Strategy Development Phase for the *Strategic Assessment of the Impact of the Utilisation of Research Findings in South Africa*

for the

National Advisory Council on Innovation

- Engagement Report -

20 February 2003

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AUTHOR: Rob Mulder

George Harley

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CONTACT DETAILS:
Access Market International
P.O. Box 10629
Centurion, 0046
Peter Place Park, Block F
54 Peter Place
Bryanston, 2021

[Tel] +27 (11) 548 0000
[Fax] +27 (11) 548 0010
rob.mulder@amiresearch.co.za

EXECUTIVE SUMMARY

A strategy for research utilisation was developed from extensive analysis of published information and synthesis of the survey of research outputs from Higher Education Institutions (HEI's), Science Councils (SC's) and private organisations, conducted by CENIS, 2002-3, across a number of sectors of the South African economy. Secondly inputs were derived from case studies conducted by the CSIR / HSRCon research projects where the extent of utilisation was questioned and key findings analysed. A number of key stakeholder views were also obtained from representatives across HEI's, SC's and industry and utilised in workshops were a strategy for research utilisation was developed.

From the synthesis, a number of key considerations and conclusions were drawn from the findings. The R&D strategy has the potential to addresses many issues related to utilisation, especially on the supply side. The realisation of a strategy on research utilisation would, increase investment and capacity in South Africa's science base and be aligned with the identified technology missions. It was found that a culture of commercialisation (and systems that influence behaviour) within HEI's and SC's is lacking and that collaboration between industry and SC's / HEI's is a significant factor affecting utilisation. It was also established that industry is increasingly pursuing a research strategy of collaboration and that capacity and cost are the two major factors considered by industry when deciding on collaboration (at global and country level). It was also established that programmes like THRIP are contributing significantly towards collaboration, and illustrates that research originating from outside the area where it is conducted has higher probability of being utilised. The experience of research project managers is a factor that contributes significantly to the extent of utilisation and the provision of incentives for results from research is required to drive and encourage utilisation. The measurement of the intended outcome (utility) and utilisation achieved is required within various institutions. These factors shaped the thinking around the formulation of the strategy.

The end-state definition has been derived from an in-depth synthesis of both the qualitative and quantitative findings of the research, summarised in the previous section. In addition to this inputs were considered and consensus was reached from both internal and external workshop participants.

The research utilisation goal in the long-term is envisaged to be an effective and efficient research utilisation system. The system would produce relevant research outputs that will ensure that research is utilised at levels that exceed 80% and the effectiveness of the resulting utilisation impacts on the economy in a quantifiable manner. It will also ensure that innovation goals, as outlined in the national system of innovation will be positively influenced by an ever-increasing amount of research being utilised in an efficient manner. Finally the capacity of research, across institutions and the private sector will be enhanced through effective and efficient research being conducted with the intent to utilise the same.

Three themes or grand strategies provide the context for the formulated strategic objectives, in ensuring that they remain aligned to what is envisaged for strategy utilisation in the future. These are

demand stimulation through investment in research initiatives, collaboration and communication and *research process effectiveness.*

From these themes, four main strategic objectives need to be pursued over the long term. Each strategic objective is supported by a number of interventions or initiatives that are required to be undertaken for the strategic objective to be achieved.

Table 1 Strategic objective 1

SO1	Stimulate innovation / technology development on the demand side (industry)	
SI 1.1.	Consider tax breaks for activities successfully completed throughout the commercialisation process	
SI 1.2	Strengthen funds like THRIP and the Innovation Fund through streamlining and increased funding and streamlining	
SI 1.3	Establish a Government venture capital/seed funding scheme	
SI 1.4	Link research to incentives that will in turn promote collaboration	

Table 2 Strategic objective 2

SO2	Develop a supply side culture of commercialisation	
SI 2.1	Mandate HEI's to establish functions that support and encourage cross-functional entrepreneurship	
SI 2.2	Revise and broaden the scientist recognition and grading system to include researchers and scientists in industry	
SI 2.3	Change the performance management system of HEI's and SC's (at individual, department and organisation) level to include measures of utilisable research outputs	
SI 2.4	Mandate HEI's and SC's to formalise IP policies and support structures	

Table 3 Strategic objective 3

SO3	**Facilitate collaboration and alignment between HEI's / SC's and industry**	
SI 3.1	Align research effort (funding, incentives, etc) with technology missions	
SI 3.2	Establish R&D strategies for technologies within sectors not addressed in R&D strategy	
SI 3.3	Encourage HEI's and SC's to promote capabilities and capacities to industry	
SI 3.4	Optimise the roles and linkages of transfer programmes	

Table 4 Strategic objective 4

SO4	**Improve the management and administration of research processes to improve utilisation**	
SI 4.1	Recognise value of entrepreneurial and experienced researchers and implement actions to maintain	
SI 4.2	Institutionalise formal "contracting" arrangements between research project and "client"	
SI 4.3	Align portfolio of projects (in terms of size of funding) with expected utilisation levels	

Two additional strategic initiatives, that are all encompassing, but not directly related any one of the previous strategic objectives, but essential to the over all realisation of the research utilisation strategy are to:

Table 5 Aligned strategic initiatives

SI 5	Implement the R&D strategy as a strategy support intervention	
SI 6	Design and implement a research utilisation measurement system	

The formulated strategy for the improvement of the utilisation of research is based on wide consultation and is a result of consensus being reached on the objectives and supporting interventions. Measurement criteria have been utilised in considering the execution of the different objectives and interventions.

In a strategy of this nature there is no one particular organisational entity responsible for the strategy. The rationale each behind each of the objectives and interventions is explained in the detail of the strategy, as are the suggested entities that should take responsibility for the execution. Also included are the priorities and what are thought to be the appropriate timelines for the realisation of the strategy over the next 8 years, at least.

Whoever the responsible entity or group of entities is for implementing a strategy as a whole or in part, it is absolutely essential that consensus be reached on each and every level of the strategy – the themes, the objectives and the initiatives as well a clear understanding as to when the objective has been achieved. Achieving this will in all probability result in significant in-roads being made in improving the utilisation of research in South Africa.

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1 BACKGROUND

"Failure of research utilisation is attributable to insufficient future planning"

-Anonymous-

The utilisation of research findings from research institutions has always been a problem for countries with a distinct research orientation and who are spending large amounts of money on research, both in academic higher education institutions as well as in the science councils. In some countries strict controls are imposed on the scope of research undertaken to ensure it is focused and can be utilised in the long – term to the benefit of industry and / or society.

There is strong evidence that sustained investment in research and development (R&D), as well as mechanisms for stimulating successful innovation, can have a direct impact on economic development in a country. This has been attributed to the growth in several technologically leading countries in North America, Europe and New Zealand. Work undertaken by Fedderke, DeKadt and Luiz (2000), underpins this by drawing several relationships between economic variables and economic growth.

Several problems exist in terms of undertaking research and the utilisation of research thereafter. The first is the orientation of the researcher, secondly the extent of responsibility that the researcher feels for coming up with a practicable result and thirdly the credibility of the research methodology in terms of the practical realisation of the research.

South Africa has been investing considerable amounts of money in research across Higher Education Institutions (HEI's), Science Councils (SC's), National Facilities, Government Departments and State Corporations. Although the Science vote allocation in the Department of Science and Technology was R1 509 million in 2001/2002, the investments in R&D appear from the latest reports (S&T Facts and Figures), appears to be considerably higher in some institutions. If the Higher Education Sector is taken as an example, an amount of R2 015 million has been reported, which includes labour cost, as it should. Science Councils are currently estimated to be in the region of R13 million.

Since much research undertaken is funded with public money, it is also in the public interest to assess whether this research adds value. There appears to be increasing pressure on Government to provide answers on the achievements relating to R&D expenditure, and also a public right. Answers need to be provided through the National Advisory Council on Innovation (NACI), which forms the basis of this engagement.

The South African Government has adopted an explicit strategy of innovation. Innovation is an important precursor to the promotion of successful R&D. It is the National Advisory Council on Innovation function to "develop strategies for the promotion of technology innovation, development,

acquisition transfer and implementation in all sectors". This needs to be aligned with the aims of the national economy and the sectors that are likely to make the greatest contribution. When this is understood the formulation of effective strategies for the optimisation of the outcomes of the national R&D effort are imperative.

Essential to innovation is research and the proper utilisation thereof. Given this background there appears to be little understanding on the dynamics involved on the utilisation of research findings in South Africa and to what extent South Africa is being successful or not. To this extent there is a need to understand the current situation with respect to the implementation of research findings and how any shortcomings in the process can be improved with the establishments of a model for managing research and optimising the implementation of research findings.

In order to understand whether the strategy of innovation is materialising, it is necessary to determine whether research is actually utilised.

The report that follows is the output of extensive synthesis of available research in the public domain as well as the inputs from the work undertaken by CENIS and the HSRC / CSIR consortium.

2 OBJECTIVES, APPROACH AND SCOPE

2.1 Objectives

The fundamental objectives of the overall project were as follows:

- To assess the current situation with regards to the utilisation and / or implementation of research findings in South Africa (CENIS)
- To map the dynamics of the process of implementation of research findings (HSRC / CSIR)
- Formulate recommendations and develop a model of and strategy for the optimisation of research findings that will improve the utilisation of research in South Africa.These were the main objectives outlined in the Terms of Reference.

For NACI to make an informed decision on establishing a set of recommendations to government on how to address the problems associated with the utilisation of research findings, the following sub-objectives were set.

The overall strategy formulation objective of this engagement is defined as follows:

> To improve the effectiveness and efficiency of the way in which research findings can be leveraged into utilisable and implementable outcomes that will have a positive impact on the economy
>
> To provide a strategic framework and develop initiatives to provide input to policy makers for improving the utility of research findings in South Africa.

To develop a strategy for optimising the implementation of research findings based on a business model for the effective management of the research process.

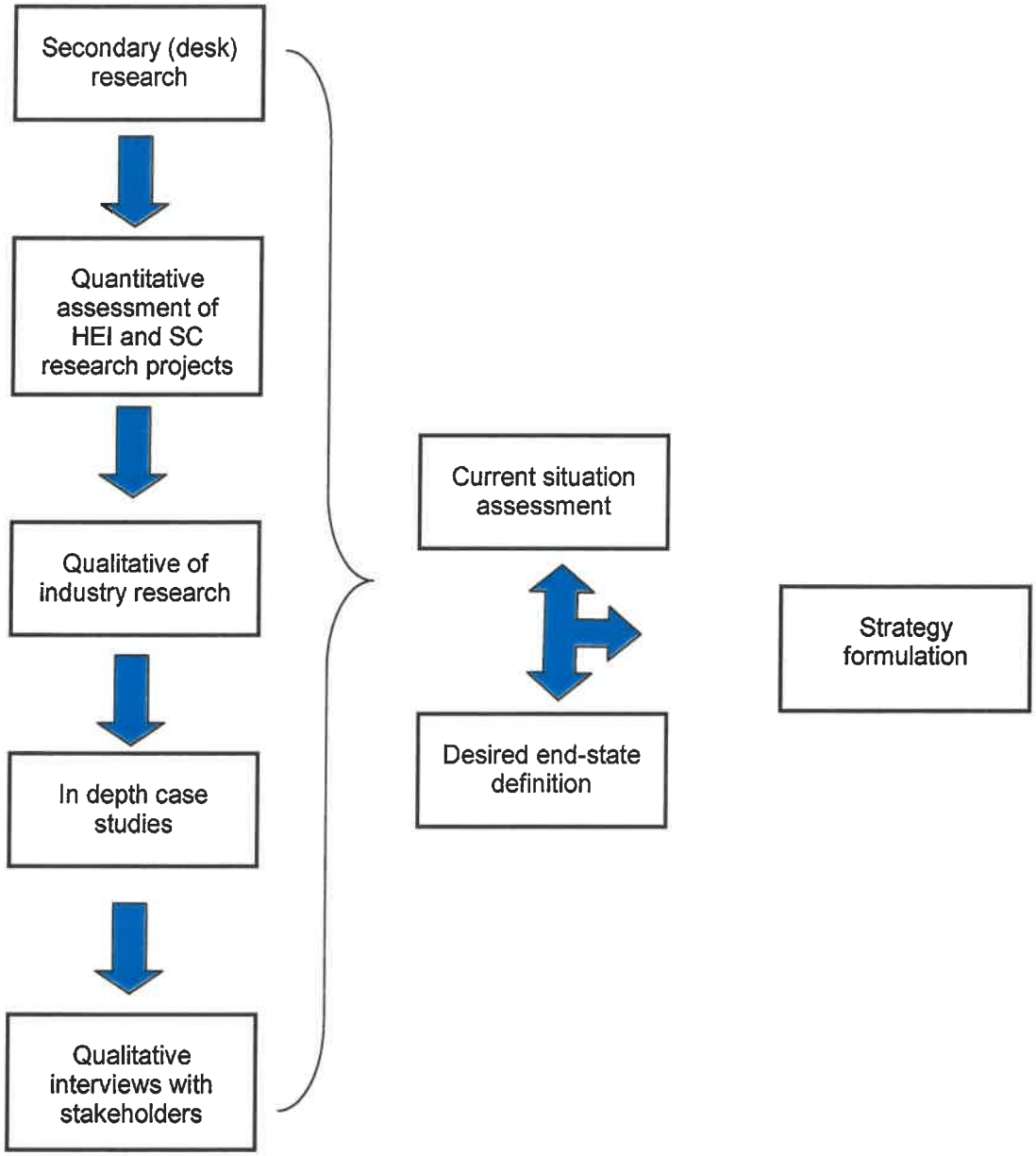
To make recommendations as to what actions need to be undertaken to address the current poor research utilisation in South Africa.

2.2 Approach

The approach followed to the development of the strategy is reflected in Figure 1 below.

It shows how the findings of primary research conducted by AMI, CENIS, the CSIR / HSRC consortium are assessed with a view of understanding the current situation, the identification of gaps between the current situation and a situation of improved utilisation, with corresponding recommendations.

Figure 1 Approach to the strategy formulation engagement



2.3 Scope

The research scope was defined as follows;

- **Geography** – The project was restricted to research conducted in South Africa
- **Producers of research in South Africa** – Higher Education Institutions (HEI's), Science councils (SC's), industry associations and public and private sector organisations
- **Institutional scope** – industrial as well as commercial research

- **Research End Uses** - This will be defined as the place where the research is utilised
- **Timing** - 2001 was used as the base year for measuring the utilisation of research from an output base year of 1997 / 1998

2.4 Inputs in to the strategy development process

Four types of inputs have been utilised for the synthesis prior to and during the strategy development process. These are:

PHASE 1 – The research institution and private sector research output survey.

CENIS conducted baseline secondary research, which was utilised to understand the context of research utilisation as well as international trends. The terminology utilised in research was also adopted for the strategy development exercise.

The sample realised in this quantitative assessment was as follows

Table 6•Quantitative assessment of research projects in HEI's and SC's, conducted by CENIS

Sector	Respondents		Projects	
	N	%	N	%
Science councils	625	30	539	30
Universities	1192	58	1081	60
Technikons	241	12	183	10
Total	2058	100	1803	100

CENIS also conducted interviews in the private sector, and the following interviews were realised:

112 interviews were conducted representing 19 sub-sectors, predominantly in the primary and secondary sectors of the economy.

PHASE 2 – A quantitative analysis was conducted on how research was utilised. This research was undertaken utilising the case study method. In total 12 cases were researched.

The sample that was realised covered the following types of institution and spanned the following sectors.

Table 7 Case Study sample frame and sector representation

SECTOR	Strategic	Applied	Commercial
Agricultural	-	Genetically engineered crop improvement	-
Mining	Rock Fracturing	-	Gold Leaching
Manufacture	Polymeric Materials	Wine technology	PET Recycling
Utilities	-	Renewable energy Power quality compensator	-
Construction Transport	-		Heavy Vehicle Simulation
Wholesale & Retail	-	-	-
Financial& Professional Services	-	-	-
Social & Welfare	-	Tobacco control	Crime DSS
Government	-	National Research and Technology Foresight Project	-

PHASE 3 – Qualitative assessment of issues for strategy development.

Some 22 stakeholder interviews were conducted by AMI to gain insights to the topic of research utilisation, across a representative range of high level stakeholders. Issues raised were recorded as well as references to suggesting practically operating examples in local and international institutions as well as in private firms.

Stakeholder interview sample breakdown:

- HEI academics = 4
- Research experts = 4 (2 international experts - indirectly)
- Government = 2
- Industry = 6
- Science councils = 6

Two important outputs emerged from the interviews. Numerous issues regarding research utilisation were raised, which were recorded and subjected to further synthesis with the outputs from CENIS and the HSRC / CSIR consortium. The second outputs from the interviews were suggestions based

on experiences that were postulated to address the issues both positive and negative regarding research utilisation.

2.5 Caveats

Research conducted in NGO's and private sector organisations was not representative of the different sectors in the South African economy. Results emerging from this analysis were regarded as indicative rather than representative of the full spectrum of industry.

Case study information was limited in terms of the representativeness of the 12 case studies that were reported on and the lessons learned in the utilisation of research. The extensive variability of research projects was restricted due to the number of cases undertaken, due to budget constraints.

For this reason an extremely limited number of sectors were covered as well as types of research undertaken by the different producers of research. For this reason cross tabulations in terms of content analysis across sectors, types of research and type of research institution producing research were not possible.

3 THE CONTEXT OF RESEARCH UTILISATION

3.1 Definition of research utilisation

For purposes of this strategy formulation task, the following definition of research utilisation was utilised[1].

Table 8 Definitions of research utilisation

Epistemic utility (knowledge)	Economic and/or commercial utility	Social or political utility
Advancement of knowledge	Solving technical or applied problems	Solving social/environmental problems
Solving theoretical problems	Development of a new technology	Influencing decision-makers
Skills development	Engineering a prototype	Changing behaviour
Training of students	Modification of existing products and designs	Changing legislation
	Entrance into new markets	

The above defines utilisation in terms of the outcome (or utility) of research and has been used extensively as a basic in the strategy formulation process. Three broad categories of possible outcomes are as follows:

- *Epistemic utility*: This is where the outcome or utility of the research contributed to the development of the knowledge domain related to the research. It is often said that this research is conducted for the "sake of producing knowledge".
- *Economic and/or commercial utility*: This is where the outcome resulted in commercial or economic gain (utility), most typically through the successful commercialisation of the knowledge resulting in new or improved products and processes
- *Social or political utility*: This is where the research has value (utility) for the society at large, or for political decision making.

AMI feel that these categories should be utilised on an ongoing basis as a useful framework for tracking research utilisation. The utility or value in each of the three categories is obviously distinctly different, and it is felt that relative proportions of the activity and therefore investment needs to be related to the prevailing circumstances in the current economic situation of a country. One conclusion

[1] CENIS, 2002

that can be drawn is that if for example the *epistemic utility* is very high, due to primary focus on knowledge generation the commercial / economic and social / political needs may not be efficiently addressed. It is however realised that investments in the *epistemic utility* resulting in knowledge generation, may not always be relevant immediately, but turn out to be very relevant in the future. Therefore AMI concluded that the "right mix" of the three utilities of research that is aligned to the countries needs, thus impacting on the economy in a most positive way, is of paramount importance.

Since much research undertaken is funded with public money, it is also in the public interest to assess whether this research adds value. Utilising the definitions suggested by CENIS and reaching consensus on the relative proportions of funding and investment within the three categories might be to improve utilisation over the medium term.

3.2 The broader context of research and the utilisation thereof

The broader context of research and research utilisation is defined at both the macro – and micro level.

3.2.1 Macro-level context

The industrial development blueprint for South Africa, which includes NEDPAD, The presidential imperatives, the white paper on science and technology, the R&D Strategy as well as various industrial development strategies.

Some of the key considerations and these are not meant to be exhaustive but reflective of the role is as follows:

- New Africa Initiative (NEPAD)
  - Market access
  - Beneficiation / diversification of production and exports
  - Investing in ICT and basic infrastructure
  - Developing financing and investment mechanisms
  - Human development
- Presidential imperatives
  - Job creation
  - SMME development
  - Human resource development
  - Development of indigenous business
- Relevant aspects of industrial development
  - FDI (Foreign direct investment)
  - Export promotion

- Globally competitive industries

Key components of the above are the system for innovation, the need to attract direct foreign investment (FDI), export promotion and SMME development.

In order to understand whether a system of innovation, as presented in the R&D strategy, is materialising, it is necessary to determine the contribution of one of the components, that is, whether research is actually utilised. The utilisation of research has a significant impact the system for innovation. By looking at the definition previously advocated, it impacts on knowledge generation as well as all aspects of the economy, either in a direct or indirect way.

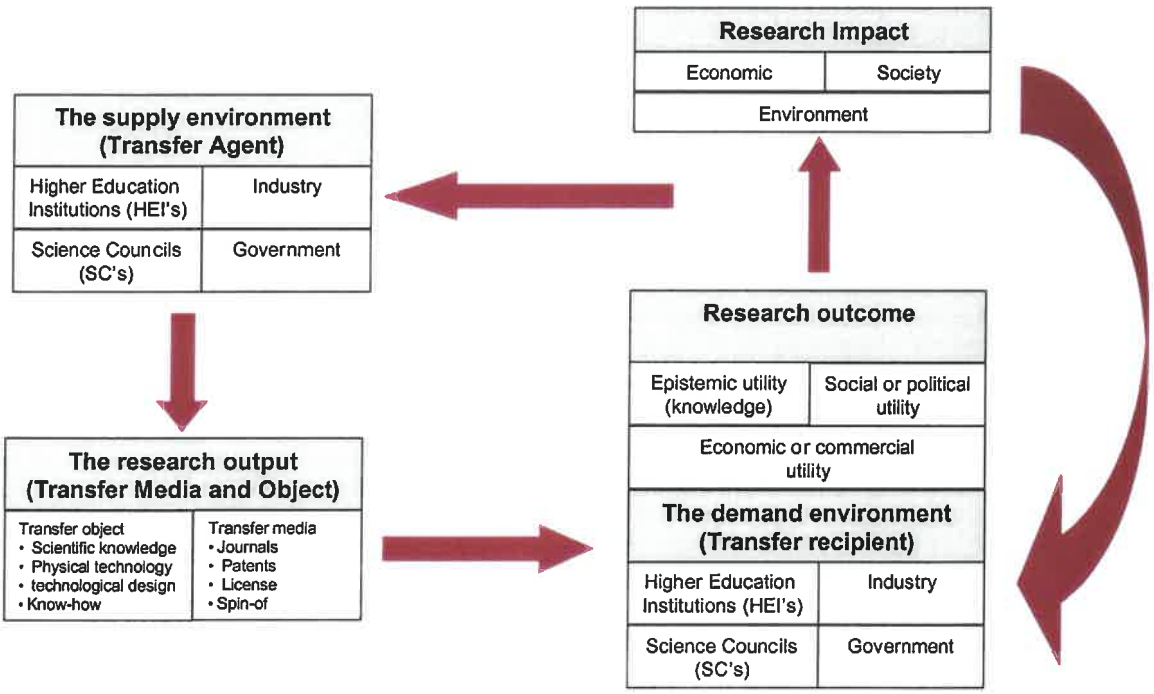
3.3 Research utilisation model, modified Bozeman model

The model used as basis for analysis is depicted below. It is adaptation of the "contingency effectiveness model of technology transfer", developed by Bozeman. The Bozeman model identified the key components of the transfer trajectory as follows:

Dimension	Focus	Examples
Transfer agent	The institution or organisation seeking to transfer the technology	Government agency, university, firm
Transfer medium	The vehicle, formal or informal, by which the technology is transferred	License, copyright, person -to-person, formal scientific literature
Transfer object	The content and form of what is transferred	Scientific knowledge, technological device, process, know -how and specific characteristics of each
Transfer recipient	The organisation or institution receiving the transfer object	Firm, agency, consumer, user group, institution and associated characteristics
Demand environment	Factors (market and non -market) pertaining to the need for the transferred object	Price for technology, substitutability, relation to technologies now in use, subsidy, market shelters

The model was modified for two reasons. The first is to cater for practical implications such as the reality that the demand environment and transfer recipient is more than often essentially the same. The second is related to terminology, for example "research impact" is probably a better descriptor of the outcome than effectiveness.

Figure 2 Modified Bozeman model



4 CURRENT SITUATION ASSESSMENT

The modified Bozeman model formed the basis of the assessment of the current state of utilisation in South Africa, as follows:

- Assessment of the demand environment, including an assessment of research outcome (intended utility and levels of utilisation)
- Assessment of the supply environment, including an assessment of research output and transfer modes

4.1 Research outcome and the demand environment

A number of issues relating to the demand side, i.e. the outcome of research and the users of research are of paramount importance for the development of a strategy for improved research utilisation. The primary issues assessed are as follows:

- What is the current intent of research, and what should be the future desired intent?
- What are current and future desired levels of research utilisation?
- What is the relationship between the types of research conducted, the domains in which it is being conducted and the levels of utilisation achieved?

- How is research initiated (triggered) and how does the contracting arrangements between the user and researcher impact utilisation?
- To what extent do incentives for research and technology development impact on utilisation?
- What are the drivers of research in industry, what is industry's approach to research, and what are the factors that impact utilisation of research in industry?

4.1.1 The intent of research

The intent of research conducted by SC's and HEI's, in terms of expected utility is summarised in the following diagram.

Table 9 Intent of research conducted

Epistemic utility (knowledge)	% success-ful	Economic utility	% success-ful	Social or political utility	% success-ful
Advancement of knowledge	**69%**	Solving of technical or applied problems	**24%**	Solving social and environmental problems	**21%**
Solving theoretical problems	**13%**	Development of a new technology	**14%**	Influencing decision-makers	**22%**
Skills development	**33%**	Modification of existing products and designs	**8%**	Changing behaviour	**19%**
Training of students	**29%**	Engineering a prototype	**3%**	Changing legislation	**4%**
		Entrance into new markets	**3%**		
Weighted average	**58%**		**19%**		**23%**

From the above diagram it can be see that a significant proportion (81%) of research projects were expected to result in non-commercial utility. Considering that this includes projects conducted by HEI's, it is not surprising that there is such a high emphasis on the development of epistemic knowledge. However, further analysis indicated that research conducted within SC's with the intent of commercial utility is well below expectations, as illustrated in Table 10. It is especially concerning that there is such a low focus on activities further down the commercialisation process (prototyping and entrance into new markets, It is therefore concluded that the focus of research conducted by SC's needs to be re-orientated towards research, which will have an increased chance of realising a commercial outcome.

Table 10 Successful research utilisation

Epistemic utility (knowledge)	%	Economic utility	%	Social or political utility	%
Advancement of knowledge	66%	Solving of technical or applied problems	39%	Solving social and environmental problems	16%
Solving theoretical problems	9%	Development of a new technology	24%	Influencing decision-makers	23%
Skills development	34%	Modification of existing products and designs	12%	Changing behaviour	12%
Training of students	11%	Engineering a prototype	5%	Changing legislation	5%
		Entrance into new markets	7%		

Although the desired intent in terms of research outcome was not explicitly researched, participants to the strategy development workshop indicated that the following could be used as a rough guide.

Stakeholder representatives felt that, in the light of the national system of innovation's objectives the proportion of research that should carefully considered and aligned to the needs of the country. Although the percentages in the table below are indicative, the exact proportion of research undertaken in the three previously defined categories would need to be agreed between the major government stakeholders.

Table 11 Research undertaken in the different research categories

RESEARCH CATEGORY	Science Councils	HEI's
Epistemic utility (knowledge)	**Low < 25%**	**High 50 - 75%**
Economic and commercial utility	**High 50 - 75%**	**Medium 25 – 50%**
Social or political utility	**Low <25%**	**Low > 25%**

It is believed that this concept could be used, as a strategic analysis tool in the research utilisation strategy.

4.1.2 Utilisation of research

The primary research conducted as part of this study indicated that utilisation of research conducted by SC's and HEI's varies as follows[2]:

[2] CENIS, 2002

Table 12 Utilisation of research

Epistemic utility (knowledge)	% success-ful	Economic utility	% success-ful	Social or political utility	% success-ful
Advancement of knowledge	67%	Solving of technical or applied problems	53%	Solving social and environmental problems	27%
Solving theoretical problems	42%	Development of a new technology	54%	Influencing decision-makers	28%
Skills development	67%	Modification of existing products and designs	53%	Changing behaviour	27%
Training of students	66%	Engineering a prototype	34%	Changing legislation	18%
		Entrance into new markets	53%		
Weighted average	62%		52%		27%

Since the utilisation was not unpacked to reflect utilisation achieved between HEI's and SC's only general conclusions on the state of utilisation could be made.

- In discussions with various stakeholders the general opinion that emerged is that utilisation levels of 75% and above should be pursued
- Utilisation should be even higher where research is aimed at building epistemic knowledge, since the research is conducted within the area of self-utilisation, typically the academic environment
- No definite explanations could be found for the extremely low levels of utilisation when research is conducted for social/political utility

The findings highlighted the fact that that the relatively low levels of utilisation needs to be addressed. The results have also been able to establish a baseline for utilisation, upon which improvements can be measured. This is considered to important for the tracking of any strategy setting about to improve utilisation.

4.2 Types of research and research domains

The primary research, using the standard Frascati distinction between basic fundamental, basic strategic and applied research, indicated at follows:

Although no explicit analysis of the relationship between the type of research and research utilisation was done it can readily be expected that utilisation of fundamental and strategic research will be lower than that of applied research. This distinction was not emphasised in the strategy formulation process, as initiatives relating to the research categories were deemed to be more important.

Table 13 Modes of knowledge production

Mode	Motive	Time-frame	Audience	Funding source	Dissemi-nation	Quality control
Funda-mental	Curiosity	Indefinite	World of science	Scarce Own institution Public funding	Scientific publications/ Presentations	Peer review
Strategic	Curiosity + Utility	Long-term	World of science and other as yet unidentified beneficiaries	Public funding Other sources	Scientific forms	Peer review/ Potential users
Applied	Utility	Short- to medium-term	Specific users/ beneficiaries	Private funding	Confidential contract reports/ strategic briefings	User satisfaction

This is because the mode of research already 'pre-determines' or at least 'influences' the following factors related to utilisation:

- The motivation for research, i.e. where the research is motivated by curiosity, lower levels of utilisation can be expected.
- The expected value of the research output, i.e. the expected value of applied research is more immediate and utilisation more immediate.
- The intended target audience or beneficiaries of the research output(s), i.e. when there is a specific audience utilisation can be expected to be higher.

Table 14 indicates that there is a correlation between utilisation and the research domain.

Table 14 Cross tabulation between research utilisation and broad research domain

Broad research domain	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				No. of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
Agricultural sciences	69.3	13.2	5.8	11.7	326
Environmental sciences	66.2	12.9	8.3	12.6	278
Engineering sciences	64.8	12.2	11.7	11.3	213
Biological sciences	64.6	15.8	6.7	12.8	297
Medical sciences: clinical	64.1	9.4	4.7	21.9	64
Earth sciences	63.6	19.7	5.3	11.4	132
Physical sciences	63.2	7.9	7.9	21.1	76
Applied science and technologies	60.6	16.2	12.4	10.9	340
Information and communication technologies	59.6	16.3	12.1	12.1	141
Medical sciences: basic	58.7	15.2	6.5	19.6	92
Chemical sciences	58.5	13.0	12.2	16.3	123
Marine sciences	56.8	21.6	8.1	13.5	37
Health sciences	56.6	17.2	8.1	18.2	297
Material sciences	56.0	18.7	12.0	13.3	75
Arts and humanities	53.2	18.9	5.7	22.2	333
Economic and management sciences	53.1	20.6	7.0	19.3	243
Social sciences	52.9	21.9	8.3	16.9	433
Mathematical sciences	52.3	17.4	5.8	24.4	86

The research outcome of projects within the agriculture, environmental, engineering and biological sciences domains are more likely to be utilised that those in the arts and humanities, economic and management sciences as well as the social and mathematical domains. This is hardly surprising, and in light of the previous assessment of research types and expected utilisation, it is recognised that the trigger for mathematical and socially oriented sciences are inherently more likely to be own curiosity or interest, which inherently results in lower utilisation. It must also be considered that further analysis indicates that collaboration is the overbearing factor which influences utilisation within all domains.

It is therefore concluded that when utilisation is analysed it should be considered that applied and strategic research conducted on some domains such as social sciences, would inherently be lower

that applied research conducted in more technical domains such as engineering. As mentioned previously this distinction was not considered in the strategy.

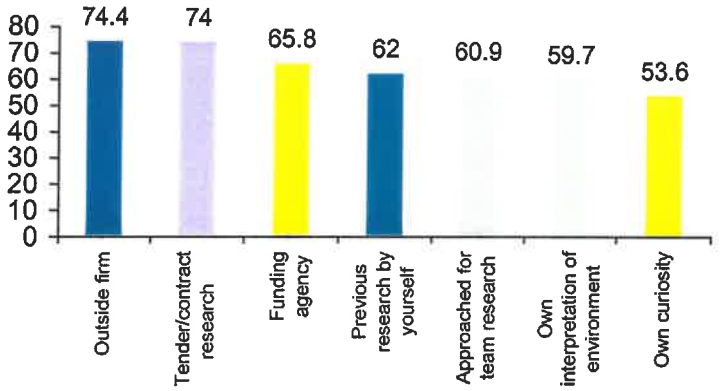
4.2.1 Research triggers and contracting arrangements between the users and researchers

The primary research indicated that research triggered outside the immediate research environment has a higher probability of being utilised, as indicated below (Table 15 and Figure 3. Furthermore, the primary research also indicates that research utilisation is higher when it is commissioned and there is a clear contract in place.

Table 15 Cross tabulation between research utilisation and the motive or reason for the research

What triggered the research?	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
An outside firm/ company/ institution approaching you	74.4	11.4	5.8	8.4	359
A tender/contract research	74.0	12.2	5.5	8.3	181
A funding agency requesting proposals	68.5	14.7	4.9	12.0	184
Previous research by yourself	62.0	15.8	5.9	16.2	727
Colleague(s) approaching you to form part of a team	60.9	14.4	8.4	16.3	417
Own interpretation of the immediate/ future environment	59.7	21.2	6.7	12.4	466
Own curiosity or research interest	53.6	17.5	8.5	20.4	858

Figure 3 Triggers of research and effective utilisation



The implication of these findings is that research is undertaken within SC's and HEI's for utilisation within these institutions, there is merit in establishing clear "customer" and "service provider" roles, with a clearly defined project objective and scope, formalised in a "contractual" arrangement.

4.2.2 Incentives and utilisation

There are currently no incentives specifically aimed at improving research utilisation. There are however a number of incentives which has an indirect impact on utilisation.

The Innovation Fund and Support Programme for Industrial Innovation (SPII) are both aimed at stimulating innovation (research is generally inherent to innovation), and subsequent commercialisation of the innovation. Although it is generally agreed that both these programmes have had a positive impact not only in terms of providing incentive for firms to conduct research and innovate but also the utilisation of such research, there is room for improvement.

Stakeholders in general agreed that both funds should provide for longer-term projects, and that application processes should be simplified. Although some stakeholders indicated that the scope of such programmes in terms of sectors targeted should be broadened (currently the focus is on advanced manufacturing materials, ICT and biotechnology), this notion is not supported if one considers the resource constraints of South Africa. An approach where incentives are focused on the technology missions as identified by the R&D strategy, is supported.

The Technology and Human Resources for Industry programme (THRIP), which is aimed at fostering collaboration between SC's HEI's and industry is generally viewed to be a successful programme, and in view of the importance of collaboration to eventual utilisation of research, it can be concluded that THRIP has a positive impact on improving utilisation. It is concluded that levels of funding available through THRIP should at least be maintained, and increased if the opportunity arises.

There are however a number of other issues, beyond that of specific incentives, that need to be considered. The first is that utilisation can be improved when more emphasis is placed on providing additional incentives for technology development and commercialisation of technology. There is general agreement that more incentives are required further down the commercialisation value chain. "Stage-gate" type tax breaks, which provide financial rewards for activities successfully completed along the value chain (e.g. patenting, prototyping, market release, etc.), should result in improved utilisation.

The qualitative research also indicated that many innovations/research does not get commercialised due to a lack of access to and availability of venture capital. It is common knowledge that South Africa has a poorly developed private sector venture capital system, and there is agreement amongst stakeholders that a publicly funded venture capital (including for seed funding) fund will not only have a positive impact on improving research utilisation, but also many other country level objectives such as SMME creation and employment creation.

4.2.3 Research utilisation in industry

CENIS and AMI conducted extensive qualitative research into the utilisation of research within industry. The key findings are as follows:

- The drivers for research within industry are more often than not regulations and standards, cost reduction and improving quality. Also mentioned, but as a lower priority were innovation, technological problem solving and technology push. This is indicative of South African industry, which by and large is still making the transition towards global competitiveness (cost, quality and compliance). It can be expected that innovation and new technology development will become more significant drivers as industry moves into the next phase of global competitiveness, which revolves around innovation and technical leadership.

- An important consideration is that industry generally has much more control over the outcome (utilisation) of research undertaken, than experienced by SC's and HEI's. This is because industry decides on the purpose and nature of the research to be conducted as well as on the acceptable risk versus return equation. The latter is especially important when assessing utilisation levels. Previous studies indicated that the levels of research conducted within the private sector are low, and a natural extension of low investment in research is low levels of risk, and therefore higher utilisation.

- Another important consideration is that firms are increasingly pursuing a research strategy of collaboration with SC's, HEI's and other research organisations. This is important for a number of reasons. First of all, collaboration has been identified as a significant factor of utilisation, and such an approach should result in higher utilisation of projects in general. Secondly, a strategy of collaboration with HEI's and SC's will in the longer term result in increased capacity within SC's

and HEI's, especially if recommendations of this study regarding more incentives for commercialisation/technology development within industry are implemented.

- The extent of collaboration, the range of partners, intellectual property arrangements, and contracting mechanisms varies between firms and no specific best practices could be identified.

- The lack of adequate skilled human resources (capacity within HEI's and SC's), the high cost of research and development, and cumbersome administrative processes of current incentives were factors that were frequently mentioned as inhibitors to utilisation.

- A last, but most important issue of national importance is that South Africa is internationally perceived to be an inexpensive site for research. Limited R&D capacity in many areas is however preventing South Africa from becoming a preferred R&D destination.

4.3 The supply environment, research outputs and the transfer modes

Three groups of issues were identified for investigation. The first group of issues are those that relate to the entities active on the supply side (HEI's, SC's, industry and other players), their roles, capacity and activities. The second category of issues is project related factors which impact utilisation, and the last is research outputs and transfer modes.

4.3.1 The role, capacity and activities of entities in the supply-side

The research conducted for this study focussed primarily on the HEI's and SC's as producers of research, as well as in industry, the latter being both a supplier and user of research. The role of government departments, which also conduct research, was excluded from the study. The following are the primary findings of the qualitative research:

There is need to establish more specialised research institutions within HEI's and SC's: Stakeholders are in agreement that there is a need for a higher degree of focus (and corresponding allocation of funding) within HEI's and SC's in terms of specialisation of research institutions, departments and programmes. The requirement for focus was also identified in the R&D strategy, and the recommendations of the R&D[3] strategy, namely that alignment with South Africa's economic and social development strategies in general, and alignment with the identified technology missions, in particular, should be pursued. The following missions, as identified in the R&D strategy, should be guiding in terms of capacity development, allocation of funding, etc.

- Poverty reduction (technologies that impact on quality of life and enhanced delivery)

- Key technology platforms (Biotechnology and ICT)

[3] South Africa's National Research Research and Development Strategy, August 2002

- Advanced manufacturing
- Developing new knowledge based industries from resource-based industries
- The primary objectives (role) of HEI's and SC's

The research capacity of the supply side need to e strengthened: The assessment of the current status of Science and Technology (S&T) capacity in South Africa, conducted during 2002 under the auspice of NACI, raised a number of concerns[4]:

- Expenditure on R&D is low, compared to the ideal of one percent of GDP (currently 0.64%)
- The population which produces research is ageing
- The number of enrolments for mathematics and science at school and tertiary level remains low
- Scientific output is nor growing, in fact there was a small decline since the mid 1990's
- The demographics of those involved in the S&T system does not reflect the demographics of the country

Although the National R&D Strategy specifies a number of interventions (and increased funding) aimed at strengthening S&T capacity, such as the development of Centres of Excellence, the establishment of networks for collaboration, new financing for capital equipment and additional funding for science focus areas, it is the view of this research team that there is not enough emphasis on stimulating the demand (industry) for research and technology development.

The rationale for the above hinges on three very strong findings:

a) The need for HEI's and especially SC's to conduct more research with the aim of increasing the economic / commercial utility. Increased activity in industry, where commercialisation is the primary intent, will induce a changed focus on the supply side.

b) Industry's apparent willingness to collaborate with HEI's and SC's implies increased activity on the demand side will result in increased capacity on the supply side.

c) The research clearly indicated that research originating outside the research institution has a higher probability of being utilised.

It is therefore concluded that investment in stimulating research and technology development on the demand side will result in capacity development. Specific interventions are recommended elsewhere in this document, as part of the strategy.

[4] South African Science and Technology - Key Facts and Figures 2002, NACI, 2002

Need to increase the commercialisation focus within HEI's

The qualitative research indicated that although HEI's are beginning to increase their focus on commercialisation of knowledge, there is a need to accelerate the implementation of mechanisms that will encourage commercialisation. It is however of utmost importance to recognise that the core business of HEI's must always be on teaching and training – a complete transformation is not desirable.

A number HEI's were in process of implementing a number of activities aimed at encouraging commercialisation. It is well worth considering some of these activities for general implementation.

- The establishment of specialised units, which has the specific purpose of commercialisation of knowledge and support to departments on matters such as patenting, licensing, feasibility analysis, etc. It in generally agreed that it is desirable to have such units operating as stand-alone units that support departments, rather than integrating commercialisation activities within academic departments.

- At many HEI's the performance measurement system for researchers is evolving to include measurements that reflect utilisation, and specifically the achievement of economic / commercial utility. This practice is supported.

- The establishment of a cross-departmental function that encourages entrepreneurship and commercialisation of knowledge is another practice that has emerged and is operating successfully in a number of HEI's. This function is however different to the specialised units which supports departments in the commercialisation process. The latter offers technical support, whereas the former is aimed at establishing a profile (culture) of entrepreneurship.

Need to review the role of Government Departments, Science Councils and transfer and diffusion agents

The findings of research conducted as part of this study echoes the need for clearer definition of roles of various role-players, as well as some re-alignment in terms of positioning and governance, as recommended in the National R&D Strategy. Stakeholders are of the opinion that HEI's, SC's and industry could be better aligned, with the national needs and objectives in the country.

4.3.2 Project related factors

The relationship between a number of project related factors and utilisation were established as part of the quantitative research conducted.

The relationship between collaboration and research utilisation

From the following diagram it can clearly be seen that collaboration is a significant contributor to improved utilisation.

Table 16 Cross tabulation between research utilisation and collaboration on the project

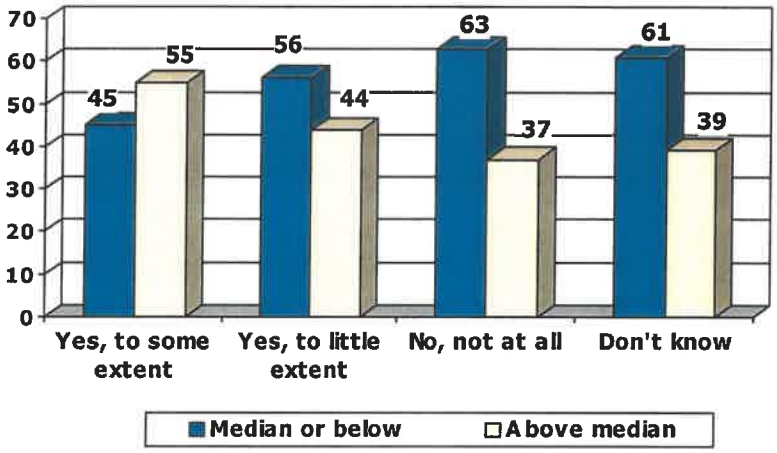
Collaboration	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
All sectors					
Yes	62.5	16.0	6.3	15.2	1320
No	39.6	19.2	13.0	28.3	407
Science councils					
Yes	66.5	17.0	6.6	9.9	454
No	47.0	12.1	18.2	22.7	66
Universities					
Yes	61.2	15.0	5.6	18.2	752
No	40.2	20.6	10.1	29.0	286
Technikons					
Yes	55.3	18.4	9.6	16.7	114
No	27.3	20.0	21.8	30.9	55

It was furthermore established that collaboration outside the immediate research environment, especially with researchers outside R&D institutions, has a positive impact on utilisation. Although progress has been made towards fostering a culture of collaboration between HEI's / SC's and industry (the positive impact of programmes such as THRIP has been discussed), Table 16 indicates that there is additional activity required to encourage collaboration between HEI's / SC's and industry.

The relationship between the experience of project leaders and research utilisation

The primary research found a strong correlation between utilisation of research and the experience of project leaders.

Figure 4 Cross tabulation between research utilisation and years of research experience



Considering the concerns around the ageing population of scientists, there is a need to implement actions aimed at not only retaining experienced researchers, but also on developing maintaining a pool of experienced researchers which can successfully lead the next generation of research projects.

The relationship between size of project funding and research utilisation

Although a correlation between the size of research projects (in terms of funding) and utilisation was established, it must be guarded against drawing a specific conclusion that it is desirable for research projects to be large.

Table 17 The relationship between the size of project funding and research utilisation

Funding	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
Higher education					
Less than R50 000	44.0	20.9	9.0	26.2	657
R50 000 – R249 000	63.8	13.0	7.2	15.9	276
R250 000 or more	74.9	12.8	5.2	7.1	211
Science council sector					
Less than R250 000	58.3	16.2	7.9	17.6	216
R250 000 – R999 000	65.1	18.6	9.3	7.0	172
R1 000 000 or more	70.8	15.4	6.5	7.3	123

According to Branscomb[5] the appropriateness of federal funding of research should rest on the identification of the expected beneficiaries of the work, not the level of abstractness or the practicality of the work or the motives of the investigator in undertaking it. When the public is the primary intended beneficiary, public investment is appropriate, provided the work is done under highly creative intellectually competitive conditions and the results are widely diffused and appreciated.

When large amounts of money are invested in research projects, it is natural that the risk profile, i.e. the probability of no utilisation, be reduced. There is always a need for smaller research projects within higher inherent risk profiles. The objective should rather be to influence the other factors that contribute to utilisation in order to improve the overall utilisation of all projects.

The relationship between the percentage of time spent on projects and research utilisation

The following diagram provides a correlation between the time spent on research projects and the intended utilisation.

Table 18 The relationship between the percentage of time spent on projects and research utilisation

Time spent on project	Did the intended beneficiaries recognise/ utilise/ implement the research as planned?				Number of projects
	Yes, to some extent	Yes, to little extent	No, not at all	Don't know	
Universities					
10-20%	54.3	15.2	6.7	23.8	466
30-40%	56.2	20.3	6.1	17.4	345
50%+	56.8	13.1	8.5	21.6	236
Technikons					
10-20%	43.1	19.4	13.9	23.6	72
30-40%	44.8	20.9	16.4	17.9	67
50%+	56.7	10.0	6.7	26.7	30
Science councils					
10-20%	69.3	13.6	4.5	12.5	88
30-40%	64.4	15.6	7.4	12.6	135
50%+	62.7	17.7	9.3	10.3	300

The table indicates that there is no consistent correlation between utilisation and the time spent on projects by researchers.

4.3.3 The modes of communication (transfer) and its relation to utilisation

The primary research conducted by CENIS indicated the following to primary knowledge transfer modes within HEI's and SC's.:

[5] Branscomb L.M and Keller J.H, *Investing in Innovation – creating a research and innovation policy that works.* 1999 USA

- Presentation to predominantly academic audiences
- Articles in refereed scientific journals
- Published conference proceedings
- Informal meetings with potential users and teams
- Contract reports

The research indicated low usage of technology transfer offices, spin-off companies, licensing, technology incubators and science parks as transfer modes. From the qualitative research findings these transfer modes were found to be relatively new, many of them only having being established during the past three years.

The above reflects two conclusions derived throughout this study. The first being that high levels of epistemic knowledge creation takes place, as to be expected, within HEI's and hence high levels of "publishing" type transfer modes. The second conclusion is SC's focus on research with the intent of economic / commercial utility is lower that expected, hence the low usage of "technology related" type transfer modes.

A last issue that has come to the attention of this study is a general view that there is a need to investigate the roles, activities and governance of the transfer and diffusion programmes such as CODISA, Tsumisano and NAMAC, with a view of possible improvement of delivery. This is echoed in the R&D strategy that indicated that these programmes would benefit from a single point of strategic direction.

4.4 Research expenditure and funding

Upon analysis of the R&D expenditure figures in 2000, as reported in the publication South African Science and Technology – Key Facts and Figures 2002, (NACI July 2002), the following figures emerged.

Table 19 Research expenditure and funding

R&D expenditure by HEI's	R 2 025 million
R&D expenditure by Science Councils	R 1 700 million
R&D expenditure by industry	R 2 000 million
Total SA expenditure on R&D	**R 5 725 million**

The research utilisation challenge relates to the R3 725 million spent by Science Councils and HEI's.

During the consultation process and discussions emanating from the abovementioned expenditure, it was felt by the stakeholder workshop group, that R&D expenditure by industry is grossly understated. Suggestions were that, taking the major private firms and state-owned enterprises in South Africa into consideration; this number could be understated by at least a half. It is suggested that better estimates be made, or a more accurate quantification be undertaken in the near future, as this is paramount to be able to more effectively track the extent to which research is utilised in South Africa and to concomitantly effect improvements thereto.

Taking the view of the private sector stakeholders view into consideration, the total expenditure on R&D in South Africa could be far higher, and might even be in the range of R4 000 to R4 500 million. The expenditure on R&D provides an indication on the ratio of expenditure to GDP and internationally recognised measure.

From the research findings it is evident the problem of research utilisation, does not really manifest in the private sector, but rather in the HEI's and SC's and it is rather this sub-optimal utilisation of research that needs to be addressed.

In the next section of the document the desired state in terms of research utilisation will be addressed.

5 DESIRED END-STATE DEFINITION

The end-state definition has been derived from an in-depth synthesis of both the qualitative and quantitative findings of the research, summarised in the previous section. In addition to this inputs were considered and consensus was reached from both internal and external workshop participants.

5.1 The research utilisation goal- how it is envisaged

In the long-term, defined at between 8 and 10 years it is expected that an effective and efficient research utilisation system can be operating, producing relevant research outputs that will have the following impact;

- Research is utilised to levels that exceed 80% and the effectiveness of the resulting utilisation impacts on the economy that ideally will be able to be quantified.
- Innovation goals, as outlined in the national system of innovation will be positively influenced by an ever-increasing amount of research being utilised in an efficient manner.
- The capacity of research, across institutions and the private sector will be enhanced through effective and efficient research being conducted with the intent to utilise the same.

Should this future state be achieved, the impact on research utilisation is likely to be significant, but more importantly is the converse, if the results of meaningful research are used more effectively, the impact would be far greater.

5.2 Key considerations and conclusions for the development of strategy

The following are the key considerations as well some conclusions that can be drawn from the findings:

- R&D strategy has the potential to addresses many issues related to utilization, especially on the supply side
  - Increased investment in South Africa's science base (capacity)Technology missions (alignment)Culture of commercialisation (and systems that influence behaviour) within HEI's and SC's is lacking
- Measurement of the intended outcome (utility) and utilisation achieved is required within various institutions
- Collaboration between industry and SC's/HEI's is a significant factor
- Industry is increasingly pursuing a research strategy of collaboration

- Capacity and cost are the two major factors when industry decide on collaboration (at global and country level)
- THRIP is contributing significantly towards collaboration
- Research originating outside the area where conducted has higher probability of being utilised
- Experience of project managers is a factor that contributes to utilisation
- Incentives for results from research is required to drive and encourage utilisation

These will be handled in the explanations of the strategic objectives and supporting interventions.

5.3 Strategy timeframes

Times frames are necessary for the effective realisation of the recommended strategy as well as emphasising that there is an element of urgency in terms of improving the utilisation of research in South Africa. The following time frames have been considered and are deemed to be appropriate for the execution of the strategy.

- Short term - end 2004
- Medium term - end of 2006
- Long term - end of 2008 to 2012

In the description of the strategy the different terms are used rather than the actual time periods.

5.4 Priorities

Priorities have also been defined. *High* priority actions are deemed to be essential for the realisation of the strategy, *medium* priority is important for the medium to long term and *low* priority are necessary and should be considered for action over the short term

6 STRATEGY TO IMPROVE THE UTILISATION OF RESEARCH IN SOUTH AFRICA

6.1 Guiding themes / strategies

Three *themes* or *grand strategies* provide the context for the formulated strategic objectives, in ensuring that they remain aligned to what is envisaged for strategy utilisation in the future are as follows:

6.1.1 Demand stimulation through *investment*

To enable the envisaged state of research utilisation to be realised, the entities demanding research for purposes of knowledge, economic / commercial benefit or the achievement of socio-political objectives need to be invested in and aligned more closely then what currently prevails.

6.1.2 *Collaboration* and *communication*

Alignment needs to be supported by effective ways of collaborating and communicating between the HEI's, SC's and commence / industry.

There is evidence that communication and collaboration between the different organisations in these environments could be improved. The role that Government could and should play in improving collaboration is of paramount importance.

6.1.3 Research process *effectiveness*

Most research processes, regardless of the types of research being produced, need to be improved through effective management of the research process.

Managing any research process with the view to effective utilisation is paramount to producing useful outputs.

6.2 Strategic objectives

The recommended strategic objectives and the supporting interventions for the NACI Research Utilisation Strategy are listed below.

6.2.1 Strategic objective 1: Stimulate innovation / technology development on the demand side (industry) [SO1]

Mechanisms need to be found to stimulate innovation and technology development, through the production of utilisable research, which will impact positively on demand.

It is felt that this is a high priority objective and should be addressed in the short to medium term, by the government and the Department of Science and Technology in particular. One of the interventions that are likely to have the greatest impact on driving innovation and technology development is the provision of incentives. A measure of the extent of the stimulation of innovation and technology development could therefore be measured in terms of the aggregate monetary value of incentives provided to researchers or research groups. Currently this mechanism is in effect already utilised in private sector research, where the utilisation is currently reported to be high.

Interventions

Consider tax breaks for activities successfully completed throughout the commercialisation process (R&D, prototyping and testing, tooling, etc.) [SI 1.1].

A tax relief system has been suggested by a number of stakeholders as a mechanism to incentivise private sector firms to make investments in research and technology. This would be done either directly, by undertaking research themselves or by funding research in other institutions, such as SC's, HEI's or industry organisations who would undertake research on their behalf. The rationale is that the return on any tax break incentive would have to be utilised for research purposes that would benefit the organisation through the products and services it produces. This in turn would have an impact on a number of economic factors, as is highlighted in the intent of the R&D strategy.

The responsibility for investigating the feasibility of introducing a research and development tax break mechanism rests with the government's Department of Finance and the SA Revenue Services. It is regarded as an intervention that should be considered in the short-term and should be handled with medium priority. In the longer term the measure of success of the monetary value of tax relief incentives granted, could be monitored by a ratio of utilisable research to tax incentives in the three defined research categories. The epistemic utility would not be important here.

Strengthen THRIP and the Innovation Fund through increased funding and streamlining [SI 1.2]

Evidence is that THRIP and the Innovation Fund are working well to stimulate industry demand for research. Some criticism is levied at the fact that approval mechanisms are slow and unwieldy. The model of these two funds does however appear to be sound and suggestions are that a process of streamlining with an increase of funding would have a direct impact on stimulating industry demand for research. The source of additional funding could be provided from a reallocation of funding of the three categories of research, for example the boosting of funding for *economic and commercial utility* research could have this effect.

Both THRIP and the Innovation Fund and to a lesser degree the SPII programmes, rely on thorough justifications to be undertaken before funding for research projects are granted. Criticisms regarding the applications of these funds are forced to be made at the near commercialisation stage, not

allowing the funds to be utilised for projects that may have a less certain commercial outcome. Application of these principles to a greater number of research projects, further back in the research process is likely to have an important impact on the utilisation of research.

To measure the increased provision of funds, as suggested, would be easily achieved through an aggregation of funds disbursed through the various funding mechanisms. This would need to be coordinated by the DST and is considered to be of medium priority and should be pursued in the medium-term.

Establish government venture capital/seed funding scheme [SI 1.3]

The provision of seed funding for commercialising promising research projects has been raised by stakeholders. In the private sector the number of organisations providing venture capital services has decreased significantly in the past 5 years. The need for such funding is being called for, by industry to be reinstated. Without the provision of this type of funding, entrepreneurs are not motivated to take ideas though the research process to commercialisation.

Venture capital should provide incentives to take innovative ideas through research, utilising high risk funding mechanisms. The controls required for venture capital funding are however paramount for the investor to effectively monitor the progress on the project. The circumstances for a venture capital application also needs to be established and precisely where in the research process funding should be sought as findings in the case studies illustrate.

The achievement of success using venture capital funding would be able to be measured, by monitoring the return on funding investments. This is however seen to be a medium to long-term initiative and is of medium priority in terms of improving research utilisation.

Link research to incentives that will in turn promote collaboration [SI 1.4]

The provision of incentives at different stages of a research project, to encourage collaboration is suggested. At the initiation stage, staged incentives should be considered to encourage the researcher to consider a utilisation opportunity. The researcher considering a research project needs to be motivated though the provision of incentives to motivate thinking of the application of the research in one of the three defined research categories. The role of the supervisor and team leader in exploring opportunities for utilisation is also essential. Evidence of the lack of provision of incentives, has been suggested to be a reason for the failure of a number of research projects to realise tangible benefits.

In certain SC's STEP funding has been utilised to provide motivation to realise effective research projects, while in some HEI's, a points qualification and points realisation systems are being considered whereby to qualify a research project for approval, points need to be achieved across a number of categories deemed to be important for the successful utilisation of the research project. Once the researcher or team qualifies for the minimum prescribed points; the research project is

approved for commencement. The successful completion of the research project is again assessed at the conclusion of the project against the initially approved points requirements. This mechanism effectively assures delivery of the research project to the requirements. Attached to the process is the qualification for a number of incentives, which if realised, are made available to the researcher or research team.

Research that links incentives to the extent of collaboration during the research project is likely to drive research towards beneficial utilisation.

6.2.2 Strategic objective 2: Develop a supply side culture of commercialisation [SO2]

HEI's and SC's need to develop a commercialisation mindset when undertaking research. This applies predominantly to the commercial /economic as well as the social / political categories of research utility and to a lesser extent for the epistemic utility category.

Focusing on the commercialisation of knowledge could be measured by improving the percentage utilisation of non-epistemic research, which now that a baseline has been established by CENIS, would be able to be tracked every three years. The responsibility for tracking the extent to which non-epistemic research is commercialised would in all likelihood be the Department of Science and Technology, being the dominant government department involved in monitoring the effectiveness of the research undertaken. The achievement of this objective needs to be given a high priority on the agenda, to enable progress to be tracked over the short-term.

Interventions

Mandate HEI's to establish functions that support and encourage cross-functional entrepreneurship [SI 2.1]

The emergence of commercialisation departments in several HEI's over the past few years, has played an important role in facilitating the utilisation of research. Departments are staffed with personnel who are experienced advisors that can exist with commercialising research and who know how to facilitate partnering with the private sector. Where advice is required on intellectual property issues related to utilisation, advice is provided to the researcher or team leader, keen to see the research utilised. As this facility does not currently exist in all HEI's, it is suggested that an initiative be adopted to mandate all HEI's and SC's to establish such functions. The primary mandates of these departments would therefore be to facilitate the utilisation of research in commercial, social, legal / regulatory and political environments where benefits to the economy or society would manifest.

The establishment of these commercialisation / utilisation functions, are likely to have a significant impact on research utilisation. The effectiveness of these functions within HEI's and SC's would therefore impact on any measure of research utilisation at the institution level. More detailed performance indicators could also be established to enable the performance of these functions to be

monitored by their own institutions and also at an aggregated level through the government departments responsible for their performance. The measures that need to be adopted would initially be the number or percentage of institutions that have established such facilities. This initiative needs to be promulgated in the short-term and should be given high priority as it is seen as a major initiative that could contribute to significantly improving the effectiveness of research utilisation.

Revise and broaden scientist recognition and grading system to include researchers and scientists in industry [SI 2.2]

The recognition of scientists is currently based on publications and peer reviews and does not necessarily emphasise the utilisation of the research undertaken and has to a large extent been focused on the epistemic utility. By enhancing the scientist recognition scheme, currently undertaken by the National Foundation for Research [NRF], to include the recognition of the utilisation of research, emphasis will be created on the latter. It is also necessary to broaden the recognition system not only to scientists but to the entire research community, including those working in commerce and industry. Researchers in commerce and industry are currently excluded from the recognition system, and this is where according to the findings by CENIS that most research is utilised. The emphasis needs to shift from rewards for publications to reward for utilisation. The legacy recognition system could over the short – term, be retained by orientating towards the epistemic utility only, so that South Africa does not lose international recognition for its scientists in their specialist fields.

By developing an enhanced recognition system in parallel, which emphasises recognition for utilisation of research, the emphasis should ideally change over time. This shift in emphasis of recognition towards a utilisation orientated system, would then drive behaviour in researchers towards the achievement and recognition in targeted research categories that would be of greater benefit to the economy and society.

It is acknowledged that changing a recognition system would be a timeous process and is therefore regarded as a medium priority initiative, which should be aimed for implementation in the medium-term. The redesign and mechanics of the recognition process should be carefully considered over the short-term, and research commissioned to establish an optimal recognition system based on international experience.

Change performance management system of HEI's and SC's (at individual, department and organisation) level to include measures of utilisable research outputs [SI 2.3]

The performance management systems in HEI's and SO's currently have distinctly different emphases and do not readily address the utilisation of their outputs in the most optimal way and do not necessarily address the best needs for the country's economic and social needs. An aggregated

measure of performance needs to be developed which is aligned and linked to the defined research output categories.

HEI research performance is largely based on recognition of research output publications, as mentioned previously and not on utilisable research outputs. Again a distinction needs to be made depending on the intent of the research. For research falling into the epistemic utility category, traditional measures should prevail. Where research is conducted with the intent of creating commercial / economic utility and social / political utility, the institutional performance measurement system needs to be redesigned. For the institutional measure of performance to be meaningful, it needs to be aggregated from faculty and department level and even research team and individual researcher level to enable the measurement system to effect the required change in behaviour.

SC performance on the other hand is currently largely based on the extent of the success of the commercialisation of research undertaken. They are reliant on the spectrum of roles that the different SC's are fulfilling, some of which are distinctly commercially orientated on one extreme while others are fulfilling more of a technology development / knowledge transfer role. What is deemed to be important, regardless of where a SC falls on the spectrum, is the extent to which research is rendered utilisable.

The allowable proportion of research projects falling in to the different categories of research should be decided upon for all HEI's and SC's at national level and then cascaded down into the institutions. Cognisance should however be taken of the industry sectors and / or institutions served, within which performance relating to research utilisation would be measured.

This is illustrated by the previously introduced concept of proportionate funding allocation across the different categories of research. This could direct the proportion of research that needs to be undertaken across the research categories and various institutions.

Table 20 Suggested research activity in the different research categories

RESEARCH CATEGORY	Science Councils	HEI's
Epistemic utility (knowledge)	**Low < 25%**	**High 50 - 75%**
Economic and commercial utility	**High 50 - 75%**	**Medium 25 – 50%**
Social or political utility	**Low <25%**	**Low > 25%**

This concept would also need to be applied at many different levels, to enable institutional performance to be measured.

What this would achieve would be to improve performance in institutions in relation to research utilisation; which would in turn impact on the delivery of utilisable research within the three defined categories of research.

The parameters for performance measurement would need to be established in the short-term against the proportionate quantum of research the different institutions need to undertake. This is regarded a high priority initiative. Without an accepted measure of performance it is unlikely that strides will be made to improve utilisation.

Mandate HEI's and SC's to formalise intellectual property [IP] policies and support structures [SI 2.4]

The ownership and transfer of intellectual property is a highly significant factor in how knowledge and technology is transferred and is directly related to the extent to which utilisation occurs. A number of institutions have made significant progress in formalising their policy on the ownership and transfer of intellectual property. It is essential that all research institutions have a policy to manage intellectual property and this needs to be mandated so that no researcher is ever unclear regarding the circumstances should research outputs be utilised and how the research may in turn be benefited.

The responsibility for this initiative rests largely with the government and in particular the Departments of Education and Trade and Industry. It is considered to be a medium priority objective, which would need to become fully entrenched in the medium to long term.

6.2.3 Strategic objective 3: Facilitate collaboration and alignment between HEI's / SC's and industry [SO3]

Mechanisms need to be established to facilitate and promote the collaboration between the producers and the utilisers of research. This objective on a broader scale is within the intent of the R&D strategy as well, which supports a number of the supporting interventions. The different initiatives suggested are deemed to be essential to better align industry and the HEI's and SC's. Collaboration has been established to be a critical factor in ensuring that research is utilised. Within the context of collaboration is communication, and as such mechanisms of formal communication are equally as important. There is evidence that research projects that have been successfully utilised have been reliant on extensive collaboration both during the research process as well the subsequently, where the research was utilised.

Encouraging collaboration across the different sectors and between various institutions and private firms, within these sectors needs to be encouraged and the extent of collaboration measured. What could be considered is some measure of collaboration that is a formal part of the research qualification process. This will ensure that research is not undertaken in isolation i,e, without knowledge of the needs of the users of research. Consideration could also be given to initiating an award scheme to researchers who have produced utilisable research though extensive collaboration.

A measure that could be considered would be the degree that collaboration occurs within research approval processes, as measured by a points qualification system, in which points would be awarded for the collaborative efforts of the researcher amongst a number of other qualifying criteria. Due to

the importance of collaboration, this level of emphasis in getting research to be utilised, would only be able to be undertaken in a relatively mature system of innovation. The timing for such a mechanism to be set up would therefore be in the medium to long-term and needs to be treated with medium priority.

Interventions

Align research effort (funding and incentives) with technology missions [SI 3.1]

An important intervention that would ensure that collaboration occurs at different levels would be the alignment of research institutions as well as private sector research conducted around the technology missions, as stated by government in the R&D strategy. Extensive consultation on defining the technology missions has been conducted at international, national and at firm levels within the relevant industrial sectors. The development of both technology and industry roadmaps is a useful technology planning methodology to align research with anticipated users of research, and even more importantly to identify areas and opportunities where commercialisation opportunities can occur.

Alignment of research that is currently being undertaken and needs to be undertaken in the future within the technology missions, can be engineered through a series of funding allocation methods, inter alia the provision of funds to selected HEI's for research in the economic / commercial utility category. This could and logically should differ in different institutions where different capabilities lie. Incentives advocated should also align with the promotion of research within the technology missions.

The achievement of this objective will need to be realistically undertaken over the short to medium-term, as it is dependent on a number of other strategic objectives advocated and the supporting initiatives. The realisation of the economic benefit of the technology missions is a long-term process, that is likely to be undertaken over more than a decade, and the concomitant research alignment, would under the circumstances take equally as long. The initiative is however deemed to be of medium priority and would need to be constantly reviewed over the medium-term.

The impact over the long-term will in all likelihood be a greater degree of utilisation of research conducted in the category of commercial / economic utility, with the resulting economic benefits being derived over the long-term.

Establish R&D strategies for technologies within sectors not covered in the R&D strategy [SI 3.2]

Practically not all research requirements of a country could ever hope to be restricted by the technology missions.

To enhance and drive collaboration from the demand side, an initiative whereby R&D strategies are developed for industries, both commercial and industrial, that reflects the needs of the firms participating in the sector. There are numerous other strategic industries in South Africa that are

strategic by their global positioning, in terms of economic contribution and are as important to sustain technologically on an ongoing basis. The establishment of industry R&D strategies, representative of the firms that they present, are likely to attract appropriate research from the HEI's and SC's as well as encourage collaboration between the producers and users of research. It is envisaged that industry R&D strategies, in both industrial and commercial sectors, could be coordinated through industry associations. The DTI could also play a major role in the shaping of such strategies, especially in terms of the services Trade and Investment SA [TISA] are offering to firms.

The above-mentioned initiative needs to be achieved over the short-term as a significant amount of sector and industry information already exists, albeit not particularly relating to the R&D needs of the industry. This is regarded as a high priority initiative that needs to be fully operational in the medium term.

The impact of this initiative will be to leverage collaboration between the producers and users of research, which should significantly contribute towards the extent to which research is produced and utilised under this regime.

Encourage HEI's and SC's to promote capabilities and capacities to industry [SI 3.3]

A further initiative to enhance collaboration is for HEI's and SC's to communicate and promote their capabilities and capacities to users of research, predominantly to firms with a need for research within the different sectors. Publicising is currently undertaken at a very low level. The NRF have from time to time publicised registers of scientists. This concept needs to be enhanced and expanded to enable industry research users, both in the industrial and commercial sectors to make use of researchers in the HEI's and SC's. Criticism has been levelled at the producers of research in HEI's and SC's that researcher competencies, domain and field expertise and experience are not well known, and therefore are not even considered for deployment. It has been suggested that HEI's and SC's publicise researcher competencies and capabilities in a framework that would enable central coordination and dissemination. This initiative goes hand-in-hand with the previously suggested renewed recognition paradigm of scientists and researchers.

Achievement of this initiative would be regarded as a medium-term initiative of medium priority, with databases being built over the long-term.

The impact of this initiative would be a quantification of innovation capacity, which if known, would further bridge the gap between HE'Is and SC's and therefore encourage more collaboration on research projects and thereby influence the extent to which research undertaken by HEI's and SC's is utilised, by the mere fact that the scientist resource pool is shared to a far greater extent.

Optimise roles and linkages of transfer programmes (GODISA, NAMAC Trust)

A number of initiatives exist that facilitate the transfer of knowledge and know-how and encourage entrepreneurs to establish technology incubators. Technology transfer programmes such as

GODISA, the Tsumisano (technology stations programme) and the NAMAC trust (SMME support) as well as the establishment of incubators involved in the utilisation of research need to be optimised, to ensure the successful utilisation of research. Linkages to HEI transfer technology and commercialisation centres needs to be enhanced and the concept aligned to a greater number of SC's.

The achievement of this initiative could be measured by the revenue generated measured as a return on the funding provided over a specific payback period. Successful projects would need to be communicated to stimulate further investment.

The impact of such a programme would be to encourage scientists to commercialise their research as well as for entrepreneurs in firms to use the mechanisms to commercialise their ideas.

6.2.4 Strategic objective 4: Improve the management and administration of research processes to improve utilisation [SO4]

Research processes must be managed and administered across HEI's and SC's to a protocol that enables the research outcomes to be utilised in one of the three accepted research definition categories. A nationally accepted points qualification system is advocated, that becomes part of the research utilisation protocol, for research project approval. Upon completion of the research project a mechanism of qualification point realisation will enable the project value to be determined in terms of utilisation. The management and administration of the research project therefore needs to be focused around attaining the relevant qualification of points.

The measure of the improvement in the management of research projects, therefore rests with an assessment of points attained in the various contributing categories, one of which the extent of collaboration and utilisation would be quantified. On an aggregated basis the utilisation would be able to be measured within HEI's and SC's as well as between them.

Interventions

Recognise value of entrepreneurial and experienced researchers and implement actions to maintain [SI 4.1]

To recognise and derive value, the impact of the experience of researchers and implement actions to "keep" experienced researchers in HEI's and SC's, a reward system based on individual and / or team performance would need to be formulated within the research protocol and incentives linked thereto. Entrepreneurial and experienced researchers would therefore be highlighted through a combination of recognition and reward.

This would need to be achieved through the number of researchers recognised in the utilisation based recognition system.

The impact of this type of recognition would be to retain top calibre researchers in the country, knowing that they are fully recognised for their utilisable research efforts that have resulted in commercial success.

Institutionalise formal "contracting" arrangement between research project and "client" [SI 4.2]

The advocated research protocol needs to accommodate a more formalised contract between the researcher and the identified "client" or user of research, based on the points qualification and achievement system within the research project protocol.

The achievement of the initiative would be the percentage of research projects commissioned in accordance with the revised protocol.

The impact of more formal contracting, where requirements are clearly defined in terms of performance and utilisation, would positively impact on the latter. One would need to caution against such a formal system impacting the freedom of certain research staff. This would need to be addressed within the protocol in terms of conducting research for epistemic utility.

Align portfolio of projects (in terms of size of funding) with expected utilisation levels [SI 4.3]

Initiatives need to be embarked upon in HEI's and SC's to align portfolios of projects (in terms of size of project funding) with expected levels of utilisation, particularly research projects falling within the technology imperatives for the country.

Alignment of approved projects to the technology imperatives in an institutional basis needs to be achieved.

6.3 Cross - cutting and linked strategic initiatives

The following initiatives are not directly related to any particular strategic objective directing the improvement of research utilisation, but are important in that they will play a significant role in supporting the execution of the aforementioned strategy.

6.3.1 Strategy support intervention: Implement the National R&D Strategy [SI 5]

Implementation of the R&D strategy especially concentrating on the complementary components that impact on utilisation.

Initiatives to enhance innovation by defining and focusing on the technology missions and platforms, provides significant emphasis to the research utilisation strategy. The drawing together of initiatives involving technology diffusion and incubation initiatives, especially with regard to funding allocation would have a positive impact on the enhancing the extent to which research is utilised.

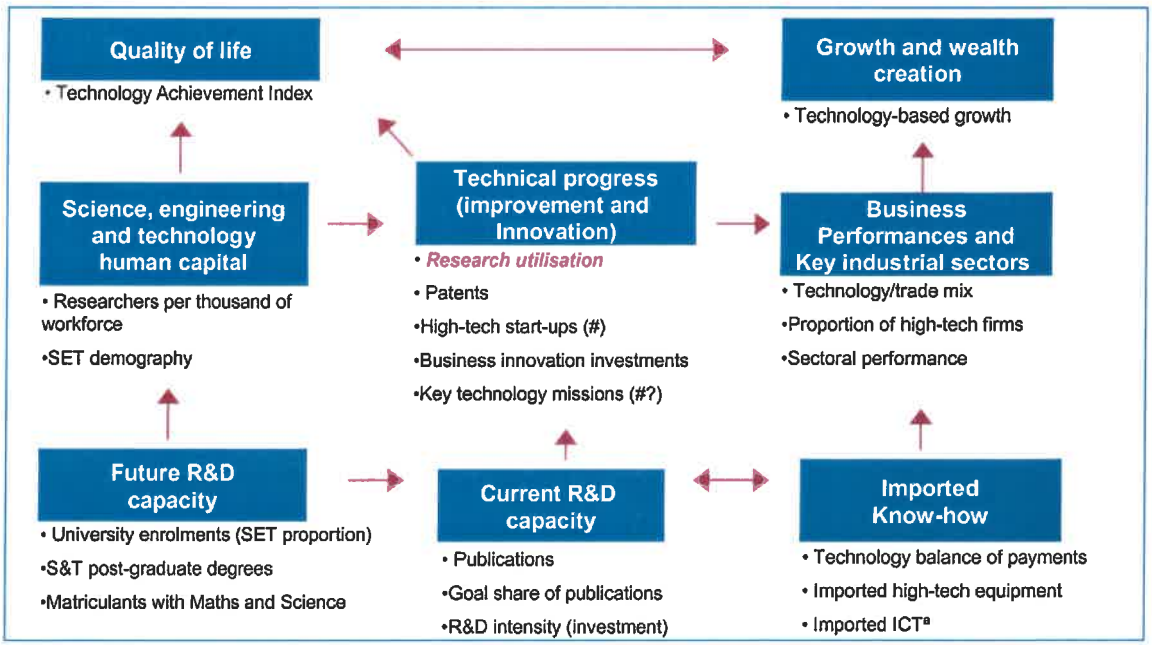
Capacity building and transformation initiatives in the R&D strategy would to a large extent be supported by the objective of driving for a portfolio of research categories to be balanced with respect to the countries needs. What this will achieve would be the appropriate type of capacity, which would be useful to the system of innovation.

The third strategic objective of the R&D strategy is totally aligned to the strategy to improve the utilisation of research. The system of research must contribute to a more effective and efficient science system in the long run and the necessity to address issues such as intellectual property, is paramount to the realisation of both strategies.

6.3.2 Design and implement a research utilisation measurement system

Mechanisms need be to found to accurately measure the extent of research utilisation that ideally impact on the economy, albeit through indirect means. Based on the work undertaken by Fedderke, reliable and acceptable measures need to be established, across the entire system of research.

Figure 5 Potential indicators of the National System of Innovation



National System of Innovation indicators provide insight into the strategies currently in operation, and allow objective assessment of its condition and trajectories

According to Fedderke et. al., technology is one of the key determinants of long-term growth, and a focus on the role of technology in the economy is paramount to economic development. This is illustrated in the R&D strategy. As is emphasised in the diagram above the role of research utilisation is pivotal in influencing technical progress and business development, which in turn influences economic growth and wealth.

What needs to be agreed are measures of research utilisation, or the converse, the cost of sub-optimally utilised research.

As previously highlighted the research utilisation challenge predominantly relates to the R3 725 million spent by SC' and HEI's. Two questions arise from the abovementioned viewpoint. What is the extent of sub-optimally utilised research, and how can we quantify the extent thereof to relate it meaningfully to macro-economic indicators. Fedderke has to some extent already undertaken this work, although the focus has been on technology outputs and the impact on the economy, by measuring gross domestic expenditure on R&D (GERD) between 1994 and 1998, and a slightly different interpretation and emphasis could have been utilised.

The rationale behind a more appropriate measure is that if the value of sub-optimally research is broadly known and a relationship can be found to link it to an economic indicator, the motivation to effect a change in the allocation for funds for research and to more effectively track the management of the same, could greatly impact on decreasing the amount of sub-optimal research undertaken and create behaviours that focus on more effective research utilisation.

Two initiatives therefore need to be considered within a project to design a measurement system

- Adopt macro utilisation indicators from this survey, and develop micro-level indicators
- Define and obtain buy-in from stakeholders of metrics at S&T system level, institution level and project level

Achieving this will place the emphasis on reducing sub-optimal utilisation and further enable the optimal mix of research funding to be utilised to maximise the benefit to the country.

7 CONCLUSIONS – THE WAY AHEAD

The strategy for the improvement of the utilisation of research that has been formulated is based on wide consultation and is a result of the interpretation of this process. The themes or grand strategies are believed to be the over-riding drivers of the strategy and the different strategic objectives, subservient to these themes.

As mentioned in the caveats of the engagement, there is no one particular owner of the strategy, who has sole responsibility for the execution of the strategic objectives and initiatives with employed or contracted parties. The situation is rather that a wide variety of stakeholders, across national and provincial government, the SC's, HEI's, industry associations and the firms within industry themselves, must all play a role in the execution of the strategy.

It is essential that the entity or group of entities responsible for implementing a strategy as a whole or in part, reach consensus on each and every level of the strategy – the themes, the objectives and the initiatives as well a clear understanding as to when the objective has been achieved.

The strategy outlined in this document, will need to be considered by NACI with the two other strategy deliverables and a consolidated view developed. The content of this strategy may therefore change to a lesser or greater degree, but the principles adhered to behind the strategy formulation be preserved. Each of the objectives and initiatives / interventions / actions should be:

- Measurable on a discreet or variable basis, in a meaningful way
- Assignable to a responsible person from within the relevant entity
- Time lined and prioritised

On each of these strategy constructs it is essential that *consensus* and *focus* be reached among the designated entities responsible for ensuring that the strategy is realised over the agreed time frame. Further to this, governance aspects relating the responsible representatives within the different entities will need to be addressed, as the process gains momentum and moves towards the envisaged goal, of an effective and efficient system of research utilisation in South Africa.

8 APPENDICES

8.1 Bibliography

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8.2 Terminology

CSIR: Council for Scientific and Industrial Research

DACST: Department of Art, Culture, Science and Technology (until July 2002)

DST: Department of Science and Technology

DTI: Department of Trade and Industry

FDI: Foreign direct investment

GDP: Gross Domestic Product

HEI: Higher Education Institution

HSRC: Human Sciences Research Council

ICT: Information communications technology

IP: Intellectual property

MRC: Medical Research Council

NEPAD: New Partnership for African Development

NRF: National Research foundation

NSI: National System of Innovation

PII: Partnership in Industrial Innovation

R&D: Research and development – two key processes of developing and applying new knowledge

SC: Science Council

S&T: Science and technology – the two key domains of knowledge that underpin innovation

SET: Science, Engineering and Technology (usually in the context of human resources)

SPII: Support programme for Industrial Innovation

SMME: Small, medium and micro enterprises

THRIP: Technology for Human Resources in Industry