TRANSPORT RESEARCH: QUO VADIS?

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ABSTRACT

It is well-recognised internationally that transport and transport infrastructure play a major role both in the stimulation of economic growth, creation of job opportunities and in poverty alleviation. This is of particular importance in South Africa with its history of apartheid cities that enforced specific distorted patterns in development, human habitat, access and mobility as is clearly indicated in the GEAR and Asgisa strategies of government. The importance of transport infrastructure was also emphasised in recent government planned expenditure. The importance of science, engineering and technology (SET) in achieving economic growth was reiterated in the National Research & Development (R&D) Strategy of 2002. However, in the 1990's the national R&D programme in transport became fragmented and consequently very little R&D has been done in the 2000s. This paper analyses the lessons learnt from six historic research programmes in both the public and private sector and in several project-level case studies. It also refers briefly to some of the new initiatives undertaken by the Department of Transport recently to start addressing the lack of a comprehensive well integrated research programme over the medium to long term. Strategic drivers for a successful R&D programme in transport are defined and a way forward for the future of transport research is suggested.

1. INTRODUCTION

It is recognised that innovation and technology have a major impact on the economic growth of a country (Porter, 1990; Pistorius, 1996). SET is of strategic importance to South Africa in a number of ways, particularly as key enabler of economic growth and as a platform for the development of human resources (DST, 2002). The South African National R&D Strategy (DST, 2002) highlights a number of key focus areas for SET development and innovation to address the future challenges facing South Africa. The strategy furthermore places specific emphasis on innovation and the management of these technologies in a coherent and integrative manner. This is re-iterated in the DST 10-year plan released recently, which highlights the importance of meeting the 2014 Millennium Development Goals to halve poverty as well as the fact that SET can play a growing role in addressing socio-economic problems, including accessibility and mobility (DST, 2007). These strategies set a target of one percent of GDP for R&D funding.

Transport and transport infrastructure play a major role in both economic development and poverty alleviation and therefore technologies that support these sectors are deemed to be of major importance (Weisbrod, 1997; Chapman et al, 2002; DoT, 2006). There is also currently a major shortage of civil engineers and other transport professionals in South Africa (SAICE, 2006). It therefore follows that R&D in transport-related fields is of significant importance to South Africa, both to develop the required technological solutions

as well as to assist in the development of quality transport professionals. However, as will be shown in this paper, the transport-related R&D programme in South Africa has suffered from a number of ailments in the last decade and the National Department of Transport (DOT) programme has dwindled to the extent where it is almost non-existent. Currently the DOT budgets for planning, policy and research at a level of 0,2% of total budget (MTEF, 2007). Of this R30m only about 10 % is budgeted for research work which is insignificant in view of the one percent target mentioned above. This paper analyses the lessons learnt from six transport-related R&D programmes and proposes a way forward to address the current problems experienced in transport-related R&D.

2. THE IMPORTANCE OF TRANSPORT INFRASTRUCTURE

There is currently a specific need in South Africa for upgrading of infrastructure, in particular transport infrastructure, to the extent that it is recognised as a major priority for government (DoT, 2006). This has also been emphasised in the recent Accelerated and Shared Growth Initiative for South Africa – Asgisa (Yemek, 2006). However, the South African Institute of Civil Engineering (SAICE, 2006) in a recent study reported that the condition of South Africa's infrastructure is not acceptable (for example national roads were rated as being in a fair condition but all other roads in a poor to very poor condition). The Road Infrastructure Framework for South Africa (RIFSA) highlights the need for investment into road infrastructure and suggests an action plan for road infrastructure development in South Africa (DoT, 2006b). Recently the South African National Roads Agency (SANRAL) stated that heavy traffic on major roads has increased dramatically in the past few years, for example on the N3, Johannesburg to Durban, the equivalent axle loading in the last three years has been the same as in the previous twenty years (Kannemeyer, 2007).

In response to the growing understanding of the need for investment in infrastructure, the South African government announced a plan in 2005 to invest R320 billion in infrastructure over the next five-year period (Engineering News, 2005). (This amount has subsequently been increased). The importance of infrastructure is also evident from the emphasis placed by government on the Extended Public Works Programme (PWP, 2008) and regionally, infrastructure is a major factor in the New Partnership for Africa Development (NEPAD, 2001) strategy.

As indicated above, transport and transport infrastructure impact on South Africa in a number of ways (DoT, 1996). Firstly, the provision of adequate transport facilities as well as road infrastructure and access streets is essential in providing in the basic needs of the people. Secondly, the road-building industry provides an ideal opportunity for job creation, the development of human resources through skills and technical training and the development of small entrepreneurs and contractors. Finally, a quality primary and secondary road network is essential to stimulate economic growth, which in turn ensures sustainable employment opportunities.

As South Africa becomes more integrated into the global community after democracy, significant events such as the Rugby World Cup in 1995 and the World Summit on Sustainable Development (2002) have been hosted. The upcoming hosting of the Soccer World Cup in 2010 is another example of such an event, but on a much larger scale. Such a world-scale event will place marked pressure on the local infrastructure and transport systems and services. These developments have therefore led to flagship projects such as the Gautrain project, providing rapid transit between Johannesburg, Pretoria and O.R.Tambo International Airport. Projects like these will require major innovation and capacity development in the transport sector.

3. THE NATURE OF R&D IN THE TRANSPORT SECTOR

R&D and new knowledge generation in the transport sector are multidisciplinary in nature, covering fields such as transport policy and planning, traffic engineering, materials science, road structural design, intelligent transport systems etc. The outputs and outcomes of research and development activities are mainly new engineering methodology, decision-support systems, prediction models, and some new hard products. The innovation process is therefore not linear, progressing from idea generation, R&D, to engineering, product manufacturing and marketing (as is mostly the case in new consumer product development), but rather an iterative, systemic process of knowledge generation and learning. The development of engineering know-how and methodology is a complex, systems-related process and the management of such activity should therefore take cognisance of complexity.

Cilliers (1998) states: *"there is no denying that the world we live in is complex, and that we have to confront this complexity if we are to survive, and, perhaps, even prosper*". The traditional way of dealing with complex issues is to engage them from what is perceived to be a scientifically determined, secure (and usually fixed) point of reference. Not only does Cilliers call this approach an avoidance of complexity, but solutions that are based on this premise will also of necessity be linear, and therefore not responsive to changes in needs and constraints. Such solutions are thus unlikely to be useful when phenomena such as human capital development and management processes need to be addressed. This is one of the reasons why the traditional linear research management models used for the development of consumer products are insufficient for the management of research, knowledge and technology development in the transport sector. R&D in the transportation field therefore requires a more holistic and systemic approach than that usually seen in hard product development processes.

A number of the challenges faced by the transport sector are external to the sector. Changes in the nature of the demand for mobility, rising conflict and security issues, and continued population growth and urbanization are some of the challenges to be addressed. Linked with this are the growing challenges on how to ensure that environmental, economic, and social sustainability can be achieved. Technological challenges relating to aspects such as the development of alternative energy sources, improved vehicle emissions technology, improved transport infrastructure technology, and intelligent transport information and communication technologies needs to be addressed.

4. RESEARCH METHOD

In South Africa there have been a number of research programmes addressing the transport industry over the past 25 years. All the significant programmes that existed for more than five years were selected for analysis. These are:

- The DOT research programme prior to 1988 (the Steering Committee era);
- The DOT research programme between 1988 and 1993 (the Research and Development Advisory Committee era);
- The DOT research programme between 1993 and 1997 (the Centres of Development era);
- Gauteng Department of Public Transport, Roads and Works research programme from 1995 to 2005;
- The Southern African Bitumen Association (Sabita) research programme from 1988 to 1997, and
- The CSIR Transportek parliamentary grant research programme from 1988 to 2005.

The DoT programmes and the Gauteng programme were resourced from public funding, the Transportek programme was grant-funded by the Department of Science and Technology and the Sabita programme was private sector funding.

The above six programmes were analysed qualitatively and quantitatively in order to distil the lessons learnt from their operation and performance. Firstly, the history and context of the programmes were analysed and secondly, the management models used, the successes and failures and the lessons learnt from their operation and performance. The information provided here has been compiled from previous work conducted (Rust *et al*, 1998) as well as from personal discussions with Dr George Dehlen (Dehlen, 2007) who was a director of the National Institute for Transport and Road Research (NITRR) at the CSIR and a senior member of the Transportek management team. Dr Dehlen was also a member of many of the committee structures discussed here. Discussions were also held with Mr Keith Wolhuter (Wolhuter, 2007) who served on the secretariat of the Navplan[1] consortium for a number of years. Thirdly, the six programmes were analysed based on the trends in number of projects per annum, number of organisations doing research and average project size. The data presented here was compiled from the CSIR Transportek financial system as well as from the records of Navplan and then analysed to produce the trends discussed below. These trends are then compared with the successes and failures of the programmes.

5. HISTORY AND CHARACTERISTICS OF TRANSPORT-RELATED RESEARCH IN SOUTH AFRICA

Exacerbating the complexity of R&D in transport-related topics, is the fact that immediately preceding and following the political change in South Africa in 1994, and because of competing priorities, very little attention was given to R&D in transport. A number of studies (CIDB, 2004; Rust and Venter,2004; CSIR, 2005) have indicated that the transport sector and the construction sector in South Africa have come through a period of underinvestment by government and a lack of service delivery from government. This environment led to survivalist strategies which impacted negatively on R&D programmes. The result was a focus on direct, immediate problem-solving rather than R&D-based activities with a view to building competences for the future. Consequently, in the early 1990s, the national transport research programme became fragmented with very little focus and subsequently did not live up to expectations (DoT, 1995). Funding decreased in real terms and the focus was narrowed down to special investigations related to short-term problem solving. However, at the same time some other research programmes, particularly the Gautrans programme and the Sabita programme made significant progress and contributions to new knowledge generation as discussed in the following paragraphs (summarised from Rust *et al*, 1998).

5.1 The DOT steering committee era (prior to 1987)

From 1953 to 1987 CSIR Transportek (one of the operating units in the Council for Scientific and Industrial Research or CSIR) was the main organisation conducting research for the DOT and provincial road authorities. In this era, the committee structures consisted of the Road Research Advisory Committee and the Roads Steering Committee (Kleyn, 2007). The Roads Steering Committee consisted of senior officials from the NITRR as well as technical officials from the road authorities. The Steering Committee prepared a proposed research agenda that was then presented to the Road Research Advisory

[1] Navplan was a consortium of CSIR Transportek, Bruinette, Kruger and Stoffberg Incorporated and Jordaan and Joubert Incorporated with the purpose of managing the RDAC era of the SADoT research programme between 1988 and 1993.

Committee (RRAC). The RRAC consisted of senior officials from the national and provincial road authorities, representatives from the consulting engineering fraternity, representatives from the construction industry as well as a representative from the oil companies. This committee provided a critical review of the proposed research agenda and associated funding and provided advice to the Steering Committee on the final composition of the research programme. The funding was in the form of a stable grant, involving a minimum of formal controls (other than statutory accounting controls), and outputs and outcomes were assessed by the steering committee. During this era, projects were not managed according to tight deadlines with the result that progress was often slow. Sometimes projects did not address real needs in the road authorities and the industry, but were "pet topics" of researchers.

5.1.1 Advantages of the Steering Committee era

- Good communication between sponsors, users and researchers;
- Guidance for research from a closely networked system of committees;
- The process was adjudicated on implementable outputs;
- The committees provided forums where researchers met with sponsors of research and users, and
- A longer-term view was taken with continuity of funding.

5.1.2 Disadvantages of the Steering Committee era

- the minimum of formal controls were used and the process was therefore not always transparent and progress often was slow;
- the split between the funding process and the programme identification process led to a lack of commitment from the funding organisations to the projects conducted, and
- the lack of a project-specific financial management system made it difficult to assess the benefit versus cost of project.

5.2 The RDAC period (1988 - 1991)

In 1986 the National Transport Commission (NTC) established the Research and Development Advisory Committee (RDAC). RDAC reported directly to the South African Roads Board (SARB) and also liaised with the relevant officials in the DOT. The overall responsibility of RDAC was to advise the SARB on research funding, to monitor and encourage research and to ensure that agreed research objectives were met and followed by implementation of the end-products. RDAC thus effectively replaced the original CSIR Steering Committees which were then also disbanded during 1987. A consortium, Navplan, consisting of staff from CSIR Transportek and two civil engineering consulting firms was created to assist RDAC with administrative tasks. The Navplan process focussed mainly on the monitoring of progress and control of research funding, and not on the technology development process as a whole. The intention was to incorporate the expertise and practical knowledge of practitioners in the industry into the research effort. To keep the process as transparent as possible, all research projects were allocated in a tendering process. This included both "client identified" and "researcher identified" projects. This sometimes led to a problem situation where a research organisation would identify a need, develop a proposal for a methodology to address this need and would then subsequently lose the project on account of not being the lowest bidder in a tendering process. Issues such as the ownership of the intellectual property of the original ideas and work as well as the parity between research organisations in terms of research capability then became very problematic. The response of the organisations and companies conducting research

was to focus on reducing cost rather than on quality R&D. This resulted in a plethora of small, unfocussed projects and subsequent fragmentation of the research effort. It is obvious that this had a severely detrimental effect on the impact and value of the research effort as is clearly shown by the trend analysis below. At the end of 1991, the Navplan system collapsed without being replaced by any other. The negative impact of this is still evident from the current lack of a comprehensive national transport R&D programme.

5.2.1 Advantages of the RDAC period

- The use of panels to guide research efforts in the various areas of knowledge, providing input from selected stakeholders (thus a broader group than during the steering committee era).

5.2.2 Disadvantages of the Navplan process

- It did not comprise a holistic, strategic approach to research and technology development and had specific shortcomings in strategic planning, implementation and technology transfer;
- There was no portfolio management ensuring a balance of projects;
- It focussed mainly on monitoring of progress and on control of funding rather than on the strategic process of research and technology development;
- The complexity of using many different research contractors to address the needs of a large body of stakeholders was not addressed;
- The research needs determination process was not inclusive due to the fact that end users of the technologies were not consulted;
- The research effort became fragmented due to severe competition in the tendering process and a lack of strategic focus and thus led to a plethora of small projects;
- The procedures it developed were bureaucratic and cumbersome, and
- It did not focus sufficiently on invention and creativity and most of the activity became knowledge application rather than knowledge generation.

5.3 Centres of Excellence/Development (1993 - date)

Following the Navplan era and a two-year period during which no research was funded by the DOT, it was decided to establish so-called “Centres of Excellence”. The intention was that three Centres of Excellence would be created, located in Gauteng, the Western Cape and in KwaZulu-Natal. A Centre was envisaged as comprising a grouping of universities and technikons that would participate, under the supervision of a Board of Control, in the process of addressing transport issues and the development of personnel and academic resources in the field of transport. The main thrust of funding was towards knowledge enhancement and human resource development through a research grant. In 1995, the “Centres of Excellence” were renamed as “Centres of Development” or CoDs. The focus of the CoDs was on the development of new knowledge and human resource development. The research needs identification process in this era ran into the same problems as those experienced in the RDAC/ Navplan era. In the first year of the Centres of Excellence, needs identification was once again conducted by the researchers and it was only later that the DOT demanded that it be consulted prior to initiation of a project. This process was, however, also not based on a comprehensive research strategy but rather the execution of a group of unlinked projects and thus the process was as fragmented as it had become during the RDAC/ Navplan era.

5.3.1 Advantages of the CoD process

- It had a strong focus on the development of human resources, and
- It contained some elements of dedicated funding which benefited longer-term capability development and provided room for enhanced creativity.

5.3.2 Disadvantages of the CoD process

- Like all the previous DoT technology management processes, it was not based on a comprehensive research strategy and the research needs determination process was not well developed;
- It did not provide for forums where discussion could take place;
- It was not output driven, and
- There was no attempt to measure outcomes and impact.

5.4 Gauteng Department of Public Transport, Roads and Works

The Gauteng Department of Public Transport, Roads and Works or Gautrans (formerly part of the old Transvaal Provincial Administration) has, over the past 10 years funded research at CSIR Transportek (and since 2005 the Built Environment Unit of the CSIR) on an annual basis. The most notable project was the Gautrans Heavy Vehicle Simulator (HVS) project which is currently still active (Rust et al, 1995). The research work conducted for Gautrans is managed by a steering committee and the work is championed in Gautrans by the Chief Engineer Materials that heads up the materials testing laboratory. The steering committee consists of representatives of Gautrans, the CSIR, other provincial governments, the South African National Roads agency and practitioners. The HVS project is relatively large (currently in the order of R4 million to R6 million per annum). In earlier years, the project was also linked to the South African HVS programme through the HVS Steering Committee. Currently the programme also participates in the HVS International Alliance (HVSIA, 2008), a forum where research co-operation and information sharing is discussed by all members, including the California Department of Transport, Gautrans, US Army Core of Engineers, the Cold Regions Research and Engineering Laboratory of the USACE, VTT in Sweden and the Florida DoT. The official committee structure is augmented through regular project meetings, site visits and informal discussions. This communication channel is vital to the success of the project. One of the other characteristics of the Gautrans HVS programme over the past 20 years was the continuity of the funding for this project. The HVS project was also complemented with materials testing, field surveys and trial construction projects - enhancing the outputs from the HVS programme significantly. The bulk of the work was conducted at CSIR Transportek in the past and now at the CSIR Built Environment Unit, but in co-operation with consulting engineering firms and universities.

5.4.1 Beneficial characteristics to be considered

- The continuity of funding which allowed for longer-term capability development and provided room for enhanced creativity;
- The fact that the project was well-focussed with the result that outputs were implementable and useful in practice;
- The use of a steering committee to provide strategic direction for the project, and
- The fact that the HVS project was linked to other projects to enhance the body of outputs.

5.5 The Sabita research programme

In 1988, the Southern African Bitumen and Tar Association (Sabita) embarked on a

strategy planning process during which the importance of generic technological development for the industry was acknowledged (Rust *et al*, 1994). Sabita and the CSIR subsequently initiated a research and development programme for the asphalt industry, the Asphalt Research Programme (ARP). It was envisaged that the ARP would enhance asphalt technology in the industry, create an improved profile for the industry and enhance the industry's efficiency, thereby making the industry more competitive and improving products and services to the industry's clients. The basis of the ARP was a needs-driven research programme based on the actual needs of the industry and its clients. Prior to the commencement of the programme, significant effort was put into the determination of research needs. A series of workshop-like meetings formed the Asphalt Research Strategic Taskforce planning process (AREST). The process included participants from the road authorities, the road industry as well as from local authorities and communities. The highest-priority projects emerging from the first AREST sessions focussed on research and technology development including work such as the 'Heavy Duty Asphalt Pavements' and 'Appropriate Standards for Bituminous Surfacings' projects. The industry's acceptance and prioritisation of projects was based on benefit/cost assessment. In 1990, the industry reviewed its needs and how the ARP projects should be realigned to address these changed needs. A major theme of the 1990 AREST meeting was to position the asphalt industry for the imminent socio-political changes in South Africa. A number of issues regarding the role of the asphalt industry and the future social development in South Africa were identified and action plans formulated. The implementation programme has yielded excellent results, particularly in the areas of large-aggregate mixes, porous asphalt, emulsion-treated bases and in addressing social development needs (Rust *et al*, 1994).

Sabita and CSIR Transportek also jointly used the Bituminous Materials Liaison Committee (BMLC) meetings (that later became the Road Pavements Forum) as a forum for obtaining input into the research and technology development programme, sharing the results from the programme and endorsing results prior to implementation. The use of the AREST meetings to define general strategic direction and the BMLC as a forum to discuss research projects, results and implementation as well as to define detailed needs for research was essential to the success of the Sabita programme. Sabita used a number of organisations including CSIR Transportek, consulting engineering firms and universities to conduct research and technology development projects. However, a significant proportion (70 per cent) of research projects was conducted by CSIR Transportek, either as the sole contractor or in co-operation with other parties. This allowed for the creation of critical mass in terms of research capability and equipment within one main research organisation. Thus the Sabita programme was based on a comprehensive strategy that addressed actual stakeholder needs and was focussed on a number of large research projects that were managed as a portfolio. This ensured that the Sabita programme did not become fragmented but remained focussed. The programme was estimated to have yielded high returns in relation to the investment (Rust *et al*, 1994).

5.5.1 Beneficial characteristics to be considered

- Based on a comprehensive strategy developed through a process which included wide participation from road authorities and industry;
- Strategic direction provided through a "steering committee" in the form of the Sabita ARP Board;
- The use of a discussion forum (BMLC) to obtain research input, to share research results and to endorse findings prior to implementation;
- The development of a special needs determination process utilising the knowledge of a broad base of practitioners and stakeholders;

- The appointment of a dedicated technical director in Sabita which had the Sabita research and technology development programme as one of his main involvements, and
- The appointment of a Key Account Manager by CSIR Transportek to manage the business issues (including financial management, progress reviews and co-ordination) related to the projects conducted by CSIR Transportek.

5.6 CSIR Transportek's parliamentary grant programme

The history of the CSIR was recently recorded in a book by Kingwill (1990). In 1945 the CSIR was formally established as a body corporate in terms of the Scientific Research Council Act Number 33 of 1945 of the Parliament of the Union of South Africa, thus a statutory body. Initially the CSIR was wholly funded by parliament. After a strategic review in 1988, the CSIR became more market orientated, foreseeing that in future it would have to be less dependent on the parliamentary grant. Currently the parliamentary grant forms approximately only 40 per cent of the CSIR's total income (CSIR, 2007). This strategy, although leading to financial success, did impact negatively on the CSIR's science and technology base, as was evident from the drop in academic publications and the increase in consultancy activity as opposed to research. In 2004 the CSIR embarked on a new strategy with renewed emphasis on building the quality of the SET base (the Beyond 60 strategy) as well as on the delivery of SET outputs such as publications, patents and technology demonstrators[2]. The optimum investment of the parliamentary grant to build future technologies for South Africa has always been an important issue for the CSIR.

Transport-related issues have been researched in the CSIR from 1950 (Bituminous Binders Research Unit) and then later in the CSIR Transportek Unit and currently the CSIR Built Environment Unit. Initially CSIR Transportek made the same mistakes as those indicated above and research projects funded from parliamentary grant became smaller every year with the resultant fragmentation. However, since 1996, a new holistic, systems-based management model and supporting tools were used to develop a comprehensive research strategy, develop a coherent portfolio of research projects and ensure effective technology transfer. Research output and value from this programme has subsequently improved significantly (Rust, 2008).

5.6.1 Main advantages from the CSIR research management approach

- It utilizes a number of internal and external stakeholder committees to provide strategic direction to the research programme;
- The research programme is based on a comprehensive strategy taking cognisance of both market needs (formal research needs determination processes) as well as technological trends (technology foresight studies);
- It is a systems approach, taking cognisance of a number of elements in the management system, their internal interaction as well as their interaction with the external environment (Rust and Vos, 1998);
- It includes a project portfolio management approach that allows for optimising output and outcome from the research investment which is vital in a scenario of scarce research funding, and
- It includes a research effectiveness measurement system that provides indications of the value derived from research programmes.

5.7 The Pavement Research Advisory Committee

[2] A technology demonstrator is a significant novel technology that has been developed over a number of years and the application of which has been demonstrated in industry.

In 2004, the road building industry of South Africa represented by road authorities, materials suppliers, consultants, universities and the CSIR, formed the Pavement Research Advisory Committee (PRAC, 2008). This committee, to which the CSIR provides the secretariat, serves as a steering group to guide all research related to pavement materials, pavement design and accelerated pavement testing. The processes and structures used by PRAC include many aspects of the new systems-based research management approach developed at the CSIR. Currently the PRAC membership includes the South African National Roads Agency, the CSIR, provincial road authorities, three universities, construction materials producers, two consulting engineering firms and the Asphalt Academy.

The PRAC has the following objectives:

- To provide advice on R&D needs and priorities;
- To assist with technology foresight studies;
- To advise on the development of strategic plans and research portfolio plans for the research programme;
- To assist with project portfolio analysis;
- To assist in the review of outcomes and objectives; and
- To assist in assessing the impact of R&D activities.

In essence therefore the PRAC provides a platform for a holistic approach to defining the road infrastructure research and technology development agenda and to evaluate the research outcomes. The first document released by the PRAC dealt with road pavement research needs for South Africa (PRAC, 2005). However, the PRAC is still relatively young and no attempt was made to analyse the outcomes from this programme.

5.8 DOT research after 2000

Projects conducted under the research directorate of the DOT after 2000 mainly focussed on investigative studies of identified problematic areas such as substance abuse of drivers, pedestrian casualties, the arrive alive campaign and potential funding mechanisms. However, the DOT recognised the lack of a comprehensive, integrated and strategically focussed research programme over the medium to long term and has recently developed the Transport Innovation and Technology Research Strategy as part of addressing these challenges. This strategy has been approved by the Minister of Transport but still needs to be endorsed by the cabinet and as such has not been implemented yet.

6. QUANTITATIVE ANALYSES OF SPECIFIC CHARACTERISTICS OF THE VARIOUS PROGRAMMES

The data analysed here was compiled from the CSIR Transportek financial system as well as from the Navplan records and then analysed to produce the trends discussed here. In order to compare critically the research programmes above, specific characteristics of the programmes were analysed by plotting the following trends:

- Number of projects in the programmes;
- Number of organisations participating in the research programme (RDAC and Sabita programmes only);
- Number of projects per organisation (RDAC and Sabita programmes only);
- Total annual research budget in each programme;
- The average project size per programme, and
- The maximum project size in each programme.

The figures were adjusted to 2005 Rand values using the official Consumer Price Index figures published by the South African Department of Statistics. These trends are shown in Figures 1 to 3 and are discussed below. As can be seen from these graphs a number of general trends can be noted:

- The steering committee era was a relatively stable period as indicated by a stable number of projects (long-term projects), a stable total research budget, a significant average project size (about R800,000) and therefore a significant number of man years per project (on average three). During this period, many of the successfully implemented research outputs that South Africa became well-known for, were developed (Rust, 2008).
- The trends during the RDAC era were very different with a significant increase in the number of projects and the number of organisations participating in projects subsequent to the DOT changing research procurement to a general tendering process.
- A sharp decrease in the number of projects per research organisation in the RDAC period that led to severe fragmentation of the research programme and also to a lack of critical mass in organisations conducting research.
- The effect of the fragmentation during the RDAC period can be seen in the average project size - the average project size decreased from R700 000 to R185 000.
- In the RDAC period, the average number of man years per project also decreased from 3.0 to values of less than 0.58 thus not creating space for any manpower development and mentoring.
- The CoD period was a very modest programme in comparison to its predecessors, however, the total budget also decreased gradually over time and the average project size was very low.
- The Sabita programme was also much smaller than the DOT programmes, however, it has been very successful in the implementation of results (Rust , 2008), mainly due to stable funding, using few organisations to conduct the work as well as a relatively high average project size and consequently a high ratio of man years per project.
- The Gautrans programme, although relatively small in total budget, has very stable levels of funding, a high average project size, a high degree of focus, and the average number of man years per project varied from 2.5 to 7, which is significantly higher than the other programmes.
- The CSIR Transportek parliamentary grant programme in many ways made the same mistakes as some of the others, showing a decrease in average project size initially.
- The implementation of a holistic, systems-based research management model (Rust and Vos, 1998), however led to a significant increase in average project size. It is interesting to note that currently the average project size in the Built Environment Unit of the CSIR is back to the same levels as those experienced during the very successful steering committee era.

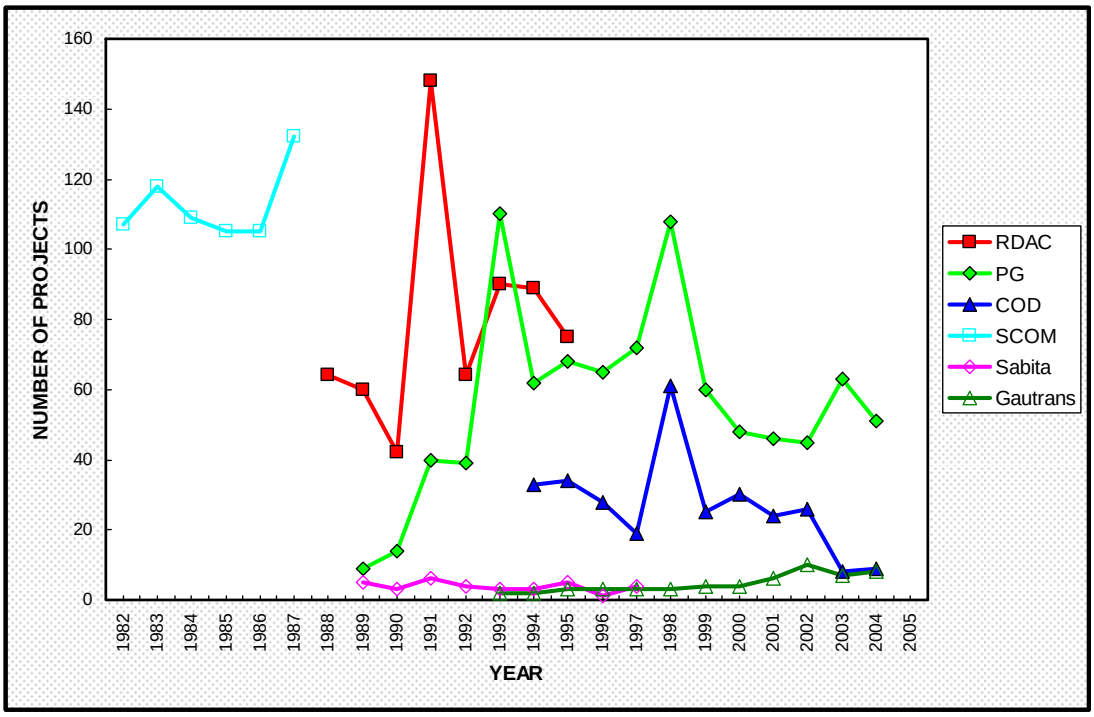

Figure 1 Number of research projects conducted per annum in each programme

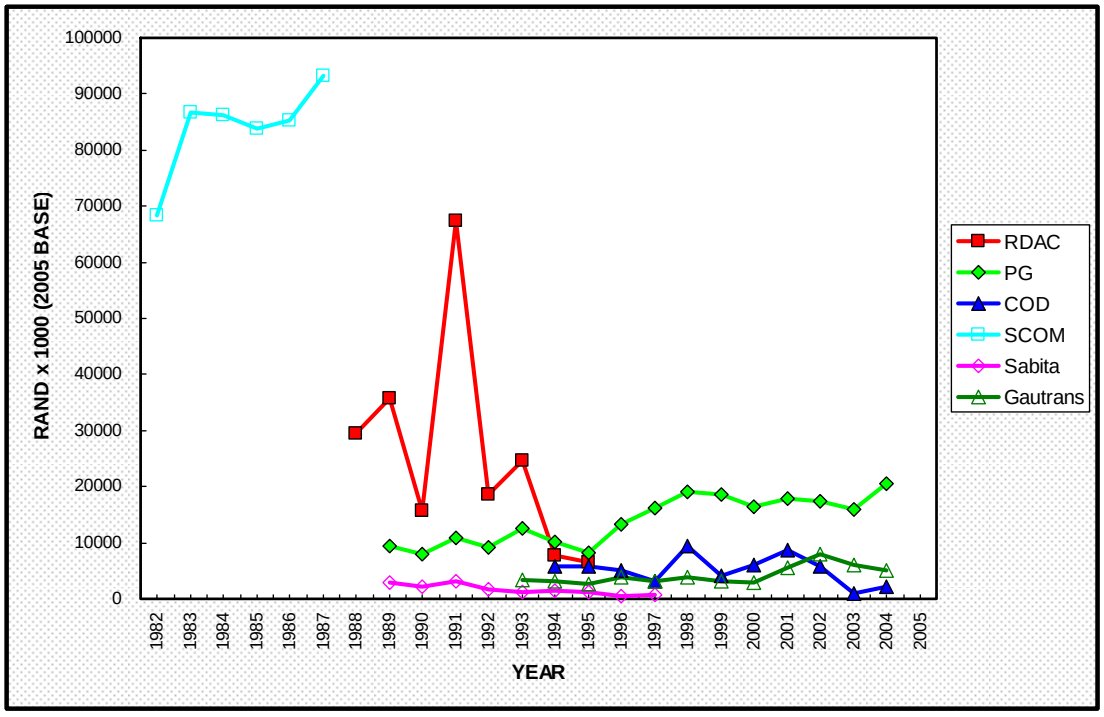

Figure 2 Total annual budget in the research programmes (2005 Rands)

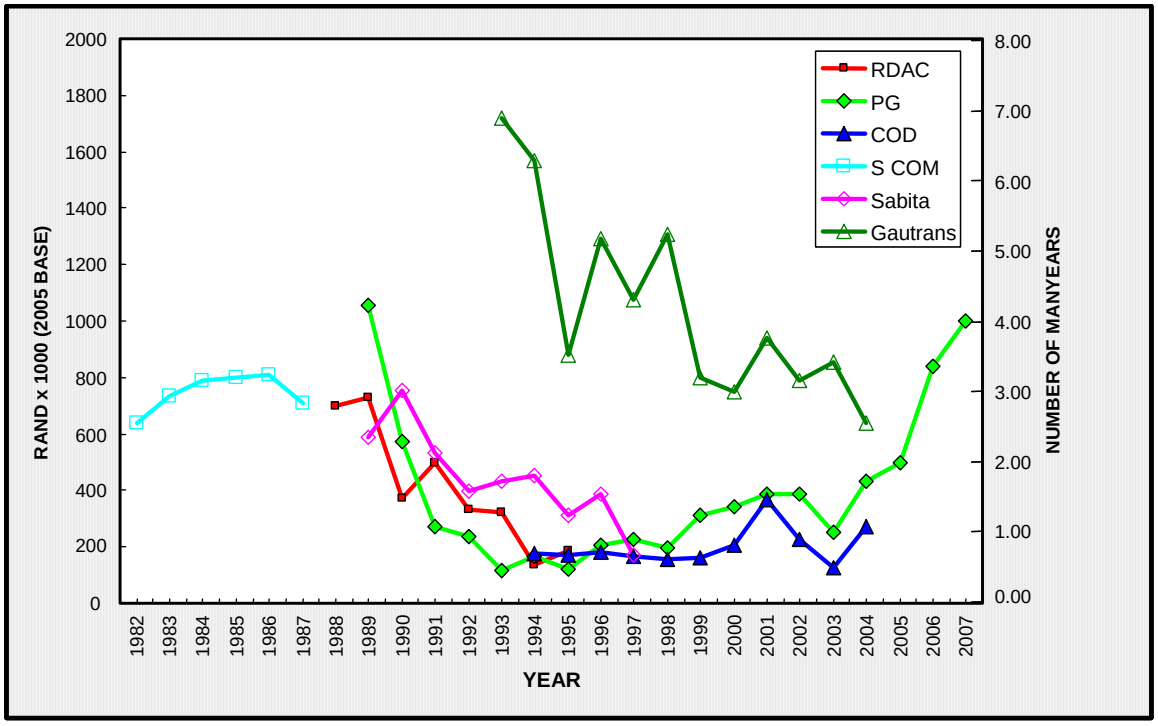

Figure 3 Average project size per annum for the research programmes (left scale) and average man years per project (right scale)

The above clearly shows the detrimental effect of the fragmentation of the DOT research programme, leading to numerous small projects conducted by 25 organisations instead of focusing the majority (almost all) of the projects in one organisation, as was done in the steering committee era, allowing for the building of critical mass in specific research fields as well as the development of a high standard of research laboratories and equipment. This fragmentation was exacerbated by the installation of a tendering system, with the result that the DOT research programme did not live up to expectations and collapsed in 1994, finally being stopped in 1996. The Sabita and Gautrans programmes seemed to be much more focussed and yielded significant results which were also well implemented (Rust, 2008).

From the above it is evident that the various research programmes did not keep up with inflation. The total budgets decreased in real terms as did the average project size. Figure 3 shows the average project cost of the programmes divided by an assumed average total cost of a researcher of R240 000 per annum, thus indicating the average number of man years spent per project. It is clear that the fragmentation of the programmes had a significant effect on the number of man years employed per project - decreasing from as high as four to as low as 0.47 in the case of the PG programme. Taking into consideration the use of technicians and other support staff, this implies that instead of teams of two or three researchers working on a project, researchers were expected to work simultaneously on a number of projects. During this period a number of negative effects were observed by the author. These included:

- Loss of focus by researchers;
- Virtually no mentoring of junior staff by senior researchers;
- Less effective peer review of research results;
- Less effective technical communication;
- Less effective development of human resources;

- Less chance to use colleagues as a “sounding board” for ideas and evaluation of results, and
- Consequently, less effective innovation and loss of research staff.

It is interesting to note that Dimitratos and Plakoyiannaki (2003), studying organisational culture and entrepreneurship, have also found that the lack of a holistic, systemic approach leads to fragmentation with the associated negative results. Nature (2000) reported that Germany had also realised the need for a more systemic approach to counter fragmentation. Similar intentions have been expressed by the European Commission in 2007 (EU, 2007).

The question remains whether this fragmentation and associated negative aspects had impacted negatively on the delivery of outputs and results from the research programmes. In order to answer this question accurately, a comprehensive retrospective study is required which is beyond the scope of this paper. However, some indicative trends can be observed, particularly in terms of the number of design guidelines and manuals produced during the periods studied under the auspices of bodies outside the CSIR. These are considered to provide some indication of the implementation of research results and usage by practitioners in industry.

During the Steering Committee era, the DOT research programme delivered 23 Technical Recommendations for Highways Manuals. These manuals are used by the South African transport industry and in some cases also internationally, for example in Australia and the USA. Most of these manuals were developed in the 1970s, 1980s and early 1990s. Only five of these manuals have been updated after 1995 and none since 1998. Similarly, the Technical Methods for Highways series consists of 12 manuals used nationally for materials and road structural testing. Only one of these has been updated in 1997, and none since. In the case of the Urban Transport Guidelines series, a total of 11 manuals, the last updates were made in 1991. These manuals were developed, based on years of research prior to 1990 and the current situation of low numbers of new manuals or upgrading of manuals is a clear indication of the negative impact of the implosion on the DoT transport research programme. Some efforts have been made by the South African National Roads Agency to rectify the situation. However, if the expenditure on small and unfocussed research projects during the RDAC era of more than R140 million (in 2005 Rands) from 1988 to 1993 is taken into consideration, it is clear that the fragmented research programme caused by the tendering process did not live up to expectations.

In a similar period from 1990 to 1997, Sabita invested about R12 million (2005 Rands) into the asphalt research programme at the CSIR. In this period 26 design manuals were delivered which are currently still in use (Sabita, 2007). In contrast to the DoT programme, all these manuals were developed during the 1990s and updated after 1995 with five having being updated after 2000. The Sabita programme also yielded significant publications in a number of international conferences including the 7th and 8th International Conferences on Asphalt Pavements (ICAP) as well as the Conference for Asphalt Pavements in Southern Africa (CAPSA). In 1994, fourteen papers from South Africa were published at the 7th ICAP conference in Nottingham from a total of 87 papers world-wide. Eight of the South African papers originated from work conducted in the Sabita programme. Similarly, in 1997 seven out of 14 South African papers at the 8th ICAP conference in Seattle originated from the Sabita programme. The contrast between the DOT programme and the Sabita programme in delivery and value for investment is mainly due to the difference in the research and development process and management models (Rust and Vos, 1998).

It is clear from the above that a new approach to the management of R&D and technology development should attempt to eliminate the negative effects discussed above. However, the answer does not necessarily lie purely in increasing research budgets, but also in an innovative approach to managing the process.

7. A NEW APPROACH

There are many international and some local examples of alternative approaches to the procurement of R&D services by government. These usually involve dedicated medium to long-term funding for centralised R&D organisations such as the Australian Road Research Board, the Belgian Road Research Institute, the Transport Research Laboratory in the UK, TNO in the Netherlands, etc. In resurrecting its transport research programme, South Africa should consider the following objectives:

- develop a transport research strategy for South Africa that takes cognisance of various current research programmes, future technology trends (technology foresight study), research needs in the industry and human resource development aspects (an initial Transport Innovation and Technology Research Strategy has recently been developed by the DoT, but should be expanded to reflect the needs of the industry more comprehensively and other aspects as mentioned above);
- initiate activities to establish transport as a research theme of national importance in the South African National R&D strategy;
- employ a project portfolio management approach, thematic research focus areas and is balanced in terms of the types of research defined in the National R&D strategy - rather than managing individual projects separately;
- counter fragmentation by planning for and executing larger projects that are coherently linked to each other in a research project portfolio;
- build critical mass in research by structuring collaborative research programmes under one strategic planning and project management umbrella;
- create dedicated funding mechanisms taking cognisance of the Public Finance Management Act, that allow for medium to long-term funding of strategic research programmes without a short-term tendering approach, and
- create the required committee and forum structures to provide strategic direction to and control the progress of the R&D programme, particularly a national forum for transport R&D co-ordination that could assist in ensuring synergy between government departments and between government and private sector in terms of developing and managing the R&D portfolio for South Africa.

8. CONCLUSIONS AND THE WAY FORWARD

The qualitative and quantitative analysis in this paper highlighted some of the success factors and failure factors of a number of transport-related research programmes in South Africa over the past thirty years. Currently there is a major increase in activity in the construction sector. At the same time, traffic on our roads is increasing at an alarming rate. In addition, rural areas are still neglected when it comes to quality transport infrastructure and services. Seen in the light of the fact that SAICE (2006) reported that South Africa's transport infrastructure is below par in quality, quantity and functionality as well as the fact that there is a dearth in transportation professionals, particularly civil engineers, in South Africa, the scenario calls for significant interventions to rectify this situation.

One such intervention should be the building of South Africa's transport engineering knowledge and know-how through a strategic transport research programme with the emphasis on developing new knowledge and technology as well as new transport

professionals with in-depth knowledge. It is therefore with trepidation that one realises that in the past decade there has been no holistic and significant research programme in transportation in South Africa – apart from some good work conducted in pavement engineering. Furthermore, the impetus that South Africa had in the late 1980's through to the early 1990's in transport research has been negated through the fragmentation of the research programme as shown above. The question arises how this situation could be reversed?

The authors argue that in view of the importance of transport and transport technologies in the future of South Africa, emphasis should be placed on re-developing the transport research capability in South Africa with specific emphasis on human resource development. Such activity requires strong leadership from the National Department of Transport and cooperation with universities and the CSIR. This can only be achieved through a proper strategic management process, utilizing management models and tools that take the whole innovation chain into account as well as through significant levels of dedicated research funding. Such management models should also ensure that the appropriate co-operation takes place between government, research organisations and universities to deliver the required technological solutions to South Africa's transport industry, which is facing some demanding challenges.

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