A SYSTEMS APPROACH TO MANAGING R&D IN THE ROAD INFRASTRUCTURE SECTOR IN SOUTH AFRICA

APPENDICES

Frederik Christoffel Rust

A thesis submitted to the faculty of Engineering, University of the Witwatersrand, in fulfilment of the requirements for the degree Doctor of Philosophy

Johannesburg, 2007

LIST OF CONTENTS

APPENDIX A: DEFINITIONS

Science is defined as: "*any system of knowledge that is concerned with the physical world and its phenomena and that entails unbiased observations and systematic experimentation. In general, a science involves a pursuit of knowledge covering general truths or the operations of fundamental laws*" (Encyclopaedia Britannica online[1]).

Engineering is defined as: "*the application of science to the optimum conversion of the resources of nature to the uses of humankind. The field has been defined by the Engineers Council for Professional Development, in the United States, as the creative application of 'scientific principles to design or develop structures, machines, apparatus, or manufacturing processes'"* (Encyclopaedia Britannica online [1]).

Technology is defined as: "*the practical application of knowledge especially in a particular area*" and "*a capability given by the practical application of knowledge*" (Merriam-Webster online[2]).

The various categories of research and development are defined as follows (Frascati Manual[3]):

"***Research and experimental development (R&D)*** *comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.*

"R&D is a term covering three activities: basic research, applied research and experimental development.

*"**Basic research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. Basic research analyses properties, structures and relationships with a view to formulating and testing hypotheses, theories or laws. The results of basic research are not generally sold but are usually published in scientific journals or circulated to*

interested colleagues. Occasionally, basic research may be 'classified' for security reasons.

*"**Applied research** is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. The results of applied research are intended primarily to be valid for a single or limited number of products, operations, methods, or systems. Applied research develops ideas into operational form. The knowledge or information derived from it is often patented but may also be kept secret.*

*"**Experimental development** is systematic work, drawing on existing knowledge gained from research and practical experience that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed."*

Innovation is defined by Roberts[4] as:
"Innovation is composed of two parts: (1) the generation of an idea or invention, and (2) the conversion of that invention into a business or other useful application. Or in simple terms:

Innovation = Invention + Exploitation"

APPENDIX B: LIST OF INTERVIEWEES, PRESENTATIONS AND WORKSHOPS

The models developed were presented to and discussed with a number of parties throughout the development process. Based on their inputs, the models and techniques were enhanced and modified as well as added to.

Interviews

The following individuals and organisations were interviewed to obtain feedback and input into the development of the model and tools:

- Dr George Dehlen, ex-director of the National Institute for Transport and Road Research (NITRR), senior member of the Transportek management team
- Mr Keith Wolhuter, member of the Navplan secretariat
- Mr Eduard Kleyn, ex-Head of Materials Laboratory, Gauteng Department of Roads, Transport and Public Works
- Mr Rob Vos, Technical Director, Sabita
- Mr Piet Myburgh, CEO Sabita
- Mr Marty Pietz, Director of Research at Washington State DoT
- Prof. Joe Mahoney, Department of Civil Engineering, University of Washington, Seattle
- Prof. Carl Monismith, Department of Civil Engineering, University of California, Berkeley
- Prof. Emile Horak, Department of Civil Engineering, University of Pretoria
- Prof. Thinus Pretorius, Department of Civil Engineering, University of Pretoria
- The Federal Highway Association, USA
- The Transportation Research Board, Washington DC
- The Transport Research Laboratory, UK.

Presentations

The following presentations were made and feedback and comments used to enhance the development of the new model and tools:

- several presentations to the Bituminous Materials Liaison Committee (later called the Road Infrastructure Forum) on the approach, new conceptual model and tools;
- paper and presentation at the South African Annual Transportation Convention, Pretoria;
- presentation to the Sabita Technical and Education Committee on general principles for holistic R&D management as well as the use of technology trees to assess project ideas and investments in research programmes (including the prioritisation of project ideas);
- presentation to the CSIR Corporate Research Management Group (CSIR Corporate accepts principles and initiates implementation);
- presentation to the Highway Materials Committee meeting in Pretoria;
- presentation to the Alaskan Transportation Week conference in Anchorage, Alaska;
- presentation to CSIR board members;
- presentation to CSIR Executive Management Board;
- presentation to and discussion with the Division for Building Technology, CSIR;
- presentation to and discussion with the Division for Mining Technology, CSIR;
- presentation to study group from the Federal Highway Association (FHWA in the USA);
- presentation to the Department of Arts, Culture, Science and Technology (DACST);
- presentations to Transportek Advisory Committees, CSIR;
- presentation to Built Environment Unit Research Advisory Panel, CSIR (RAP endorses the use of the approach and provides input into the research effectiveness measurement criteria and weights);
- presentation to the Built Environment Unit Science, Engineering and Technology committee, CSIR;
- presentation to the CSIR Strategic Research Manager's Forum; and
- presentation of Research Effectiveness Measurement process and indicators to CSIR Outcomes Management Forum.

Interactive workshops

In the above work several committees and workgroups were used in interactive workshops to develop and implement the new model and tools. These included the following:

- the Educational and Technical Committee of the Southern African Bitumen Association (Sabita) of eight members to discuss the early model and to implement the needs determination process and technology platform concepts;
- the Bituminous Materials Liaison Committee (BMLC) of 140 members to provide feedback on models and techniques and to endorse their use in the road building industry;
- the Asphalt Research Programme Board (ten members) to provide input into the implementation of the model, to prioritise research needs, to approve projects and to monitor project progress;
- the Road Materials Committee to discuss models, implement the needs determination process, to define projects and to monitor progress;
- the Sabita Technology Development Work Group to assess and approve the model;
- the CSIR Transportek advisory committees;
- the Built Environment Unit Research Advisory Panel; and
- the Built Environment Unit Science, Engineering and Technology committee.

APPENDIX C: SURVEY QUESTIONNAIRE

R&D MANAGEMENT QUESTIONNAIRE

The Council for Scientific and Industrial Research (CSIR) of South Africa is a parastatal government research organisation. The Built Environment Unit of the CSIR is conducting research in all aspects of infrastructure planning, design, materials, construction and maintenance as well as in the operation of infrastructure and traffic management. We are in the process of renewing our thinking about the management of R&D and associated projects and would therefore appreciate your time (about 15 minutes) to answer the 10 questions below. Please answer the questions or provide ratings as they pertain to your situation at the current point in time (eg current budget, current number of researchers). If you select a low rating for the extent to which you use an aspect of R&D management, then evaluate the Importance score based on your best knowledge of the topic.

The results will be treated anonymously, and your name and organisation will not be reported or stored with the data. Any identifying information will be removed before reporting any results. The results of the analysis will be shared with you for your own management planning.

1 CONTEXT

1.1 Name:

1.2 Name of organisation:

1.3 Position (please place an 'x' in the appropriate box):

General management		R&D management		Researcher	
Other					

1.4 Type of organisation (please place an 'x' in the appropriate box):

Government		State owned enterprise		Educational Institution	
Private sector Civil Engineering		Private sector other		Other	

1.5 Research field (please place an ‘x’ in the appropriate box):

Transport		Materials		Construction and building	
Infrastructure engineering		Other Engineering		Other	

1.6 Average Approximate size of annual R&D budget in your own currency (please indicate currency):

Amount:…….

Currency:……..

1.7 Approximate size of R&D team (number of researchers):……..

1.8 Average number of R&D projects in progress each year:…….

2 ASPECTS OF R&D MANAGEMENT

Indicate the extent to which you use any of the following aspects in your R&D management process and rate their level of importance by answering the following 10 questions. Type an ‘x’ in the appropriate open space.

2.1 To what extent do you link the R&D programme and projects to an overall ***strategic plan?***

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time	
Impor-tance	None		Some		Average		High		Very high	

2.2 Do you distinguish between the management processes for ***longer-term-basic R&D*** projects and ***shorter-term technology development*** projects?

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time
Impor-tance	None		Some		Average		High		Very high

2.3 Do you use ***portfolio management tools*** to balance the research project portfolio (e.g. a 2 x 2 box to plot the project portfolio in terms of technical feasibility vs market attractiveness)?

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time
Impor-tance	None		Some		Average		High		Very high

2.4 Do you have f***ormal technology transfer*** projects after completion of the research to ensure that research results are implemented effectively?

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time
Impor-tance	None		Some		Average		High		Very high

2.5 Do you do f***ormal*** assessment of the ***impact*** of R&D investment (e.g. benefit cost analysis, evaluation of social impact, evaluation of public good impact)?

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time
Impor-	None		Some		Average		High		Very

tance								high	

2.6 Do you use ***systems-based approaches*** in R&D management allowing for the evaluation of the ***interaction*** between different elements of the R&D process and providing for ***feedback loops*** to ensure team learning and value addition to the R&D process.

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time
Impor-tance	None		Some		Average		High		Very high

2.7 Do you use a ***formal investment decision*** process to allocate funding (e.g. allocating funding based on the analysis of proposed projects according to strategic selection criteria such as potential return on investment, potential for impact etc.)?

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time
Impor-tance	None		Some		Average		High		Very high

2.8 Do you use f***ormal*** planning of ***human resource development*** (e.g. career planning schedules, performance management processes, succession planning)?

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time
Impor-tance	None		Some		Average		High		Very high

2.9 Do you use ***formal project management*** processes such as PERT diagrammes or the Critical Path Method?

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time
Impor-tance	None		Some		Average		High		Very high

2.10 Indicate the extent to which you use the following R&D management tools:

a) Scenario planning

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time

b) Technology foresight studies

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time

c) Stakeholder needs analysis

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time

d) Technology road mapping

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time

e) Technology trees

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time

f) Causal maps

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time	

g) Others

Extent	Not at all		Some-times		Regular-ly		Most of the time		All the time	

If any, please name them:

……..

……..

……..

……..

……..

Reply to:

Chris Rust
e-mail: crust@csir.co.za
fax: +27 12 842 7100

Thank you, your contribution is much appreciated.

APPENDIX D: SURVEY DATA

ID	Region	Position	Organisation	ResField	Budget ($)	NoRes	NoProj	StratPlanE	StratPlanI	LongShortE	LongShortI	PortfolE	PortfolI	TechTransE	TechTransI	ImpactE	ImpactI	SystemE	SystemI	InvesDecE	InvesDecI	HumResE	HumResI	ProjManE	ProjManI	Scenario	Foresight	Needs	RoadMap	TechTrees	CausalMap	Other
1	1	1	6	3	794,512			3	3	3	2	4	3	4	3	1	1	3	2	5	3	2	2	1	1	2	3	4	3	2	2	1
2	2	3	3	1	203,252	5	10	4	4	4	2	1	1	2	3	1	3	1	2	3	3	5	3	4	3	2	2	4	1	1	2	1
3	2	2	6	4	1,016,260		10	4	3	5	3	4	4	3	3	2	3	1	4	3	3	5	4	5	4	3	5	3	1	1	3	1
4	2	3	3	6	1,524	5	7	4	3	4	3	1	2	2	2	2	3	2	2	2	2	3	3	5	3	1	1	2	2	1	1	1
5	2	2	2	6	6,097,561	200	200	5	4	4	3	3	3	2	4	1	2	4	3	5	4	5	4	4	4	2	2	3	2	2	3	3
6	3	2	1	1	7,050,000	45	100	4	4	2	3	1	2	2	3	3	4	4	3	4	4	4	4	2	2	1	1	5	2	1	1	2
7	1	2	3	3	356,199	10	10	3	3	5	4	1	2	2	3	1	3	2	2	3	3	3	3	1	2	2	2	3	1	1	2	1
8	2	1	2	6	4,573,171	60	30	5	3	4	3	4	2	3	4	3	3	1	2	3	3	4	3	2	3	2	2	2	2	2	2	1
9	3	2	6	1	40,000,000	13	50	5	4	3	3	1	2	5	3	2	3	5	4	4	3	1	2	5	4	3	3	5	4	2	2	5
10	2	2	3	4	81,301	4	2	2	2	2	2	4	2	4	3	3	2	3	3	3	2	4	3	2	2	3	2	2	1	1	2	2
11	2	3	3	2	71,138	7	5	3	3	3	3	1	1	3	3	2	2	2	2	1	2	2	2	5	4	4	3	2	3	1	3	1
12	1	1	1	4	9,425,684	25	100	5	3	5	3	5	4	3	3	2	2	2	3	2	3	3	3	5	3	3	4	3	1	1	1	3
13	3	2	1	1	8,000,000	2	200	5	4	4	3	2	4	3	4	5	4	3	3	2	3	4	4	4	4	1	2	3	5	2	1	1
14	3	3	3	4	250,000	5	4	3	2	2	2	1	1	3	3	2	2	1	1	2	2	2	2	3	2	2	2	3	1	1	1	1
15	3	3	1	4	7,000,000	10	15	4	3	2	2	3	2	4	2	2	3	4	3	4	3	1	2	4	3	2	2	3	2	2	1	1
16	2	2	2	6	18,100,610	170	45	5	4	4	3	3	3	4	3	3	2	3	2	4	3	4	3	4	2	3	3	4	3	3	2	3
17	4	3	2	6	3,299,546	35	15	3	3	2	2	1	2	1	2	2	3	1	3	4	3	4	3	1	1	2	2	2	2	1	1	1
18	2	2	2	6	813,008	13	8	4	4	4	3	3	2	2	2	2	2	3	3	4	2	4	3	2	2	1	2	4	2	2	1	1
19	2	3	3	3	1,016,260	15	15	2	3	4	4	1	2	2	3	1	2	4	4	2	4	2	2	5	4	3	2	4	2	1	2	1
20	4	2	2	4	263,964	10	10	3	3	4	4	2	2	3	3	3	3	2	2	4	4	2	3	2	2	3	2	3	3	2	1	1
21	2	2	2	5	16,260,163	200	185	4	3	2	2	2	2	2	3	2	3	2	3	2	2	3	3	2	3	2	2	4	2	2	2	2

22	2	2	2	5	16,260,163	200	185	4	3	2	3	3	3	2	2	1	3	1	2	4	3	3	4	3	3	2	2	2	2	2	1	1
23	2	3	3	6	203,252	6	6	5	4	3	3	1	2	2	3	1	3	2	3	1	3	2	2	2	2	3	1	4	1	1	1	2
24	2	2	2	2	16,260,163	200	40	4	4	4	3	2	2	3	3	2	2	3	3	4	4	4	3	3	2	2	2	3	2	2	1	1
25	2	2	3	6	101,626	15	15	4	4	3	2	1	1	1	1	2	2	1	1	3	2	5	4	2	2	2	2	3	3	1	2	1
26	2	2	2	6	12,703,252	180	80	5	3	4	2	3	3	4	3	2	2	5	3	4	3	5	4	3	3	1	2	3	2	1	1	1
27	1	2	3	2	2,927,835	10	20	4	3	4	3	1	2	2	2	1	2	1	2	1	3	4	3	4	3	1	1	1	1	1	1	1
28	3	2	3	4	1,200,000	3	6	4	4	4	2	1	2	2	3	1	3	2	2	1	2	2	3	5	4	2	1	5	1	1	1	1
29	2	2	1	4	609,756	5	3	5	3	4	3	1	1	4	4	4	4	4	4	3	4	3	3	5	4	3	1	5	1	4	1	1
30	2	1	3	5	101,626	5	3	4	3	4	5	2	5	2	2	2	5	2	4	2	5	3	3	3	5	2	1	3	1	1	2	1
31	2	2	1	1	508,130	6	8	5	4	2	4	1	3	2	4	2	4	1	4	5	4	3	3	2	5	3	1	3	2	1	1	1
32	3	2	3	4	5,000,000	10	9	5	4	4	3	1	1	2	3	2	4	3	4	1	1	4	4	4	4	1	3	4	4	1	1	1
33	4	2	2	6	5,279,274	20	7	5	4	3	3	4	3	4	4	3	3	3	3	5	4	3	3	3	5	3	5	5	5	3	3	1
34	1	3	3	4	384,833	8	10	2	5	3	5	1	2	2	3	2	3	1	2	1	2	2	2	1	1	1	2	3	1	1	1	1
35	3	2	1	1	4,000,000	15	25	3	4	2	2	1	1	2	4	2	4	3	3	3	4	3	4	2	4	3	3	3	3	1	1	1
51	2	2	2	3	1,016,260	15	10	5	3	4	3	2	2	2	3	2	3	2	4	4	3	5	3	2	2	1	3	4	1	4	2	1
52	2	2	2	6	1,829,268	25	20	3	4	4	3	2	2	3	4	2	3	2	4	4	4	4	4	2	2	2	2	3	2	3	2	1
53	2	2	2	6	2,337,398	25	10	5	4	3	4	1	4	5	5	1	3	3	3	3	2	3	4	4	1	4	4	5	1	4	1	1
54	2	2	2	4	1,422,764	17	12	5	4	4	4	3	4	5	5	3	4	4	4	4	4	3	4	4	3	4	4	5	1	5	2	3
55	2	2	2	4	4,065,041	23	15	5	4	3	3	3	5	4	4	3	5	4	4	4	4	5	5	5	3	5	4	5	1	5	1	1
56	2	3	2	4	2,032,520	14	10	3	3	4	3	3	5	3	3	2	5	3	3	5	4	3	3	3	5	3	4	3	1	4	1	1
57	2	3	2	2	2,032,520	14	10	4	4	4	4	3	3	4	4	2	3	4	3	5	3	5	4	4	3	3	4	5	1	4	1	2
58	2	3	2	4	2,032,520	14	10	4	3	4	3	3	3	3	3	3	3	4	3	4	3	4	3	2	5	2	4	3	1	5	2	1
59	2	2	2	6	1,138,211	11	5	5	4	4	4	3	4	4	3	3	3	4	4	5	4	4	4	2	3	4	3	5	2	4	1	1
60	2	1	2	1	14,634,146	110	105	4	3	4	5	2	3	3	3	2	3	3	5	3	3	4	4	2	5	3	3	3	2	5	4	1

APPENDIX E: RESEARCH EFFECTIVENESS QUESTIONNAIRE

QUESTIONNAIRE ON THE MEASUREMENT OF RESEARCH EFFECTIVENESS

BACKGROUND

The measurement of *research effectiveness*, and particularly its tracking over time through trend analysis, is a very important element of the strategic management process in the BE Unit and is one of the factors influencing the funding and resource allocation decision. Enhancement of this measurement process will lead to a more effective research programme and ultimately to improved benefit to the Built Environment sector and stakeholders in South Africa.

The purpose of this questionnaire is to assist the CSIR Built Environment Unit to enhance its system to measure *research effectiveness* and to calibrate the inherent scoring system.

WHAT IS RESEARCH EFFECTIVENESS AND WHY MEASURE IT?

Research Effectiveness includes the research process, research inputs, research outputs, research outcomes and impact. These elements are defined as follows:[1]

Process — a course of action taken to achieve a goal - this includes research planning and outputs measurement processes.
Input — tangible quantities put into a process to achieve a goal – this includes project costs, investment into research infrastructure etc.

[1] The National Research Council of the National Academies, USA. *Thinking Strategically: The Appropriate Use of Metrics for the Climate Change Science Program*. Committee on Metrics for Global Change Research, Climate Research Committee, National Research Council ISBN: 0-309-55042-4, 2995

Output — products and services delivered – this includes publications, patents, technology demonstrators, reports, new prediction models etc. Example: a new design guideline for medium density housing)

Outcome — results that stem from use of the outputs - unlike output measures, outcomes refer to an event or condition that is external to the program and is of direct importance to the intended beneficiaries (e.g., scientists, agency managers, policy makers, other stakeholders). Example: the use of the guideline to design new settlements.

Impact — the effect that an outcome has on something else – this includes long-term societal, economic, or environmental consequences. Example: an increase in the standard of living and quality of life of people due to new medium density housing settlements.

The Built Environment *Research Effectiveness* measurement system focuses on the output and outcomes categories with some elements of impact. Inputs are used in the final indicator analysis to normalise the results by, for example, dividing by the project cost. Research Effectiveness indicators therefore ultimately link the BE research programme to the impact of the research.

THE APPROACH

The *research-effectiveness* measurement system of the BE Unit is based on the following principles:

- The development of a score card in which the concept of ***equivalent scores*** is used to make it possible to compare scores and indicators in and across a number of categories (e.g. to be able to say that x number of papers are equivalent to y number of patents or to z percentage of R&D contract income)
- The calibration of the scores based on the ***perceived value*** (to researchers, stakeholders and users) of categories of research outputs, outcomes and impacts, and
- The monitoring of the ***trend in the change in these scores and indicators***.

The *equivalent scores* are defined as the "equivalent Rand value" of the achievement as perceived by stakeholders e.g. researchers, practitioners and academics.

Please Note: that the absolute accuracy of the equivalent scores is less important than the analysis of the ***trend in the change of the values***. Therefore, although the scores will be calculated as accurately as possible, the emphasis for strategic management will be on trend analysis.

The CSIR benchmark scores shown in this questionnaire were derived from a literature review and some analysis, as well as from an in-depth discussion in the CSIR Built Environment's Science, Engineering and Technology (SET) Committee that consists of 15 senior researchers from the BE Unit. In this process the number of indicators was reduced from an initial 42 to 26 and the SET committee rated the indicators individually.

This questionnaire is aimed at obtaining your input to **verify** the work done to date. At the end of the questionnaire, there is space for you to indicate additional indicators that you think should be included.

THE PROPOSED SCORE CARD

The score card reflects the measurement of a number of indicators in the following categories:

- Financial factors (e.g. contract income as an indicator)
- Strategic human capital development (e.g. number of new PhDs as an indicator)
- Quality of the Science and Technology base (e.g. value of equipment as an indicator)
- Science and Technology outputs (e.g. number of papers as an indicator)
- Socio-economic impact (e.g. number of socio-economic projects as an indicator)
- Environmental impact (e.g. number of environmental projects as an indicator)

Socio-economic impacts and Environmental impacts are very complex and difficult to measure. However, under these categories the system will initially look at a few very simple measures (such as the number and size of the projects where a new technology or knowledge package is deployed) in an attempt to assess these impacts. It is envisaged that these indicators may be improved in the future.

In the case of the Financial category, the equivalent Rand value is derived by multiplying the year-end result in the BE Unit with a factor of one or less than one. The benchmark factors used for contract R&D and royalties are based on the research done to date[2] In the case of contract R&D income the factor of 15% is based on an analysis of the profitability of private sector contract R&D organisations. Therefore, if the BE Unit achieved contract R&D income of R80 million in a particular year, this results in R12 million of equivalent Rands. In the case of royalty income, the factor is 100 percent, based on the fact that royalty income is treated as profit with no post-licensing cost associated with it. Royalty income is also strategically very important to the CSIR as an indicator of the usage of new technologies in the market.

As explained above, in order to be able to compare such a diverse range of indicators, an equivalent Rand score is allocated based on the perceived value indicators. For example, the percentage of contract R&D income (R12 million in the example above), can then be compared with the value of 8 new PhD degrees (at equivalent Rands of 1,5 million each).

In order to verify the work that we have already done, it is important to get your view on two aspects:

- The importance rating for each of the categories, and
- The relative value of each indicator compared with the others in the same category.

---

2 Walwyn, D. "**Evaluation of Core Parliamentary Grant (PG) Expenditure".** Discussion document. CSIR February 2007.

The importance ratings will be used to calculate a pseudo return on investment indicator, based on the total equivalent Rands divided by the research cost.

Once again, we would like to stress that these values are intended to be used in trend analysis over a period of time. These trends, at the research portfolio level, will be one of a number of factors used to make strategic research-investment decisions.

The Built Environment Unit wants to thank you in advance for your effort to assist us in improving the value derived from our research and development activities.

SECTION A: RELATIVE RATING OF THE INDICATORS WITHIN EACH CATEGORY

The indicators will be monitored at a Unit or research portfolio level, and the measurements will be cumulative over a period of time. In order to assist you with the rating process and to allow for compatibility with existing systems in the CSIR, we have entered **some** benchmark figures in the tables below (marked in grey in Column 2). Assume the benchmark values as fixed. We have furthermore also provided you with typical year-end results in the BE Unit so that you can see how your ratings of the equivalent values affect the equivalent scores (which are the values times the results).

CATEGORY 1: FINANCIAL INDICATORS

Action required by you: Please complete the last two cells in Column 2 (marked in yellow) by giving a rating of the equivalent value for the indicators, as you perceive them (i.e. what percentage of the result should count as equivalent?), compared with the benchmark values in Column 2.

Table 1: Equivalent value of financial indicators

1 Indicator	2 Equivalent value[3]	3 Typical Result for BE	4 Proposed equivalent Score
Contract research income to CSIR	**15%**	80 000 000	12 000 000
Royalty income to CSIR	**100%**	1 000 000	1 000 000
Estimated cost savings to government and industry (in the case of government this implies more delivery for the same budget)	-	50 000 000	-=
Estimated business increase to industry (creating new and enhancing existing)	-	10 000 000	=

[3] Figures in bold in the grey cells are CSIR benchmarks

CATEGORY 2: STRATEGIC HUMAN CAPITAL DEVELOPMENT

Notes: In this category the relative values of training courses, a Masters degree and a professional registration (professional engineer, architect or scientist) are compared with the value of a PhD degree at a benchmark level of R1,5 million equivalent Rands.

Action required by you: Please complete the last three cells in Column 2 (marked in yellow) by giving a rating of the equivalent value for the indicators, as you perceive them (i.e. what equivalent score should be allocated per unit?), compared with the benchmark values for a PhD in Column 2.

Table 2: Equivalent value of Strategic Human capital Development indicators

1 Indicator	2 Equivalent value[4]	3 Typical Result for BE	4 Proposed equivalent Score
Number of PhDs conferred	**1 500 000**	2	3 000 000
Number of non-CSIR people trained in the year through CSIR presented courses		300	
Number of masters degrees conferred		3	
Number of new professional registrations		3	

[4] Figures in bold in the grey cells are CSIR benchmarks

CATEGORY 3: QUALITY OF THE SCIENCE AND TECHNOLOGY BASE

Notes: In this category the quality of the Science and Technology (S&T) base will be estimated by assessing the value of the research infrastructure (proposed benchmark is that 15% should count as an equivalent) the number of significant collaborations with universities (more than R1 million Rand worth of research activity per annum) as well as the total number of citations of publications by authors from the BE Unit and finally, the number of memberships of R&D committees and key note addresses at conferences.

Action required by you: Please complete the last three cells in Column 2 (marked in yellow) by giving a rating of the equivalent value for the indicators, as you perceive them (i.e. what equivalent score should be allocated?), compared with the benchmark values for research infrastructure in Column 2.

Table 3: Equivalent value of Science and Technology (S&T) base quality indicators

1 Indicator	2 Equivalent value[5]	3 Typical Result for BE	4 Proposed equivalent Score
Total value of research infrastructure and equipment	**15%**	60 000 000	9 000 000
Total unit citations of publications		1 000	
Total number of co-authored publications with parties external to the CSIR (including research reports)		30	
Number of committee memberships and key note addresses		6	

[5] Figures in bold in the grey cells are CSIR benchmarks

CATEGORY 4: SCIENCE AND TECHNOLOGY OUTPUTS

Action required by you: Please complete the last four cells in Column 2 (marked in yellow) by giving a rating of the equivalent value for the indicators, as you perceive them (i.e. what equivalent score should be allocated?), compared with the benchmark values in Column 2, and based on the definitions given below Table 4.

Table 4: Relative value of S&T output indicators

1 Indicator	2 Equivalent value[6]	3 Typical Result for BE	4 Proposed equivalent Score
Peer reviewed conference paper	**250 000**	50	12 500 000
Paper in refereed journal	**500 000**	15	7 500 000
Book Chapter	**500 000**	5	2 500 000
PCT International patent	**12 000 000**	1	12 000 000
Technology Demonstrator International application	**10 000 000**	2	20 000 000
CSIR published technical report		100	
National design guideline		1	
South African provisional patent		1	
Technology Demonstrator local application		2	

[6] Figures in bold in the grey cells are CSIR benchmarks

Definitions:

Peer reviewed conference paper is as per the Department of Education policy

Paper in refereed journal is as per the Department of Education policy

Book chapter is as per the Department of Education policy

Patent Co-ordination Treaty (PCT) patent filing is a coordinated process to obtain a patent subjected to examination

CSIR published technical reports are important reports published by the CSIR on approval of a Unit Director

National design guideline is a design guideline prepared by the CSIR under the auspices of a peer review committee and published by a government department or industry organisation for national use.

South African Provisional patent is a local patent filing (non peer reviewed)

A technology demonstrator is a hardware or software solution based on a significant multi-year research project (value of investment more than R2 million) and the application of which has been demonstrated in government or industry

CATEGORY 5: SOCIO-ECONOMIC INDICATORS

Notes: Socio-economic factors are very difficult to measure, nevertheless, a few indicators have been selected in an attempt to have some measure of research effectiveness in this category.

Action required by you: Please rate the relative equivalent score of the social indicators in Column 2 (for value of social projects where the technology is deployed, indicate the percentage of the project value that should count in order to provide the right equivalent ratio to the other indicators). No benchmarks are given in this table please use the benchmarks in the previous tables as an indicator of relative value.

Table 5: Relative value of Socio-economic impact indicators

1 Indicator	2 Equivalent value[7]	3 Typical Result for BE	4 Proposed equivalent Score
Estimated number of external jobs created (direct)		1 000	
Number of significant[8] socio-economic projects where technology is deployed		2	
Rand value of socio-economic projects where technology is deployed		50 000 000	

[7] Figures in bold in the grey cells are CSIR benchmarks

[8] Total project value more than R10million.

CATEGORY 6: ENVIRONMENTAL IMPACT

Environmental impact is very difficult to estimate, nevertheless, a few indicators have been selected in an attempt to have some measure of research effectiveness in this category.

Action required by you: Please rate the relative equivalent score of the environmental impact indicators in Column 2 (for value of environmental impact projects where the technology is deployed, indicate the percentage of the project value that should count in order to provide the right equivalent ratio to the other indicators). No benchmarks are given in this table, please use the benchmarks in the previous tables as an indicator of relative value.

Table 6: Relative value of environmental impact indicators

1 Indicator	2 Equivalent value[9]	3 Typical Result for BE	4 Proposed equivalent Score
Number of significant[10] environmental projects where technology is deployed		1	
Rand value of environmental projects where technology is deployed		50 000 000	

[9] Figures in bold in the grey cells are CSIR benchmarks

[10] Total project value more than R10million

SECTION B: THE RELATIVE IMPORTANCE OF THE CATEGORIES

Please provide your view of the importance of each of the six categories through a score out of ten (score between 1 and 10, where 10 is very important).

Table 7: Relative importance of the main categories

	Your Importance score (out of 10)
Financial indicators	
Strategic Human Capital development indicators	
Quality of the S&T base	
Socio-economic impact indicators	
Environmental impact indicators	
S&T output indicators	

SECTION C: GENERAL COMMENTS

Please give general comments and/or indicate additional indicators that should be included:

……

……

……

……

Thank you for your time. The results of this exercise will be reported back you in due course.

Name :……..

e-mail address:……..

APPENDIX F: LIST OF PROJECT IDEAS IDENTIFIED BY THE BMLC

PROJ No	PROJECT TITLE	AVG TECH	AVG RA's	AVG COM	AVG IND	TOT AVG	TOTAL Score
23	Evaluation of quality standards for LIC	4.60	5.00	4.00	4.40	4.50	90
4	User-friendly products to upgrade community roads	4.20	4.20	4.80	4.40	4.40	88
43	Technologies for implementation by means of labour-intensive construction methods	4.20	4.20	4.80	4.20	4.35	87
21	Identification and development of technologies for LIC (including equipment and materials)	4.20	3.80	4.80	4.00	4.20	84
47	Product Performance Guarantee Systems (PPGS) Phase II	4.00	4.60	2.80	5.00	4.10	82
28	Development of fatigue curves for LAMBS (second phase)	5.00	4.60	1.40	4.80	3.95	79
46	Assessment of the quality of workmanship in the bituminous road construction industry	4.20	4.00	2.80	4.80	3.95	79
1	Roads as a catalyst for sustainable social and economic development - activity streets	1.40	4.60	5.00	4.80	3.95	79
29	Design & quality control method for asphalt mixes to prevent overfilling of voids - Phase I	4.80	4.60	1.40	5.00	3.95	79
33	Uniform process for manufacturing samples for asphalt mix design and quality control	4.80	4.60	1.20	5.00	3.90	78
30	Physical tests for composition of bitumen and recycled bitumen	5.00	4.80	1.40	4.00	3.80	76
31	Methodology for quantification of the absorption of aggregate fines by bitumen	4.60	4.40	1.20	4.80	3.75	75
53	BMLC	5.00	5.00	3.50	5.00	4.62	74
16	Evaluation of the effect of increased axle loads and tyre pressures on the life cycle of roads	4.40	4.40	2.00	3.80	3.65	73
22	Evaluation of cost implication of LIC	2.20	4.80	4.20	3.40	3.65	73
15	Reseal selection matrix	4.40	4.60	1.80	3.60	3.60	72
24	Evaluation of the performance of roads built with LIC	4.75	4.75	4.75	3.50	4.44	71
32	Effect of diluents on the curing and performance of bitumen-rubber & polymer-modified binders	4.60	3.60	1.20	4.80	3.55	71
50	User-friendly product specification aimed at small entrepreneurs	4.00	4.00	5.00	4.75	4.44	71

14	Database of results obtained with the Hugo hammer compaction method	4.60	4.20	1.00	4.00	3.45	69
34	Design procedures for bitumen rubber mixes	4.40	3.40	1.00	4.40	3.30	66
48	Monitoring of long term performance of GEMs and LAMBs	4.75	4.75	1.75	5.00	4.06	65
51	Simplified tendering procedures (general)	2.00	4.75	4.75	4.50	4.00	64
2	Maintenance of Phuthaditjhaba community roads	3.50	3.25	5.00	3.75	3.88	62
49	Product Performance Guarantee Systems (PPGS) Phase I	3.50	4.50	2.25	5.00	3.81	61
35	Affordable testing devices for dynamic properties of unbound structural materials	3.00	3.80	1.00	3.20	2.75	55
5	Evaluation of and training in the use of the 'red book' vs other codes	3.00	3.60	1.60	2.40	2.65	53
54	Establishment of task group for co-ordinating dissemination of SA roads technology	3.00	5.00	5.00	5.00	4.50	36
37	Development of thin layers asphalt (thinner than 20mm)	5.00	5.00	3.00	5.00	4.50	36
8	Transfer of training modules for formal education sector	4.50	3.50	5.00	4.00	4.25	34
36	Guidelines for the use of local bituminous products	5.00	5.00	2.00	5.00	4.25	34
3	Development and implementation of community training modules for road maintenance	4.00	3.50	5.00	4.00	4.12	33
6	Guidelines for using local materials	5.00	3.50	4.00	3.50	4.00	32
42	Benefits of stage construction to LIC / or rapid development of community infrastructure	3.50	4.50	4.00	3.50	3.88	31
7	Synthesis of Labour-intensive techniques	5.00	4.00	3.00	3.00	3.75	30
17	Overload control - law enforcement	1.50	5.00	3.50	4.00	3.50	28
12	Foam treated gravels for community roads	5.00	5.00	5.00	5.00	5.00	20
11	Appropriate pavement design standards for community roads	5.00	5.00	5.00	5.00	5.00	20
55	Implementation of Road Maintenance Initiatives project in SA	5.00	5.00	5.00	5.00	5.00	20
9	Labour intensive technology transfer to current practitioner	5.00	5.00	5.00	5.00	5.00	20
10	Ultra thin asphalt thin surfacings for community roads	5.00	5.00	5.00	5.00	5.00	20
27	Evaluation of the performance of pathways and walkways built with LIC methods	5.00	4.00	5.00	4.00	4.50	18
52	Assessment of suitable project sizes for developing entrepreneurs	3.00	5.00	5.00	4.00	4.25	17

40	Identification and procurement of suitable rural road materials	3.00	5.00	4.00	5.00	4.25	17
39	Frequency of testing for dynamic tests	5.00	5.00	1.00	5.00	4.00	16
41	Review and update of LAMBs guidelines	5.00	5.00	1.00	5.00	4.00	16
19	Gyratory compaction of SA asphalts	5.00	5.00	1.00	5.00	4.00	16
56	Co-ordinated Industry approach to politicians on results being achieved	2.00	5.00	4.00	5.00	4.00	16
13	Assessment criteria for user-friendly products	5.00	5.00	2.00	3.00	3.75	15
20	Impact of freight roads on SA economy	3.00	5.00	2.00	5.00	3.75	15
44	Shelf-life of bitumen products	4.00	3.00	4.00	3.00	3.50	14
38	Evaluate US superpave methods and specification for SA use	5.00	4.00	1.00	4.00	3.50	14
18	Comparative assessment of currently applied light rehab special maintenance procedures	4.00	4.00	1.00	4.00	3.25	13
26	Collect locally developed information on LIC	4.00	4.00	1.00	4.00	3.25	13
45	Use of RAP in low cost roads layers	3.00	5.00	4.00	1.00	3.25	13
25	International experience on LIC	3.00	4.00	1.00	3.00	2.75	11

APPENDIX G: SABITA TECHNOLOGY TREES

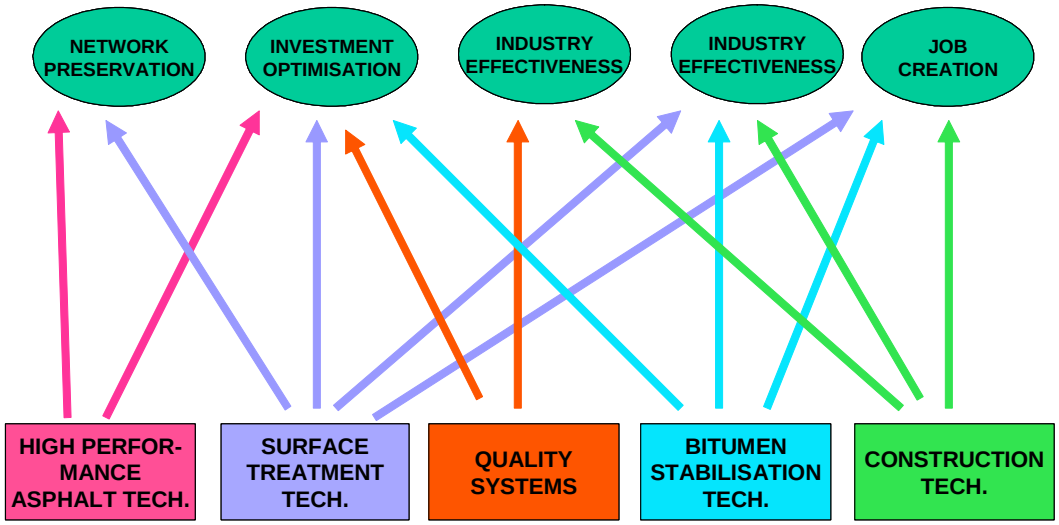


Figure G.1: Sabita technology platforms and links with dominant issues

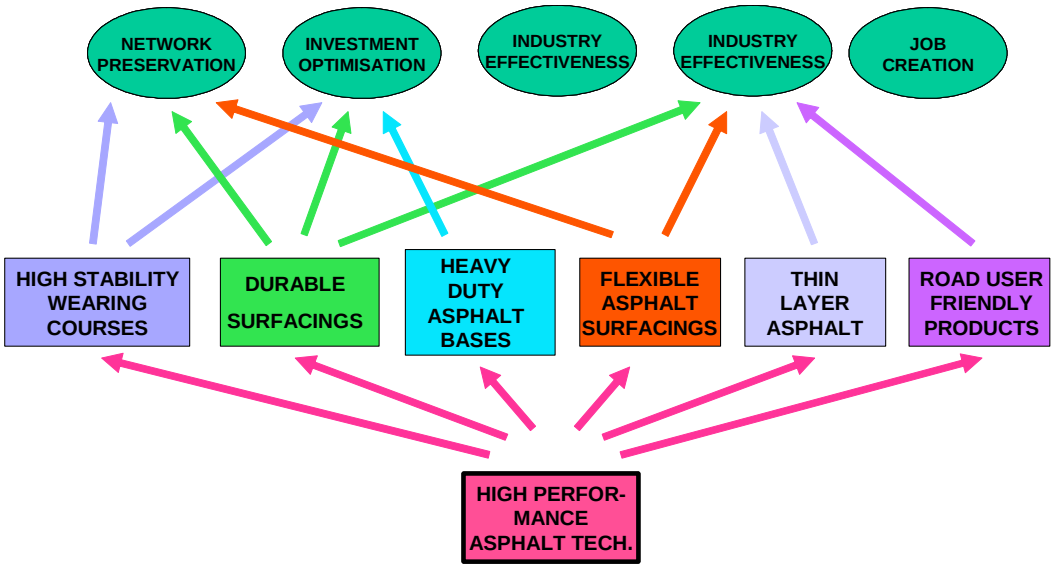


Figure G.2: The Sabita High Performance Asphalt technology platform, its Key Solutions and their links to the Sabita dominant issues

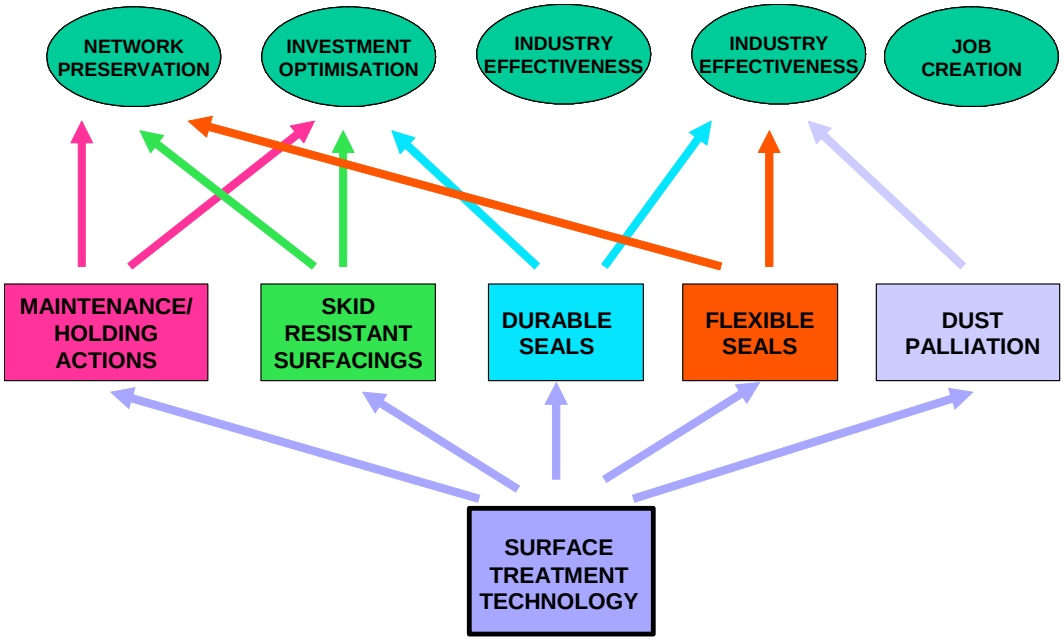


Figure G.3: The Sabita Surface Treatment technology platform, its Key Solutions and their links to the Sabita Dominant issues

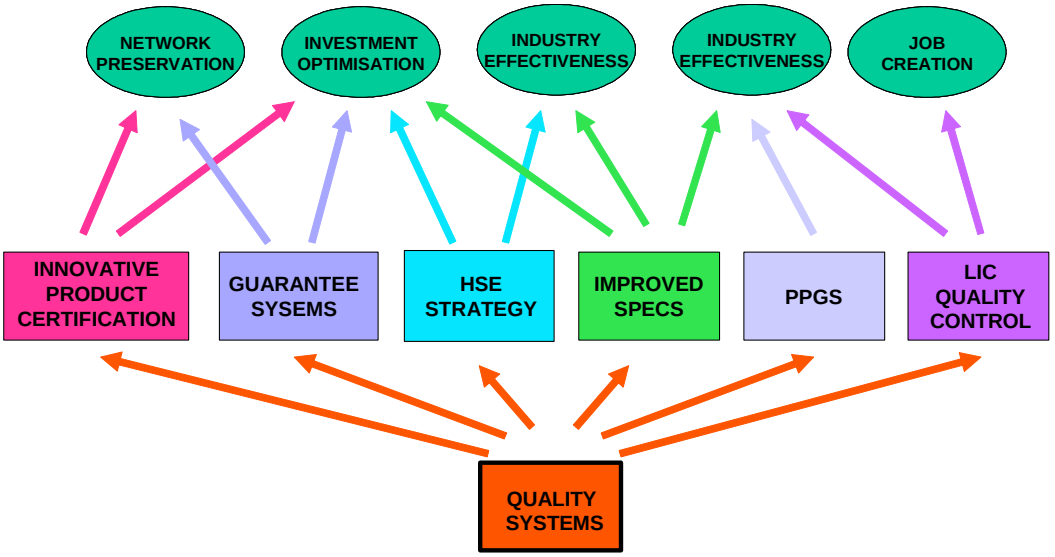


Figure G4: The Sabita Quality Systems technology platform, its Key Solutions and their links to the Sabita Dominant issues

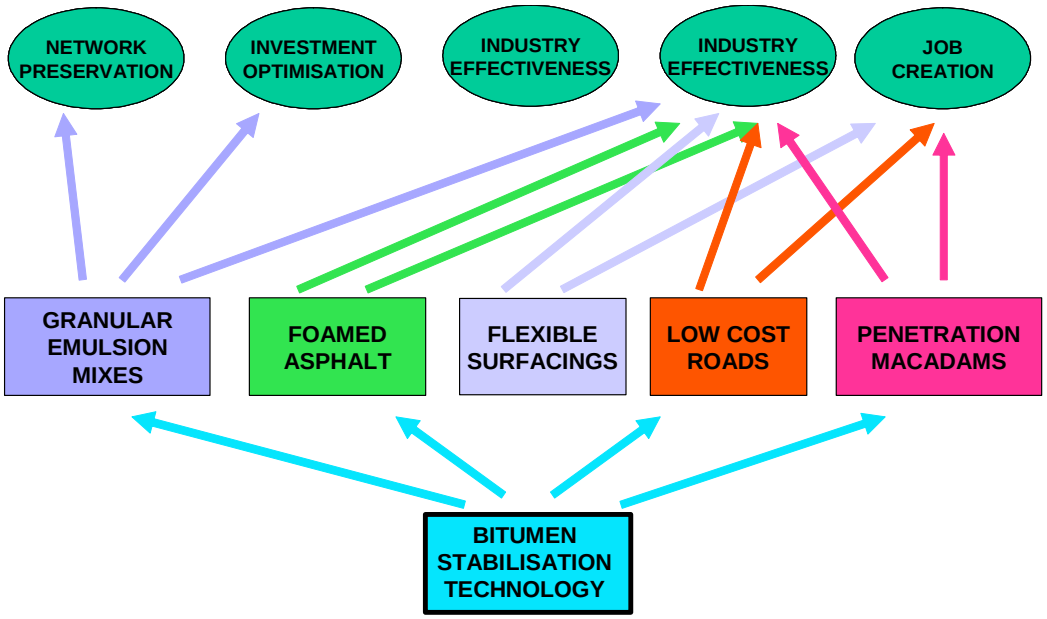


Figure G5: The Sabita Bitumen Stabilisation technology platform, its Key Solutions and their links to the Sabita Dominant issues

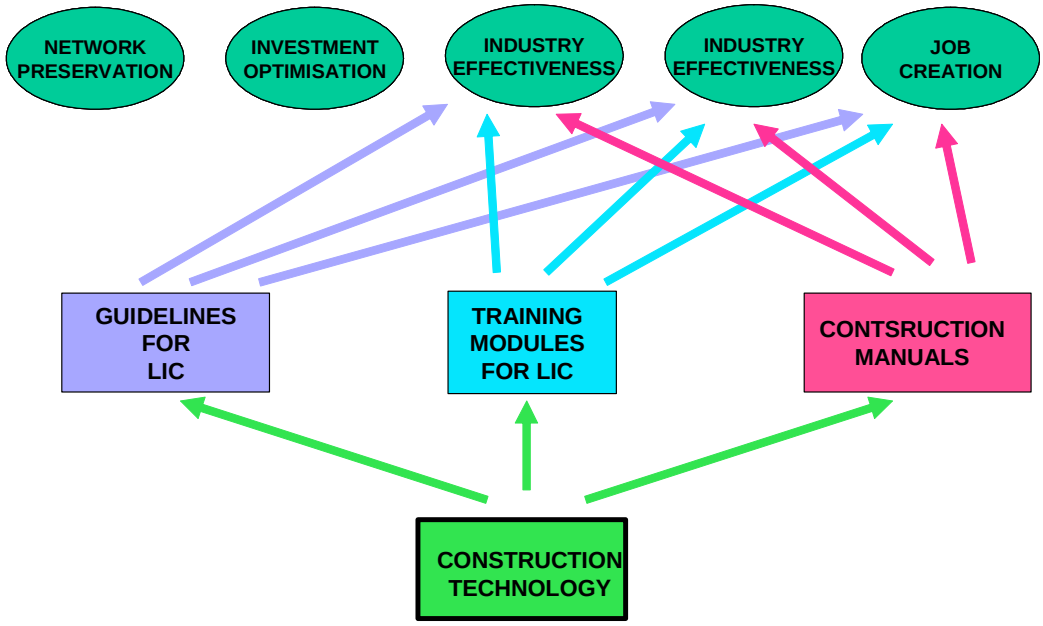


Figure G6: The Sabita Construction technology platform, its Key Solutions and their links to the Sabita Dominant issues

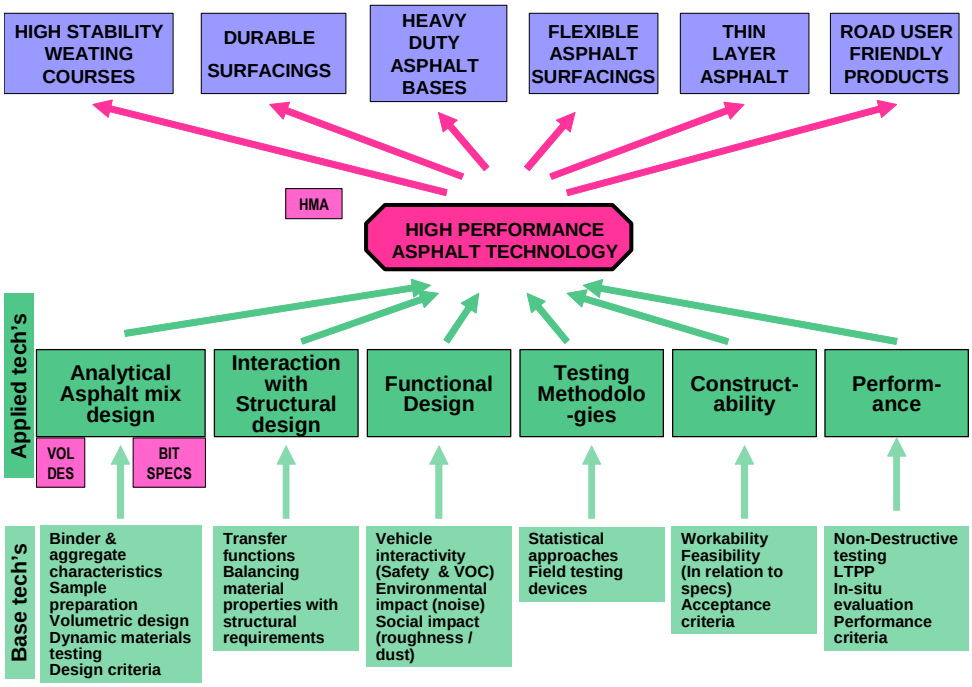


Figure G7: The Sabita High Performance Asphalt technology tree with the positions of projects shown

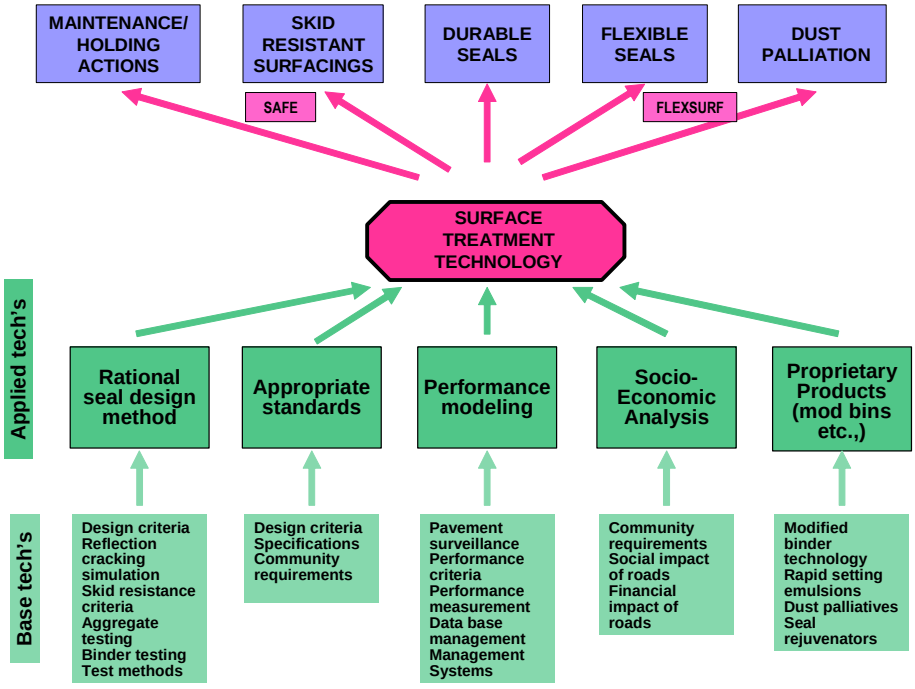


Figure G8: The Sabita Surface Treatment technology tree with the positions of projects shown

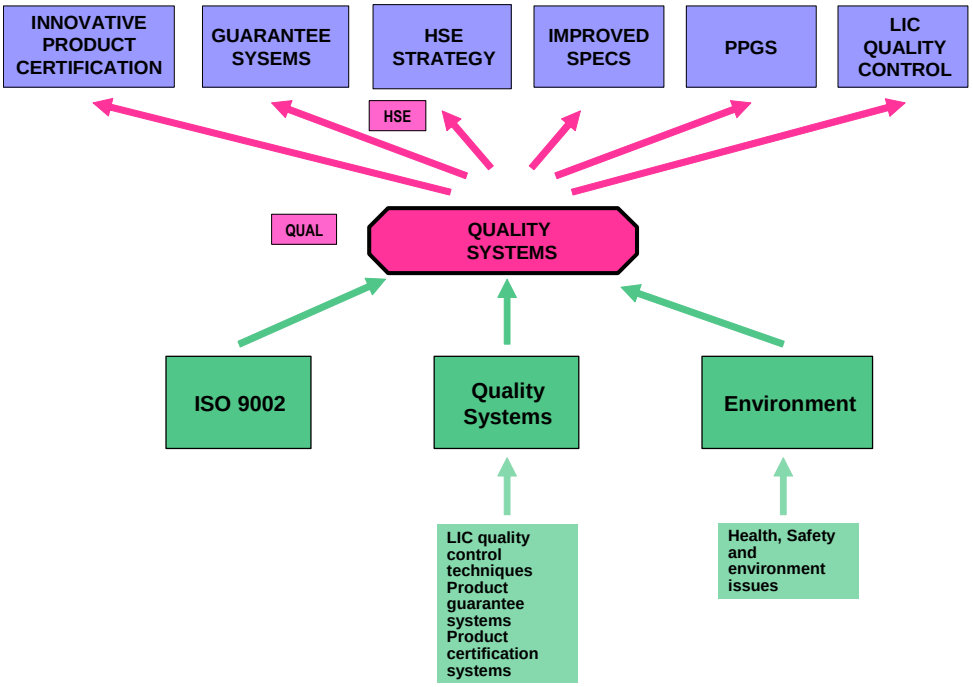


Figure G9: The Sabita Quality Systems technology tree with the positions of projects shown

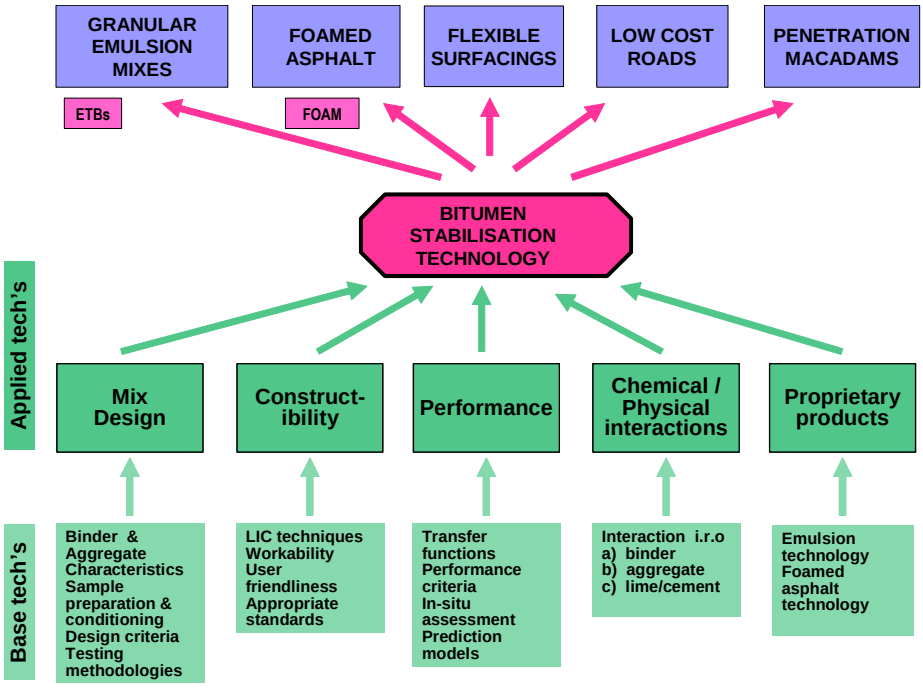


Figure G10: The Sabita Bitumen Stabilisation technology tree with the positions of projects shown

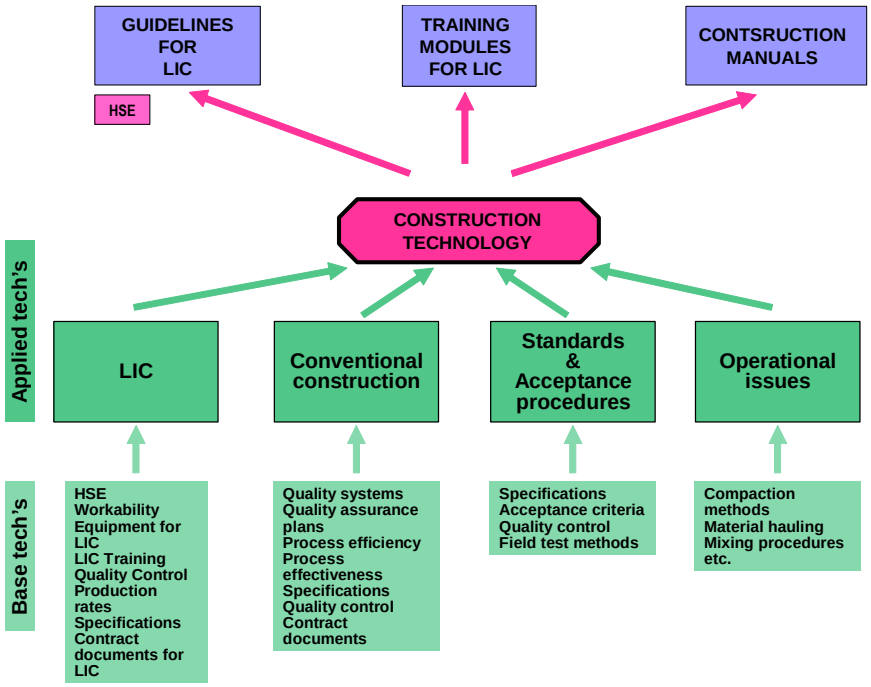
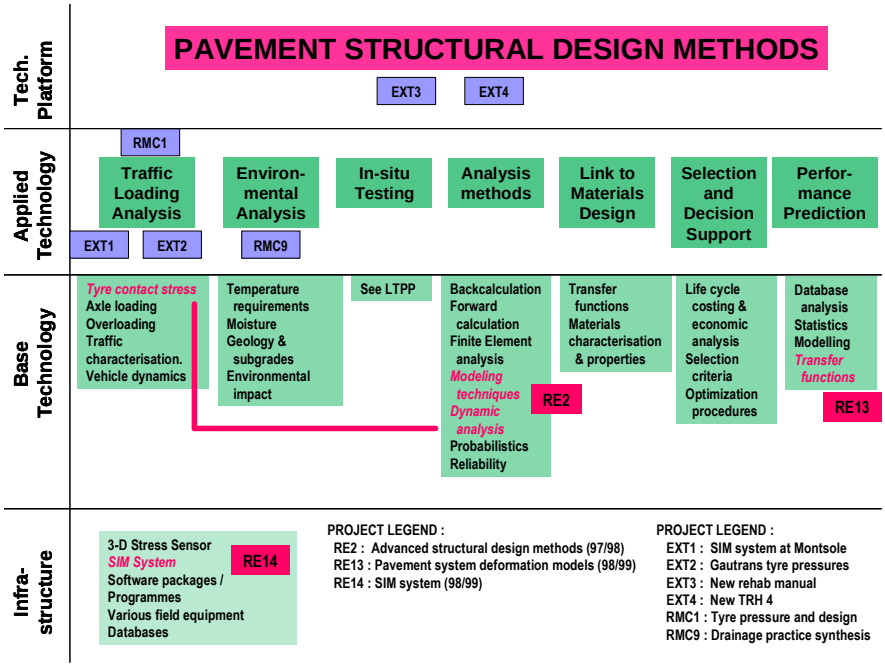


Figure G11: The Sabita Construction technology tree with the positions of projects shown



Fure G12: The CSIR pavement structural design methods technology tree showing parliamentary grant projects (red) and contract R&D projects (blue)

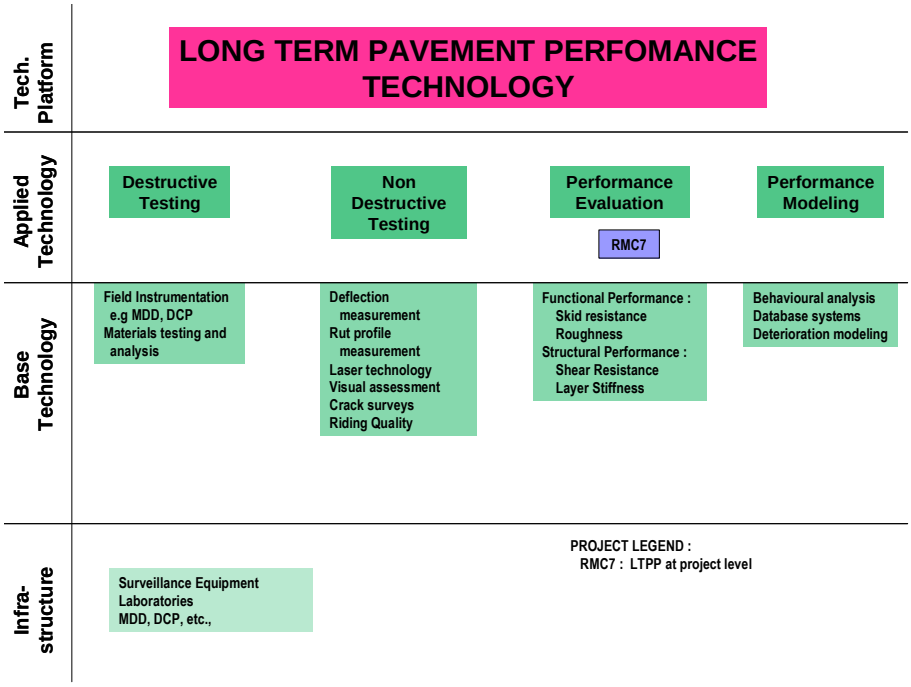


Figure G13: The CSIR long-term pavement performance technology tree showing parliamentary grant projects (red) and contract R&D projects (blue)

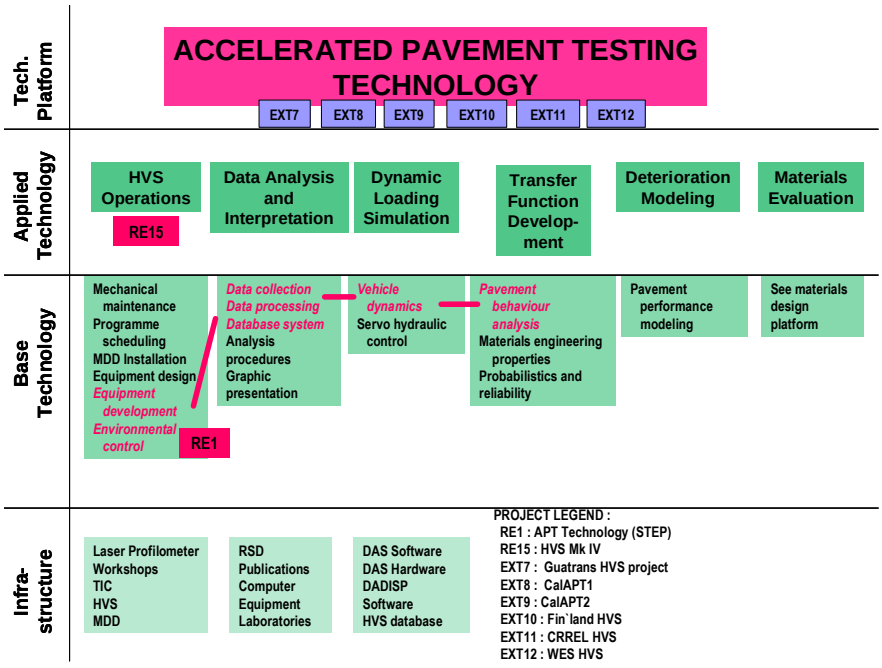


Figure G14: The CSIR accelerated pavement testing technology tree showing parliamentary grant projects (red) and contract R&D projects (blue)

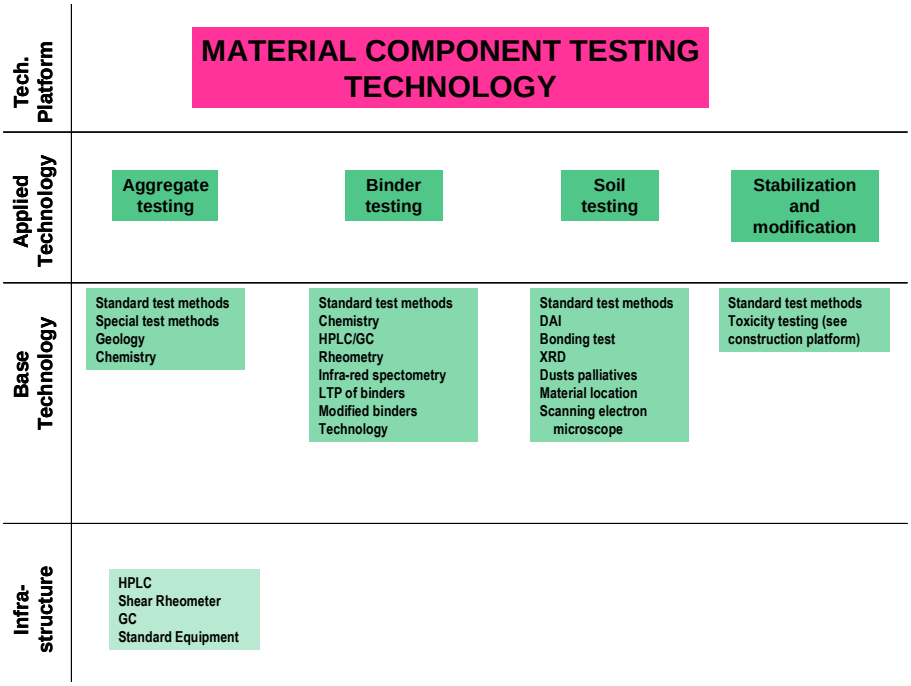


Figure G15: The CSIR material component testing technology tree

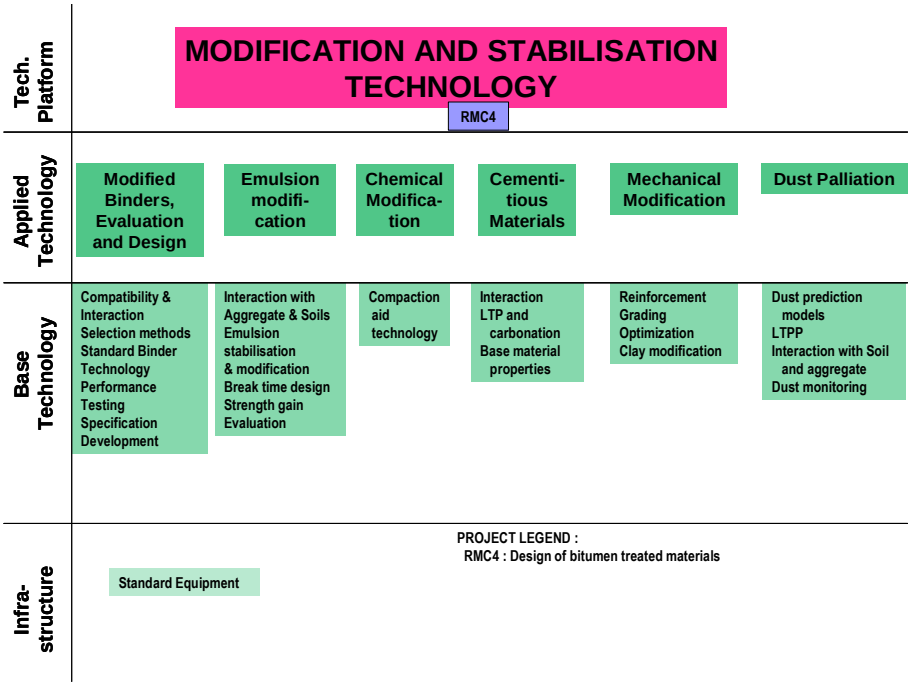


Figure G16: The CSIR modification and stabilization technology tree showing parliamentary grant projects (red) and contract R&D projects (blue)

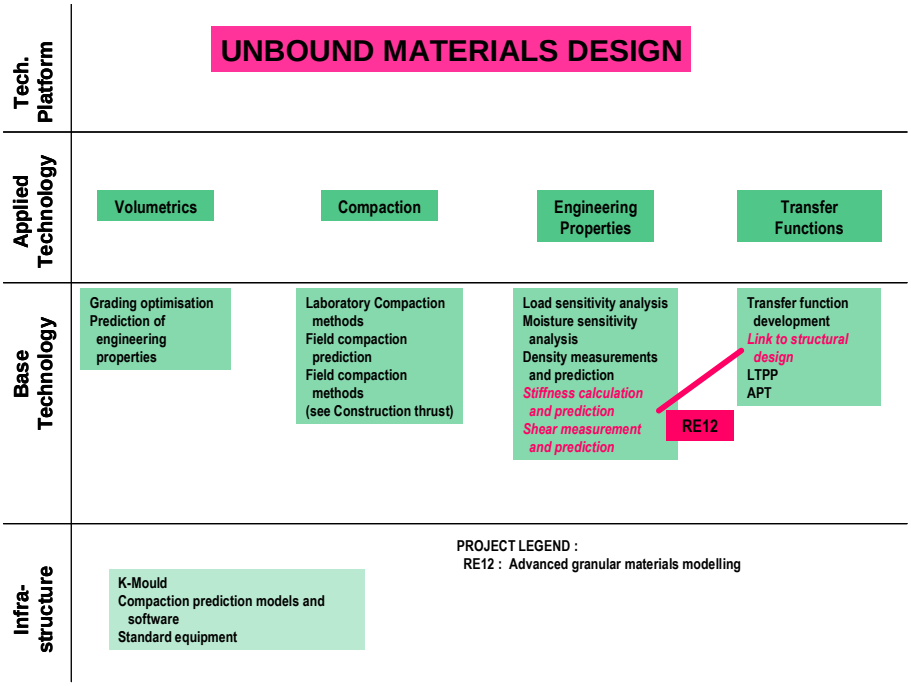


Figure G17: The CSIR unbound materials design technology tree showing one parliamentary grant project (red)

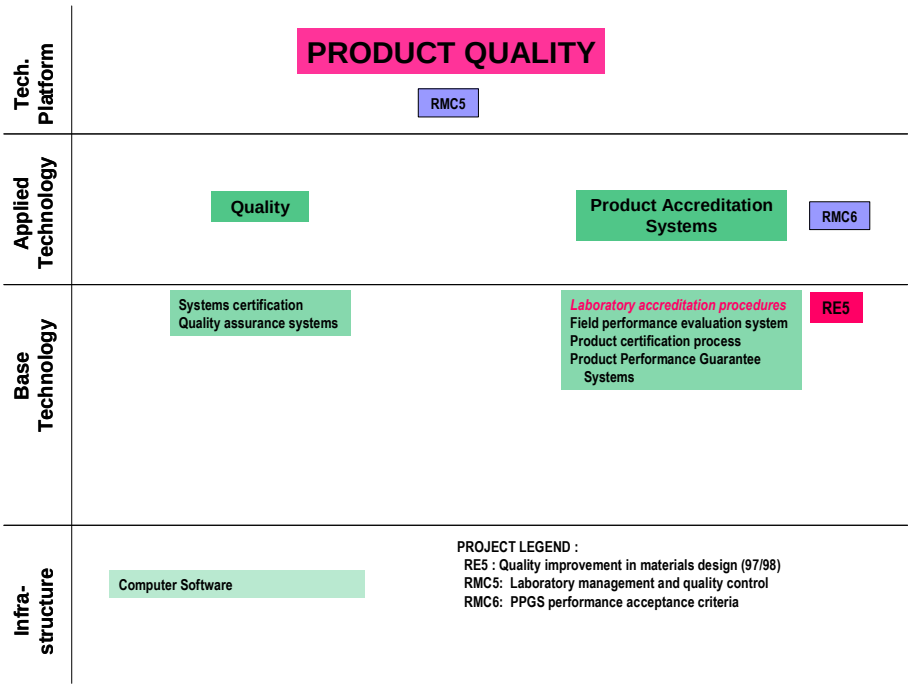


Figure G18: The CSIR product quality technology tree showing parliamentary grant projects (red) and contract R&D projects (blue)

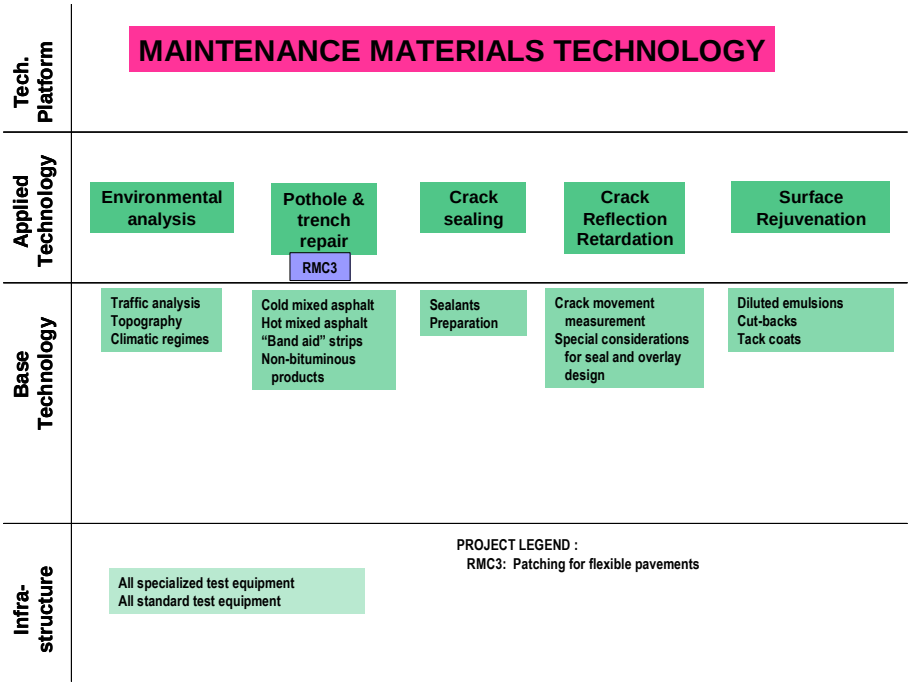


Figure G.19: The CSIR maintenance materials technology tree showing one contract R&D project (blue)

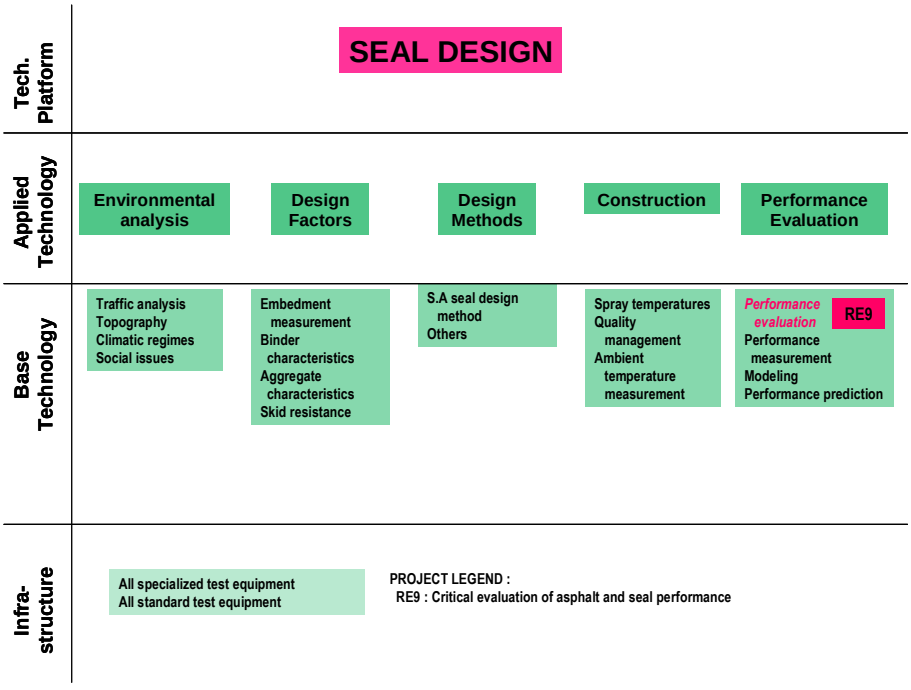


Figure G.20: The CSIR seal design technology tree showing one parliamentary grant project (red)

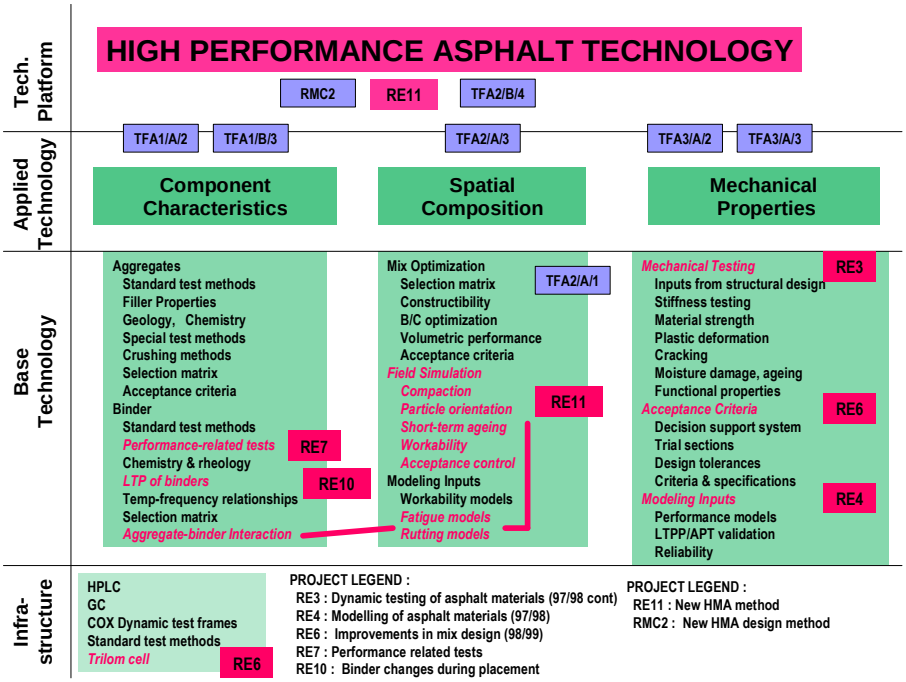


Figure G.21: The CSIR high performance asphalt technology tree showing parliamentary grant projects (red) and contract R&D projects (blue)

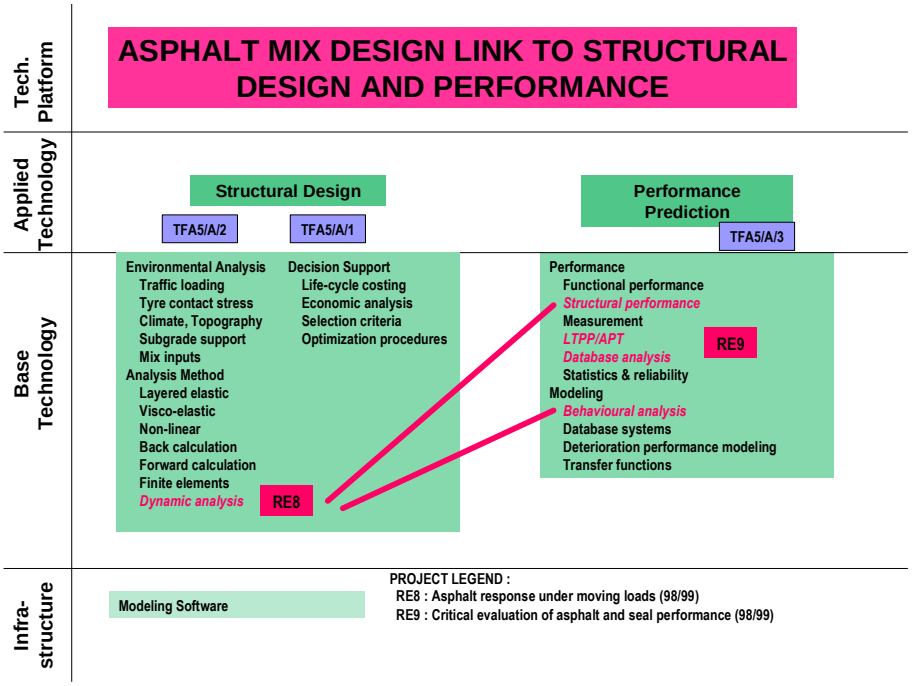


Figure G.22: The CSIR asphalt mix design link to structural design technology tree showing parliamentary grant projects (red) and contract R&D projects (blue)

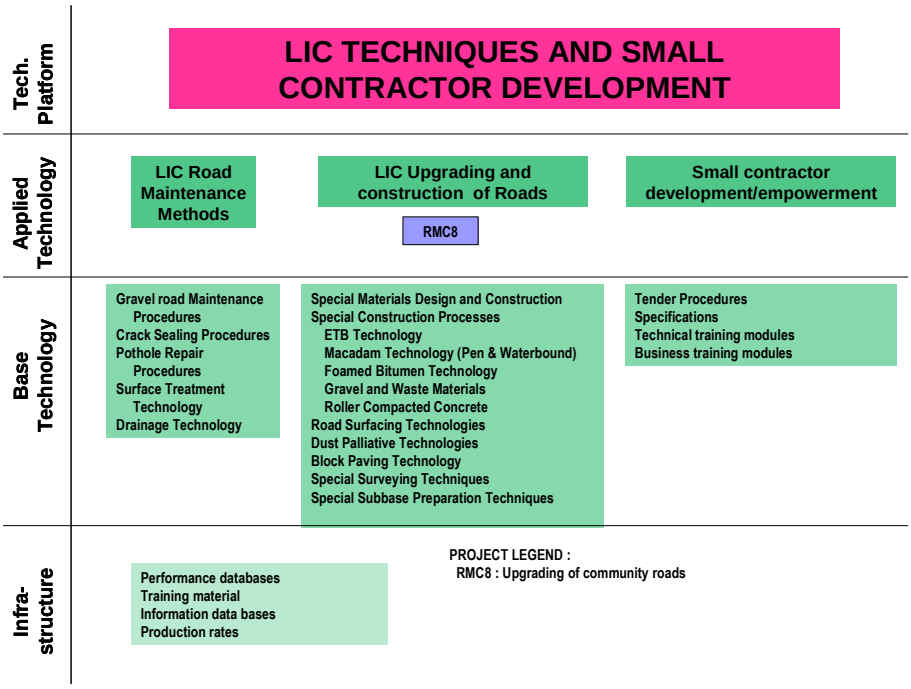


Figure G.23: The CSIR labour intensive construction and small contractor development technology tree showing one contract R&D project (blue)

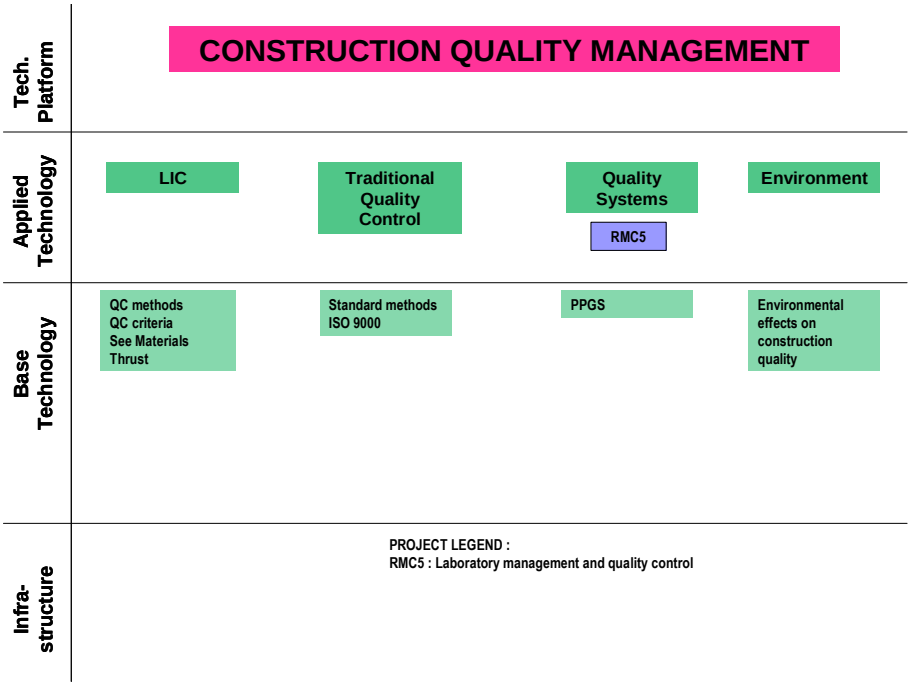


Figure G.24: The CSIR construction quality management technology tree showing one contract R&D project (blue)

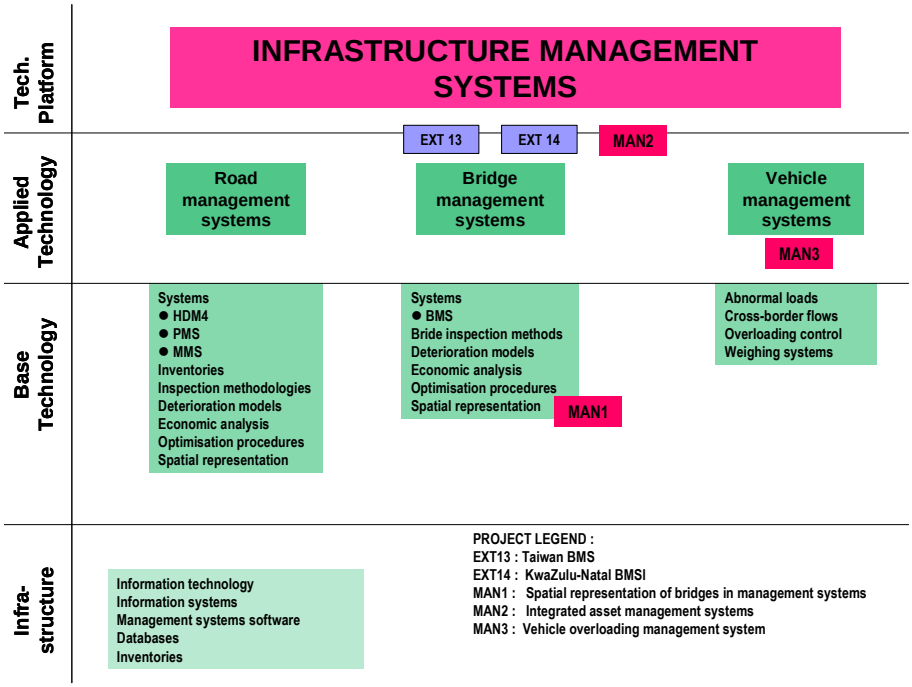


Figure G.25: The CSIR infrastructure management systems technology tree showing parliamentary grant projects (red) and contract R&D projects (blue)

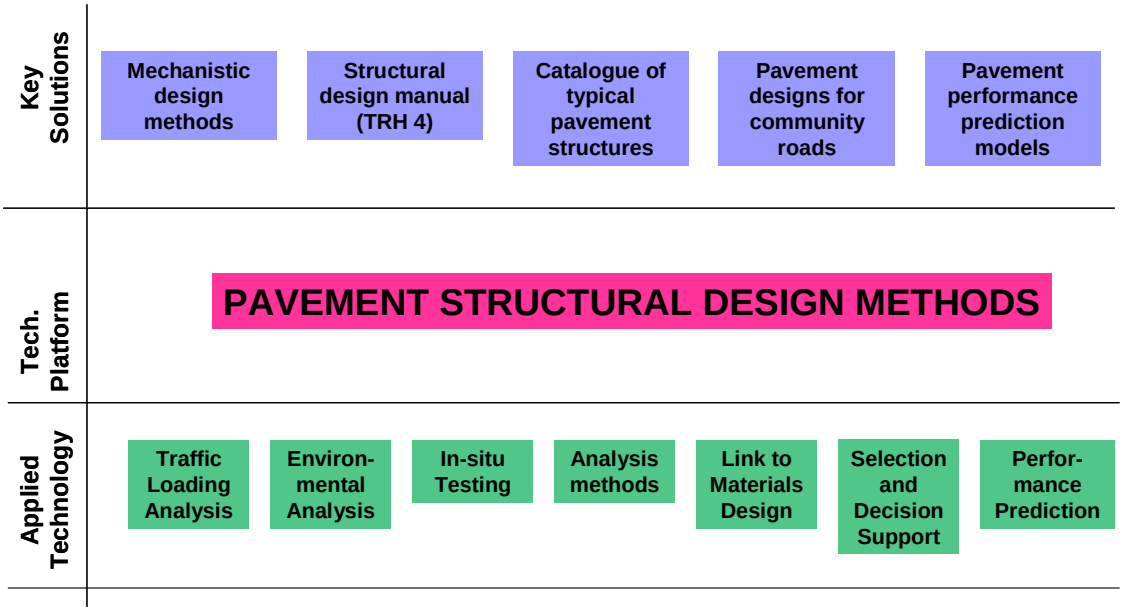


Figure G.26: The CSIR pavement structural design methods technology platform showing Key Solutions

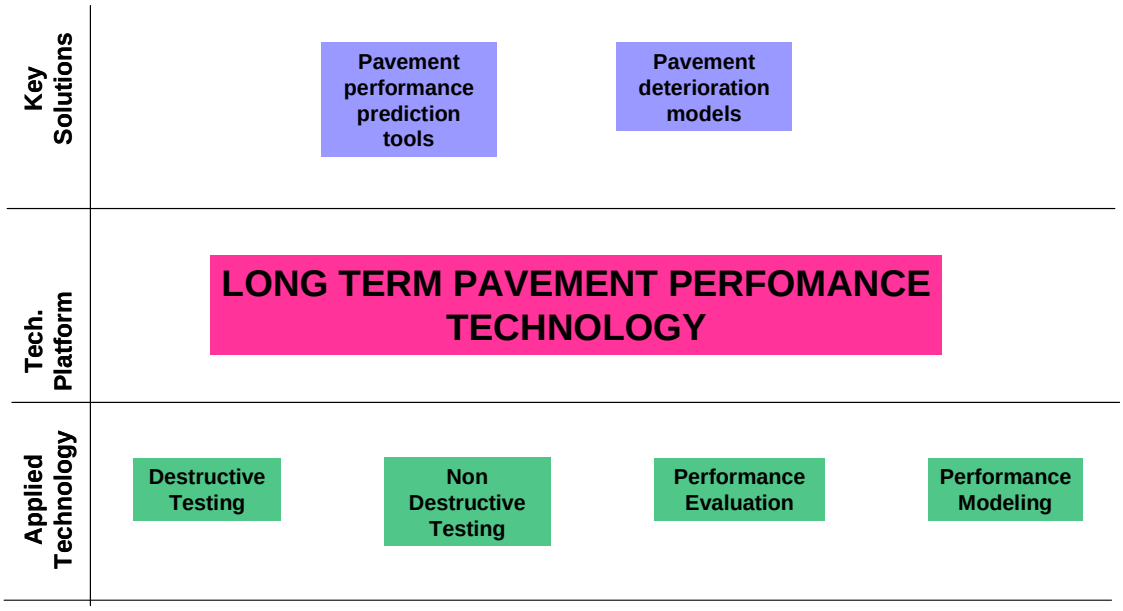


Figure G.27: The CSIR long term pavement performance technology platform showing Key Solutions

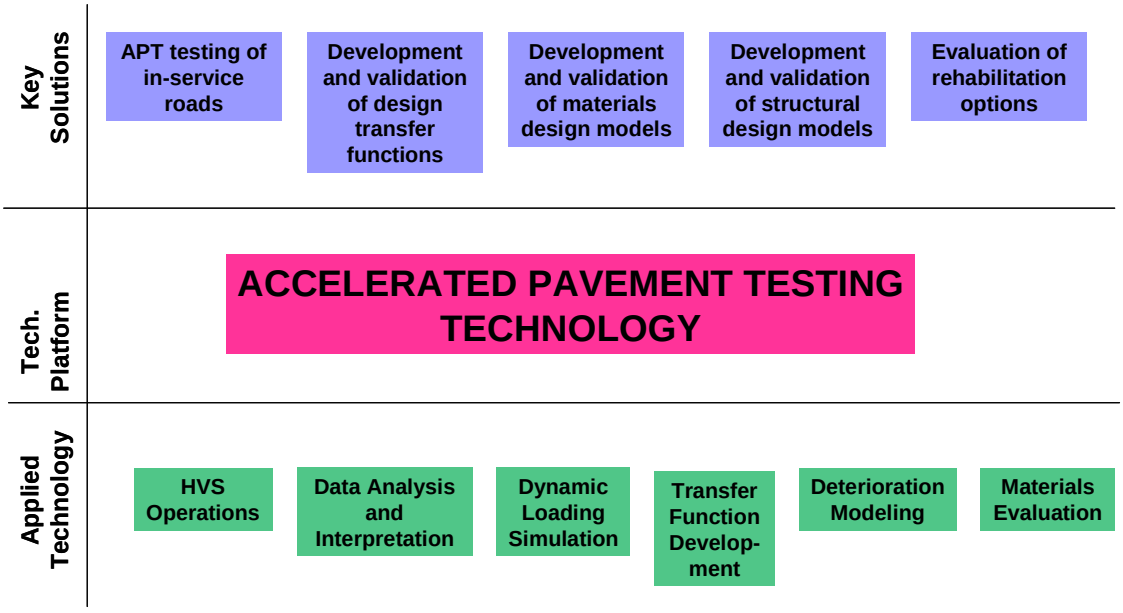


Figure G.28: The CSIR accelerated pavement testing technology platform showing Key Solutions

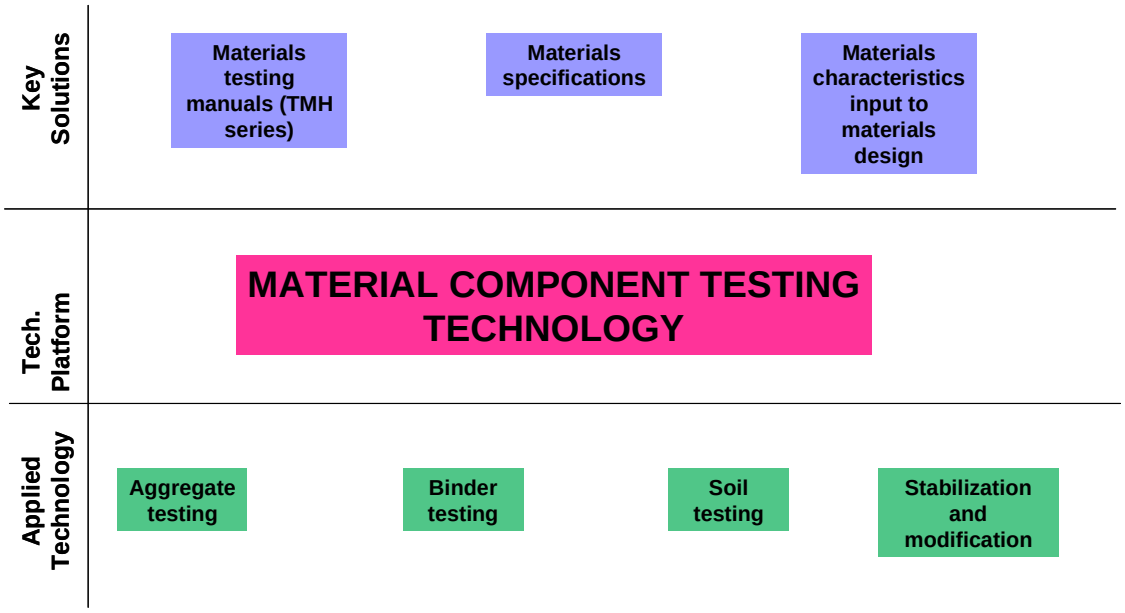


Figure G.29: The CSIR material component testing technology platform showing Key Solutions

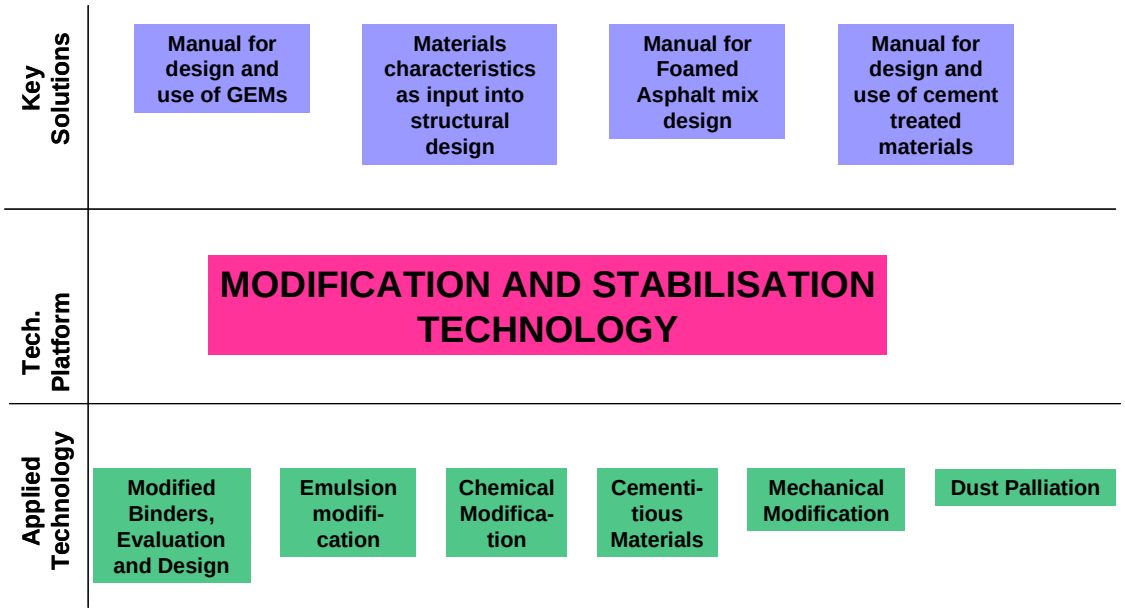


Figure G.30: The CSIR modification and stabilization technology platform showing Key Solutions

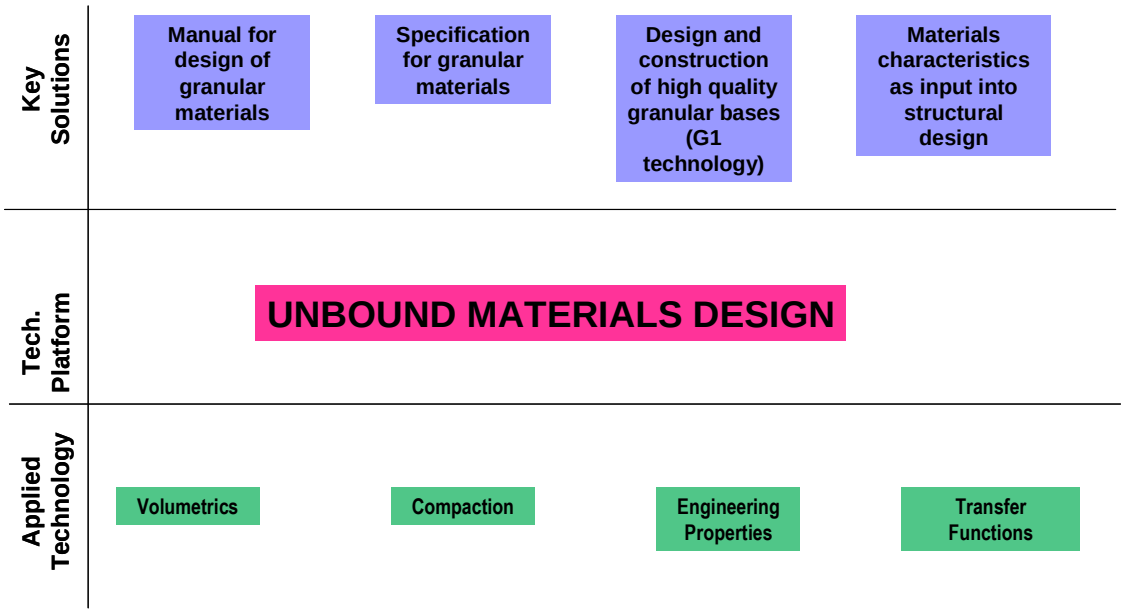


Figure G.31: The CSIR unbound materials design technology platform showing Key Solutions

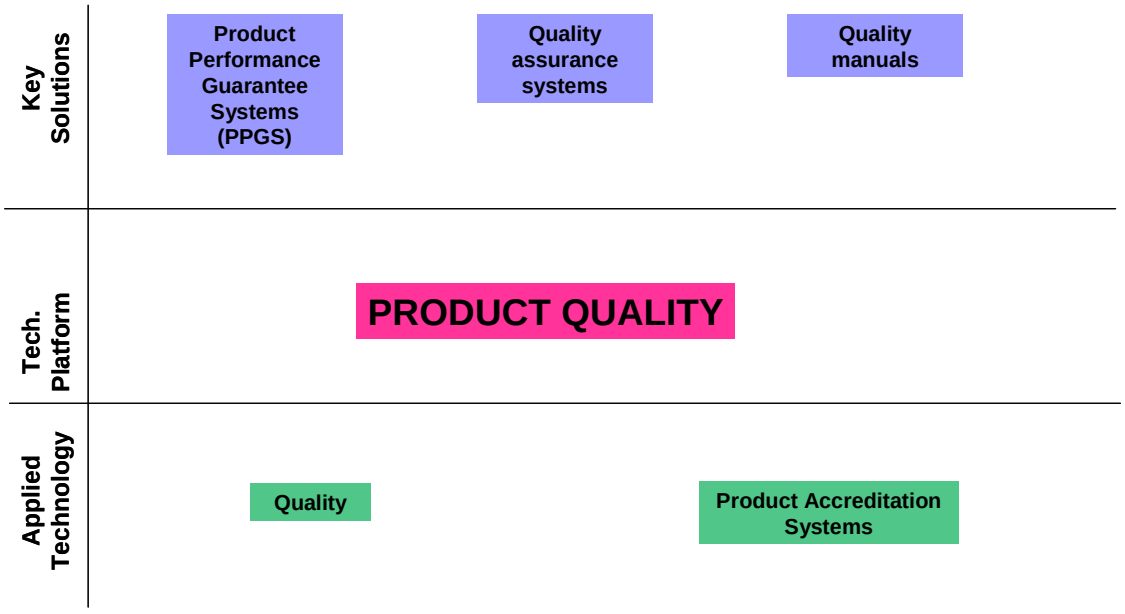


Figure G.32: The CSIR product quality technology platform showing Key Solutions

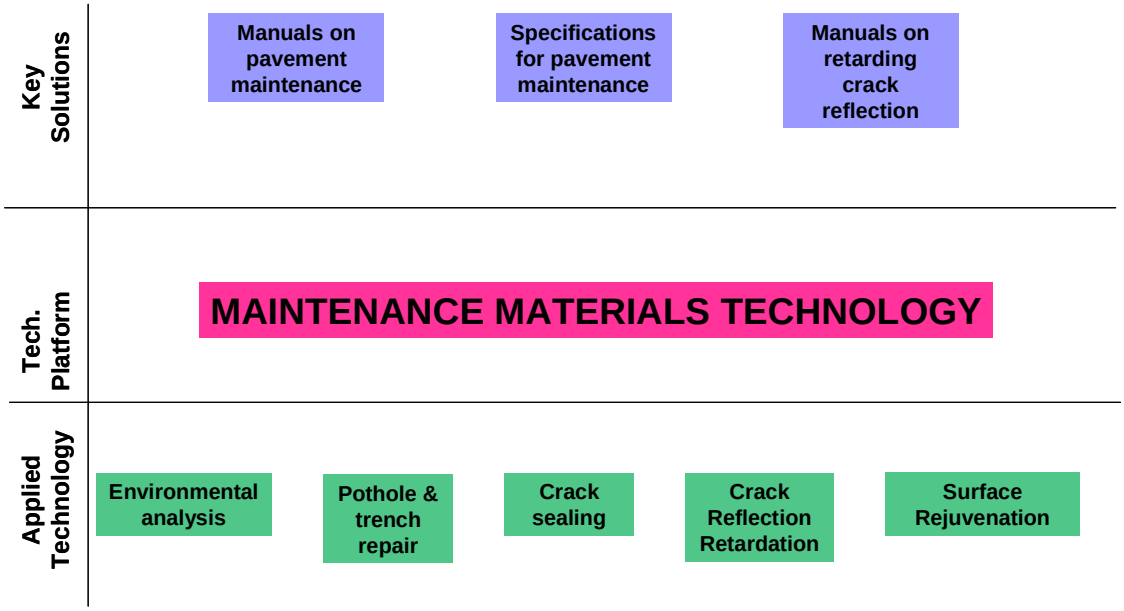


Figure G.33: The CSIR maintenance materials technology platform showing Key Solutions

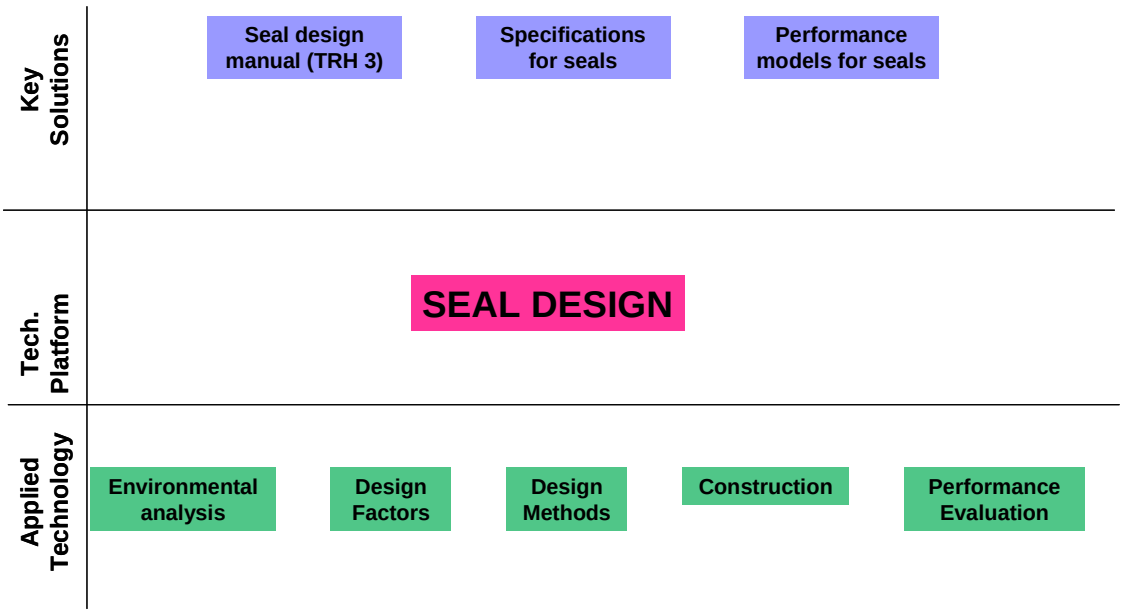


Figure G.34: The CSIR seal design technology platform showing Key Solutions

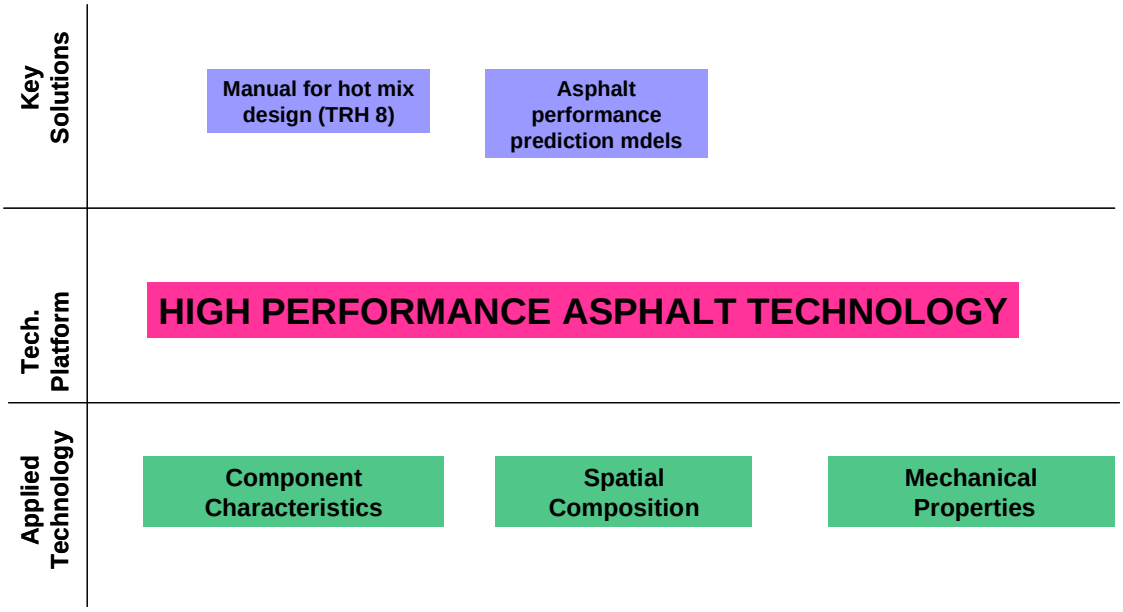


Figure G.35: The CSIR high performance asphalt technology platform showing Key Solutions

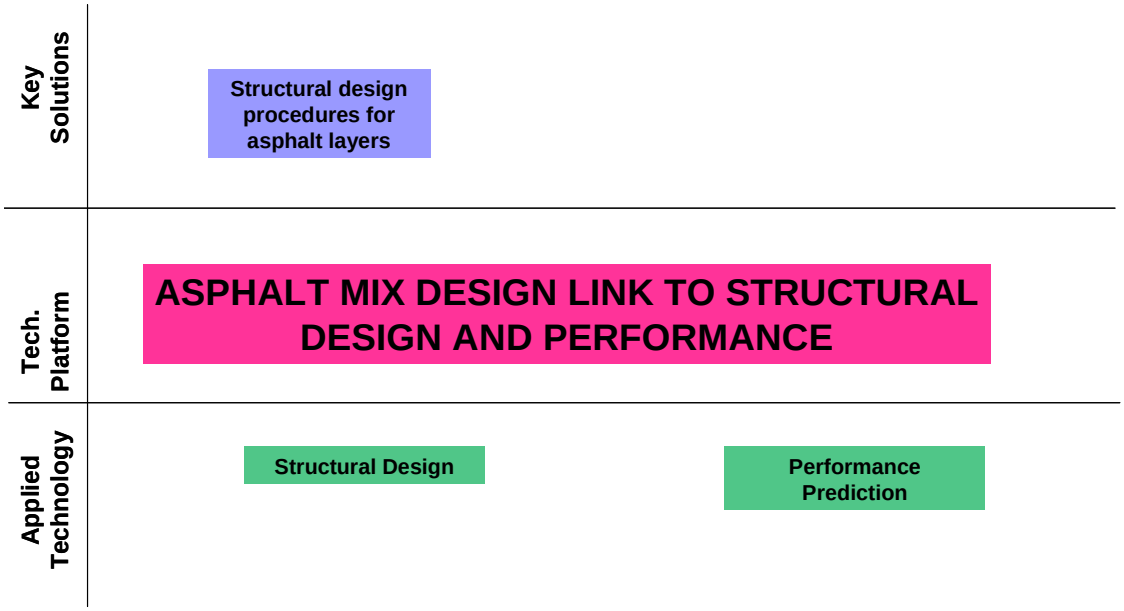


Figure G.36: The CSIR asphalt mix design link to structural design technology platform showing Key Solutions

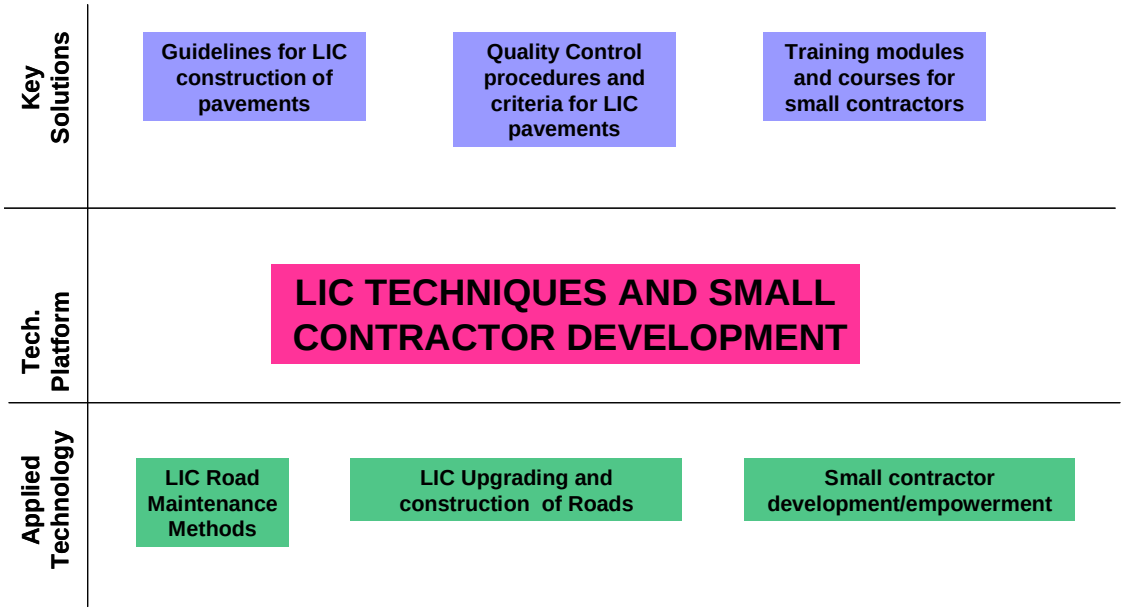


Figure G.37: The CSIR LIC techniques and small contractor development technology platform showing Key Solutions

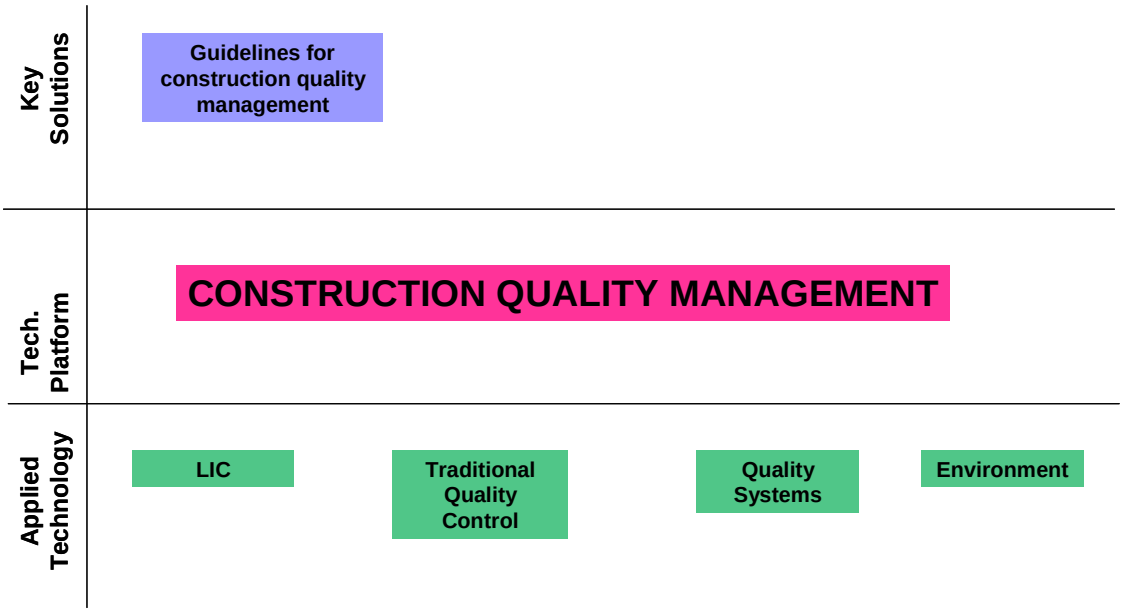


Figure G.38: The CSIR construction quality management technology platform showing Key Solutions

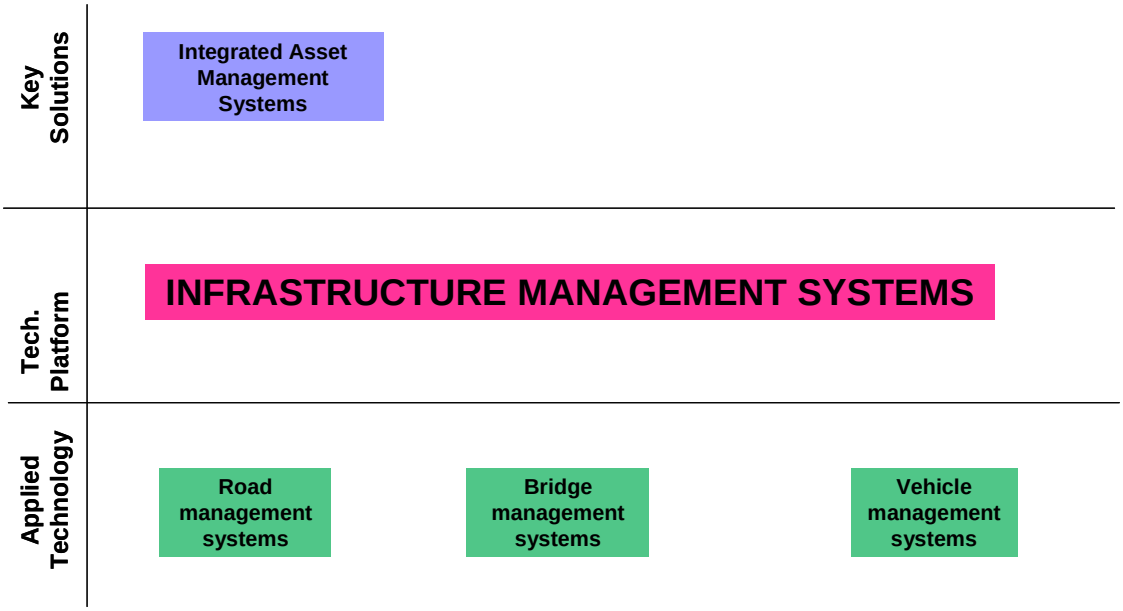


Figure G.39: The CSIR infrastructure management systems technology platform showing Key Solutions

APPENDIX H: SABITA E&T COMMITTEE RANKING OF KEY SOLUTIONS

PLATFORM, KEY SOLUTION	TOTAL	RANKING
HIGH PERFORMANCE ASPHALT TECHNOLOGY	**136**	**1**
High stability wearing courses	27	3
Durable surfacings	45	1
Heavy duty asphalt bases	8	4
Flexible asphalt surfacings	36	2
Thin layer asphalt	9	5
Road user friendly products	9	5
SURFACE TREATMENT TECHNOLOGY	**69**	**3**
Maintenance and holding actions	8	4
Skid resistant surfacings	16	2
Durable seals	25	1
Flexible seals	15	3
Dust palliation	5	5
QUALITY SYSTEMS	**37**	**4**
Innovative certification of products	4	5
Product guarantee’s	8	4
HSE strategy	0	
Improved specifications	20	2
PPGS	0	
LIC quality control	5	5
BITUMEN STABILISATION TECHNOLOGY	**91**	**2**
GEMS	36	2
Foamed bitumen	5	5
Flexible surfacings	15	3

Penetration Macadams	10	4
Low cost roads	25	1
CONSTRUCTION TECHNOLOGY	**0**	**5**
Guidelines for LIC	0	
Training modules for LIC	0	
Construction manuals	0	

APPENDIX I: BRIEF DESCRIPTION OF KEY SOLUTIONS, PLATFORMS, APPLIED TECHNOLOGIES AND BASE TECHNOLOGIES FOR THE SABITA PROGRAMME

I.1 KEY SOLUTIONS FOR HIGH PERFORMANCE ASPHALT TECHNOLOGY PLATFORM

High stability asphalt wearing courses

Asphalt wearing courses that are resistant to deformation and shear failure - intended for use on all roads, but specifically at intersections.

Durable thin surfacings

Surfacings including conventional and modified binders that are resistant to environmental effects and traffic loading.

Heavy duty asphalt bases

Asphalt bases that can carry heavy traffic is in excess of 75 million standard axles over a twenty year life - intended to be competitive with concrete bases.

Flexible asphalt surfacings

Flexible surfacings that can accommodate some movement (e.g. sagging, deformation) such as can be expected on low volume roads or low cost roads - intended to seal low cost roads effectively against the ingress of water.

Thin layer asphalt technology

Technology for the design, construction and quality control of thin asphalt layers (less than 25 mm thick) - intended as an alternative solution to seals for wearing courses of low cost roads.

Road user friendly products

Asphalt products that are road user friendly with specific emphasis on usage in developing communities where roads are used for more than just carrying traffic.

I.2 KEY SOLUTIONS FOR THE SURFACE TREATMENT TECHNOLOGY PLATFORM

Technology for maintenance and holding actions

Technology (new products, design methods, construction methods etc.) for use of products that can be used to maintain roads and as “holding actions” for roads in need of major rehabilitation - intended for the situation in the road building industry where funding is decreasing and resources are not always immediately available to conduct necessary rehabilitation of roads.

Skid resistant surfacings

New products for improving the skid resistance of roads (road safety aspect), including the assessment of skid resistance and its impact on road user safety.

Durable seals

Seals which are resistant to environmental effects and traffic loading.

Flexible seals

Flexible seals that can accommodate some movement (e.g. sagging, deformation) such as can be expected on low volume roads or low cost roads - intended to seal low cost roads effectively against the ingress of water.

Technology for dust palliation

Technology (new products, design methods, construction methods etc.) for the controlling of dust problems on gravel roads, with specific emphasis on use in developing communities as an interim measure before sealing or surfacing.

I.3 KEY SOLUTIONS FOR THE QUALITY SYSTEMS PLATFORM

Innovative product certification systems

Systems for certification of road building products which will simplify and facilitate the tendering process.

Product guarantee systems

Systems for facilitating guarantees for road building products

Health, Safety and Environment strategy

A strategy for dealing with issues related to the toxicity of bituminous products.

Improved materials specification systems

Improved systems for materials specification, including quality control and acceptance testing.

Product Performance Guarantee Systems

Systems for allowing the guarantee of bituminous products based on performance-related parameters.

Quality control for labour-intensive construction

Revised quality control methods and criteria for the labour-intensive construction of roads.

I.4 KEY SOLUTIONS FOR THE BITUMINOUS STABILISATION TECHNOLOGY PLATFORM

Granular Emulsion Mixes (GEMS)

Technology for the design and use of emulsion treated bases containing low percentages of emulsion. Intended as a cost-effective solution where high quality road building materials are not readily available.

Foamed Bitumen

Technology for the design and use of foamed bitumen to stabilise bases. Intended as a cost-effective solution where high quality road building materials are not readily available.

Flexible surfacings

The use of bitumen emulsions and modified bitumen emulsions as binder in seals for flexible surfacings that can accommodate some movement (e.g. sagging, deformation) such as can be expected on low volume roads or low cost roads, intended to seal low cost roads effectively against the ingress of water.

Low cost roads

Designs (material and structural) for low cost roads.

Penetration Macadams

The design and use of Penetration Macadam bases and Composite Macadam bases, specifically for use in labour intensively constructed roads in developing communities.

I.5 KEY SOLUTIONS FOR THE CONSTRUCTION TECHNOLOGY PLATFORM

Guidelines for labour-intensive construction

Guidelines on the design, specifications and quality control for labour-intensively built roads.

Training modules for labour intensive construction

Training material (including videos, courses etc.) for training new players in labour-intensive construction techniques.

Manuals for construction practices

Manuals on best practices in asphalt construction.

I.6 DESCRIPTION OF THE HIGH PERFORMANCE ASPHALT TECHNOLOGY PLATFORM

Analytical asphalt mix design

Test methods, material design methods, specifications and criteria for the design of asphalt mixes based on analytical procedures as opposed to empirical methods.

Emphasis is on performance-based engineering properties and dynamic testing of materials.

Binder and aggregate characteristics

Test methods and criteria for determining binder and aggregate characteristics that are relevant to performance-based engineering properties and dynamic testing of materials.

Sample preparation

Procedures for asphalt sample preparation, including constituency, pre-conditioning, compaction and post-conditioning.

Volumetric design

Design principles based on the volumetrics and spatial composition of the asphalt mix.

Dynamic materials testing

Equipment, procedures and criteria for the testing of asphalt materials using dynamic (cyclic) loading.

Design criteria

Criteria for the design of asphalt materials based on the above procedures.

Interaction with structural design

Methodology, procedures, engineering properties and models for linking asphalt materials design interactively with the structural design of roads.

Transfer functions

Models and formulae for transferring materials properties into structural design parameters.

Balancing materials properties with structural requirements

An interactive process for achieving the optimum balance between material properties in order to satisfy the structural requirements.

Functional design

Procedures, methods, specifications and criteria for designing of asphalt surfacing materials for functional requirements such as skid resistance, noise attenuation, drainage capabilities (porous asphalt), impermeability etc.

Vehicle interactivity (Safety & VOC)

Skid resistance measurement and design criteria. Models for determining rolling resistance and its influence on Vehicle Operating Cost.

Environmental impact (noise)

Measurement of and models for predicting the noise generated by different surfaces. Design criteria and specifications.

Social impact (roughness/dust)

Measurement of roughness of surfaces and the impact of dust-free surfaces on residents, farm produce etc. Design criteria and specifications.

Testing methodologies

Methods, procedures and criteria for the evaluation of materials *in-situ*.

Statistical approaches

Procedures for the use of statistical approaches to ensure representivity of sampling and relevance of results.

Field testing devices

Test methods and criteria for evaluating materials and layers *in-situ* and in field laboratories.

Constructability

The ease of construction. Methods for avoiding problems such as segregation. Achievability of specifications with materials available.

Workability

Parameters for optimising ease of construction and *in-situ* engineering properties

Feasibility (in relation to specs)

Methods for predetermining the feasibility of achieving the required specification with the material available and under the prevailing conditions.

Acceptance criteria

Criteria for the acceptance of materials and layer works.

Performance

Methodologies, prediction models and parameters for predetermining the likely performance of materials and layers.

Non-destructive testing

Test methods and criteria for evaluation of the structural integrity of layers in-situ without disturbing the material.

LTPP

Long Term Pavement Performance measurement and data analysis.

In-situ evaluation

In-situ evaluation of material properties.

Performance criteria

Criteria for the evaluation of the performance of materials and pavement structures.

I.7 DESCRIPTION OF THE SURFACE TREATMENT TECHNOLOGY PLATFORM

Rational seal design method

A seal design method based on analytical rather than empirical models.

Design criteria

Design criteria for optimising the performance of seals i.r.o. functional requirements.

Reflection cracking simulation

Methods for the simulation of crack reflection, testing of materials for crack reflection, design criteria and specifications.

Skid resistance criteria

Measuring methods, design criteria and specifications for skid resistance.

Aggregate testing

Specific test methods for evaluation of the suitability of aggregates for seal applications.

Binder testing

Specific test methods for evaluation of the suitability of conventional and modified binders for seal applications.

Test methods

Test methods specifically related to seal design *e.g.* the embedment test.

Appropriate standards

Standards and specifications for seals relevant to their usage under a variety of conditions and applications.

Design criteria

Design criteria for seals and their application in a variety of circumstances.

Specifications

Specifications for seals and their application in a variety of circumstances.

Community requirements

Specific functional requirements for seals used in residential areas with emphasis on developing communities. Texture of seals. Resistance to special environmental conditions e.g. oil spillage, detergents etc.

Performance modelling

Measurement of, modelling of and prediction of the performance of seals.

Pavement surveillance

Technologies for pavement surveillance measurement, including riding quality, cracking, bleeding etc.

Performance criteria

Criteria for the functional performance of seals.

Performance measurement

Methods and procedures for the measurement of the performance of seals.

Data base management

Technologies for the development and maintenance of data bases on seal application and performance.

Management systems

Linkage to pavement management systems related to seals and their performance.

Socio-economic analysis

Analysis of factors related to the socio-economic impact of seals including cost/benefit analysis and social factors.

Community requirements

Specific functional requirements for surface treatments used in residential areas with emphasis on developing communities. Resistance to special environmental conditions e.g. oil spillage, detergents etc.

Social impact of roads

Social impact of the surfacing of roads.

Financial impact of roads

Impact of the surfacing of roads in terms of the stimulation of economic growth.

Proprietary products

Technologies, methods and criteria for the assessment of proprietary products for use in surface treatments including conventional and modified binders as well as emulsion products.

Modified binder technology

Technology for assessing the applicability of new modified binders for use in surfacings.

Rapid setting emulsions

Technology for assessing the applicability of rapid setting emulsions for use in surfacings.

Dust palliatives

Technology for the evaluation of the performance of dust palliatives.

Seal rejuvenators

Technology for the evaluation of the performance of seal rejuvenators.

I.8 DESCRIPTION OF THE QUALITY SYSTEMS PLATFORM

ISO 9000

Existing codes and specifications for quality management.

Quality systems

Specific systems for managing the quality of road building.

LIC quality control techniques

Techniques and specifications for the control of quality in labour-intensive construction.

Product guarantee systems

Systems and procedures for guarantee of the quality of bituminous products used in roads.

Product certification systems

Systems and procedures for certifying proprietary bituminous products for road building.

Environment

Assessment of the impact of environmental issues on product quality.

Health, Safety and environmental issues

Assessing the impact of occupational health issues, worker safety issues and environmental issues on the quality of bituminous products.

I.9 DESCRIPTION OF THE BITUMEN STABILISATION TECHNOLOGY PLATFORM

Mix design

Procedures, test methods, criteria and specifications for the design of materials using bituminous products as a stabilising agent, including cut backs, emulsions and foamed bitumen.

Binder and aggregate characteristics

Test methods and criteria for determining binder and aggregate characteristics that are relevant to performance-based engineering properties of materials.

Sample preparation

Procedures for sample preparation, including constituency, pre-conditioning, compaction, post-conditioning and the simulation of field strengthening.

Design criteria

Performance-related design criteria for materials stabilised with bituminous binders.

esting methodologies

Testing methods specific to stabilised materials (*e.g.* Unconfined Compressive Strength).

Constructability

Performance factors and guidelines related specifically to the constructability of materials stabilised with bituminous products.

LIC techniques

Techniques and specifications for the labour-intensive construction of materials stabilised with bituminous products.

Workability

Criteria for assessing the workability of materials stabilised with bituminous products and the influence thereof on engineering properties and performance.

User friendliness

Issues and guidelines related to the ease of use of materials stabilised with bituminous products.

Appropriate standards

Construction standards appropriate to the nature of these materials including recognition of the fact that they strengthen in the period immediately after construction.

Performance

Methodologies, prediction models and parameters for predetermining the likely performance of materials and layers taking cognisance of special properties such as field strengthening.

Transfer functions

Specific transfer functions for predicting the structural properties of layers of these materials taking cognisance of their special properties (such as field strengthening).

Performance criteria

Specific transfer performance criteria for these materials taking cognisance of their special properties (such as field strengthening).

In-situ assessment

Specific test procedures (e.g. using DCP measurements over time) to determine the behaviour of these materials in the field.

Prediction models

Specific performance prediction models for these materials taking cognisance of their special properties (such as field strengthening).

Chemical/Physical interactions

Technologies for determining and knowledge of the chemical and physical reactions taking place between stabilisers and aggregate or between two stabilisers (*e.g.* emulsion and cement or lime).

Proprietary products

Existing technologies for the manufacture and use of proprietary products utilising emulsion technology and foamed asphalt technology.

1.10 DESCRIPTION OF THE CONSTRUCTION TECHNOLOGY PLATFORM

LIC

Issues, guidelines and technologies related to the labour-intensive construction of layers containing bituminous materials.

HSE

Issues and guidelines for the health and safety of workers using bituminous products in labour-intensive construction.

Workability

Issues and guidelines related to the ease of use of materials containing bituminous materials and using labour-intensive methods.

Equipment for LIC

Equipment designed for LIC and procedures for their use.

LIC Training

Training modules for labour-intensive construction using bituminous products.

Quality control

Procedures and guidelines for quality control of labour-intensive construction.

Production rates

Planning criteria related to LIC production rates.

Specifications

Specifications suitable for LIC.

Contract documents for LIC

Contract documents suitable for LIC.

Conventional construction

Issues and guidelines related to conventional construction.

Quality systems

Systems for managing quality in conventional construction.

Quality assurance plans

Process efficiency

Criteria and guidelines for ensuring optimisation of value for money.

Process effectiveness

Guidelines for ensuring that objectives are met.

Specifications

Quality control

Contract documents

Standards and acceptance procedures

Standards for and acceptance procedures for materials and layers works containing bituminous materials.

Specifications

Acceptance criteria

Quality control

Field test methods

Operational issues

Compaction methods

The effect of field compaction on engineering properties and acceptance criteria.

Material hauling

Issues and guidelines related to the hauling of bituminous materials from the mixing plant to construction sites including cooling of material, segregation and digestion of bitumen rubber.

Mixing procedures

Guidelines on the effect of plant mixing on the engineering properties of bituminous materials.

APPENDIX J: BRIEF DESCRIPTION OF SABITA PROJECTS DEFINED

PROJECT NAME: APPROPRIATE STANDARDS FOR EFFECTIVE BITUMINOUS SEALS (APPSTDS)

AREST NO.: 1 (1989)

SUB-PROJECTS: Highly Flexible Surfacings (1997)

PROJECT STATUS: Completed 1992

GOALS: To develop a new catalogue of cost-effective surfacings for low volume and temporary roads. To reduce the negative effect of conservative adherence to “fail safe”, high quality seal types for low volume and temporary roads which militates against product market expansion due to their negative effect on determining economic warrants.

NEED: Strict material and construction requirements make the construction and/or upgrading of many low volume roads uneconomic. Particularly for roads carrying less than 100 v.p.d. and for roads in developing urban areas appropriate bituminous surfaces should be provided. Cost-effective low maintenance bituminous surfacings which overcome the high maintenance costs, dust and erosion of unpaved roads would enable the asphalt industry to corner a significant share of the millions spent annually on the maintenance of unpaved roads.

DELIVERY: To reduce both energy needs and costs and to improve the environmental friendliness of road-building materials and construction processes, techniques have been developed for the design and

evaluation of granular mixes stabilised by the addition of bitumen emulsion.

Preliminary laboratory design methods have been utilised in the construction of trials sections in the Free State. These were subjected to testing by the HVS. The results of this study were presented at CAPSA '94.

In October 1993, Sabita launched a design manual for GEMs with recommended design procedures for both stabilised GEMs (high emulsion contents) and for modified GEMs (low emulsion contents; similar in concept to ETBs). A series of seminars was held in South Africa and the proposed design methods were also presented at CAPSA '94.

Very good performance has been achieved with the use of ETBs in South Africa. This is also indicative of the economic viability of the use of bitumen emulsion in rehabilitation. A series of guideline documents on ETBs is currently being prepared.

OUTPUT: Seven regional seminars were held to disseminate the information and two easy-to-use manuals were produced in 1992. Sabita's Manual 10: *Appropriate Standards for Bituminous Surfacings for Low Volume Roads* (May 1992) provides guidelines to practitioners from rural road authorities, city and town engineers and development agencies on the choice and selection of bituminous surfacings for low volume roads. The work of this project was included in the Department of Transport's project on appropriate standards. 14 Reports were published.

PROJECT CONDUCTED BY : CSIR Transportek (LR Sampson)

PROJECT NAME: NATIONAL SPECIFICATION FOR BITUMEN (SABS307) (BITSPECS)

AREST NO.: 1,2 (1989, 1990)

SUB-PROJECTS: None

PROJECT STATUS: Completed 1996

GOALS: To revise the penetration-based specification so as to produce fit-for-purpose standard specifications for penetration grade bitumens.

NEED: The isolation of South Africa during the late 1970s and 1980s and the associated oil embargo resulted in excessive secrecy around sources of petroleum products and in a lack of understanding of changes taking place in specifications for bitumen in the developed countries. A revised basis for specifying and testing bitumen in South Africa was required.

Following a series of investigations, revised SABS-307 specifications (amendment 4) were issued in April 1995. Amendment 4 was perceived by many as an improvement on previous specifications as properties which indirectly define the rheology of the binder at operating and application temperatures were covered. Also, certain aspects of cohesion and ageing were better covered than in previous specifications. However, at the BMLC meeting in May 1995, it was stated that some of the specifications limits were not totally satisfactory and that “report only” properties needed to be specified.

DELIVERY: Through the influence of the BMLC Bitumen Specification Task Force, supported by the SABS, with Sabita providing the secretariat, a revised basis was developed for specifying and testing of bitumen in South Africa. A project, jointly funded by the National Department of Transport and Sabita, was undertaken by CSIR Transportek and the University of

Stellenbosch in which measurable physico-chemical properties of bitumen were identified. The ability of SABS 307 to specify a balance of these properties was evaluated in terms of fundamental principles as well as by comparison with international specifications.

OUTPUT: The recommendations made by the project team, complemented by the views and opinions of the BMLC Bitumen Specification Task Force, formed the basis for Amendment 5 of SABS 307. Three reports published.

IMPACT: A revised basis for specifying and testing bitumens in South Africa has been established.

PROJECT CONDUCTED BY : CSIR Transportek (BMJA Verhaeghe)

PROJECT NAME: DESIGN AND PERFORMANCE OF BITUMEN EMULSION TREATED MATERIALS (ETBs)

AREST NO.: 1 (1989)

SUB-PROJECTS:
Granular emulsion modification (GEMs) (Arest 1,2)
Implementation of GEMs (Arest 1,2,3
Britstown GEMs implementation report (Arest 1,2,3)
Extension of design scope for less than 1.5 % (Arest 2,3)

PROJECT STATUS: Completed in March 1999.

GOALS: With regard to stabilised GEMS, to develop nationally acceptable mixing, testing and evaluation methodologies for GEMs, with emphasis on the upgrading of substandard materials to base standards by the addition of relatively high percentages of bitumen emulsion (residual bitumen contents in excess of two per cent).

With regard to Emulsion Treated Bases (ETBs), to broaden the range of application of ETBs as a competitive basecourse material in both rural and urban applications by extending the design scope of the current technology and entrenching it in practice, and to produce best practice guidelines for structural design, material design and construction, as well as economic guidelines.

NEED: The low credibility of bitumen emulsion treated materials needed to be enhanced by the formulation of laboratory design techniques aimed at defining the product in terms of its engineering properties and/or by capturing best practice. This would lead to greater confidence by

practitioners in the use of a cost-effective product where diminishing reserves of conventional road construction materials indicate the need for innovation.

DELIVERY: To reduce both energy needs and costs and to improve the environmental friendliness of road-building materials and construction processes, techniques have been developed for the design and evaluation of granular mixes stabilised by the addition of bitumen emulsion.

Preliminary laboratory design methods have been utilised in the construction of trials sections in the Free State. These were subjected to testing by the HVS. The results of this study were presented at CAPSA '94.

In October 1993, Sabita launched a design manual for GEMs with recommended design procedures for both stabilised GEMs (high emulsion contents) and for modified GEMs (low emulsion contents; similar in concept to ETBs). A series of seminars was held in South Africa and the proposed design methods were also presented at CAPSA '94.

Very good performance has been achieved with the use of ETBs in South Africa. This is also indicative of the economic viability of the use of bitumen emulsion in rehabilitation. A series of guideline documents on ETBs is currently being prepared.

OUTPUT: This project has received support from the emulsion industry and from the National and Provincial Departments of Transport in continued funding of the HVS. Presentations have been made to ICAP in Nottingham as well as to CAPSA in Cape Town and the results were well received.

GEMS have been successfully used in a wide range of applications, from surface courses for low-volume roads to bases for high-volume freeways.

The easily used design method was introduced through the implementation project.

Sabita's Manual 14: *GEMS - The Design and Use of Granular Emulsion Mixes* (Oct. 1993) provides guidelines for the use of bitumen emulsion treated granular materials, with emphasis on the upgrading of substandard materials. However, the same principles may be applied to a wide range of materials, applications and conditions. 18 Reports published.

IMPACT: Bitumen sales worth R 1,5 million have resulted through GEMS. The expected growth rate is 8% per annum. Savings in material costs at Heilbron were estimated at R 30 000 per km. GEMS technology can be used on over 2 000 km of road in the OFS alone.

PROJECT CONDUCTED BY: CSIR Transportek (FC Rust)

PROJECT NAME: FATIGUE OF MODIFIED BINDERS UNDER SIMULATED CRACK MOVEMENT (FATMOD)

AREST NO.: 1 (1989)

SUB-PROJECTS: Performance of modified binders in N3 trials

PROJECT STATUS: Completed in 1993

GOALS: To categorise the performance requirements of modified binders in laboratory tests and to compare the results with full scale performance achieved on the N3 trials. If suitable tests are found this will mean that the introduction of innovative modified binders will be simplified and the cost of trials considerably reduced.

NEED: Cracking of pavements is a problem which is experienced worldwide and on different types of pavements. Cracks allow the ingress of water through the surface to lower layers in the pavement, which is one of the factors that can lead to acceleration in the rate of deterioration of a pavement. The advent of modified binders on the South African market prompted a need to research the proper use of these in various applications such as in asphalt and surface treatments.

DELIVERY: The N3 trials project was initiated when the Department of Transport discontinued funding the experiment on a number of commercially available flexible binders on the N3 near Alberton. Guidelines on sealing of active cracks in road pavements using bituminous binders were produced in March 1994. This resulted from research into the aspects of reflection cracking and the prevention thereof, using modified bituminous binders. It was found that modified binders can be used effectively to keep cracks sealed and to retard their reflection to the surface.

OUTPUT: Work on the N3 trials was built upon and included ongoing monitoring of the modified binders placed during the crack movement experiments. A design methodology was developed to categorise the various binders and was presented to ISAP in 1992. A further project called MODCRACK was undertaken to combine the results of all published South African researchers into a publication to facilitate adequate technology transfer of the results. Three reports published.

IMPACT: The above work has not only resulted in a better understanding of crack reflection and the factors controlling it, but has as its ultimate objective the development of performance-related design procedures, criteria and specifications for the use of modified binders to seal active cracks. This approach will lead to more cost-effective use of resources and could potentially save road authorities significant amounts of money.

PROJECT CONDUCTED BY: CSIR Transportek (FC Rust)

PROJECT NAME: IMPACT OF FLUCTUATIONS IN ROAD INVESTMENT (FLUCFUND)

AREST NO.: 1 (1989)

SUB-PROJECTS: STAGE CONSTRUCTION

PROJECT STATUS: Completed in 1990

GOALS: To gain a better understanding of the cause and effects on industry of erratic road funding patterns adopted by the state and to develop means

whereby the adverse effects can be alleviated, thereby enhancing the quality of the asphalt industry.

NEED: Varying growth levels in the national economy result in fluctuating investment in roads which obviously has a detrimental impact on Sabita. This fluctuating level of funding not only makes planning difficult in terms of staffing, capital investment, training and so forth, but can also lead to the inefficient allocation of scarce resources. A quantification of the problem and a strategy to counter this was required.

DELIVERY: The impact of fluctuations in road investment on the members of Sabita was determined and recommendations made to improve the situation. Expenditure on road construction and maintenance projects by the various road authorities and their use of bitumen and tar products was also examined. A strategic plan to alleviate the adverse effects of fluctuations in road funding of the asphalt industry was then developed.

OUTPUT: As a result of the outputs given under this project great strides have been made towards forming alliances with other transport-related industry groups and forming contact and communication forums with funding bodies to redress an unacceptable situation. This has been enacted through the communication forum at the BMLC which has enabled industry participation in standard setting and direct contact with its clients.

IMPACT: Three reports published.

PROJECT CONDUCTED BY: CSIR Transportek (PC Curtayne)

PROJECT NAME: DESIGN AND PERFORMANCE OF HEAVY DUTY ASPHALT PAVEMENTS (HDAPs)

AREST NO.: 1 (1989)

SUB-PROJECTS: LAMBs.

PROJECT STATUS: Completed in early 1992, an implementation project was started in 1993.

GOALS: To develop the technology related to full depth and/or deep strength asphalt pavements to meet the current and future demands in terms of expected traffic density and loading. This field has not been adequately researched since the late 1950's. The objective is to have technology and products in place to compete in the field of traffic demands in the higher categories (50xl0~fully loaded axles) and beyond - as is expected.

NEED: Technology related to HDAPs needed to be developed to provide a cost effective and competitive product in this pavement category. Deep asphalt pavements have performed extremely well in the past under extreme traffic conditions. These performances have, however, not been evaluated systematically in recent times and interest needed to be revived to ensure the maximum use of asphalt in heavy duty applications.

DELIVERY: A design method for large-aggregate mixes was established and trial sections were constructed. These were subjected to HVS testing and produced results which confirmed that large-aggregate mixes could carry a volume of traffic equivalent to that which could be carried by rigid pavements. These findings where used in an approach to the Minister of

Transport with a request to review the Department of Transport's view that a certain percentage of pavements should be constructed with concrete.

OUTPUT: The work has been presented locally and internationally and has received acclaim.

IMPACT: The project has encouraged Johannesburg and other large urban authorities to rehabilitate their existing heavy traffic routes with large stone mixes. 17 Reports and papers published.

PROJECT CONDUCTED BY: CSIR Transportek (FC Rust)

PROJECT NAME: LARGE AGGREGATE MIXES FOR BASES (LAMBs)

AREST NO.: 1,2 (1989,1990)

SUB-PROJECTS: Implementation of LAMBs

PROJECT STATUS: Completed 1993.

GOALS: To formulate a new design method for large aggregate mixes for bases which does not require sophisticated and expensive equipment and which is relatively simple yet accurate. To test the construction of LAMBs in the field and to draw up specifications for quality control. To provide an economic analysis and life cycle costing of LAMBs.

NEED: Traffic volumes, axle loads and tyre pressures are increasing world-wide. On some major routes in South Africa traffic has increased to levels

beyond the current highest design class. This situation, in conjunction with the decrease in road funding in South Africa, has put new demands on the engineering properties and cost-effectiveness of asphalt mixes. Large aggregate mixes have considerable structural and economic advantages over conventional asphalt. Lower binder contents and reduced aggregate crushing result in the cost of this type of mix being less than that of conventional asphalt mixes.

DELIVERY: Extensive research on alternative designs for heavy duty asphalt pavements led to investigations into the use of large aggregate asphalt mixes in bases as a cost-effective solution to an increasingly aggressive environment. The research, development and implementation work covered the development of an analytical design approach for large aggregate mixes, the development of laboratory compaction and design procedures, the establishment of design criteria, an investigation into the performance of large aggregate mixes and the constructability of these materials. It was shown that LAMBs are a cost-effective and durable option for roads carrying very heavy traffic.

OUTPUT: Sabita's Manual 13: LAMBs - *The Design and Use of Large Aggregate Mixes for Bases* (October 1993) provides guidelines on the mix design method, the constructability and quality control of LAMBs, cost considerations on the use of LAMBs and case study material to provide practical illustrations. This manual is currently being revised by the University of Stellenbosch. The revised manual is due to be published in 1997.

As the road authorities in Natal had expressed considerable interest in the use of LAMBs it was considered important to transfer the current state of knowledge and technology to this industry. Therefore state-of-the-art knowledge on the design and construction of LAMBs was disseminated at a seminar in Pietermaritzburg (March 1993) and assistance was given to consultants in Natal with the structural and mix designs of LAMBs.

IMPACT: R 16 million worth of extra bitumen sales on LAMBS contracts have been achieved over a two year period. LAMBS have resulted in a 5 % growth rate in bitumen sales in Natal. Five reports and papers published.

PROJECT CONDUCTED BY: CSIR Transportek (FC Rust) and University of Stellenbosch (F Hugo)

PROJECT NAME: STAGE CONSTRUCTION (STAGECON)

AREST NO.: 1 (1989)

SUB-PROJECTS: FLUCTUATING FUNDING

PROJECT STATUS: First stage completed in 1990.

GOALS: To demonstrate that constructing a pavement in stages holds considerable economic advantages and renders asphalt the preferred material, since it lends itself to this type of strategy.

NEED: Stage construction was investigated because it holds the potential to overcome problems such as the lack of certainty over growth in traffic volumes and loads which has financial implications, enables funding to be spread over several years and minimising the total cost of construction and pavement maintenance.

DELIVERY: The economic advantages where clearly demonstrated in phase one. Expansion of the project to accommodate user delay costs and to extend the scope to include higher traffic volumes is under consideration.

OUTPUT: One report published.

IMPACT: Not determined.

PROJECT CONDUCTED BY: CSIR Transportek (PC Curtayne)

PROJECT NAME: IMPROVED GUIDELINES FOR THE SURFACING OF UNPAVED LOW VOLUME ROADS (SURF)

AREST NO.: 1 (1989)

SUB-PROJECTS: Update and improvement on SURF (linking to CB roads)

PROJECT STATUS: Completed in 1990, revised by mid 1993.

GOALS: To distil current world-wide practice into a user-friendly method, easily accessed by specifying authorities, whereby the real advantages in terms of total costs can be readily determined, and thereby redressing the distorted bias towards unsurfaced roads as a result of considering agency costs only.

NEED: The need for concise, user-friendly guidelines for the upgrading of unsurfaced roads to a surfaced standard was identified by the asphalt industry in 1988. Available packages are generally difficult to use and dependent on too detailed inputs for use in the planning stage or too general inputs for use in the design stage. The growing recognition of social and environmental impacts of road projects has also meant that increasing consideration must be given to these factors in the evaluation process.

DELIVERY: State-of-the-art improved guidelines for the surfacing of unpaved roads were produced. A unique, user friendly computer package has been introduced and distributed to consulting engineers and public authorities. Sabita's computer manual: *SURF - Surfacing of unpaved roads: feasibility assessment* (October 1989) explains the SURF suite of programs designed to undertake economic analysis of roads in the

planning and design stages of projects, with a specific aim of upgrading roads from a gravel to a surfaced standard.

The program was later revised by the CSIR to bring the user interface up to date and in line with the other Sabita computer programs.

OUTPUT: The package greatly facilitates the performance of economic studies at both the network and project level thereby improving decision making considerably. Strong support for its use has come from neighbouring countries due to its ease of use and road network orientation. Three reports published.

IMPACT: Not determined.

PROJECT CONDUCTED BY: CSIR Transportek (LR Sampson)

PROJECT NAME: COST AND PERFORMANCE HISTORY OF PREMIUM PAVEMENTS (PREMPAV)

AREST NO.: 1 (1989)

SUB-PROJECTS: None.

PROJECT STATUS: Completed in 1991

GOALS: To compare various types of strong pavements in terms of initial costs, maintenance and rehabilitation costs and road user delay costs. To prove

that, in the case of pavements built in South Africa since the 1950's and designed to give adequate service over prolonged periods, asphalt, when compared to concrete and crushed stone bases is a more cost-effective road building material, when all factors are brought into reckoning.

NEED: Several premium pavements - defined as a low maintenance facility, capable of carrying relatively heavy traffic during its design life - were constructed in South African since the mid 1960's. Information on the performance of these pavements over time was required.

DELIVERY: Road sections throughout South Africa were selected and relevant data compiled for the study. Future expected maintenance and rehabilitation costs were established by using mechanistic analysis techniques and generally accepted theory was used in calculating the cost-effectiveness of each solution.

OUTPUT: The results of this project, which was reported at the ATC'92, indicate the significant effect that environment plays on the life of a pavement. The economic viability of long term investments in rigid pavements could be severely questioned when the regular premature failure due to environmental factors was considered. This information was used to assist in persuading the Minister of Transport to reconsider the reserving of certain high volume national roads for construction in concrete. One report published.

IMPACT: Not determined.

PROJECT CONDUCTED BY: Bruinette, Kruger & Stoffberg (P. J. Strauss)

PROJECT NAME: POROUS ASPHALT MIXES (PAMs)

AREST NO.: 1 (1989)

SUB-PROJECTS: Investigation into polymer modified asphalt wearing courses
Design of porous asphalt mixes

PROJECT STATUS: Completed in 1994.

GOALS: To tailor the properties of asphalt wearing courses so as to cope with increasing demands made on asphalts in heavy duty applications in terms of strength and resistance to permanent deformation as well as to improve the durability of open-graded road noise attenuating layers.

NEED: Current design methods and evaluation techniques for conventional mixes do not reflect the benefits obtained by the addition of polymer modifiers to the bitumen. An investigation was required to identify the likely benefits to be obtained by making use of polymer-modified binders, particularly in view of the increasing demands made on asphalts in heavy duty applications.

Porous asphalt technology improves road functionality, promotes driver safety and comfort in all weathers and considerably reduces noise pollution. As available mix design methods for dense-graded asphalt mixes were not considered to be applicable to porous asphalt mixes, a new design approach was required.

DELIVERY: The fundamental differences between the various types of polymers have been identified, which will influence the direction of future research. A design method has been established for porous asphalt mixes. The

use of both bitumen-rubber and homogeneous binders are considered in this method.

OUTPUT: Sabita's manual 17: *Porous Asphalt Mixes - Design and Use* (1995) addressed the design considerations, gave guidelines on the mix design and constructability, as well as covering quality control and maintenance. The research results motivated Gautrans and Johannesburg City Council to consider porous or whisper asphalt for inclusion in their upgrading of P206/1 and the M2, respectively. 26 reports and papers published.

IMPACT: The introduction of an analytical mix design method for extra porous asphalt has resulted in its use on a number of major projects, including the M1 and M2 freeways in Johannesburg. Porous asphalt provides a sound absorbing surface which greatly reduces traffic noise, and research has shown that it can reduce accidents significantly through improved road texture and improved visibility during rain.

PROJECT CONDUCTED BY: CSIR Transportek (BMJA Verhaeghe)

PROJECT NAME: EXPANSION OF THE ASPHALT MARKET BY USING CAPE FLAT SANDS (SAND ASPHALT)

AREST NO.: 1 (1989)

SUB-PROJECTS: USE OF WASTE MATERIALS IN ASPHALT

PROJECT STATUS: Completed in 1992.

GOALS: To improve the understanding in the design, manufacture, practical application, engineering performance and economic viability in the use of sands for asphalt surfacings. Thus enabling use of the relatively low priced and abundant sand and other waste materials in asphalt to provide a lower priced product to assist in enlarging the bituminous market.

NEED: The need for paved road and parking surfaces in areas which do not necessarily need high quality asphalt materials and engineering control has become more and more evident as rising costs and recession limit and prevent the replacement of such asphalt mixes. The occurrence of many deposits of various types of so-called “waste sands” is plentiful in certain regions of Southern Africa and the possible use of such sands for asphalt surfacings instead of more expensive materials was therefore investigated.

DELIVERY: An evaluation of the performance of existing sand asphalt projects was undertaken. The engineering properties during both manufacture and construction were analysed and the influence of materials on the engineering properties of sand asphalt was studied in the laboratory. All research was then consolidated to form appropriate engineering standards for the use and expansion of sand asphalt as a cost-effective asphalt surfacings alternative to surface seals in low volume road works.

OUTPUT: Guidelines and recommendations were formulated on the design, manufacture and performance expectations of Sand Asphalt in possible target markets. Sabita Manual 18: *Appropriate Standards for the Use of Sand Asphalt* (1996) covers the mix ingredients of sand asphalt and looks at performance, applications and specifications. The manufacture and construction of sand asphalt are also considered with quality control and cost-effectiveness analysed. Two reports published.

IMPACT: Not determined.

PROJECT CONDUCTED BY: Hawkins, Hawkins & Osborne (A Laatz)

PROJECT NAME: ACCEPTANCE CRITERIA FOR THIN-LAYER ASPHALT (ACTLA)

AREST NO.: 2 (1990)

SUB-PROJECTS: Field study (1997) to evaluate the impact of changes in the mix design process on the characteristics of mixes paved on site in order to enable a revised framework of acceptance of thin-layer asphalt mixes with compacted thickness of between 15 and 25 mm to be established through the ACTLA Task Group.

PROJECT STATUS: Completed

GOALS: To investigate alternative ways by which thin-layer asphalt mixes are formulated, constructed and accepted by the road authorities.

NEED: Thin-layer asphalt mixes, defined as mixes with a compacted thickness not exceeding 30mm, are sometimes rejected by clients on the basis that the density requirements were not met. The use of cost-effective materials such as thin-layer asphalt mixes has, however, been identified as a possible way of meeting the challenge of providing road infrastructure and access streets to deprived rural and urban communities within budget constraints.

DELIVERY: To address this, the Bituminous Materials Liaison Committee appointed a task group whose functions were supported by the Sabita research project looking at the acceptance criteria for thin-layer asphalt.

OUTPUT: A report was produced in which current methods of specification and performance-related criteria applicable to thin-asphalt mixes were reviewed and aspects such as the design, quality control and performance of such mixes were addressed. Guidelines were drawn up which formulated alternative ways of specifying the quality of end products. One report published.

IMPACT: The road industry has been sensitised to the problems which are often associated with the formulation and compaction of thin-layer asphalt mixes. This, to a limited extent, is reflected in the revised draft CSRA Standard Specifications for Road and Bridge Works.

PROJECT CONDUCTED BY: CSIR Transportek (BMJA Verhaeghe)

PROJECT NAME: FUTURES RESEARCH INTO THE EFFECT OF A CHANGING SOUTH AFRICA ON THE ROADS INDUSTRY(FURES)

AREST NO.: 2 (1990)

SUB-PROJECTS:
Effect of road deterioration on the economy
Value of road provision, maintenance & use to petroleum companies
Commercial implications of the emerging market place for the bitumen industry

Investigation & critical analysis into capital budgeting decisions of government with particular emphasis on road building & surfaces Activity streets

PROJECT STATUS: Completed in 1995.

GOALS: To identify likely future political structures as they relate to financing of road and road improvement projects. To provide well researched, clearly stated information to assist industry in making prudent and responsible decisions regarding road financing, taxes, potential markets, and areas of influence.

NEED: As part of Sabita's second Asphalt Research Task Force mission to identify major issues and needs of the southern African community and of the asphalt industry in the sub-continent, and to tailor Sabita's research and development efforts to address these needs effectively futures research, notably in economics and political scenario building was undertaken.

DELIVERY: The following research was undertaken: An inquiry into South Africa's political and economic future as this will effect the Roads Industry; a cost benefit analysis of rural road projects; the value of road provision, maintenance and use to petroleum companies, roads as a catalyst for sustainable social and economic development and the emerging market place for the bituminous material industry.

OUTPUT: The results of the project have been published and circulated to members. A seminar was held on 9 June 1992 to present the findings to members with selective release of the results since then. A VIP release of the findings was postponed. 8 Reports published.

IMPACT: The findings have provided Sabita members with a view of the changing South and southern Africa offering suggestions for courses of action and

possible avenues to follow. The major direction shifts have been integrated into the revised strategic plan of the association.

PROJECT CONDUCTED BY: Institute for Transport Technology (Stellenbosch University), Corporate Image & special consultants, TRC Africa (Pty Ltd), Transportek: CSIR, School of Economics (University of Cape Town)

PROJECT NAME: HEALTH, SAFETY & ENVIRONMENT (HSE)

AREST NO.: 2 (1990)

SUB-PROJECTS: Environmental impacts of bitumen & tar products
Environmental impacts of bitumen & tar products - legal aspects

PROJECT STATUS: Complete 1995.

GOALS: To pro-actively address the health, safety and environmental impacts associated with bitumen and coal tar products and provide guidelines to the industry.

NEED: Sabita in recognition of rapidly developing international and local safety, health and environmental legislation and awareness decided in 1993 to address all such issues affecting its members and the industry.

DELIVERY: On the initiative of the Health, Safety and Environment Subcommittee of Sabita a guideline document was produced. The document alerts producers and users to the potential health, safety and environmental

implications associated with bitumen and coal tar products. Comment is also made on the relevant legislation affecting the industry.

OUTPUT: Sabita's *Health, Safety and Environmental Guidelines - Bitumen and Coal Tar Products* (1995) presents guidelines which are proposed to be voluntarily accepted by the industry but are also useful to legislators and the authorities. Three reports published.

IMPACT: Sabita obtained agreement in the industry about conformance with worldwide standards in health, safety and the environment. Sabita is participating in the process, guided by the Department of Manpower, to implement reasonable "norms" to apply in future.

PROJECT CONDUCTED BY : Ninham Shand Inc., Syfret Godlonton-Fuller Moore Inc.

PROJECT NAME: LABOUR ENHANCED CONSTRUCTION (LEC)

AREST NO.: 2 (1990)

SUB-PROJECTS:
Training material for emerging contractors
Training of emerging contractors
Local government training in road management & benefits

PROJECT STATUS: Completed.

GOALS: To develop principles for labour enhanced construction of bituminous surfacings within the existing standards of quality, the existing contractor

system and by using existing plant and equipment for critical surfacing components. To provide manuals and training material in support of labour enhanced construction.

NEED: The creation of employment opportunities and development of entrepreneurial skills to satisfy the material aspirations of the burgeoning population of South Africa is of paramount importance. The construction industry is thus challenged to create and adapt construction activities in such a way as to provide some of these employment and entrepreneurial opportunities within this industry.

DELIVERY: Research was undertaken on the form and content of publications to assist emerging contractors and developing communities in benefiting from the bituminous product industry in South Africa. This enabled Sabita to refocus its manual and video productions to accommodate these new needs. Manuals and a video were produced to assist practitioners in applying labour enhanced construction and to train instructors in the appropriate methods.

OUTPUT: Sabita's manual 11: *Labour enhanced construction for bituminous surfacings* (March 1993) gives recommendations on bituminous surfacings suitable for labour enhanced construction, and also guides and advises the first-time practitioner in the technical and social aspects. The companion manual 12 (March 1993) presents methods and procedures for labour enhanced construction of bituminous surfacings to provide guidelines for the appropriate techniques. Manual 12 is intended to be used by the supervisors for training of construction workers and is also applicable to the client bodies, contractors and consultants. It can also be included in the contract document as a method specification. This is supported by the Sabita video series on black-top rods for reconstruction and development, which highlights the advantages offered in the use of black-top roads in social upliftment and development. An instructor training module was also produced which focuses on the actual

construction and training of people to provide black-top roads to the community. Seven reports published.

IMPACT: Labour enhanced construction methods for bituminous products have been prepared in terms of the expectations of participating in the Government's reconstruction and development programme. It is expected to generate a demand for some 75 000t over the next five years.

PROJECT CONDUCTED BY: Sabita and various consultants

PROJECT NAME: PRODUCT PERFORMANCE GUARANTEE SYSTEM FOR SA - PHASE 1 (PPGS)

AREST NO.: 2 (1990)

SUB-PROJECTS: Implementation of PPGS

PROJECT STATUS: Project completed in 1994

GOALS: To investigate the feasibility of introducing new contractual arrangements based on the quality and performance of products originating from the road construction industry. The development of a new quality management system which would see contractors certifying their products and production processes and eventually also carrying and sharing the responsibility for the performance of the product over an agreed guarantee period.

NEED: A quality road network is essential as it provides the means for growth in a country by supplying efficient access to all sectors of the economy.

Currently an end product control system is used in road construction to ensure that the required level of quality is attained. There is, however, no guarantee that the final product will perform as anticipated, it is costly to operate, does not necessarily ensure quality workmanship and sometimes results in the acceptance of sub-standard end products. The South African asphalt industry foresaw the need for a new quality management system.

DELIVERY: The basic principles of quality management were established to act as a foundation for the project and developments in Europe were investigated to determine their applicability in South Africa. Sabita also promoted the concept through publications and at the Bituminous Materials Liaison Committee (BMLC). On the initiatives of Sabita, the BMLC appointed a task group to address the need for a new quality system. The framework for the proposed system and the provisional evolutionary process up to the implementation of the system were addressed.

PROCESS: At the BMLC meeting of November 1993, a PPGS task group was formed. The task group drafted the framework for PPGS, supported by the outputs of a special study tour. At the 6th Conference on Asphalt Pavements for Southern Africa (CAPSA) in 1994, a special PPGS workshop was held and CAPSA '94 produced a resolution supporting PPGS. The task group refined the PPGS framework, but also concluded that progress would be quicker through a number of demonstration or pilot projects. Thin-layer asphalt overlays were considered to be most suitable for pilot implementation of PPGS and a PPGS-ACTLA task group was formed (ACTLA stands for Acceptance Criteria for Thin-Layer Asphalt). The experience gained through pilot projects has been captured and been used to modify the concept. Having gained experience from the pilot projects, a BMLC PPGS Task Group and various working groups were formed in 1997. The objective of the task group is to consider and recommend appropriate product performance guarantee systems. A series of seminars was held in July 1997 to market the concepts of PPGS to the road industry. The concept of PPGS was also presented at the 8th

International Conference on Asphalt Pavements in Seattle in August 1997. It was found that the PPGS drive is in line with international developments. Seven reports published.

IMPACT: Two projects conducted in accordance with PPGS principles are currently being monitored. Additional projects are being planned. The Product Performance Guarantee System not only promotes innovation but also encourages the adoption of quality assurance principles in contractor organisations. While proper technology management through product certification would encourage and facilitate the introduction of new quality products onto the market, quality systems supported by product performance guarantees would ensure that the processes employed by contractors would be directed towards providing quality products on the actual road.

It is believed that the move towards a PPGS is of great advantage to all communities as competition would not only be quality driven, which would be conducive to the delivery of durable, cost effective pavements, but would also be ideally suited to cases where the design, administration and inspection capabilities of the client are inadequate for a project.

PROJECT NAME: ECONOMICS OF SHORT TERM REHABILITATION MEASURES (REACT)

AREST NO.: 2 (1990)

SUB-PROJECTS: Preparation of REACT software

PROJECT

STATUS: Completed in 1993.

GOALS: To identify and allow the true economic costs of "hou aksies" or holding actions to be determined. By being able to accurately assess short term rehabilitation options versus reseals and full rehabilitation, specifying authorities are less likely to undertake uneconomical options. This should benefit the reseal and hot-mix overlay components of industry as the marginally longer investment period will be able to be included in an economic assessment which takes road user benefits into account.

NEED: With the current shortage of funds, road authorities are increasingly making use of short term rehabilitation actions (alias “holding actions”) to protect the integrity of roads. The program (REACT) was thus developed to assist in the selection and economic appraisal of short term actions for surfaced roads which require rehabilitation.

DELIVERY: The program REACT allows for the assessment of the cost consequences of the postponement of the rehabilitation of a road. Various short term rehabilitation actions (holding actions), a do-nothing action and long term rehabilitation actions can be compared in terms of construction costs, road user costs or total costs over an analysis period of up to 40 years. The program also allows for a road to be divided into any number of sub-sections each requiring a different type of rehabilitation.

OUTPUT: Sabita’s Manual 16: *REACT Economic analysis of short-term rehabilitation measures* (October 1994) assists the user in comparing the expected life-cycle costs of various appropriate pavement rehabilitation options and strategies at a project level. Two reports published.

IMPACT: Not determined.

PROJECT CONDUCTED BY: ACE (GJ Jordaan).

PROJECT NAME: STRATEGIC INFORMATION SYSTEM (SIS)

AREST NO.: 2 (1990)

SUB-PROJECTS: None.

PROJECT STATUS: Completed 1995

GOALS: To develop a strategic information system for easy use and access by Sabita members to suit their purposes.

NEED: In 1991, Sabita members identified a need to develop and maintain a Strategic Information System (SIS) containing data of relevance to the members.

DELIVERY: A survey of Sabita member's requirements for a Strategic Information System was undertaken in 1993. This established a data needs profile and an appropriate database was identified in which to develop the SIS. It was decided to develop the database in phases, initially concentrating on South Africa and more specifically on national (provincial) level and incorporating data that were readily available. This database will in future be expanded to contain data relevant to the "new" provinces, greater municipal areas, developing areas and relevant identified countries.

OUTPUT: The Sabita SIS was developed to be installed on the personal computers of approved Sabita users. A Strategic Information System Computer User

Manual (Version 1) was produced in October 1995 containing the basic instructions for the installation and operation of the Sabita SIS. Data can be exported to spreadsheets for easy manipulation. Five reports published.

IMPACT: Not determined.

PROJECT NAME: SOCIAL DEVELOPMENT NEEDS RELATED TO ROADS & ROAD TRANSPORT
(SOCDEV)

AREST NO.: 2 (1990)

SUB-PROJECTS: None

PROJECT STATUS: Completed 1993.

GOALS: To identify social development and economic issues related to road transport which can be used to strengthen the demand for roads and to quantify potential markets for Sabita members' products as part of the social upliftment scheme.

NEED: Sabita identified the need to research social development issues and their relationship to road transport to assist the bitumen industry in remaining relevant, pro-active and viable within the then “new” South Africa, and within the rapidly changing business environment.

DELIVERY: The project commenced in 1991. A literature survey of issues affecting the need for roads was correlated with a nationwide study of south

African attitudes towards the benefits of roads and the value of mobility in social upliftment. The results were accepted and future course of the research project directed by a Forum consisting of key players in the development area, emerging business and civic leaders, transport authorities and the researchers. The next phase of the project included an overall assessment of the needs for road construction and maintenance in the poorer areas, the economic viability for upgrading and a pilot study to endorse the findings within the affected community. This phase is expected to report its findings in March 1993.

OUTPUT: The project has provided Sabita with an excellent opportunity to access and influence emerging decision makers in the transport and road infrastructure field, The need for easy access to the bituminous product industry and the opportunity for larger markets in labour enhanced construction or small surfacing contractor development has been highlighted by the forums. Thirteen reports published.

IMPACT: There was found to be 220 000 kms of “uncharted” roads, serving disadvantaged communities. These are intrinsic to research and development objectives and represent a potential for 144 000t of bitumen over the next seven years.

PROJECT CONDUCTED BY: CSIR Transportek, Miller, Servas & Associates and Transport Research Consultants

PROJECT NAME: IMPROVED DESIGN METHODS FOR HMA (HMA)

AREST NO.: 3

SUB-PROJECTS: Refinement of LAMBs design method

Volumetric design method (Phase 1)

PROJECT STATUS:

Volumetric design method (Phase 1): Completed 1995

Refinement of LAMBs design method: Completed 1997

Development of a new HMA design method: Initiated: October 1997

GOALS: To produce and implement a new South African hot-mix asphalt design method which will be integrated with pavement design, construction and performance.

NEED: Asphalt mix design often based on empirical approaches, with little consideration given to the required properties of the mix in order to form an integrated part of the pavement structure, can lead to several shortcomings. A new approach was deemed necessary by the road industry.

DELIVERY: With regard to volumetric design, a review of the current status of asphalt mix design on a volumetric basis with recommendations for future work.

With regard to the revised LAMBs design method, the establishment of guidelines, based on a state-of-the-art review which presented a summarised synthesis of the review discussed and debated by the research team, with inputs from the industry. A brief evaluation of LAMBS in use (to allow for implementation of the findings quickly) and the identification of other important issues for further research.

OUTPUT: A synthesis document on volumetric design of which recommendations were disseminated at the BMLC (1995) and incorporated in a seminar on “Spatial Approach”. A revised manual on the design of LAMBs.

IMPACT: A greater awareness on the importance of volumetric criteria as part of the mix design process. The results of the study on volumetric design let to the introduction of gyratory testers in South Africa. These devices were used in the monitoring of LAMBs mixes placed on the N2, north of Durban. Based on the experience gained from the N2-LAMBS contracts, a firm basis was established which let to the revision of Sabita Manual 13 on LAMBs.

PROJECT CONDUCTED BY: CSIR Transportek, VKE, UP

APPENDIX K: SUMMARY OF RMC TECHNOLOGY FOCUS AREAS AND PROJECT IDEAS

ASPHALT MIX DESIGN

- Suitable lab compaction for asphalt mixes
- Lab blending of bitumen rubber binders
- Mix designs for cold mixed asphalt
- Design and performance of micro surfacings with emulsion
- Film thickness
- New Hot Mix Asphalt (HMA) design method
- Recycling

BITUMINOUS BINDERS

- Bitumen binders : compositional balance, shear, specifications, pre-coating
- Specifications for winter grade binders

CHEMICAL STABILISATION

- Design of foamed bitumen mixes
- Improved GEMS (Granular Emulsion Mixes) mix design
- Chemical reactions in lime stabilisation
- Structural classification
- Soil stabilisers and dust palliatives

MANAGEMENT SYSTEMS

- Frequency of surveillance measurements
- VOC costs models and updating data HDM IV
- Model for predicting rehabilitation measures
- Calibration of surveillance equipment
- Slope stability management system
- Skid resistance criteria
- Evaluation of block pavements

QUALITY CONTROL

- Testing frequency
- Lab management system and framework
- Reference lab (Precision limits)
- Interpretation of test results

LONG TERM PAVEMENT PERFORMANCE (LTPP)

- Pavement performance database
- Data analysis
- LTPP section selection, monitoring and experimental design

PPGS

- Quality Assurance
- Specifications for acceptance criteria

DETERIORATION MODELS (PERFORMANCE)

- Development of and calibration of deterioration models

GRANULAR MATERIALS DESIGN

- Breakdown characteristics during construction (lab method)
- Influence of PI on performance of granular base
- Mechanical stabilisation of G2, G3 base materials
- Preparation of large aggregate granular material samples
- Aggregate shape and shear strength

ENVIRONMENTAL ISSUES

- Use of waste materials in pavements
- Selection of borrow pits
- Porous asphalt
- Noise attenuation

PAVEMENT DESIGN

- Catalogue of designs : Transfer functions into TRH4

- Expert system for rehabilitation design
- Fatigue curves : LAMBS, GEMS, Asphalt surfacings; Pen Mac, modified binders
- Transfer functions : SHEAR, WB, G1, gravels
- Transfer functions for asphalt deformation base and surfacing
- Tyre contact pressure and pavement design
- Validate design models
- Back- and forward calculations
- Design of thin layers of concrete and asphalt
- Use of the K-Mould to determine engineering properties of materials
- Link materials design with structural design

MATERIAL COMPONENT TESTING

- PSV specifications

CONSTRUCTION TECHNIQUES & MAINTENANCE

- Innovative techniques for provision and upgrading community roads
- Synthesis of drainage practice (implementation)
- Concrete patching materials
- Patching materials for flexible pavements
- Fast setting concrete for patching
- Labour Intensive Construction Techniques

ACCELERATED PAVEMENT TESTING (APT)

- Influence of environmental effects on APT results
- Scaled down APT testing

APPENDIX L: DOMINANT ISSUES, FUTURE CHALLENGES AND KNOWLEDGE GAPS IDENTIFIED BY THE TRANSPORTEK ADVISORY COMMITTEES

L1 ROAD INFRASTRUCTURE

Classification of Focus Areas and/or Research Needs Identified

Focus Areas and/or needs identified by PRAC	Sub-theme	Main Theme
A: Current Technological Challenges		
Capacity building (industry, research, education, etc): Room for people growth	Human Capital	Resources
Labour-intensive construction: guidelines, methods, review and monitoring	Construction & Maintenance	Infrastructure Delivery
Funding (infrastructure, maintenance, research, etc): prioritisation of expenditure	Construction & Maintenance	Infrastructure Delivery
	Contracting Systems for Construction & Maintenance	Infrastructure Delivery
	Funding & Transport Economics	Policy, Economics & Decision Support
Asset management (roads, structures, furniture, etc): integration and key performance indicators	Management of Assets	Infrastructure Engineering
	Road Furniture & Structures	Infrastructure Engineering
	Performance Measures	Policy, Economics & Decision Support
Land use planning: integration with	Land Use & Infrastructure	Planning &

infrastructure development	Planning	Operations
Public & political awareness and communication: ability to sell road grids/networks and impact assessment	Land Use & Infrastructure Planning	Planning & Operations
	Construction & Maintenance	Infrastructure Delivery
• Quality: design guidelines & national standards; • Design and national standards and guidelines (archaic, not suitable, etc) • Knowledge management • Information technology	Management of Knowledge & Information	Resources
	Bound & Unbound Pavement Materials	Infrastructure Engineering
	Geometric & Structural Design of Roads	Infrastructure Engineering
Infrastructure development and maintenance: technical aspects	Construction & Maintenance	Infrastructure Delivery
Efficient/effective delivery: owners, industry & providers	Construction & Maintenance	Infrastructure Delivery
	Contracting Systems for Construction & Maintenance	Infrastructure Delivery
Health, Safety & Environment	Safety of Road Workers	Infrastructure Delivery
	Environmental Impact of Roads	Environment
	Preservation of Natural Resources	Environment
Technological innovation: problem solving and trouble shooting	Bound & Unbound Pavement Materials	Infrastructure Engineering
	Geometric & Structural Design of Roads	Infrastructure Engineering
Infrastructure users: congestion, safety, user costs, inventory, overloading and other misuses, impact of ITS	Management of Assets	Infrastructure Engineering

	Accessibility & Mobility	Planning & Operations
	Road User Information Systems	Planning & Operations
Infrastructure planning: identification of needs and supply of options	Land Use & Infrastructure Planning	Planning & Operations
Accessibility and mobility: rural access and gravel versus surfaced	Accessibility & Mobility	Planning & Operations
	Bound & Unbound Pavement Materials	Infrastructure Engineering
Infrastructure economics: road pricing and impact of overloading	Funding & Transport Economics	Policy, Economics & Decision Support
	Management of Assets	Infrastructure Engineering
Loading patterns: heavy vehicle configurations, bridge formula, ITS, overloading, legislation	Traffic & Operational Environment	Infrastructure Engineering
	Road Furniture & Structures	Infrastructure Engineering
	Management of Assets	Infrastructure Engineering

6

Materials: optimisation of scarce resources, sustainable resources, alternative materials, combination of materials, recycling, characterisation and uniformity	Bound & Unbound Pavement Materials	Infrastructure Engineering
	Preservation of Natural Resources	Environment
Maintenance: methods, materials, quality, cost and uniformity	Construction & Maintenance	Infrastructure Delivery
	Bound & Unbound Pavement Materials	Infrastructure Engineering
Inter-modal planning (rail, roads, harbours, airports)	Land Use & Infrastructure Planning	Planning & Operations
Construction methods and constructability: methods, technologies, quality, materials & constructability, enterprise development and supervision	Construction & Maintenance	Infrastructure Delivery
Institutional issues: procurement	Contracting Systems for Construction & Maintenance	Infrastructure Delivery
Information technology (including systems)	Road User Information Systems	Planning & Operations
Impact of global change	Funding & Transport Economics	Policy, Economics & Decision Support
	Performance Measures	Policy, Economics & Decision Support
Tourism and events	Land Use & Infrastructure Planning	Planning & Operations
Freight transport: loads accreditation and legislation	Management of Assets	Infrastructure Engineering

B. Future Technological Challenges (5 – 10 years' horizon)		
Sustainability of road infrastructure	Funding & Transport Economics	Policy, Economics & Decision Support
	Bound & Unbound Pavement Materials	Infrastructure Engineering
	Geometric & Structural Design of Roads	Infrastructure Engineering
	Construction & Maintenance	Infrastructure Delivery
	Land Use & Infrastructure Planning	Planning & Operations
	Accessibility & Mobility	Planning & Operations
	Environmental Impact of Roads	Environment
	Preservation of Natural Resources	Environment
Heavier loads	Traffic & Operational Environment	Infrastructure Engineering
	Road Furniture & Structures	Infrastructure Engineering
	Management of Assets	Infrastructure Engineering
Maintenance and construction under traffic: rapid construction	Bound & Unbound Pavement Materials	Infrastructure Engineering
	Construction & Maintenance	Infrastructure Delivery
Perpetual pavements	Bound & Unbound Pavement Materials	Infrastructure Engineering
	Geometric & Structural Design of Roads	Infrastructure Engineering
Environment: energy and noise	Bound & Unbound Pavement Materials	Infrastructure Engineering
	Environmental Impact of Roads	Environment

Preservation of Natural Resources	Environment	
Innovative funding	Funding & Transport Economics	Policy, Economics & Decision Support
	Contracting Systems for Construction & Maintenance	Infrastructure Delivery
Innovative pavement materials and pavement designs	Bound & Unbound Pavement Materials	Infrastructure Engineering
	Geometric & Structural Design of Roads	Infrastructure Engineering
Urbanisation	Land Use & Infrastructure Planning	Planning & Operations
	Accessibility & Mobility	Planning & Operations
ITS	Road User Information Systems	Planning & Operations

L.2 INTELLIGENT TRANSPORT SYSTEMS

L.2.1 Major issues

Standards/Architecture
Interoperability
Interface standards
EVI standards
Official ITS Architecture
Communications constraints

HR
ITS career development
HR development
Skills shortage in traffic engineering

Funding
Predictable funding streams

ITS public funding

Specific Problems
Vehicle roadworthiness
Cost effective communications
Flow speed control
Overcome rubber necking
Traffic lights out of order
ITS and Freight
Vehicle crime
Incident management
Congestion management

Policy and governance
ITS focus in government
ITS policies
Lack of coordination and clear direction
ITS exports
Modal integration
Trade off security vs Crime protection systems

Information and data
Route info (e.g. construction)
Information access

Legislation
EVI – importance of electronic licensing
Communication legislation and implications on ITS viability

Impact
Evaluation business case
Determination of business case of ITS applications
Impact of ITS on quality of life
Relevance of ITS to national imperatives
Road deaths – economic impact

Leadership management
Position ITS in progressive agendas
Leadership in ITS
What R&D is in SA universities doing ITS
Level of innovation/research required in SA
Strategic importance of ITS
How to accelerate ITS applications
Cross functional utility of ITS leads to managerial negligence.

L.2.2 Future challenges

Implementation
Innovative application of existing technologies for Africa
Adopt 1st world systems for developing countries

Systems/ Architecture
Interoperability
Migration of systems technology

Specific problems
2010 World cup
Open road tolling
WC 2010 / improved transport technologies
Increased road congestion – need clever solutions
Reduced pedestrian death
Traffic flow management
Maintenance – equipment
Technical: Comms 2way between vehicles over wide area
Increased congestion
ITS systems support

Leadership/Strategy management
Trade-off meeting social

Learning for national interest needs vs technical need
Keeping up with change

Policy / governance
Privacy
Compulsory roadworthy testing
Vitalising taxi transformation
Inclusiveness of ITS industry

Information/data
Information management and ownership
Detailed data/info generation
Information crime

Technical solutions
Increase vehicle occupancy rate
EVI could be used for ramp metering
EVI could be used as traffic flow metering
Telematic services to be implemented

Impact
Cost – ITS is expensive
Political attractiveness
Political attractiveness vs cost benefit
Info on good public transport relieves road transport needs
EVI tags will increase economic benefits
Growing local export industry
EVI tags will generate all R100m lost license fees

Implementation
Innovative application of sensing technologies in SA context

Socio economic
Problem of increasing gap between vehicle ownership and income

Hi-tech vehicles on the road together with old vehicles (safety)
Vandalism
ITS for the poor

Organisational
Road safety – who's responsibility
Lobbying to politicians for ITS
The understanding of treasury or government bodies
Inter-provincial and national government cooperation
SASITS

HR
Appropriate application of scarce resources
Critical mass for TMC's

L.2.3 Knowledge gaps

Standards/Architecture
National ITS framework / architecture
Industry using technology that is not operable
Automated public/private transport vehicles/systems
The next generation faster transport system

Crime prevention
Save effective vehicle immobilisation by police
How to eradicate vehicle theft & hijacking
Tracking / monitoring technologies
ITE/Crime combat technologies

Base technologies
Video analysis technology
Optical electronic interface
Innovative communications

Software defined radio
Image recognition

Organisational
SA Centre of excellence in ITS

HR
HR with ITS knowledge
ITS training at university
Lack of tertiary education

Strategy Leadership Management
Lack of freight projects that use ITS
Planning for ITS
Government coordinated and or leadership role
How to convince NDoT to take technology and leadership role
Not enough funding for R&D

Socio/economic
Response prediction

Implementation
Localisation of ITS technology (Ruggedised/ temp , etc)
Integrated ITS systems

Evaluation/impact assessment
Learn from mistakes & successes RSA and World

L.3 PASSENGER TRANSPORT

G.3.1 Major problems/issues currently facing the industry

Theme	Issues raised
Skills Knowledge	Poor capacity building for both officials and politicians.

Theme	Issues raised
	Need to build capacity
	Dwindling expertise in transport authority arena
	Low HR capacity in industry
	Lack of staff capacity
Funding	Unfunded mandates
	Lack of funding
	In Survival mode
	Affordability of being part of the urban system
	Funding and Funding Strategies
Institutions /Governance	Lack of institutional tolerance and cooperation
	Poor Consultative Mechanisms between Government and other relevant Stakeholders
	No common transport Strategy
	Lack of Common National Vision
	Constant Transformation and Restructuring
	A lack of political will to implement/ enforce (Traffic Behaviours, Land Use). Commitment Continuity.
	Preference to "Back – to- Basics" Mode
	Low levels of capacity to implement
	Lack of National Commitment to Supporting National Transport Policy
	Uncoordinated research effort
	Emphasis on social scenario
	Lack of Leadership - Political will
	Strong short term focus
	Transport planning became "routine" (Statutory)
	Buzz word/Strategies as vision, waiting for what cannot materialise
	Understanding how decisions around transport are made, and how to improve that process.
Planning/Methodology	Insufficient data and 'tools' to support planning
	A real lack of understanding the process/mechanism in private land use decisions, trip making and public interventions
	Integration of land use and transport mostly at strategic level and not on execution level.
	Lack of long term Interventionist and long term public transport plans
Why is public transport important	Understanding and application of transport development areas
	Poor prioritization mechanisms for Transport
	Understanding role of passenger transport in social

Theme	Issues raised
	development (e.g. poverty).
	Limited understanding of Transport ‘s role in society
	Role of transport in development not well positioned
Legislation	Changing legislation and policies
Communication	Technical arrogance with regards to political decision making
	Making communicating linkages between transport and higher level government goals.
	Lack of trust between Politicians and Transport Planning Fraternity
	Destructive competitions

L.3.2 Future challenges (5 – 10 years)

Theme	Issues raised
Methodology /Planning	Densification?
	Development supportive of public transport corridors
	Spatial, socio demographic & economic trends
	Scarcity of land for housing development
	Modal integration
Institutional & governance	Finalizing on taxi formalization
	Devolution of functions
	"Import" of inappropriate to solutions to speed up delivery
	Extensive implementation of public transport plans
	End to re-structuring
	More ad hoc public intervention
	Role of private sector in transport provision
	Institutional reform due to "Poor Performance"
	Job creation
Funding	Public transport subsidy
	A lack of public funding
	Committed investment to 5 year transport plans through Medium Term Expenditure Framework.
Environmental	Environmental lobby
	Environmental degradation, air pollution
Legislation	Enforcement of restructured transport system legislation
Mobility	Increasing difficulty in movement for all, but more so for the urban poor
	Lack of parking space
	Encourage usage of non-motorized transport
	Increased private and public transport congestion
	Growing immobility, congestion and bad public transport
	Increasing congestion
	Growth in and use of private vehicles
Soccer World Cup 2010	The misleading notion that the 2010 World Cup is a real issue (An opportunity to get funds, yes: A problem no.)
	State of preparedness 2010 World Soccer Bid
Social Issues	HIV/AIDS increasing
	Population growth (exploding)
	Unemployment
	Safety and Security

Theme	Issues raised
	Social exclusion.
Infrastructure	Ageing rolling stock and transport infrastructure
	Reviving rail as backbone
Skills	Exchange Public Transport skills in Authorities agencies.
	Skills mobility
Transport promotion	Reconciling Economic Rationale with Political Rationalisation.
	Promoting Public Transport over Private Transport
	Transport as basic need
	International competition
Implementation	Effect Implementation

L.3.3 Knowledge and competence gaps

Theme	Issues raised
Type1 / 2 Knowledge generation	General theory of transport
	Understanding of the mechanisms that produce decisions/behaviour with regards to Trip making, Public and Private interventions
	Understanding process and needs of decisions makers
	Model of enforcement strategy
Type 2 / 3 Tools for problems solving	Travel behaviour modification strategy
	Competency – Credible land use/ transport strategy model based on basic research
	From basic and applied research, translate proposals into expected results for decision makers
	Lack of practical and simple planning tools for South Africa and Region
	Analysis tools for social impacts / equity issues of transport projects
Skills and training	Technology development versus importation
	Skill retrenchment versus transformation
	Lowering standards versus accelerating skills development
	Arrest brain drain

Theme	Issues raised
	Lack of quantitative and analytical skills
	Skill development
	Empowerment
	“Best Practice” for African developing countries
	Poor knowledge and information sharing
Information and data	Expensive technology and data!
	Well structured and maintained data bases
Process	How to influence private sector to do what we want
	Lead in research versus lag in application
	Credibility and transparency of research
	Mismatch between public authority and research/private sector
Communications	Role of transport to decision makers in relevant language
	Inform people of the implications of Transport interventions (in support of Public Interventions) (based on basic and applied research
Techniques and management systems (not that transport specific)	Sustain & Maintain
	Asset Management
	Project Management
	Transport Economics /Engineering skills
	Financial Management
Funding mechanisms	Funding Mechanism
Policy and Strategy development	Policy Strategy Development

L.4 TRAFFIC MANAGEMENT AND SAFETY

IMMEDIATE NEEDS/PROBLEMS

Funding

research impact fencing & ped bridges
funding for safety programmes/initiatives
dedicated resources at local level (finance, HR, equipment)
funding for safety
local gov access to national/prov funding
sponsorship FOR Siyabonana (Drama)
funding & improvement

Research Road-user Behaviour

road safety education at schools
co-ordinated road safety education programmes at schools

Pedestrian & animals on freeways
child safety pedestrians/occupants/cyclist
product development links to TRAC
road safety education materials, programmes, research

Legislation

FUTURE CHALLENGES

transport

integrated transport system - accessibility, safety
adequate infrastructure

decent public transport
public transport system accessibility
reliable public passenger transport system
land use partners

organisation

leadership
maintaining momentum (institutional, focus)

CSIR Transportek support to RTMC

co-ordinate road safety efforts
root out corruption or bribes

funding

easy access to funding
maximisation of existing resources

TECHNOLOGICAL/RESEARCH NEEDS

Infrastructure/Roads

conditions of roads in rural areas related to road safety
road signage nationally
pedestrian crossing adjacent to public buildings and schools
needs assessment for expanding informal settlement
sound signals at pedestrian crossing
more pedestrian bridges

Roads Users

Effect of HIV/AIDS on transport and road safety
community safety projects- develop best practice model

incorporate road safety into curriculum
develop material to enable teachers to implement integrated road safety education syllabus

Organisation

cost-effective KPIs
prioritising - best return on investment

driver training standards
legislation for child car seats needs to be revisited
Legislation to incorporate reflective materials in school uniforms

Law Enforcement
capacity
manpower deployment for Traf Officers
law enf capacity
visible policing

development for traffic law enforcement
one uniform traffic officers force - fragmentation
co-ordination

Acc Stats
accidents
statistics
reporting - poor/underreporting
improvement in account reporting
crash stats should incl injury figures

up to date crash stats required
effective measures of risk to be identified

Traffic Officers

well trained and motivated traffic officer
retraining of the TOs

Socio-economic issues
population growth - road safety
social economic issues - road safety
dealing with illiteracy

increased mobility level
effect of HIV/AIDS on road safety

Road user
reflectorised pedestrians
pedestrian education are we winning?
responsible road users

data
data collection system

GIS- based on site accident reporting

Vehicles

Data information systems
Accident Data

improve ITS/information system
real -time traffic info
GIS system to quantify accident risk
road traffic info
accurate and simple accident info capturing system

Drivers
a standardised uniform driver education & training model (incl test - schools)
formalisation of driver training industry
computerised driving tests
driver licensing technology
driving experience for heavy vehicle drivers

evaluations/monitor
effective evaluation methodologies

EMS
Availability of emergency medical assistance response times
emergency service response time

related co-operation

co-op between local, prov, nation gov dept

co-ordination of road safety issues

co-op with the DOT

uniformity

management /organisations

land use model to reduce accident exposure

organisation to operate

quality of mobility/vehicles

vehicle safety features

Law Enf

traffic officer training programmes

traffic law enforcement development technology

uniform of enforcement system

L.5 TRANSPORT POLICY, DECISION SUPPORT AND RURAL TRANSPORT PLANNING

L.5.1 Major issues

- Social upliftment
- Policy coordination
- Communication
- CSIR/Government relationship
- Linking transport planning and integrated planning
- Human resource development (learnerships, capacity building in government)
- Funding sources and opportunities
- Urbanisation and urban poverty
- Infrastructure maintenance
- Law enforcement

L.5.2 Future challenges

- Rural logistics
- Infrastructure maintenance decision system
- CSIR's role with Government and Africa
- New vehicles (omni-bus)
- Social issues (e.g. traffic safety)
- Developing DSS tools
- Impact assessment of research
- Human resource development
- Policy co-ordination
- Funding
- Mega trends – sustainable cities, urbanisation, sprawl etc
- Interventions, implementation and pilot studies

L.5.3 Knowledge gaps

- Gender and transport

- Research into better vehicles
- Low cost maintenance solutions
- Innovative funding sources
- Technology transfer and capacity building
- Monitoring and evaluation (bus subsidy system, implementation, spending etc)
- Impact analysis (quantitative & qualitative economic impact, employment creation)
- Public participation methods
- Tools for policy trade-offs
- Strategy and policy – integrated, innovative transport and land use planning

APPENDIX M: DESCRIPTION OF ELEMENTS IN THE CSIR TRANSPORTEK TECHNOLOGY TREES

M.1 DESCRIPTION OF THE PAVEMENT STRUCTURAL DESIGN METHODS PLATFORM

Traffic loading analysis

Technologies for measuring and analysing traffic loading including axle loads, tyre contact pressures, vehicle speeds and dynamic loading characteristics.

Tyre contact stress

Equipment and procedures for measuring tyre contact stress of traffic in motion.

Axle loading

Equipment and systems for measuring and analysing traffic axle loads - both static and in motion.

Overloading

Systems and technologies for determining an managing overloading of heavy trucks.

Traffic characterisation

Procedures for classification of traffic as input into design systems.

Vehicle dynamics

Understanding of aspects of the dynamic behaviour of axle loads in order to conduct the above more accurately.

Environmental analysis

Analysis of environmental factors such as temperature, moisture and gradient in order to determine its influence on the behaviour of materials and structural parameters.

Temperature requirements

Temperature regimes and effects of temperature as input into design systems.

Moisture

Temperature regimes and effects of temperature as input into design systems.

Geology and subgrades

The effect of geology (*e.g.* materials availability) and subgrade conditions on the design of roads.

Environmental impact

Consideration of the impact of road building on the environment ("green issue").

In-situ testing

The testing of materials and structures *in-situ* in order to enhance materials and structural design procedures and systems.

Analysis methods

Methods for the analysis of pavement structures.

Back-calculation

Methods for the calculation of material properties *e.g.* layer stiffness from *in-situ* measurements such as surface deflection.

Forward calculation

Methods for the calculation of structural design parameters such as stresses and strains from material properties.

Finite element analysis

Specific application of finite-element methods for the above.

Modelling techniques

Techniques for the modelling of pavement and material behaviour under traffic loading and environmental conditions.

Dynamic analysis

Analysis of the impact of vehicle dynamics on pavement behaviour, methods for simulating vehicle dynamics, incorporating dynamic analysis principles into pavement structural design.

Probabalistics

Use of probabalistics theory in pavement design.

Reliability

Use of reliability theory in pavement design.

Link to materials design

Techniques and parameters to link structural design interactively to materials design (see Platform).

Transfer functions

Models and formulae to transfer material parameters into structural parameters.

Materials characterisation and properties

Techniques, test methods and analysis methods for determining relevant engineering properties of materials to facilitate link to structural design.

Selection and decision support

Methods and data for the optimum selection of pavement types in support of design decisions.

Life cycle costing and economic analysis

The analysis of the cost of providing and maintaining typical pavement structures over its design period.

Selection criteria

Criteria for pavement type selection.

Optimisation procedures
Procedures for optimising pavement type selection.

Performance prediction
Methods, models and data for the prediction of pavement performance.

Data base analysis

Statistics

Modelling
Procedures and techniques for modelling pavement performance.

Transfer functions
Models and techniques for transferring pavement design parameters into pavement performance parameters.

M.2 DESCRIPTION OF THE LONG TERM PAVEMENT PERFORMANCE (LTPP) TECHNOLOGY PLATFORM

Destructive testing
In-situ test methods for material parameters and structural capacity that are destructive in nature.

Field instrumentation
Equipment, installation methods and measuring methods for *in-situ* testing of pavement structures.

Materials testing and analysis
Equipment and procedures for *in-situ* and laboratory testing of materials.

Non-destructive testing

In-situ test methods for material parameters and structural capacity that are non-destructive in nature.

Deflection measurements

Rut profile measurement

Laser technology

Visual assessment

Crack surveys

Riding quality measurement

Performance evaluation

Methods and procedures for the evaluation of the performance of pavements.

Functional performance

Methods and procedures for evaluation of the functional performance of pavements e.g. skid resistance and roughness.

Structural performance

Methods and procedures for evaluation of the structural performance of pavements e.g. shear resistance and layer stiffness

Performance modelling

Methods and procedures for the modelling of the performance of pavements.

Behavioural analysis

Techniques, procedures and data for analysing the behaviour of pavement structures and materials under traffic loading and environmental influences.

Data base systems

Deterioration modelling

Techniques and systems for modelling the deterioration of pavements under traffic loading and environmental influences.

M.3 DESCRIPTION OF THE ACCELERATED PAVEMENT TESTING PLATFORM

HVS operations

Procedures, methods and technologies for the operation of the Heavy Vehicle Simulator.

Mechanical maintenance

Programme scheduling

MDD installation

Equipment and procedures for the installation of Multi-Depth Deflectometers (MDDs) for the measurement of pavement layer deflections in-depth.

Equipment design

Technology for the design of innovative pavement response measurement equipment.

Equipment development

Environmental control

Control and measurement of the environmental factors *(e.g.* temperature, moisture) of the pavement test section.

Data analysis and interpretation

Equipment and methods for the measurement of pavement response characteristics, analysis techniques, data base management and calculation of pavements response trends.

Data collection

Equipment, procedures.

Data processing

Software and procedures for data validation and data processing.

Data base system

Data management.

Analysis procedures

Analysis of data, calculation of pavement response trends.

Graphic presentation

Dynamic loading simulation

Technologies, hardware and software to simulate the dynamic behaviour of moving traffic loads.

Vehicle dynamics

Measurement technologies, models and control systems for simulating dynamic loading.

Servo-hydraulic control

Servo-hydraulic systems for controlling traffic loading mechanisms.

Transfer function development

Methods and analysis techniques for developing transfer functions under accelerated trafficking with the HVS.

Pavement behaviour analysis

Analysis of pavement behaviour and deterioration under accelerated traffic.

Materials engineering properties

Determination of changes in materials engineering properties (behaviour) under accelerated traffic.

Probabilistics and reliability

Use of statistics, probabilistics and reliability theory in data analysis.

Deterioration modelling

Modelling of pavement deterioration under accelerated trafficking.

Pavement performance modelling

Calibration of pavement performance models.

Materials evaluation

Link to materials evaluation to provide input into APT results.

M.4 DESCRIPTION OF MATERIALS COMPONENT TESTING PLATFORM

Aggregate testing

Standard test methods

Special test methods

Geology

Chemistry

Binder test methods

Standard test methods

Chemistry
Chemical analysis of binders with emphasis on chemical balance.

HPLC/GC
High Pressure Liquid Chromatography and Gas Chromatography technologies to conduct chemical analysis of binders.

Rheometry
Methods and procedures for determining binder rheology *e.g.* viscosity.

Infra-red spectrometry
Method and procedure for determining type and quantity of modifier in binders.

LTP of binders
Methods for determining the Long Term Performance of binders.

Modified binder technology

Technology, procedures and criteria for sample preparation and handling of modified binders, special test methods for modified binders.

Soil testing

Standard and specialised testing of soils and gravels used in road building.

Standard test methods

DAI

Bonding test

XRD

X-ray defraction.

Dust palliatives

Special tests to determine compatibility of soils with dust palliatives.

Material location

Scanning electron microscopy

Stabilisation and modification

Tests to determine the compatibility of soils with stabilisers and the amount of stabiliser required.

Standard test methods

Toxicity testing

M.5 DESCRIPTION OF MODIFICATION AND STABILISATION TECHNOLOGY PLATFORM

Modified binders evaluation and design

Procedures for designing the modification of bituminous binders with polymers and rubbers.

Compatibility and interaction

Test methods and procedures to determine the compatibility of binders with modifiers

Selection methods

Procedures and methods for selecting optimum binder modification systems.

Standard binder technology

Performance testing

Special testing to evaluate the performance of modified binders.

Specification development

Emulsion modification

Interaction with aggregate and soils

Chemical reaction of cationic and anionic emulsions with aggregates and soils.

Emulsion stabilisation and modification

Technologies, procedures and test methods for modification of materials with emulsion.

Break time design

Design of the time to breaking of emulsion.

Strength gain evaluation

Procedures and test methods for the evaluation of the gain in strength of emulsion treated materials.

Chemical modification

Compaction aid technology

Technology for the evaluation of compaction aids.

Mechanical modification

Reinforcement

Mechanical reinforcement of soils.

Grading optimisation

Stabilisation through the mechanical modification of the aggregate grading.

Clay modification

Methods for the addition of clay to provide cohesion.

Dust palliation

Dust prediction models

Models for predicting dust on gravel roads by analysing gravel type.

LTPP

Interaction with soil and aggregate

Methods and procedures for evaluating the interaction between dust palliatives and soils.

Dust monitoring

Equipment and techniques for monitoring dust on gravel roads.

M.6 DESCRIPTION OF UNBOUND MATERIALS DESIGN PLATFORM

Volumetrics

Design of unbound materials based on volumetric properties.

Grading optimisation

Optimisation of the grading of granular materials through optimisation compatibility.

Prediction of engineering properties

Models and techniques for the prediction of material engineering properties based on volumetric measurements.

Compaction

Laboratory compaction methods

Development of and evaluation of laboratory compaction methods for sample preparation.

Field compaction prediction

Prediction of field compaction based on material properties and compaction effort.

Field compaction methods

Assessment of field compaction methods.

Engineering properties

Load sensitivity analysis

Procedures and test methods for the analysis of the effect of load on the engineering properties of granular materials.

Moisture sensitivity analysis

Procedures and test methods for the analysis of the effect of moisture on the engineering properties of granular materials.

Density measurement and prediction

Stiffness calculation and prediction

Shear measurement and prediction

Transfer functions

Transfer function development

Development of models and formulae to determine the *in-situ* engineering properties of granular materials based on laboratory test results.

Link to structural design

Interactive design processes: materials and structural design

LTPP

Link to long term pavement performance.

APT

Link to accelerated pavement testing.

M.7 DESCRIPTION OF THE PRODUCT QUALITY PLATFORM

Quality

Systems certification

Certification of quality systems.

Quality assurance systems

Product accreditation systems

Laboratory accreditation procedures

Field performance evaluation system

Systems for the evaluation of contractor performance.

Product certification process

Product Performance Guarantee Systems

Innovative systems for guarantee of products over their life time in order to share the risk between road authorities and contractors.

M.8 DESCRIPTION OF THE MAINTENANCE MATERIALS TECHNOLOGY PLATFORM

Environmental analysis

Analysis of the effect of environmental aspects on the performance of maintenance materials.

Traffic analysis

Topography

Climatic regimes

Pothole and trench repair

Methods and procedures for the repair of potholes, patches and trenches.

Cold mixed asphalt

Design methods for cold mixed asphalt.

Hot mixed asphalt

Procedures and specifications for the use of hot mixed asphalt in pothole repair, patching and trench repair.

Band aid strips

Procedures and specifications for the use of band aid strips to prevent cracking adjacent to repairs.

Non-bituminous products

Crack sealing

Sealants

Methods for evaluating crack sealants.

Preparation

Methods and specifications for preparing cracks prior to sealing.

Crack reflection retardation

Methods and procedures for retarding crack reflection. Evaluation of materials for retarding crack reflection.

Crack movement measurement

Equipment and procedures for measuring crack movement in the field.

Special considerations for seal and overlay design

Special aspects such as the ability of materials to retard reflection cracking, the effect of spray rates, the effect of ageing of materials.

Surface rejuvenation

Methods and specifications for rejuvenating aged surfacings.

Diluted emulsions

Cut-backs

Tack coats

M.9 DESCRIPTION OF SEAL DESIGN PLATFORM

Environmental analysis

Traffic analysis

Topography

Climatic regimes

Social issues

Procedures for evaluating the social requirements (community requirements) and impact on society of seals.

Design factors

The evaluation of special design considerations for seals.

Embedment measurement

Equipment and procedures for determining the embedment of aggregate into old surfacings.

Binder characteristics

Equipment and procedures for assessing special binder characteristics applicable to seals (*e.g.* viscosity at spraying temperature).

Aggregate characteristics

Equipment and procedures for assessing special aggregate characteristics applicable to seals (*e.g.* average least dimension)

Skid resistance

Equipment and procedures for assessing the skid resistance of seals against design criteria.

Seal design methods

Methods for seal design including, pre-evaluation of old surfacing, materials testing, traffic evaluation etc.

Construction

Special considerations in the construction of seals and their impact on seal design.

Spray temperatures
Specifications.

Quality measurement
Construction quality, product quality.

Ambient temperature measurement
Equipment and procedures for measuring ambient temperature as input into construction quality management.

Performance evaluation
Special considerations related to the performance evaluation of seals.

Performance evaluation

Performance measurement

Modelling

Performance prediction

M.10 DESCRIPTION OF THE HIGH PERFORMANCE ASPHALT TECHNOLOGY PLATFORM

Component characteristics

Aggregates:

Standard test methods

Filler properties

Methods for the determination of the effect of filler properties on binder and asphalt mix properties.

Geology

Methods for determination of the effect of aggregate type on mix properties.

Chemistry

Effect of aggregate and filler type on chemical properties of binders.

Special test methods

Crushing methods

Effect of aggregate crushing methods and thus aggregate shape on asphalt mix properties.

Selection matrix

Selection of aggregate type based on physical and geological properties to provide specific mix properties.

Acceptance criteria

Criteria for the acceptance of aggregates.

Binder:

Standards test methods

Performance-related tests

Special test methods and criteria to predict the performance of binders in mixes.

Chemistry and rheology

LTP of binders

Long term performance of binders (ageing etc.)

Temp-frequency relationships

Effect of temperature and frequency of loading on binder properties.

Selection matrix

Selection of binder type based on physical and chemical properties to provide specific mix properties.

Aggregate binder interaction

Specific consideration of the interaction between aggregate and binder (*e.g.* chemical reactions) and the influence thereof on mix properties.

Spatial composition

Mix optimisation :

Selection matrix

Matrix for the selection of aggregate and grading to optimise volumetric properties.

Constructability

Optimisation of ease of construction based on spatial composition.

B/C optimisation

Optimisation of benefit obtained *vs* cost of mixture (*e.g.* binder content).

Volumetric performance

Performance of mixture in volumetric testing and against volumetric criteria.

Acceptance criteria

Criteria for the acceptance of mixes based on volumetric properties.

Field simulation:

Compaction
Laboratory compaction equipment, procedures and criteria to simulate field compaction and thus field properties.

Particle orientation
Laboratory simulation of the orientation of aggregate particles in the mix.
Short term ageing
Laboratory simulation of the ageing of binder in the mix during plant mixing.

Workability
Optimisation of and prediction of field workability of mixes.

Acceptance control
Procedures for the field acceptance of paved asphalt.

Modelling inputs:

Workability models
Inputs into the development of models for the workability of mixes based on volumetric properties.

Fatigue models
Volumetric input into fatigue modelling of asphalt mixes.
Rutting models
Volumetric input into modelling of rutting of asphalt mixes.

Mechanical properties

Mechanical testing:

Inputs from structural design

Structural design requirements of asphalt mix.

Stiffness testing

Equipment, test methods and criteria for determining stiffness of asphalt mixes

Material strength

Equipment, test methods and criteria for determining the strength of asphalt materials (*e.g.* indirect tensile strength).

Plastic deformation

Equipment, test methods and criteria for determining the plastic deformation of asphalt materials (*e.g.* dynamic creep modulus). Prediction of asphalt plastic deformation.

Cracking

Equipment, test methods and criteria for determining the cracking resistance of asphalt materials (*e.g.* low temperature cracking, fatigue cracking).

Moisture damage and ageing

Equipment, test methods and criteria for determining the effect of moisture and ageing on asphalt materials (*e.g.* stripping, binder ageing).

Functional properties

Equipment, test methods and criteria for determining the functional properties of asphalt materials after paving (*e.g.* skid resistance).

Acceptance criteria:

Decision support system

A decision support system for the acceptance of asphalt mixes.

Trial sections
Procedures for the evaluation of asphalt mixes in trial sections prior to construction.

Design tolerances

Criteria and specifications

Modelling inputs:

Performance models
Engineering parameters for performance modelling.

LTPP/APT validation
Validation of asphalt mix design procedures through Long Term Pavement Performance and Accelerated Pavement Testing.

Reliability
Use of reliability concepts in asphalt mix design.

M.11 DESCRIPTION OF THE ASPHALT MIX DESIGN LINK TO STRUCTURAL DESIGN PLATFORM

Structural design

Environmental Analysis:

Traffic loading
Equipment and procedures for determining traffic loading (*e.g.* Weigh-in-Motion counts)

Tyre contact stress

Special measurements to determine tyre contact stress distribution.

Climate, topography, subgrade support

External conditions that determine asphalt mix design requirements.

Mix inputs

Feasibility of achieving structural requirements parameters with existing materials.

Analysis methods:

Layered elastic

Visco-elastic

Non-linear

Back calculation

Link between materials properties and back calculation procedures.

Forward calculation

Input materials properties for calculation of stresses and strains in pavement layers.

Finite elements

Dynamic analysis

Equipment and procedures for the testing and analysis of material behaviour under dynamic loading.

Decision support:

Life-cycle costing

Economic analysis

Selection criteria

Optimisation procedures

Performance prediction

Performance:

Functional performance
Models for the prediction of functional performance of paved asphalt.

Structural performance
Models for the prediction of functional performance of paved asphalt.

Measurement
Methods and procedures for measurement of performance.

LTPP/APT
Validation of performance through Long Term Pavement Performance and Accelerated Pavement Testing.

Data base analysis

Statistics and reliability

Modelling:

Behavioural analysis

Analysis of the behaviour of materials in relation to pavement structure and definition of failure mechanisms.

Data base systems

Deterioration performance modelling

Transfer functions

M.12 DESCRIPTION OF THE LABOUR-INTENSIVE CONSTRUCTION/SMALL CONTRACTOR DEVELOPMENT TECHNOLOGY PLATFORM

LIC road maintenance methods

Gravel Road Maintenance Procedures

Construction procedures for the maintenance of gravel roads using LIC methods

Crack Sealing Procedures

Procedures and specification for sealing of cracks using LIC methods

Pothole Repair Procedures

Procedures and specifications for the preparation and repair of potholes using LIC techniques

Surface treatment technology

Procedures and specifications for applying surface treatments with LIC methods with special emphasis on occupational safety issues.

Drainage Technology

Procedures and specifications for constructing drainage features using LIC methods.

LIC upgrading and construction of roads

Special materials design and construction

Special considerations for materials design, specifications and construction aspects for LIC construction with special emphasis on workability of materials

Special Construction Processes

Construction processes for special materials such as ETBs, foamed asphalt, Macadam bases and waste materials

Road Surfacing Technologies

Special methods for constructing road surfacings using LIC methods

Dust Palliative Technologies

Procedures and specifications for the use of dust palliatives to upgrade gravel roads

Block Paving Technologies

Procedures and specifications for the construction of block paving for roads

Special Surveying Techniques

Special surveying techniques for LIC methods

Special subbase preparation techniques

Special LIC techniques for preparing subbase layers

Small Contractor Development/Empowerment

Tender procedures

Special tender procedures for small contractors

Specifications

Special specifications for LIC and small contractors

Technical training modules

Business training modules

M.13 DESCRIPTION OF THE CONSTRUCTION QUALITY MANAGEMENT PLATFORM

Labour-intensive construction (LIC)

Special considerations for quality control during LIC

Quality control methods

Quality control criteria

Special materials considerations for LIC quality control

Traditional Quality Control

Standard procedures and specifications

Standard Methods

ISO 9000

Quality Systems

Product Performance Guarantee Systems

Environment

Environmental effects on construction quality

M.14 DESCRIPTION OF THE INFRASTRUCTURE MANAGEMENT SYSTEMS PLATFORM

Road Management Systems

Systems

Software systems and programs such as Pavement Management Systems and Maintenance Management Systems

Inventories

Data base inventories of road network systems

Inspection Methodologies

Methods and guidelines for visual inspection of pavement performance

Deterioration Models

Models for predicting long term pavement performance

Economic Analysis

Including pavement life cycle cost analysis

Optimisation Procedures

Procedures for optimising the effect of expenditure on network maintenance and rehabilitation

Spatial representation

Geometric representation of road networks using for example GIS methodologies

Bridge Management Systems

Systems

Software systems and programs for Bridge Management

Bridge inspection methods

Deterioration models

Economic Analysis

Optimisation Procedures

Spatial representation

Vehicle Management Systems

Abnormal Loads

Methods for monitoring and managing abnormal loads

Cross-border flows

Methods for monitoring and managing international truck traffic and axle loads

Overloading control

Methods and software for monitoring and controlling overloading

Weighing Systems

Technology for developing weighing systems to monitor axle loads

APPENDIX N: BRIEF DESCRIPTION OF SELECTED PARLIAMENTARY GRANT PROJECTS

PROJECTS INITIATED IN THE 1997/98 FINANCIAL YEAR

Project RE1/97: Improvement of APT technology

The advantages of HVS technology and its market potential are well known. Investment will focus on the levers in the technology tree. These include:

- the development of a dynamic loading capability for the HVS (RE1/97/1)
- the development of associated data analysis and modelling techniques that can utilise dynamic loading data (RE1/97/2)
- the development of a user-friendly data processing, data analysis and data management environment (RE1/97/3)
- the development of the next generation of data acquisition equipment and systems which can be protected through patents (RE1/97/4)

Project RE2/97: Advanced structural design methods

The aim of this work is to develop basic platforms from which new, advanced pavement design methodologies will be developed. The focus will be on the following tasks:

- continued development of the 3-dimensional stress sensor (RE2/97/1);
- methodologies for the evaluation of the impact of non-uniform tyre pressure on current pavement structural design methodologies leading to an inception report for further work to be conducted (RE2/97/2);
- technologies for the modelling of pavement behaviour including vehicle dynamics and pavement analysis methodology (RE2/97/3);
- capacity building in advanced test methods for pavement behaviour and performance (RE2/97/4), and
- capacity building in the modelling of pavement deformation (RE97/2/5).

Project RE3/97: Dynamic testing of asphalt materials

The work will focus on the following tasks:

- Fatigue evaluation of asphalt mixes to build capacity in the use of the 4 point beam testing apparatus (RE3/97/1), and
- basic technologies for the dynamic testing of asphalt materials that will include enhancement of the dynamic creep test, a confined test method for asphalt materials (including the K-mould) and required basic work on the Superpave dynamic testing equipment (RE3/97/2).

Project RE4/97: Modelling of asphalt materials

Work will be conducted in the basic technologies required for enhanced materials modelling. This project will include the following tasks:

- basic technologies for modelling asphalt deformation in the laboratory including the commissioning of a wheel tracking device, specialised SHRP equipment such as a shear rheometer and specialised analysis routines for modelling basic materials behaviour (RE4/97/1, and
- capacity building in new materials design technologies (RE4/97/2).

Project RE5/97: Quality improvement in materials design

This project will focus on the improvement of quality in materials design and industry liaison and will focus on the following tasks:

- accreditation of the soils and asphalt compaction labs (RE5/97/1);
- capacity building in the soils and asphalt compaction labs (RE5/97/2), and
- the BMLC (RE/97/3).

PROJECTS INITIATED IN THE 1998/99 FINANCIAL YEAR

Project RE6/98: Improvements in asphalt mix design

Task RE6/98/1: Load frequency and strain magnitude effects in beam fatigue testing

The objective of the task is to investigate the relative importance, or shift in the estimated fatigue life that is due to the frequency of testing. Beam fatigue tests will be done at different frequencies and the relative shift in fatigue life will be studied. The load-time spectrum from roads will also be measured using Weigh in Motion sensors. This information will be used to obtain a randomized load frequency spectrum. The results of such a loading spectrum, which will include longer rest periods than routine lab testing, will provide insight into the laboratory to field shift factor that is needed to estimate fatigue life of asphalt.

Task RE6/98/2: Improvements to the TRILOM Cell

This task is a continuation of previous work related to the development of the TRILOM cell and is aimed at addressing the following issues:

- The configuration of the vertical measurement devices needs to be investigated. It is recommended that the three vertical LVDTs which measure deformation at the top of the loading platen be used instead of the single LVDT situated in the loading ram. If the use of these LVDTs still leads to unacceptably low stiffness values, the use of a side-mounted LVDT or even of a strain gauge would have to be investigated.

- The variability of TRILOM test results needs to be improved. Although there were indications that the variability of the TRILOM test results was decreasing as experience and confidence increased during this project, there were still instances in which the variability of test results were unacceptably high. Although no specific action is recommended

at this stage, an awareness of variability issues needs to be inculcated and, where possible, test procedures should be changed in order to reduce this variability.

- A special membrane needs to be designed for use during confined testing. The membrane could be similar to that used in triaxial testing on soils, but would need stiffening at the points where horizontal deformation is measured. This stiffening can possibly be achieved by replacing the rubber by a stiffer material (such as aluminium) at those positions where horizontal deformation is measured.

- The dissipation of friction between the loading platens and test specimens.

Project RE7/98: Dynamic shear properties of binders

Task RE7/98/1: Capacity building in the use of the Dynamic Shear Rheometer

This is a continuation of STEP project TRA67. Further understanding on the interpretation of the data obtained from the DSR is required. The project will focus on two generic types of binder (unmodified and polymer-modified). The effects of shear rate, temperature and frequency on the shear modulus and phase angle will be investigated and it will be attempted to relate the properties obtained to both chemical and physical properties. The proposed project is situated at the lower end of the technology tree and is considered important in order to enable the ad hoc section of the sub-programme Asphalt Technology to market this technology, to keep abreast of competition (e.g.. SRT) and to generate sales in the area.

Project RE8/98: Measurement and modelling of asphalt response under moving wheel loads

The aim of the project is to investigate strain gauge instrumentation and measurement of strains in asphalt layers. Existing and emerging models of asphalt behaviour will be evaluated through comparison with the measured responses. The study will enhance the asphalt measurement and instrumentation capabilities of CSIR Transportek. At the same time results will be used to obtain indications of the relative importance of assumptions that are made in the routine evaluation of asphalt behaviour. These assumptions include linear elasticity (as opposed to visco-elasticity), linearity (as opposed to non-linearity) etc.

Project RE9/98: Critical evaluation of asphalt and surface seal performance at different ages: first stage (data base development)

The objective of the project is to develop an extensive and reliable data base of pavements with different surfacing types. PMS data will form the nucleus of the database but other information such as deflections, roughness measurements etc. can also be used where available. The project will thus consist of data gathering, data base development and cleaning up of data. This work will lead to an invaluable tool for evaluating asphalt and seal performance in the long and short term. The data base can form the basis from which more refined project proposals can be developed. Such projects can be financed by clients with specific needs that can be addressed by means of the data base. For example, the fatigue life of surface seals can be compared to that of asphalt. Or, the average fatigue life of asphalt layers can be determined and used to identify early failures. The reason for such early failures can then be determined and recommendations can be made for improving design and construction practice.

Project RE10/98: Changes in bitumen properties during production and placement

Some changes in the properties of bitumen do occur during production and placement of asphalt. Depending on the source of the crude and of the bitumen/ asphalt production process used, some bitumens undergo a greater amount of change than others, which would affect the life expectancy of the final product.

The objective of the project is to characterize the amount of change which occurs in the various types of bitumens locally produced in South Africa and to identify at which stage of the production process the greatest amount of change occurs. The results from this study will be used to assist bitumen producers in fine-tuning the compositional balance of their bitumens and to assist asphalt producers in optimizing their production process so as to ensure that the final product is of greater quality.

Additional benefits of this project include: capacity building in the use of the dynamic shear rheometer and the interpretation of data, and the development of short-term ageing models for bituminous binders.

Project RE11/98: New hot mix design method (Phase I)

The tasks to be conducted are:

RE11/98/1: TFA1/A/1: Qualitative assessment of the influence of (super) fines on binder rheology and durability, and procedures for establishing the selective sorption potential of aggregate on long-term performance.

RE11/98/2 TFA2/A/2: Synthesis and validation of laboratory procedures for the simulation of construction processes in the laboratory

RE11/98/3 TFA3/A/1: Synthesis of test procedures which can be employed to assess the resistance of HMA to permanent deformation and cracking

Project RE2/97: Advanced structural design techniques (continued)

Mechanistic design procedures consist of two major components. The first being the stress and strain or structural analysis component and the second the performance prediction component. The structural analysis packages commonly used in South Africa for the analysis of pavements are based on the integral transformation solution for a linear elastic multi-layer system loaded by a uniform circular load. Real life traffic loading and pavement systems are, however, of a completely different nature. Analysis procedures have fortunately advanced far beyond the solutions schemes commonly used. Two areas of development warrants further research:

- advanced multi-layer solution schemes, and
- 3-dimensional finite element solutions.

The objective of the project is to initiate the use of advanced multi-layer and finite element analysis in pavement design. The project will build on two projects from the previous year. The first project was a COD-project on the basics of multi-layer solution procedures and identified advanced multi-layer solution schemes for future use in South Africa. The second project was a STEP-project with the aim to identify a finite element analysis package to be used for pavement analysis at TRANSPORTEK.

The technical aim of the project will be to use both an advanced multi-layer and a finite element solution scheme to incorporate the following aspects in the analysis of pavements and then to compare the results from these two sources to the results from current analysis routines:

- the non-uniformity of the applied stress distribution, and
- the non-linearity of materials.

Project RE12/98: Advanced granular material modelling

Mechanistic pavement design in South Africa is still done by linear elastic analysis although it is generally accepted that road building material behave non-linearly. Structural analysis techniques have, in addition, advanced far beyond linear-elastic analysis. There are unfortunately very few non-linear material models published for South African road building materials. The specialised equipment for developing these material models, namely the K-mould and Triaxial apparatus is now operational at TRANSPORTEK.

Material has been collected from the HVS-test site on R2388 and various other previous HVS-sites for the purpose of other projects during the current financial year. These materials are now available for testing and development of non-linear material models under this project.

The objective of the project is to establish an initial data base of non-linear material models in South Africa that may then be used in mechanistic design and the evaluation of roads. The project will have the additional objective of making a critical evaluation of the use of the K-mould and triaxial cell in developing these non-linear material models.

Project RE13/98: Pavement system deformation models

This project is a follow on from Project RE2/97. The development of permanent deformation models using data from past HVS tests was initiated by the development of the Elasto-plastic design method. This process was continued with the initiation of the development of a similar design approach for pavement foundation materials in South Africa during the previous financial year. This research, combined with the elasto-plastic method will provide a comprehensive permanent deformation model for all unbound pavement layers. The development of the models for the pavement foundations, however, needs to be finalised.

The objective of the project is to finalise the development of permanent deformation transfer functions for pavement foundations. These will then be the only set of transfer functions for pavement foundations developed in South Africa from data generated in South Africa.

Project RE14/98: Stress-in-motion (SIM) system

The project is aimed at the development of systems which can be used to measure the contact stress between tyre and road in order to develop the capability to improve traffic loading analysis for the purposes of optimising the structural design and evaluation of both flexible and rigid pavements. The project is a follow on from the 3-dimensional stress sensor development.

Project RE15/98: Heavy Vehicle Simulator Mark IV

The new mark IV plus HVS of the CSIR will be finished towards the end of September 1998. The aim of this STEP project is the commissioning of the new HVS and the training of personnel in its use.

APPENDIX O: LIST OF PROJECT IDEAS AS REVIEWED FOR THE HMA PROJECT

TFA1: COMPONENTS

A1: Binder selection prior to asphalt mix design; current practice does not include a critical examination of all the options for material selection (spatial or volumetric approach, nature of binder) (A Thomson, BMLC May 1995; VKE, Sept 1997; B Kingdon, SAT 1997)

A2: Performance related specifications and test methods for bituminous binders and aggregates (B Nothnagel, BMLC May 1997; M van de Ven, SAT 1997)

A3: Methodology for quantification of the absorption of aggregate fines by bitumen (BMLC May 1995)

A4: Quality of aggregates (L Sampson, BMLC May 1995) and shape and roughness of aggregate (D Burger, BMLC May 1995; VKE, Sept 1997)

A5: Performance criteria for modified binders (H Thompson, BMLC May 1995)

A6: Importance of filler (D Burger, BMLC May 1995)

A7: Greater emphasis on aggregate properties. Variability of materials obtained from the quarries needs to be addressed. HMA design should be based on what can be produced at the quarries (ASPASA, BMLC Nov 1997)

TFA2: SPATIAL COMPOSITION AND PROCESSES

B1: Gyratory compaction of SA asphalts (BMLC May 1995; BMLC HMA Task Group, May 1996)

B2: Design and quality control method for asphalt mixes to prevent overfilling of voids (BMLC May 1995)

B3: Analytical methods based on volumetric principles or spatial approach (M van de Ven, SAT 1997)

B4: Relationship between (bulk) volumetrics and performance (M van de Ven, SAT 1997)

B5: Systems for field management of hot-mix asphalt volumetric properties (NCAT) (M van de Ven, SAT 1997)

B6: Uniform process for manufacturing samples for asphalt mix design and quality control (H Thompson & D Burger, BMLC May 1995)

B7: Simulation of field processes in the laboratory (A Thomson, BMLC May 1995; B Nothnagel, BMLC May 1997; VKE, Sept 1997; D Rossmann & T van Rijckevorsel, SAT 1997)

B8: Selection of gradings to achieve objectives; aggregate distribution related to performance and constructability (L Sampson, BMLC May 1995; T van Rijckevorsel, SAT 1997; VKE, Sept 1997)

B9: Differentiation between structural and functional requirements (D Rossmann, SAT 1997)

B10: Relationship between composition and workability (D Rossmann, T van Rijckevorsel & M van de Ven, SAT 1997)

B11: Evaluation of the effects of temperature, loading conditions, ageing of the mix and support conditions to determine the optimum mix composition for a particular environment and for particular performance requirements (B Verhaeghe, SAT 1997)

TFA3: PERFORMANCE-RELATED PROPERTIES AND HMA DESIGN MODELS

C1: Performance related mix design integrated with traffic loading, environment, construction and durability (B Nothnagel, BMLC May 1997; P Myburgh, D Rossmann & B Verhaeghe, SAT 1997)

C2: Revised system which will be able to predict performance; performance-related tests as input in performance prediction models (P Myburgh, M van de Ven & B Verhaeghe, SAT 1997)

C3: Reliance on transfer functions relating mix composition and easily determinable engineering properties to predicted performance on the road in a given environment (B Verhaeghe, SAT 1997)

C4: Should take cognisance of the influence of variables such as support conditions, tyre pressures, temperature fluctuations and ageing on behavioural characteristics of the mix (B Verhaeghe, SAT 1997)

C5: Practical and multi-layered system in terms of complexity to serve levels of confidence appropriate to a range of applications (P Myburgh & B Verhaeghe, SAT 1997)

C6: Design procedures for bitumen rubber asphalt (BMLC May 1995; VKE, Sept 1997)

C7: Design criteria for asphalt mixes using modified binders (AREST 3; D Rossmann & T van Rijckevorsel, SAT 1997)

C8: Frequency of testing for dynamic tests (BMLC May 1995)

C9: Development of fatigue curves and transfer functions (A Thomson & D Burger, BMLC May 1995)

C10: Development of dynamic testing equipment (A Thomson, BMLC May 1995; A Taute, SAT 1997)

C11: Dynamic testing: correlation between laboratory and field (H Thompson, BMLC May 1995)

C12: Semi-circular bending test (VKE, Sept 1997; B Nothnagel, Oct 1997)

C13: Development of a simple test method to assess rut resistance (VKE, Sept 1997)

C14: Inadequacy of current test methods to address rutting (T van Rijckevorsel, SAT 1997)

C15: Improvements to the indirect tensile strength test (B Verhaeghe, SAT May 1997; VKE, Sept 1997)

C16: Relationship between stiffness under oscillating load and under rolling wheel needs to be investigated as well as its impact on the development of a specific type of equipment (J Lourens, BMLC HMA Task Group, May 1996)

C17: Impact of stiffness and damping ratios as inputs into structural design and the development of dynamic testing devices to obtain such outputs (J Lourens, BMLC HMA Task Group, May 1996)

C18: Resistance to fatigue through ITT? (B Kingdon, SAT 1997)

C19: Test configurations often operate in a totally different environment of confinement and shear (P Myburgh, SAT 1997)

C20: Marshall method to be phased out and replaced with more rational testing (A Taute, SAT 1997)

C21: Importance of relying on one or two fairly simple test devices (e.g. gyratory and rut tester). Need for the introduction of simple tests (T Lewis, BMLC Nov 1997)

C22: Need for standardized test procedures at all levels of design (A Taute, BMLC Nov 1997)

C23: Dedicated, region-bound designs for which one would have high confidence (P Molenaar & A Taute, BMLC Nov 1997)

TFA4: CONSTRUCTION

D1: Constructability and quality control issues (AREST 3)

D2: Rapid field testing of materials for relevant engineering properties (AREST 3)

D3: Establishment of a quality assessment system (AREST 3; BMLC May 1995)

D4: Guidelines for the implementation of ISO 9000 in the asphalt industry (BMLC May 1995)

D5: The effect of field compaction on the engineering properties of asphalt (AREST 3)

D6: The use of asphalt materials in SMMEs (AREST 3)

D7: User-friendly asphalt materials for labour-enhanced construction (AREST 3)

D8: Quick tests for quality control (M van de Ven, SAT 1997; B Spottiswoode, BMLC Nov 1997)

D9: Importance of compactability. The gyratory tester tends to direct the mix towards coarser, stiffer and less workable mixes. Vibratory compaction becomes the norm rather than the exception. How this affects the base (particularly for thin layers) also needs to be addressed (J Newell, BMLC Nov 1997)

D10: Construction should form the departure point for HMA design (JC van der Walt, BMLC Nov 1997)

TFA5 : STRUCTURAL DESIGN

E1: The effect of cross-border traffic on the remaining structural life of major routes and effective ways of strengthening them (AREST 3)

E2: Assessing the need for roads in developing areas and the use of current products in addressing this need (SOCDEV) (AREST 3)

E3: Evaluation of the effect of increased axle load and tyre pressures on the life cycle of roads (AREST 3, BMLC May 1995; VKE, Sept 1997)

E4: Design of community roads must consider the elements of appropriate standards, design procedures and criteria (within the context of community participation and heightened expectations) (AREST 3)

E5: Thicker asphalt layers and importance of rutting and of weaker supports (A Taute, SAT 1997)

E6: The pavement structure needs to be brought into the process of mix design. In rehabilitation design, the variability is much greater than in new construction (M White, BMLC Nov 1997)

VALIDATION OF RESULTS AND GENERAL ISSUES

F1: Monitoring the field performance of asphalt materials in the medium and long term (AREST 3; VKE, Sept 1997)

F2: Refinement of decision support systems such as PMS - asphalt deterioration models (AREST 3)

F3: No reliable performance data are yet available (G Rutland, BMLC Nov 1997)

F4: LTPP/APT database is important and should be instituted as soon as possible (E Sadzik, BMLC Nov 1997)

F5: To provide cost-effective solutions to the roads industry (AREST 3)

F6: Health, safety and environment (AREST 3)

F7: Effective training programmes at Universities, Technikons and Technical colleges (AREST 3)

F8: *Issue:* Flexible methodologies and specifications that can be used with materials in neighbouring countries (AREST 3)

F9: *Issue:* Concrete is perceived as a cheaper and more user-friendly alternative - testing of asphalt is too complex and expensive (AREST 3)

F10: *Issue:* Perception of asphalt as being too high-tech to be relevant to the new situation in RSA (AREST 3)

F11: *Issue:* Benefits from expenditure, particularly in view of a shortage of funds, must be optimised, through the development and use of cost-effective materials, designs, methods and equipment (AREST 3; P Myburgh, SAT 1997)

F12: *Issue:* Must cater for inexperienced practitioners (P Myburgh, SAT 1997)

F13: *Issue:* Should cater for a wide array of mix types and binder types (A Taute & T van Rijckevorsel, SAT 1997)

F14: Need for specialized, centralized test houses (G Rutland, BMLC Nov 1997)

F15: One design system for all applications (Q Smith, BMLC Nov 1997)

F16: Uniformity in specifying the product. Revisit the way specifications are set up for the purpose of tendering and the way tender documents are put together (D Burger, BMLC Nov 1997)

F17: Deep-strength asphalt as an economic alternative (AREST 3)

APPENDIX P: BRIEF DESCRIPTIONS OF DEFINED HMA PROJECTS

TFA1: COMPONENTS

TFA1/A/1 Qualitative assessment of the influence of (super) fines on binder rheology and durability, and procedures for establishing the selective sorption potential of aggregate on long-term performance

Objectives: development of procedures by which potentially problematic materials can be identified, quantification of the risk profile associated with their use and the development of guidelines as input to TFA2/B/4.

Duration: 8 months (April 1998 to November 1998)

Deliverables: test procedures, criteria and guidelines.

TFA1/A/2 Synthesis of test procedures for the assessment of the durability (ageing and loss in flexibility) of bituminous binders and qualitative assessment of the effects of ageing on binder stiffness

Objectives: identification of appropriate procedures for the simulation of field ageing and for the assessment of the long-term effects of binder hardening on measurable properties, including dynamic stiffness.

Scope: unmodified and modified binders

Duration: 8 months (April 1998 to November 1998)

Deliverables: recommended test procedure for the simulation of field ageing, criteria and characteristic curves for dynamic stiffness (pre- and post-aged, as input to TFA3/A/3).

TFA1/B/3 Reassessment of relevant test methods and of specifications for mix components and compilation of new test procedures and specifications for mix preparation, compaction and characterization (as proposed by TFA2 and TFA3)

Objectives: Review of relevant test methods and of specifications for mix components (including aggregate durability and hardness tests) based on a state-of-the-art survey and the incorporation of the findings of TFA1/A/1 and TFA1/A/2 into such test methods and specifications; compilation of test procedures and specifications for new test methods resulting from the completion of TFA2/A/2, TFA2/A/3, TFA3/A/2 and TFA3/A/3 (where applicable).

Duration: 2 months (April 1999 to May 1999)

Deliverables: test methods and specifications

TFA2: SPATIAL COMPOSITION

TFA2/A/1 Conceptualisation of spatial composition

Objectives: definition of the concept of spatial composition, taking cognisance of local and international work conducted on this topic in the asphalt industry and in the cement concrete industry, in the field of unbound materials (e.g. methods for the optimization of the packing characteristics of crushed stone bases) and in other related fields, and the identification of the best approach (and

alternatives), taking cognisance of implementation issues, by which the spatial composition of HMA can be optimized to yield the required results.

Duration: 2 months (April 1998 to May 1998)

Deliverables: definition of concepts, approaches and procedures which can be used to optimise the spatial composition of HMA, recommendations for validation and further refinement as input to TFA2/A/3.

TFA2/A/2 Synthesis and validation of laboratory procedures for the simulation of construction processes in the laboratory

Objectives: identification and validation of laboratory mixing, compaction and conditioning procedures for the simulation of construction processes (mixing, short-term ageing, transport, paving and compaction), taking cognisance of the spatial parameters required for design and those achieved during construction.

Scope: all mix types, two binder types (high and low viscosity binders)

Duration: 2 months (synthesis) + 5 months (validation) (June 1998 to December 1998)

Deliverables: mix preparation and compaction methods, taking into consideration the level of design reliability required for a given project.

TFA2/A/3 Development of volumetric/spatial design procedures and the establishment of criteria, taking cognisance of environmental effects (traffic, climate, etc), constructability, design reliability and performance requirements

Objectives: validation of the findings of TFA2/A/1, development of procedures (models, laboratory procedures or other) and criteria by which the spatial composition can be optimized for a given environment and performance requirements (including skid resistance and permeability) so as to produce an HMA design method for low-volume, low design reliability applications and a sound foundation for applications requiring a greater design reliability, recommendations on simple (quasi) performance tests in support of the spatial approach and recommendations for the assessment of workability.

Scope: All mix types

Duration: 8 months (note: 2 months for ACTLA) (August 1998 to March 1999)

Deliverables: a stand-alone mix design method for HMA mixes used in general applications (i.e. low design reliability applications), mix optimization techniques for applications requiring a greater design reliability, acceptance criteria based on spatial parameters and simple (quasi) performance tests, workability assessment models, procedures and guidelines.

TFA2/B/4 Development of a mix selection matrix

Objectives: Development of a mix selection matrix taking into consideration factors such as availability of mix components, structural requirements, layer thickness, traffic type, volume and speed, pavement geometry, climate, user requirements, constructability and cost, based on inputs obtained from other TFAs.

Duration: 3 months (April 1999 to June 1999)

Deliverable: mix selection matrix

TFA3: PERFORMANCE-RELATED PROPERTIES

TFA3/A/1 Synthesis of test procedures which can be employed to assess the resistance of HMA to permanent deformation and cracking

Objective: review local and international test procedures for the assessment of permanent deformation and cracking of HMA and formulation of recommendations, taking cognisance of implementation issues.

Duration: 2 months (April 1998 to May 1998)

Deliverables: Approach and recommendations for further study, as input into TFA3/A/2 and TFA3/A/3.

TFA3/A/2 Development of procedures for the prediction of permanent deformation of HMA

Objectives: Development of a simple test device and associated test procedures and criteria, based on inputs obtained from TFA3/A/1 and TFA5/A/1, for the characterization of the resistance of HMA to permanent deformation which produces outputs which can be used in mechanistic models to predict performance, and the development of mix selection guidelines as input to TFA2/B/4.

Scope: all mix types, all binder types

Duration: 10 months (June 1998 to March 1999)

Deliverables: simple test device, test procedures and criteria, mix selection guidelines.

TFA3/A/3 Refinement of procedures and development of constitutive models for the characterization of the resistance of HMA to fatigue and reflective cracking, taking cognisance of ageing effects with time

Objectives: Refinement of evaluation procedures and development of constitutive models which can be used to assess the stiffness of HMA and its resistance to fatigue and reflective cracking as input into mechanistic models and for the prediction of performance, the development of a simple test protocol for fatigue testing and the development of mix selection guidelines as input to TFA2/B/4.

Scope: all mix types, all binder types

Duration: 10 months (June 1998 to March 1999)

Deliverables: laboratory models and/or test procedures, mix selection guidelines which also address the issue of flexibility (ability of HMA to conform to movement of the substrata without cracking).

TFA4: CONSTRUCTION

TFA4/A/1 Investigation and synthesis of constructability/workability problems experienced in the field

Objectives: identification of past and current problems experienced with the construction of all plant-mixed, paver-laid HMA and of future problems which can be foreseen, through a review of local and international developments in HMA construction.

Duration: 2 month (first cut) + 4 months (April 1998 to September 1998)

Deliverables: prioritized list of all constructability/workability problems associated with HMA construction with respect to components and their availability, mix type, mix formulation, condition of support, layer thickness, surface texture, pavement geometry, climate, plant & equipment, QC & QA aspects, specifications, time constraints.

TFA4/B/2 Construction of trial sections

Objectives: Construction of trial sections to hone in on constructability/workability issues and for the validation of recommendations issued by other Technical Focus Areas.

Scope: the activities are limited to management and inspection issues and the costs do not make provision for the construction of trial sections and for testing.

Duration: 9 months (September 1998 to May 1999)

Deliverables: As built reports covering issues such as purpose, scope, locality, pavement structure, materials, processes & equipment used and constructability & workability.

Note: Costs of trial sections and associated testing will be carried on actual road construction contracts

TFA5: STRUCTURAL DESIGN AND PERFORMANCE

TFA5/A/1 Identification of most appropriate mathematical modelling procedures and identification of required input parameters for mechanistic modelling

Objective: identification of most appropriate mathematical modelling procedures and determination of input parameters to be used in mechanistic modelling of performance as input to TFA3/A/1, TFA3/A/2 and TFA3/A/3.

Duration: 2 months (April 1998 to May 1998)

Deliverable: Input parameters for mechanistic modelling and recommendations on appropriate mathematical modelling procedures

TFA5/A/2 Situational analysis and sensitivity analysis, taking into consideration environmental influences and traffic loading

Objectives: situational analysis and sensitivity analysis to determine the relative effects of dimensional aspects (such as layer thicknesses) and input parameters (such as climate, contact pressures, layer stiffnesses and Poisson's ratios) on parameters influencing the performance of HMA (e.g. stresses and strains), taking cognisance of the variation of input variables (e.g. layer thicknesses and stiffnesses, and applied loads - i.e. a probabilistic approach) and reliability concepts.

Duration: 5 months (April 1998 to August 1998)

Deliverable: methods and/or procedures for the incorporation of environmental influences and traffic loading patterns in the input parameters of TFA3 (2 months), and a range of critical values, as input into TFA3, for parameters affecting the performance of HMA for typical pavement structures used in South Africa, taking cognisance of traffic classes, road categories and the environment (i.e. temperature cycles and moisture cycles).

TFA5/A/3 Review of available performance data and recommendations

Objectives: Identification of existing experimental/trial sections and assessment of available data as input into the development of transfer functions (TFA5/B/4) and the formulation of guidelines for the establishment of LTPP sections and a performance database in South Africa.

Duration: 9 months (April 1998 to December 1998)

Deliverables: Summary on the performance of existing experimental/trial sections in South Africa and guidelines for the establishment of LTPP sections and of a performance database.

TFA5/B/4 Development of plastic deformation and fatigue transfer functions and their incorporation into a mechanistic design system

Objectives: Development of models for cracking originating from the surface, plastic deformation models, models for reflective cracking and fatigue models based on feedback received from TFA3/A/2 and TFA3/A/3 and the incorporation of such models into a mechanistic design system

Duration: 6 months (January 1999 to June 1999)

Deliverables: Systematics which enable the structural performance of pavement structures incorporating HMA to be predicted with a greater degree of confidence

REFERENCES

[1] **Encyclopaedia Britannica**, accessed at http://www.britannica.com, October 2006.

[2] **Merriam-Webster dictionary**, accessed at http://www.m-w.com/, October 2006.

[3] **"Main Definitions and Conventions for the Measurement of Research and Experimental Development (R&D) – A Summary of the Frascati Manual"**. Organisation for Economic Co-operation and Development, Document Number OCDE/GD(94)84, Paris, France, 1994.

[4] Roberts, EB. "Managing invention and innovation". **Research Technology Management,** 31(1): 11-29, February 1988.