Department of State and Regional Development

Audit and Review of Science, Technology and Innovation (STI) Infrastructure in Victoria

Volume 1: Executive Report

June 2000

Howard Partners
51 Allara Street
Canberra ACT 2601
Tel: 02 6247 0200. Fax: 6247 0300
www.howardparners.com.au

Contents

Executive Summary

This is the report of the Audit and Review of Victoria's Science, Technology and Innovation Infrastructure. The Report is accompanied by:

- Volume 2: *Compendium of Capacity and Capability in STI Organizations Based in Victoria* – which contains details about infrastructure resources including distinctive capacities and capabilities and collaborative arrangements
- An *STI Database* in electronic format – which contains more detailed information about STI assets, fields of research and capability
- Volume 3: *Statistical Appendixes* - which include research and development expenditure details in Victoria and other supporting information.

This documentation contains the major elements of the information that was sought in the Project Terms of Reference, that is:

- Physical location, ownership, purpose and application of identified infrastructure installations
- Principal research fields using the equipment
- Capacity, utilisation rates, access regimes and profile of users
- Capital and running costs
- Effective life cycles and replacement schedules
- Views on how the infrastructure compares with the "state-of-the-art" infrastructure elsewhere
- Current strategies employed by STI organizations to finance the upgrade, replacement and filling of infrastructure gaps
- The relationship between access to key infrastructure and the ability of the organization or user organizations to attract/maintain key personnel, research programs and research funding
- Clustering of activity around key infrastructure installations - including (but not limited to) Clayton, Parkville, Fishermans Bend and around the Alfred Hospital.
- Mechanisms to update information on Victorian STI Research Infrastructure in a cost effective manner.

The information is intended for use in identifying important gaps in Victoria's strategic infrastructure.

The Project Terms of Reference place a specific emphasis on "physical infrastructure". This is interpreted to mean infrastructure facilities and major items of equipment located in STI organizations.

The major publicly owned facilities located in Victoria with an estimated value in excess of $1m are listed below.

Organization	**Main Research Field**	**Estimated Replace-ment Cost**
		$'000
CSIRO, Australian Animal Health Laboratory	Biological Sciences	$600,000
CSIRO, Food Science Australia, Research Facility	Applied Sciences and	$40,000

Organization	Main Research Field	Estimated Replace-ment Cost
		$'000
	Technologies	
Bureau of Meteorology, Research Centre, CSIRO, High Performance Computing & Communications Centre	Information, Computer and Communications Technologies	$18,900
CSIRO, Division of Textile and Fibre Technology, Vertically integrated textile mill with full research instrumentation of all equipment.	Applied Sciences and Technologies	$18,000
CRC for Cochlear Implant and Hearing Aid Innovation, Laboratories, Surgical Theatre, Research Centre	Medical and Health Sciences	$11,500
Department of Natural Resources and Environment, Keith Turnbull Research Institute	Biological Sciences	$6,500
. Quarantine Facility - $5m		
. Plant and insect propagation facilities - $1.5m		
Department of Natural Resources and Environment, Rutherglen Research Institute, Buildings	Agricultural Sciences	$6,094
Deakin University, Cell and Organism Bio-Engineering Group, Research Facilities	Biological Sciences	$7,500
Walter and Eliza Hall Institute of Medical Research		
. Genome Research Facility	Medical and Health Sciences	$8,000
. Laboratories		$3,000
Boeing Australia Limited, Aerospace Technologies of Australia Ltd Research and Development Workshop	Applied Sciences and Technologies	$3,115
Department of Natural Resources and Environment, Marine and Freshwater Research Institute, Institute Facilities	Biological Sciences	$2,000
Department of Natural Resources and Environment, Victorian Institute for Dryland Agriculture, Grain Chemistry Laboratory	Agricultural Sciences	$1,288
DSTO, Aircraft Structural Testing Facility, Structural Test Laboratory, Wing Bay, Fatigue and Fracture Laboratory	Applied Sciences and Technologies	n.a.

The valuations are as supplied by the organizations. More detailed information about these facilities is set out in Section 3.1 and in the STI Database. Information is also included in Section 3.1 in relation to a number of private facilities that contribute to the STI resource base, but are not part of the STI infrastructure.[1] The Boeing Australia Limited, Aerospace Technologies of Australia Research and Development Workshop is the only privately owned facility with capability that is generally available.

Boeing/ASTA was the only organization that provided comprehensive information on capacity, utilisation rates and access regimes and replacement schedules. This level of information was not provided for other facilities. Some of the Agriculture Research Institutes provided access and utilisation related information.

In summary, the Audit has revealed that:

[1] That is, the facilities are owned privately and do not generally allow external access for commercial reasons.

- Four of the major research facilities are in the biological sciences
- Four are in applied sciences and technologies
- Two are in the medical and health sciences
- Two are in the agricultural sciences
- One relates to information, computer and communication technologies.

The identification of facilities in terms of physical assets, however, substantially understates the importance of Victoria's STI capability in medical and health sciences, particularly in biotechnology.

Capability in these areas is driven more by *knowledge assets*, although access to sophisticated laboratory equipment and computing facilities is important. These capabilities are reflected in the *operational budgets* of the health and medical research institutes as well as in their *intangible assets.* We have endeavoured to capture these capabilities in the Audit through the information collection process.

The focus on physical capital also understates capability in materials sciences where there is a highly developed capability in polymers and coatings and the application of optic and laser technologies. These technologies have major application in the aerospace and automotive industries where Victoria has considerable strengths.

In addition to the facilities identified above, the Audit and Review also identified 19 items of specialised equipment valued at over $1m in organizations based in Victoria. These are listed in detail in Section 3.2. The more significant are listed below

Organization and main Field of Research	Type of Equipment	Estimated Value $'000
CSIRO, Australian Animal Health Laboratory	DNA Sequencer, Three Scanning Electron Microscopes, Applied Bioprotein Sequencer, Electrospray Mass Spectrometer Systems, Fluorescent Activated Cell Sorter (FACS)	$15,000
La Trobe University, Australian Geodynamics Cooperative Research Centre	'AUSTRALIS' ultra high-resolution accelerator mass spectrometer for in situ isotope studies for geochemistry and geochronology.	$6,000
University of Melbourne, Centre for Animal Biotechnology	Major equipment items for protein chemistry, molecular biology, and immunology.	$5,000
Monash University, Faculty of Medicine	Numerous Microscopes, DNA sequencers, centrifuges, steilizers, computer and scanners	$4,951
Department of Natural Resources and Environment, State Chemistry Laboratory	Analytical Instrumentation, including microwave digesters, ICP-MS machine, autoanalyser, a super critical fluid extractor, GLC, etc.	$3,100
La Trobe University, Department of Chemistry	Spectrometers, including Bruker DRX-400, Bruker AM-300, magnetic resonance spectrometer, atomic absorption spectrometer, etc	$3,000
Walter and Eliza Hall Institute of Medical Research	Chemical Protein Sequencers	$3,000
Microanalytical Research Centre (MARC), University of Melbourne	NEC 5U Pelletron Accelerator with REIF - funded upgrade to make it one of the brightest accelerators in the world for nuclear microprobe operation.	$1,000
	Two MeV Ion Microphobe Beams Lines and other associated instrumentation.	$1,000
	Pulsed Laser Deposition System, f or the synthesis of thin films of advanced materials.	$1,000
Centre for Material and Surface Science, La Trobe University	Imaging X-ray Photoelectron Spectrometer	$1,200
	X-ray Photoelectron Spectrometer	$600

Organization and main Field of Research	Type of Equipment	Estimated Value $'000
	High Resolution Angle Resolved Photoelectron Spectrometer	$1,500
	III-V Molecular Beam Epitaxy Facility	$1,500
	II-V Molecular Beam Epitaxy Facility	$1,500
Swinburne University of Technology, Industrial Research Institute	Excimer Laser Work Station	$1,500
Department of Natural Resources and Environment, Victorian Institute for Dryland Agriculture	Plant Breeding Field Equipment, including trucks, sowing, harvesting equipment etc	$1,500
Department of Natural Resources and Environment, Rutherglen Research Institute	Research Instrumentation/Equipment	$1,012
Mental Health Research Institute of Victoria Inc	Laboratory Equipment	$1,125

Although organizations were asked to provide information about capacity, usage rates, access regimes and user profiles, this information was not forthcoming. The main reason is that as the research organizations do not operate on a commercial basis they do not keep this type of information. We were advised that to extract it would have required a substantial amount of effort.

Notwithstanding the lack of specific information on usage, for each of the organizations identified in the above listing, we have collected a large amount of information about capability and capacity, cooperation and collaboration and affiliations. This information stresses the *alliance and partnership* nature of relationships between organizations in research and development – rather than the procurement and "purchaser-provider" arrangements that are being instituted in Government. It is now well recognised that alliances and strategic partnering are critical for sustainable innovation outcomes.[2]

The Report provides an analysis of "science clusters" in Victoria and concludes that co-location provides the basis for "horizontal" cooperation and collaboration among the science community but more effort is required to achieve "vertical" collaboration between research organizations, financiers and companies involved in the commercialisation process. Suggestions are also made to improve R&D management capabilities, particularly in relation to multi-disciplinary and multi-party research and development efforts.

Material provided in submissions to the Audit and Review are used as a basis for comment about the biotechnology sector in Victoria. Material provided by biotechnology and pharmaceutical companies is particularly useful in this regard. Our main conclusion is that Victoria would benefit from:

- Support from a publicly sponsored equity fund for seed and early stage commercialisation of biotechnology with a view to securing IP and developing and implementing an integrated marketing and communications strategy
- A clear understanding that seed funding is for product and management development and not further "discovery" research

[2] These observations are based on analyses contained in recent publications such as Ganguly, Ashok (2000) *Business Driven Research and Development: Managing Knowledge to Create Wealth* and Allen, Gene and Rick Jarman (1999) *Collaborative R&D: Manufacturing's New Tool*

- Encouraging, through foreign direct investment (FDI) initiatives, pharmaceutical companies to locate (or remain) in Melbourne
- Advocating greater cooperation and collaboration among research centres and institutes, through consortiums and partnerships, that can work effectively in joint ventures with pharmaceutical companies
- Making available independent, high quality professional business advice and assistance to scientists and "academic entrepreneurs" in their negotiations with large pharmaceutical companies. Such advice should reflect intimate knowledge of product development and marketing strategies.

We have included at the end of the Report a summary of responses that address perceived gaps in the STI resource base. Interestingly, not all responses advocate increased funding. A significant number of responses are concerned with capacity building and encouraging networks.

1. Project Overview

1.1. Purpose

This project reflects recognition by the Victorian Government of the importance of science, technology and innovation (STI) infrastructure to the State's strength as a location for investment in research and experimental development (R&D) in universities and other research institutions and in new product introduction by industry.

The Audit and Review was undertaken to provide baseline details of current infrastructure and identify gaps in the infrastructure base in order to inform policy and assist in attracting inward investment. The following baseline information was sought:

- Physical location, ownership, purpose and application of identified infrastructure installations
- Principal research fields using the equipment
- Capacity, utilisation rates, access regimes and profile of users
- Capital and running costs
- Effective life cycles and replacement schedules
- Views on how the infrastructure compares with the "state-of-the-art" infrastructure elsewhere
- Current strategies employed by SET organizations to finance the upgrade, replacement and filling of infrastructure gaps.

It was intended that Information collected would be used to identify important gaps in strategic infrastructure.

Specific comments were sought in relation to:

- The relationship between access to key infrastructure and the ability of the organization or user organizations to attract/maintain key personnel, research programs and research funding
- Clustering of activity around key infrastructure installations - including (but not limited to) Clayton, Parkville, Fishermans Bend and around the Alfred Hospital.
- Mechanisms to update information on Victorian SET Research Infrastructure in a cost effective manner.

1.2. Definition of infrastructure

The Project Brief does not define infrastructure. However, a conventional view is that infrastructure is an asset that is available for collective use. It is generally classified in terms of:

- *Physical Capital* – purpose built facilities, laboratories, machinery, equipment

- *Human Capital* - skilled personnel, including scientists, engineers, R&D managers, entrepreneurs
- *Social Capital* - the networks and relationships that engender trust and collaboration between people
- *Natural Capital* - the natural environment in which development takes place
- *Structural Capital* - the management arrangements for planning, resource allocation and reporting performance as well as a range of administrative support services.

The terms of reference for the Audit and Review focus explicitly on physical capital. Issues concerned with human capital, social capital and structural capital were canvassed extensively in discussion and consultation during the Audit and Review. A substantial amount of information has also been collected in this area.

We do not regard privately owned assets that are not available for collective use as constituting "infrastructure". Thus, facilities and equipment used in the processes of commercial production, and which could not be accessed by other businesses for purposes such as research and product development are nor included within the definition of infrastructure.

1.3. Infrastructure and Research and Development Capability

The existence and availability of physical capital is an important indicator of current and prospective performance in R&D and innovation. In application however, performance is impacted by *capabilities embodied in the combination of resources* that are available for R&D and innovative effort. A resource is anything that can be thought of as a strength that provides a distinctive capability. Physical capital is only one such resource.

STI resources include:

- *Tangible assets* - such as facilities, equipment, property, patentable inventions and proto-types
- *Scientific and technical knowledge* – both explicit[3] and implicit reflected in organisational and corporate memory
- *Intangible assets* - such as image, reputation, professional contacts and personal relationships
- *Networks* - formal and informal, that engender cooperation and collaboration
- *Management capacity and capability* – skills in strategic and business planning, R&D management, leadership and communication
- *Financial resources* - for investment in research and development, joint product development and marketing.

[3] Explicit knowledge may be reflected in an intellection property right (patent) or in documentation that is of a "commercial in confidence" nature.

In the context of the "knowledge economy" capabilities embodied in tangible assets are by no means the most important contributors to R&D and innovation outcomes. Success is associated with strong capabilities in knowledge, intangible resources and management capability.

Knowledge resources are now being seen as one of the most important contributors to business success. Corporations are giving an ever-increasing amount of attention to the issue of knowledge management – how to measure and manage what they know. It is, however, very difficult to "value" knowledge assets using conventional economic and accounting concepts.

Intangible resources are developed through experience as well as processes of interaction on a formal and informal basis between researchers and research organizations, business and government. Information was collected during the Audit and Review about the knowledge, skills and experience of people in the research environment. A substantial amount of information was also collected about collaborations, affiliations and other forms of interaction.

Within the constraints of the terms of reference for the Audit and Review, we have endeavoured to provide a *resource-based* perspective of Victoria's STI infrastructure. In particular, we have addressed the other issues in the project terms of reference concerning STI Infrastructure in terms of capability and resources rather than in terms of physical capital alone.

A resource-based view of STI infrastructure is also necessary to address capability in areas such as biotechnology where physical capital is an important, but by no means the critical, contributor to R&D and innovation outcomes.

To this end, we have provided a great deal of reference information about STI capability in Volume 2 of this Report, *Capability and Capacity in Science, Technology and Innovation (STI) in Victoria.* We have provided detailed information about STI tangible assets in the *STI Database* in electronic format. The Database also includes extensive information about knowledge and intangible assets, including qualifications and experience of scientists and other R&D personnel.

1.4. Cooperation and collaboration

In the current industrial climate business is increasingly being conducted through complex interlocking clusters, groups and alliances that represent fully and formally developed systems of cooperation and collaboration. These "clusters" may be geographically based – or be based on a broader concept of "community of purpose".

Cooperation, collaboration and interaction between universities, research organizations, business and government is becoming much more important in the context of the cost and complexity of research and development. Corporate research and development is now extensively outsourced under various forms of alliance arrangement between these organizations.

Collaborative arrangements allow for different organizational forms to co-exist: for example, the "organic" structure of a research team with the formal

authority and control structures of a large corporation. In Victoria, these collaborative arrangements exist in the following forms of organization:

- Publicly funded research organizations
- University research centres
- Commonwealth funded Cooperative Research Centres
- Commercialisation of technology based start-up ventures.

A substantial amount of information was collected in the Audit and Review in relation to the extent of cooperation and collaboration between research organizations, business and government. This information is included in the *Compendium* and the *STI Database*.

2. Approach to the Audit and Review

2.1. Collection of Information

Information about Victoria's STI resource base was collected from people and organizations identified as being involved in science, technology and innovation activity. Information was sought by way of submission in response to a specific *Request for Information*.

The format of the *Request* was discussed and agreed with the Department of State and Regional Development. The list of organizations contacted was drawn from the *Australian Technology Directory* and the *Technology Directory of Australia.* This directory information was added to by contacts provided by staff in the Department of State and Regional Development and other sources.

Respondents were asked for information in the form of a submission rather than a response to a questionnaire. Our experience is that questionnaires can miss important contextual information and can direct responses in particular directions. In addition, respondents often prefer to provide information in their own format.

In many cases respondents indicated that they did not have the time or resources to provide the information in the format requested. In these cases we asked for copies of Annual Reports, submissions to the NH&MRC, the IR&D Board and other documentation that described purpose, activities and achievements. Reference was also made to Internet based information sources.

We note that many of the Victoria based Health and Medical Research Institutes produce excellent Annual Reports on activities. Copies of Reports and documentation are available in the Department of State and Regional Development STI Library.

It became the role of the Review Team to extract information from the Annual Reports and other documents provided for incorporation into the STI Database. This was a time consuming and resource intensive exercise. We believe, however, that the effort has been worthwhile in that we have been

able to produce a comprehensive profile of the capabilities of Victoria's STI resource base.

2.2. Response Profile

The returns from organizations with details for inclusion in the STI Database were uneven. The coverage of organizations is indicated Table 1.

Table 1: Responses to the STI Request for Information

Organization Category	Number of Requests	Returns Completed	Returns Partially Completed	Response Rate (%)
Public Organizations				
CSIRO Business Unit	24	12	1	54
Other Commonwealth Organization	7	5	1	86
University Research Centre/Faculty	222	44	3	21
Medical/Clinical Research Institute	23	11	5	70
Agricultural Research Institute	20	18	2	100
Other State Government Institute	2	2	0	100
Cooperative Research Centre	18	10	1	61
	316	102	13	36
Private Organizations				
Companies	370	41	2	12
Industry/Professional Association	51	18	2	39
	421	59	4	15

More detailed information about which organizations responded to the Request for Information is provided in the Annexes to this report.

With the exception of University Research Centres, the response rate for public organizations was satisfactory. The low response rate from University Research Centres is a reflection that some centres are not fully functional or have been disbanded. While many research centres have a significant investment in STI resources, others are vehicles for submitting requests for funding from the various research funding agencies.

The response rate from companies is disappointing. There are a number of reasons for this:

- STI performing companies do not consider that their facilities fall within the scope of the definition of infrastructure being available for collective use. A number of companies indicated that their R&D capabilities are subject to commercial in confidence constraints
- Companies did not participate because they do not currently receive, and are unlikely to request, support and assistance from the Victorian Government for infrastructure purposes.

2.3. Presentation of Information

The information collected has been presented in the form an electronic Report – ***The Victorian STI Database***. The Database can be used on an interactive basis in Microsoft Access 2000. The Database identifies the following resource elements:

- Organizational characteristics

- Facilities and equipment details
- Skilled personnel
- Information and knowledge
- Research focus –
  - Field of research
  - Socio-economic objective
- Cooperative and collaborative arrangements and affiliations
- Capital and funding arrangements.

The Database can be interrogated for information regarding STI assets and report formats have been prepared. A number of sample reports have been provided to the Department of State and Regional Development. We understand that the Department will develop a "front end" search engine and Internet access.

Further refinement could involve the development of an interactive search capability for use on the Internet.

2.4. Extent of Information Provided

The following comments are provided in relation to the quality and content of the information that has been provided as part of the Audit and Review.

2.4.1. Facilities and equipment details

An extensive range of data has been collected. However, the information relating to purpose and application is often included in the overall information about the organization – respondents arguing that it is the purpose of the total infrastructure that is important not the individual items.

2.4.2. Principal Research Fields

Apart from the data that came in via the email survey (which has been incorporated into the *STI Database*) there were not many non-academic institutions that provided information to this question.

Fields of Research have been given in relation to an organization not individual facilities or items of equipment.

2.4.3. Capacity, Utilization rates, Access Regimes, User Profiles

There was very little response to this question. Most organizations do not collect this data on an ongoing basis. The reason being that asset information is kept in an organization's financial system. These systems are designed to meet financial reporting requirements and, as capacity and utilisation is not a normal reporting requirement, it is not collected.

To obtain the information it would have been necessary for organizations to undertake a completely separate data collection exercise. The STI Audit was not seen as being of sufficient importance for most organizations to justify the cost of embarking on this exercise.

For private sector organizations the question is largely irrelevant. Users are either their own staff or customers.

2.4.4. Capital and Running Costs

A substantial amount of data was collected in this area. However, it has been provided on a variety of different bases. For example, publicly listed companies generally responded by sending a copy of their financial statements for the year: this discloses only net profit after tax, a net position and therefore does not disclose total operating costs.

Where possible, we analysed cashflow statements and worked out total cash payments to suppliers and employees, this was then used as a proxy for operating expenditure. However, there was still no way of determining what the capital component was - in fact for many private sector organizations, the capital concept is irrelevant as the decision to purchase new items of equipment is a financing decision - eg debt, equity or lease.

For many public sector organizations, there was a wide range of different data provided. In particular, many university organizations only disclosed what funds they received in total - not even split across years.

2.4.5. Life Cycles and Replacement Schedules

Generally, this information is not available. We did get some information on depreciation schedules but it was not seen as relevant given that financial accounting and tax law determine depreciation schedules rather than technical obsolescence.

For example, while the economic life of an asset may be 10 years, it could be technically obsolete in less than two years. It is also unlikely that organizations would replace an existing asset with the same asset: a new asset may have significantly greater capacity and functionality, and may in fact cost less.

Effective life cycle will therefore depend upon the intent of the organization in using the asset and where they want to be relative to the leading edge of technology. These points are well made in the submission from the St Vincent's Institute of Medical Research:

> The equipment for protein chemistry and crystallography is especially expensive, and all of it has been obtained through grants from granting bodies, Trusts and Foundations, and from private donations. The total value of equipment of this type in the Institute is of the order of $3 million. A list of specific apparatus can be made available if required.
>
> All of the major items of research equipment in the Institute have been purchased from specific grants for that purpose. In general, replacement must be by upgrading the technology, and some of the Institute's expertise requires resource intensive support. Presently we are attempting to upgrade the Mass Spectrometry facility at a cost in excess of $1.3 million.
>
> Because technology tends to advance at a more rapid rate than the life cycle of any specific item of equipment, it has not generally been necessary to maintain a replacement schedule. Rather, a continual cycle of purchasing new equipment and technology is maintained, the rate of implementation being dependent on the availability of grant opportunities and success with these applications.

2.4.6. Comparison to State of the Art Infrastructure

The comments on STI Gaps provided in response to the Request for Information and the email survey (see below) of capability suggest that there is very little state-of-the-art infrastructure in Victoria. We understand that this observation is consistent with a recent survey of major research facilities undertaken for the Department of Industry, Science and Resources.

2.4.7. Current strategies employed by SET organizations to finance upgrade, replacement and filling of infrastructure gaps

There was very little response to this question.

There was not one organization that responded to the Request for Information indicating that it had made a strategic decision to maintain a given level of technical capability.

2.4.8. E-mail survey

Organizations that provided information in response to the Information Request were asked, through an electronic survey instrument about research capability in the areas where research effort was applied (socio-economic objective).

Research capability was ranked 1 to 5, with 1 equating to basic and five equating to world class. There were 53 responses from a total of 400 organizations contacted. The data provides an indication about where research capability is concentrated. The results are reported in Section 4.

2.5. Mechanisms to Update Information

A large amount of information has been provided on STI resources arising from this project. The information has been presented in the form of an electronic Database and a hard copy document that summarises capacity and capability in STI organizations in Victoria.

We understand that a “front end” inquiry and presentation capability is to be developed for the Database for posting on the Internet. We suggest that STI organizations should update the information directly to the Internet through an editor contracted by the Department of State and regional Development.

3. Physical Infrastructure

The terms of reference for the Audit and Review have a specific focus on physical infrastructure, or capital assets. In this Section of the Report information on physical infrastructure is provided under the following headings.

- Major research facilities
- Major capital equipment

3.1. Major Research Facilities

The Commonwealth Government's Coordinating Committee on Science and Technology (CCST) Major Facilities Working Group has defined a major research facility as:

- A world class instrument, collection of instruments or connected nodes of information and expertise, devoted to research in the physical, chemical, engineering or biological sciences, designed to be used for scientific purposes
- A significant collection of specimens, samples, data or information in scientific research
- Any other physical or virtual construction of a unique nature that allows the conduct of research not otherwise possible.

The facility must be *major*. That is, it is likely to require a large financial investment to construct, or a series of smaller investments to assemble, and thus have a replacement value exceeding $5m at current prices.

The definition emphasises capital investment. On the basis of this definition, the CCST Working Group identified four major research facilities in Victoria:

- The Australian Animal Health Laboratory
- The Molecular Beam Epitaxy Laboratory at Latrobe University
- The Low Speed Wind Tunnel and Air Operations Simulation Centre at the Defence Science and Technology Organization.

The CCST Working Group identified eight facilities as "possible major facilities" in Victoria, in that they did not meet all of the criteria in the above definition.[4]

The CCST definition relates mainly to "capital intensive" capability. For this reason none of the medical research institutes in Australia are identified as major research facilities. The Australian Genome Research facility is identified as a "possible major facility".

The results of the CCST Survey as well as general comments about gaps in STI infrastructure in Victoria made during the STI Audit and Review[5] indicate that there is very little cutting edge technology *in physical assets.* While there are some expensive facilities, they are not necessarily unique

[4] A full listing of major facilities identified by the CCST Working party is to be published on the Commonwealth ISR Website shortly.
[5] This observation is supported from the data obtained from the email survey and reported in Section 4 below.

in a global context. This observation is made in the context of very high capability levels in *knowledge capital.*

In the current industry environment, where attention is being focussed on "knowledge intensive" capability, it is our view that a facility should be considered as major if it involves a substantial level of *recurrent* expenditure, where that expenditure relates to personnel undertaking research and development activity as well as purchase of materials and access to technology.

A full listing of research facilities that were provided to the Review team in the Audit and Review is contained in the STI Database. All of these facilities make a contribution to Victoria's strength as a location for R&D and new product innovation. Facilities considered to be of major significance, in terms of capital investment and operating expenses, are listed in Table 2. Information is grouped under the major Field of Research (FOR) categories.

Table 2: Major Research Facilities in Victoria

Organization	Facility Type	Brief Description	Estimated Replace-ment Cost $'000	Most Recent Capital Budget $'000	Most Recent Operating Budget $'000
EARTH SCIENCES					
Bureau of Meteorology, Research Centre, CSIRO	High Performance Computing & Communications Centre	NEC SX-4 Supercomputer - one of the world's fastest supercomputers. Peak speed of 64 Gop/s, main memory of 8 Gbyte. It is a multi-processor, parallel vector, shared memory computer. SX-5 Supercomputer - Peak speed of 104 Gop/s, main memory of 128 Gbyte. NEC SX-5, which will replace the SX-4.	$18,900	n.a.	$5,600
CSIRO, Division of Atmospheric Research	Miscellaneous Laboratories	Located in Aspendale Victoria. Includes aircraft instrumentation lab; geophysical data processing facility; global atmospheric sampling lab; ice core extraction lab; precipitation chemistry lab; and a high performance computing and communication centre.	n.a.	n.a.	$15,000
La Trobe University, Australian Geodynamics Cooperative Research Centre	Research Laboratory	Located on the Bundoora campus of La Trobe University; includes seismic imaging and interpretation facilities.	n.a.	n.a.	$9,400
APPLIED SCIENCES AND TECHNOLOGIES					
Boeing Australia Limited, Aerospace Technologies of Australia Ltd	Research and Development Workshop	See equipment (less than 500k) section for details of equipment.	$3,115	n.a.	$197,474
CSIRO, Composite Fabrication Centre	Research & Industry Nodes	Located at various sites in Melbourne, Sydney & Adelaide.	n.a.	$200	$4,000
	Management Headquarters	Located at Notting Hill, Melbourne.			
Centre for Material and Surface Science, La Trobe University	Surface Analytical Instrumentation	CMSS is the largest grouping in Victoria; it is the only high resolution imaging instrument in Victoria.	n.a.	n.a.	n.a.
	Photoemission Spectroscopy	CMSS academic staff are world leaders in the area; significant future commercial potential.	n.a.	n.a.	n.a.

Organization	Facility Type	Brief Description	Estimated Replace-ment Cost $'000	Most Recent Capital Budget $'000	Most Recent Operating Budget $'000
	Semiconductor Research	The only semiconductor materials growth capability in Victoria.	n.a.	n.a.	n.a.
CSIRO, Division of Textile and Fibre Technology (formerly Wool Technology)	Textile Mill	Vertically integrated textile mill with full research instrumentation of all equipment.	$14,000	n.a.	n.a.
	Microscopy Laboratory		$2,000		
	Textile Testing Laboratory		$2,000		
CSIRO, Food Science Australia	Research Facility	Werribee and Highett facility, Victoria.	$40,000	$95,000	$33,000
DSTO, Aircraft Structural Testing Facility	Structural Test Laboratory	1100 sqm open test area. Reticulated hydraulic power around perimeter 540 l/min @ 20.7 MPa. Overhead cranes, control rooms, workshops, storerooms, hydraulic clean rooms & strain gauge laboratories service floors. 1700 channels of data acquisition.	n.a.	n.a.	n.a.
	Wing Bay	700 sqm open test area. Reticulated power around perimeters 720 l/min @ 20.7 MPa. Overhead cranes, control rooms, workshops, storerooms, hydraulic clean rooms & strain gauge laboratories service floors. 1700 channels of data acquisition.	n.a.	n.a.	n.a.
	Fatigue and Fracture Laboratory	12 servo hydraulic universal fatigue testing machines (15kN to 2000kN) all individually computer controlled for random variable load sequences. Linked to a file server computer for archiving. Environmental conditioning chamber, atmosphere generator etc	n.a.	n.a.	n.a.
Invetech Operations Pty Ltd	Tangible Company Assets	Major operating equipment is in computers and software. Company will soon move to larger premises.	$1,200	$780	$23,000
Kraft Foods Ltd	R&D Facility	No details provided.	$6,000	n.a.	
Monash University, Monash Science Centre	Museum and Education Building	Building aims to incorporate low impact, energy efficient design, and attempts to be 'user friendly' for the visiting public.	$9,500	n.a.	$300
ENGINEERING					
Ceramic Fuel Cells Ltd	Development/ Fabrication	Mixing & milling equipment, tapecasters, screen printers, calcination & sintering furnaces, sputter desposition unit.	$900	$2,900	$12,200
	Ceramic Powder Fabrication		$400		
	Fuel Testing Infrastructure		$1,500		
Rio Tinto	R&D Facility - Thomastown	Extensive office, lab, and pilot plant equipment.	n.a.	$6,000	$45,000
	R&D Facility - Bundoora	Extensive office, lab, and pilot plant.	n.a.		
AGRICULTURAL SCIENCES					
CSIRO, Australian Animal Health Laboratory	Australian Animal Health Laboratory	One of the most sophisticated laboratories in the world for the safe handling of exotic livestock diseases.	$600,000	$1,000	$20,000
	Biosecurity Facility	Biosecurity level BSL4. Highest level biosecurity, which is required for research into diseases that can effect humans as well as animals or for which no cure is available.			

Organization	Facility Type	Brief Description	Estimated Replace-ment Cost $'000	Most Recent Capital Budget $'000	Most Recent Operating Budget $'000
Department of Natural Resources and Environment, Catchment Agricultural Services	Research and Operations Facilities	Locations in Port Phillip, the South West, the North East, the North West, and Gippsland.	n.a.	n.a.	$13,000
	Quarantine Facility	This facility allows the importation and study of biotic agents. It is Victoria's only Level II Quarantine facility	$5,000	n.a.	$2,000
Department of Natural Resources and Environment, Keith Turnbull Research Institute	Plant and insect propagation facilities	Insects; mass-rearing insectary, glasshouse & field cages. Plants; 4 glasshouses, 6 large polyhouses, herbicide application/herbicide technology facilities and laboratory, a toxicology laboratory, animal laboratory and extensive field compounds.	$1,500		
	Assorted administration building	Facilities include a main administration building with library and a conference centre.			
Department of Natural Resources and Environment, Marine and Freshwater Research Institute	Institutes Facilities	See under Machinery Equipment <500k. Includes all installation.	$2,000	$423	$10,000
Department of Natural Resources and Environment, Rutherglen Research Institute	Buildings	Various buildings, old and new, at the Rutherglen establishment.	$6,095	$300	$5,500
Department of Natural Resources and Environment, Victorian Institute for Dryland Agriculture	Grain Chemistry Laboratory	A variety of large items of equipment, including; texture analyser, spectrophotometer shimadzu, extensograph, amylograph.	$1,288	n.a.	$10,000
Department of Natural Resources and Environment, Victorian Institute of Animal Science	Quarantine Area	50 ha.	n.a.	n.a.	$11,450
	Farming Land	650 ha irrigated and dryland.			
	Research Laboratories	Contains equipment for research in microbiology, chemistry, physiology, etc.			
MEDICAL AND HEALTH SCIENCES					
AMRAD Corporation Ltd	Land and Buildings in Total		$12,750		$150,000
Anti-cancer Council of Victoria, Victorian Breast Cancer Research Consortium Inc	Laboratories	Research laboratories are located in host research institutes: Peter MacCallum Cancer Institute (2 groups), Prince Henry's institute of Medical research, St Vincent's Institute of Medical Research & The Walter & Eliza Hall Institute of Medical Research. The Consortium is an Institute without walls.		n.a.	$3,000

Organization	Facility Type	Brief Description	Estimated Replace-ment Cost $'000	Most Recent Capital Budget $'000	Most Recent Operating Budget $'000
Austin and Repatriation Medical Centre, Austin Research Institute	Research Facility	Facility consists of 7 laboratories; Cancer Immunotherapy Lab, Cellular Cytotoxicity Lab, Immunology & Vaccine Lab, Immunology & Biotechnology Lab, Complement Regulation Lab, Molecular & Immunogenetics Lab, Biological Research Lab & Transgenic Lab	n.a.	n.a.	n.a.
Austin and Repatriation Medical Centre	Clinical Centre	Includes outpatient, inpatient, and dedicated diagnostic facilities.		$3,455	$330,177
	Clinical Research Precinct	Site includes: several University departments and centres; the Austin Research Institute; Ludwig Institute for Cancer Research; Brain Imaging Foundation and National Stroke Research Institute.			
Baker Institute	Clinical Research Laboratories	Undertakes basic and clinical research in a number of specialised laboratories in vascular biology, endocrinology and metabolism, neuroscience, cardiology, blood coagulation.	2,429	n.a.	14,599
Biomolecular Research Institute Ltd	Structure Laboratory	Modern rotating anode X-ray diffraction generators and image plate detectors for X-ray diffraction studies. Facilities also include devices for freezing protein crystals and collecting data from them at liquid nitrogen temperature.	n.a.	n.a.	n.a.
	NMR Facility	NMR facility consists of Bruker DRX-600 and AMX-500 spectrometers, linked to a network of Silicon Graphics workstations. The DRX-600 is equipped with a triple-axis gradient system and four channels, the AMX-500 with a z-axis gradients and three channels.	n.a.	n.a.	n.a.
CRC for Cochlear Implant and Hearing Aid Innovation	Laboratories	Specialised sound proof laboratory facilities for speech perception and language testing; specialised biological laboratory facilities.	$6,000	n.a.	n.a.
	Surgical Theatre	Specialised experimental surgical theatre for biomedical device design work.	$3,000	n.a.	n.a.
	Research Centre	Biological research centre.	$2,500	n.a.	n.a.
Deakin University, Cell and Organism Bio-Engineering Group	Research Equipment	Includes current and new lab instrumentation.	$7,500	n.a.	$1,300
Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne	Research Facility	The Faculty has approximately 750 Research Staff and slightly over 700 Research Post-graduate students. All major areas of biomedical research are represented.	n.a.	n.a.	$44,900
Foundation for the Detection of Genetic Disorders – operating as the Mutation Research Centre	Laboratory	The laboratory is equipped to carry out modern molecular genetics, including genetic engineering, proteing chemistry and expression and cell tissue culture.	n.a.	n.a.	n.a.
	Start-up company	The Centre has helped incubate a startup biotechnology company (Cytopia).			

Organization	Facility Type	Brief Description	Estimated Replace-ment Cost $'000	Most Recent Capital Budget $'000	Most Recent Operating Budget $'000
Glaxo Wellcome Australia Ltd	Pharmaceutical Development Facility	Contains: pilot plant containment facility; controlled stability rooms; analytical laboratory can test all dosage forms; equipment for inhaled product development; particle & mass spectrometry; integrated LIMS system; clinical trials supplies group.	$10,000		
	Clinical Research Department	Located in Boronia. Consists of 28 professional and administration staff, 8 staff involved in Phase ii-iv trials.		n.a.	n.a.
	Production Facility	Opiate R&D at Port Fairy. Consists of 5 scientists with limited access due to security required for drugs of dependence. Plans to expand are in progress.			
Howard Florey Institute	Clinical research laboratories	Undertakes basic and clinical research in neural development, gene regulation, neurobiology, relaxin, neurochemistry, fetal physiology, cardiovascular pharmacology, functional neuro imaging	n.a.	n.a.	n.a.
Institute of Drug Technology Australia Limited	Non-cytotoxic manufacturing facilities	Facilities capable of producing multi-tonne quantities of commercial active pharmaceutical ingredients. Further expansion planned.	n.a.	n.a.	$9,491
	Cytotoxic manufacturing facilities	Key drug production includes Cisplatin and Carboplatin. Further expansion planned for 1999/2000. Company has received USFDA approval for the manufacture of anticancer products for a major US client.			
Institute for Reproduction and Development	Medical and biotechnology research laboratories	IRD comprises 10 research groups conducting medical and biomedical research into molecular reproduction and endocrinology, prostrate biology, molecular genetics, baby health, early human development, gynaecology and infertility, endometrial physiology and reproductive angiogenesis	n.a.	n.a.	n.a.
Ludwig Institute	Clinical laboratories	Undertakes basic and clinical cancer research	n.a.	n.a.	n.a.
Macfarlane Burnet Centre for Medical Research Ltd	Containment Laboratories	Fully equipped PC2 & PC3 laboratories for research using recombinant genetic material and infectious agent.	n.a.	n.a.	$11,717
Monash Medical Centre, Prince Henry Institute of Medical Research	Office buildings	Located in the Monash Medical Centre to provide administrative services and clinical services.	n.a.	n.a.	$5,733
	Large animal laboratory	Located at Werribee.	n.a.	n.a.	n.a.
	Small animal laboratory	Located within the Monash Medical Centre.	n.a.	n.a.	n.a.
National Ageing Research Institute	Research Clinic	Falls and Balance Clinic - Melbourne Extended Care and Rehabilitation Clinic. Established in 1998 as the first falls clinic in Australia.		n.a.	$2,500
	Research Clinic	Cognitive Dementia and Memory Service - Melbourne Extended Care and Rehabilitation Clinic.			
	Research Clinic	Pain and Wound Management Clinic - Melbourne Extended Care and Rehabilitation Clinic.			

Organization	Facility Type	Brief Description	Estimated Replace-ment Cost $'000	Most Recent Capital Budget $'000	Most Recent Operating Budget $'000
Swinburne University of Technology, Brain Sciences Institute	Main Facility	Undertakes research in the human brain sciences with particular emphasis on functional brain imaging and the development of related biomedical instrumentation	n.a.	n.a.	n.a.
Walter and Eliza Hall Institute of Medical Research	Buildings and offices	The Institute has a 40-year lease on a purpose built building within the Royal Melbourne Hospital. The Institute also has a primary mouse breeding facility and small animal quarantine facility.	n.a.	n.a.	$29,800
	Genome Research Facility	The Institute is also responsible for the Melbourne Division of the Australian Genome Research Facility. This facility is also located within the Royal Melbourne Hospital. The research facility has sophisticated robotics systems capable of performing thousands of pipetting steps daily, DNA amplification & electrophoresis. This is supported by generation sequenators, PCR machines, bioinformatics programs & staff of 20.	$8,000	n.a.	n.a.
	Laboratories	Flow cytometry and confocal microscope laboratory. Joint Protein Structure Laboratory (Ludwig Institute for Cancer Research).	$3,000	n.a.	n.a.

It is apparent from the information provided above, supported by the detail in the STI Database, that there may be duplication and overlap between organizations in facilities. There is possibly scope for organizations to pool their resources and acquire facilities of a greater scale and technical capability. We understand that some University Science faculties now are collaborating on this basis.

3.2. Major Equipment

Information has been collected in the Audit and Review on major equipment located within research organizations. Equipment with an estimated value in the vicinity of $1m or more listed in Table 3. Details of all equipment provided in the Audit and Review is contained in the STI Database.

Table 3: Major Equipment located in Research Organizations in Victoria

Organization and main Field of Research	Type of Equipment	Description	Estimated Value $'000
CHEMICAL SCIENCES			
CSIRO, Composite Fabrication Centre	Reactive Extrusion Facility	Used for the chemical modification of polymers during melt processing and has created considerable industry attention.	$700
La Trobe University, Department of Chemistry	Spectrometers	Includes: Bruker DRX-400, Bruker AM-300, magnetic resonance spectrometer, atomic absorption spectrometer, etc.	$3,000
	Other Laboratory Equipment	Includes microscopes, chromatographs, microwave equipment.	$500

Organization and main Field of Research	Type of Equipment	Description	Estimated Value $'000
Department of Natural Resources and Environment, State Chemistry Laboratory	Analytical Instrumentation	Includes microwave digesters, ICP-MS machine, autoanalyser, a super critical fluid extractor, GLC, etc.	$3,100
EARTH SCIENCES			
La Trobe University, Australian Geodynamics Cooperative Research Centre	Spectrometer	'AUSTRALIS' ultra high-resolution accelerator mass spectrometer for in situ isotope studies for geochemistry and geochronology.	$6,000
	Miscellaneous Equipment	Includes microscopes, IT equipment, and another spectrometer.	n.a.
APPLIED SCIENCES AND TECHNOLOGIES			
Centre for Material and Surface Science (MASS), La Trobe University	Imaging X-ray Photoelectron Spectrometer	Includes monochromated and non-monochromated x-ray sources, high-resolution ion source, two sample treatment chambers, vacuum sample heating and cooling, crystal cleaving. Allows collection of high-energy resolution spectra and photoelectron images to a spatial resolution of 2 um. Wide range of applications in manufacturing, minerals processing, plastics and chemical industries.	$1,200
	X-ray Photoelectron Spectrometer	Includes standard resolution spectrometer, non monochromated x-ray source, mall spot electron source, ultraviolet source, sample heating and cooling. Ideally suited to on-going research and development tasks.	$600
	High Resolution Angle Resolved Photoelectron Spectrometer	Unique, state-of-the-art toroidal electron energy analyser and associated spectrometer system under construction. System designed for synchrotron radiation and laboratory-based studies.	$1,500
	III-V Molecular Beam Epitaxy Facility	An integrated semiconductor desposition system. Instrument allows the one off manufacture of unique semiconductor structure for research and development purposes.	$1,500
	II-V Molecular Beam Epitaxy Facility	A customed designed facility providing semiconductor deposition capability together with optical, mass spectral and scanning probe diagnostics. Instrument allows the one off manufacture of unique semiconductor structure for research and development purposes.	$1,500
University of Melbourne, Microanalytical Research Centre (MARC)	NEC 5U Pelletron Accelerator with REIF	Funded upgrade to make it one of the brightest accelerators in the world for nuclear microprobe operation.	$1,000
	Two MeV Ion Microphobe Beams Lines	And other associated instrumentation.	$1,000
	Dilor Confocal Raman Spectrometer		$500
	Joel UHV AFM		$700
	Pulsed Laser Deposition System	For the synthesis of thin films of advanced materials.	$1,000
Swinburne University of Technology, Industrial Research Institute	Laboratory Equipment	Excimer Laser Work Station.	$1,500
	Laboratory Equipment	Nd:YAG Laser.	$750
	Laboratory Equipment	Flexible Manufacturing System.	$750
BIOLOGICAL SCIENCES			
CSIRO, Australian Animal Health Laboratory	DNA Sequencer, Three Scanning Electron Microscopes, Applied Bioprotein Sequencer, Electrospray Mass Spectrometer Systems, Fluorescent Activated Cell Sorter (FACS)		$15,000
Department of Natural Resources and Environment, Institute of Sustainable Irrigated Agriculture	Laboratory Equipment	Inductively coupled plasma atomic emission spectrometer.	$180
	Laboratory Equipment	Atomic absorption spectrometer.	$60
	Laboratory Equipment	Continuous flow spectrometer.	$160
	Laboratory Equipment	Automated chemical titration analyser system.	$140

Organization and main Field of Research	Type of Equipment	Description	Estimated Value $'000
	Laboratory Equipment	High pressure liquid chromatograph.	$90
Department of Natural Resources and Environment, Marine and Freshwater Research Institute	Research Vessels		n.a.
	Marine Aquarium Systems	This system has access to oceanic water and is temperature controlled.	n.a.
La Trobe University, Plant Biotechnology Centre	Laboratory	Laboratories for recombinant DNA research and development with high-speed centrifuges and ultracentrifuges.	$600
	DNA Sequencing Equipment	Equipment for high-throughput DNA sequencing.	$600
	Biorobotic Capacity	Biorobotic capacity for high-throughput performance.	$500
Department of Natural Resources and Environment, Victorian Institute for Dryland Agriculture	Plant Breeding Field Equipment	Trucks, sowing, harvesting equipment etc. VIDA's plant breeding capability is dependent on field equipment.	$1,500
University of Melbourne, Centre for Animal Biotechnology	Misc Laboratory Equipment	The CAB has major equipment items for protein chemistry, molecular biology, and immunology.	$5,000
AGRICULTURAL SCIENCES			
Department of Natural Resources and Environment, Rutherglen Research Institute	Research Instrumentation/Equipment	Includes laboratory equipment, technical farm equipment, etc.	$1,012
	Technical and IT Support	Includes computer hardware and software, etc.	$483
	Farm Equipment	Stables, cattle shed, shearing shed etc.	$280
MEDICAL AND HEALTH SCIENCES			
Mental Health Research Institute of Victoria Inc	Lab Equipment	Not provided	$1,125
	IT Equipment		$770
Monash University, Faculty of Medicine	Lab Equipment	Numerous Microscopes, DNA sequencers, centrifuges, sterilisers, computer and scanners	$4,951
Walter and Eliza Hall Institute of Medical Research	Proteomics	Chemical Protein Sequencers. Mass spectrometry protein sequencers. Proteome analysis equip (protein/peptide sep'tion). Proteome analysis equip (protein/peptide/DNA syn). Data interrogation (bioinformatics). The capability to develop new proteomics methods via a suite of nanomethods that will facilitate a targeted proteomic approach for studying dynamic protein modifications and molecule interactions. Applicable for the control and cure of cancer.	$3,000
	Computing and information technology	A variety of multi user systems supporting some 700 internal and external users. A satellite node of the GenBank network. Also maintain alliances with neighbouring institutes to access HPCs (Convex, Cray & MasPar)	
	Radiation	The Institute maintains a customised 60 Cobalt irradiation machine. In addition to internal users the Institute provides services to 20 external organisations.	
	Animal breeding and storage	The Institute breeds Specific Pathogen Free mice (around seventy inbred lines) and genetically manipulated mice. The Institute also maintains a quarantine building which houses rabbits and all mice obtained form external organizations. The premises has been approved by AQIS. The Institute has developed expertise in microinjection, embryo collection and transfer, and embryo freezing.	

The equipment profile demonstrates a concentration of equipment types – for example DNA sequencers, spectrometers and other measurement

equipment. As we suggested in relation to facilities, there may be scope for organizations to work cooperatively and acquire equipment with greater technical capacity and capability.

4. Views on How Infrastructure Capability Compares with "State of the Art" Infrastructure Elsewhere

To obtain views on how scientists and others viewed Victoria's STI capability compared with "State of the Art" infrastructure elsewhere, organizations that provided information in response to the Information Request were asked, through an electronic survey instrument about research capability in the areas where research effort was applied (socio-economic objective).

Recipients were asked to select the SEOs relating to their current R&D activities. They were then asked to select a capability level appropriate to that SEO ranked between 1 and 5. The general descriptors provided were:

5	Unique capability on science and technology frontier (no other leaders)
4	World-class capability that matches that of leaders in the research field/market
3	Near world-class capability that would be relatively easily translated into a world-class capability
2	Supporting capability that allows some participation or contracting with world-class teams/firms
1	Base-line capability

Respondents were then asked to nominate the FORs relating to that particular SEO.

The capability levels that have been calculated on the basis of the responses provided are set out in Table 4.

Table 4: Capability Indicators In Major Fields of Research

Field of Research	Total Count of SEOs	Total Capability	Average Capability
Mathematical Sciences	7	26	3.7
Physical Sciences	29	103	3.6
Chemical Sciences	103	349	3.4
Earth Sciences	26	88	3.4
Information, Computer and Communication Technologies	149	565	3.8
Applied Sciences and Technologies	176	597	3.4
General Engineering	62	211	3.4
Biological Sciences	168	454	2.7
Agricultural Sciences	27	73	2.7
Medical and Health Sciences	86	244	2.8
Social Sciences	54	160	3.0
Humanities	2	6	3.0
Total	889	2876	3.2

The data is interpreted as follows:

- Total Count of SEOs: the total number of times that a particular SEO was selected against that particular FOR.
- Total Capability: This is the sum of the capability for that SEO and FOR
- Average Capability: the Total Capability divided by the Total Count of SEOs excluding any SEOs for which there was no Capability Level nominated.

The data suggest that:

- The highest level of capability is in Information, Computer and Communication Technologies, Physical and Mathematical Sciences
- Chemical and Earth Sciences, Applied Sciences and Technologies and General Engineering reflect capabilities that are close to world class and could be translated relatively easily into world class capability
- Biological Sciences, Agricultural, and Health and Medical Sciences have a capability that allows participation and contracting with world-class teams.

While the response to the survey was quite low, the data was supported by observations made in discussion and consultation.

The results of the survey indicate that Victoria cannot be complacent in respect of its relative capability and capacity in Science, Technology and Innovation.

5. Access to Infrastructure and Capacity to Attract and Maintain Key Personnel

In this Section of the Report information is provided that addresses matters concerned with access of scientists and researchers to STI infrastructure and the capacity to attract and retain them in Victoria.

5.1. Skilled personnel and conditions

Many organizations contacted during the Audit regarded it as imperative that Victoria retains its best research scientists and was able to discourage them from being attracted interstate and overseas (on a permanent basis). It is also seen to be of immense value to the State to attract the best research workers to bring their ideas and their commercial potential, rather than go elsewhere.

Funding conditions for research, both for salaries and for equipment and running costs, are regarded as poor in Australia compared with overseas. Other states, notably Queensland, have made a concerted effort to improve conditions for biomedical research in their state, and are having success at building and strengthening their climate for research, from which commercial benefits will undoubtedly flow.[6]

Research organizations consider that Victoria should provide incentives for the best research workers to place themselves in Victoria. Several mechanisms were advocated:

- Matching all competitively won grant dollars over a certain base level (say $200,000 per year) with state funds
- Matching all 5 year grants with state funds
- Rewarding registration of provisional patents or publication in certain high profile journals with financial bonuses.

Commenting on these issues, the Australian Neuroscience Society observed that:

> Whatever the mechanism, the focus needs to be on rewarding the best research scientists, not all, so that this is an incentive for excellent researchers to locate themselves in Victoria. Mechanisms that provide financial rewards to the individual scientists are unlikely to be administratively simple or effective. Typically, it is the ease of adequate funding for their research that is attractive to research scientists.

Rofin Australia Pty Ltd pointed out that the company has some difficulty in finding people with both strong research and teamwork capabilities and is concerned with capabilities in Australia of optics generally.

The Research Centre for High Energy Physics identified personnel gaps in the areas of:

- Industrial liaison personnel

[6] This initiative is already attracting excellent workers to Queensland: the announcement of Prof Mark von Itzstein's move from Monash University to Queensland is a recent example.

- Individuals to give briefings to industry and academia on state of the art techniques
- Support personnel to assist academic and industry joint applications for funding.

The Australian Institute of Radiography pointed out that there is a severe shortage of Radiographers and Radiation Therapists in Australia, and in Victoria, and suggested that workforce-planning surveys are required. The Institute has made representations to the State Government for support for this project.

5.2. Research Training and Career Structures

There is seen to be a serious gap emerging in Victoria's STI resource base in the area of training in basic research. For example, the Microanalytical Research Centre pointed out in a submission to the Audit that:

> The present lack of suitable career structure for young researchers in the university system (and the great stress in the university system produced by the federal government's cuts to funding) is considered to have put the prospects for future innovators in doubt.[7]

There is also a concern about the loss of career opportunities as major companies close their research and development laboratories. The Australian Institute of Physics is concerned that physicists have lost jobs through closure of research and development laboratories at BHP (1999) and the former CRA now Rio Tinto (1998). The Institute noted that:

> . . . concern also exists with regard to trends in society and science and technology policy issues meaning that there are not enough opportunities for physicists to contribute to the future of Australian industry. Views expressed about the role of R&D by the heads of some of the largest Australian companies at the National Innovation Summit were depressing and short sighted.

In its submission, Rio Tinto commented that there were no specific gaps in the Victorian infrastructure that affect the company. The global nature of the business, and the ability to work with institutions worldwide means that companies like Rio Tinto are less dependent on local facilities than most companies.

The company pointed out, however, that technological strength of the local universities, and of the CSIRO, is important and the existence of these institutions in Victoria is an important factor behind Rio Tinto maintaining Victoria as the centre of its internal R&D.

5.3. Project Funding

The Mutation Research Centre pointed out that in the early 1980's, good projects and laboratories were well funded, but that in 1999/2000, between one third to one half of valuable projects and workers are not funded. For example, the Ludwig lodged 11 NHMRC grants without success and La Trobe University were only awarded one from 23 applications. Whilst the NHMRC is

[7] The Microanalytical Research Centre (MARC)

doubling its budget over the next years, it was suggested that the impact of funding increases will be minimal.

The Centre argued that the State needs to recognise that funding for key individuals and projects may be terminated and should provide for "special grants", perhaps funding projects with scores within 0.5 of NHMRC cut-off, and which are seen to be strategic. The Centre observed that:

> Many good PhD students miss out on funding and several of these approached us before they found their funding was not awarded. Students are the life blood of any centre and are often responsible for the lion's share of any progress and keep established staff on their toes with questions. Not only are stipends (very small) needed, but also student awards do not include laboratory expenses.

To resolve the situation, two initiatives were suggested:

- Offering funds to fund a certain number who do not get Federal grants
- Infrastructure grants should include laboratory costs.

These items are key in the Centre's fundraising drive. The point was made, however, that the less that scientists' have to do with fundraising and its associated pressures, the more productive they will be.

6. "Clustering" of Activities

The Project Brief required that specific attention be given to the "clustering" of activity in a number of areas of Melbourne. The existence of clusters is of interest from a geographic point of view, but the implications for industry policy, including STI strategy, are not clear-cut. Of particular interest is the unit of analysis - that is, the "size" of a cluster in relation to possible economic benefits.

For these reasons we have provided some background and addressed issues in relation to clusters in the Victorian STI context.

6.1. Background

Cluster analysts argue that information and knowledge become embedded within a region when regional resources become difficult to replicate and imitate in other areas. This depends on historical conditions, the existence of tacit, complex and specific knowledge that is unique to the region, the social interaction of the participants and the openness of communication. Silicon Valley is probably the exemplar of this situation – and is in many respects a special and unique case.[8] It is also very difficult to replicate.

Clusters include government institutions, universities, standard setting agencies, think tanks, vocational training providers, and trade associations that provide specialised training, education, information, research and technical support. The linkages and complementarities define boundaries across industries and institutions that are most important to competition. From an international perspective clusters tend to be identified as cities or States rather than specific precincts.

Potentially, clusters allow participants to benefit *as if* they had greater scale or *as if* they had joined with others formally – without being required to sacrifice flexibility. They impact on competition through:

- Increasing the productivity of companies based in the area through factors such as:
  - Better access to suppliers
  - Complementarities
  - Access to institutions and public goods
  - Motivation and measurement
- Driving the direction and pace of innovation – which underpins future productivity growth
- Stimulating the formation of new businesses, which expands and strengthens the cluster itself.

[8] See Saxenian, Annalee, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Cambridge, Mass: Harvard University Press, 1994. Saxenian makes the point that Silicon Valley is unique in terms of the extent of collaboration between universities, entrepreneurs, corporate research laboratories, and venture capitalists, the communication networks and the freedom of communication.

6.2. The Emerging Significance of "Science" Clusters

Overseas and Australian trends point to universities becoming much more involved in "problem driven" research. This development has been associated with greater collaboration with industry and the development of trans- and interdisciplinary approaches to scientific inquiry.[9] The consequence of these developments has been a new way of generating, managing and exploiting knowledge with significant implications for the STI base.

Moreover, in the American context, but increasingly relevant to Australia, the emergence of this new way of working had not been clearly foreseen or visualized and did not quite fit the linear management models of the day, the creation of trans- and interdisciplinary science clusters, which were task or sector specific, evolved more or less by trial and error. [10]

In this context, science and technology clusters represent "utilizable entities of fundamental knowledge flowing in from a critical mass of related scientific research"[11]. Science clusters are defined in terms of the interactions and relationships of scientists and business R&D managers and their respective fields of expertise. With information technology, such clusters may reflect a combination of regional, national and international dimensions.

At the same time, however, a science and technology cluster may be seen in a geographic sense where independent institutions, in combination and collaboration, build a critical mass of utilisable knowledge. This can be observed in areas such as molecular biology, a field of inquiry that has evolved as a result of the way questions are framed and research undertaken in immunology, genetics and cell biology across a number of organizations.[12]

6.3. Clusters in the Victorian STI Context

There are several science and technology clusters located in Melbourne and in regional centres such as Ballarat and Horsham. The Melbourne clusters are at Parkville, Clayton, Werribee and Fishermans Bend.

The co-location of the large number of university faculties, research institutes and organizations in these areas offer a great deal of potential for effective cooperation and collaboration. It needs to be recognised, however, that current research funding arrangements promote a fiercely competitive culture between institutions and organizations. This will continue as long as funding is based on application and submission for specific research projects.

There is probably more to be done, however, in promoting collaboration and cooperation between scientists and attracting and sustaining *corporate* interest and involvement.[13] For example, Glaxco Wellcome advised the Review Team that

---

[9] For example, it was largely industry that saw the emergence of new business opportunities emerging following the insights into DNA and the silicon chip driven growth fuelled by the computer industry.
[10] Ganguly, Ashok, *Business Driven Research and Development,* p. 37
[11] Ibid
[12] In Melbourne, the universities, the CSIRO and the medical research institutes have a very strong capability in this area. It is also an area that is of intense interest to companies.
[13] There is, for example, only one major corporation involved in the Parkville area of Melbourne.

> The lack of collaboration between scientists and institutions is a major disadvantage in innovation in drug discovery in Australia. The competitive process and the low rate of funding for projects are disincentives for collaboration. Vertical collaboration between multi-disciplinary sciences is critical in drug discovery.
>
> To develop the capability of drug development, scientists will have to work together in a multi-disciplinary approach. In the future, innovation in medical research will come from discoveries in genetics and identification of new targets for drug design. These opportunities will be achieved through close working relationships between geneticists, molecular biologists, chemists, pharmacologists, toxicologists and clinicians.

This observation was repeated in a similar vein on a number of discussions and consultations throughout the review process. For example, Professor Richard Cotton of the Mutation Research Centre pointed out that[14]:

> Victoria's medical research effort is spread through a significant number of research institutes located throughout the metropolitan area. Under such circumstances collaborative effort is not easily facilitated and researchers may tend to work in greater isolation than need be the case.
>
> If Victoria is to generate world competitive biological research and development it will only be achieved through interactive collaborations clustered around sophisticated equipment and a high quality shared infrastructure.

The development of effective networks requires some form of basic organisational and management input – such input must emphasise the management capacities of leadership and facilitation, as distinct from control and direction.

It is also apparent that the emergence of potential for greater cooperation, collaboration and partnership between universities and business, on the basis of knowledge capability, has not been accompanied by formal institutional mechanisms to train managers and equip them to manage large R&D projects in multi-party, multi-disciplinary, collaborative programs. The vital elements of extracting synergies and exploring potential value generation is difficult, but essential, to develop.

We are of the view that the Department of State Development can have an important role in initiating programs to train people in R&D management, particularly as it impacts on inter-organisational cooperation and collaboration.

[14] Mutation research Centre, Submission

7. The Biotechnology "Industry"

Reference is often made to the emerging biotechnology industry. It is not possible, however, to point to a "biotechnology" industry *per se*. Biotechnology, like information technology, is an *enabling technology.* It has a number of important applications in several industries, including pharmaceuticals, food and agriculture.

7.1. Background

There is now an appreciation on the part of pharmaceutical companies that they must incorporate biotechnology into their drug discovery and development strategies in order to survive[15]. Biotechnology aided drug discovery differs from the traditional "pipeline" strategies which are very time consuming, risky and expensive. Biotechnology, which provides for a mix of combinatorial chemistry for rapid syntheses of drugs, and genomics for finding specific targets, can shorten the discovery process significantly.

Biotechnology based drugs are seen as the direction of the future. Biotechnology provides pharmaceutical researchers the opportunity to tailor new compounds with above average chances of making it through testing and getting compounds out of the laboratory quickly[16]. The difficulty that the pharmaceutical companies have is acquiring biotechnology capability. They have two options:

- Develop the capability in-house, either by establishing their own labs or acquiring them through mergers and acquisitions
- Enter into licensing agreements or seeking R&D collaborations.

Internal approaches allow companies to focus on particular diseases and to develop new tools to accelerate drug discovery and development as well as retaining control over IP. But they can be bureaucratic and miss out on opportunities outside their spheres of interest.

In principle, collaborations and joint ventures provide access to a close knit entrepreneurial environment of small biotech companies. They can also partner with academic researchers who have excellent ideas and achievements, but because of an unwillingness to lock into a particular patron, prefer to license the results of their research.

These developments create significant opportunities for biotechnology research and development in Victoria and an environment for the creation of biotech start-up companies.

7.2. Implications for Victoria

The strength of the science base in biotechnology in Victoria is widely acclaimed.

[15] McKay, Niall, "The New Crusades", *Red Herring*, April 2000, p298
[16] "Research Fellows", *Red Herring"*, p. 306

At this stage, Australia, and Melbourne, are strong on the "Science and Technology" aspects of the STI resource base; there is a weakness with respect to the "Innovation" component. In particular:

- The venture capital sector does not have a strong capability in biotechnology – there is only one firm in Melbourne that has substantial experience in biotechnology investments
- Because of the absence of seed and early stage venture capital for start-up companies, the opportunities for development of the biotechnology sector are severely constrained: the culture of VC firms in Australia is that they are not "patient" enough for biotechnology
- In contrast to the UK, Ireland and Germany, and parts of the US, which have strong biotechnology sectors, Australian Governments do not invest in biotechnology companies at the start-up stage
- There is not, therefore, a large pool of biotechnology companies that can enter into collaborative R&D arrangements with pharmaceutical companies for drug development
- The absence of seed capital for start up companies means that technology passes directly from research laboratories to the pharmaceutical companies without the opportunity for further development of the technology and for the generation of employment.

A number of organizations commented during the Audit that it is essential that Victoria be placed at the forefront of efforts to exploit the molecular information that will flow from sequencing the human genome. To this end, Victoria needs to ensure adequate funding of core facilities.

Some facilities are already in place and well funded. Others need to be better and more reliably supported, both for equipment and professional salaries, including: - Bioinformatics - Transgenic animal facilities and technology - cDNA arrays/chip technology

The Australian Biotechnology Association Ltd pointed out in a submission to the Audit and Review that despite Victoria's strong scientific community and research institutes related to biotechnology, when successful biotech ventures in Victoria are compared with the scientific infrastructure the outcomes are somewhat limited. The Association argued that:

> We believe that there is a pent-up demand by investors to identify and invest in short term and strategic industries in the biotech area. These include the industry manufacturing drugs and therapeutics and also devices. It perhaps comes as no surprise to realise that CSL and Cochlear are the two 'darlings' of the stock market in the biotech area at the present time.
>
> It has been pointed out on many occasions, but it is worth noting again that Victoria and other states need to be able to fund and support the pre-commercial developments that are necessary to get fledgling business on its feet. In many cases this requires long term finance at favourable rates and some form of mentoring with large successful companies, particularly those that can manage brands successfully on the international market. For example, Bonlac has a strong record in developing and positioning new bio products in the domestic and international markets.

The Association suggested that the Victorian Government should give support to the development of suitable pre-commercial large-scale testing facilities, or at least expedite a database for developing a public network so

that the availability of these resources is well known so that there is a strategic Australia-wide network that people can use to develop any products in the stage between the laboratory and full scale production.

One of the problems that Victoria must overcome is the distance from large markets. As we have indicated earlier, it is most unlikely that scientific discovery will result in commercialisation without the contribution of equity finance and the involvement of a large company[17] and/or government.

We would argue that development of an industry using biotechnology capability should focus clearly on the *innovation* aspect[18] – that is bringing the technologies into a commercial application (this can include "public benefit" applications). This means being able to access the large European and US markets where demand is located, but which are also highly competitive.

While a great deal is being done by government agencies to understand how the biotechnology sector works, and to "develop policy", very little is actually being delivered. In its response to the Audit and Review, the Walter and Eliza Hall Institute commented that:

> There is a lack of co-ordination, and consequent duplication of data-gathering about biotechnology. At the federal level there are: Biotechnology Australia, IP Australia, Emerging Industries Groups [Industry, Science and Resources]: similar multiple groups, roundtables and forums/conference organizations is occurring at State level also. It is becoming impossible to know of real funding sources - eg. COMET, BITS, R&D START, so that we can actually begin to achieve the goals of a vibrant biotechnology industry.
>
> The Australian Governments (State and Federal) must appreciate the urgency and begin to implement its strategies, and establish funding mechanisms. We are rapidly slipping behind our international competitors.

Government support and assistance to offset, for the time being at least, the investments and higher transactions costs faced by newly established start-up companies seeking to enter distant and difficult markets should, in our view, be given a high priority.

7.3. Capability for Pharmaceutical Development

Glaxo-Wellcome pointed out in a submission to the Audit and Review that knowledge of drug development is relatively low in Australia and the country lacks the capability to fully develop a new molecule into a medicine - that is, to "take a molecule to market".

The expertise exists in Australian institutions and industry to achieve parts of drug development process - conducting clinical research, preparing regulatory submissions, pharmaceutical development and commercial manufacture, but there are substantial gaps.

According to Glaxo and other pharmaceutical companies, Australia does not yet have sufficient capability for automated combinatorial chemical synthesis

[17] There is, incidentally, now a growing literature on the importance of large organizations in innovation. The research of Alfred Chandler jnr has been of particular significance. See Chandler, Alfred D. et al.(eds) *Big Business and the Wealth of Nations*, Cambridge: Cambridge University Press1997

[18] We assume funding for research would continue through existing mechanisms, but as discussed elsewhere in this Report, with a more focused "consortium" approach.

and screening of molecules for physicochemical properties, pharmacological and toxicological development and scale up of chemical synthesis to commercial primary production of active therapeutic agents. Another important capability that is in short supply relates to project management in the drug discovery and development process. The multi-disciplinary approach in drug development requires strong project management skills.

In their submission to the Audit and Review, the Australian Diagnostic Manufacturers Association pointed out that:

> . . . experience indicates that the commercialisation of a great deal of 'technology' is not passed to the professionals but attempted by the scientists of research institutes eg Universities set their own commercialisation groups eg 'Xtech' and staff them from within or with technology qualified people.

In the view of the Association there are insufficient experienced commercial, general management, sales and marketing people being employed.

In our view, and with the current situation in the pharmaceutical industry, Victoria would benefit from:

- Support from a publicly sponsored equity fund for seed and early stage commercialisation of biotechnology with a view to securing IP and developing and implementing an integrated marketing and communications strategy[19]
- A clear understanding that funding is for product and management development and not further "discovery" research
- Encouraging, through FDI initiatives, pharmaceutical companies to locate (or remain) in Melbourne
- Advocating greater cooperation and collaboration among research centres and institutes, through consortiums and partnerships, that can work effectively in joint ventures with pharmaceutical companies
- Making available advice and assistance to scientists and "academic entrepreneurs" in their negotiations with large pharmaceutical companies.

There are, however, a number of biotechnology companies that are doing well and have developed effective working relationships with the pharmaceutical companies. These include Institute of Drug Technologies and AMRAD. However, for the Victorian biotechnology base to move from "S&T" to "I", investments must be made to support the commercialisation process.

7.4. Biotechnology in Food and Agriculture

The potential for application of biotechnology in agriculture is well recognized. It allows for greater crop yields that use less land and less toxic chemicals. With the rapid depletion of Australia's natural capital associated with the problem of dryland salinity there are major long terms issues and strategies that can be developed around agricultural biotechnology.

[19] The current Commonwealth Innovation Investment Fund (IIF) Program does not sufficiently address needs in the biotechnology sector.

There are, of course, many issues to be overcome, the most fundamental of which relate to food safety. Much is still unknown about the long-term effects of GM crops on the environment. There has been a substantial consumer backlash to GM foods.

The reaction to the consumer backlash has seen many of the large biotechnology companies spin off their biotech agriculture operations. Monsanto is in the process of being acquired by a pharmaceutical company with the acquirers intending to stick to biotech drugs.

In their submission to the Audit and Review, Genetics Australia Co-operative Ltd pointed out that:

> It would be helpful if there were a strategy for bringing together research and commercial interests to capitalise on existing strengths in biotechnology. A strategy to develop agricultural applications with a focus on research likely to improve agriculture's competitive position. The willingness of institutional research organizations to work collaboratively with other institutions and commercial partners on focussed projects is a particular consideration.

Consumer demand for non-GM foods creates opportunities for innovative approaches to improving agricultural productivity using the resources of the Victorian Agricultural Institutes, the CRCs and the University Research Centres. Food manufacturers are now competing on the basis of the lack of bio-engineered ingredients. There are several issues to be addressed, including:

- Assisting in the development of the market for naturally grown foods
- Developing technologies that will restore and replenish natural capital.

These issues should be addressed in the context of further development of the Victorian STI strategy.

Appendix: Gaps Identified in the Victorian STI Resource Base

In this Part of the report we have set out specific proposals for infrastructure investment put forward by respondents to the "Request for Information" circulated in December/January. The proposals were put forward in response to the request to identify specific gaps in the State's STI infrastructure.

The proposals are grouped as follows:

- Facilities and equipment
- Capacity and capability building
- Cooperation, collaboration and networking
- Support for commercialisation.

The content of many of the proposals is reflected in the analysis and recommendations contained in earlier Parts of the Report. However, we have not made any comments about the economic benefits or merits of the proposals.

Facilities and Equipment

For presentational purposes, STI gaps are identified under the main fields of research to which the identified capability gaps relate.

Chemical Sciences

The Department of Chemistry, Latrobe University

The Department has pointed out that in the Bundoora area, the future collaboration between La Trobe University (LTU) Chemistry and the Victorian EPA and other organizations (e.g. AGAL, Police Forensic Labs and RioTinto) would be strengthened by ensuring that advanced analytical equipment is accessible to all groups in the locality (much like it is in the Parkville area).

The key equipment to be considered includes ICP/MS, NMR, MS, surface analytical equipment, thermoanalytical, X-ray, electroanalytical, CE and chromatography. The Department submits that it desperately needs to upgrade the 300 MHz NMR spectrometer. It is a very heavily used hybrid machine. The console was built in 1985 and requires an upgrade because of its age and limited capabilities. The magnet has many years of life left.

The Department is aware of the development at CSIRO Clayton of a Microwave Reactor specifically designed for chemical laboratory use. This purpose built machine has applications in synthetic chemistry, polymer preparation, biotechnology and geology.

The Department considers that it is well placed to use one of these reactors in numerous applications in its own research program and to provide access to other users in the commercial field. This microwave technology is an important emerging field for research and application and one that is currently not available in Australian universities.

The Department would also like to upgrade its mass spectrometry instruments to complement the machines currently held with extra capabilities which will substantially add tot the interest from external users and to the teaching and research areas of the departments activities. Specifically, an ICP-MS (cost $1.0M) and a TOFSIMS ($1.2M) would be invaluable acquisitions.

The State Chemistry Laboratory

The Laboratory submitted that there is an on-going requirement for high-quality, cost-effective research and analyses to support the government's "Naturally Victorian" initiative, sustainable agriculture programs, resource management and environment protection, and to increase market access for agricultural produce.

As part of Agriculture Victoria, SCL sees itself as being well placed to provide scientific input to all of these programs, but increased state investment is necessary to enable the laboratory to contribute fully. Funds would be required to purchase very high cost ($500K) research and analytical instrumentation, particularly LC-MS and High Resolution GC-MS, which is needed both for research purposes (eg. functional foods) and complex analyses (eg. antibiotic residues in animal tissues).

The current annual capital allocation, ($160,000) is seen as insufficient to allow the purchase of such high cost instrumentation or replace the capital base value ($3.1M).

PROBE Pty Limited

The Company was established and funded by ICI (Australia) and has pioneered the use of Nuclear Magnetic Resonance as a major industrial problem solving tool in Victoria. It is a recognised centre of expertise in chromatographic analyses. The company considers that its progress as a leading innovator in both areas will be drastically impeded unless it receives assistance with its capital expansion program.

Assistance with funding to purchase a new 500MHz NMR Spectrometer and Electrospray LC-MS equipment is seen as an immediate requirement. Approximately $1.2m would be needed to restore PROBE to its former position of the leading independent, industrial consulting laboratory in Australia

The Manager of Probe Limited also pointed to the opportunity the company could provide to young Victorian Science graduates:

> If we had funding to assist with capital expansion, we would be in a better position to hire young scientists. Their natural enthusiasm and recently acquired skills would be a shot in the arm for laboratory staff here not to mention the knowledge we could pass on to Victoria's future top guns..

Information, Computer and Communications Technologies

High Performance Computing

The CSIRO Division of Atmospheric Research has a substantial capability in Victoria. The Division's capabilities are, to a large extent, dependent on ready availability of high-performance computers. It is one of the largest supercomputer users in the world, but currently receives little support from the Victorian Government. The Division suggests that:

> Victorian Government support for a scalar multi-processor computer would enable CSIRO Atmospheric research to act as a demonstration site, showcasing to industry, Australia and the world, the high level of IT innovation and application in Victoria. This would be a highly effective way of encouraging use of modern, high-performance supercomputing technology throughout the State, using the existing management and technical infrastructure.

The Division considers that there would be significant benefits to the State if the Victorian Government were to contribute to the CSIRO/Bureau of Meteorology supercomputer facility. It argues that such a contribution would:

- Ensure that the facility would be better utilised by research groups and industry
- Provide distinct economic advantages for Victoria if scientists and industry were able to gain access to one of the world's most powerful computing facilities.

Applied Sciences and Technologies

Victoria has a strong capability in the applied sciences, and is reflected in various technologies including aerospace, manufacturing and process technologies, industrial biotechnology and materials sciences.

Boeing/Aerospace Technologies of Australia [ASTA Components]

ASTA identified the technical infrastructure capability gaps as paramount to ASTA's future success as:-

- Infrastructure in Aluminium Castings technology
- Fabrication and Assembly Automation
- Design/Manufacturing Optimisation for efficient Concurrent Engineering of new parts
- Understanding of resin characteristics and behaviour for liquid moulding
- Damage behaviour of metallic structures
- Rapid Prototyping
- Contemporary low cost tooling design
- Differential Scanning Calorimetry [DSC] polymer characterisation
- Advanced CAD/CAE logistical operation.

The Centre for Material and Surface Science (CMSS)

CMSS are strong supporters of the acquisition of a synchrotron for Victoria, with envisaged purchase cost $100-150 million. As major synchrotron users, CMSS staff are currently required to travel to Germany, USA, and Japan to conduct experiments. Extension of CMSS successful industrial surface analysis program to industrial clients is not possible under the current access arrangements.

Food Science Australia

FSI has been working closely with a number of Victorian based companies involved in innovation in the food industry. The organization advocates a facility for commercial process scale-up and start-up for value added food, nutraceuticals and bioproducts.

The Industrial Research Institute, Swinburne (IRIS)

IRIS provided a brief list of equipment that it "could make good use of":

- Frequency quadrupled laser for micromaching and plasma analysis;
- 300GHz high power source for biotechnology and micro-processing of materials;
- Synchrotron for micromanufacturing, advanced lithography, surface analysis, protein X-ray cystallography, etc.; and
- A class 1 clean room facility for semi-conductor, micromachine, and biomaterial fabrication.

Laboratory for Turbulence Research in Aerospace and Combustion (LTRA&C)

A significant proportion of aerospace activity in Australia is located in Victoria. Aerospace activity can be found in the private and commercial aviation and air transport sector, the air force, DSTO, and in education. At present this sector is lacking an appropriate level of support in research and development, and in the supply of people with a high level of training in these skills.

LTRA&C are presently able to only partially fill the gap that exists in this support. If the present gap is to be filled, and if this gap is to remained filled, greater support from the LTRA&C, for example, to this sector is required.

While the laboratory receives funding to undertake work on a project-by-project basis, expansion of the laboratory's activities to meet the future needs of, for example an expanding Victorian Aerospace Industry, will require additional targeted funding.

The Laboratory considers that the need for more funding is made even more crucial when it is considered that the LTRA&C is presently operating at maximum capacity in respect of both its experimental infrastructure and in its 'bricks and mortar'.

Engineering

The Australian Pulp and Paper Institute

The Institute has pointed to gaps in its ability to carry out necessary research for product development for the new digital printing and decorating technologies.

These inadequacies appear as the Institute is seeking to put together a co-operative research proposal (in the form of a CRC) that will address these technologies and stop associated jobs going off shore.

DSTO – Micro Electro-Mechanical Systems (MEMS)

MEMS argued in a submission to the Audit and review that a complete prototyping facility for MEMS devices is needed in order that Victoria (or Australia) can participate in the emerging micro-machining revolution in manufacturing.

The Victorian Micro Fabrication Facility (VMFF) would offer the following services to industry and research establishments:

- a clean-room for MEMS fabrication with an appropriate level of CMOS circuit fabrication to make “Smart” MEMS devices
- computer aided design and modelling tools
- a single point interface to other (local and off shore) MEMS and CMOS fabrication facilities.

An estimated cost of between $25-30M spread over 3-4 years to set up a facility has been provided.

Further information on this proposal has been provided to the Audit and Review Team.

Robotics and Mechatronics Research Laboratory (RMRL)

The RMRL identified specific gaps in Victoria’s STI infrastructure in the areas of non-contact sensing, prototyping equipment, optical measurement, autonomous systems research, multiarm robotics facility, and medical robotics.

RMRL emphasised that it has the capacity to conduct the necessary research and that the number of RMRL research staff is growing rapidly in order to conduct major R&D programmes in collaboration with industry. A constraint on further development is that the current building is limiting capacity.

Biological Sciences

Australian Animal Health Laboratories

The AAHL pointed out in its submission that pharmaceutical companies and research institutes often need to access commercial fermentation and cell culture capability, for production of vaccines and recombinant gene products.

This needs to be done to Good Manufacturing Practice (GMP) in order to enable them to be evaluated. There appears to be a significant under capacity in Australia for this type of service and a number of Victorian institutes are keen for an additional facility to be developed.

Currently, the only GMP facility in Victoria is owned and operated by CSL Limited. This is made available on a commercial basis to outside parties at times when CSL Limited does not require the facility. AAHL argued that development of an additional, small-scale GMP facility for pharmaceutical and biological products would place Victorian biotechnology in a very competitive position.

AAHL has an uncommissioned vaccine production unit that could be activated with input of resources, to convert to GMP standards, and to install the required equipment. This facility has all the relevant services required, including gas, water, electricity, steam, ducted liquid nitrogen and HEPA filtered air supply, together with the required isolation areas. It could then be leased or made available to commercial parties through some other arrangement.

The Plant Biotechnology Centre

The Centre, which is within the NRE/Agriculture Victoria sees a requirement for a further enhancement in current capacity in bioinformatics and high-throughput genotyping and plant gene expression profiling to offer a suite of platform technologies for plant genome analysis and plant functional genomics - including gene expression arrays, DNA chips and high-throughput assays for plant gene function analysis. This would be of significant value to the collaborative partners and industry.

The Centre also seeks a once-off capital investment for upgrade and relocation of NRE's Plant Biotechnology Centre, Agriculture Victoria at La Trobe University to purpose-build facilities at the Precinct of the La Trobe R & D Park and Technology Enterprise Centre, and for an extension of the available environmentally controlled- and containment glasshouse facilities jointly used by DNRE and La Trobe University. This will further enhance collaborative interactions and partnerships with Academia and particularly with Industry (e.g. plant breeding companies, seed production companies, life sciences companies)

The Plant Cell Biotechnology Research Centre (PCBRC)

PCBRC is looking for funding to aid in the purchase of a new high throughput sequencing mass spectrometer and a new automated nanobore HPLC system. These additions to our existing facilities would double existing mass spectrometer sequencing capabilities. The Centre also hopes to secure support for one senior researcher and a number of support staff to allow other research organizations and industries much broader access to both our facilities and our experience.

Changes to the PCBRC's funding arrangements in 2000-04 will put pressure on instrument usage rates and access to facilities. Currently, 95% of the

Centre's instrumentation and personnel time are committed to major collaborations.

Royal Botanical Gardens and National Herbarium

The RBG is seeking funding to increase its IT capacity in order to be in a position to deliver secure electronic services online. This increased capacity would enable the RBG to meet its public sector obligations, and develop and provide additional products and value-added services.

The investment would integrate RBG capabilities with the other scientific and cultural agencies by linking electronically with the Museum of Victoria, National Gallery of Victoria and the State Library of Victoria. A broadband network currently proposed for links to Federation Square could provide the necessary access and linkages for the RBG.

At the moment, a large amount of information on the labels of the specimens in the RBG collection is currently inaccessible to researchers and the public at large because the majority of the specimens have not been data-based. There is a pressing need to database the entire collection so that this information associated with the collections can be made available electronically. Major funds are required to achieve this goal.

The Victorian Institute of Animal Science

The Institute has pointed out that recent investment through the Science Technology and Engineering Initiative has provided a much-needed boost to VIAS' capacity in molecular genetics and genomics. This has added to VIAS' strategic capacity in platform technology in recombinant vaccine development and genetic engineering.

VIAS has submitted that further commitment to the ongoing support of these programs through the STI (or other) initiative is needed to maintain strategic advantage in these fields of animal science and to maximise the return from these investments in the medium to long term.

Agricultural Sciences

DemoDairy

DemoDairy is seeking support to upgrade its milk harvesting facilities. It argues that the direct and indirect benefits would be reflected in:

- Improved access to accurate information for southwestern dairy farmers (who have missed out in the past because no public dairy research facility was provided in the dairying region in the South West)
- Support the rapid growth of the industry in the area.

It is argued that community ownership of this facility would also mean that the community, not government is responsible for ongoing maintenance and replacement.

The Ellinbank Dairy

The Dairy has identified glasshouse facilities to undertake detailed agronomy work. As a key gap in Victoria's STI infrastructure.

The Institute of Dryland Agriculture

The Institute submitted that:

- If NRE's involvement in development of GMO products is endorsed, the Institute will require additional facilities (handling areas and glasshouses) to ensure that products can be isolated to standards demanded by GMAC and expected by clients.
- A capacity to undertake weed research as an important input into integrated farming systems of the future
- A major potential gap in oilseeds laboratory equipment if NRE establishes it's own oilseed analytical capacity (much of the current routine work is done through a joint venture with AgSeed Research). Significant purchases ($300-400,000) would be required eg. HPLC, Leco Protein Analyser and a second NIR etc.

The Institute of Sustainable Irrigated Agriculture

The Institute has perceived gaps in Victoria's STI infrastructure capability in three main "needs" categories

- More comprehensive modelling of a variety of systemic factors of importance to irrigated agriculture, including catchment scales, soil/water/plant/atmosphere systems, salinity, farm management practices, etc.
- A selection of more specialized equipment in relation to laboratory analysis and field sampling (e.g. ICP Mass Spectrometer) which is too expensive to purchase for individual projects
- More comprehensive data base design and management in a number of fields of generic application to irrigated agriculture.

The Joint Centre for Crop Improvement

The Centre identified the following gaps in infrastructure capability:

- Equipment and laboratories to allow an expansion of research and training in agronomy and farming systems at Horsham. The facilities would be shared between the University of Melbourne's Longerenong College and the Victorian Institute for Dryland Agriculture. The priority for expansion of these areas was identified by the 1997 Review of the Joint Centre (copy enclosed)
- Laboratory space and glasshouses for recombinant DNA and plant physiology research a Parkville
- Appropriate accommodation for the expanding student body at Horsham. At least five and probably more, postgraduates have/will commence work at Horsham in 2000.

The Marine and Freshwater Institute

The Marine and Freshwater Institute submitted that the construction of quarantine laboratories is required. Noting that there are such facilities in Victoria the Institute points out that none have the capacity for an aquatic focus.

The Pastoral and Veterinary Institute

The Institute pointed to a requirement for capacity to overcome soil constraints to productivity as an important input into integrated farming systems for the future. The major gap is in PC2 grade laboratories and glasshouses to ensure biotechnological advances in pasture plant breeding are captured in new cultivars. Research of this type must be conducted under strict quarantine and GMAC conditions.

The Institute also pointed out that the Feedtest laboratory requires additional handling and preparation areas and land area is required for research and experimental purposes.

The Rutherglen Research Institute

The Institute is seeking the addition of mass spectroscopy capability which it considers would markedly improve its ability to define more accurately plant and soil processes in the rhizosphere.

Medical and Health Sciences

The Centre for Early Human Development/Animal Gene Storage and Resource Centre of Australia

The Centre submitted that expansion of the its activities will soon exhaust the capacity of its present allocation in the Monash Institute of Reproduction building. To remain internationally competitive, the Centre would require access to certain classes of research infrastructure that are not currently readily available. The major classes are:

- High quality animal research and breeding facilities: Current facilities are inadequate, especially for the generation and maintenance of transgenic animals. The Centre has capabilities in cryopreservation which will play a major role in future management of transgenic stocks.
- Access to genomics and proteomics technology, including microarray, high throughput sequencing, protein micro sequencing and two dimensional gel analysis, bioinformatics. Current access is on a piecemeal basis or is very expensive. To facilitate access to such technology will require a centre on or near the Monash site.
- Modern facilities for cell biological research: A proposed development of an integrated facility bringing together key items of major equipment for modern cell biological research, including confocal microscopy, conventional light microscopy, image analysis, flow cytometry, laser

scanning cytometry, laser capture microdissection, electron microscopy, optical tweezes.

Although the Centre currently has access to some of this equipment, much is outdated, and some is lacking altogether. An integrated approach to management, maintenance and operation of such a facility would be highly advantageous. No such centre exists at present but it would be highly used by many groups within close proximity to the Monash campus.

The Mental Health Research Institute (MHRI)

The MHRI submitted that the contribution it makes to Victoria's knowledge capital may be threatened in coming years by closure of Royal Park Hospital, as part of the mainstreaming of mental health services by Australian governments.

The Institute considers that closure of the Hospital would deprive it of its ready and reliable access to patients and clinical colleagues and may rob it of its momentum at a time when there are enormous opportunities for advances in brain research.

World Health Organization Collaborating Centre for Influenza

The Centre considers that it currently represents a unique potential benefit to Victoria and to Australia in the ability to deal with an influenza pandemic that could have devastating consequences worldwide.

The Centre's ability to develop potential pandemic strains of influenza virus and reagents could greatly accelerate vaccine production in the event of a pandemic threat or pandemic. However, the Centre currently lacks a high containment laboratory facility. This severely restricts its activities in this area and, for example, prevented it from working on the influenza A(H5N1) virus isolates responsible for the 'chicken flu' outbreak in Hong Kong in 1997.

Developing STI Capacity and Capability

A number of organizations pointed to the need to build capacity and capability as a means to strengthen the Victorian STI Resource base. The proposals are outlined below.

Earth Sciences

Climate and Weather Forecasting

CSIRO Atmospheric Research suggests that the Victorian Government should invest in the application of weather and climatic forecasts on the basis that there would be economic benefits for Victorian industry, such as power generators and manufacturers, to incorporate accurate, timely and pertinent forecasts into their planning process.

The Centre suggested that there is an apparent lack of appreciation of recently acquired improvements to forecasting ability of weather and climate,

as well as of how this capacity can be translated into innovative improvements to industrial and commercial performance.

The Queensland government has successfully implemented systems to enable agriculturists to better take advantage of climatic outlooks for activities including crop planning, stocking rates and fertiliser use.

Geological Survey of Victoria

GSV submitted that industry has concerns about the GSV being effectively supported by the NRE. It suggested that if significant global minerals companies are to be attracted to Victoria, there must be a vibrant and strong GSV.

GSV noted that while Victoria has many competent research institutions, what is missing is the review of projects in the context of the State's interests - a gap the GSV can fill. The GSV also wishes to pursue the development of computer-based models to permit the 3D visualisation of data in its own right and the testing of theoretical geological models. This is seen as a fundamental research activity far beyond the resources of private companies – and an area where GSV could and should be active.

Geospatial information

The Arthur Rylah Institute (ARI) considers that more complete geospatial (including GIS capabilities) information is needed on flora, fauna and freshwater biota to help in planning decisions across Victoria.

ARI sees itself as being well placed to provide strategic ecological scientific input to many Victorian environmental programs. It regards increasing industry and community involvement in catchment management issues draws even greater requirement for access to interdependent and reliable ecological information. This may require completion of current vegetation mapping (EVCs) and further modelling to predict fauna distributions.

ARI also sees a need to build dynamic models that predict changes in flora and fauna over time in response to climatic change or effects of management. A better understanding of ecological needs of flora, fauna and freshwater systems is essential to help resolve potential conflicts with benefits for biodiversity and Ecologically Sustainable Development.

Palaeo-Environments Group

The Group would like the Government to continue to support the geosciences in Victoria by maintaining the government research and development roles etc in the State Geological Survey, for the petroleum and resources sector and the provision of data for industry exploration and development, university research and development for the future growth of the state's economy. The excellent quality of the recent past is a testament to the commitment of recent state governments to the development of the state.

The Centre for Applied Hydrology

The Centre for Applied Hydrology notes that an emerging need in infrastructure and analysis is associated with remotely sensed data. NASA's new Terra satellite will be producing data of relevance to environmental issues and will be available at low cost but requires specific infrastructure to process the data.

Information and Communication Sciences

High Performance Computing and Communications Centre

The Centre has submitted that Victoria has traditionally been the centre for industry in Australia, and in particular, the centre of the automotive industry and its key suppliers. HPCCC has played a key part of the engineering design for overseas automotive companies and suppliers, but has not played a major part in Australia.

The Australian subsidiaries of overseas companies have tended to make limited use of facilities provided in their headquarters, but the usefulness has been limited by slow networks, and the problems of visualisation of large amounts of data.

There is an opportunity in this industry to build an integrated design capability, as has been done at the University of Stuttgart for Daimler-Chrysler, Porche, and others.

Similar opportunities exist for other industries, e.g. oil exploration, ship building, electricity market analysis, etc.

Victorian Software Engineering Institute

The Department of Computer Science and Computer Engineering has proposed the establishment of a Victorian Software Engineering Institute. It also proposed:

- Increased security in long-term funding
- Increased funding for replacement purposes
- The introduction of HECs liability for its graduate diplomas.

Applied Sciences and Technologies

CSIRO Textile and Fibre Technology

CSIRO Textile and Fibre Technology suggests that demand chain activities especially in the TCF sector are critical to successful business practise. State based programs to encourage demand chain improvements based on innovation are essential. This division has found the supply chain program very useful in identifying innovation opportunities in the TCF&L Industry.

CSIRO Molecular Science

The Advanced Composite Group sees a big gap in Victoria's STI infrastructure is in the composite polymers area outside aerospace. The Group is presently attempting to fill this gap with a combination of industry and public sector input.

The Fluid-dynamics Laboratory for Aeronautical and Industrial Research (FLAIR)

FLAIR is a major provider of research and training in fluid mechanics and possibly the largest one in Victoria. Formed only 5 years ago, it has the potential of being the central focus of fluid mechanics for industry and government.

There is at present no Victorian centre to support industry in fluid dynamics, particularly in the manufacturing and automotive areas. There is an opportunity to capture a far greater share of the defence research spending in aerodynamics and hydrodynamics, which is currently undertaken in other states.

Food Science Australia

FSA suggests that a commitment be made to understanding the human and business processes aiding and holding back commercialisation of innovative technologies in the food manufacturing industry, so that barriers can be overcome by appropriate government programs.

FSA suggests that maximization of benefits from a national approach to STI infrastructure in food related areas, and improved mechanisms to provide for the needs of the States (mechanisms involving other States, beyond the Victorian/Commonwealth approach embodied in Food Science Australia).

Kraft Foods

Kraft noted that over the last several years, the Victorian government has taken significant steps to improve the linkage of the STI infrastructure to industry, to focus the resources on fewer and bigger opportunities and to create fewer centres of more significant critical mass.

The strategy is seen as development of expertise in some areas that are important to the food industry but which were previously under funded, eg, process engineering and sensory consumer science. Kraft would be keen to see continued moves in these general areas.

VicHealth Centre for Tobacco Control

VCTC receives Federal and State research grants but does not receive commensurate infrastructure support funds. The centre is seeking support at least equal to the proportion universities would receive for success in the competitive grant arena to secure its capacity for analytic testing of tobacco products

General Engineering

Melbourne Water Corporation

Melbourne Water advised that from a technical aspect the most significant issues in the water industry are being addressed at national, state and regional levels. It pointed out that some gaps in capability (knowledge) exist and deficiencies need to be expedited in a number of areas - some of which involve national and interstate collaboration. For example the National Water Quality Management Strategy (NWQMS), which began in 1991, is still to be finalised.

The Corporation identified the following issues that need to be addressed

- Aspects of the relationship between drinking water quality, enhanced water quality standards and public health benefits
- Automated systems for process monitoring and control of sewerage processes and systems
- The health of rivers and the relationship with environmental flows and general water resource allocation
- Relationship between standards imposed by the environmental regulator and environmental benefits and costs in meeting them
- Health aspects and public acceptance of recycled treated sewage effluent and stabilised biosolids.

Water Studies Centre

The WSC has an existing high quality and well-developed base in the area of water quality and well-developed base in the area of water quality research. Victoria has a growing need for the generation of new knowledge in water quality to assist in better managing the State's water resources.

WSC considers that STI infrastructure funds would enable it to consolidate and then expand its existing research and information exchange capabilities. This would then provide the base from which to target a range of key water quality management projects that would contribute to improving Victoria's sustainable development program.

VicRoads

VicRoads has identified a series of gaps in knowledge within its four areas of business:

- Significant opportunities exist in the development of intelligent transport systems to improve traffic flow, reduce accidents and managed demand;
- Development of network level performance measures to improve confidence in the prediction of long-term road pavement performance;
- Development of new bridge testing methods to measure load endurance etc.

- Use of advanced composite materials for road and bridge strengthening. Additional funding for work on these areas would be effectively used

Biological Sciences

The Centre for Animal Biotechnology

The Centre for Animal Biotechnology submitted that the establishment of a "Large Animal Research Centre" by the government with a minimum 5 year budget allocation would provide a better structure for career development and would free-up time from writing grant applications to fostering increased collaborations with other research centres and industry partners.

Ovens Research Station and Institute for Horticultural Development

The Station and the Institute identified specific gaps in STI infrastructure as follows:

- Diagnostic science plant diseases - a classical diagnostician required for the commercial diagnostic service
- Industry specialist ornamentals - no expertise currently available to service demands of the cut flower and nursing industries
- Non English Speaking Background and horticultural scientists- no expertise currently available to service needs of Victorian vegetable industry.

Agricultural Sciences

Centre for Land Protection Research

Specific gaps in Victoria's STI relevant to CLPR were identified in the areas of: Catchment hydrology, wetland hydrology, groundwater modelling, groundwater resource assessment, rural social science.

Medical and Health Sciences

A Victorian Institute of Neuroscience

The Australian Neuroscience Society Incorporated has proposed the establishment of a Victorian Institute of Neuroscience. The roles of such an Institute could include:

- Supporting the provision of expensive core infrastructure facilities (such as primate colonies, transgenic animal facilities, functional MRI, PET scanning facilities, bioinformatics, IP/commercialisation-of-science expertise).
- Facilitate collaborations between research groups with complementary skill, by providing responsive and rapid access to short-term funding requests arising from urgent new developments.

- Coordinating Victorian and/or national clinical trials in the neurosciences (similar to the Australian Stroke Trials Centre, a national coordination centre already based in Melbourne).
- Provision of professional advice on intellectual property, provisional/full patents, potential venture capital partners, expansion of and gearing-up research programmes, and commercialisation of research outcomes in the neurosciences.

A detailed proposal was provided to the Audit and Review Team and has been passed to the Department of State and Regional Development.

Support for Research Infrastructure

Mutation Research Centre

The Centre advocated greater provision for salaries and on-costs, which are difficult to obtain from the granting bodies. The Centre pointed out that:

> This is true "Infrastructure" and includes secretaries, business managers, and laboratory managers. Patent, legal and library costs are in this category and are crucial for commercialization and scientific advances.

The Centre noted that Germany has a system where one can apply to the state for patent fees, a topic of vital interest. It pointed out that grants awarded to research centres vary widely from year to year and while current infrastructure costs relate to competitive grants, there should be an averaging system, so that when a centre has a bad year, the funding is not reduced as much as it would be, if the rule was strictly enforced. This would allow the Centre to recover with new grants in the future.

St Vincent's Institute of Medical Research

The Institute pointed to a number of national studies have shown that there is a real infrastructure cost of 70 cents for each dollar of direct funding (i.e. 42 percent of total research expenditure is infrastructure). The State Government presently attempts to allocate to each institute a sum to support infrastructure to the level of 20 percent of peer-reviewed funds. While this level of support is seen as important to individual institutes, it still does not cover the real cost of infrastructure, which must then be met from other sources.

The St Vincent's Institute has recommended that the Victorian Government should increases infrastructure support to independent health and medical research institutes, initially to a level of 35 percent of peer-reviewed funds, and encourages the Federal Government to provide matching levels of support.

Cooperation, Collaboration and Networking

Aerospace Technologies of Australia [ASTA Components]

ATSA identified the logistical infrastructure gaps paramount to its successful operation as follows:

- Infrastructure logistics for International Research and Development cooperation with USA companies is lacking. This requires government-to-government cooperation at a high level to formulate the requisite agreements.
- There is currently poor access for industry to defence related programs.

There is currently no indigenous product/program in Australia which brings aerospace entities together and provides a catalyst for cooperation.

Australian Meteorological and Oceanographic Society

The Society is concerned that past applications made to Government for assistance in the holding of International meetings in Melbourne have been unsuccessful. It does not, therefore, feel encouraged to bring such projects to the State. Whilst the Society is willing to communicate its research to the community, it is concerned with the time and effort and the consequent cost.

Composites Institute of Australia

The Institute advised that the composites industry in the northern hemisphere is currently undergoing major technological shifts after a prolonged period of relatively static manufacturing processes. For the local industry to remain competitive it is imperative that these technologies be made available to local industry practitioners.

CIA endeavours to meet this need by bringing out leading experts in the relevant fields to conduct seminars in the major local cities. The consulting fees asked by these people, together with the associated travel costs which it must meet, limit the extent to which we can conduct these events, even though it charges a registration fee for the attendees.

Nufarm Ltd

Nufarm pointed out that Australia is well positioned to segregate GM and conventional crops. With the controversy over GM crops seemingly at its height leadership from government would assist Australians to learn from the lessons from Europe and the US. Nufarm believes that the long-term prospects for the technology are good.

Support for Commercialisation

Australian Ingredient Centre

Traditional R&D centres in the agrindustry focus exclusively on the development of a product or process, rather than coming-up with a total package which includes commercialisation.

The AIC is one of the few organizations in the State which attempts to service clients and stakeholders by simultaneously conducting scientific and market research.

Composites Institute of Australia

As compared with other State's Universities, Victorian Universities have been sadly lacking in commercial focus as far as the composites industry is concerned, with only the Wackett Aerospace Centre involved as RMIT is a CIA member.

Glaxo Wellcome Australia Ltd

Glaxo is of the view that the skill to recognise the value of technology and innovation in biomedical sciences is lacking in Australia. The venture capital needs to be well directed. Venture capitalists are needed who can add management value and strategic skills as well as money. This is the mix of skills that have been so successful in the US.

According to the company, too often Australian scientists and small start up R&D companies reject the advances of multinational pharmaceutical companies because of the desire to keep the discovery in Australia. This is a naive notion because the high costs of drug development, gaps in development capability and because the return on investment requires the successful commercialisation in global markets.

The company notes that the Australian pharmaceutical market accounts for 1-2% of the value of the global market. Australian scientists can realise value for their intellectual property through licensing deals with large multinational companies. Potential royalties to individuals and institutions from global sales are likely to be substantial.

The Company suggested a number of strategies to address the situation:

- *Strategies to achieve economic benefits* - training of scientists in intellectual property - strategic analysis of drug development in Australia to identify skill gaps - multi-disciplinary and collaborative approach to R&D and commercialisation - focus on new technologies - world class education system and research facilities which will attract and retain world class scientists in Australia.
- *Funding and Incentives* - funding for projects that have significant commercial potential - environment conducive to pharmaceutical R&D, manufacturing and export activities - increase the amount of funding for pharmaceutical industry - reduce corporate taxation to 31% as planned and restore the 150% R&D tax concession - Government should reconsider the implementation of draconian pricing policies for reimbursed medicines
- *Collaborations between Industry and Science* - collaboration between industry and medical research scientists - Government funding of research should be linked to industry investment. - Technology Parks should be encouraged industry should provide scholarships, work experience and training positions for tertiary level students and academics.

Invetech Operations Pty Ltd

Invetech pointed out that a healthy innovation system requires a lively venture capital sector. Given that venture capital is now a global business, for so long as our capital gains tax regime lags so far behind the US in its treatment of corporate venture capital, the smart money will continue to head for NASDAQ, and the smart ideas and people will follow it.

Water and Eliza Hall Institute of Medical Research

The Institute identified a number of issues in the commercialisation arena:

- Funding to establish and operate 'incubator' stage prior to 'investment-ready'
- Management of 'Investment-ready' marketing / securing investors / entrepreneurial skilled people
- Support to offset costs of maintaining international patents, and management of Intellectual Property
- Greater co-ordination of Government activities
- Impoverishment of funding for clinical research.

St Vincent's Institute of Medical Research

The Institute noted that there is now much greater focus on the proper management of intellectual property that emerges from the higher education research sector, including the independent medical research institutes. This management includes the protection of any intellectual property by taking out appropriate patents etc. The Institute commented:

> It has been recognised by all commentators that there exists a major funding gap in this process, between taking out a provisional patent and the registration of a full patent internationally (and the recruitment of a commercial partner and access to additional funding). Most researchers and their administering institutions do not have the finance available to support this crucial activity (up to $100,000).
>
> These funds can not be supported from research grants. As a result, many potential developments are not protected, and hence are lost from further development and national advantage.

The Institute recommended that the Victorian State Government should develop procedures to assist researchers to finance the gap in protection of intellectual property, between the initial registration of provisional patents and the recruitment of a commercial partner and taking out full international patent protection.