

Reply to Lutjeharms and Thomson

Commercializing the CSIR and the death of science?

D.F. Toerien, N.M. Walters, D.H. Swart* and H.P. Hofmeyr

Lutjeharms and Thomson¹ decided that it was opportune to assess 'critically' what had been wrought by the 'dramatic organizational and cultural changes' to 'the largest scientific organization in Africa', the South African CSIR. This analysis by two former CSIR employees has a guise of scientific objectivity, and takes a 'brief' look at the new philosophy, the new structure, the management style and some preliminary results of the CSIR. It then concludes 'that the present financial position of the "new" CSIR suggests only ambivalent success in attracting funds from the private sector' and because this was the main 'rationale for the whole restructuring', the process was unsuccessful and 'achieved at the expense of the entire scientific enterprise within the CSIR'.

While we welcome any constructive criticism of the CSIR, we will show that many of the facts presented by Lutjeharms and Thomson¹ are either erroneous or open to different interpretation, that they selectively quote from the literature to support particular points of view, that they ignore major factors in their analysis, and that if we use their own measure, quoted above, the restructuring of the CSIR was in fact highly successful.

Approach of Lutjeharms and Thomson

Lutjeharms and Thomson¹ use the following approach to build their case: they examine certain aspects of the 'old' CSIR, considered some of the external pressures which influenced the organization in the mid-eighties, provide their perception of the way the CSIR was managed during its transition, compare on a selective basis quotes from the literature which support their perceptions of the 'new' CSIR, assess its outputs on a very limited (and in some instances erroneous) basis, and then reach some very strong conclusions.

The mental models of Lutjeharms and Thomson¹ about a number of issues such as the link between science and economic prosperity, the role of national research organizations in the setting of a developing country, and the management of R&D organizations are never stated explicitly and make the assessment of the quality of their analysis of the CSIR more difficult. For this reason, we will point out where their analyses have

weaknesses and where they completely ignore important and relevant issues. We followed the outline (see above) of the process they use.

The old CSIR

Lutjeharms and Thomson,¹ referring to Kingwill,² stated that 'the Council for Scientific and Industrial Research was established in 1945 with the express aim of bringing into existence a South African national research organization to address national technological problems and to serve as a central scientific powerhouse'. We believe this is a fairly liberal interpretation of:

● Kingwill's words that 'General Jan Smuts ... was acutely aware of the need for science-in South Africa to be geared to meet the challenges of a rapidly changing world',² or that,

● 'according to Dr Basil Schonland the purpose of the Bill was to promote the following:

— The better application of scientific research, pure and applied, to the development of the natural resources and industries in the Union.

— The proper co-ordination of research everywhere in the country, in government departments, universities, technical colleges and all state-aided organizations.

— The training of the workers, including technicians, needed for scientific research'² or,

● the concluding words of Minister Hofmeyr in Parliament during the discussion of the Act to establish the CSIR. He said that the functions of the CSIR were such that: '... it will itself undertake certain types of research work, it will assist research work sponsored by others, it will foster the establishment of industrial research institutes, it will encourage the training of research workers, it will act in liaison with research activities in other countries and it will provide for the collection and dissemination of information in regard to research'.²

It seems clear to us that the three central figures in the creation of the CSIR, General Smuts, Dr Schonland and Minister Hofmeyr, expected the CSIR to serve the interests of South Africa, particularly the development of natural resources and industries. We do not find evidence of a philosophy that the CSIR's main purpose should be to create knowledge.

Lutjeharms and Thomson¹ conclude from the fact that the National Physical Research Laboratory and the National Chemical Research Laboratory were established in 1945, that the 'basic sciences ... formed the cornerstones' of the strategy to develop the CSIR. Later they also use this as their reason for having a disciplinary approach to scientific research in South Africa. However, they do not mention that the National Building Research Institute, a multidisciplinary institute, was also established in 1945. This clearly shows that a multidisciplinary approach was also used to deal with some of the challenges which faced the CSIR at the time.

Lutjeharms and Thomson¹ conclude that the growth of the CSIR, until the period of change in the mid-eighties, was as a result of the development of a need external to the CSIR to establish a new institute (their words are: '... such an institute was then allowed to develop in a natural and organic way from the existing mother laboratories') or took place because 'research groups and laboratories that hitherto had been independent were placed under the CSIR's umbrella ...'. This points to the fact that, in the period 1945–1986, the CSIR largely reacted to events outside of itself and that in this period there were no formal CSIR corporate (and thus pro-active) strategies to grow the organization or to allow the different institutes, laboratories and other groups to act in concert to achieve overarching goals. We believe that by the mid-eighties this position was no longer tenable.

Lutjeharms and Thomson¹ refer only in passing to the role of the 'old' CSIR to 'foster research at universities' and to maintain a scientific library and offices abroad. They do not refer at all to the 'old' CSIR's role to co-ordinate research, but they add other roles such as: 'perhaps in not quite so obtrusive a way the CSIR also played an important supportive role for the national research effort through its vast and excellent infrastructure' and 'through maintaining the ... best scientific workshops it served the wider scientific community'. We found no evidence that either of these roles formed part of the reasons in 1945 for establishing the CSIR; nor that they formed part of an explicitly stated strategy in the period

Dr D.F. Toerien is a vice-president, Dr N.M. Walters and H.P. Hofmeyr are at Marketing and Business Development, and Dr D.H. Swart is director of the Division of Earth, Marine and Atmospheric Science and Technology, CSIR, P.O. Box 395, Pretoria, 0001 South Africa.

*Author for correspondence.

1945 to 1985. Thus limited importance should be attached to these roles.

Some of their reasoning about the old CSIR tend to confuse. For instance, they distinguish between the activities of universities, the CSIR and factory (sic) laboratories on the basis of universities doing 'more esoteric basic research', the CSIR doing 'contract and basic research', and industrial laboratories doing 'narrowly focused product research'. What they understand under these concepts is never explained. They also refer to 'disciplinary (our emphasis) institutes' which cover 'a broader range of subjects in their respective disciplines than any university could manage' and maintain that for these reasons 'national laboratories are highly rated ... for their ability to maintain large multidisciplinary projects that are difficult to run anywhere else'. The logical connection between a unidisciplinary nature in one case justifying a multidisciplinary approach in another is indeed mystifying.

Lutjeharms and Thomson¹ also fail to point out that the CSIR was created through an Act of Parliament in 1945,² which makes Parliament the *de facto* 'owner' of the CSIR. Although they mention the CSIR Council in passing, Lutjeharms and Thomson fail to explain the role of this governing body (on behalf of Parliament). This leads to an illusion that the CSIR Executive is free to choose and implement actions. The fact is that the CSIR Executive, in the 'old' and 'new' CSIR, has always been under the control of a governing body. (The Council in the 'old' CSIR and the Board in the 'new' CSIR.) Council members played an important role in the restructuring of the CSIR.

The way in which Lutjeharms and Thomson¹ discuss the 'old' CSIR suggests that they selectively paint a picture, apparently to justify their own ideas of the importance of a discipline-based structure for a national research organization. We believe that this view is incompatible with the emphasis placed from the start on the CSIR as an R&D vehicle for the development of the country by whatever means, whether through unidisciplinary and/or multidisciplinary approaches. We do not agree that the purpose of the national laboratories was seen from the start by the people responsible for its creation to be mainly the pursuit of knowledge (that is, basic research).

External pressures

Lutjeharms and Thomson¹ correctly state that some of the pressures which came to bear on the CSIR in the mid-eighties were the May 1985 White Paper on a national strategy for industrial

development, the views about the CSIR expressed in Parliament on 16 April 1986, and the negative views held at that time in some university and industry circles about some of the national laboratories. As the *de facto* 'owner' of the CSIR, the views and decisions of Parliament about the CSIR were extremely important to the CSIR, and these and other reasons prompted the organization at that time to rethink its future. In this process, the Board of the CSIR, as representatives of the owner (Parliament), played a significant guiding role, for which they were well suited by virtue of the extensive private sector/business expertise vested in the Board.

Lutjeharms and Thomson¹ fail to mention a number of other important external pressures which also influenced the CSIR. For instance, they do not consider the policy of Framework Autonomy³ which was evolved by Government as a management approach for the scientific councils. This policy has been an important determinant, in conjunction with the official science policy,³⁰ in the operation of the CSIR, and other scientific councils, after its introduction.

Although authors such as Peter Drucker and Tom Peters are quoted by Lutjeharms and Thomson,¹ they do not point out that these authors also warn about the difficulty of managing complex organizations in turbulent times. In fact, the changing and turbulent world reflected in books such as *Future Shock*,⁴ *Mega-trends 2000*,⁵ *The Art of the Long View*,⁶ *The World and South Africa in the 1990s*⁷ and *The Third Wave*⁸ is ignored as a factor which has helped to shape South Africa, and hence institutions such as the CSIR.

The economic trends in South Africa during the eighties (partly as a result of political isolation) are also completely ignored. Surely any assessment of the degree of success of a market-driven strategy should consider the ability of the market-place to drive that strategy? Lutjeharms and Thomson¹ did not even consider the state of the economy and its influence on Parliament to fund research, and on state departments and private companies to fund contract research.

Furthermore, Lutjeharms and Thomson¹ also do not mention that the political processes which started in February 1990 resulted in a drastic reduction in spending on defence. Naturally, this also affected funds for R&D in this sector, as a result of drastic changes in State spending, and it also affected R&D funding in other ways. This fact is also not considered. We believe, therefore, that Lutjeharms and Thomson¹ do not discuss the CSIR, 'old' and 'new', in the context of

all the major external influences which have impacted upon it over the past few years. This results in a rather simplistic analysis.

The change process

Lutjeharms and Thomson¹ correctly state that a firm of management consultants advised the CSIR's Board and Executive in developing the strategy for the future course of the CSIR. However, they, choose to ignore the fact that the development of the strategy was based on extensive consultation with stakeholders outside the CSIR as well as internally with many staff members at different levels of seniority. The impression created, therefore, of a 'top-down' change which 'allowed no criticism or discussion' of this process is simply not true. What is true, is that it was not practically possible to involve every member of staff in the decision whether to change the organization or not, but during the process of change greatly enhanced communication processes, which included question-and-answer sessions by senior managers which involved all staff, allowed ample and extensive opportunity for questions and criticism. We would submit that very few organizations in South Africa, particularly in the scientific and academic world, practise open communication to the same extent as was, and still is, the norm in the CSIR. Readers can ask themselves if they regularly have the opportunity to put any question about their organization to their senior managers. CSIR staff have this opportunity as part of our regular and open communication practices.

Lutjeharms and Thomson¹ also fail to mention that the management of the change process in CSIR was not done on simple 'gut feel'. Before the change process was initiated, senior managers, together with the management consultants, went abroad to leading business schools in the USA to study how major organizational change is successfully managed. In addition, different countries and organizations (which have undergone major restructuring, some successfully and others not) were visited to extract the lessons learnt.

Stacey⁹ points out that change is today's central business concern. Kanter¹⁰ compares the old bureaucratic change-resisting organizations with a set of highly innovative corporations that are market leaders because they anticipated the need for change and stimulated corporate entrepreneurs to guide it. James Belasco¹¹ starts his book, *Teaching the Elephant to Dance: Empowering Change in Your Organisation*, with the words: 'We need to change. We're in trouble. Business as

usual is out.' His recipe for the management of change is: build a sense of urgency, create a clear tomorrow, develop a migration path, and reinforce the new behaviour.

Lutjeharms and Thomson¹ do not draw upon the change lessons from Stacey,⁹ Kanter,¹⁰ Belasco,¹¹ and others; in fact, they even ignore the change-management lessons which do not coincide with their views when they quote the literature of authors such as Peters and Waterman¹² and Drucker.¹³

We believe that Lutjeharms and Thomson¹ underrepresent the turbulence which is sweeping the world and has forced change upon all organizations. Instead, they endeavour to sketch a scenario in which the CSIR could have continued doing 'more of the same' and at the same time could have escaped the disastrous consequences of this course of action. We believe that all evidence is against such an hypothesis.

Lutjeharms and Thomson¹ create the illusion that the CSIR management at the time of the change could have operated without any constraints (from external forces, government policies, its Board, the practicalities of the management of a large organization, and the natural resistance of humans to change). By ignoring the facts, they introduce a bias in their reasoning and illustrate a poor understanding of the checks and balances inherent in the management of a large and complex organization.

Lutjeharms and Thomson¹ seem to be upset by the fact that the strategic planning process of CSIR uses the standard process of identifying competitors and assessing how a competitive advantage, if any, can be obtained. They thus ignore the realities of a competitive world which is so eloquently described, amongst others, in the books of Stacey,⁹ Michael Porter,^{14,15} and Kenichi Ohmae.¹⁶ In fact, it is noteworthy that Lutjeharms and Thomson¹ in their text refer to Richard Foster's book¹⁷ by only half its title. They called it *Innovation*, although the full title is *Innovation, the Attacker's Advantage*. Foster clearly shows how competition between technologies often determines the demise or success of organizations. We believe that, instead of ignoring or at least misstating the realities of a competitive world, also in the scientific arena, Lutjeharms and Thomson¹ should take it into account in their analysis.

Lutjeharms and Thomson¹ also try to create the impression that the creation of 'a market orientation for science' is outdated. Their reasoning is again based on selective quotes from the literature. In a recent work, *Third Generation R&D:*

Managing the Link to Corporate Strategy, Roussel, Saad and Erickson¹⁸ develop concepts to promote the management of R&D as a strategic competitive weapon. They show that it is necessary to break the isolation of R&D and to investigate technology/R&D and business strategies. This approach requires a sound understanding of markets.

We believe the trend world-wide is towards an increased commercial bias in 'national research organizations'. The TNO in the Netherlands, CSIRO in Australia, DSIR in New Zealand, and the National Physical Laboratory and National Engineering Laboratory in the UK have all gone this way. Lutjeharms and Thomson¹ disregard the evidence when they try to create a different impression.

Although they quote examples from the USA and Germany about government policies on the funding of basic research, they ignore (deliberately?) the underlying philosophies of the policy of Framework Autonomy³ and the science policy,³⁰ which set out the expectations of the South African government of the scientific councils, including the CSIR. This policy provides the backdrop against which the CSIR operates and it expects a greater market orientation in the activities of all scientific councils. The reason for the above is the expectation that it will improve the process of technology transfer, one of the final steps in the chain of events between an invention and its successful introduction in the marketplace.¹⁹⁻²¹

The 'new' CSIR has three important thrusts in its activities:

- To be the technology partner of the South African industry, both in the formal and informal sectors, in order to leverage the role of technology in the creation of wealth for the nation.
- To use the leverage of technology in assisting decision-making processes in the private and public sectors, and
- To use technology to benefit the process of community development in its widest sense.

None of these can be successfully handled without a proper understanding of the needs of the various sectors, now and in the future. We believe that the market orientation of the CSIR has increasingly aided it to be more effective in these roles.

Effects on employees

The traumatic effects that the change process had on the CSIR staff appear to have shocked Lutjeharms and Thomson.¹ Alvin Toffler⁴ helps us to understand the dynamics involved:

'Future shock is a time phenomenon, a product of the greatly accelerated rate of change in society. It arises from the superimposition of a new culture on an old one. It is a culture shock in one's own society ... He also states: Change is avalanching upon our heads and most people are grotesquely unprepared to cope with it'.

The reactions of CSIR staff were therefore normal human behaviour in turbulent times and not a reflection of bad management practices, as Lutjeharms and Thomson¹ intimate.

They also do not ask why flat management structures were introduced into the CSIR, but merely criticize the CSIR for creating 'micro-management down to the lowest levels'. In our opinion the latter statement is untrue, because of the dramatic reduction in codes of practice and hence red tape following the reorganization of the CSIR. What is true, however, is that many CSIR staffers did not like the increased responsibility and accountability that went along with flat structures. However, a flat structure was needed to create a flexible and responsive organization which could become truly market-orientated.

Kanter²² points out that companies today are changing their shape frequently and dramatically. Restructuring is but one of the strategies pursued. The others are the opening of their boundaries to form strategic alliances and/or joint ventures, and developing explicit programmes of investment and coaching to stimulate and guide the creation of new ventures from within.

Stacey⁹ discusses the need for hierarchy in an organization in a turbulent environment. He points out that, because turbulent change is taking place at all levels in an organization and because scanning the environment cannot be specialized, all people in the organization are required to be in touch with the environment and to respond to it. All are required to act in the face of change. He goes on to say that widespread participation and the empowering of people is called for. Although Lutjeharms and Thomson¹ depict some of the characteristics of the 'new' CSIR in a negative light, authors such as Kanter¹⁰ and Stacey⁹ teach us that these characteristics are needed for success.

We suspect that Lutjeharms and Thomson¹ use an exception to try to prove a rule when they state: 'In a number of cases where researchers have successfully undergone this transformation, they have left the CSIR to set up shop for themselves with large personal remunerative advantage'. Some people did indeed leave the organization to set up their own businesses, but this has

always been the case, even before the change. In addition, Lutjeharms and Thomson¹ quote erroneous statistics on CSIR staff turnover. Prior to the restructuring, the CSIR's staff turnover was calculated on a different basis, and pre- and post-restructuring turnover figures are therefore not directly comparable. The 8% prerestructuring turnover figure quoted by them applied only to a particular staff category. In fact, when one compares total annual staff turnover, it can be seen that the comparable staff turnover is now lower than it was before the change process started (Table 1).

In 1991 the CSIR's annual average staff turnover was 14%, which compares favourably with the 18% average for technology-intensive industries in the RSA. At present, our average annual controllable turnover, that is excluding those staff members who die, retire or are retrenched, is less than 8%.²³

Staff turnover in the CSIR has been affected by a number of other factors during the past few years and not only by the cultural effects of the change process. For instance, a number of groups transferred into and from the CSIR. The Foundation for Research Development and the national facilities [National Accelerator Centre (NAC), the South African Astronomy Observatory (SAAO) and the Radio Astronomy Observatory (RAO)] left the CSIR, while the South African Forestry Research Institute joined the CSIR. Those events have influenced changes in the CSIR's staff complement, a fact not highlighted by Lutjeharms and Thomson.¹ They create the impression that all changes in staff numbers resulted from the reorganization and the new management style.

Lutjeharms and Thomson¹ also comment that in the CSIR 'all groups as well as individuals are regularly judged by financial returns or potential returns' leading to a 'fast-buck syndrome'. They offer no factual proof to support this claim. The truth of the matter is that only the 12 divisions of the CSIR represent business units, not groups nor individuals. It is true that an organization which is expected to generate continuously more of its own income will be sensitive to how well it is investing its resources (financial and human) into activities that will help to achieve the goal of greater financial self-sufficiency. The CSIR is committed to a coherent set of long-term strategic goals to develop its market orientation and its resources. The CSIR therefore does not take this goal of self-sufficiency to the extremes ascribed to it by Lutjeharms and Thomson,¹ because the CSIR recognizes that long-term via-

Table 1. Annual staff turnover from April 1986 to March 1992.

Period	Total staff	Annual staff turnover (%)
April '86–March '87	4788	14.2
April '87–March '88	4688	16.1
April '88–March '89	4471	18.4
April '89–March '90	4135	14.9
April '90–March '91	3788	13.9
April '91–March '92	3427	12.5

bility is just as important as short-term survival.

We believe that Lutjeharms and Thomson¹ misrepresent the negative effects of the restructuring on CSIR employees, as well as ignoring some of the beneficial effects. They do not dwell on the increased teamwork, growth in skills and confidence, and heightened 'ownership' and empowerment of CSIR staff. We know that this is the case, because employee attitudes are regularly assessed by independent assessors.

Management success

Lutjeharms and Thomson¹ endeavour to create the impression that the CSIR's management style and philosophies are out of step with the best modern thinking in managerial science. They quote William Deming to prove that a performance-based remuneration system is out of touch with practical realities. However, the Hay system used for remuneration management by the CSIR is an internationally accepted system²⁴ which is widely used in South Africa and at least 24 other countries. Battelle Laboratories, a leading non-governmental contract research institution in the United States, also uses the Hay system.²³ Results-based performance management through 'key performance areas' is also widely practised.^{25,26} Belasco¹¹ stated that one should 'use your performance appraisal system to empower your people to use your vision'. The CSIR is thus operating in line with the practice of many of the world's foremost organizations.

Lutjeharms and Thomson¹ refer to the CSIR's pride 'on the efficient manner in which each project is managed by budgetary measures'. They then criticize this as being outdated on the basis of the approach propounded in *In Search of Excellence* by Peters and Waterman.¹² It should be stressed that Peters changed many of his original ideas in his later books: *A Passion for Excellence*²⁷ and *Thriving on Chaos*.²⁸ Many of the companies Peters and Waterman¹² at first identified as being excellent were no

longer considered to be excellent five years later. In his recent works, Peters has indeed emphasized the importance of cost control and sound financial management. In fact Lutjeharms and Thomson¹ deal very superficially with the underlying philosophies of different schools of thought on management practices. Although they refer to authors such as Drucker, Peters and others, they do not point out that two broad schools of thought are represented by the authors they cite.

Stacey⁹ points out that diametrically opposed explanations are often offered for the success of organizations. He also states that authors such as Drucker and Ansoff stress the rational approach, while Peters and Waterman proposed an entrepreneurial approach. By ignoring the fact that there are many different views of the management approaches necessary for success, Lutjeharms and Thomson¹ only put forward a view consistent with their ideas. We do not claim that the CSIR's management system is the only correct one; however, we know that it works for the CSIR.

Lutjeharms and Thomson¹ comment negatively on the fact that project management in the CSIR is coupled to budgetary issues. They omit to state that project management embodies a wide range of issues and does not concentrate only on financial ones. They then quote Peters and Waterman¹² as stating that this approach is outdated. While agreeing that exclusive emphasis on financial aspects is inappropriate, we believe it is also necessary to refer to Kerzner,²⁹ who in his tome on project management states that project management of R&D projects endeavours to obtain more efficient utilization of resources within an organization. He adds: 'Furthermore, all projects must be completed within the constraints of time, cost and performance. If the project is for an outside customer, then there exists a fourth constraint — good customer relations.' He also comments that R&D personnel were probably the first true project managers in the world, but that even today very little project management training is provided for R&D personnel. It is clear that the CSIR's practices are built on views such as those of Kerzner,²⁹ not only for project management but also for the training which our staff receive in it.

Lutjeharms and Thomson¹ conclude that the CSIR's change-management process was too rapid and that the organization is in danger of demise. Yet, by their own admission, this change process 'can only be considered a resounding and remarkable success'. We do not understand these simultaneous, but opposing,

government departments and defence establishments have been more than what the organization could make up in the private sector. This meant that the organization has undergone some rationalization and shrinkage. Nevertheless, the fact that the CSIR has now moved to approximately 60% financial independence (this percentage also takes interest and other non-operational income into account, as it had also done before 1988) indicates that the organization has handled the challenges posed by external pressures and changes in the patterns and quantities of government funding very well. We believe that this could never have been the case if the organization did not go through the restructuring process in the mid-eighties.

Technology and implementation success

Lutjeharms and Thomson¹ generalize about a 'rule of thumb' to link the required production of novel ideas, patents and financially successful products with one another, but unfortunately provide no reference for this. They then apply this rule, together with the output of patents by a research institute in Taiwan and a quote, taken out of context, of the CSIR President, to conclude that emphasis on returns from research is incompatible with the production of financially successful innovations. We find this an extraordinary approach.

As will be seen from Fig. 1, the CSIR definitely meets the requirements of the patents 'test' for market-orientated technological research. This figure shows that the number of patent applications filed by the CSIR in the RSA and in foreign countries has grown very significantly since 1987.

We agree that the only test of successful innovation is in the market-place. That the CSIR has managed to increase its external income (Table 2) must reflect successful innovation, not only for products, but also for services and processes (the 'products' of the CSIR include services, processes and physical products). If clients were not satisfied with the level of innovation in the organization and its products, they would not support the CSIR. The CSIR has increased its external income relative to the parliamentary grant it receives (Table 2). This is again an indication that the market success of the organization has improved markedly.

Lutjeharms and Thomson¹ also state 'that there is no argument that the new CSIR no longer sees itself as playing a role in basic or fundamental science in South Africa'. What these words mean is not explained, especially in terms of the outputs expected by them. If they are

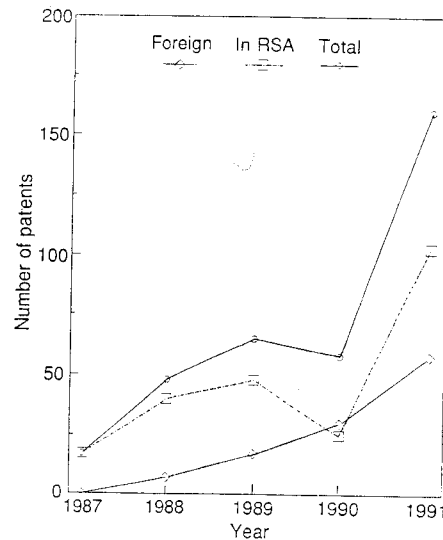


Fig. 1. Growth in number of patent applications filed since 1987 by the CSIR, at the South African Patent Office (□), in foreign countries (Δ), and total (○).

referring to the pursuit of science simply for the sake of creating new knowledge, with no hope that this knowledge could ever be of value to South African society, the answer is that they are correct. We do not believe that South Africa, as a developing country, has the resources to pursue science in a way First World countries can. As stated earlier, we find no evidence in the reasons or actions which resulted in the creation of the CSIR in 1945, nor in the Act and government policies which govern the 'new' CSIR, to suggest that scientific pursuit without any link to potential benefits which might accrue to South African society at large was ever seen as the reason for being of the CSIR. We believe that Lutjeharms and Thomson¹ suffer from a fallacious myopia about science in South Africa.

In the CSIR, we understand that our longer-term competitiveness will be determined by, among other things, our ability, through our investments, to develop those products, services and processes which will make an impact in the market-place. Thus, under certain circumstances, it is in our best interests to invest in basic research, provided it is aligned to our mission and fits our strategic objectives.

The practices of the CSIR in its R&D activities are not out of step with any of the statements quoted by Lutjeharms and Thomson¹ on innovation and the role of basic science. It must, however, also be recognized that South Africa performs only about 0.2% of the world's R&D and that, like all small countries, we have to be sensitive to the acquisition of the results of fundamental scientific research from elsewhere in the world. On the

other hand, the CSIR also appreciates that we have to maintain some long-term scientific efforts in those areas where we have a scientific competitive advantage, and to explore pro-actively scientific and technological areas not adequately addressed by other local or international research organizations. Therefore, when we as the CSIR enter into these areas we do expect such R&D aims ultimately to benefit the country.

When Lutjeharms and Thomson¹ refer to recent products of the CSIR, they use a rhetorical question and are very selective in what they present, to make a case for 'gimmickry'. If their approach is scientifically objective, why do they not also refer to products such as the Zebra battery, referred to in the annual report of the Anglo American Corporation³¹ and now under test at Daimler Benz? They do not mention the development of the first all-composite-material technology-demonstrator trainer aircraft, and many other significant achievements. We would not argue that the CSIR has never been guilty of developing some gimmicks; however, 'the peristaltic pump, sweetened egg products...', etc. have a role if they are needed in the market-place and we can offer our customers some benefits through their development or adaptation. Most importantly, though, Lutjeharms and Thomson¹ choose not to present the CSIR's 'products' in their total context, namely all the services, processes and products which we offer. The fact that you do not earn in the order of R200 million external income if your products are gimmicks, is not even considered — another example of (deliberate?) misrepresentation.

The effect on science

Lutjeharms and Thomson¹ state that the 'final product of ... scientific activity, namely publications in peer-reviewed literature, is at best tolerated and at worst discouraged' in the CSIR. They do not quote the source of this statement, which must therefore be seen as a perception and not necessarily a truth. In fact, each CSIR division reports extensively every three months to the CSIR Executive on all of its activities, including publications and attendance at conferences.

It is a pity that Lutjeharms and Thomson¹ claim that 'measurable results of' the so-called 'restrictive policy' (for the existence of which they submit no proof) have been 'immediately evident', and yet they provide no hard data. This is also the case in their statements on participation in national scientific societies. By vague innuendos they create a picture of the CSIR which they do not balance with facts supporting their statements. Why do

they not refer to the major participation of CSIR in events such as the Annual Traffic Convention, the Biennial Conference of the International Association of Water Pollution Research and Control, among others?

When Lutjeharms and Thomson¹ discuss the availability of CSIR infrastructure, such as its library, to the South African scientific community, they are once again guilty of doing so without taking into account the context in which the CSIR operates. The CSIR's mandate is to provide decision-makers and specialists in the private and public sectors with comprehensive, yet cost-effective, access to local and global sources of information. It faces the dilemma that South Africa is critically dependent on overseas information, which is becoming increasingly expensive as a result of the deteriorating exchange rate. Adequate and affordable access to international sources of scientific and technological information can be maintained in future only if the CSIR provides its information services on sound business principles. This approach ensures that information remains affordable to the individual end user, because the cost of the infrastructure is shared by many users. At the same time, market pressure ensures efficient and cost-effective services.

This approach has been tested over the past few years. Its success is demonstrated, firstly, by the fact that the use of the service by private and public-sector organizations is increasing. Secondly, through its buying power and influence, the CSIR has been able to reduce transatlantic telecommunication charges for users, to negotiate discounts on database connect time, and to ensure fast and reliable service from overseas service providers.

As mentioned before, the policy of Framework Autonomy sets the scene against which they should test their concepts. Instead, they prefer to blame the CSIR's management for what they consider to be a retrogressive approach. Simply put, we ask how is an organization which is continually receiving less-direct state funding supposed to maintain facilities for the science community in the country and simultaneously also ensure that it increases its financial independence? They ignore the realities of a weak economy and changing government funding priorities when they seemingly imply that what the government and CSIR could provide yesteryear should continue to be provided in the future. They also ignore the fact that some of these functions have been transferred to other institutions.

Conclusions

Right from the start, the CSIR's function was to serve the interests of South Africa (and not only the interests of South African scientists), and its recent restructuring has enabled it to better meet this goal. The analysis of Lutjeharms and Thomson¹ is therefore based on incorrect perceptions of the CSIR's overall objective, as well as on incorrect assumptions that the 'old' CSIR consisted only of discipline-orientated institutes. The reasons behind the decision

The 'new' CSIR has three important thrusts:

- To be the technology partner of South African industry.
 - To use the leverage of technology in assisting decision-making in both private and public sectors.
 - To use technology to benefit community development.
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and actions to restructure the CSIR are exactly those confronting all South African scientific and technological institutions today, namely,

- the rapid and turbulent change in the internal economic and political climate, as well as in many important global environmental conditions
- the revised national emphasis on the relevance of scientific and technological activities to the country as a whole; and
- the reduced availability of government funding for science and technology, in view of both the economic situation and the need for funds by other important components of South African society.

The CSIR should therefore not be castigated by way of incomplete and inappropriate analysis for its 'sin' in reading the signs earlier and therefore reacting through restructuring sooner than most of the other players in the local science and technology arena. Perhaps it should rather be commended for what it has achieved in this regard and be held up both as an example to be followed post-haste by all other players in this arena and as a source of learning about how to do it.

In line with the reduction in government funding for science and technology, it was inevitable that those support services which were provided in the past by the 'old' CSIR and which were not transferred to other bodies such as the Foundation for Research Development, could no longer be supplied free of charge to all comers. In cases where it is not worthwhile for other organizations to provide such services, these are, in most

cases, still available from the CSIR if those requesting them can support their desire for such services by paying for them.

In line with management studies and international experience, the process of change at the CSIR was thoroughly planned and implemented, with as much involvement as practically possible from its own staff, but also from all the other equally important stakeholders. In addition, the similar patterns of 'commercialization' actions by other major applied science and technology institutions elsewhere in the world, and the CSIR's own financial success in recessionary conditions, confirm the viability of the market orientation and proper strategic management for applied science. Similarly, the employment of suitable managerial approaches, such as flat management structures, management partially but not exclusively based on financial budgets and returns, and performance-based management and remuneration, arose from the challenge to move the CSIR as rapidly as possible to a position in which both its short-term survival and its long-term viability could be ensured. In this respect the CSIR's growing contract income, especially from the private sector, is proof that the CSIR has acted in time and, in doing so, not only averted large numbers of possible redundancies, but also created the basis for future viability in an environment which promises to become even more turbulent.

This growth in contract income is also sufficient evidence of the increasing technological relevance of the CSIR to the country. The scientific approach within the CSIR has therefore been saved from demise, in that it has become much more focused on what the country needs and can afford, and in this way will enable other science players in the country to establish and maintain their rightful niches.

While it was inevitable that such fundamental reorientation would cause 'shock' amongst many employees, these effects were in fact anticipated, so that suitable mechanisms could be put in place to assist employees to cope with the change process. The net effect of these changes on CSIR employees was actually to stimulate them, both individually and in groups, to accept the challenge of commercializing science, except in the case of a limited number of staff members who were not prepared or able to adapt to conditions which already apply in any case to most, if not all, South African institutions, and which will become even more pronounced in future.

The restructuring has enabled the CSIR to build up many resources more relevant to the present and future needs of South Africa, including valuable expertise in technology management and innovation. Therefore, rather than hijacking part of this country's limited resources for science and technology, these CSIR resources are now even better positioned to tackle any scientific or technological activities which our customers deem worthwhile to fund, and so to guarantee their own and South Africa's economic future. The rapidly growing number of projects in which our organization co-operates with universities and other research bodies, locally and internationally, is further evidence of both the CSIR's willingness to collaborate in building up South African science and technology, and the appropriateness of the CSIR's scientific and technological resources.

1. Lutjeharms J.R.E. and Thomson J.A. (1993). Commercializing the CSIR and the death of science. *S. Afr. J. Sci.* 89, 8-14.
2. Kingwill D.G. (1990). *The CSIR — The First 40 Years*. CSIR, Pretoria.
3. DNE (1988). *A System of Framework Autonomy for Scientific Councils*. Department of National Education NATED 11-007 (88/04), Pretoria.
4. Toffler A. (1970). *Future Shock*. Pan, London.
5. Naisbitt J. and Aburdene P. (1990). *Megatrends 2000: Ten New Directions for the 1990s*. William Morrow, New York.
6. Schwartz P. (1991). *The Art of the Long View*. Doubleday, New York.
7. Sunter C. (1987). *The World and South Africa in the 1990s*. Human and Rousseau, Cape Town.
8. Toffler A. (1980). *The Third Wave*. Pan, London.
9. Stacey R.D. (1991). *The Chaos Frontier: Creative Strategic Control for Business*. Butterworth-Heinemann, Oxford.
10. Kanter R.M. (1983). *The Change Masters: Innovation and Entrepreneurship in the American Corporation*. Simon and Schuster, New York.
11. Belasco J.A. (1990). *Teaching the Elephant to Dance: Empowering Change in Your Organization*. Crown Publishers, New York.
12. Peters T.J. and Waterman R.H. (1982). *In Search of Excellence*. Warner, New York.
13. Drucker P.F. (1985). The discipline of innovation. *Harv. Busin. Rev.* May-June 1985, 67-72.
14. Porter M.E. (1990). *The Competitive Advantage of Nations*. Macmillan, London.
15. Porter M.E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*. The Free Press, New York.
16. Ohmae K. (1990). *The Borderless World: Power and Strategy in the Interlinked Economy*. Collins, London.
17. Foster R.N. (1986). *Innovation: The Attacker's Advantage*. Pan, London.
18. Roussel P.A., Saad K.N. and Erickson T.J. (1991). *Third Generation R&D: Managing the Link to Corporate Strategy*. Harvard Business School Press, Boston.
19. Steele L.W. (1988). *Managing Technology: the Strategic View*. McGraw-Hill, New York.
20. Tushman M.L. and Moore W.L. (1988). *Readings in the Management of Innovation*, 2nd edn. Ballinger Publishing Company.
21. Burgelman R.A. and Maidique M.A. (1988). *Strategic Management of Technology and Innovation*. Irwin, Homewood.
22. Kanter R.M. (1989). *When Giants Learn to Dance*. Simon and Schuster, London.
23. Camphor R.F. (1992). Personal communication.
24. Rock M.L. (1984). *Handbook of Wage and Salary Administration*, 2nd edn. McGraw-Hill, New York.
25. Morrisey G.L. (1983). *Performance Appraisals in Business and Industry: Key to Effective Supervision*. Addison-Wesley, Reading, Massachusetts.
26. Odiorne G.S. (1984). *Strategic Management of Human Resources*. Jossey-Bass, San Francisco.
27. Peters T.J. and Austin N. (1985). *A Passion for Excellence*. Random House, New York.
28. Peters T.J. (1988). *Thriving on Chaos: Handbook for a Management Revolution*. Alfred A. Knopf, New York.
29. Kerzner H. (1989). *Project Management: A Systems Approach to Planning, Scheduling and Controlling*, 3rd edn. Van Nostrand Reinhold, New York.
30. DNE (1988). *The Science Policy and System of the Republic of South Africa*. Department of National Education NATED 11-005 (88/06), Pretoria.
31. Anglo American Corporation of South Africa Ltd. (1992). *Annual Report 1992*. Johannesburg.

Rain augmentation research in South Africa

G.K. Mather and D. Terblanche

Certain clouds can be induced to produce more rain via seeding. The next logical step will be to test the capability of the technology to augment surface rainfall.

For the past 10 years, rain augmentation research has been pursued at two centres in South Africa; Bethlehem in the Orange Free State, and Nelspruit in the eastern Transvaal. This research has been funded by the Weather Bureau and the Water Research Commission. The research is centred upon the search for an economical method of augmenting South Africa's critical water supplies by cloud seeding. As the population grows, the country's water supplies and capacity to produce food, fibre and timber products are less able to keep up with demand and especially to withstand the strain of recurring droughts.

Recently, the two centres at Bethlehem and Nelspruit were amalgamated under a single banner — the National Precipitation Research Project (NPRP). This article briefly describes the results of the research to date and shows, at least in the short term, where the NPRP is heading.

Precipitation 'efficiency'

The study of the precipitation formation processes in convective clouds has led to the identification of two precipitation formation mechanisms. The first, called the ice-phase process, is initiated by a few ice crystals which grow by the sublimation of water vapour from their environment until they are large enough to grow by riming (collecting the supercooled water drops which freeze on contact with ice crystal). The second is the formation of precipitation via the condensation-coalescence growth of water drops. These can then freeze and continue to grow by riming. Growth of precipitation via the condensation-coalescence process appears to be the more efficient of the two. This is because the coalescence process, once initiated, leads to the rapid formation of large drops, which, when frozen, grow faster by riming than an equivalent ice crystal. The rate of riming is proportional to the density of the particle, and recently

frozen water drops have a density close to that of water (1 g cm^{-3}). Ice crystals, formed by the sublimation of water vapour, typically have densities of around 0.2 g cm^{-3} when they reach their riming 'threshold'.

If rainfall is to be augmented by cloud seeding, a plausible mechanism or hypothesis outlining how this might be achieved should precede any seeding experiments. After years of observations and measurements, such an hypothesis has been formulated for the thunderstorms of the Transvaal and Free State. These storms produce most of the rainfall in these summer-rainfall areas. However, research has shown that these storms are not efficient producers of rainfall. Of the tons of atmospheric water vapour processed by each storm, only 20 to 30% reaches the ground as rain. The rest is transported up into the high, non-raining anvil clouds which characteristically cover the whole sky by mid-afternoon on days with extensive storm activity. The reason for this inefficiency lies in the strength of the updrafts in the large storms. To collect the condensed water vapour (cloud water) in these updrafts, precipitation embryos growing in the

Dr G.K. Mather is with CloudQuest (Pty) Ltd, P.O. Box 1135, Nelspruit, 1200 South Africa. D. Terblanche is with the Weather Bureau, Bethlehem.