RATEGIC OVERVIE

RS&T: 2010

The Government's Strategy for Research, Science and Technology in New Zealand to the year 2010

STRATEGIC OVERVIEW

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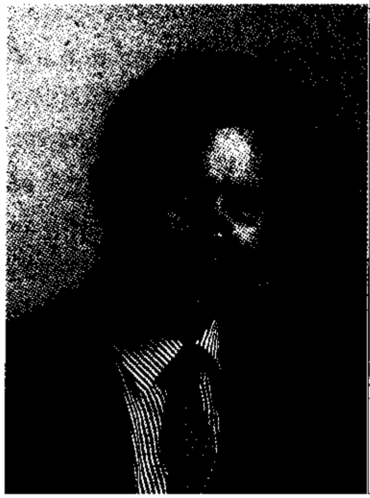
CONTENTS



During the past few years, New Zealand's science and technology institutions, and the way resources are allocated to science, have been the subject of thorough reform. These changes are now well bedded in and are providing the platform for an unprecedented rate of growth in public investment in science and technology.

A long decline in funding for science and technology occurred throughout the 1980s, and only began to reverse in 1992 when the Government announced the first of a series of increases in public investment. RS&T:2010 amplifies the Government's 1993 commitment, made in "Path to 2010", that it would increase public investment in research, science and technology towards a goal of 0.8% of gross domestic product (GDP) by the year 2010.

RS&T:2010 provides the strategic framework for ensuring that the increased investment contributes effectively to achieving national goals. However, it is more than an investment plan. It also sets goals for science, research and technology in a broader sense and in doing reaffirms the Government's view that the enhancement of New Zealand's future quality of life will be increasingly reliant on scientific knowledge and technological know-how. Ensuring that we develop the knowledge-base and skills necessary depends not only on increased investment by the Government, but on many other factors. These factors include increased private sector investment in technological innovation, the sending of the right messages to young people by employers, and the appraising of the wider community of the value of science and technology in their contribution to New Zealand's prosperity and well-being. By spelling out its own investment and wider policy intentions in RS&T:2010, the Government hopes that science and technology institutions, private enterprises, and groups in the community will be better enabled and motivated to plan strategically to achieve their own goals.

Simon Upton

Minister of Research, Science and Technology

EXECUTIVE SUMMARY

Research, science and technology (RS&T) are important to the achievement of prosperity and well being for all New Zealand. The purposes of RS&T:2010 are to provide a strategic context for investment in science by the Government, and more generally to encourage the skills and motivation which will make science and technology work for our national benefit. This document provides a strategic overview. A more detailed 'agenda for action' is given in the companion document entitled *Action Agenda and Investment Framework*.

RS&T:2010 sets out a vision of a New Zealand society which understands the importance of science and technology and is actively investing in research and technological innovation for our country's benefit. Three major goals that need to be achieved are as follows:

- *Fostering societal values and attitudes that recognise science and technology as critical to future prosperity;*
- *Ensuring an adequate level of investment in science as a component in national life which has cultural value in its own right; and*
- *Maximising the direct contribution of science and technology to diverse social, economic and environmental goals.*

Science and technology should be the concern of everyone, not just the Government, but roles need to be defined so that the collective efforts are as effective as possible.

The Government invests in RS&T for two main reasons; first to support those activities which are of wide public use and would not occur without Government funding, and secondly to help individuals and enterprise overcome barriers to their own full participation in the RS&T system. In the first area, the Government fully supports compulsory education and provides high levels of post compulsory assistance in the form of funds that underpin scholarly research. Additionally the Government ensures that its own activities are well-supported by research. In the second area, the Government ensures that information is available to assist human resource and education decisions, to support the promotion of science and technology and to assist enterprises to become effective in sourcing and using technology. An underlying theme is to ensure complementarity between public and private sector activity.

The Government also has an ownership role in science through Crown Research Institutes (CRIs). This role is undertaken to ensure that strategically important and long term scientific capabilities are maintained, irrespective of short term changes in the need for science outputs. Ownership of CRIs carries little commercial risk because most CRI research is purchased by the Government itself. However, it helps to reduce wider risks such as the diversion of science resources into activities other than research.

This overview strategy sets out an analysis of trends, strengths, vulnerabilities and opportunities affecting New Zealand's future. Significant positive results of this analysis are that New Zealand has strengths in niche areas, and that there is human and institutional flexibility. Such strengths need to be applied in a global environment which is becoming increasingly open and competitive. However, there are substantial opportunities available if we have the determination to take them. These opportunities depend on applying New Zealand's strengths to the sustainable use of our unique physical, economic and human resources.

Decision-making in science investment to date has been driven almost exclusively by information about social, environmental and economic conditions and trends. Socio-economic factors will continue to be crucial because they underie the justification for investment. Increasingly however, information about trends and developments in science itself - ie. a "science-based perspective" - will also be applied, both to link science itself into decision-making and to ensure that our knowledge bases and capabilities in science reflect long-term needs. Examples of key questions that come out of a consideration of the knowledge base are given in the overview strategy. A more detailed description is given in the companion document, *Action Agenda and Investment Framework*.

The complexity of science demands continuing coordination. The National Science Strategy approach will be maintained but will be complemented by other initiatives as well.

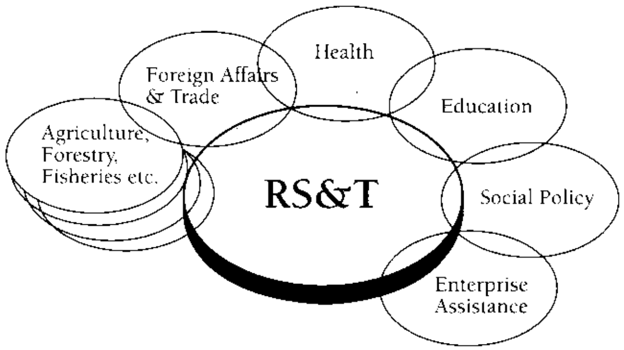
Strategies need to be backed by resources for implementation. Underlying RS&T:2010 is the Government's commitment to increase public investment in science towards a goal of 0.8% of GDP by the year 2010. Substantial progress already has been made in the last three Budgets. Achievement of the goal will however depend on ensuring value for money and corresponding commitment from the private sector.

Public investment in science will in future be managed through a "science envelope" which incorporates science, research and technology-related funding from all portfolios, not just the RS&T vote. A pattern of setting overall levels of RS&T increase three years ahead has now been established, and increases will be allocated with a strategic framework and not directly to Votes and programmes. To complement this approach and provide feedback, evaluation of the results will be comprehensively pursued.

The strategy pulls together the strands that guided the reforms of the early 1990s, and provides a rationale and platform for the Government growth commitment. However, success depends critically on that commitment being matched by private sector investment and by the more general understanding and commitment of the whole New Zealand community.

PURPOSE AND SCOPE OF THE STRATEGY

If total investment in research, science and technology is to achieve its potential to contribute to New Zealand's prosperity and enhance quality of life it is important that the investment occurs within the context of a comprehensive and coherent strategy. The first purpose of RS&T:2010 is to provide that strategic context. However, it also sets out more widely the policies and programmes that are needed to create a society which understands the importance of science and technology and has the capability to realise their potential.



The Government's investment in science spans more than one portfolio, as does the RS&T:2010 Strategy.

The overall strategy is divided into two parts. This first part, entitled "RS&T:2010 Strategic Overview", provides an overview. It sets out a vision for the future, the goals that must be achieved to make this vision a reality and discusses the knowledge bases in science. The role of the Government in science is also described. The overview then sets out parameters for quantifying and managing the investment across all of the Government's activities. The programmes contained in Vote:Research, Science and Technology, and the Government's ownership of the Crown Research Institutes, are important elements of the "science system", accounting for over half of the Government's total investment. However, the Government additionally makes major investments in research in the tertiary education sector, and in health research through the Health Research Council. Government departments themselves also carry out a significant amount of research to ensure that government policy and operations are well-founded.

The second part of the strategy, "RS&T:2010 - Action Agenda and Investment Framework", sets out an agenda for action for the first years of the period to 2010 - an agenda that will thereafter be regularly updated and advanced. Long-term objectives are set and indicators of headway are identified. The knowledge base concept is expanded. The document finally describes an administrative framework for ensuring that the resources are invested to best strategic effect.

The Vision

The vision for Research, Science and Technology in New Zealand to the year 2010 is a society which understands and values science and technology, and their critical role in assuring New Zealand's future prosperity and wellbeing. It is for a society that maximises the contribution of science and technology to wider economic, social and environmental goals through scientific research and technological innovation of the highest quality.

Roles

All New Zealanders have a role in achieving the vision for research, science and technology. Obviously it is not necessary for everyone to be biochemists or sociologists. However, it is important for everyone to appreciate why research, science and technology are important in New Zealand, and how our industries, health services, environmental agencies, community organisations and indeed all our enterprises can benefit from new knowledge and new and improved ways of doing things. Individuals, educators, private firms, industry groups, local and regional bodies and central government all have a role in making the vision a reality.

In science and technology, as in other areas, it is essential that the role of the Government is clearly defined and understood. All participants, in both the public and private sectors, can then implement their respective roles with purpose and determination. The roles of the Government in science investment and in owning science institutions are described in the next section.

GOALS

To fulfil the vision for research, science and technology, the following goals need to be achieved:

- ***Fostering societal values and attitudes that recognise science and technology as critical to future prosperity;***
- ***Ensuring an adequate level of investment in science as a component in national life which has cultural value in its own right; and***
- ***Maximising the direct contribution of science and technology to diverse social, economic and environmental goals.***

THE GOVERNMENT INVESTS IN RS&T

This strategy talks about investment in science rather than spending on science. The choice of words is deliberate. Spending money on research is just as much an "investment" as buying new machinery, educating our young people, or building a hospital. It is about spending now for future benefit.

Investment in research, science and technology is important in both the public and the private sectors, as is the interaction between the two is sectors. But if the interactions are to be effective then the respective roles need to be understood and actioned.

The role of the Government in investing in science is spelt out in the following sections, looking at each of the three goals in turn.

IGNS Volcanologist undertakes seismograph monitoring at Craters of the Moon, Wairakei. (IGNS Photo Library)

GOAL 1 - Positive Values and Attitudes

Fostering societal values and attitudes that recognise science and technology as critical to future prosperity.

A positive commitment to science, technology and innovation is an essential prerequisite for success in the modern world. Without the confidence and commitment of New Zealanders, the potential contribution which science and technology offer in achieving our social, economic and environmental goals will not be realised. New Zealanders as a whole do not yet have this commitment in the way that other countries do. A strategy to foster this commitment throughout New Zealand society must have both a short term and a long term component, and must aim to develop both trust and understanding.

In the long term, the solutions lie in educating a generation of New Zealanders who have acquired fundamentally different attitudes and skills, and who will progressively advance to influential positions in enterprise and the community. The role of the Government in achieving this through the support of compulsory education is unchallenged. The contribution of Government input through to tertiary level education and training is also widely accepted. The new curricula for science and technology have rightly been emphasised as core educational requirements.

However, providing a broad compulsory education and providing the right choices of course at tertiary level may not be enough. Parents need to actively encourage their children to take science and technology subjects, and signals coming back from employers need to confirm that science and technology capabilities are valued. To support decision-making, information, promotional material and role models need to be made available to parents, students, educators and employers. These need to convey the value of science and technology qualifications and careers. Basic information about supply and demand trends relating to these skills is also needed. Educational and science institutions, businesses and employers must take a major share of the responsibility in this area.

Main Public Investments

Support for the Promotion of Science and Technology

Careers Information

Resources for Science and Technology Education

Support for Science Centres

GOAL 2 - The Place of Science in Our Culture

Ensuring an adequate level of investment in science as a component in national life which has cultural value in its own right.

The way our society is organised, and the way we view the world, partly reflect the role of science and rational thinking in our culture. Advances in science and technological innovation are now widely associated with improvements in our quality of life. A culture which recognises and values objective scientific reasoning and investigation will not only ensure that improvements continue, but will enrich our lives in a wider sense as well.

However, scientific and technological information can be used for good or ill. Science does not operate in a vacuum; those who commission and carry out research must take responsibility for the ethical consequences of their actions and be accountable for them.

The public funding of scientific research whose results are widely available to all (within New Zealand and overseas) is in part a reflection of the importance of science in our culture. Research undertaken to extend the frontiers of knowledge for its own sake is an important contribution the Government can make to the scientific fabric of our culture. Although only a relatively small percentage of public research funds are spent in this way, this spending is vital affirmation of New Zealand's participation in the global quest for knowledge. This is also an area of investment where the Government not only has a clear responsibility to take a lead, but is best placed to determine the level and general scope of the investment.

An important aspect of a vigorous science culture is a climate that encourages researchers to challenge conventional wisdom. It is for this reason that the Government affirms the role of academic freedom within the universities and provides opportunities for research that can reach outside formal research priorities. By ensuring that researchers are not entirely restricted in their choice of research topics, we can maximise the chances of unforeseen, spontaneous extensions of scientific understanding.

The value of science in our culture is also reflected by support for major scientific institutions, by honouring those who achieve highly in research and engineering, and by acknowledging the investment scientists make within voluntary professional organisations.

Main Public Investments
The Marsden Fund
Research in Universities
Support for The Royal Society of New Zealand

GOAL 3 - Contribution to Economic, Social and Environmental Goals

Maximising the direct contribution of science and technology to diverse social, economic and environmental goals.

INVESTMENTS FOR THE PUBLIC GOOD

In addition to its "cultural" investment in science, the Government has a more direct role in contributing to the generation of knowledge and expertise that will help to realise the community's social, environmental and economic goals, where the benefits of the research cannot be sufficiently appropriated by the private sector. This is where the majority of the Government's investment is made.

Underpinning knowledge enables New Zealanders to be informed about the physical and natural environment of New Zealand. It influences health and safety, it permits an understanding of forces that shape New Zealand society, and it underpins successful enterprises. In addition, the support of research aimed at developing technology of a generic or widely-applicable nature is also an important part of the Government's role.

The Government also invests in research, science and technology to support its own core services and to ensure that it receives high quality policy advice. The areas in which such investment is required span the whole range of governmental activities, including social policy and services such as health and education, environmental policy and management, and industrial and economic policy. Enhanced capability in social science research is needed to contribute to informed, well-targeted policy in all areas, and to evaluating the effectiveness of government policies.

Main Public Investments

The Public Good Science Fund

The Health Research Council

Operational Research in Government Departments

INTERACTION WITH THE PRIVATE SECTOR

The Government's core investment strengthens the overall national infrastructure for research, science and technology. It especially helps to ensure the availability of resources, particularly human resources, necessary to conduct effective public and private research and development, and to ensure the effective use of technology in enterprises. However, the role of the Government goes beyond this. There are circumstances in which private investment may not take place despite potential benefits. Usually this is characterised by a distinction between appropriable and non-appropriable research. In more practical terms, factors which may alter investment include the extent of applicability of the technologies generated, high transaction costs because of small firm or sector size, uncertainty, longtime horizon of potential benefits, lack of skills and the lack of a technology sensitive organisational culture. In these instances investment by the Government can have a pivotal catalytic impact. The most important investments the Government can make are educational; ie. in helping firms to recognise scientific potential, to upskill and access knowledge.

However, it needs to be ensured that public investment in science and technology complements, and does not overlap with or duplicate, private sector investment which directly leads to commercial benefits. Complementarity between public and private sector investments is essential for the health of New Zealand's overall investment, with each partner recognising areas of responsibility and mutual benefit.

Promotion of Technology for Business Growth

What the Government Expects of Crown Research Institutes

The Government makes its strategic investment in science and technology by purchasing research, technology development and services from Government-owned Crown Research Institutes (CRIs), universities, Research Associations and the private sector. CRIs, which are the largest providers, are corporate bodies, at arms length from the Crown, with full commercial powers. They are strategically focused on economic and environmental sectors, eg. forestry and environmental land care management. This combination of a strategic sector focus and commercial powers enables CRIs to make an important contribution to the community through the transfer of research results and technology. It also helps to develop sectoral "ownership" of science.

The Government does not intend to sell CRIs. Science is a long-term investment and so is investment in science institutions. It is important that the Government, through its ownership of CRIs, ensures that strategically important research skills and assets are maintained within New Zealand. Such skills permit the pursuit of research of national importance when required, irrespective of short term fluctuations in demand.

The legislation which provides a framework for government ownership of the CRIs describes their purpose as undertaking research. The legislation requires that they should operate in a responsible manner so as to maintain financial viability, pursue excellence in all activities, benefit New Zealand, and promote and facilitate uptake of their research results and technology development. Financial viability is defined as generating an adequate rate of return on shareholders' funds. This is a return that will ensure the physical and intellectual fabric of the institution and enable it to withstand a financial "shock" without recourse to the shareholders. CRIs are not intended to maximise profits.

To monitor performance against these requirements financial performance indicators have been devised and are being measured routinely. The development of non-financial performance indicators is under way.

The Government wishes to ensure that strategically-important research skills and assets remain within New Zealand. The Government does not intend to achieve this by taking a direct role in funding "inputs" such as capital equipment or human resource development. The responsibility for managing inputs lies with the science and technology institutions themselves. However, as owner, the Government will seek assurances from CRIs that they will maintain and develop their human capital bases.

Broad Trends Affecting New Zealand RS&T

- The world will become progressively more interdependent as investment, skills, and information become less constrained by national borders. The international competitive advantage of a nationís enterprises will correspondingly be based increasingly on the skills and knowledge of its people.

- Countering the trend towards greater interdependence will be forces for regional, national or ethnic splintering and trade protection.

- New Zealand will increasingly be identified with relatively untouched natural environments.

- A continuing international demand for efficiently-produced high-quality food products , forestry products and other biologically-based products, will see a continued reliance by New Zealand on production of biological raw materials. Although efficiency and sustainability of production will continue to be important to the viability of our biological industries, the ability to meet specific market demands, as well as to differentiate and add value, will be the determinant of real wealth creation.

- Growth rates in non-food manufacturing have considerably exceeded pastoral exports and that trend is expected to continue. In creasingly manufacturers are adding service components to their products as part of their broader marketing strategies. Consequently the distinction between secondary and service sectors is becoming blurred.

- While service industries associated with tourism will continue to grow in significance, growth will become increasingly dependent on our ability to deal with the associated environmental and social impacts.

- New Zealand will increasingly benefit from, and be bound by, international treaties and agreements, particularly in the areas of trade and environmental management.

- Ethical and social issues will continue to emerge surrounding the introduction of biotechnology, and the introduction of exotic biological controls to counter environmental risks.

- New Zealand's location will increasingly offer opportunities to provide the differentiated, high-quality products in demand in dynamic Asian markets.

- Maori development objectives and issues deriving from the Treaty of Waitangi will continue to have a major influence on society and the economy, and will increasingly influence private sector markets.

- Improved international telecommunications and electronic information systems will make New Zealandís geographical isolation increasingly irrelevant.

- Advances in technology and changes in the biomedical environment will increasingly influence access to, and demand for, health services.

- New Zealand demographics will be increasingly characterised by an older and more ethnically and socially diverse population and society will change markedly as a result. In parallel, the aspirations of different ethnic and cultural groups will come into sharper focus.

- The future will see a continued decline in the demand for low-skilled labour, as the economy focuses more strongly on provision of skill-intensive products and services. Investment in well-educated and highly-skilled people, and leading-edge technologies, will increasingly become key determinants of a successful economy.

RS&T: Our Strengths

- New Zealand science has established world leadership in niche areas of research, deriving from unique aspects of our environment, geography, society and economy, as well as from the expertise of key individuals.

- Researchers in New Zealand have a marked capacity for innovativeness and lateral thinking, and many have developed cross-disciplinary skills, in part reflecting the necessity imposed by a relatively small-scale science and technology system.

- New Zealand has a strong scientific infrastructure, and well-established information bases, in the physical and biological sciences, biomedical sciences and engineering.

- New Zealand has strong international links through individuals, institutions and voluntary professional associations.

- New Zealand is developing a strong secondary and tertiary education system in science, technology and engineering.

- The move to a more open science system in New Zealand, including Crown Research Institutes (with their full commercial powers) and a range of other institutions, is enabling a stronger and more responsive focus on relevant research and effective links with end-users.

- The distribution of resources across the Government's science investment portfolio is now able to be changed readily in response to evolving demand and opportunities.

Our Vulnerabilities

- New Zealand continues to be underdeveloped technologically. Investment in research and development (as a percentage of GDP) is only half that of other developed countries-under-investment by the private sector accounts for most of the difference.

- The steady decline in science and technology funding during the 1980s, and the short-term contracts which characterised the introduction of the new science funding system, have negatively affected the willingness of science institutions to plan positively for the future.

- The increasing globalisation of science will create high demands for resources relative to other larger countries to permit New Zealand's participation in international activities, eg. in areas such as climate change and biodiversity.

- University research is under pressure as resources are stretched to meet demands created by increasing student numbers.

- Restructuring the science system to focus on the purchasing of outputs has resulted in low priority being given to analysis of issues such as human resources, databases, and the physical infrastructure.

- New Zealand's research capabilities continue to be dominated by historical patterns rather than future challenges and opportunities.

- There is inadequate information about human resources capability, supply and demand in science and technology-intensive occupations.

- The small size of New Zealand's research base means that there will always be a tendency for some researchers to be drawn to larger, better-paying, international groups.

- Until a new career structure is established the morale of science staff and thus their contribution will continue to be a concern in Crown Research Institutes.

- The participation of Maori and Pacific Island peoples in science, technology and engineering is very low.

- There is a growing concern in the Maori community in particular over the protection and utilisation of traditional Maori knowledge (Matauranga Maori) in the context of public investment of science.

- An overarching strategy and coordination are required to achieve maximum benefit from social science research.

- Appreciation of the role and value of science and technology among New Zealanders and in New Zealand businesses remains limited.

- There is evidence of a poor appreciation of technology strategy in many New Zealand businesses, and how it fits within broader business strategy.

- Structures for funding health research cause an artificial separation from other scientific research, and prevent priorities being set across all research.

- Resolution of ethical and social issues will be required if we are to take advantage of new technologies such as genetic engineering.

Science and Technology Opportunities

- New Zealand has established strengths in areas of international interest, including the environment, earth sciences and engineering, and biological control. These provide opportunities for leadership in collaborative research and exchange of scientific and technological services.

- New Zealand's unique geological, biological and geographical situation within a global context presents opportunities for New Zealand to play an important international role in environmental science and technology.

- This country's modified ecosystems with combinations of introduced species provide internationally unique opportunities for advancing global ecological knowledge.

- Successful negotiation of international trade and environmental agreements and the surmounting of trade barriers will increasingly require an understanding of scientific and technological issues; this will create opportunities to develop alternative approaches and products.

- The characteristics of our population, a well-developed infrastructure and a deregulated economic environment will continue to provide opportunities for research and "test-bedding" of new technologies, eg. telecommunications, energy and others.

- Our strengths in food and nutrition research, pharmacology, human health and performance, will generate opportunities, for example in "nutriceuticals" and food design, in the increasingly scientific areas of sports performance, leisure and health industries.

- Continuing international concern for animal welfare in meat and related industries will provide opportunities for New Zealand to build competitive advantage from strengths in animal production and management research.

- The implementation of national strategies for environmental monitoring, and for exploring the marine resources within our Economic Exclusion Zone, are leading to New Zealand enhancing expertise in related measurement, signal processing and analysis technologies.

- New Zealand's rich and unique flora and fauna provide opportunities for identifying and commercially developing new food, industrial and pharmaceutical products.

- The growing strength of New Zealand manufacturing and processing industries in exploiting niche markets overseas provides an opportunity for the growth of associated scientific and technological support.

- New Zealand's relatively large and untapped marine resources provide opportunity for science and technology-led development.

- Our combination of social, cultural and ethnic mix, our size, and our history, provide us with the potential to make unique international contributions in the social sciences.

Information to Support Cultural Investments

At a broad level, the Government makes a distinction between that investment which is made to advance knowledge "for its own sake", and that which is made to achieve social, environmental and economic goals. The ratio of these two kinds of investment is approximately 25:75.

Investment in the advancement of knowledge is made on the basis of the scientific merit of the research. The knowledge required for making informed decisions in this area thus resides in scientists themselves. It is applied by processes such as peer review.

Information to Support Socio-Economically-Driven Investment

Investment in science and technology which is intended to contribute to national goals is made in a quite different way. The Government considers a range of investment sectors, such as manufacturing, health, forestry, and the dairy industry. The process used is wide ranging and consultative, and encourages a broad consensus to be forged on key factors. This process was used in 1995, through the Science Priorities Review Panel, to develop recommendations on priorities for the Public Good Science Fund. Within each sector area, factors considered include the following:

- *the future contribution of that sector to the economy and to our quality of life;*
- *the extent to which the sector is reliant on research and development for quality and/or competitiveness; and*
- *the nature, cost and productivity of the research and development involved.*

These factors are predominantly socio-economic in character.

An Additional Science-Oriented Perspective

The Government's view is that decision-making in both of the areas identified would be enhanced by providing information from an explicitly science-oriented perspective.

It is important that New Zealand can build on the opportunities offered by its science, technology and engineering research strengths, and be up-to-date with scientific progress. Conversely, it is necessary to know where there are gaps in the nation's capability. In future, this sort of information will be included more explicitly in decision-making.

This knowledge base analysis is different from "technology foresight". Other countries, especially those in a position to lead the development of new global technologies, devote considerable resources to this sort of exercise. However, the usefulness of these attempts to "pick winners", especially to a small economy focussing on niche markets, is limited. However, it is necessary to maintain an awareness of the dynamics of advances in the knowledge base, so that New Zealand's capability can be adjusted accordingly.

Investing in Knowledge

A full appreciation of the New Zealand knowledge base in science will be developed over the next few years and progressively applied to decision-making. Initial analysis will consist of identifying gaps and opportunities. However, the analysis will eventually provide a powerful additional influence on the next major review of science priorities in 2000/01.

As well as characterising the knowledge base, this analysis will help to identify the security of New Zealand's science capabilities. All of this work will take a long-term view.

The second part of the RS&T:2010 strategy, "Action Agenda and Investment Framework", examines the knowledge base in more detail. This overview provides only a context for the analysis. The importance of being aware of our knowledge base, and investing in new knowledge, can be best illustrated at this level by a number of examples.

What Insect is That?

The Government's 1995 strategy on the environment, the "Environment 2010 Strategy", identifies environmental goals and a plan of action which will require the contribution of science and technology if progress is to be made. Protecting biological diversity is just one of the pressing issues that must be addressed in New Zealand. Yet to date, only half of our insect species have been fully described by biosystematics experts. Such work is also essential to containing and controlling pests which threaten our primary production industries. Maintaining capability in areas such as biosystematics is crucial. New knowledge is also needed to protect New Zealand's indigenous biodiversity where it is estimated that 20% of our plants, 40% to 50% of our birds, and at least 50% of our amphibians and reptiles are at risk.

Under-Sea Wealth?

The Exclusive Economic Zone surrounding New Zealand comprises ocean-based resources covering an area 14 times larger than the landmass. It contains most of the country's fisheries resources and significant potential mineral wealth. To date less than 10% of this part of New Zealand has been even crudely explored. Of the fish stocks that form part of the quota management system, stock size relative to that which will produce maximum sustainable yield is known for only 40% of the fish stocks. We will need to develop new capabilities in marine science and under-sea technologies to ensure that we understand how to make the most of our resources in a sustainable and environmentally-friendly way.

What's That Smell?

New Zealand has developed significant strengths in research areas relating to our primary production industries, particularly meat, dairy and forestry. The country needs to exploit these strengths, and to pursue the potential benefits of new knowledge in areas such as molecular biology, gene manipulation and breeding management. When it comes to developing processed products to meet niche market requirements, however, there are significant gaps in the knowledge base. For example, relatively little is known about what makes sheep meat smell the way it does, which is a significant barrier in some potentially large markets.

What Social Knowledge do we have about Ourselves?

There are many gaps in our information base on New Zealand society, for example on Maori society and on women. The delivery of social services and consideration of the implications of trends such as the ageing of our population and the distribution of wealth rely on a sound information base and rigorous social research methodologies. We must act positively to build up a knowledge base to underpin moves to better promote a cohesive society.

World Class?

Not all investment in new knowledge is to "fill gaps". Investment in further new knowledge in some already-strong areas will maintain New Zealandís competitive advantage and develop new opportunities in closely-linked enterprises. For example, New Zealanders have developed particular expertise in educational research and in the delivery of education to remote areas, in digital telecommunications engineering within a mountainous country, in niche areas of software application design. All of this, linked with the new opportunities afforded by the expanding global communications infrastructure, means that New Zealand commands significant potential advantage in the delivery of distance learning worldwide.

Did the Earth Move?

Geologically, New Zealand is being deformed by the grinding together of the Pacific and Indo-Australian plates. Movement of the plates is related to the time between earthquakes but there is only limited understanding of why. This process has resulted in a large potential for geothermal energy. A key knowledge gap for our geothermal systems is better understanding of deep heat flows into those systems. Without that knowledge there is the risk of the system running dry. The rapid uplift of New Zealand's land-mass also results in rapid erosion and sedimentation offshore, and has given rise to the sedimentary basins from which our hydrocarbon resources are derived. Only about 20% of these sedimentary basins have been systematically assessed. Geological knowledge of these structures must be advanced, both for national and international reasons.

Understanding the Science Basis for Good Health

Biomedical science has been revolutionised by the development of new technologies in molecular biology, genetic manipulation, imaging techniques such as magnetic resonance imaging, and other areas. It is one of the world's fastest-growing research fields. Because innovation in medicine is so rapid, it is important to be at the leading edge of new knowledge development in order to be able to make informed and effective use of new medical technologies, no matter where they emerge from. Because New Zealand has some unusually severe health problems, such as high levels of asthma and respiratory diseases, it is important that new knowledge is pursued. New Zealand's biologically-based economy also makes it particularly important to maintain capability and develop l eadership in biomedical research, as much of the new knowledge generated is relevant not only to human health, but also to the production of plants and animals.

The Need for Coordination

Many of the big issues facing New Zealand as 2010 approaches will require the concentrated and coordinated attention of scientists and technologists whose joint expertise lies not in a single narrow area, but spans a range of fields of knowledge. Moreover, like other countries there must be a move towards sustainable management of resources. This requires knowledge about the environment, about industrial processes, about human behaviour, urban development, agricultural production and much more besides. Opportunity needs to be taken to make the most of advances in information and communications technology by making use of expertise in the social, engineering and scientific arenas. Improving the health of New Zealanders is another important goal which will require the combined effort of biomedical researchers and engineers, health services investigators, clinical researchers and social scientists.

The need to have regard to specific threats to New Zealand's environment, society or economy is another important reason for ensuring a coordinated and effective science and technology effort. Recent examples have been marine biotoxins infecting shellfish beds in New Zealand, and the threat of other diseases, weeds and insects (such as fruit-flies) crossing our national borders and threatening agricultural production.

National Science Strategies

National Science Strategies are the principal mechanisms which the Government uses to coordinate science and technology in tackling these big issues. Development of a National Science Strategy can help focus research through identifying gaps and opportunities. Strategies currently operating, under development or under consideration are as follows:

- *Eradication of Possums and Bovine Tuberculosis;*
- *Climate Change;*
- *Marine Science;*
- *Sustainable Land Management; and*
- *Biodiversity.*

The National Science Strategy concept is intended to be applied selectively and for limited periods of time.

Other Approaches to Coordination

Coordination can be achieved in many ways of which the National Science Strategy concept is but one. For example the Government has already set up special purpose groups to deal with issues surrounding "mad cow disease", and applied social science research to support policy development in government. The Foundation for Research, Science and Technology, as the main purchaser of public good science, is also able to have a constructive coordinating influence, and this will be encouraged by the Government.

Coordination is also encouraged by holding workshops and conferences on specific topics, such as ballast water, to bring together the most up-to-date scientific information to help solve important problems.

Current Patterns of Investment

Total research and development expenditure in New Zealand is over $670 million. The breakdown of this expenditure, based on a 1992/93 national survey of research and development by the Ministry of Research, Science and Technology, is illustrated on the right.

A comparison of New Zealand's science investment with that of other OECD countries indicates there is a relative under-investment in New Zealand. The imbalance is most marked for the private sector. The ratio of private sector investment to public sector investment in New Zealand is close to 1:2, which is the reverse of the ratio for the OECD as a whole. In Asian economies, the ratio of private sector to public sector investment can be as high as 5:1. The rate of investment in the public sector in New Zealand is more comparable with, but still less than, the OECD average.

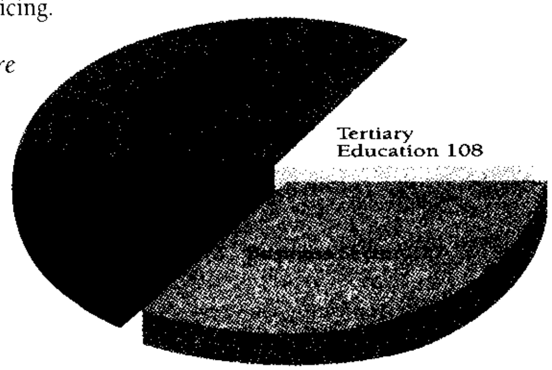
Although public sector investment in science and technology in New Zealand is increasing, it is doing so at a significantly lower rate than the leading nations in Asia. For example, since the late 1980s, the annual rate of increase in government expenditure on research and development in Korea, China and Singapore has been around 15%, 24% and 27% respectively. These countries, and Taiwan, are all working towards targets for national investment (public and private combined) in research and development of greater than 2.0% of GDP by the mid 1990s. Korea has a target for science and technology spending of 5.0% of GDP by the year 2000, with its Government contributing 1.2% by 1996. While such comparisons of the levels of national investment in other countries do not lead directly to policy conclusions, they do highlight the importance some of our key trading partners attach to the development of knowledge-intensive societies.

A Commitment to Increased Future Investment

The Government is committed to increasing its own investment in research, science and technology toward a goal of 0.8% of GDP by 2010. This increased investment is being made in recognition of the critical contribution of science and technology towards the achievement of our goals for the economy, the environment and for society. It also reflects the Government's belief that New Zealand's level of investment should be comparable to that of other countries. This investment can be confidently made now that structures and processes linking the major part of the science investment to national goals are firmly established.

It is unusual for the Government to express targets as percentages of GDP but occasionally there is good reason for doing so. New Zealand's expenditure on Overseas Development Assistance, for example, is monitored as a percentage of GDP and compared with that of other developed nations. Similarly, in the 1994 Budget, the Government set itself the target of reducing public debt below 30% of GDP in the medium term. Clearly, the absolute level of debt is less important than the ratio of debt to the size of the economy, because the risks inherent in high debt relate to the relative burden of debt servicing.

Major items of R & D Expenditure in New Zealand (1992/93, $ million, excluding GST). Total public sector investment was $443 million (0.57% of GDP), and business sector investment was $227 million (0.29% of GDP).



...MUCH SHOULD WE INVEST AND WHERE?

Likewise, while it is not possible to establish a "correct" amount for public science investment, it is reasonable that the level of investment should be considered in the context of the size of the economy, amongst other factors. Most developed countries and many East Asian economies take this view and monitor science and technology expenditure relative to GDP as New Zealand has done. This is because the risks associated with an inappropriate level of investment in science and research, as well as the opportunities associated with exploiting particular strengths, will vary as the economy changes.

As New Zealand grows richer it will be better able to address the many unanswered questions that have constrained development. There are also powerful reasons to increase investment in science and research so as to answer fundamental questions thrown up by rapid social, environmental and economic change.

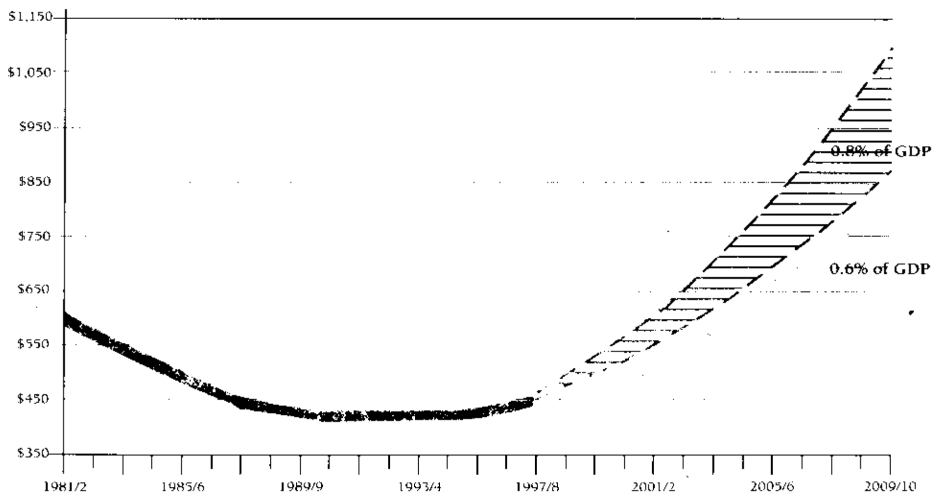
Increasing public investment towards the goal of 0.8% of GDP will be more or less costly in absolute terms depending on the rate of growth of GDP, as illustrated on the right. Our current level of investment is not even 0.6% of GDP, despite the significant increases announced through to the 1996 Budget. The Government's intention is to achieve a continuing public investment of at least 0.6% of GDP as soon as is practicable, to provide a platform for future growth toward 0.8% of GDP by 2010.

Ensuring Value for Money

The Government's commitment to increasing its investment in science is not open-ended, and is conditional on the on-going generation of fiscal surpluses. It is essential that growth in public investment continues to represent value for money, and that there is also an increase in investment by the private sector. It is only through enterprises that scientific and technological achievements can be transformed into tangible benefits.

SCENARIOS FOR INCREASED GOVERNMENT INVESTMENT IN RESEARCH, SCIENCE AND TECHNOLOGY

Range for each scenario is 2% to 3.5% GDP Growth (Real $1994)



Level of the Government's investment at 0.6% of GDP (lower pair of curves) and 0.8% of GDP (upper pair of curves) for GDP growth in the range 2.0% (lower curve of each pair) to 3.5% (upper curve of each pair). Figures are in real 1994 dollars.

Managing the Increased Investment

Public investment in science occurs across the whole range of Government activities. This means that a cross-portfolio approach needs to be taken to setting investment priorities and evaluating the results. Set out below is a brief description of how this will be done. A more detailed explanation is given in the second part of the RS&T:2010 strategy *Action Agenda and Investment Framework*.

Defining the Science Envelope

Before priorities can be set the scope of the investment has to be described. The scope of the science envelope (or public investment in science) comprises most of the science Vote, the research component of EFTS funding for universities, health research funding, and investment in research as a part of operational activity in every Vote and government department. The science envelope currently amounts to approximately 0.57% of GDP.

Setting Priorities at Top Level: A Strategic Approach

It is intended to initially set priorities for new science envelope funding at a strategic level. Once strategic decisions are made these will be a basis for allocating funding into particular programmes or portfolios. The strategic framework which will apply will comprise investment in the following:

- *underpinning research, science and technology development, especially through the programmes like the Marsden Fund and the PGSF;*
- *the application of science and technology in both the public sector and in enterprise; and*
- *management of the overall investment and the provision of support services.*

Implementation

The science envelope approach will be applied for the first time to the funding of allocations from the $45 million increase which has been announced from 1997/98. The process will however be applied more comprehensively to the $40 million increase announced for 1998/99.

Interim Priorities

Management decisions have already been taken over the future directions of two major components of science investment.

...UCH ...ULD WE INVEST AND WHERE?

The Government's principal investment in science is the Public Good Science Fund (PGSF). This fund provides underpinning research for all sectors of the economy. The Government developed in 1995 a Statement of Science Priorities for the PGSF. This statement sets out funding trajectories for each of seventeen different sectors. The PGSF will continue to be the largest single component of the Governments investment.

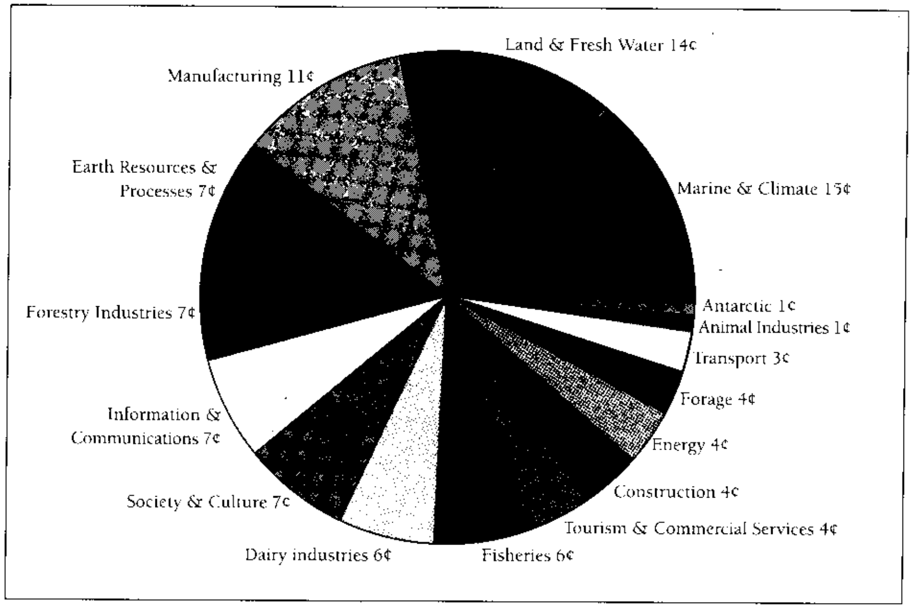
Each new research dollar invested in the PGSF between now and the year 2000 will be distributed as shown on the right.

The Marsden Fund supports excellent researchers in the advancement of knowledge. Investment in this "blue skies" fund will grow until a level of 10% of the value of the PGSF is reached.

Evaluation of the Investment

To complement the measures in place for prioritising and allocating science funding, an evaluation programme will be set in place. A full evaluation programme for the PGSF is targeted to be in place by 1998.

Allocation of Each $1 of Additional PGSF Funding (in cents)



The first stages of an implementation plan for the RS&T:2010 strategy are described in detail in the companion document *Action Agenda and Investment Framework*. The summary below sets out the key actions that will be taken within the next two to three years towards achieving each of the three goals of the strategy.

Goal 1: Positive Values and Attitudes

The quantity and quality of careers information on science, technology and engineering will be improved. This will be supplemented by initiatives to encourage more direct interaction between employers, teachers, students and science and technology professionals.

Expenditure on science promotion will be better coordinated and directed to more effectively target key areas of concern.

Strategies for increasing Maori participation in science, technology and engineering at tertiary and post-graduate levels will be a particular focus.

Additional training and learning resources will be provided to give teachers personal knowledge of how science and technology contribute in industry, the environment and the community, and to ensure that this experience is utilised in teaching.

Goal 2: The Place of Science in Our Culture

The Marsden Fund, supporting excellent research and researchers, will be grown to a level of 10% of the total investment in the Public Good Science Fund (PGSF) as soon as practicable and maintained at this level through to 2010.

The Government will work with universities and other tertiary institutions to strengthen their research role.

The role of the Royal Society of New Zealand will be recognised by continued funding support, with this funding focused into activities of the Society which are particularly important to the overall health of the science system.

Action will be taken to promote New Zealand's participation in the International Council of Scientific Unions and in international associations of scientific societies and academies.

Goal 3: Contribution to Economic, Social and Environmental Goals

Investment in the PGSF will be increased as a component in overall increases in the public investment in science.

Social science research will be promoted so that social policy decision-making will be supported by better understanding of society in order that policies can be better designed to meet people's needs, and social outcomes will be monitored.

Technology-linked programmes will receive an increasing share of the overall investment in science and technology, and these will focus more strongly on the key issues of improving access to and use of technology, assisting firms to become technology-capable, and helping move effective enterprises into new areas of technology with growth potential.

The Government will publish "milestone reports" once every three years as an indication of progress towards the goals.

Key steps in implementing the investment framework, which are expanded upon in the companion document, include the following:

- *implementation of the science envelope process, including the setting of strategic priorities; and*
- *the development of specific goals and performance measures for individual programmes, both to expand upon the three broad goals set out in the strategy and to provide a basis for full evaluation of the investment.*

CONCLUSION

The overview set out in this document provides an important watershed for the development of research, science and technology in New Zealand.

In the first place, it brings together the various strands that have run through the process of science reform during the 1990s.

Secondly, it explains the rationale for the growth in science funding to which the Government is committed. That rationale is one which needs the support of the whole community if it is to continue. However, the rationale has a deeper significance again. A theme running through the strategy is that it is not enough for the Government to invest in science. There needs to be a complementary investment from other sources, especially enterprise. Success depends critically on a truly national commitment.

Isotope technology is used to detect whether sugar has been added to pure fruit juice. (IGNS Photo Library)

Appendix – What are Research, Science and Technology?

Within the context of this strategy, terms have the meanings set out below.

Research is the process of advancing knowledge through systematic investigation. The advancement of scientific knowledge traditionally involves postulating and testing hypotheses to gain new insight into, and understanding of, phenomena, and analysing observed phenomena to elicit underlying principles. Other rigorous and internationally-accepted methodologies for formulating "research questions" may underpin the advancement of knowledge in the social sciences and some applied research. The term scientific knowledge includes knowledge arrived at using these methodologies. Much research is a creative, long-term endeavour, often characterised by serendipitous side-tracks and unexpected spin-offs.

SCIENCE is used as a broadly inclusive term in this document, to encompass research and also the routine gathering of raw information as an input to research, the development of scientific methodologies and principles, and the operation of instruments and facilities needed to carry out research. The latter activities are very different to research itself. They are predictable and of predefined outcome. It is important that all activities contributing to the advancement of scientific knowledge are recognised and valued accordingly.

TECHNOLOGY is know-how or practical knowledge which is directly able to create improved and/or more cost-effective products, processes and systems. Know-how might be attained through the application of science, but might equally be attained through empirical observation, cumulative practical experience, or a combination of all of these. Although science and technology are not necessarily linked at any point in time, technology is increasingly becoming science based and its usefulness can be extended and enhanced if its scientific basis is understood. Conversely, the process of technological innovation can yield questions which ultimately give rise to fundamental advances in scientific knowledge.

ENGINEERING is often not explicitly referred to in this document, to simplify phraseology. However, engineering research is included in "science", and "research", and the disciplines and professional practice of engineering are strongly associated with the development of "technology", so are also implicitly included when the term "technology" is used.

Relationship Between Science and Technology

The interactive nature of the relationship between science and technology is now well accepted internationally and has been throughout the science reform process in New Zealand. That is to say, it is acknowledged that basic research only rarely flows through in a linear fashion to applied research, development and application. Rather ideas can develop at any stage, and basic research may be as much driven by practical problem-solving or product development as vice versa. However, technological innovation can and does occur quite independently of research and development. It is thus important that the national system by which new products, processes, practices, systems and so on are developed, in all sectors of the economy, across government operations and throughout health care, education and other services are, where possible, examined as an integrated whole.

Other Kinds of Knowledge

Throughout RS&T:2010, as emphasised by the definitions given above, the world view providing a broader context for the strategy is one based on the broad international understanding of science. This approach is intended to be trans-cultural rather than mono-cultural, since science, as described above, is very much a global endeavour with agreed methodologies and international peer-groups. However, this does not mean to say that other kinds of knowledge, such as the traditional knowledge of the Maori, have no place in New Zealand society or culture. These other spheres of knowledge can be studied in their own right and sometimes have areas of overlap with the global scientific one, and where this occurs the strategy addresses specific issues which arise.