6.4 Operational Considerations

The intention behind ORIP is to establish a centralised facility that should serve firstly as the repository of evaluation information on the NSI and an expert site for its distillation and distribution to inform strategy and steerage at the highest levels and more broadly.

Secondly, the agency should encourage good-practice evaluation much more widely in the system. The strength of a complex, relational and multi-actor NSI will arise from strong, localised monitoring and evaluation (M&E) capacity distributed through every part of the system, where all sites of practice are making decisions based on astute localised insight. This distributed, localised knowledge needs, however, also to be assembled centrally to inform system-wide strategic views, both for state steerage and to inform thinking throughout the system. Part of galvanising the system towards a number of national priorities is the need to keep all the players informed about what is happening, what is working and what is not. Sustaining shared commitment over time depends on the capacity for collective learning, and the ability to become a learning society.

6.5 Recommendations

Recommendation 29: The intention behind the proposal for the establishment of an Office for Research and Innovation Policy (ORIP) (see Recommendation 3) is to **establish a centralised facility to serve as a repository of evaluation information on the NSI, and an expert site for its distillation and distribution to inform strategy and steerage at the highest levels and more broadly.**

Secondly, the agency should encourage good-practice evaluation much more widely in the system than is presently the case. The strength of a complex, relational and multi-actor NSI will arise from strong M&E capacity distributed through every part of the system, where all sites of practice are making decisions based on astute localised insight. This distributed, localised knowledge needs also to be assembled centrally to inform system-wide strategic views, both for state steerage and to inform thinking throughout the system. Part of galvanising the system towards a number of national priorities is the need to keep all the players informed about what is happening, what is working and what is not. Sustaining shared commitment over time depends on the capacity for collective learning, and the ability to become a learning society.

Recommendation 30: The Committee recommends that the mandate of the proposed Office for Research and Innovation Policy (ORIP) must include systematic monitoring and evaluation for the entire NSI, as outlined above. **The approach should be based on the different elements outlined above, namely system-mapping, analysis, building, steerage, evaluation, learning and foresight.** This would include:

- Provision of **the research and intelligence needed for the functioning of the proposed National Council on Research and Innovation,** from which ORIP would receive its strategic mandate and its systemic authority.
- **Provision of the research and intelligence needed for the policy-making and regulatory functioning of the DST and the proposed three policy-incubating nexuses focused**

respectively on higher education, the business sphere and social innovation (see Recommendation 5).

- **Design the range of instruments and methodologies** needed to fulfil the systemic functions outlined above, and contract and outsource those that ORIP cannot practically undertake itself. Among other things, consideration should be given to the future location of the Centre for Science, Technology and Innovation Indicators (CeSTII), support for and cooperation with CREST's SA Knowledgebase, and functional linkages with the Higher Education Information Management System (HEMIS) and the intended Research Information Management System (RIMS).

- **Oversight of the follow-through on review reports** of public research organisations and other NSI-related institutions.

- **Oversight of a policy that all major research, development and innovation projects attracting significant levels of state funding (above an amount to be determined by the DST from time to time) should be subject to statutory evaluation,** the results of which should be publicly available through ORIP.

- **Maintenance of a system whereby publicly funded databases relevant to the national R&D system make their data available to ORIP** (and thus to the public) through appropriate data access protocols.

- **Extraction of the optimal meta-analytic value from all NSI-related surveys, evaluations and indicator studies in order to inform the strategies and purposes of the NSI.**

Recommendation 31: The Committee recommends that the role of the Academy of Science of South Africa (ASSAf) should be strengthened and broadened to provide independent evidence-based advice on key issues relevant to the NSI. These might come in various formats such as commentaries on policies or draft legislation; full consensus studies; facilitated, forum-type conferences and workshops; and other deep investigations.

Recommendation 32: A thorough investigation of data collection and interpretation related to the NSI is urgently needed. Particular considerations in this regard include:

- The NCRI and national government priorities relating to social development and social innovation must be included within the range of instruments and indicators deployed by ORIP. In addition, ORIP should seek to recruit NGOs and company corporate social responsibility directors in a sustainable network of information-gathering and analysis.

- The Committee recommends that an **annual summative review of the outputs** of all the science councils and other public research or S&T-based technical service organisations be considered. The annual summative CHE review of higher education should include the key indicators selected by ORIP for monitoring and evaluation of the system as a whole. The annual report on higher education research outputs produced by the DHET should be expanded after detailed consultation among stakeholders, and made public.

- **The accuracy of the official figures for technology balance of payments should be subjected to scrutiny.**

Recommendation 33: The **annual Science and Technology Activities (STA) Report** compiled by the DST should be **linked to the new prospective research, innovation and development cluster budget** for the year in question, to enhance accountability and to provide a valuable complement to the National R&D Survey for the same year. This should be associated with a greater degree of linkage in that survey to contexts and policy outcomes.

Recommendation 34: Ten years after the most extensive exercise of its kind in this country, attention must again be given to **foresight studies**, as well as carefully designed social fabric studies as a basis for effective social innovation.

SECTION 7: FINANCING THE SYSTEM

This section examines how the various dimensions of South Africa's complex national system of innovation should be resourced to facilitate the further evolution of the resource- and efficiency-driven South African economy into one where high-level knowledge and skills are added to the system as powerful and creative new drivers.

The Committee firmly believes that such an evolution is absolutely necessary so that the country can make its living in the future.

This is because the review of the available data shows clearly that the NSI in South Africa is now generally in stasis, heavily stabilised and constrained within itself, and can only be moved to a different state by becoming very much more of a knowledge economy.

The biggest constraints (as shown elsewhere in this report) are the stuttering pipeline of trained and knowledgeable people, at all levels; the inadequate investment in the existing research teams; not keeping up with infrastructure requirements; and failing to incentivise private investment in innovation, both within and from outside the country.

Changing the trajectory of the NSI in a sustainably upward direction will be achievable only by concerted interventions, seeking synergies and forms of momentum that can disrupt the considerable inertia in the system and move it to a new, better and more sustainable position. Many such interventions have been discussed in other sections of this report. This section deals with financing the system in a new and more purposeful manner.

7.1 A Recent Macro-view

It is useful to quote some highly relevant sections from a recent draft strategy issued by the DST (2011b), entitled *Enhancing the NSI to support growth and development: a strategy to increase R&D investment in South Africa*:

> The 2008/09 National R&D Survey indicates that South Africa has maintained a steady growth in R&D expenditure over the past decade, with GERD growing from about R4 billion in 1997/98, to about R21 billion in 2008/09. The ratio of GERD as a percentage of GDP has also expanded over this period, indicating the growing role of R&D within the economy. From 2007/08, however, there was a decline in GERD as a percentage of GDP for the second year in succession, from 0.93 per cent in 2007/08 to 0.92 per cent in 2008/09 as illustrated in Figure 4 and Table 1. The 1% target remains elusive.
>
> The decline in GERD as a percentage of GDP is an indication that R&D investments have grown at a lower rate than growth in GDP. Starting in 2007/08, the nominal increases in

GERD have been slower than the increases in nominal GDP. Events leading to the economic crisis may have played a role in influencing R&D investment decisions within the private sector. Globally, some companies were scaling down, postponing or cancelling their R&D and innovation investments due to shrinking cash flows.

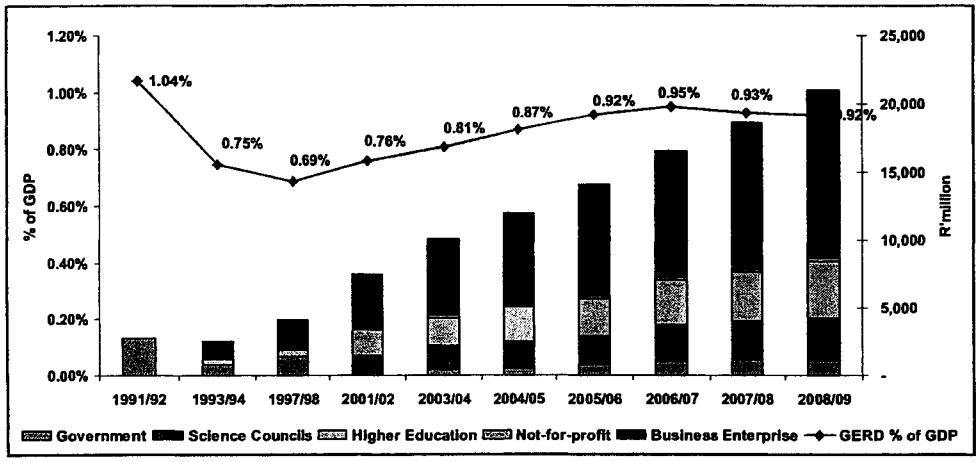

Figure 4: Performance of R&D in South Africa (National R&D Surveys 1991–2008)

Table 1: Selected data on trends in R&D expenditure

Sector	1997/98 (R)	2001/02 (R)	2005/06 (R)	2006/07 (R)	2007/08 (R)	2008/09 (R)
Business enterprise	2 216 000	4 023 576	8 243 776	9 243 165	10 738 456	12 332 012
Government	1 380 000	203 110	844 640	1 021 355	1 154 399	1 139 676
Higher education	496 000	1 896 156	2 732 215	3 298 808	3 621 862	4 191 366
Not-for-profit	11 000	70 778	226 514	212 538	223 202	240 649
Science councils	-	1 294 454	2 102 094	2 744 718	2 886 094	3 137 343
Gross Expenditure on R&D	4 103 000	7 488 074	14 149 239	16 520 584	18 624 013	21 041 046
% of GDP	0.69%	0.76%	0.92%	0.95%	0.93%	0.92%

The Committee applauds the government's intention to promote the increase in the **R&D intensity (GERD)** of the country to the ambitious target of 1.5% of GDP within a few years (specifically 2014); this target is obviously dependent on the actual growth of GDP over that period. For example, the above-quoted DST document states, "South Africa will need to double-up on its 2008 levels of GERD (of R21 billion) to between R41 billion and R46 billion by 2014 if it is to reach the 1.5 per cent GERD/GDP target. Ideally, GERD should grow between 16 and 20 per cent annually for the next three years." These figures are based on assumptions of GDP growth of 5–6% per annum, but most indications are that the growth rates will in fact be somewhat below these figures, reducing the (imposing) estimates of GERD required to attain the 1.5% of GDP target.

In any case, the increases required in national GERD are such that (i) the case for making them will have to be very strong in the face of huge competing demands, and (ii) the investments will have to be so structured that they achieve the objectives of making them, both effectively and efficiently. It is also obvious that such increased investment is a product of both the public and private sectors.

The Committee's report as a whole strongly supports the DST's case for much-increased investment in GERD. The Committee emphasises throughout, however, that only a **well-planned and concerted approach**, based on thorough understanding of the causes of inertia, will render such an investment as effective as desired.

This section seeks to suggest an optimal structure for the increased investment in financial terms.

7.2 2008/09 National Survey of Research and Experimental Development

The National R&D Survey already cited provides a useful point of departure in comparing current, relevant financing flows in the 'whole' NSI; this section provides necessarily summarised data from the survey in order conveniently to illustrate the Committee's thinking and recommendations:

- Overall, just under 50 million citizens, of whom 13.7 million are employed (10.7 million in industry), have generated a GDP of R2.3 trillion (the industry share is R2.15 trillion). The gross expenditure on R&D was R21.04 billion (0.92% of GDP), involving efforts by about 19 400 full-time equivalent (FTE) researcher performers (if doctoral students and postdoctoral fellows are included, the headcount is nearly 40 000).
- Total R&D expenditure by each of the five categories was: business R12.3 billion (58.6 %), government R1.14 billion (5.4%), higher education R4.2 billion (20%), NGOs R240 million (1%) and science councils R3.14 billion (15%)
- Basic research accounted for about 20% of the total, applied research 33%, and experimental development 46%; while 16% was spent on capital and 84% on operational costs, about half of this on labour.
- Funds were sourced in the system by the combined five categories as 53% own resources, 30% from government, 5% from other sources within South Africa, while 11.5% was of foreign origin
- More than 87% was spent overall in the natural sciences, engineering and technology fields (24.4% in engineering, 15% in health and 13% in computers/communications), and 12.5% in the social sciences and humanities.

Within **business/industry**, the relevant data were as follows:

- Two-thirds of the total of R12.3 billion funds expended was sourced from within, 20% from government, and 11.3% from abroad
- By industrial classification, R&D spending was greatest in manufacturing (39%, of which nearly half was in chemicals, oil and coal, and pharmaceuticals), financial intermediation (27.5%), electricity, gas and water supplies (19%) and mining (5%)

- The personnel deployed comprised 6100 FTEs as researchers (8560 headcount), 3800 FTEs as technicians (5584 headcount), and 2500 FTEs as 'others' (4451 headcount), totalling 12 500 FTE persons (18 591 headcount).

The **government sector** comprises national, provincial and local government departments, government research institutes and museums. Its spending on R&D was as follows:

- The expenditure of R1.14 billion was divided into national (R290 million) and provincial levels (R230 million), institutes (R580 million), as well as museums (R41 million).
- Half was spent on applied research, and the sources were own funds (65%), other government funds (28.5%) and foreign funds (5%); only 2000 FTE staff were involved.
- The spending pattern by field, interestingly from the point of view of social innovation (see Section 4 of the Phase Two report: The enabling environment for innovation in the private and social sectors), was 18.5% on social sciences, 18.5% on health, 17% on agriculture, 11% on earth sciences, 10% on biological sciences, and only 2.5% on engineering.

The **higher education institutions' (HEIs)** expenditure on R&D was broadly as follows:

- Of the total R&D expenditure of R4.2 billion, R3.9 billion (93%) was spent on R&D by universities, and only R300 million by universities of technology; the mix was 47% on basic research, 35% on applied research, and 18% on experimental development.
- The sources of funds were own resources 47%, foreign 10%, government agencies 16%, science councils and business/industry 11% each, and only 1.1% as individual donations.
- The distribution among research fields was 70% in the natural sciences, engineering and technology (21.5% in health, 10.6% in engineering, 7% and 5% respectively in biological and agricultural sciences, and under 10% for the grouped physical, chemical and earth sciences), and 30% in the social sciences and the humanities (20% and 10% respectively).
- The personnel figures were 3643 FTE researchers (out of a headcount of over 16 000), 541 FTE technicians (out of a headcount of 2054) and 674 FTE other staff (out of a headcount of 1856); there were 627 postdoctoral fellows, 10 376 doctoral students, and 35 524 masters students.

The **not-for-profit (or NGO) sector** was too small to be summarised here (R240 million). Most of its funding was foreign in origin, and most of it was spent on the social sciences.

The **science councils**, with 25% less R&D expenditure than higher education, showed a pattern of relevant data contrasting with that of higher education:

- The type of R&D was 25% basic, 44% applied and 31% experimental development.
- Government-derived funds accounted for 71% of the total expenditure of R3.14 billion (three-fifths of this sourced as grants and the rest as contracts), business/industry for only 4.4%, foreign sources 12.5%, and own sources 12%.
- The spread of funding over fields was overwhelmingly in favour of the natural sciences, engineering and technology (92%), with engineering at 23.4%, agriculture at 19%, health

at 12.5%, biological sciences at 11%, and physical, chemical and earth sciences at about 10%.

- The headcounts (which were close to the FTEs) were researchers 2650, technicians 1300, and other staff 1650.
- The distribution of expenditure on R&D among the major science councils was R1.4 billion for the CSIR, R536 million for the ARC, about R390 million each for both Mintek and the MRC, R167 million for the NRF (national facilities) and R94 million for the Council for Geoscience.

Returning to the overall picture, it is important to mention that comparison of the 2008–2009 data with those for 2007–2008 revealed an increase in total 'real' expenditure of only 1.3%, while the total number of researchers and R&D personnel generally was static, and actually fell when expressed as a percentage of the total employment in the country to only 1.4 researchers per 1000 persons employed.

These headline figures, and much else described in other parts of this report, are the basis for the Committee's conclusion that the NSI in South Africa is generally in stasis, heavily stabilised and constrained within itself.

7.3 Higher Education Institutions

The general situation of the HEIs illustrates the problem very well. They derive their revenue from three streams: government subsidies mostly determined by a policy-driven formula, self-set student fees, and a third stream acquired through research grants and contracts from both government agencies or business/industry, private donations from within and outside the country, and mobilisation of revenue from a variety of owned assets.

The autonomy enjoyed by university councils and executive management under the Higher Education Act (Act No. 101 of 1997) means that the ways in which the complex and highly inter-dependent functions of teaching, research and extension/outreach are set up and sustained are generally **at the discretion of the institution itself**, within its available means. If the leadership wants the institution to be research-led (as many do), undergraduate programmes will reflect the aspiration to attract able students, will infuse a spirit of enquiry in diverse ways, and permit the harvesting of a substantial fraction of the graduates (mixed with some attracted from other institutions) into active and productive postgraduate programmes that are often organised as 'virtuous' assemblies of established researchers who also teach, developing researchers at various levels, and support staff, sustained in well-equipped facilities by a mix of substantial, mostly but not entirely external grants, and recognised for promotional purposes as centres, units, research chairs or institutes.

In a very general way, the subsidies made to HEIs by government to date have been based on the premise that the funds concerned, together with fees and third stream income, will be used to set up and sustain the entire infrastructure of facilities and systems necessary both for teaching/training and for the performance of R&D (i.e. the **overheads of research activity are**

assumed to be covered in this way, and are not included in any further government-derived agency grants awarded for research projects). (There has long been a kind of quiet dispute between business/industry as to whether the payment of corporate taxes is enough to justify a refusal to include overheads in contracts with public universities – most firms do in fact pay overheads, but at a rate well below the real additional costs, in a compromise approach.)

The state also regards developing capacity for research (i.e. growing new timber, as part of the assumed general overhead cover. The teaching/training functions of research-active HEIs cannot thus be separated from the research functions, and recommendations designed to increase R&D at HEIs must take into account the basic **design of the resourcing model** as well as the consequences for the rest of the system.

One can now examine the implications of setting out at HEIs to increase the volume of high-quality human capital generation for the NSI (in the form of greater numbers of well-trained honours, masters and doctoral graduates as well as postdoctoral fellows, drawn from the talent of the whole population) as well as that of research outputs (such as high-impact peer-reviewed articles and scholarly books), commercially exploitable patents and useful innovations generally.

Essentially, many of the required concerted interventions have already been outlined in Section 5 of the Phase Two section of this report: Human capital and knowledge infrastructure. Many of these will require expenditure of funds held by HEIs or granted to them by government agencies and/or business. The following systemic investments can be added to these:

- Reorganising a much better-resourced external government agency system to focus primarily on the purposeful and adequate resourcing of the best-performing, multiple-output research groups
- Providing (much-increased) quanta of such group support, appropriately designed in terms of operational, capital and human resource provision, at various levels such as groups (including most of the national Research Chairs [SARChI] or institutional equivalents), units (some of the SARChI chairs and equivalent), multi-project centres (such as the national Centres of Excellence), and institutes (with multiple principal investigators, projects, and expanded, quasi-autonomous organisational models)
- Improving infrastructure (as outlined in Section 5 of the Phase Two report: Human capital and knowledge infrastructure)
- Enhancing the interaction between business/industry and HEIs by strengthening and widening the incentive schemes operated by the dti and TIA/DST, especially in the form of the so-called triple- and quadruple-helix relationship and in Centres of Competence
- Expanding further foreign grant-making for (mostly internationally collaborative) work at South African HEIs, through strengthening the links with other countries or regional blocks that are especially productive in this way
- Progressively shifting the overall balance between basic, applied and experimental development research, from just under half on basic research in the direction of about two-thirds of expenditure being devoted to the latter two categories, as was done with success in Ireland under similar national conditions

- Facilitating and optimising, through appropriate legislation, regulation and administrative practice, the potential of local HEIs to recruit high-level staff from other countries, and to maximise their impact.

To go back to the above summaries of the main resource flows in the NSI, the Committee is arguing for measures that would increase R&D expenditure in HEIs by 2014, in broadly the following indicative way, bearing in mind that the mix of R&D that would be found if GERD/GDP reached 1.5% might not continue to reflect the current pattern:

- R5.9 billion (increased from the current R4.2 billion) to be spent on R&D by universities, and R600 million (now R300 million) by universities of technology, giving a total of R6.5 billion per annum.

- The increased expenditures come from an altered pattern of funding, changing so that funding of R&D would be 37.5% from own resources (now 47%), 12.5% from foreign sources (now 10%), 30% from government departments or agencies such as the NRF, the dti, TIA and the MRC) (now 16%), 14% from business/industry as contracts (now 11%), 4% from science councils (now 11%) and 2% from individual or corporate donations (now only 1%).

- The target mix would be 40% on basic research (now 47%) and 40% on applied research (now 35%), with 20% on experimental development (now 18%).

- The distribution among research fields would be 80% for natural sciences, engineering and technology (20% for health, 20% for engineering, 12.5% for each of the biological and agricultural sciences, and 15% for the grouped physical, chemical and earth sciences) and 20% in the social sciences and the humanities. This would reflect the emphasis on applied sciences and experimental development.

- A major recruitment drive, oriented to achieve the research field balance as above, would take the headcount from the present 16 000 to 24 000. The personnel figures would be 5000 FTE researchers (out of a total headcount of over 24 000) (presently 3643 out of a headcount of over 16 000), 1000 FTE technicians (out of a headcount of 4000) (presently 541 out of a headcount of 2054), and 500 FTE other staff (out of a headcount of 1500) (presently 674 out of a headcount of 1856).

- There would be 1200 postdoctoral fellows (now 627), 15 000 doctoral students (now 10 376), and 60 000 masters students (half of them in research specialisation(see Section 5 of the Phase Two report: Human capital and knowledge infrastructure) (presently 35 524).

7.4 Science Councils

The question of 'new target' resourcing flows depends largely on what the individual and grouped mandates of the government-owned science councils should be in future (see Section 3 of the Phase Two part of this report: Governance of the NSI). Suffice it to say in this section that the competitive advantage arising from the marked systemic economies of scale, the multiple beneficial outputs of HEI-based R&D, the constant entry of talented newcomers, the richness of the multiple-discipline environment, and the independence of the general mind-set, makes an unanswerable case for funding and performing at HEIs a very large percentage of the total national R&D that is not performed within business enterprises.

If the arguments made in Section 3 for the revision of the **mandates of science councils** are accepted, these organisations would variably be special purpose vehicles of government or of a sector (or sectors) of government, designed and funded to perform operational R&D directly linked to government functions and especially service delivery, as well as R&D that is not easily or optimally done at HEIs (whether for reasons of justified secrecy; or continuing linkage to an indefinitely required scientific/technical public service; or based on a unique facility in terms of cost and scale; or simply, and probably temporarily, to supply a skills-set that no HEI [yet] possesses; or for other valid reasons).

Funding implications would attend a decision to move into the science councils many of the **scientific and technical services** that are currently housed in government departments, which would be much more effective and innovative if they were incorporated into a relevant science council. This would also apply if most or all of the **national research facilities** currently operated by the NRF were relocated to other bodies (see Section 3 of the Phase Two report: Governance of the NSI).

The weakness of the existing policy framework governing the science councils and the need for a new and clearer mandate for the organisation and financing of government R&D and technical services, extends the motivation for the Committee's proposals that a new National Council for Research and Innovation, supported by a new Office of Research and Innovation Policy be responsible for establishing coherent cross-system policy and for coordinating planning and (public) funding within the entire NSI.

The Committee recognises that its suggestion that the science council system be re-formulated and re-organised at a fundamental level means that it will be more difficult to indicate the kinds of target R&D expenditures that could be envisioned in the future. The following are accordingly indicative figures for 2014:

- The type of R&D would be 10% basic, 45% applied and 45% experimental development (now respectively 25%, 44% and 31%).
- Government would account for 75% of the funding used for a total expenditure of R4 billion (half of this as grants, and the other half as contracts), business/industry for 15%, foreign sources 5%, and own sources 5% (now respectively 71%, 4.4%, 12.5% and 12%).
- The spread of funding over fields would be overwhelmingly in favour of the natural sciences, engineering and technology, with engineering, agriculture and health at 20% each, physical, chemical and earth sciences at about 10% each, biological sciences at 5%, and social sciences at 5%.
- The distribution of expenditure on R&D among the major science councils would be revised to match their new R&D mandates and continuous functions and services.

7.5 Business/Industry

Private business/industry is the most important source of finance for, and performer of R&D, and a key strategic partner for government to engage with in promoting R&D investment in the country. The sector consists of local businesses, including small, medium and large enterprises,

foreign-owned companies in South Africa and other foreign R&D-intensive companies that invest in South Africa in a variety of other ways.

Government has little direct control over the private sector in respect of self-driven R&D, but plays a critical role in creating favourable **framework conditions** for product and process innovation, as well as steering to support mainstream policies and attain national objectives.

Government obviously exerts much more control over **state-owned enterprises**, several of which are major performers of R&D, both here and elsewhere, which accounts for the 20% of total business R&D expenditure sourced from government. Eskom, Denel and Transnet report to the Department of Public Enterprises, and from time to time receive additional funds when they face budget shortages; such injections might go toward product innovation (as in the case of the now-abandoned Pebble Bed Modular Reactor programme). Increasing R&D in this sector is relatively simple if the will to do so is present and the required framework conditions are favourable.

State-owned enterprises have considerable potential for energising innovation through their large-scale procurement activity and through international linkages. They are also extensively involved in technology transfer, with attendant opportunities for local adaptive innovation.

The contributions that government could, and should, make to enable the emergence of a substantial high-capacity workforce in the country has already been discussed, together with the kind of R&D expertise that should be available at HEIs and science councils for possible partnerships with industry, in effect the outsourcing of some or most of the R&D needed by firms for their business/industrial innovation. This can, and should, be energetically complemented by a varied set of incentive schemes carefully designed to achieve high take-up in areas considered critical to national economic and social development, and to succeed wherever possible in complete commercialisation of the innovative products and/or processes involved.

It is deeply disturbing that business/industry-funded R&D in the entire public sector has fallen from 19% in 1997 to about 10% in 2007.

The extensive array of **corporate social investment** activities contains little that could be said to contribute to public sector R&D or the capacity for it.

Both of these phenomena must be addressed as a matter of urgency; this will only happen if business/industry is drawn closely into the design of the necessary instruments and arrangements.

One such instrument is the so-called **triple helix** between government/science councils, HEIs and business/industry; **quadruple helix** formation takes place when civil society also becomes directly involved. The Committee regards it as extremely important that every effort is made to ensure

the smooth initiation and sustainable operation of such complex partnerships so that the decline in business/industry funding in the public sector can be reversed. The submission by HESA rightly points out the need for seamless funding arrangements in multi-helix innovation strategies, both along innovation chains and over time in each enterprise.

As reviewed by Kahn (2011b), the current stable of **incentive schemes** run by the dti and TIA/DST is investing about R600 million of government money in innovation projects in South African business/industry, most of it actually spent in HEIs and science councils. The tax benefit for business R&D activity that meets set criteria is being taken up increasingly despite administrative problems. The tax expenditure or tax revenue forgone due to the R&D tax incentives is estimated to be just over R1 billion for the period 2005/06 to 2008/09. The DST estimates an amount of R632 million for the year 2009/10 (DST 2011: 7d).

These generally successful schemes should be increased in size, scope and effectiveness.

The incentive schemes are additional to large-scale **government financing of private sector innovation projects**, which flows through a number of routes, including the Industrial Development Corporation, Land Bank, Public Investment Corporation and National Empowerment Fund. These funding flows need to be better documented, and integrated, in government innovation-related reporting.

SPII and THRIP are among a number of smaller funding-for-purpose schemes that **the dti** has developed over the years. These include the Enterprise Investment Programme, Black Business Supplier Development Programme, Critical Infrastructure Programme, Business Process Outsourcing and Offshoring, the Sector Specific Assistance Scheme and the Cooperative Incentive Scheme. A second dti thrust is the Seda Technology Programme. This brings together the functions of technology transfer and various technology incubators covering stainless steel, platinum, aluminium, base metals, furniture, medical devices, biotechnology, software, essential oils, bio-diesel and the automotive industries. Other dti schemes are directed toward export promotion, attracting foreign direct investment and the Coega Industrial Development Zone.

The innovation-targeted **SPII** is administered by the IDC (under the Economic Development Department since 2009) and consists of two broad schemes: (i) The Matching Scheme (providing maximum grants of R1.5 million), targeting small- and medium-sized companies and the Product Process Development Scheme, targeting small enterprises, and (ii) the Partnership Scheme which makes grants larger than R1.5 million and is open to all companies.

THRIP is managed by the National Research Foundation (NRF) on behalf of the dti. It is a collaborative intervention across industry, universities and science councils that seeks to increase the number and quality of skilled people in the development and management of technology; promote interaction among researchers and technology managers in industry, HEIs and science councils, with the aim of developing skills, technology transfer and commercialisation of research; stimulate industry and government to increase investment in research, technology development, technology diffusion and the promotion of innovation; and promote large thematic collaborative

research and development projects in priority areas of the dti. Industry and the dti share the costs of THRIP projects on a R2 to R1 basis, but dti support may be doubled if a project supports certain THRIP priorities. During the 2008/09 financial year, 240 projects received R138.9 million from the dti, while industry provided R227.5 million. THRIP activities took place at 18 universities, the ARC, CSIR and Mintek. Of these combined funds, 92% went to universities, as a source of funds close to 10% of HERD (and indeed some 20% of non-labour costs).

The **Innovation Fund**, originally operated by the NRF for the DST, was mandated to promote technological innovation by investing in late-stage research and development, intellectual property protection, and commercialisation of novel and inventive South African technologies. The operation of the Innovation Fund has been accompanied by its own innovations, such as institutional development involving staff capacity in intellectual property management, which laid the basis for the establishment of what is now the National Intellectual Property Management office (NIPMO), as well as the IPR capability of the new TIA. Other innovations were the Commercialisation Manager Development Programme and the National Innovation Competition.

The 2001 **Biotechnology R&D Strategy** noted the successes of South African science and firms in exploiting first- and second-generation biotechnologies, but lamented an underlying market failure in that the country had failed to extract value from the third-generation biotechnologies based on genetics and genomic sciences. Regional centres (BRICs) were established as nuclei for the development of biotechnology platforms, from which a range of businesses offering new products and services could be developed. The four BRICs – Cape Biotech, Plantbio, Biopad and Lifelab – were incorporated into TIA in April 2010. Prior to that they made 128 investments with a cumulative total of R980 million split R277m, R167m, R270m and R265m respectively between the four BRICs; these investments comprised grants (with royalty conditionality), loans and equity stakes.

Venture capital for innovation is actually readily available in South Africa, but the total amount invested is very small (Kahn 2011b); it appears that certain tax and exchange control regulations impair the ability of fund managers to create value. The flow of private funds into innovation depends critically on further expansion of the number of capable operators in this area, and the stimulation of risk appetite among wealthy individuals who are willing to commit part of their means in order to realise rich returns in a sufficient proportion of their ventures.

Both the **Innovation Survey** of 2005, covering the period 2002–2004, and the more recent Innovation Survey of 2008, covering the period 2005–2007 (DST/HSRC 2009, 2011) yielded data that suggested a high degree of innovation in South African business enterprises (comparable with that of many OECD member states), much of it generated locally, and with a significant impact on profitability. Total expenditure on innovation was estimated at about 3% of the total turnover.

The Innovation Survey population collectively considered that the level of public funding of business innovation activity was low, and suggested also a low incidence of innovation-related information coming from universities (5%) and government research performers (3%), as well as a low overall level of patent registration. The direct annual government input of R600 million in

business R&D (although effectively outsourced to HEIs and science councils), plus the tax forgone through R&D claims of R600 million, amounts to a total of R1.2 billion contributed by government in addition to the total business R&D spend of R12.3 billion (i.e. the level of public funding of business R&D is actually about 10%). That this was perceived as low by the survey population is interesting and clearly requires further elaboration (perhaps in the next Innovation Survey).

The role of **foreign firms** in the South African economy has increased considerably in the last decade, with FDI rising from 1% of GDP in 2003 to about 4% in 2009. Regrettably, most of the investment is in equity purchases or share portfolios rather than in 'green field' investments in innovative industry. It is clear that everything possible must be done for South Africa to become the preferred destination on the African continent for R&D-related foreign direct investment. Among the ingredients of a determined push in this direction would be (i) strong, research-intensive HEIs; (ii) a critical mass of highly skilled people; (iii) a much higher proportion of research workers in the labour force; and (iv) an appropriately designed and operated regulatory environment. All these are advocated in this report.

The country also has a widening **technology balance of payments**; domestic demand should increasingly be met through domestic capacity, as a matter of some urgency.

The Committee believes that the decisive move towards an economy driven by knowledge to a much greater extent than at present, will require in respect of the business sector:

- Much higher R&D expenditure by business/industry, probably as much as 50% more than at present
- A greater degree of partnership between business/industry, and HEIs and science councils, representing the outsourcing rather than the performance of part or all of the R&D concerned, preferably in well-regulated and well-facilitated triple- or quadruple-helix arrangements;
- Expansion of the incentive schemes offered by the dti and TIA/DST, both in total amounts applied and in the range of enterprises serviced in this way
- Assisting more purposely the realisation of innovative capacity in small and medium-sized businesses
- Enhancing the national capacity to transfer and adapt new technologies as much as the capacity to create new ones
- Facilitating and optimising through appropriate legislation, regulation and administrative practice the potential of local firms to recruit high-level staff from other countries, and to maximise their impact
- Energetically promoting foreign direct investment so that multi-national companies carry out globally applicable R&D in this country rather than elsewhere
- Mobilising the skills of business to enhance social innovation and improved service delivery in the public sector

- Expanding the venture capital industry as well as the application of corporate social investment in achieving innovation in various different ways.

The Committee's projection of the R&D expenditure data for business/industry would indicatively be as follows in 2014:

- More than 70% of the total of R18 billion expended on R&D would be sourced from within business, 15% from government (state-owned enterprises) and 15% from abroad.
- More than R1 billion would be provided to the sector by government through incentive schemes, for spending on R&D actually performed in HEIs and science councils; the tax forgone through take-up of the R&D tax benefit would be about R2 billion.
- By industrial classification, R&D spending would be greatest in manufacturing (40%), financial intermediation (15%), energy generation (15%), essential infrastructure (20%) and mining (10%).
- Personnel deployed would comprise 10 000 FTEs as researchers, 6 000 FTEs as technicians, and 2 500 FTEs as 'others', totalling 18 500 FTE persons.

Space precludes a similar treatment of the small not-for-profit sector.

7.6 Government Sector

Many of the suggestions made in the above sections on HEIs and science councils make it difficult to model the fifth sector covered in the annual National R&D Survey, namely the government sector, which is rather heterogeneous, but potentially highly significant.

It is not widely recognised that innovation in the government sector is a high priority in a knowledge economy.

In this context, it is useful to add information from the DST's annual reporting on National Science and Technology Expenditure to that already cited above from the annual National R&D Survey. The Expenditure Report was meant (after the placement of the majority of public research organisations under, or within sectoral departments in 2004 through the New Strategic Management Model) to be used for the generation of a single government S&T expenditure plan covering and integrating all DST and sectoral R&D plans. In the words of the New Strategic Management Model, the post hoc report was intended to "guide the clusters and government as a whole on the deployment of resources ... while retaining absolute accountability in the relevant departments".

The Expenditure Reports collate expenditure in three different categories across the large number (25 out of 34) of departments with significant Science and Technology Activities (STAs). The STA categories are Scientific and Technological Innovation (STI, about 63%), Scientific and Technological Education and Training (STET, 20%) and Scientific and Technological Services (STS, 17%). The assistance of the National Treasury was obtained to mine the relevant information from its annual Estimates of National Expenditure (ENE) in respect of the departments concerned, supplemented by questionnaire-derived information and direct consultations with departments.

The Committee had access to four such successive reports, which appear to provide the beginnings of an informative cross-system view of government S&T expenditures. Closer inspection revealed, however, that the highly significant contribution to national STAs (STI and STET) of the Higher Education Branch of the former Department of Education (now the Department of Higher Education and Training) is either not reflected in the reports, or is grossly under-estimated, depending on how the activities of HEIs are classified. Some high figures that are reflected in the reports are problematic, such as, for example, the more than R2 billion attributed to STET of the Department of Health, which represents a questionable set of data in that the large sums earmarked for education and training in academic hospitals universities are not spent exclusively, or even extensively, on real STAs. It seems that the inclusion of such STET expenditure in the STA system is misleading, especially if the much more well-defined STET activities of the DHET are under-estimated.

The Committee notes with approval the intention of the DST to encourage improvements in expenditure classifications within the Basic Accounting System of the National Treasury for greater accuracy in the STA reporting system; it is imperative that the reports be brought to the point where they can permit the generation of a prospective national S&T expenditure plan as originally envisaged.

A matter that does deserve attention is the reportedly **low expenditure of many central line departments of government on Science and Technology Activities (STA)**, which suggests that problems encountered in service delivery or policy implementation are not being innovatively addressed. This is hardly good practice in a knowledge economy context, and perhaps requires a smoothly operating channel for necessary contracted work to be done by science councils (or HEIs, as the case may be) – a case can probably be made for a kind of THRIP-type mediation in such contracting processes, offered by a suitably situated and resourced agency, perhaps (as for THRIP), the NRF.

The generation of successive annual reports has not to the knowledge of the Committee led to the generation of a prospective **National S&T Expenditure Plan**, the beneficial results of which might be expected to include direct examination of the R&D and innovation requirements of central line departments, and assistance to them in establishing the necessary client–customer relationships.

The Committee has proposed that some existing activities in line departments might be shifted to science councils or even HEIs (scientific and technical services, government research institutes, etc.). Such a shift would also allow greater focus on the more general but no less real service delivery-related needs of the departments concerned.

Government departments involved in development activity and service delivery are presently poor initiators and supporters of innovation in their areas of responsibility, and are prime candidates for a much expanded programme of steered and assisted social innovation along the lines suggested in Section 4 of the Phase Two part of this report: The enabling environment for innovation in the private and social sectors. The financing of these newly focused activities would depend on the organisational arrangements, the wide participation of sponsoring and/or

partnering companies, the interplay between different levels of government, and the way in which the developmental state is re-envisaged by government in the next few years.

7.7 Recommendations

Recommendation 35: Public resourcing of R&D conducted at HEIs should be significantly increased, with a focus on the best-performing, multiple-output research groups, the extension of the system of Research Chairs and Centres of Excellence to Research Institutes, and the provision of improved infrastructure. Furthermore, consideration should be given to the subsidisation of national licences for high-impact commercial journals and the free-online e-publishing platform, SciELO-South Africa, for high-quality local journals.

Recommendation 36: The public funding of the science councils should be adjusted to match their newly formulated individual and collective mandates.

Recommendation 37: Business/industry should be encouraged and incentivised to increase its R&D expenditure, probably as much as 50% more than at present, through much more pervasive triple and quadruple helix formation with government/science councils and the HEIs, and involving extensive outsourcing of the R&D required for business innovation.

Recommendation 38: The incentive schemes offered by the dti and TIA/DST should be expanded, both in the total amounts applied and in the range of enterprises serviced in this way, with a special focus on the realisation of innovative capacity in small and medium-sized businesses.

Recommendation 39: Everything possible must be done for South Africa to become the preferred destination on the African continent for R&D-related foreign direct investment (FDI).

Recommendation 40: The potential of local firms, HEIs and science councils to recruit high-level staff from other countries should be facilitated and optimised through appropriate legislation, regulation and administrative practice.

Recommendation 41: Measures should be devised to encourage government departments to improve service delivery through research, development and innovation, including the effective use of the annual survey of government expenditure on science and technology activities, to draw up prospective expenditure plans annually for such activities.

SECTION 8: CONCLUSION

In July 2010, the Minister laid out the terms of reference for the Ministerial Review Committee to conduct a review of the science, technology and innovation landscape in South Africa. The Committee comprised nine experts drawn from higher education, business and innovation policy, who served through sessional and other engagements.

The Committee's report speaks to the mandate that the Committee should sketch out what the research and innovation system should look like ten to thirty years hence. The work of the Committee complements other synoptic views, notably that of the National Planning Commission that was published on 11 November 2011.

The starting point for the review was to perform a high-level diagnostic assessment of the science, technology and innovation landscape, its strengths and weaknesses, and the role of government and the private sector, as well as to offer an assessment of the 2007 OECD review and its recommendations. This was to form the basis for further desk studies, informed by interviews with key players, which would lead to recommendations on governance and structure, the necessary inputs of skilled personnel and funds, the capacity to monitor and evaluate the priorities of national development, and the shift towards a knowledge economy.

The Committee took note of the Diagnostic Report of the National Planning Commission as a clear indication of a 'national crisis' in the country's ability to map a pathway to an inclusively prosperous future for its people. Together with other prevailing signs and symptoms in relation to the economy, the 'wake-up call' is loud and clear. The Committee firmly believes that knowledge application and innovation, added as a diversifying and amplifying stimulus to the country's existing resource- and efficiency-based economic system, are crucial to the ability to achieve national goals in what amounts to crisis conditions. It is therefore necessary to accord top priority to the issues dealt with in this report.

To this end, the Committee adopted an inclusive view of innovation as being the capacity to generate, acquire and apply knowledge to advance economic and social purposes. This implies that innovation is an imperative at the core of the country's transformative project. It must address all corners of the economy, it must include all social actors, and it must provide for inclusive and sustainable futures.

The Committee looked at case studies where the achievement of the necessary coherence, alignment and investment in an NSI had arisen as a consequence of a sharp and commonly held perception of a 'crisis' that must be confronted as a national emergency. These demand signals may act as focusing devices needed for the achievement of coherence, of both purpose and effect, in a system of innovation.

The Committee's discussions offered a glimpse of the future through a plausible scenario in which well-being and the quality of life show significant measurable gains, with absolute poverty being halved and morbidity being slashed. Attaining these goals requires a well-functioning and inclusive research and innovation system, and this in turn pivots on appropriate governance structures.

The analysis pointed to an as-yet sub-optimal set of governance arrangements. Drawing upon national evaluations and comparative studies, the Committee has suggested the structural changes needed for the system to respond better to demand, to attain internal alignment among the major actors, and to enjoy the benefits of policy learning. In so doing, the Committee does not claim novelty. The two core recommendations – to introduce a high-level coordinating body and to reform NACI – have previously appeared in one form or another, yet they have failed to gain traction.

This failure arises, the Committee believes, because South Africa has yet to fully mobilise political leadership and authority adequately behind the promise that the idea of the NSI holds. For the research and innovation system to reach its potential in addressing the twin problems of competitiveness and poverty, which the Committee has termed the Janus Mission, the inception of a National Council on Research and Innovation is recommended to set the agenda and make the call on high-level prioritisation. The second recommendation is the establishment of a unitary Research and Innovation Vote should be established, to function as a macro-coordinating mechanism to ensure that the country's public researchers in all public research-performing institutions are adequately supported. The third recommendation is that NACI should be reconfigured as the Office for Research and Innovation Policy. The fourth key recommendation is to establish Industrial Research and Innovation Funds, whose revenue derives from the existing mineral royalty stream, and which would serve to articulate industry needs for research towards innovation and other innovation activities. The science councils bring with them considerable legacy expertise, but in general have yet to engage strongly with the war on poverty or sufficiently with the expressed needs of established and emergent industry. For this reason, the Committee called for a systematic review of their entire range of offerings, aimed at achieving greater alignment between their activities and the priorities of the NSI. The Committee has also noted shortcomings in the framework conditions that impact upon the research investment climate.

The private sector is the engine for economic growth and value addition. While South Africa's leading companies have expanded abroad, there has been only limited expansion and diversification at home. One of the paradoxes that was noted was the high propensity to innovate alongside the low propensity to patent, despite a long tradition of patent activity, albeit at modest levels. The Committee took note of the Harvard Group's suggestions that agriculture, chemical, machinery and equipment, and pharmaceuticals could become stronger exporting sectors, linking these to scientific expertise and patenting activity. For this to happen, it is crucial that business become integrated into the agenda-setting and prioritisation processes, and that a relationship of far greater trust is built between government, business and organised labour. The achievement of such informed dialogue rests upon the availability of skilled government technocrats with work experience in large firms and small, medium and micro enterprises (SMMEs), and other brokerage agents that might be available in higher education or civil society. However, it also rests on the capacity for far-sighted leadership in the public, private and civil sectors, able to rise above parochial and sectional interests in the pursuit of shared futures.

The awareness of the social dimensions in all technological activity has informed The Committee's deliberations. Technology impacts both positively and negatively on peoples' lives; people in turn shape the uses of technology in similar ways.

It is the considered view of the Committee that the research and innovation system is key to a 'better life for all'. To this end, considerable renewal of the country's knowledge base (in all its forms) is needed, with attendant fiscal implications at a time of fierce competition for resources. The justification for an investment in a resurgent NSI is that it should ultimately deepen the impact of human and budgetary resources. Research and innovation have previously delivered in responses to the demands of the day. The imperative now is to lay the foundations of a new contract between the research and innovation system and society at large. The new contract, with Janus as its logo, is predicated upon a participatory articulation of economic and social needs, and their fulfilment through innovation activities. As such, the research and innovation system needs to be advanced as a values-driven and deeply embedded part of society, championed by compelling and inclusive leadership.

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APPENDIX 1: LIST OF ACRONYMS

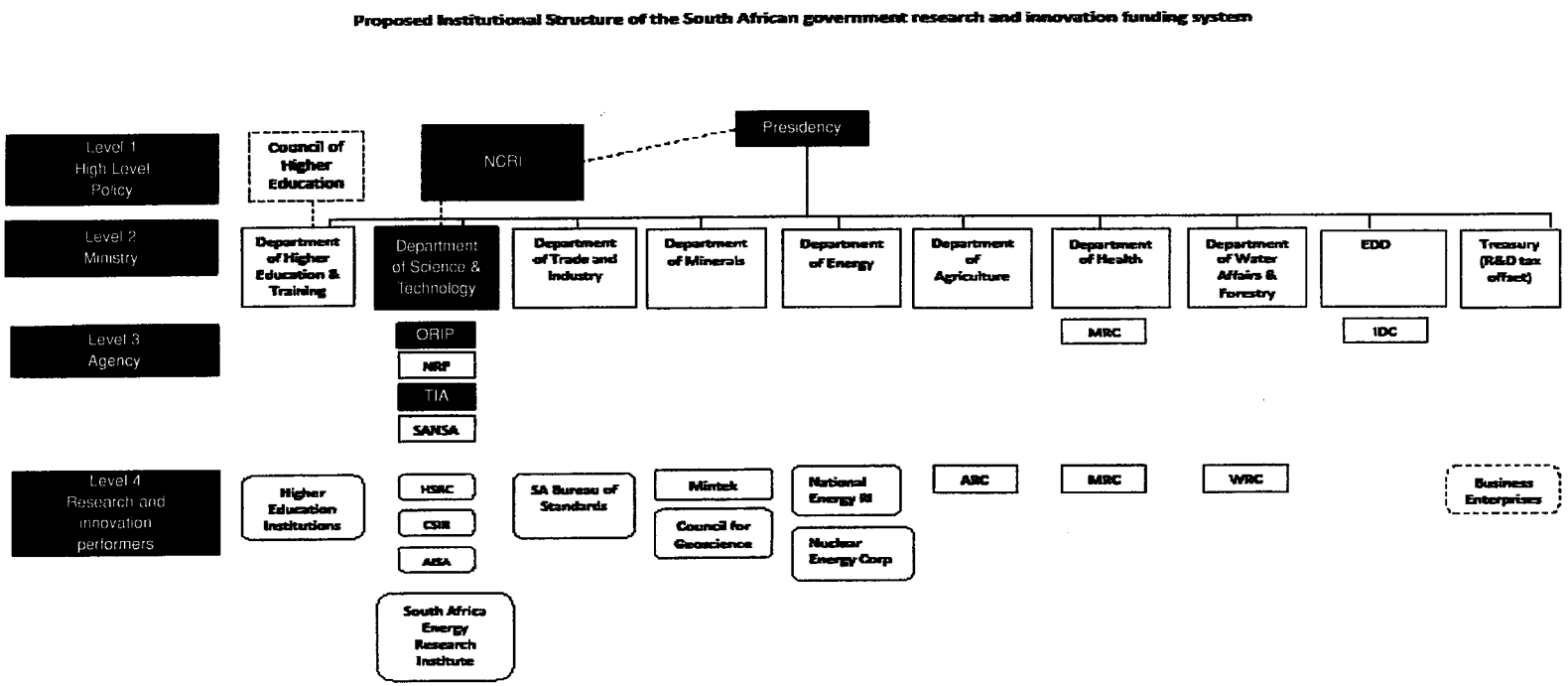
AIDP	Automotive Industry Development Programme
AIDS	Acquired immune deficiency virus
AISA	Africa Institute of South Africa
AMS	Advanced Manufacturing Technology Strategy
ANC	African National Congress
ARC	Agricultural Research Council
ASGISA	Accelerated and Shared Growth Initiative for South Africa
ASSAf	Academy of Science of South Africa
BBBEE	Broad-based black economic empowerment
BERD	Business expenditure on R&D
BLSA	Business Leadership South Africa
BRIC countries	Brazil, Russia, India, China
BRIC	Biotechnology Regional Innovation Centre
BSC	Balanced Scorecard
BTech	Bachelor of Technology
CBO	Community-based organisation
CDE	Centre for Development Enterprise
CEO	Chief executive officer
CERN	European Organisation for Nuclear Research (*Organisation Européenne pour la Recherche Nucléaire*)
CeSTII	Centre for Science, Technology and Innovation Indicators
CHE	Council on Higher Education
CIPC	Companies and Intellectual Properties Commission
COFISA	Cooperative Financial Institute of South Africa
COHORT	Committee of Heads of Organisations of Research and Technology
CREST	Centre for Research on Evaluation, Science and Technology, Stellenbosch University
CSI	Corporate social investment
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation's
CV	Curriculum vitae
DACST	Department of Arts, Culture, Science and Technology
DEEM	Design, engineering, entrepreneurship and management
DG	Director-General
DHET	Department of Higher Education and Training
DNA	Deoxyribonucleic acid
DoE	Department of Education (until 2009)
DoE	Department of Energy (since 2009)
DoH	Department of Health
DMR	Department of Mineral Resources
DPE	Department of Public Enterprises
DRDLR	Department of Rural Development and Land Reform
DRAM	Dynamic random-access memory
DSD	Department of Social Development
dti	Department of Trade and Industry
DVC	Deputy Vice-Chancellor
EDD	Economic Development Department
FDI	Foreign direct investment

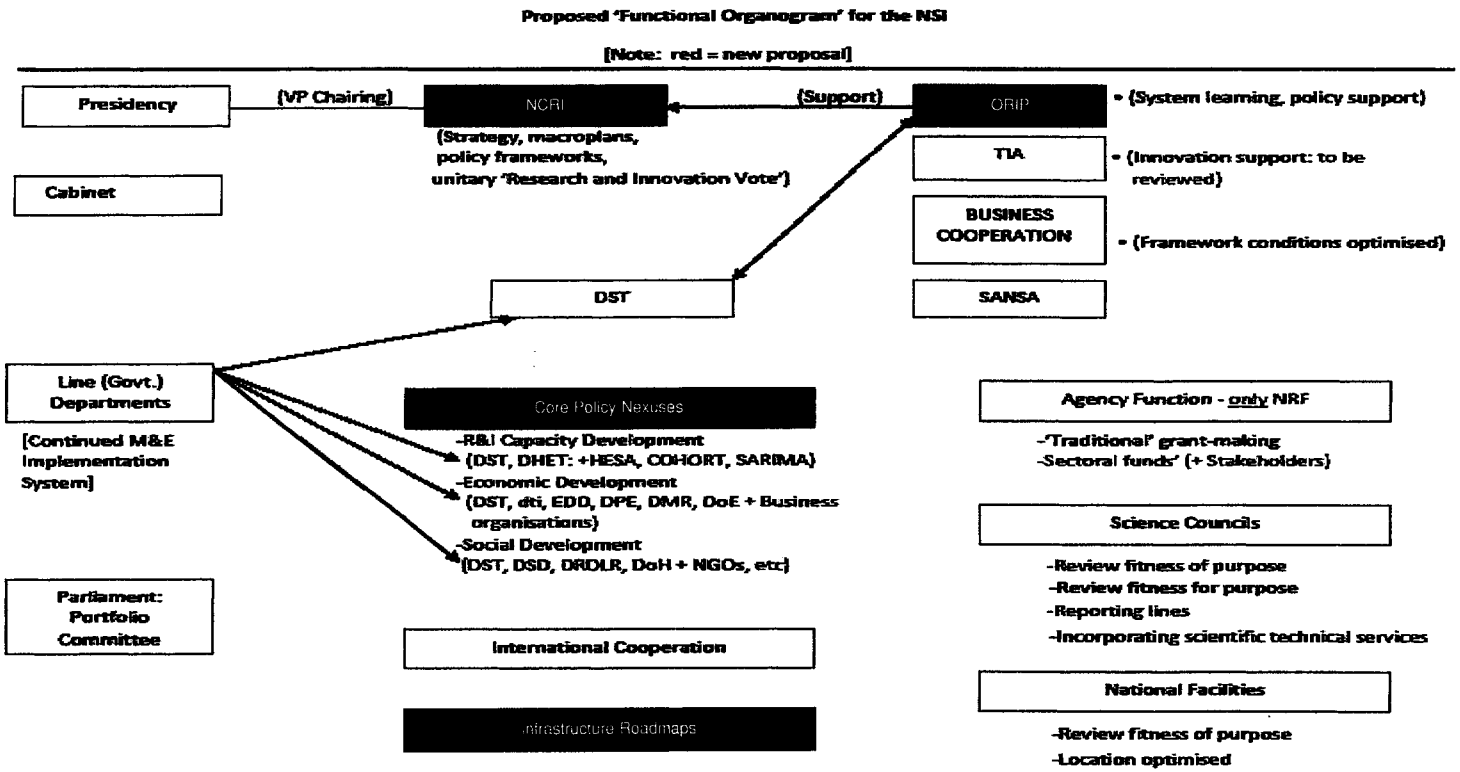
FRD	Foundation for Research Development
FTE	Full-time equivalent
FTSE	FTSE Group
GERD	Gross domestic expenditure on R&D
HCD	Human capital development
HEI	Higher education institution
HEMIS	Higher Education Management Information System
HEQC	Higher Education Quality Committee
HEQF	Higher Education Qualifications Framework
HESA	Higher Education South Africa
HET	Higher education and training
HIV	Human immunodeficiency syndrome
HSRC	Human Sciences Research Council
ICSU	International Council for Science
ICT	Information and communication technology
ID	Identity
IDC	Industrial Development Corporation
IDRC	International Development Research Centre
IP	Intellectual property
IPAP	Industrial Policy Action Plan
IPR	Intellectual property rights
ISI	Institute for Scientific Information
iThemba LABS	iThemba Laboratory for Accelerator-based Science
JET	Joint Education Trust
JINR	Joint Institute for Nuclear Research
JSE	Johannesburg Securities Exchange
KAT	Karoo Array Telescope
KPI	Key performance indicators
M&E	Monitoring and evaluation
MCOST	Ministers' Committee on Science and Technology
MDG	Millennium Development Goals
MDM	Mass Democratic Movement
Mintek	Council for Mineral Technology
MIS	Management information system
MoU	Memorandum of understanding
MP	Member of Parliament
MRC	Medical Research Council
MTEF	Medium-Term Expenditure Framework
NACI	National Advisory Council on Innovation
NARS	National Agricultural Research System
NASA	National Aeronautics and Space Administration
NCRI	National Council on Research and Innovation (proposed)
NECSA	South African Nuclear Energy Corporation
NEP	National Equipment Programme
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organisation
NIFU-STEP	Nordic Institute for Studies in Innovation, Research and Education - Centre for Innovation Research
NIPMO	National Intellectual Property Management Office
NNEP	National Nanotechnology Equipment Programme
NPC	National Planning Commission
NPO	Non-profit organisation
NQF	National Qualifications Framework

NRDS	National Research and Development Strategy
NREN	National Research and Education Network
NRF	National Research Foundation
NRTF	National Research and Technology Foresight
NSF	National Skills Fund
NSI	National System of Innovation
NSMM	New Strategic Management Model
NSTF	National Science and Technology Forum
OECD	Organisation for Economic Cooperation and Development
OEM	Original equipment manufacturer
ORIP	Office for Research and Innovation Policy (proposed)
PBMR	Pebble Bed Modular Reactor
PhD	Doctor of Philosophy
PIC	Public Investment Corporation
PRO	Public research organisations
R&D	Research and development (sometimes Research and experimental development)
R&I	Research and innovation
RIMS	Research Information Management System
S&T	Science and technology
SA	South Africa/ South African
SAASTA	South African Agency for Science and Technology Advancement
SADC	Southern African Development Community
SAIMR	South African Institute for Medical Research
SALT	Southern African Large Telescope
SANBI	South African National Biodiversity Institute
SANReN	South African National Research Network
SAPSE	South African Post-Secondary Education
SANSA	South African National Space Agency
SARChI	South African Research Chairs Initiative
SARIMA	Southern African Research an d Innovation Management Association
SARS	South African Revenue Service
SAYAS	South African Young Academy of Science
SCiELO	Scientific Electronic Library Online
SET	Science, engineering and technology
SETI	Science, engineering and technology institutions
SKA	Square Kilometre Array
SME	Small and medium enterprises
SOE	State-owned enterprises
SPII	Support Programme for Industrial Innovation
SRIP	Strategic Research Infrastructure Programme
STA	Science and Technology Activities
STEM	Science, technology, engineering and mathematics
STET	Scientific and Technological Education and Training
STI	Scientific and Technological Innovation
STS	Scientific and Technological Services
TB	Tuberculosis
TBOP	Technology Balance of Payments
TENET	Tertiary Education and Research Network of South Africa
THRIP	Technology and Human Resources for Industry Programme
TIA	Technology Innovation Agency
TIPTOP	Technology Innovation Programme for the Transfer of People
TNC	Transnational corporation

TYIP	Ten-Year Innovation Plan
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USPTO	United States Patent and Trademark Office
VDU	Visual display unit
WoK	Thomson-Reuters Web of Knowledge
WRC	Water Research Commission
US	United States of America
VP	Vice President

APPENDIX 2: ORGANOGRAMS OF THE PROPOSED INSTITUTIONAL STRUCTURE FOR THE SOUTH AFRICAN NSI





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