between longer term and short term R&D
National Bureau of Standards	Transportation engineering		Revision/standardisation of specifications	
Taiwan Area National Freeway Bureau (TANFB)	Pavement engineering	Forecasting of road users' needs; materials and pavement design/maintenance durability of materials bridge maintenance	Materials and methods for pavement and bridge maintenance	
Taiwan Highway Bureau (THB)	Setting up of an overall multi-modal transportation systems master plan for ROC; standardisation of specifications and codes of practice; innovations in materials and technologies; operation of a transportation systems information centre to the benefit of all transport authorities in ROC; studies of future technologies.	Specialist advice i r o new materials and methods; centralised data collection and survey/surveillance service; specialist materials testing laboratories, training of post-graduate students	Improvement of road riding quality pavement designs appropriate to local conditions assessment of the performance of new methods and materials; quality control systems for construction works	Wholly funded by government professional staff must be attracted through better salary structures R&D programmes must seek cooperation with other institutions
National Science Council (NSC)	Must serve the needs of private and public sector transportation agencies	Coordination of R&D activities and creating opportunities for universities, etc to take part in research efforts		Government funded, but longer term thinking should allow for private sector participation

SUMMARY OF INDUSTRY RESEARCH NEEDS AND OTHER COMMENTS (CONTINUED)

ORGANISATION	PRIMARY FOCUS AREAS OF TERC	OTHER REQUIRED SERVICES	R&D NEEDS OF RESPONDENT	FUNDING AND OPERATION OF TERC
Engng Office of High Speed Rail	Systems design and engineering; Safety analysis; environmental impact assessment.	Development of design, construction, maintenance and testing technologies;	Railway signalling; noise and vibration reduction in train sets; quality assurance; heat-resistant braking systems; use of regenerated electricity; training of professionals; benefits of HSR to Taiwan.	Government should take the lead, but private sector must have the opportunity to participate The objectivity and independence of TERC is important.
Public Construction Supervisory Board, Executive Yuan	Pavement engineering including materials R&D and full-scale testing; Traffic management, signalling and control.		Coordination of road management efforts of city and semi-urban/rural transport authorities; Holistic transportation planning from a systems perspective, in realisation that Taiwan is becoming urbanised.	TERC should make optimal use of existing facilities, should ultimately play a a coordinating role, and efforts must be aimed at implementation
National Taiwan University	Pavement engineering	Testing facilities and equipment that are either too expensive or too specialised for universities to own	Comprehensive data acquisitioning services in all areas of transportation engineering; coordination of research efforts in ROC	TERC's mission should be to contribute toward the improvement of level of service offered by the transportation systems in ROC, eg reduce congestion, improve traffic safety, upgrade quality of road systems.
National Central University	Pavement engineering initially, may expand later	Coordination and integration of transportation R&D activities in ROC; information service to all of industry, gathered from local and overseas sources.	Materials testing; pavement engineering; TERC should act as a technology transfer agent.	Availability of manpower may inhibit establishment of TERC, therefore should start on smaller scale in areas where visible benefits could be achieved early; independent character of TERC is important; TERC should establish strong links with R&D agencies and industry.

APPENDIX C

THE APPLICATION OF INFORMATION TECHNOLOGY IN IOT

APPENDIX C

The application of Information Technology in the Institute of Transportation, ROC

Confidential Contract Report IOT/93/3

Dave Lockwood

Computer Technology
TRANSPORTEK, CSIR

March 1994

CONTENTS

APPENDICES

1. INTRODUCTION

As part of the the CSIR study into the establishment of a Transportation Engineering Research Centre (TERC) in the Institute of Transportation (IOT), it became increasingly clear that the application of information technology (IT) in IOT could have a major impact on the role of IOT within the broader transportation industry within Taiwan.

This report has three functions.

- Definition of what is meant by IT and its application to the current research environment in the 1990's
- An assessment of existing computer facilities and usage within IOT
- Definitions of actions that need to be taken in order to ensure that information technology in it's true sense becomes a reality within the IOT/TERC organisation.

2. INFORMATION TECHNOLOGY AND RESEARCH: BACKGROUND

Information Technology can be defined as the set of computer and telecommunications technologies that makes possible the computation, communication, as well as the storage and retrieval of information. It has changed the conduct of research - be it scientific, engineering or clinical research.

Much of the following reflect the findings of an American study into "Information Technology and the Conduct of Research"[1]. This study was undertaken on behalf of the National Academy of Sciences, National Academy of Engineering, Institute of Medicine and the Committee on Science, Engineering and Public policy (National Academy Press, 1989).

2.1 Technological developments

The first programmable computer appeared almost 50 years ago. These early computers were substitutes for other means of carrying out arithmetic calculations. They were large, expensive, often unreliable and only accessible to a small number of scientists and engineers. The development of the integrated circuit (the computer "chip") led to vastly increased computational speeds and power.

Recent developments in desktop personal computer (and UNIX Workstation) technology and similar developments in telecommunications technology have joined to create a new technology - **"Information Technology"**.

In the data communications field, large developments have taken place in modem and switching technology. Prices of modems have decreased rapidly recently (even the cheaper modems today have fax capabilities) and speed capabilities have increased significantly. Telephone networks have seen large increases in data transfer speeds. Satellites are also becoming available for general communication.

Politically, the end of the so called "cold war" has released many resources for public use. A classic example is the INTERNET which was originally established as a western defence communication network with no clearly defined centre. As defence budget funding dried up, the operators of INTERNET (typically universities) are forced to look for other paying users to cover costs.

These changes in technology (and politics) have given the ability for more numerical analyses to be undertaken at higher speeds and for information to be easily accessed by all. Changes in these technologies must obviously have an impact on research and the undertaking of research.

2.2 Information technology and research

Four aspects of the research process have been fundamentally impacted by Information technology. These are:

Data collection and analysis: A number of trends can be identified, including:

- Growth in the amount of information researchers can store and analyse
- Creation of new families of computer-controlled instruments
- Proliferation of (global) computer networks dedicated to research
- Increasing availability of "off the shelf" software packages supporting research activities.

There are currently a number of problem areas associated with data collection and analysis, including uneven access to computer resources, problems in obtaining support for specialist software development and maintenance and unnecessary complexities of transmitting data over computer networks.

Communication and collaboration: Information in the 1990's can be shared more quickly and more importantly, researchers are developing new collaborative arrangements. Three enabling technologies (word processing, electronic mail and electronic information storage/retrieval) make this possible.

Word processing and **electronic-mail** can be seen as been the most prevalent of all routine uses of computers in research communication. Electronic mail is starting to partially replace written and telephone communication amongst many communities of scientists. Global networks are often used by scientists for conversation and the repeated exchange of ideas as well as text and data files.

Amongst the most important applications for information technology is the emergence of truly national (and international) research networks. These types of links are becoming well developed in the sciences (for example BIONET) but less so in the engineering sector.

There are a number of problems in communicating via electronic mail and with file transfer, including:

- Incompatibility between text and data processing systems
- Incompatibility between network protocols
- Network limitations (for example bandwidth), cumbersome addressing conventions, non-existent locator services and overall network availability/reliability.

Electronic information storage and retrieval: Computer technology holds enormous advantages as information can be stored economically, found quickly without going to another location and moved easily. For all disciplines, both scientific data and reference databases promise to be a significant source of knowledge for both basic and applied research.

There are however a number of problems areas:

- Researchers have difficulty getting access to data stored by other researchers
- When they do get access, they have difficulty reading the data
- If the above two hurdles are overcome, there is often no information on the *quality* of the data
- A more fundamental problem lies in undertaking searches on references databases. Most searches at present tend to be incomplete, cumbersome, inefficient, expensive and only executable by specialists.
- Stored data becomes obsolete - either through the storage technology becoming obsolete or through decay of the physical media.

New computer-based technologies will, and indeed are overcoming these problems and offer new ways of finding, understanding, storing, and communicating information. This must increase both the capabilities and productivity of researchers.

2.3 Other impediments to the implementation of information technology in research

Many difficulties in the implementation of information technology are underpinned by institutional and organisational behaviour.

- Financial impediments can be chronic. There is a tendency to motivate computer technology in terms of reduced costs - however the true implementation of information technology requires investment and makes continual demands on research funds.

- The lack of simplified and consistent standards for the operation and interconnection of computer systems have major impact on research communication and productivity. The development of standards is a slow and controversial process.

- The need to safeguard and maintain confidentiality of an individuals' personal data is a major issue, both legally and ethically.

- There are significant gaps in training and education. Learning to use information technology requires considerable investment both financially and in time and effort. Researchers who make these investments often receive little help. While this impediment should diminish in time, it does affect current attitudes towards the use of information technology.

- Organisations and administrators can be (understandably) reluctant to make the substantial changes required to make use of information technology.

- Finally, there tends to be a lack of infrastructure for the use of information technology; access to experts (or support mechanisms to develop new experts); tools for developing and managing software; storage and retrieval systems as well as support services for communication and collaboration among researchers.

3. EXISTING COMPUTER RESOURCES WITHIN IOT

IOT computer resources are mainly based around the IBM compatible PC, but with some other peripheral computer resources.

3.1 Computer support facilities

The Transportation Information Systems Division is currently responsible for the support and maintenance of computer facilities within IOT. Dr Humphrey Hu takes responsibility for this function - with five other staff members. There is a small Computer Room on the third floor of the IOT Building, but no formal Computer Centre currently exist within IOT. The Computer Room houses an IBM System 36, a Wang terminal, several printers and dedicated PC's as well as a Novell file server and two laser printers.

3.2 IBM compatible computer hardware

There are currently 101 PC's in IOT (mainly 486/VGA based):

Division	No staff*	No PC's	Networked PC's
DG/DDG/Sec Gen	7	3	0
Transportation Planning	15	17**	10
Transportation Engineering	13	15	4
Transportation Operations & Man	14	14	4
Transportation Safety Systems	12	15	5
Transportation Information Systems	17	19***	9
Interdisciplinary Research	10	10	3
Administration	4	2	0
Personnel	4	2	0
Accounting	5	4	0
TOTAL	101	101	35

* Only one or two administrative staff per Division
** Plus five note-books
*** Including computer room and Information Centre (3)

All staff members who have a need, have access to a Personal Computer. However the number of PC's with access to the network is currently low as a percentage of all PC's (35%).

3.3 IBM compatible computer software

There is an equal split between DOS users (mainly admin staff) and Windows users (mainly research staff). Typical software used is:

Windows	Windows 3.1, Microsoft Word, AmiPro, Powerpoint, Excel, Harvard Graphics and dBase-III. Windows has been "driven" into IOT over a 14 month period.
DOS	(DOS 5), Lotus 1-2-3, PE2, Wordstar, dBase-III and Fox-Pro, Autocad, Transcad.

Software piracy is not a major issue within IOT. IOT stated policy is that pirate software will not be used. To this end NT$1.2m was invested in the purchase of software in the last financial year (including NT$500 000 on Oracle). NT$350 000 has been spent this year to date. Departmental memo's are regularly distributed to all staff as a reminder that they are personally responsible for software in their environment.

3.4 Software standards

With the exception of pirate software, there are no standards in place to define which or what software is used within the organisation. If a new research officer has a justification for using his own preferred software (eg SAS), then that software will be purchased. This can lead to problems in data or document interchange - and in the worst case, ASCII is used for interchange.

In addition, Dr Hu informally guides users towards a limited range of packages - 70% of all users use Microsoft Excel (spreadsheet) and in the Windows environment, 60% use MS-Word and 40% AmiPro (though there are some small problems with interchange).

3.5 Data-base systems

IOT does not currently maintain or develop routine data-base systems, but are regular users of data-bases from other Government Departments. Small IOT systems (developed for research use) tend to be based on DBase III, Clipper and more recently, Oracle.

Vehicle registration and Traffic licence and violation data is maintained at the Data Communications Institute in an HP9000/INFORMIX system and accident data system at Police headquarters. This data is used regularly by the Transportation Safety Division of IOT.

There are plans to set up an extensive and comprehensive Transportation data base system. This is discussed separately.

3.6 Network facilities

A Novell file server was installed in November 1993. However only a small proportion (35%) of IOT PC's are currently connected to the LAN system. The LAN is based on a Novell v3.11 operating system (50 user licence) and 802.3/UTP 10BaseT topology.

The file server itself is a 486DX-33Mhz with 32 Mb RAM. Two SCASI 600 Mb hard drives allow for disk mirroring under SFT level II.

The LAN is currently not used extensively with typically 3 to 7 users at any one time. Researchers tend to either operate their own PC's independently - or are not yet connected to the LAN. In this regard, a further 25 network cards have been recently approved by for purchase.

A number of remote HP laser printers (up to 20) are distributed around the building (with two in the Computer Room), but most seem to be either idle or not connected to the LAN. It is expected that the recent purchase of an A3 laser printer will attract users to the LAN environment.

Most LAN users work in a Windows (3.1) environment. Windows version 3.11 (more appropriate to a LAN environment and complete with a Microsoft E-mail and a Scheduling facility) is not used as Microsoft have not yet published a Chinese version.

A new 486 based computer has also been reserved to provide a remote control facility for a fax machine.

3.7 E-mail facilities

Given that the network facility only extends to a few users in IOT, and that MOTC has yet to set up any extensive LAN, it is not surprising that e-mail has not been established in IOT. There are no plans to set up such a system in the forseeable future. Currently, communication between IOT and MOTC (over and above the telephone) consists of a Wang printer and a messenger system with two deliveries per day.

3.8 PIPMAIL

Tests are under way using an e-mail system operated by the Taiwan public telephone company. This system (called "**PIPMAIL**") is X400 based and allows E-mail connectivity between organisations.

PIPMAIL has five disadvantages:

- There is no automatic way of knowing that mail is waiting
- The sender is not aware that the recipient has picked up the message
- The recipient cannot sign to indicate receipt of the message
- A mail box would only be established for each IOT Division, not for individuals
- Each link into PIPMAIL involves a local telephone call

While PIPMAIL is not suited to communication within IOT, it could however enable communication between IOT and several other MOTC offices (as well as other transportation related offices). PIPMAIL is currently available from one test PC in the Computer Centre.

Global Message Handling Systems (MHS) has not been considered, WordPerfect (Office) is not very popular in Taiwan and individual e-mail boxes are not seen as important at this stage. Messages can be stored in the IOT (or MOTC) VoiceMail facility and with only three floors in the building, people are happy to walk. Further, there are currently no Chinese e-mail systems available in Taiwan.

3.9 Voice mail

Voice mail facilities are used extensively within Taiwan. Most companies have exchange systems which have electronic messaging to advise the caller to dial the extension number required or to leave a message (on tape) if there is no answer. A similar facility exists on the IOT exchange system.

However, this particular system involves a number of steps and key presses to leave a message. Messages are stored on tape (each extension number represents a mail-box) and recipients can store their messages, add comments, or delete the message. The message cannot be passed on to other users.

In practice, the voice mail facilities are not widely used within IOT.

3.10 IBM System 36

This machine is used primarily for administration within each Division. The computer is old and obsolete but there are plans to upgrade as soon as budget permits (possibly 1995).

3.11 WANG remote terminal

This terminal (linked by dial-up modem to MOTC) is basically used by the Safety Division to input accident data, undertake ad-hoc analysis and down load traffic accident reports from the Wang computer system at MOTC.

A slave printer on the terminal is also used by MOTC when they want to send an important/urgent message between MOTC and IOT. Messages are printed on the printer, and hand delivered to the recipient.

3.12 IBM 386

This computer is used solely by the Personnel staff to link to the MOTC mainframe computer via a Baseband modem. A terminal emulation package is used for this purpose.

3.13 Switching facilities

A patch panel system enables network users to be manually switched between the Novell LAN, Wang or IBM System 36. Dr Hu does this on behalf of users on request. In practice, this facility is rarely used as it is quicker to walk to the computer room to use Wang or System 36 resources.

3.14 INTERNET

INTERNET is not widely known and access to the INTERNET is not seen as a high priority until the new Computer Centre and proposed data-base systems are operational.

IOT can access TAINET (Inter Taiwan system linking all colleges and campus's) and which is managed by the Ministry of Education as well as BITNET. These links are seen to be adequate.

The Ministry of Education manages the Taiwan section of the INTERNET. The Ministry could link IOT into the INTERNET. In theory therefore, it should be relatively easy to set up a link into the INTERNET via TAINET.

3.15 Chinese characters

A major problem restricting the application of computer technology in IOT is the difficulties in generating Chinese characters. Recent hardware developments (the 496 chip, Windows, the VGA screen and True-type printer fonts etc) have improved matters.

The basic problem lies with the ASCII standard (a global standard setup to define how computers communicate with each other). The ASCII standard, developed in the English speaking world defines 127 fixed characters (in terms of Binary digits) as well as a number of extensions to accommodate a further 128 characters. However, there are 4000 Chinese characters in popular use, about 14000 characters in the general language, and up to 17000 characters used by information centres such as libraries. When the 4000 base characters were simplified earlier this century, the scale of the problem increased further.

Five methods have been developed to enable the input and printing of Chinese characters which are screen displayed or printed from a font set. The most common way is to input the phonetic symbols for each word which are then concatenated by the software to generate the Chinese character. A number of packages (such as Microsoft Word and third party add-ons") now allow input in this way. A normal ASCII character uses two bytes to generate the character. A two-byte combination is used to indicate the character required. WordPerfect has not yet released a Chinese version of their products and is therefore not popular in Taiwan.

While this method gets around the problem, the input method is cumbersome and 15 characters (or words) per minute is considered good. For example the word "today" requires 12 key strokes to generate the Chinese character. The character data is still stored on disk in ASCII and large amounts of disk space are required for screen and printer font storage.

Therefore some Chinese computer users work in English and translate the document if required, while others either work slowly or write manually (even if they have a PC) and employ typists to input the characters.

It is important to keep in mind that at both IOT and the MOTC, the language problem was cited as the main reason why E-mail (and individual E-mail boxes) cannot be used in their environment.

3.16 Planned Computer Developments within IOT

A number of developments are taking place within IOT regarding Information technology and computers:

- The LAN is still been expanded on an ad-hoc basis.

- Approval (in principal) has been obtained for the establishment of a Computer Centre within the Information Division. It is planned to expand the existing 5 computer staff to 15 and to generate a significant data base system for the Transportation industry.

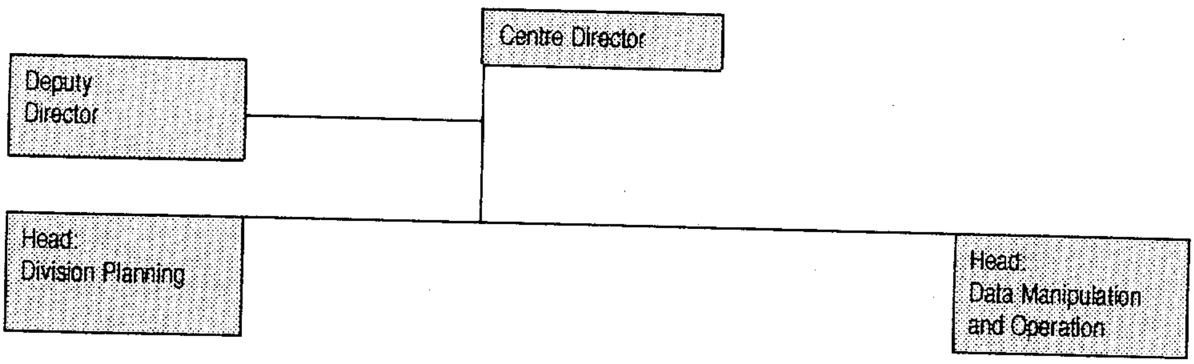
- It is planned to set up the Centre during 1995 if funds become available. The new Centre would have up to 15 staff (compared to 5 people presently). The development of this Centre is discussed separately in Section 4.

- IOT will be moving to a new building in May 1995. The Computer Centre will be housed on the 6th floor (seven offices, a computer room and large laboratory). Existing IOT Divisions have been allocated the 5th to 12th floor - the 1st to 4th floor will be left empty (for expansion) or let to another government unit. There will be 2 to 3 floors allocated for TERC. The total construction cost will be in the region of NT$750m.

4. PROPOSED NEW COMPUTER CENTRE

It has previously been identified in this report that there is at present no formal Computer Centre within IOT. However, there has been much progress towards the founding of such a Centre.

Approval has been granted in principal to establish the Centre - with a planned start-up date of July 1996 - in the new building. A number of details still have to be finalised between IOT and MOTC, but it is envisaged that the Centre will operate with around 20 staff members, as follows:



1	Senior Planner	1	Senior Information Analyst
2	Information System Planners	1	Assistant Systems Analyst
2	System designers	2	System operators
3	Assistant System Designers	4	Assistant system operators

The above structure refers to the Head as "Centre Director". This is how the structure was described. However, this does not necessarily indicate that a third Centre within IOT will be formed. It is not yet clear exactly where the Computer Centre will fit into the IOT/TERC hierarchy. Three possibilities were identified:

- The new Centre will reside as now as part of the Transportation Information Division of IOT
- The new Centre becomes a new Division of IOT in it's own right
- The new Centre actually does become a third Centre within IOT as implied by the title "Centre Director".

It would appear that the location of the new Computer Centre within the IOT heirachy will not be finalised until the actual roles of the Computer Centre are defined and implemented.

Three possible goals, or operational areas for the Centre have already been defined by IOT:

- Computer support to IOT research staff
- Co-ordination of software development
- Development of a number of National Transportation data bases

4.1 Goal 1: Computer support to IOT staff

This will continue in much the same way as now. Support will be at two levels. Firstly PC hardware and software support to IOT users, and secondly support and management of the existing network. It is expected that the network will continue to grow.

In addition to user support, the Centre will also make training facilities available. At present, when a new package is purchased, a training voucher is also supplied (valid for six months) which allows the end-user to arrange his own date to go on a training course on that package.

4.2 Goal 2: Co-ordination of software development

IOT do not in general develop and market their own software. If research findings could be applied to a new package, a specification may be drawn up and given to a computer company (who have to submit a proposal first) to develop and distribute. It is also envisaged that copyright would be held by IOT who can then claim a royalty income. However, this income would not go towards IOT funds, but would be returned directly to Central Government funds.

It was not clear how many packages have been developed to date, but the above reflects current thinking on how software could be developed and distributed in the new Computer Centre.

4.3 Goal 3: National Transportation data base management system

The most ambitious goal for the new Computer Centre is the development of a National Transportation data base system. It is envisaged that the Data-base system will have 48 Transportation sub-systems (listed below) plus 12 internal IOT administrative systems (financial, personnel, budgeting etc).

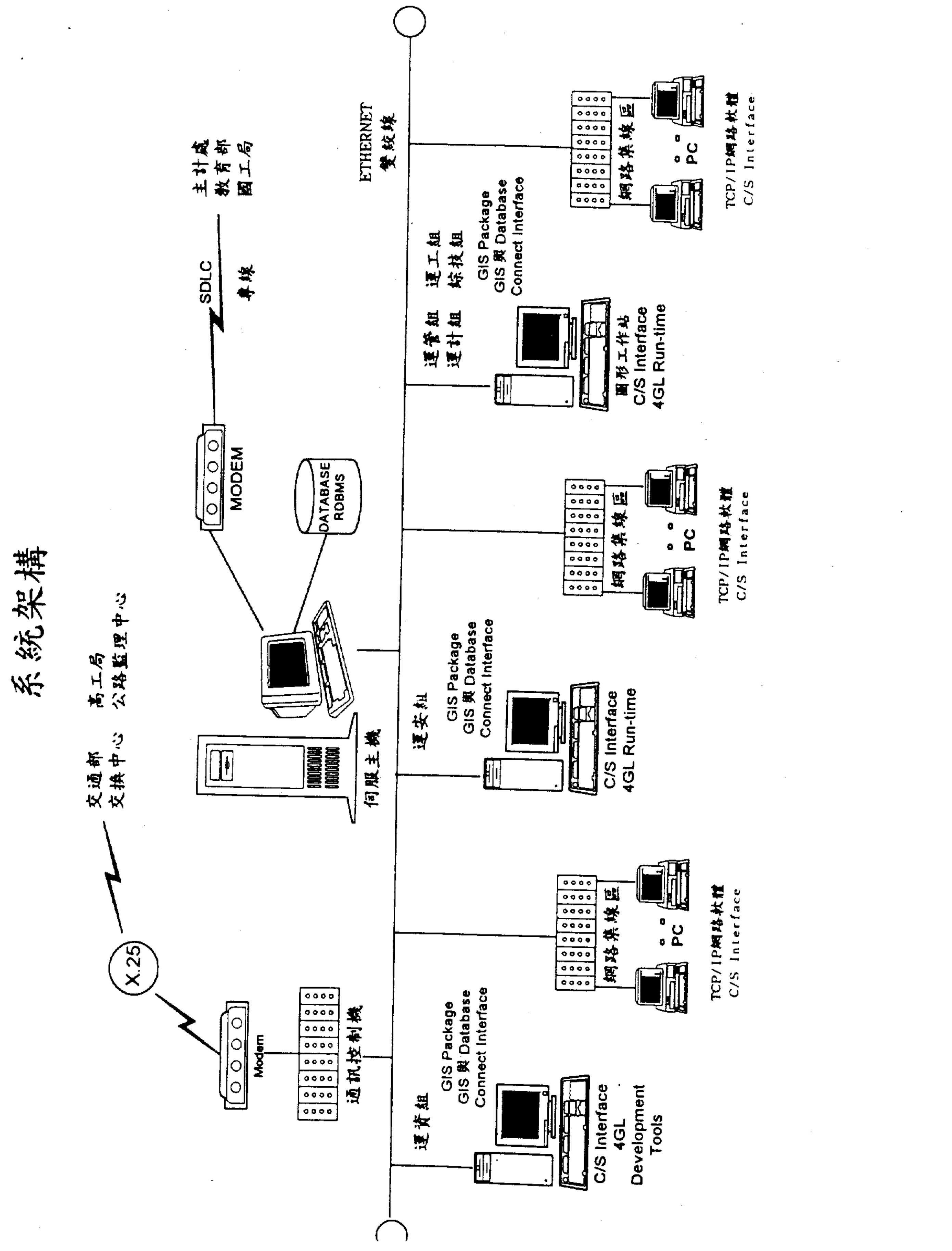
Data will be collected from any Government office and will be stored in a uniform format (designed by IOT). Any Transportation related organisation (government or private) will have access to the data.

The project is seen as a 10 year project, and the hardware/software costs alone are seen to be in the region of NT$25m. In the proposed staff structure above, six operators will be devoted to data-base maintenance. It is likely that a RISC6000 computer will be used, together with an Ethernet network (running TCP/IP) in the Computer Centre. Figure 1 shows the proposed hardware installation.

The data-base systems are likely to be based on SYBASE. The main motivation for this is that MOTC is already using SYBASE extensively on SUN Micro-workstations and it makes good sense to remain fully compatible. However, Oracle has not yet been ruled out. The captured data will be used as input to GIS analysis.

When this goal is implemented, external electronic IT links will be essential.
X25 (and/or SDLC) links to the Data Communications Institute (DCI) and the MVDIS-II system housed there were mentioned as well as Electronic Data Interchange (EDI). There are however, no plans for EDI at the moment.

Figure 1: PROPOSED HARDWARE SETUP FOR IOT DATA BASE SYSTEM



The proposed data-base areas are listed below. The descriptions of some areas may seem ambiguous, but these names were as translated from the Chinese documentation:

1 Road transport planning
2 Short term planning of road transport
3 Railway transport planning
4 Municipal transport planning
5 Harbour engineering planning
6 Water (ocean and river) Transport planning
7 Airport engineering planning
8 Airport transport planning
9 Passenger transport fare planning
10 Railway passenger and freight fares planning
11 Water passenger and freight fare planning
12 Airway passenger and freight fare planning
13 Harbour operation fee planning
14 Airport operation fee planning
15 Municipal passenger fee planning (bus fares)
16 Tourist area transport management
17 Road engineering maintenance and construction management system
18 Road transport management system
19 Railway transport management system
20 Municipal passenger and freight transport management
21 Harbour operations management
22 Waste transport management
23 Harbour management
24 Airport management
25 Land use management
26 Transport energy management
27 Transport monitoring system (volumes etc)
28 Transport construction projects
29 Transport environmental protection system
30 Transport regulation management
31 Transport and environmental user opinion system
32 Transport safety laboratory management system
33 Road accident statistical analysis
34 Railway accident statistical analysis
35 Municipal traffic accident statistical analysis
36 Water accident statistical analysis
37 Airline accident statistical analysis
38 Transport data management - raw data
39 Railway transport data management - raw data
40 Municipal transport data management - raw data
41 Water data management - raw data
42 Airway data management - raw data
43 Social economy information (population, land use, GDP, vehicle ownership etc)
44 Transport technology information system
45 Transport model data - bus management
46 Transport - survey volumes
47 International transport data management
48 International social economy data collection

49 to 60 Internal IOT systems (financial, budgeting, personnel etc)

5. DISCUSSIONS WITH DIVISION CHIEFS WITHIN IOT

Discussions were held with Division Chiefs, (or a designated alternate) to obtain an insight on present computer facilities, the type of work being undertaken and with who they have external links. This information is required to determine possible requirements in terms of information technology.

5.1 Transportation Systems Planning (Mr Jeng)

The Transport Planning Division employs 15 people (2 in administration) and has 17 PC's (of which 10 are linked to the LAN).

Their work revolves around the transport planning area. Recent studies include toll road studies, comparison of major airports/seaports in the Western Pacific Region, GIS, regional impacts of High Speed Rail, high occupancy vehicles and investigation of the most appropriate cargo transportation modes.

They have contact with a number of Taiwanese transportation authorities at central and local government levels, but no overseas contact with research agencies.

Mr Jeng identified TRB, MIT, CSIR and TRL as being possible candidates for overseas contacts.

He was enthusiastic about the possibilities of central project management for project and financial control.

5.2 Transportation Engineering (Dr Ho)

The Transport Engineering Division employs 13 people (1 in administration) and has 15 PC's (4 are linked to the LAN).

The work undertaken tends to be project specific and involves very large projects in the field of Transportation Infrastructure. Examples include the East-West Tunnel projects, High Speed Rail, MRT studies (Taipei, Kaohsiung, Taichung and Tainan); CKS Airport upgrade and deep water ports. They work with all transport modes, including road, rail, sea (seaports etc) as well as airport infrastructure.

Contact with other Government Departments are extensive and are at all levels. These contacts are dictated by the needs of each project and are varied. They include MOTC, Ministry of Fishery Affairs, Harbour Bureau, Civil Aeronautical Administration, High Speed Rail Provincial Office, POHSR, National Taiwan freeway Bureau, Yang Min Shipping Company (state) as well as Evergreen (private).

Many of the projects undertaken require the services of outside specialist consultants. These are normally from overseas and include:

- Parsons Breakenhoff International Inc - high speed rail, TRUPO and other advisory work
- Ralph Hassan - CKS Airport design
- Morrison Knordinson - high speed rail project management consultant
- Gryno Consultants - airport planning
- Deutse Isenbaum Consultants - high speed rail, Taiwan railway upgrade
- SOGRIA - port planning
- SOVRIA - railway projects
- Airport du Paris - airport planning
- SORFEDU - MRT
- Dutch and Danish airport planners and seaport planning.

The Division annual budget is around NT$50m and this covers their routine work. However, projects of up to NT$500m are managed by the Division, but much of this work is undertaken by the above consultants.

In addition, they also have contact with:

- Korea Research Institute (KORI)
- Japan Mitsui Research Institute, Port and Harbour Research Institute, Railways Research Institute and highways Research Institute
- British Marine research Institute (Hydrological Research, Wallingford, Oxford).
- US Army Corps of Engineers, Pittsburgh, Virginia
- Texas A&M and California Universities.
- CSIR Stellenbosch - Institute of Oceanographic Research
- A number of European research institutes.

Some form of central project management would be attractive.

5.3 Transportation Operations and Management Division (Dr Chiu)

The Transportation Operations and Management Division employs 14 people (1 in administration) and has 14 PC's (5 linked to the LAN).

The Division addresses Transport Planning and Policy work within Taiwan covering all areas of Transportation - road, rail, air and sea. Recent studies include measures for promoting bus transit services, Strategies for the privatisation of transportation projects and deregulation of bus services on the Sun Yat-Sen Freeway.

In their work they have regular contact with the various Provincial Governments, National Road Authorities and TRUPO. Their only overseas contact was with SOVRIA (French Railways) on the planning for High Speed Rail.

Contacts with both US Universities and other Government Research organisations would be desirable.

The idea of on-line Project Management Systems was well supported both for project and financial control.

Two previous studies of IT within IOT (undertaken by Universities) were also referred to. No other trace of these studies could be found.

5.4 Transportation Safety Division (Mr Fong-Fu Lin)

The Transportation Safety Division employs 12 people (1 in administration) and has 15 PC's (5 linked to the LAN).

Their work covers the safety engineering, hazardous locations and human factors.

Their main contact in Taiwan is with the Police Departments and various road authorities at both central and local government level, as well as universities. They have no contact with overseas organisations.

Their data is from three primary sources:

- Motor vehicle, traffic violation and driver licence Information - obtained from the MVDIS system maintained at the Data Communications Institute at MOTC. Version II of the MVDIS system is based on two HP9000 computers with INFORMIX data base systems operating at 8 regional centres. This facility is discussed separately.

  Data is currently transferred to IOT on magnetic tape - for a fee. IOT also pays for any processing undertaken by DCI. For example, a recent data sort cost NT$20 000.

- Accident data from MOTC (with the police imputing data from A1 accidents and IOT imputing A2 and A3 level data)

- Traffic volume data from the various road authorities. This is normally supplied on disk/tape, but Taipei City Government is starting a computerised monitoring system (two sites currently).

Overseas links with National Highway Traffic Safety Administration (NHTSA), Transportation Research Board, Japan

Research Institute, Korea Transportation Development Institute (as well as CSIR) would be desirable.

Centralised Institute with project management was not seen as a priority.

5.5 **Transportation Information Systems (Dr Hu)**

Their work is based on the dissemination of transportation information within IOT to other Research Divisions. The primary focus at this stage is on library systems and manages over 1000 books and periodicals and 3000 technical papers and reports are managed. They are developing a Transportation Information System for IOT and provide technical support for publication of project reports.

The Information Division has access to dial up data-bases for reference searches (via another Government Office). It is also planned to scan all IOT reports and store these on CD-ROM (using a Hitachi system costing US$15 000). The CD-ROM system will be accessible via the network for all IOT staff to refer to.

5.6 **Interdisciplinary Research (Ms Yang)**

The Interdisciplinary Research Division employs 10 people (1 in administration) and has 10 PC"s (with 3 linked to the LAN).

The Division undertakes work in the fields of Transportation Energy, Alternative fuels (for example, Electric Scooters), new vehicle technology, air traffic control, vehicle overloading, weigh in motion systems and environmental impact assessment of transportation projects.

Data is obtained from other Institutes, including traffic generation (impact studies), consumption and supply of energy (Energy Bureau), and fuel sales (Ministry of Economic Affairs - MOEA). They would also like to obtain technical development data from other universities and research institutes - *as well as research results from other Divisions within IOT.*

They currently have a number of co-operative projects with overseas organisations, including:

- University of Kansas Transportation Centre
- Japan Research Institute
- Sakura Research Institute
- Korea Transport Institute (KOTI)
- Federal Highway Administration (FHWA)
- University of Illinois State, Department of Transportation

The Division would like to develop links with TRB, ARRB and TRL. Previous attempts at this were not successful. E-mail would be an easy way of developing these contacts particularly with US organisations.

A centralised computer based project management system would be attractive - for budget, financial as well as project control as long as it was reliable and more accurate then existing systems. *Present financial systems are not reliable or accurate.*

The Inter Disciplinary Research Division has also recently installed a RISC6000 computer (with 20" screen). This is dedicated to monitor and down load (dial up modem) traffic flow data from two monitoring sites on the Taipei boundary - presenting the data in a GUI form.

5.7 **Administrative office (Mr Jeng)**

The Administration Office controls 4 people - of which 2 are computer users. They tend not to use the network because of performance and line speed problems ("the system is too slow").

Each Division has its own typist so most documents are generated internally. With "60 to 70 computers (on the IOT Property list) and 20 laser printers in IOT", Mr Jeng believes that few, if any computers will be bought in the forceable future.

5.8 Personnel Office (Mr Ho)

This office has four staff members and two PC's. As with the Financial Office, data is updated locally and the Executive Yuan picks up the information each evening.

5.9 Accounting Office (Ms Liu)

This office employs 5 people, all being computer literate, including the Financial Chief who has a 486 based computer, operates in Windows (Microsoft Excel) and has a HP Laserjet 4 printer in her office. The financial function is not seen as part of the IOT research function, although, given a LAN environment, Division Chiefs could complete a budget and pass it through to the Financial Office. There is no reason to pass detailed financial information back to the Division Chiefs.

Financial transactions are recorded locally on a daily basis, and up-loaded to the Department of Accounting and Audit (Executive Yuan).

6. DISCUSSIONS WITH EXTERNAL ORGANISATIONS

Discussions were held with several external organisations who collect data in which IOT is interested in. These organisations (and the data they collect) relate to vehicle registrations, driver registrations and accident records.

6.1 Ministry of Transportation and Communication (Charles Y L Fan, MIS Dept)

MOTC has a considerable computer department - using mainly WANG (10000 and 7310 models) and SPARC workstations. The move to Workstation technology was guided by four other Government offices who had already moved in that direction. Therefore existing expertise was available. However, there are moves to downsize towards an open-system and a PC environment.

A WANG network is also in place at MOTC, but there are plans to move to an Ethernet (802.3) system, using UTP cabling and TCP/IP protocols to link with the WANG and SUN stations. Currently, 25% to 30% of users have access to PC's - and use them to access the Wang computer system. This process started in June 1993 and it is planned to replace all terminals and place PC's on the desk of everyone who can benefit within a five year period. Each Division within MOTC will have it's own Ethernet network, presumably one network, but with inter-connected Divisional file servers.

In addition, two PC based networks exist:

- The Accounting Office has a Banyan Vines network installed. There are plans however to convert to Novell.
- The MOTC Computer Centre is investigating Microsoft LAN Manager. However for compatibility reasons, Novell is also been considered.

All Government offices have access to X.25 facilities, which can be used for inter-office communications and file transfer (though speeds tend to be slow).

An ISDN link exists, but is not used, and a Frame relay link is under test (this could be good for high-speed file transfer).

Finally, the Public Telephone Company operate a X.400 based E-mail facility - "PIPMAIL". This can be used as a link between MOTC and IOT (and is currently under test) as well as between IOT and the transportation industry. The MOTC/IOT viewpoint regarding communications is shown in figure 2.

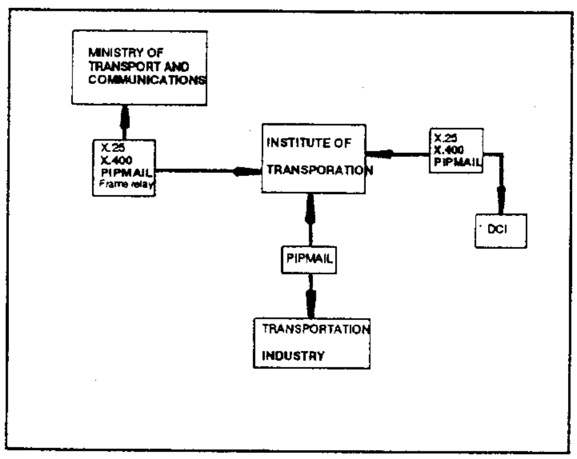


Figure 2
IOT-MOTC-DCI planned computer links

As in IOT, individual E-mail post-boxes are not seen as important. The working environment is not seen to be appropriate and again the problem of Chinese characters was cited. A first step in the implementation of E-mail is seen to be the establishment of an Department based system linked by PIPNET.

It is envisaged that computer links will be established eventually between IOT, MOTC as well as the Data Communications Institute. However, it was suggested that one of the main problems is people's perceptions of the potential benefits.

MOTC also assist IOT with the structure and collection of road traffic accident data. A data-base system was designed by Mr Dah-Yuh Lin of IOT with the data being stored on the WANG system at MOTC. Accident data is divided into three levels:

A1 Fatal and serious. This data is captured and recorded into the MOTC Wang data-base system by the Police authorities).

A2 Slight injury. The data is captured by the Police, but input to the data base by IOT.

A3 Damage only (More than NT$5000). This data is handled in the same way as A2.

There is no formal data analysis, or annual reports produced for accident data. IOT will do ad-hoc analyses for individual and/or research needs. Summary data is written to magnetic tape or a printer by MOTC according to IOT demands.

No other routine transportation, engineering or management databases are maintained by the MOTC although some data may be kept at regional offices (for example, a Maintenance Management System is in operation at the Freeway Bureau).

6.2 Data Communications Institute (DCI) and MVDIS II (Ms Wu)

A computerised system for the recording of motor, violation, driver information system (MVDIS-I) was established on June 1st 1984 and designed by the then Digital Data Communications Institute (DDCI).

Version 1 of the system was based around five regional Computer Processing Offices (CPO's) and 23 regional offices. HP1000 computer technology was installed at each of the five CPO's with modem links to remote PC's or terminals. MVDIS-I was used for 10 years and was replaced by MVDIS-II on February 28th 1994.

Development started on MVDIS-II in May 1992. A team of ten people were involved in the planning and development of the system and has cost in the region of NT$500m. The new system was implemented on 1st March 1994. Appendix 1 of this report shows the structure of the MVDIS-II system.

Under MVDIS-II, each of eight regional nodes are equipped with two HP9000 database servers, as well as two HP9000 terminal servers. These systems are linked by Ethernet 802.3 UTP cabling to two local area networks. Router connections are used to connect each of the regional offices to the X.25 cloud and/or leased lines. IP addressing standards are used for client-host communication.

The raw data is kept in an INFORMIX-SQL data-base system. A query system has already been developed in INFORMIX. Extensive disk mirroring, dual ports etc have been incorporated for disaster recovery.

IOT do not use data from the MVDIS system but there are no on-line links. DCI undertake data analysis (at a cost) and then write the summary data to tape for delivery to IOT. IOT then analyse the data further in-house.

DCI could provide IOT with more open on-line links into the MVDIS-II system if required.

Such a link could be established in one of three ways; X.25, TELNET/FTP or dedicated lease line. IOT need to simply apply for a user number.

There are no charges to log in to MVDIS, however a usage fee is charged to all users. This is based on a cost of NT$500 per Execution Hour plus NT$0.000318 per byte for disk storage (per month).

Assuming that IOT use the existing DCI query system and the resulting query files are immediately downloaded to local IOT network storage, the DCI storage charges would be minimised.

6.3 National Police Administration (Mr Jen Shui-Lin)

The National Police Administration are responsible for crime as well as traffic law enforcement. The Highway Police Bureau form part of the National Police Administration. The Highway Police have six main missions:

- To perform general police duties
- To maintain traffic order and safety on freeways and highways
- To execute highway traffic inspections and control of violations
- To manage highway traffic accidents
- To maintain security on freeways and highways and
- To enforce highway laws.

The National Police Administration use computer technology extensively to communicate between offices, stations and police vehicles:

National Police Administration (AEC Mainframe S3800 - Supercomputer) 1
County Police Stations AEC Mainframe - S3400) 23
Local Police Bureau's (AEC Mainframe - S3300) 365
Local Police stations (IBM compatible 486 computers) 1500

Police vehicles (notebook PC's for on-line enquiries) 2600

Most data (for example accident data) is input at the local police station level. Data is compiled by the National Police Administration to produce National crime and traffic offence statistics.

All levels of accident data (A1, A2 and A3) are input by the local police station. However, only A1 data is used as part of the official police accident statistics. The balance (A2 and A3 data) are handed over to IOT (in the form of a computer printout). IOT staff then re-enter the data onto the Wang computer at MOTC.

There have been a number of complaints from the police on the current accident reporting form. It is seen to be too complicated. Ms Lieu of IOT is currently looking at a simpler format for the form.

There are no formal or on-line computer links with the Data Communications Institute. Vehicle registration and driver licence data (from DCI) is stored at the National Police Administration - the data is transferred weekly from DCI by magnetic tape. This is seen to be adequate for their purpose.

7. EXISTING COMPUTER FACILITIES WITHIN IOT - A SUMMARY

Computers, particularly PC's are used extensively for data analysis, data modelling and document preparation. Most are used as stand-alone computers, though some have been linked by an Ethernet network to a Novell file server. There are a number of ad-hoc ways that IOT links with other Government organisations. However, these tend to be based on dial-up or baseband modem technology and accessible to only a few (primarily administrative) staff members.

Access to the national accident data-base is via a terminal link to the Wang system housed at MOTC. The personnel Office use a 386 computer to emulate a terminal in order to gain access to a MOTC mainframe (again via modem). An aged System 36 machine is used for the administration of each Division.

Information Technology in the true sense of the word is not being used in IOT. Computers are used to undertake bigger calculations than were previously possible (albeit much faster, more accurately and at a lower cost) and extensive use is made of word processing technology.

However Information technology involves the interlinking of three technologies: word processing, electronic mail and most importantly, computer communications. The last two technologies are only applied marginally in the IOT. The biggest obstacle to electronic mail is difficulties in using Chinese characters on conventional ASCII based computers.

Most Division Chiefs indicated that easier, faster, electronic links with other IOT researchers as well as other research organisations around the world are desirable. In terms of global communication therefore, the "Chinese character" issue may be of secondary importance.

There is a problem with inter-departmental E-mail within IOT (as well as with other government agencies). However, this problem should not be confused with the need to communicate globally where other languages are used.

The network facility is being installed on an incremental basis and this is leading to some frustration. It also lowers expectations within other Divisions.

As the following table shows, there is considerable demand within IOT for national or international communication links. To achieve this, it will require strong commitment from all levels within IOT and the fundamental pre-requisites for this will be network PC's and external computer links.

	PC's linked to LAN (%)	Desire to link to other:		LAN based project/cost management
		Taiwan	International	
Trans. Systems Planning	59	Y	not sure	Y
Transportation Engineering	31	Y	Y	Y
Trans. Ops. and Management	36	Y	Y	Y
Transportation Safety	33	Y	Y	N
Information Systems	53	?	?	?
Interdisciplinary Research	30	Y	Y	Y
Administration	0	Y	N	N

The following points are highlighted by Table 1 above.

- Currently there is a low percentage of PC's (35%) connected to a LAN system. The approval for a further 25 cards will increase this percentage to 60%. However, the new investment in network cards will not automatically increase the current 3 to 6 consecutive network users.

- The present research Divisions of IOT have expressed a need to communicate with other organisations both within Taiwan as well as internationally. The research organisations mentioned were mainly US based, but also included several European organisations, other Pacific Rim Research organisations and the CSIR in South Africa.

- There is a willingness to use some form of central network based project planning/cost control system to control and manage projects.

Other identified problems to the implementation of Information Technology within IOT include:

- **Cost and cost saving:** Implementation of Information Technology implies an increased investment in capital equipment as well as higher running costs. However, there is some resistance to this, as the benefits to be gained from Information Technology are not always fully understood.

  The network, amongst other things, enables users to gain access to "dial out" on other external communication facilities.

- **Network infrastructure:** Until the basic LAN is in place, there can be little or no progress towards "Information Technology".

- **Electronic-mail** (electronic mail) is a significant component of any "Information Technology" strategy and provides the ability for IOT researchers to easily communicate with their Taiwanese and International colleagues. A full E-mail implementation within the organisation is required with individual mail-boxes. Electronic-mail systems world-wide operate at the individual, not organisation level.

- **INTERNET**, or some other global communication system, is essential to facilitate international communication with other research organisations. As the INTERNET becomes more commercial, this medium will facilitate communication with commercial consultants who are sub-contracted to IOT projects, as well as between Transportation Research organisations world-wide.

- **Software and hardware standards:** With the exception of pirate software, there are no formal prescribed standards for commonly used software. Some minor problems with incompatible hardware (eg IBM system 55 PC's and the network) as well as data formats and document transfer (eg Microsoft Word and AmiPro) do occur.

  Care must be taken to ensure that incompatibilities are kept to a minimum. Unnecessary time can be wasted when "ASCII" is used for document interchange and format codes have to be re-inserted.

- **Gaps in training and education:** While most researchers and managers are computer literate, there are some gaps in expertise. An investment in training is required to ensure that everyone understands how to (a) use the resources of the LAN fully and (b)understand Information Technology sufficiently to take advantage of it's power and ability to access other resources optimally.

- **Risk of organisational change:** The application of information technology within any organisation requires considerable change in attitudes. It is normal to find some resistance to this. Accordingly it is important to generate a positive atmosphere to these changes.

- **Lack of infrastructure, access to expertise and support mechanisms:** User support for computer users and the network within IOT is undertaken on an informal basis. To encourage and develop expertise amongst users and improve the awareness of IT, it is recommended that this support be provided on a more formal basis. This is one of the goals of the proposed new Computer Centre.

8. STRATEGIC ACTIONS TO ENHANCE INFORMATION TECHNOLOGY IN IOT

The following short-term actions were identified as necessary to create an enabling climate for Information Technology within IOT and TERC:

- Establish a formal Computer Support Function within IOT (with at least 2nd level functions as defined in Appendix 2) *either under the control of the current Information Systems Division or as a separate Division, BUT not as part of TERC.*

  This function would then act in support of both the current IOT Divisions and TERC.

- Provide sufficient manpower and financial resources in order to fully complete the basic network installation as soon as possible. A basic network should be as follows:

  - LAN cards in and UTP cabling to each PC in the current IOT
  - The creation of standard login procedures and names for all PC users (8 digit user names and matching directory names to take advantage of Novell's %LOGIN_NAME feature)
  - A formally structured file server, for example:
    Users installed under a F:\USERS\; directory;
    DOS software installed under F:\DOSAPPS\ and
    Windows software under F:\WINAPPS\
  - A good range of commonly used software (defined by developed standards)
  - A formal back up system with nightly back-ups to tape and off site storage
  - Adequate shared printers on each floor and access to a shared colour printer via the LAN
  - Basic user training on available facilities.

- Install the Novell Management System (NMS) software to monitor the IOT network. Complaints that the existing system is slow indicate abnormally high traffic, Ethernet traffic collisions or faulty components. NMS system will help identify and resolve these and other problems.

- Develop a written standard as a guide/policy in terms of what the software packages (eg word-processing) recommended for use. This proposed standard may simply describe a document interchange format (eg MS-Word or WordPerfect).

- In addition to existing training programs, additional facilities (possibly video programs) should be used to create an awareness of Information Technology. This will ensure support for Information Technology proposals and also ensure that users and managers access Information Technology in the most effective manner.

- Expand the availability of external computer links to include:

  - Fax gateway card in the file server to handle outgoing and incoming faxes. Novell (or similar) software should be used to monitor the gateway and users for auditing purposes.
  - Installation of an ASYNC card to handle dial-up lines. This will enable IOT staff to dial out to other external services (including MOTC computers as now); bulletin boards etc. It would also enable registered external users, or IOT/TERC staff, to dial in (for example from home by modem; from overseas to pick up electronic mail or from the TERC remote laboratory).
  - Install an X25 gateway (card in fileserver) to facilitate links to the MVDIS II system at DCI (an ASYNC line could also possibly be used for this)
  - Access to INTERNET (possibly via TAINET) to enable IOT computer users to contact fellow researchers around the world and allow other overseas research institutions to make contact with IOT. This would also require personal E-mail boxes.

- Install a professional, easy to use E-mail system (PC based and with X400, SMTP and MHS gateway facilities) and make this available to all network users in IOT/TERC. The selected system should preferably have both Chinese and English versions and user names should match the Novell (8 character) login names.

- Ensure that the new IOT building and any TERC remote sites have (where practical) UTP level 5 cabling installed to every office and laboratory to facilitate future moves.

- In terms of the more traditional Information Technology drive, the broad goal for the new Computer Centre should be to become a Transport Industry information provider (through the development of the proposed 48 data-base sub systems). Many of the above proposed actions are ultimately geared towards IOT and TERC fulfilling this role.

Most of the above actions, systems and skills can be readily moved to the new building when IOT move, when TERC is established and can also be applied to TERC remote laboratories.

9. REFERENCES

1. *Information Technology and the conduct of research.* The user's view report of the panel on it and the conduct of research. Washington 1989

APPENDIX 1

MVDIS-II

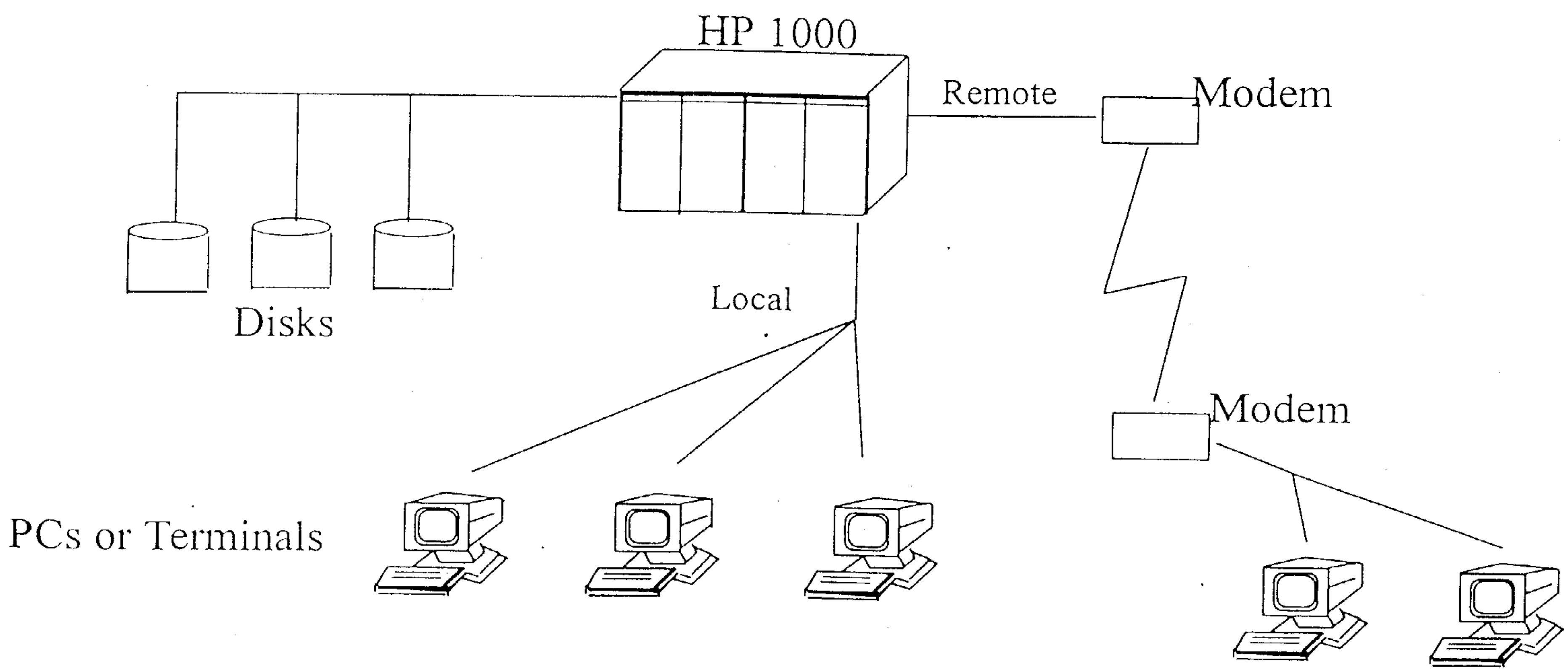
Motor vehicle, driver Violation and Driver Information System

Specification sheets

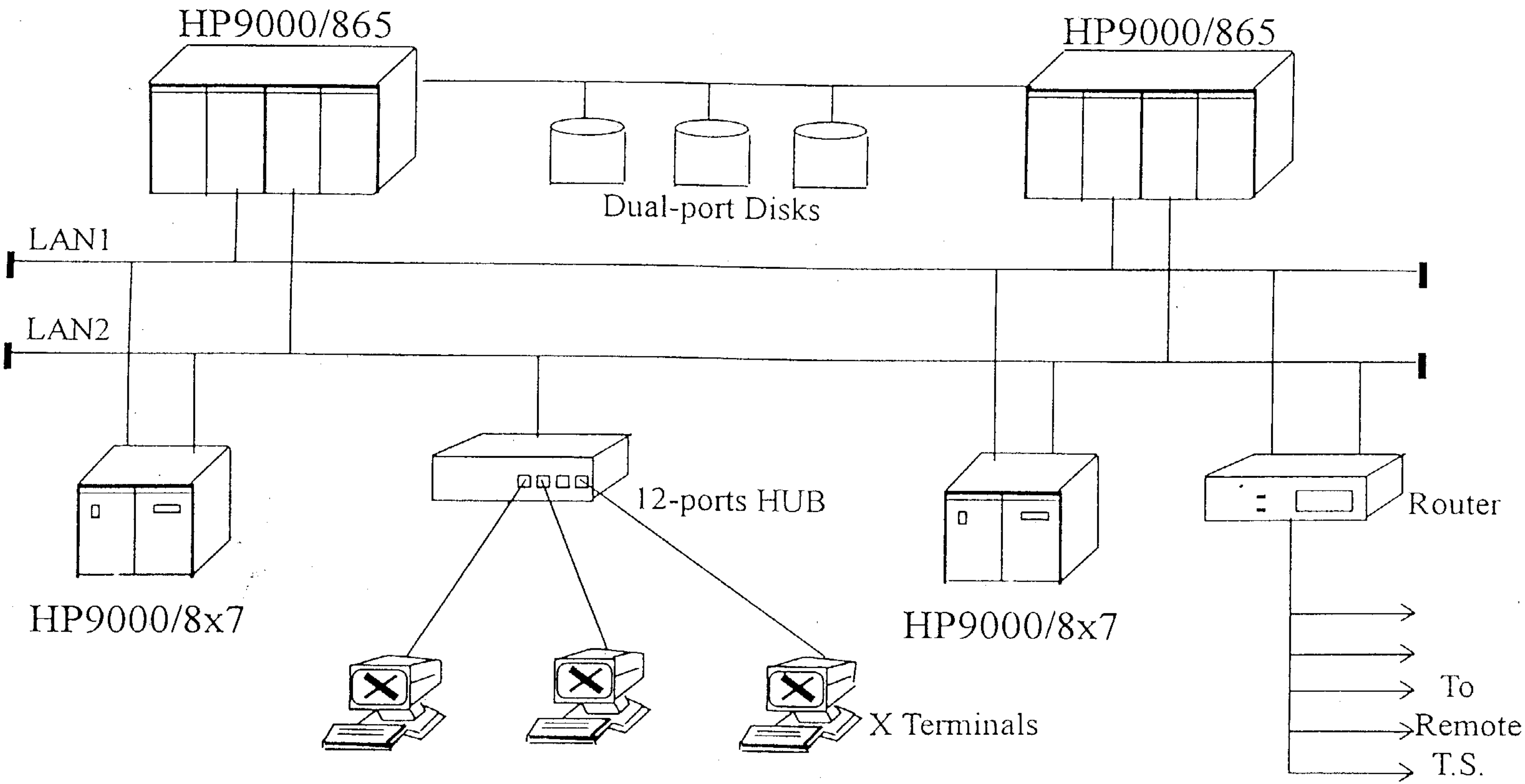
MVIDS II

Motor, Violation, Driver Information System

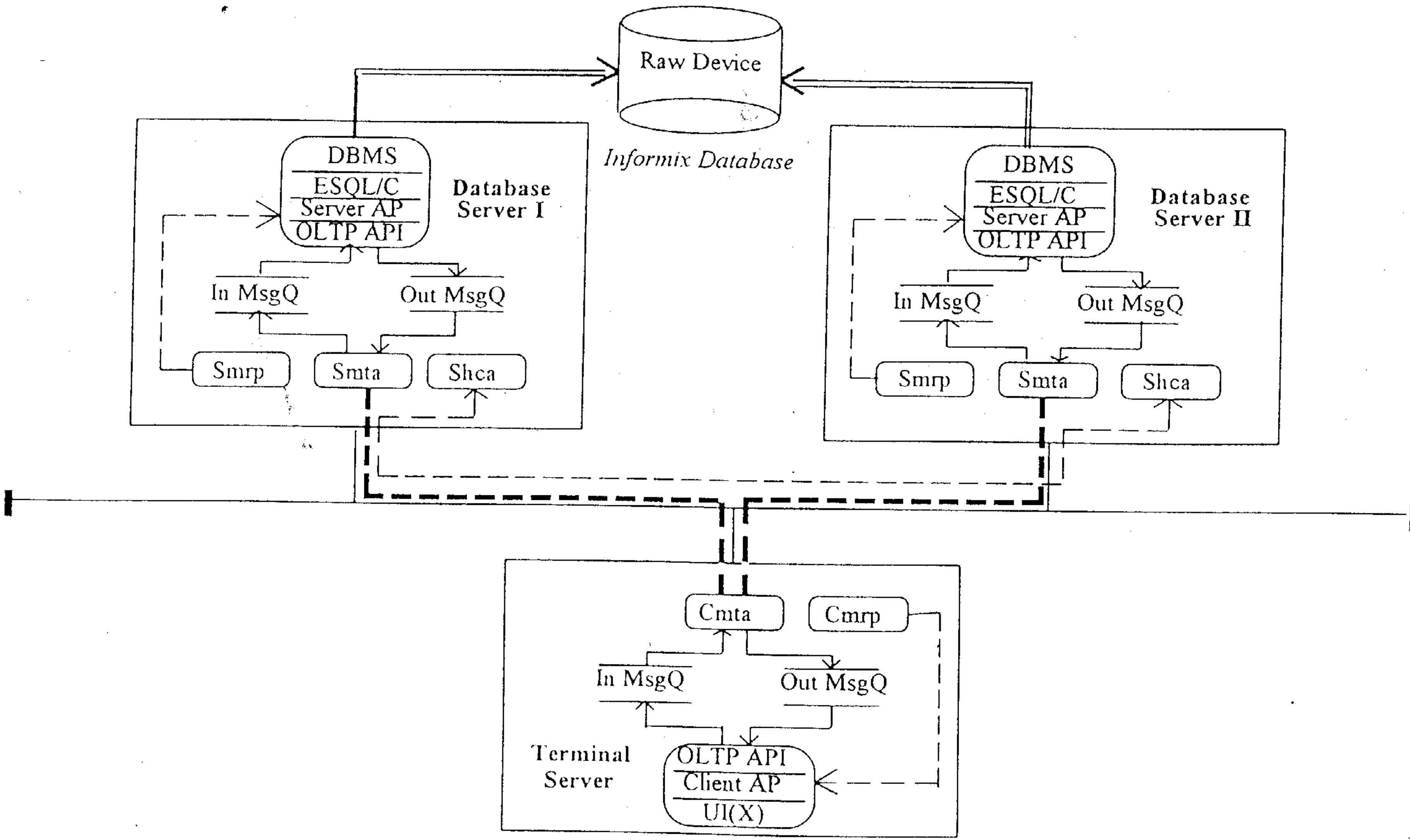
MVDIS I Computer Environment



MVDIS II Computer Environment

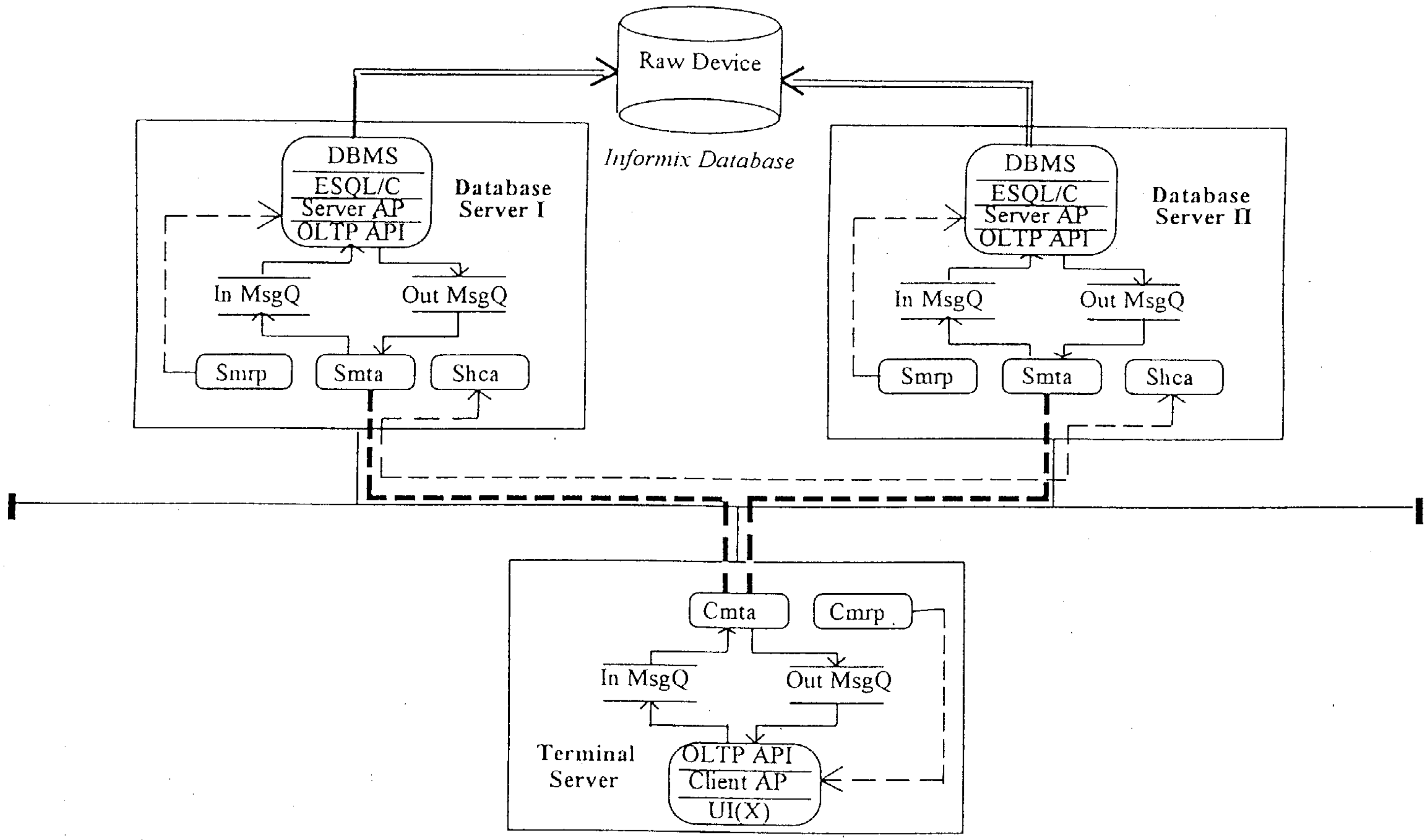


HP9000/865: Database Server
HP9000/8x7: Terminal Server



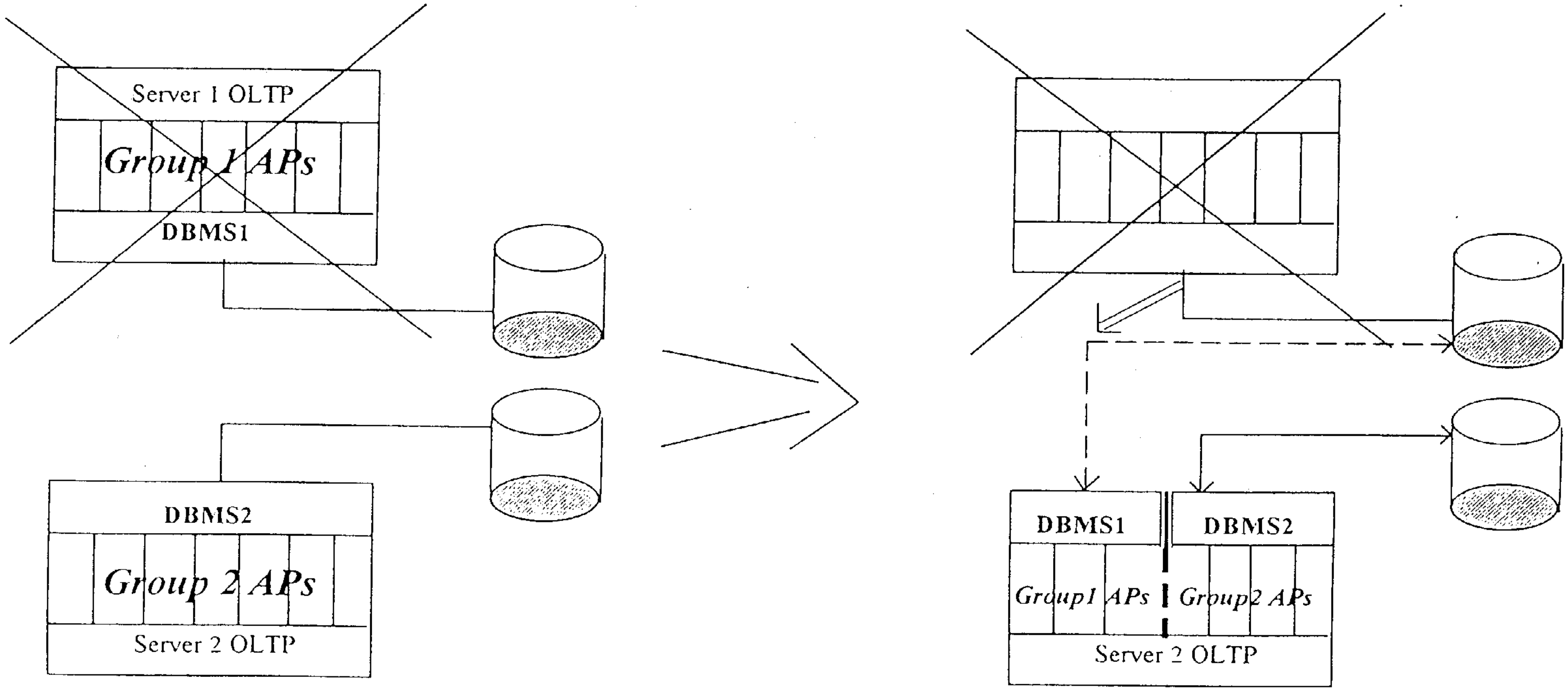
Smta, Cmta : Message Trrausfer Agent
Smrp, Cmrp : Process Monitor Agent
Shca : Host Checking Agent

MVDIS II OLTP Architecture

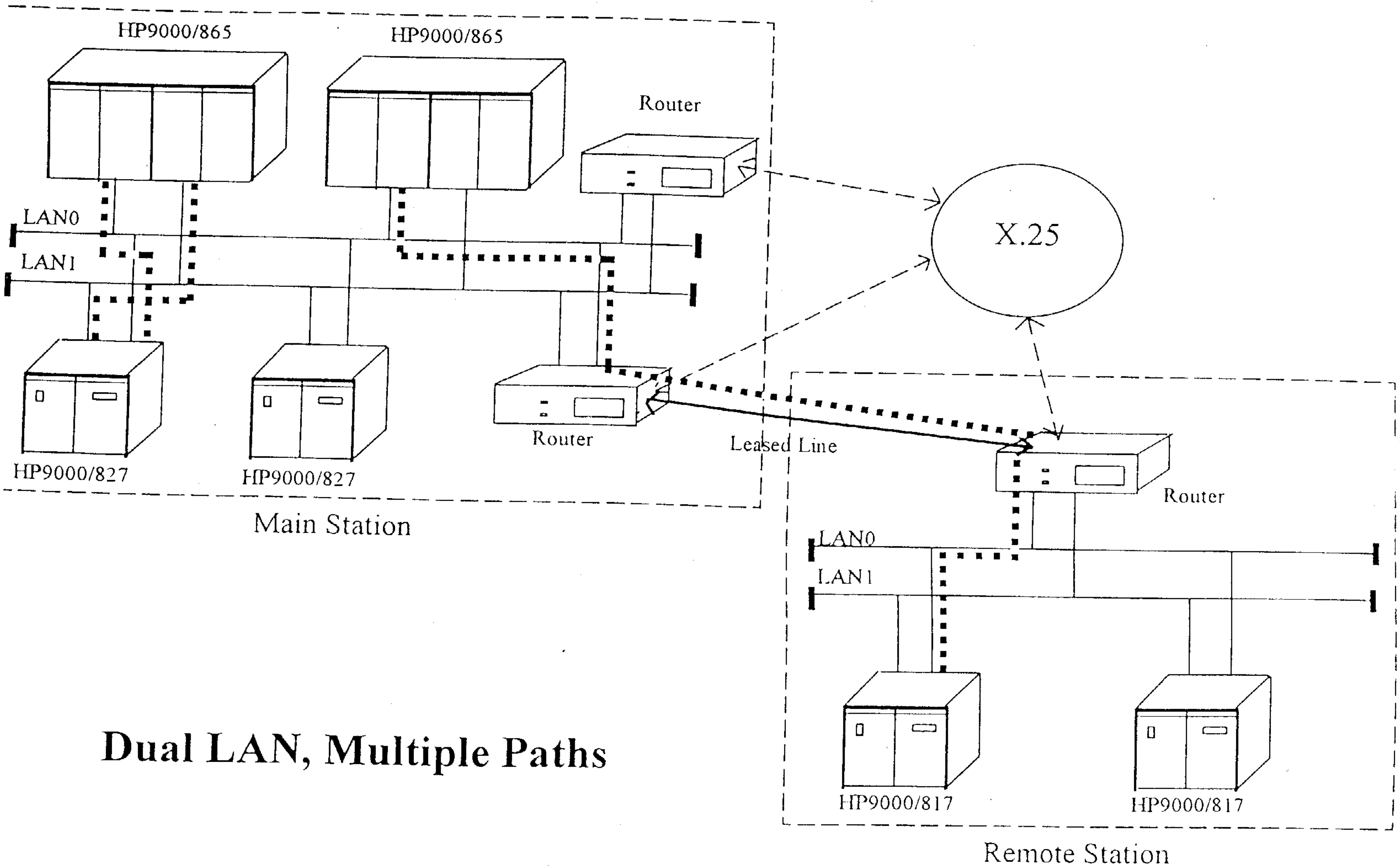


Smta, Cmta : Message Trransfer Agent
Smrp, Cmrp : Process Monitor Agent
Shca : Host Checking Agent

MVDIS II OLTP Architecture

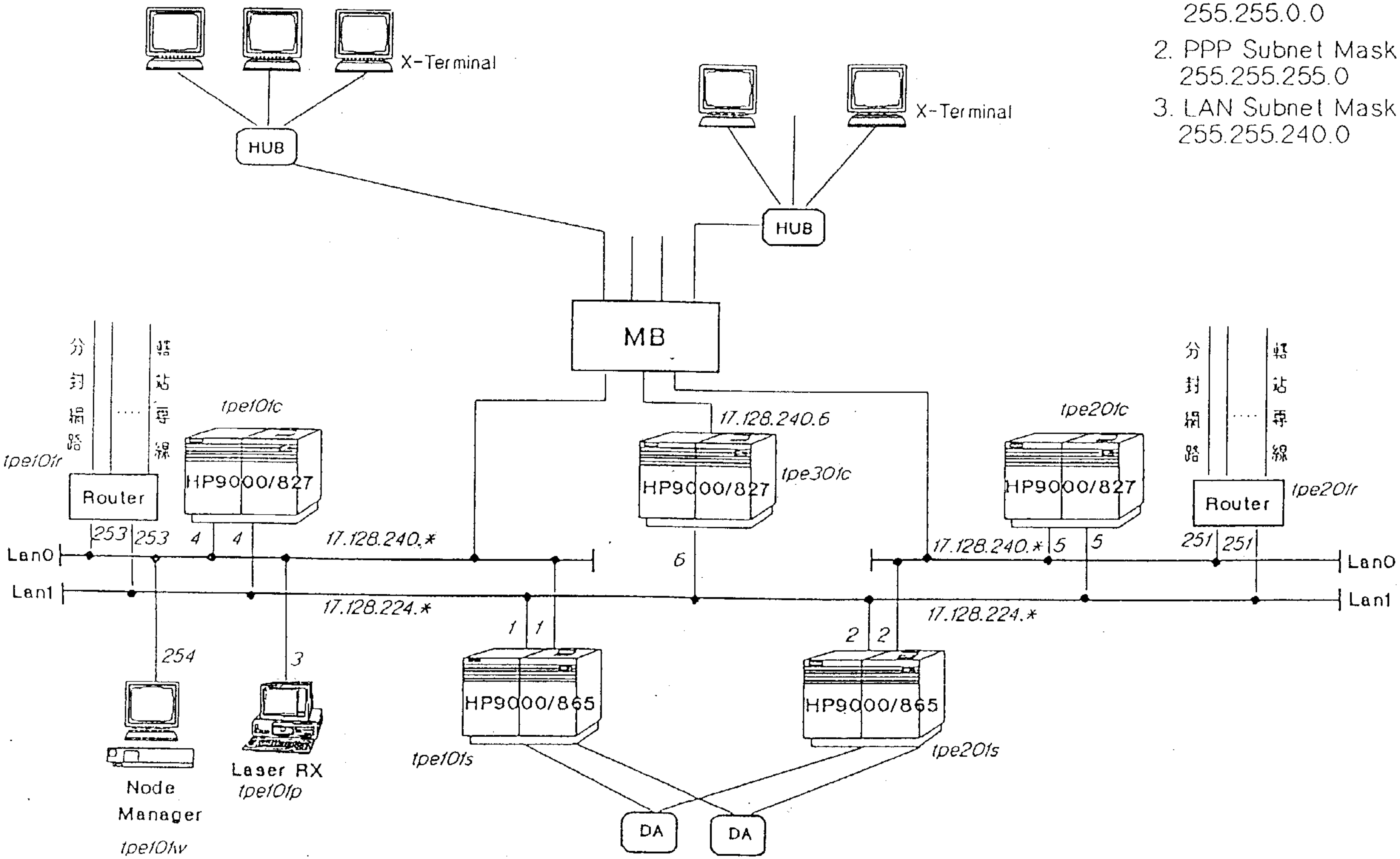


Server Failure Recovery



Dual LAN, Multiple Paths

台北市監理處網路架構圖



1. X.25 Subnet Mask
   255.255.0.0
2. PPP Subnet Mask
   255.255.255.0
3. LAN Subnet Mask
   255.255.240.0

第二代公路監理系統網路架構圖

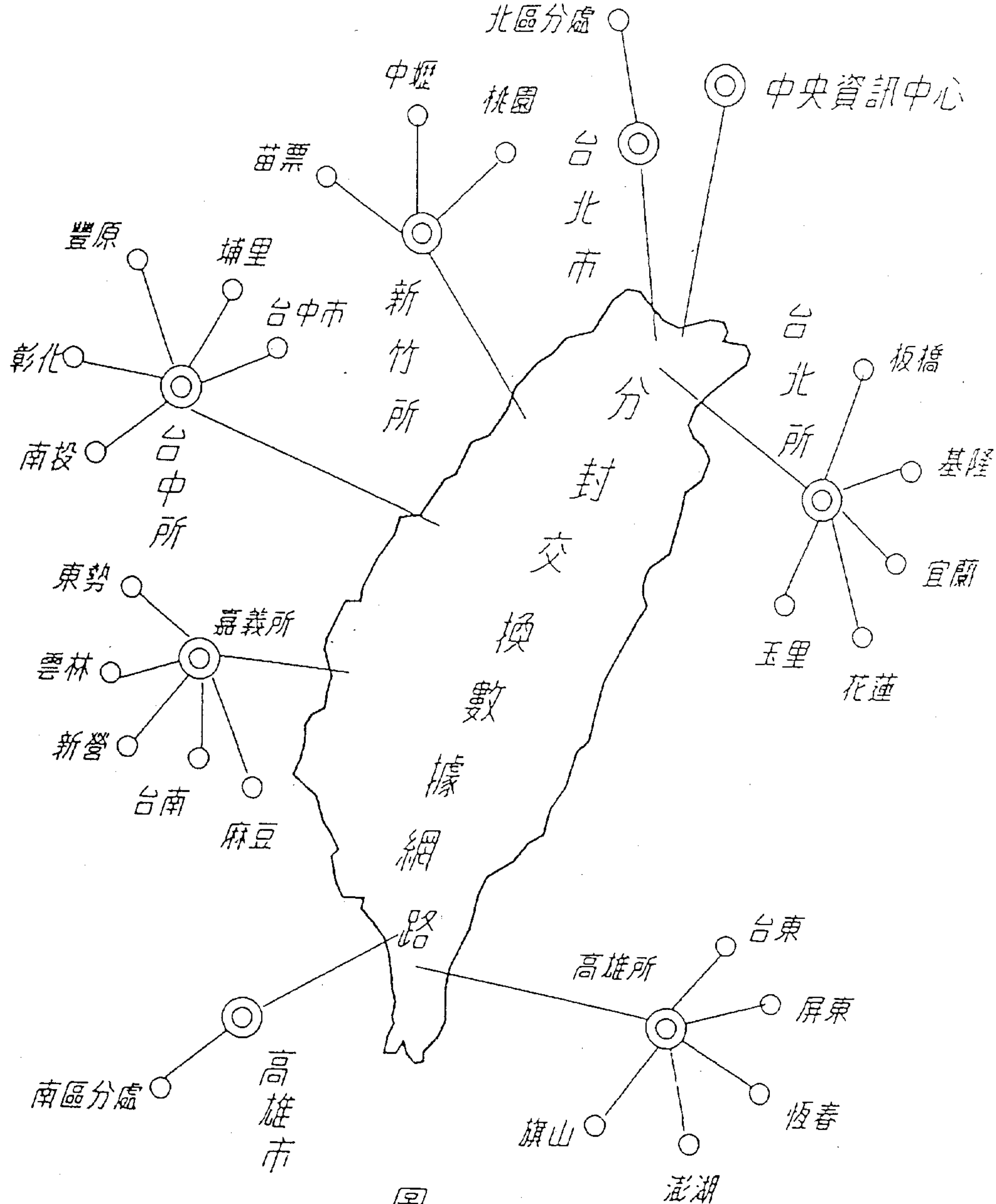


圖 一

各節點之硬體結構

第二代公路監理系統硬體架構圖

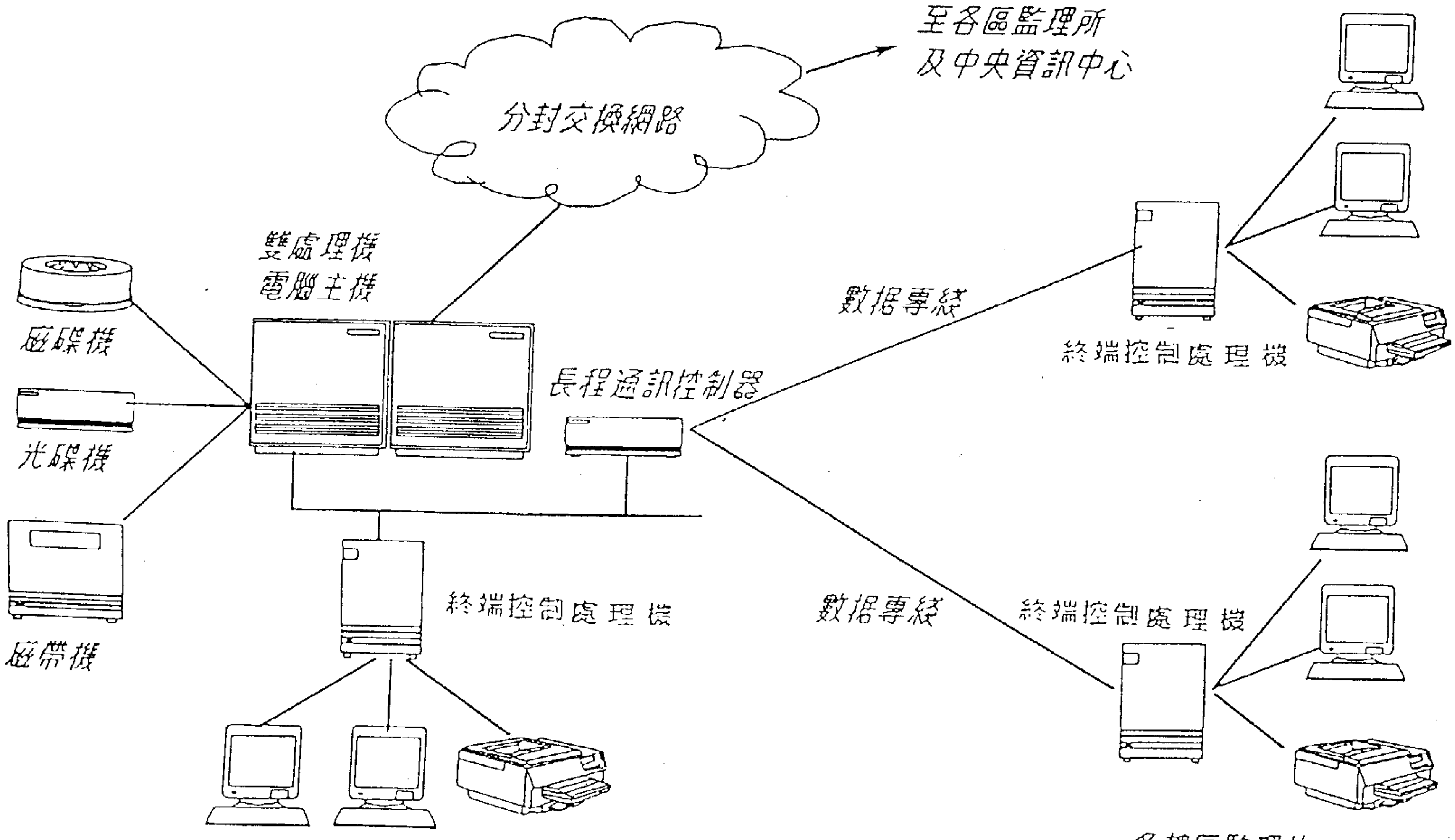


圖 二

APPENDIX 2

Three typical levels of operation for a Computer Centre

APPENDIX 2

Levels of operation for computer centre operation

There are in general three levels that a Computer support section can operate. At the simplest level, support is given internally to computer users within the organisation. An intermediate level sees the Computer Centre also providing communication channels to give the staff of the organisation the ability to obtain external data. A final level takes the first two levels and also ensures that not only does information come into the organisation, but that the organisation becomes a funnel - it brings information in, adds value and ensures that the new information is made easily available to users and other interested parties within industry.

Some typical roles at each of these three levels are described below:

1 Internal support for IOT staff:

- Hardware and software procurement; repairs; determination and implementation of standards
- LAN installation, management & support; user software installation and support; user training
- Development of specialised software for IOT in-house use.

2 The use of Information technology concepts to the benefit of IOT staff:

- Inter-office communications (E-mail and possibly Scheduling)
- Communication and file transfer between the Institute and other offices and regional laboratories (E-mail and possibly Scheduling)
- Communication and file transfer between the organisation and other similar organizations (for example, CSIR, TRL, TRB via INTERNET)
- Communication and file transfer between IOT and Taiwan Transportation industry
- Provide the ability to easily use other computer facilities remotely (UNIX or mainframe computers at MOTC)
- Document retrieval and key word searches (eg DOBIS and other overseas library data bases)
- Links to external Bulletin Board Systems (eg CompuServe, TRUMPET, news services, overseas Transportation forums)
- Enable access to other data base systems within IOT and other Government Agencies (eg accident, vehicle registrations, drivers licensing, traffic volumes, pavement management databases)

3 Support and Information provider to Taiwanese Transportation industry:

- Transfer of new technology (IOT/TERC/TPPRC research findings) to the Taiwanese Transportation industry through the development and distribution of specialized transportation or engineering software.
- Identification/modification of appropriate overseas software - and distribution to Taiwanese users.

- Establishment of a Transportation Forum on a Taiwanese Bulletin Board (BBS) (with E-mail and file transfer capabilities) for the Transportation industry (Government, Local Authorities, consultants, hauliers, shippers, railways, bus companies, overseas agencies etc). IOT researchers should be information providers on such a system.

- Generate significant Transportation data as a central service and allow access to any qualified user within industry via some form of Bulletin Board Service.

  This may be as advanced as the NIBS concept described in the following section.

NIBS

The NIBS project at CSIR is designed to facilitate communication and information transfer throughout Southern Africa - for industrial, professional and home users. It represents a fundamental shift in the way that information is made available to computer users in all spheres of life.

NIBS is a gateway system based on a RISC computer. Registered users (for a low monthly administrative fee) will be able to access the NIBS computer via for example dial-up modems; X25; X28; X400; IP or IPX. Once a connection has been made to NIBS a user has ready access to a vast amount of information via a menu system.

A beta system will be in operation by the end of March 1994.

An extensive number of Bulletin Board Services, "shopping malls" and forums will be connected to the NIBS computer. Examples of interested companies to date include Novell, Microsoft, WordPerfect, the Johannesburg Stock Exchange, Bradeys (electronic yellow pages), Credit control companies and CompuServe. Some of these services will be freely accessible to all; some will be available for an additional monthly fee (eg CompuServe) and some will be closed forums.

A Transportation forum will be one of the first technical forums to be established on the system. Initially the CSIR will be the primary information provider but it is expected that other users will add value (and information) to the system. The following structure has been proposed for the CSIR Road Transport Bulletin Board forum:

PROPOSED STRUCTURE FOR THE CSIR TRANSPORTATION INDUSTRY BULLETIN BOARD

The transportation industry can be divided into four sections, i.e. Road, Rail, Air and Sea. Road Transportation will be considered during phase 1.

BULLETIN BOARD ROAD FORUMS AND SUBSECTIONS

Specialist and general forums have been proposed. Subsections on each forum could setup by "experts" in each field.

FORUM	SUBSECTION
Transportation Management	Transport Planning Transport Economics Urban & Rural Development Land Use Strategy & Policy Regulation & Administration
Road Infrastructure Management	Road Management Road Monitoring
Traffic Management and Safety	Engineering Education Enforcement & Emergency Services
Road Engineering	Road Construction Road Maintenance Road Rehabilitation Road Materials Low Volume Roads Bridges & Structures
Passenger Transport	
Freight Transport	
Vehicle Manufacturing	
Environmental Issues	
Conferences, Seminars and Courses	
Software	
Publications	
Tenders	

APPENDIX D

LIST OF EQUIPMENT FOR TERC SUPPORT FACILITIES

APPENDIX D - 1

RAILWAY TRACK COMPONENT TESTING LABORATORY

D-1 : RAILWAY TRACK COMPONENT TESTING LABORATORY

FACILITY	REQUIREMENTS	APPROXIMA COST US$
Testing Laboratory	Pumping room for hydraulic pressure source	475 000
	Strong floor : steel floor with reinforced concrete base (to anchor machinery) (2,5m x 1,4m x 0.14m(depth))	80 000
	2 x load frame - 250 kN capacity, (speed 80 km/h)	1 350 000
	Track trench with concrete wall for lateral forces (2m thick), reinforced concrete floor (18m x 4m x 1m deep)	320 000
	Computer control room	320 000
Mobile data acquisition unit	Computer in unit	800 000
	Wagon	1 600 000
	Horse (truck tractor)	1 100 000
	Amplifiers (132 channels)	2 270 000
TOTAL		8 315 000

APPENDIX D - 2

ENGINEERING WORKSHOP

D-2 ENGINEERING WORKSHOP

EQUIPMENT	ESTIMATED VALUE US$
Drill Press	4 500
Brand Saw	5 000
Milling Machine	370 000
Lathe	119 000
Tool Grinder	3 000
Drill Sharpner	1 500
Bench Grinder	1 000
Bench Polisher	1 000
Sanding Disc	1 000
Cutt-off Saw	3 000
Plate Guillotine	3 000
Plate Bending Machine	3 000
Crank Press	20 000
Various Tools	15 000
Work benches & shelving for storeroom	50 000
TOTAL	600 000

APPENDIX D - 3

ELECTRONIC WORKSHOP

D-3 ELECTRONIC WORKSHOPS

EQUIPMENT	REQUIREMENTS	COST US$
Various Tools		5 000
Computer	• PC 486 with large screen and 250 Mb disk • Software for electronic equipment	20 000 50 000
Universal Programmer		2 000
Multimeter		1 000
Frequency Counter		3 000
Oscilloscope		20 000
Power Supply		4 000
Workbenches		35 000
TOTAL		140 000

APPENDIX D - 4

MATERIALS TESTING LABORATORY

D-4 MATERIALS TESTING LABORATORY

Test Name	Standard	Material	Equipment	Cost US$
Kinematic Viscosity		Bituminous	Viscometer	26 000
Los Angeles Abrasion	ASTM/SABS	Aggregate	LAA Mill	20 000
Compressive Strength	ASTM C109	Cementitious	Moulds, workability equipment	
Chemical Analysis	ASTM C114		Spectrophotometers	25 000
Chemical Analysis	ASTM C114	Cementitious	AA, Spectrocolorimeter, Wet Chemistry LKP	62 000
SG & Absorption - Coarse	ASTM C127	Soils		
SG & Absorption - Fine	ASTM C128	Soils		
Drying Shrinkage	ASTM C157	Cementitious	Moulds, Comparators	
Compressive Strength	ASTM C170	Soils	Universal testing machine	57 400
Heat of hydration	ASTM C186		Calorimeters	
Consistency	ASTM C187	Cementitious	Mixers, consistency guages	
Relative density	ASTM C188		Vicat flask	
Setting times	ASTM C191		Vicat needles	
Alkali reactivity	ASTM C227		Moulds, compactor	
Alkali Sillica reactivity	ASTM C227	Aggregate	Compactor	
Abrasion resistance	ASTM C241	Soils	Abrader	
Setting times	ASTM C266	Cementitious	Vicat needles	
Petrographic examination	ASTM C295	Soils/cementitious	Petrographic microscope	40 000
Tensile strength	ASTM C307	Chemical	Universal testing machine, moulds	Instron
Working and setting times	ASTM C308	Chemical	Flow and setting needles	
Full oxide analysis	ASTM C411	Cementitious	AA, Spectrocolarimeter, Wet chemistry	-
Destructive testing	ASTM C496	Cementitious	Tensile and compression machines, core drill, impactors, diamond saw, test bed for 150mm cylinders	35 000
Creep	ASTM C152	Cementitious	Creep frames, laoding ring, dial guage, demec	
Cone penetration consistency	ASTM C7	Cementitious	Cone penetrometer, mixer	5 500
Modulus of elasticity	ASTM C747	Soils	Resonant frequency device	

Test Name	Standard	Material	Equipment	Cost US$
Flexural strength	ASTM C880	Soils	Universal testing maching	Instron
Water retention	ASTM C91	Cementitious	Flow table, suction apparatus	
Modulus of rupture	ASTM C99	Soils	Universal testing machine	Instron
Mix design		Soils/Cementitious	Mixer, compression testing machine	
X-ray diffraction analysis quanitative			X-ray diffractometer	150 000
Consolidometer	BS 1377	Soils	Oedometer	18 000
Grading	BS 1377	Soils	Sieve shaker, sieves	10 000
Ring shear	BS 1377	Soils	Ring shear apparatus	
Shearbox	BS 1377	Soils	Shearbox	36 500
Sulphates and chlorides in soil	BS 1377	Soils	Wet chemistry	
Triaxial	BS 1377	Soils	Triaxial machine	
Mix proportions on Mortars, Concrete	BS 1881	Cementitious	AA, Wet chemistry	
Non-destructive testing	BS 1881	Cementitious	Schmidt hammer, pundit, demec	9 000
Polished stone value	BS 812	Aggregate	PSV wheel and skid resistance motor	45 000
Aggregate impact value	DRTT	Aggregate	Impact machine	6 100
Air permeability	DRTT	Bitumen	Permeability meter	7 500
Binder recovery (hot)	DRTT	Bitumen	Hot centrifuge	55 000
Cation exchange	DRTT	Soil	Various	
Core drilling	DRTT	Bitumen	Diamond core drill	15 000
Cutting briquettes	DRTT	Bitumen	Diamond saw	10 000
ICL and ICC	DRTT	Soils	pH meter	4 000
Moulding briquettes	DRTT	Bitumen	Compactor and moulds	-
Water Analysis (aggressive chemistry)		Everite, con doc	Wet chemistry	
Coarse particles	SABS 746	Cementitious	Sieves	6 000
Relative Density	SABS 747	Cementitious	Gas comparison pycnometer	1 500
Specific surface	SABS 748	Cementitious	Blaine	
Compressive strength balance				12 290
Flexural strength balance				12 200
Standard consistency	SABS 751	Cementitious	Flow table, mixers	
Setting times	SABS 752	Cementitious	Flow table, mixers	
Soundness	SABS 753	Cementitious	Le Chateller moulds	

Test Name	Standard	Material	Equipment	Cost US$
Autoclave soundness	SABS 754	Cementitious	Autoclave	
Sieve analysis	SABS 829	Aggregate	Sieves, balances	11 000
Chloride content	SABS 830	Aggregate		
Presence of chlorides in aggregate	SABS 831	Aggregate		
Organic impurities	SABS 832	Aggregates		
Sugar	SABS 833	Aggregates		
Deliterious impurities	SABS 834	Aggregate		
Water demand	SABS 835	Aggregate		
Influence on shrinkage	SABS 836	Cementitious	Mixers, moulds, drying ovens	
CBR Compactor	SABS 854	Aggregates		31 000
Destructive testing	SABS 863	Cementitious	Tensile and compression machines, core drill, impactors, diamond saw	-
Destructive testing	SABS 864	Cementitious	Tensile and compression machines, core drill, impactors, diamond saw	-
Compressive and Flexural Strength (ISO)	SABS 866	Cementitious	Universal load test equipment, mixers, compactors, workability gauges and moulds	
Tar viscosity	STMH 1	Bitumen	Tarviscometer	10 000
10% FACT	TMH 1	Aggregate	Moulds	2 000
ACV	TMH 1	Aggregate	Moulds	2 500
Anionic emulsion viscosity	TMH 1	Emulsion	Engler viscometer	6 560
Anthracene paste content	TMH 1	Bitumen	Glassware	1 000
Atterbergs	TMH 1	Soils	Casagrande cup	1 090
Automated wet/dry durability	TMH 1	Soils	Brush machine	7 500
Average Least Average Least Dimension (ALD)	TMH 1	Aggregate	Measuring gauge	4 600
Binder content	TMH 1	Bitumen	Washing flasks	2 000
Binder recovery	TMH 1	Bitumen	Distilling plant	8 000
Binder suitability	TMH 1	Bitumen/Aggregate	Marshall test equipment, compactor (B32)	4 700
Bulk density	TMH 1	Aggregate	Balance	8 000
Bulk relative density and voids	TMH 1	Bitumen	Vacuum source	6 000

Test Name	Standard	Material	Equipment	Cost US$
CBR (Stabilised and unstabilised)	TMH 1	Soils	Press for CBR	27 000
Conductivity	TMH 1	Soils	Conductivity meter	6 000
Ductility	TMH 1	Bitumen	Ductility bath	32 000
Flakiness index	TMH 1	Aggregate	Gauge	400
Flow resistance (Marshall)	TMH 1	Bitumen	Marshall test	22 000
Fraas brittle test	TMH 1	Bitumen	Fraas apparatus	4 000
Immersion index	TMH 1	Bitumen		
Lime content (EDTA)	TMH 1	Soils		
Matter insoluble in tolnene	TMH 1	Road tar	Glassware	1 000
MMD/OMC	TMH 1	Soils	Compactor and moulds - see CBR Compactor	
Organic impurities	TMH 1	Soils		-
Penetration value	TMH 1	Bitumen	Penetrometer	11 000
pH	TMH 1	Soils		750 000
Phenol content	TMH 1	Bitumen	Glassware	1 000
Relative density	TMH 1	Soils	Balance	8 000
Relative density of binder	TMH 1	Bitumen	SG Bottles	11 200
Residue on sieving	TMH 1	Bitumen		
Sand equivalent	TMH 1	Aggregate	Measuring cylinders and shaker	6 000
Sieve analysis (wet and dry)	TMH 1	Soils	Sieves and shaker	-
Slump on concrete	TMH 1	Cementitious	Mould	2 500
Softening point (Ring and Ball)	TMH 1	Bitumen	Ring and Ball	2 000
Tar distillation	TMH 1	Bitumen	Distilling sleeve	1 500
Tensile strength	TMH 1	Soils	Press	Instron
Thin film oven test	TMH 1	Bitumen	Thin film oven	60 000
Trichloroethylene solubility	TMH 1	Bitumen	Glassware	1 000
UCS (stabilised)	TMH 1	Soils	Press	45 000
UCS on concrete	TMH 1	Cementitious	Moulds	2 500
Viscosity	TMH 1	Bitumen	Saybolt furol viscometer	26 000
Water content (Dean and Starke)	TMH 1	Bitumen	D & S Glassware	2 500
Wet/dry durability	TMH 1	Soils	Brush	1 000
Sundry items			Moulds and ovens etc	100 000
Computers				100 000
TOTAL				1 998 540