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PRACTICAL IMPLEMENTATION OF A TECHNOLOGY TRANSFER SYSTEM FOR ASPHALT PRACTITIONERS

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Synopsis

The paper reports on development of South African systems for technology transfer to roads practitioners. The need to develop effective technology transfer arose out of SABITA's active research programme. Using this and other research programmes, a number of methods were tried including single and multi-theme seminars, workshops, short courses, tutorials, field exercises, videos, and handbooks. The geographical disposition of practitioners in South Africa has meant that this was developed to suit a framework of widely separated locations, several road authorities, and often a need to co-ordinate with occasional national and regional meetings/conferences. The effectiveness of the various methods is discussed, and this is correlated with communication theory. Practical aspects covered include cost and time estimates for technology transfer activities and the structuring of research contracts to provide for technology transfer.

1 INTRODUCTION

The ongoing improvement of asphalt technologies has been a feature of the South African asphalt industry. The most recent comprehensive research and development programme was initiated by SABITA and the CSIR for the asphalt industry in 1988 (Rust et al, 1994). The products of this generated a need to transfer many new technologies to industry. This paper focuses on the transfer process and practical issues deriving therefrom.

Technology transfer is familiar to practitioners in both South Africa and Australia. Typically a range of seminars and courses are held for dissemination of information to industry. Papers and articles are published at technical conferences and in the technical press to promote discussion, evaluation and acceptance of research findings. In South Africa, there is also a bi-annual Bituminous Materials Liaison Committee (BMLC) which serves as a forum where the industry is kept up to date with technological developments.

The SABITA asphalt research programme led to a peak of new technologies in the early 1990s. This provided the opportunity to use and evaluate a range of technology transfer options in a relatively short time. Academic input into this process was available from SABITA's educational drive. The results of the evaluation are presented here. Generally these findings are applicable to Australia, because of the following similarities between the two countries:

- similar structure of State and local road authorities,
- similarly urbanised population, with engineers and technologists concentrated in a few centres,
- the geographical dispersion of urban centres in eastern Australian is similar to South Africa,
- both countries have industry associations (SABITA / AAPA) and road research organisations (DRTT-CSIR / ARRB).

2 DEFINITIONS

The terms used commonly in technology transfer terms have varied meanings, and the ones used in this paper are:

<u>Lecture</u> Speaker talks to audience. Little audience participation, except for limited questions.
<u>Seminar</u> Similar to Lecture, but with more audience questions and interaction. Possibly includes a panel discussion.
<u>Workshop</u> Speaker and audience heavily involved. An example would be the demonstration of a new piece of software followed by the audience trying out the programme on individual machines. May include tutorials.
<u>Tutorial</u> Audience working individually or in small groups on solving problems. Lecturing is limited to demonstrating solutions or to discussing common mistakes.

3 SABITA RESEARCH PROGRAMME

3.1 Sabita Asphalt Research Programme development

The drive for improvement in asphalt research arose in 1988 through a close relationship between the CSIR and industry (through SABITA), driven by a desire for more useable research products. The initial research direction was set through a SWAT-type analysis of knowledgeable players within the asphalt industry, client and consultant materials engineers, academics and researchers. The projects were generally highly technical by nature and tended to be aimed at breakthrough research focused on technical issues. Projects included Heavy Duty Asphalt for Pavements, Emulsion Treated Bases, Appropriate Standards for Bituminous Surfacing of Roads, and Economic Warrants for Surfacing Roads.

In the early 1990s, the impending changes in political focus within SA resulted in a re-analysis of asphalt research direction. A similar approach to selection was adopted and the players were expanded to include non-technical representatives of the new political players. The programme was considerably regeared and was characterised as being oriented to the needs of the client and the commercial arm of the industry. The projects were focused to be goal oriented. They were bundled into shorter sub-projects to allow redirection or cancellation as results were derived.

Funding averaged some $A700 000 per annum over the last 5 years. Cost benefit analyses have shown that the investment generated a positive return within two to three years.

3.2 Research Projects

The research projects of the SABITA Asphalt Research Programme included:

<u>Product / technology development</u>
Heavy duty asphalt pavements (HDAP),
Emulsion treated bases,
Polymer modified wearing courses,
Labour enhanced construction of bituminous surfacings.

<u>Performance evaluation for standard setting</u>
Appropriate standards for bituminous surfacings,
Crack sealing and crack reflection.

<u>Decision support</u>
Warrants for upgrading gravel roads.

<u>Industry strategic issues</u>
The value of roads in social development,
Futures research into the changing South Africa,
The value of new markets developing in South Africa.

<u>Education, training and technology transfer</u>
Support and involvement with the BMLC,
Support for a University Chair in Asphalt Pavement Engineering.

The makeup of an individual project can be seen by the approach to the HDAP project:

<u>Project : Heavy duty asphalt pavements</u>
R1m research and implementation cost

Need: provide an effective alternative to concrete pavements for roads carrying in excess of 50 million E80 standard axles.

Goal: provide a design method for a large aggregate asphalt mix capable of meeting the need, and marketing it in competition to other products.

Product: LAMBS - large aggregate asphalt mixes for bases. This has sold $A29 million of new product, in competition with concrete, within three years.

3.3 Technology transfer

The technology transfer process was included in the research programme and more importantly was budgeted for as part of each research project. The research approach of identifying needs gave rise to research goals. These became technology transfer or technology implementation goals. Projects were often considered on a linear time scale, and went through identification of need, research goals, actual research, final product, analysis of success in achieving the research goal, technology transfer of findings, review of technology transfer success, and analysis of success in satisfying the original need. In practice the projects are all interrelated and the goals overlapping, resulting in a circle of assessment which is shown in Figure 1.

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Technology transfer in an engineering environment requires acceptance by a wide range of practitioners. The no or low risk approach by professionals concerned about professional liability and by clients who are not rewarded for risk means that technology transfer must address these aspects in its development.

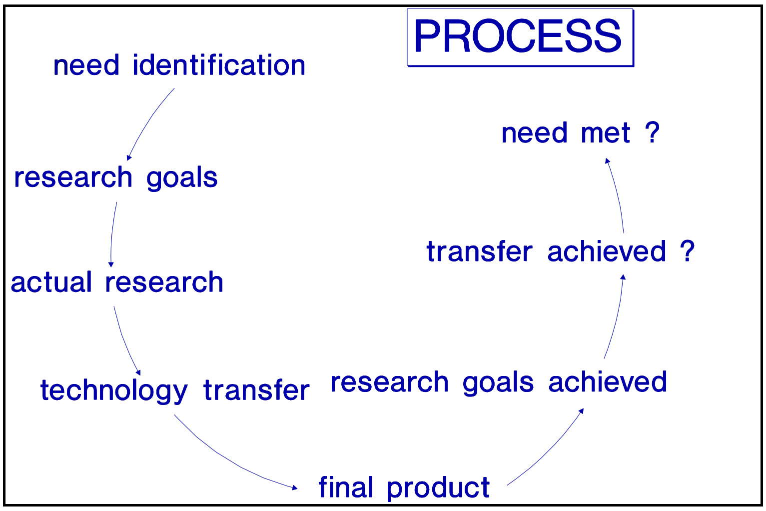

Figure 1 Assessment process

New technology, typically from high standard research, is very different to stepping stone adaptations of existing technology. The peer-group levels within the road industry can play a major role in acceptance and risk sharing.

To ensure acceptance, research should be as open to confrontation and review as possible. Forums need to be established to expose the researcher and the broad industry to the conclusions and findings of the research as it occurs. The researchers would preferably be linked to respected centres of achievement/excellence through the use of mentors. Alternately experts from different research organisations could be teamed into the project. When the research findings are complete they are subjected to national and international peer review through conference publications and papers to journals. The research findings would then be consolidated to address the originally stated and identified needs into a draft manual. A committee of local experts, not from the research organisation, would then review the manual for completeness and accuracy and give their approval for its release. At this stage the findings would be considered ready for release to the general industry and the training process would begin. The procedure adopted to this stage addresses the levels of peer groups involved and allows for a broad based interaction and redirection or refocusing of inadequate research. The above is all considered to be part of the preparation of research for release through technology transfer.

A high level of academic involvement in the acceptance of research findings assists in bridging local and international findings and results in the inclusion of recent developments into training material used for new entrants to the industry. To this end SABITA supported the formation of a chair in asphalt pavement technology at a South African university. The incumbent to the chair was involved in most of the implementation of research findings and was supported to broaden his upgrading of asphalt knowledge to sister tertiary level teaching institutions.

4 OTHER RESEARCH/TECHNOLOGY TRANSFER ACTIVITIES

Outside the SABITA programme, there are also asphalt research programmes of the

Department of Transport South Africa (DoT), DRTT-CSIR (Transportek, formerly NITRR), industry, and various Universities.

4.1 Department of Transport

The DoT transportation research programme averaged $A1,5 million annually over the last five years. Part of this programme was spent on asphalt related research. Their approach consciously did not include a technology transfer component in the various research projects. Dissemination of findings was by adhoc papers and articles published at technical conferences. In recent years this was augmented by articles published in a DoT technical magazine with general circulation. The result was disappointing and the output from many projects was lost to industry.

After strong motivation by SABITA on political and technical levels, a new direction in technology transfer was taken in 1993 with a DoT research project on appropriate standards for low volume roads. This had a substantial implementation component including a series of two day seminars at 8 locations across South Africa.

In another recent attempt to disseminate their research, DoT recently produced a computer database which gives an index to research projects, and the final reports of projects can be purchased from DoT. However neither the database nor the DoT sales office lie in the pathways commonly trodden by asphalt researchers, and it is expected that much research will stay undiscovered in the archives. This is in stark contrast to the DoT's dissemination of the series of TMH and TRH road engineering manuals which form the backbone of many road engineers' libraries in South Africa and overseas.

4.2 DRTT-CSIR (Transportek; formerly NITRR)

DRTT-CSIR is South Africa's largest road research organisation with a staff of approximately 160; it is somewhat similar to ARRB. DRTT-CSIR is the most experienced organisation at technology transfer and most of the technologies discussed in this paper were undertaken with their involvement. Changing funding systems have meant that in recent years DRTT's own research is contract-based, and technology transfer depends on the client's needs.

For their own transfer, DRTT-CSIR run an annual Road Infrastructure (RI) course. This is aimed at junior engineers, senior engineers with limited roads experience, and senior technologists. The course is slanted towards current research projects of the DRTT, and is not as such a comprehensive road design course. It runs for 3 days in Pretoria. The participant takes away a useful set of manuals containing 20-25 lectures. Technology transfer is primarily by lecture (high standards, usually with excellent 35mm slides, excellent venue). About 10% of the time is spent looking at a static display of road inspection and research equipment. Occasionally specialised workshops on new software or advanced software are held. There are few or no tutorials.

4.3 Other Institutions

The universities and technikons tend to transfer technology through ad-hoc short courses rather than through their existing courses. Recent examples include courses on pavement management and backcalculation of deflection bowls. The format of these is either lectures or lectures with some tutorials.

Other organisations such as the South Africa Road Federation and South African Institution of Civil Engineers also run short courses and/or lecture series on various aspects of roads.

5 TECHNOLOGY TRANSFER METHODS

Transfer methods used in South Africa include all of lectures, seminars, workshops, short courses, tutorials, field exercises, videos, and handbooks. The lecture/seminars may be packaged into a multi-theme presentation to ensure that there is something for everyone. This is especially useful at the smaller centres which do not always get visited. The use of several lecturers adds variety to the session.

Lectures are still the primary method of transfer, although the trend is very much to supplement these with tutorials and other activities to improve communications. Lectures are little different to those presented in Australia and will not be discussed further here. Several initiatives are being used such as tutorials, videos and manuals.

5.1 Tutorials

Tutorials have been used to good effect, and it is considered that these are a most effective component of technology transfer. The typical course format is to have lectures on a topic, followed by a demonstration of a worked example, followed by tutorials in which participants have to personally work out selected problems. The tutorial is run by a lecturer, with a number of "tutors" to assist participants. These tutors tend to be the other lecturers. A staff/student ratio of 1:20 is desirable, and 1:30 is probably the maximum.

For practical reasons, the participants usually work in groups of two to five around a table. The small group interaction plays a useful part in the process, because participants can help each other. The members of the groups are often selected to complement each other; it is undesirable to have junior/senior staff sitting together because one group inhibits the other.

Tutorial preparation needs careful attention, and it usually takes several days to prepare a half-day tutorial session. It is extremely valuable to have the tutorial pre-tested by a junior engineer from one's own office; this serves to check that the problems can indeed be solved. A common failing is setting too much work in the tutorial. The researchers tend to know their subject too well, and can therefore answer questions much more quickly than the audience. The speed ratio is in the order of 3:1 or even 4:1. Thus if the researcher/lecturer can complete their tutorial in 30-40 minutes, 2 hours will be needed at the seminar. One very useful technique is to issue worked answers to the problems at the end of the seminar. These, along with the tutorial questions and manuals, form a powerful self-teaching pack.

5.2 Manuals, specifications, handbooks, and textbooks

Manuals, specifications, handbooks, and textbooks are valuable reference works, and they serve to entrench technology into the workplace and into the education system. They support lectures and other transfer activities. Their appearance, with typesetting and binding, adds an aura of weight and permanence to the topic. However they are inadequate on their own for technology transfer because they do not:

- cater for widely varying levels of audience,
- create images that can be stored in the memory.
- answer questions and clear up minor misunderstandings,
- measure the recipient's level of understanding.

From a purist communication perspective, many engineering manuals are poorly written and presented. They usually lack adequate examples and do not encapsulate background/practical knowledge. An approach recently adopted has been to have the completed manual edited by a communications professional. The resulting changes can vary from small to significant depending on the language proficiency of the researcher or author. This approach has also facilitated a consistent appearance and style in manuals and technical guides produced.

5.3 Cost of transfer

The cost of transfer is surprisingly similar for the different methods (Table 1), and there appears no correlation between cost and effectiveness.

Table 1: Cost of technology transfer (1994 prices)

Course	Length (days)	Number of venues*	Total ** participants	Cost per head per day ***
DoT Appropriate standards for low volume roads workshops	2	8	600	$A115 (R300)
SABITA labour enhanced construction workshops	0,5	2	120	$A105 (R275)
SABITA LAMBS, GEMS, SURF+ seminars	1	3	400	$A90 (R240)
University PMS short course	5	1	20	$A105 (R275)
SARF course on road design	2	1	50	$A95 (R250)
DRTT Road Infrastructure Course	3	1	150	$A205 (R535)

Notes
* Number of cities / towns that the course was presented in.
** At all venues.

*** Almost all courses are non-profit and break-even. Course attendance fee is similar to cost.

5.3.1 Cost of lecturers

The cost of the courses is made up of lecturers, hall hire, sustenance, and manuals. A significant cost component is the lecturers (and their travel). These are drawn from industry and academia, and their remuneration varies widely.

5.3.2 Cost of printed and video presentation material

The other significant cost is manuals and video presentation material. SABITA spends $A65,000 (R170 000) annually on printing and reprinting manuals. The distribution of manuals and videos costs a further $A11,500 (R30 000), and is shown in Table 3. These are generally distributed free or below cost, and the annual income from them is $A5,000 (R13 000). The annual manual distribution is 4,500 to 6,000, into a base of approximately 6000 professional civil engineers and a larger number of technologists.

Table 2: Lecturing costs (1994 prices)

Technology transfer activity	Lecturer's remuneration		
	Honor-arium*	Reduced consulting rates**	Full consulting rates***
SABITA research contracts	yes	yes	
Institution of Engineers (SAICE)	yes		
DRTT-CSIR	yes	yes	
Universities	yes	yes	
Road Federation (SARF)	yes		
Other	yes	yes	yes

Notes * Nominal payment / book vouchers.

** Hours reimbursable do not include part or all of travel, preparation and waiting.

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*** Hours reimbursable includes all of travel, preparation, etc.

Table 3: Manual distribution

Distribution	Recipients	Number distributed
Initial distribution per new manual	Seminars	400
	Libraries	150
	State / Local authorities	100
	Educational institutions	250
	BMLC	150
	Sabita members	50
Annual usage per each of 15 manuals	Sales	75
	Educational	50
	Seminars / Courses	125

6 IMPROVING THE EFFECTIVENESS OF TECHNOLOGY TRANSFER

Part of the process involved studying and improving the effectiveness of the technology transfer activities.

6.1 Effectiveness of communication

A key component of effective technology transfer is good communication. The quality of this depends on how well human characteristics are provided for in the process (Fielding, 1994). With the bulk of technology transfer oriented towards lectures, attention was given to effective communication.

The quality of lecture needs to be high, with good accompanying graphics. For organisations active in technology transfer, formal speech training has been found to be important. A specific speechcraft course (half or full day) is occasionally run at DRTT-CSIR for their junior staff prior to their RI course. Other organisations have an informal involvement with Toastmasters or similar public speaking clubs. Most organisations use professional help in preparing graphics to achieve a high standard.

Other human aspects to consider are a limited attention span, and a memory retrieval process which is optimised to recall images,

Attention span tends to be lost after a short period, and academic experience is usually that maximum length of a lecture should be about 40 minutes. In addition, it has been found that a long series of lectures leads to overload. One university runs a postgraduate block course over week-long blocks. Each week has two complete subjects offered. The students emerge with complete information overload, and their subsequent performance at work shows that little has been learned.

The memory retrieval process is aided by enabling the audience to store memories in pictorial form, since any new topic (such as industrial health and safety) cannot be effectively taken on board until it has been visualised. To do this, examples and hands-on experience are used (such as showing an injured worker or getting the audience to physically set out traffic control on a work site).

6.2 Level of participants

The ability/level of the participants varies widely in practice, which creates problems in matching the presentation to the audience. If the presentation contains too much basic material, the higher level participants get bored. If there is insufficient supporting material, then participants with less experience can become lost.

One practice has been to restrict entry to a selected level such as 'experienced road technicians', but this has had only mixed success. It can be unacceptably restrictive, particularly if a presentation is done in regional centres where few roadshows normally go. Another approach tried was to provide a range of courses covering different levels throughout the year. Co-ordination of these was informal and it proved imperfect. The most successful approach was found to be a combination of:

- multi-topic seminars, to give something for everyone, and
- using tutorials. The questions in the tutorials are graded from easy to severe, so that all participants can complete questions related to their level. It was noteworthy how many experienced engineers appreciated the opportunity to revisit the basics in the non-public, non-confrontational atmosphere of tutorials.

6.3 Overcoming barriers to learning

A number of barriers to learning were identified which had to be addressed in improving technology transfer. Typical barriers which affected the lecturing and question process were:

- pride, i.e. know all about this subject,
- fear of being made to look a fool of in front of others, and particularly where there was a mixing of senior/junior staff.

Tutorials overcame these barriers to a certain extent, but it was found necessary to specifically deal with the barriers. In the tutorials, an early situation is usually contrived where the lecturer admits to not knowing the answer, in order to break down some of the barriers. It was also found to be useful to have a 5-10 minute pre-lecture on the educational/communication process. This covers how we communicate, the value of tutorials in reinforcing our knowledge, and emphasising that none of us can know it all.

6.4 Benefits of lectures combined with tutorials

The combination of lectures and tutorials (often termed workshop) was found to be far superior to other means of technology transfer. The tutorial forces participants to work through the technology, and shows up the misunderstandings and weaknesses. Results from tutorials in DoT appropriate standards workshops illustrate how effective it is (Table 4).

In these workshops, the first day was given over to lectures covering geometrics, hydraulics, traffic, materials, construction, maintenance, safety, and pavement structural design. The second day consisted of tutorials covering the main elements of the first day. Most tutorials were structured reasonably well (especially after fine tuning following the first presentation) and achieved good results. One tutorial was not well-structured and attempted to cover too much ground, but even so it was a substantial improvement on lectures alone.

Table 4: Benefits of lectures plus tutorials

STUDENT CAPABILITY WITH LECTURES ONLY	
Competent in new technology	8%
Not competent	92%

PERFORMANCE IN THE TUTORIALS FOLLOWING LECTURES	POORLY STRUCTURED TUTORIAL	WELL STRUCTURED TUTORIAL
Needed help to do tutorial	60%	83%
Could not complete tutorial, even with help.	36%	6%
STUDENT CAPABILITY AFTER LECTURES COMBINED WITH WELL STRUCTURED TUTORIALS		
Competent in new technology	64%	94%
Not competent	36%	6%

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6.5 Ideal structure for workshops

The ideal structure for a technology transfer workshop must provide for:

- varying audience level,
- technical topic,
- the audience to take it on board.

The exact programme depends on the topic and the audience. A numerical topic such as a new pavement design method demands more time spent on tutorials. It may even demand an extra day or part thereof. A soft topic such as new environmental legislation demands examples, but little calculation. The ideal structure provides variety to keep audience interest with short periods to retain attention. The programme is busy, but does not overload the audience. The content enables the audience to form images through practicals or tutorials. The timing of a one day, single subject seminar could be something like:

08h30 Introduction (with possible short video)
08h45 Lectures on research/theory
10h00 Tea
10h30 Lectures on field trials/case histories
11h20 Activity session: video, touching samples, or viewing a machine in the carpark
12h00 Worked example, i.e. a design
13h00 Lunch
14h00 Field inspection or tutorial session.

Evening (optional: workshop session for a part of the audience. Example would be a hands-on session on a new Pavement Management System, with about 10 computers each serving two people).

The refreshment timings are, not surprisingly, carefully thought out. It has been found that 15 minutes is too short to organise a tea break, but 30 minutes provides time for interaction and unhurried refreshment. Lunch has been found too difficult to organise in less than about 40 minutes; instead allowing 60 minutes allows some slack in the day to pick up the schedule and it allows participants to relax a little longer. It should be noted though that seminars are very busy outside these refreshment periods, and the timings are not a reflection of slow pace; rather they are a brief period of rest before a period of hard work.

To expand on the issue of seminar pace, it is felt highly desirable to push the participants and make them feel as though they have worked hard. The participants usually feel as though a busy day is more worthwhile. To cater for faster students, optional extra questions are put into the practicals and tutorials.

The use of well constructed videos can be an excellent teaching tool as well as a useful change of pace. SABITA have prepared videos covering all the bitumen test methods. Typically these cover a test in about 6-10 minutes, which contrasts well with a demonstration or practical which would have taken a whole afternoon. The video coverage is far better than the practical or demonstration.

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7 MONITORING

Most technology transfer activities in South Africa are subject to monitoring. A questionnaire is usually supplied to all audiences at all venues, and its completion and return is encouraged. The evidence from returns over the last four years have shown the audience appreciation of the improving technology transfer.

The analysis of questionnaires is somewhat difficult because many people tend not to be harshly judgmental. Thus on a scale of 1 (poor) to 5 (good), most people will record a 3 or 4. However the monitoring can indicate broad trends such as the success of a particular venue or the failure of a particular activity such as a demonstration. Various analysis methods have been tried to extract underlying trends, such as analysis of variance or normalisation (z-scores), but simple averaging has proved as good as any method.

8 CONCLUSIONS

The process of technology transfer can be enhanced to more effectively translate research findings into practice. The process of research should provide for technology transfer. The methods used include all of lectures, seminars, workshops, short courses, tutorials, field exercises, videos and handbooks. Lectures are still the primary method of transfer, but it was found that these have a number of shortcomings which require supporting activities to correct.

Tutorials were found to be a very valuable adjunct to lectures resulting in significant improvements in student capability. The ideal structure for a workshop includes both lectures and tutorials, and there are a number of guidelines which should be met.

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